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Factors for success in Swedish biogas

A study based on the Swedish agricultural sector

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Abstract/ Summary

The energy sector of modern time is currently faced with several challenges. These are both production oriented and environmental oriented in nature. The energy of the future is intended to support an increasing demand while at the same time reduce its environmental affection. This stresses a development towards production methods of renewable energy. Among the existing methods, biogas is presented as an attractive alternative. Further, biogas is also perceived as an attractive business concept within the agricultural sector, since this sector contains a good supply of substrate that can be used in the biogas process. As an effect, biogas would enable renewable energy production in combination with biological waste treatment and thus there are several environmental benefits with using this method.

The potential for producing biogas in Sweden today, is relatively unexploited. Studies shows that there still is a large potential for producing biogas in Sweden, where a large share is represented by agricultural products. This study aims at identifying factors that are important for a further development in agricultural based biogas production. The study have been based on interviews with 31 agricultural biogas producers, where the findings has been analyzed using resource based view and Diffusion theory.

The study has shown that agricultural biogas production in Sweden needs to develop in order to become competitive. To enable such a development, factors such as support from external parties and investments in technological development is viewed as important.

Sammanfattning

Energisektorn är i dagsläget en sektor som innehåller flera problem. Dels finns det miljömässiga som produktionsmässiga problem. Framtidens energi ska dels kunna bistå en ökande population med energi samtidigt som den ska minska sin miljöpåverkan. Detta kommer att kräva nya metoder för att producera energi. Biogas presenteras som ett attraktivt alternativ för att producera förnyelsebar energi. Vidare är biogas ett intressant affärskoncept inom jordbrukssektorn, då det finns god tillgång till substrat som kan användas i biogas processen. Effekten av biogas skulle innebära produktion av förnyelsebar energi kombinerat med biologisk avfallshantering. Således finns det flera miljömässiga effekter med biogas produktion.

Potentialen för att producera biogas är i dagsläget i relativt liten i Sverige. Studier visar att det finns stor potential att utöka produktionen av biogas, där en stor andel beräknas komma från jordbruks produkter. Denna studie syftar till att identifiera framgångs faktorer för den Svenska jordbruksbaserade biogas produktionen, för att utforska möjligheterna till en fortsatt utveckling. Studien baseras på intervjuer från 31 jordbruksbaserade biogas producenter där insamlad data har analyserats med resursbaserad teori och spridnings teori.

Studien visar att jordbruksbaserad biogas produktion är i behov av utveckling för att bli konkurrenskraftigt. För att möjligöra en sådan utveckling, pekas faktorer såsom inverkan från externa parter samt vidare satsningar i teknik ut som viktiga.

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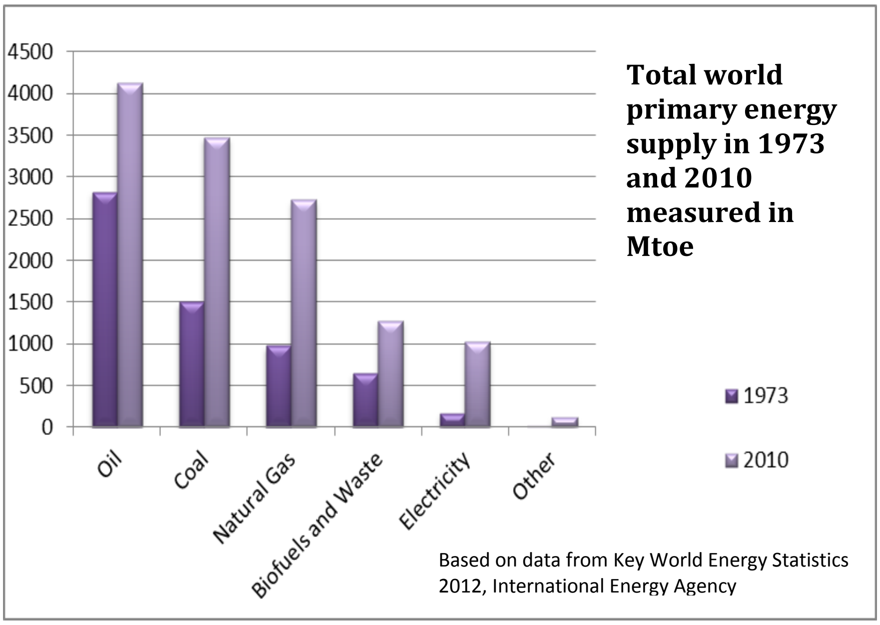
1 Introduction

The energy sector is a cause of significant environmental concerns that remain a big challenge for today's society. The energy production is today mostly based on fossil fuels (European Commission, 2011a, 2011b). Reports indicate that 80% of the total energy in the world is being produced from these sources (IEA, 2012). In order to reduce the environmental impact within this sector, new alternatives to production have to be developed. However, the problem with transitioning into new sources is that they hardly can compete with fossil fuels (Deutch, 2005). Since fossil based energy production is already well developed in modern society, this sector will have advantages in the form of being optimized to produce energy at low costs.



At the same time there is an increasing demand for energy due to improved living standards in developing countries such as in the Asian region (European Commission, 2011b; IEA, 2012). As fossil fuels are limited in supply, these will only be able to cover the increasing needs for about 100 - 300 years forward (Wünsch et al., 2012). As supplies are consumed one can also expect increasing energy prices from fossil fuels.

Currently there is a large focus on developing alternatives that use renewable energy sources as supplement for fossil fuels. Among the renewable sources certain interest has been given to biogas (Brown et al., 2007).

Biogas is created from biological products that are being processed by various bacteria in an anaerobic environment. As biomass decomposes from these bacteria, gas is created that mainly consist of methane (50 – 70%), carbon dioxide (20 - 50%), small traces of hydrogen sulphide and water (Energimyndigheten, 2012; Lantz et al. 2007). It is the methane that is of interest since it is very energy intense and holds a high affection on global warming; about 21 times stronger affection than carbon dioxide (Energimyndigheten, 2012; White et al., 2011). By combusting the methane it is possible to generate energy in the form of heat, electricity and vehicle fuel while at the same time disabling the affection the gas would have if exposed to the environment.

The perquisite with producing biogas is that it requires organic material. By using organic waste from other production areas as fuel it is possible to combine waste treatment with energy production and thus gain environmental benefits in both of these areas (Brown et al., 2007; Wünsch et al., 2012).

Further, biogas is also a promising alternative for the agriculture sector (since it is very energy intense) (Potter, 2002). The modern agricultural sector uses a lot of machinery, which can make costs like vehicle fuels and electricity consumption quite demanding. Farm companies that are focused on husbandry or cropping usually have large amounts of production waste left such as manure and crop residues. This waste, which is generally used as fertilizer, affects the environment as methane- and carbon emission are released through the process of decomposition and as nitrogen leakage when it is applied to the soil (Brown et al., 2007).

Using biogas could become fruitful for both the farmers and the society since it results in less environmental affection and provide new business concepts for farmers (Brown et al., 2007). Some reports indicate that the remaining material that is not converted into gas, also known as digestate, contains a more applicable form of nitrogen to soil (Brown et al., 2007; Wünsch et al., 2012). This makes the digestate an interesting alternative to industrial fertilizers (Brown et al., 2007; Wünsch et al., 2012). Further, Biogas production on a farm level could also provide new possibilities to supply energy in areas where big companies are not able to operate.

1.1 Problem background

Adapting to biogas is however not without risks. Reports indicate that the amount of biogas produced is dependent on several factors (Brown et al., 2007). Since the production of biogas involves anaerobic bacteria that are digesting biomass, there is a need for a certain environment that the bacteria's can operate effectively within. Factors such as pH, temperature, type of biomass and time intervals between deposits of biomass may affect the output from a biogas facility.

There are also economical constraints associated with the biogas production. The total investment cost is generally very high despite governmental support programs (Butler, 2010; White et al., 2011). It is also hard to achieve profitability without a large supply of biomass. As a result there is a risk that investors gets bound to a business that is unprofitable. Further, there are also other factors such as extra labor hours and transportation costs that may restrict the investor. This would indicate that only farms with certain conditions are able to become profitable in the biogas production industry.

Adding to the economical barriers there are also political and technological aspects that need to be taken into account with biogas. The energy production from fossil fuels is currently more developed than most renewable fuels. As a result there is a need for governmental interventions to stimulate the market for renewable energies. Further, there is also a need for increased developments in biogas production methods, to be able to compete with the fossil fuels.

There are, however, possibilities to create beneficial situations for agricultural biogas producers. As an example a group of farmers may invest in a joint biogas facility that is able to process large quantities of biomass. This would present them with an increased capacity that in turn could result in a profitable business concept. The farmers could then expect favorable synergy effects such as economies of scale and increased availability of social capital (Butler, 2010; White et al., 2011).

1.2 Problem

A total of 233 biogas facilities were registered in Sweden in 2011 with a total energy production of 1 473 GWh (Energimyndigheten, 2011). Out of these 233 facilities only about 40 can be considered farm based. Although this is a relatively small part comparing to the total number, there has been a recent increase in the amount of farm based biogas facilities. Further, energy production from farm based biogas estimated to have increased by about 20% between 2010 and 2011 (*Ibid*). At the same time, the total amount of energy produced in all biogas equals only 1% of the total energy production in Sweden.

It should also be noted that the entire contribution of agriculture to biogas production is not represented by the farm-based biogas facilities. During 2010 the farm based biogas production accounted for 36% of the biogas production from manure, while the remaining 63% was used in industry co-digester facilities (Energimyndigheten, 2011). The co-digester facilities also are the mayor users of energy crops, slaughter residues and food residues. Thus, farm-based biogas is only a part of the full biogas potential from the agricultural sector.

It has been noted that the biogas potential from the agricultural sector in Sweden is rather unexploited (Lantz et al., 2006; linné et al., 2008). In comparison to the ca. 40 farm-based biogas facilities in Sweden, in Germany there were more than 4500 farm-based biogas facilities registered in 2010 (Wünsch et al., 2012). This suggests that there is room for significant further development of farm based biogas production in Sweden. If this potential is to be realized, however, there is a need for a better understanding of the factors that underlie or hinder the development of successful farm-based biogas ventures.

1.3 Aim

The aim of this study is to investigate factors that are significant in the development of agricultural-based production ventures in Sweden.

From this aim, the following research questions are investigated:

- What factors are significant for the successful development of farm based biogas ventures in Sweden?
- What practices are being used in farm based biogas production in Sweden today, including technical aspects, resources and organizational aspects such as collaboration?

1.4 Delimitations

This study is limited to only Swedish biogas facilities that are largely based on agricultural substrates, and can be considered to be originating from within the agricultural sector. As a result, the study does not include industrially operated biogas plants where the share of agricultural substrate, in relation to other substrates, is relatively small. Nor does this study take consideration to sewer waste treatment facilities even thought they use a large share of agricultural products. The reason for this is that digestate produced from these facilities generally lies outside of agricultural industry (Lantz et al., 2006).

Additionally, this study does not investigate the effects of different types and quality of substrates. These are aspects that may certainly affect the yields and success of biogas production, but given their technical complexity and the scope of this project, these factors were not given priority.

1.5 Outline

This first chapter has been devoted to introduce the problems that exist in the energy sector in general. As an alternative to the energy consumption in the agricultural sector, biogas may provide renewable energy. From this it has been concluded that it is important to investigate factors that makes this concept successful.

Chapter 2 will focus on the theoretical framework that has been used in this study. The chapter will start with an introduction chapter that defines success in this study. The chapter continues with a presentation to resource based view and diffusion theory.

Chapter 3 is focused around the methods that have been used in this study and also describing what choices has been made. The chapter will start with presenting the general approach of this paper. Further, the chapter will continue with explaining what data that has been gathered and how it was collected.

Chapter 4 will describe the biogas process along with important aspects that is used when dealing in the biogas sector today. The chapter will begin with describing the biogas production and the various methods for doing this. The chapter will then continue with describing the market for biogas production.

Chapter 5 will present a summary of the findings in this study.

Chapter 6 is focused on analyzing the data based on the theoretical framework presented in chapter 2.

Chapter 7 will then summarize the findings from this study with the concluding remarks from the previous chapter and a discussion.

2 Theoretical perspective and literature review

The previous chapter presented an introduction to the situation within Swedish biogas production in the agricultural sector. Further, the chapter presented the aim and research questions of this study. The following chapter will present a theoretical framework that will be used to address the research questions. As a result this chapter will present definitions and theories that will aid in the understanding of success in the farm-based biogas sector.

2.1 How to address Success

In order to assess success factors in the biogas sector, it is important to understand how success is defined. According to the oxford dictionary, success is defined as “the accomplishment of an aim or purpose” (www, Oxford dictionaries, 1, 2013). This indicates that success is very much based on an individual perspective and thus it needs to be contextualized (Pabedinskaité, 2010). As an example: assume two climbers, an amateur and an expert, that are to climb the same mountain. Further assume that they only manage to climb halfway up the mountain. While the goal of the climb was to reach the top of the mountain, the climb may still be viewed as a success to the amateur depending on his previous experience. The expert climber may however see the climb as a failure since they did not reach their designated goal which was the top of the mountain. Similarities can be seen in the farm-based biogas production. Some farmers may view certain aspects of the biogas a success while others do not. An example could be the production of digestate as a fertilizer for organic farmers.

The question is thus what perspective should be used and how can success in the biogas sector be measured? While the Danish biogas expansion is regarded as successful in general (Raven & Gregersen, 2004) it is possible to use their context to gain an understanding of the success in biogas. According to Raven and Gregersen (2004) the Danish biogas production is considered successful since development has improved the number of producers to be among the highest in Europe. This type of success could be interpreted as factors that benefit the operation of biogas. As a result performance could be viewed as a factor for success. This is backed up by Cowling (2007) who argues that the most basic measurement of success in businesses is survival.

This would suggest that economic factors would correlate very well with success. It should, however, be noted that this may apply in great extent to mayor companies but when addressing smaller firms, success may be looked upon differently (Forsman, 2004). Success within smaller firms may in fact be dependent on several factors. What is common to these factors is that they should support certain benefits that the entrepreneur wants from the company (Bridge et al., 1998). Returning to the Danish context, it was apparent that success was achieved in great extent due to networking with other actors. As a result, this enabled new innovations and concepts of operation in the biogas sector. Further, it has also been shown that certain innovations in reactor technologies on farm-scale digestion have improved economical values (Svesson et al., 2005).

Based on these findings one may assume that success is dependent on the collaboration of different actors, economic values and none economic values. While collaboration may result in new innovations it is interesting to understand how new technologies and concepts are being spread. Diffusion theory will be used since it provides an explanation of how new technologies spread through populations. In order to understand how economic and non-economic factors may become important for success it is interesting to see the differences that exists among producers. Estimating economic value from non-market benefits is complicated since it depends on how such values are applied (Brown et al., 2007). This requires a model that can address both these values. By using Resource Based View it is possible to gain an understanding of how certain advantages in a business is created using combinations of resources.

While all actors perspectives matters to the success within the farm-based biogas sector this study will focus on the perspective of farmers or producers of agricultural-based biogas. The overall perspective of biogas producers will also be considered in some extent since it may be of importance for the development in the agricultural-based biogas production.

2.2 Resource based view

The previous section presented how success can be assessed in the agricultural-based biogas sector. This section will be devoted to describing how important factors for becoming successful arise. By using resource based view, further mentioned RBV, it is possible to identify resources that enable firms to gain advantages over other actors.

2.2.1 Basic assumptions

The theory of RBV is mainly focused around opportunities that arise from the resources that companies or individuals possess. Each company possesses a unique set of different resources. By combining these to form new more valuable resources it is possible for a company to gain advantages to competing methods and operations (Boon, 2000).

However, in order to understand the concept of RBV one must be aware of four general assumptions that are used (Boon, 2000):

1. Opportunities that arise for one company are not the same to another company. This is based on the fact that all companies are unique in their possibility to acquire certain resources.
2. Differences in how a company may alter their ways of disposing a resource in relation to other companies are generally low or unchanged. This indicates that companies cannot perform any radical changes in the way resources are used. As a result, knowledge cannot be transferred from one company to another due to its abstract nature. Instead this is a learning process that develops over time.
3. Differences in production between companies are a result of different processes of working. This indicates that resources, which are developed in a company, will attain different capabilities.
4. Businesses will always try to maximize their profits and thus they will always strive to attain competitive advantages.

These assumptions create the basic understanding for how companies will dispose their resources. The following section will describe the different resource types that companies may possess.

2.2.2 Resources and capabilities

The meaning of the term “resource” may vary among individuals. What is considered a resource in classic economic theory is not the same in strategic management theory (Forsman, 2004). What differ these definitions is the nature of the resource. It is argued that resources can either have a tangible or an intangible nature. Tangible resources generally consist of machinery and various objects that can be relatively easy moved between companies, this is generally how the classic economic theory describes resources (*Ibid*). Intangible resources on the other hand reflect abstract resources such as knowledge and experiences. These resources are in contrast to the tangible resources, generally hard to transfer from a company (Boon, 2000; Das & Teng, 2000).

Based on the nature of a resource, it is possible to divided resources into groups depending on their attributes. While there are some differences onto how these grouping should be performed, Barney (1986) presents three categorize that has been used in this report. These were selected since they provide a simple picture of the different types of resources. These categorize are:

- Physical capital resources
- Human capital resources
- Organizational capital resources

Physical capital resources consist mainly of facilities and machinery. One can say that these resources generally have a tangible nature. Human capital resources consist of experience, and education that are stored in managers and employees of a company. Organizational capital resources focus on structures, culture and working methods.

When addressing the value of resources, it may be noted that resources in themselves have no value until a company specifies how it ought to use them and when the resources reveal certain properties (Hofer & Schendel, 1978). What determines a resource value is thus the company's' ability to use and dispose of various resources (Boon, 2007).

Further, one can note certain types of resources depending on the perspective of a company. First there are resources that have direct effect on the performance of a company (Landström & Löwegren, 2009). Examples of such resources could be facilities or production machines. Second, resources that are used in order to provide the company with other resources that indirectly is important for the performance of the company (*Ibid*). Third and finally, there are resources that only provide weak or no benefits to a company (Das & Teng, 2000). Such resources are generally not applicable within the company and hard to convert into something useful.

One may also distinguish between resources and capabilities (Grant, 1991; Javidan 1998; Rosenbörjer, 1998). Capabilities can be described as a capacity or a bundle of resources that co-ordinates resources to perform certain operations (Grant, 1991). It should be noted that there are differences in the literature whether capabilities are distinct from resources. It is argued that capabilities are embedded in a company's organization and process and thus it should be regarded as an organizational capital resource (Makadok, 2001). In this study resources and capabilities will be used in order to clarify the relationship that exists between these terms.

This distinction between capabilities and resources enables an understanding to how some companies improves their performance while other companies fail. The outcome of a company's performance is thus based on the interaction between resources and capabilities (Forsman, 2004). As companies manage to combine resources, it is possible to gain positive synergy effects. In other words, when one company is better at using a certain resource than another company they possess a competitive advantage. The interaction between capabilities and resources may be seen as a loop where capabilities are created by resources which enable the creation of new resources or strengthening the already existing resources (Rosenbröjer, 1998).

2.2.3 Competitive advantage and strategy

Combining capabilities and resources do, however, not give any guarantees for creating competitive advantages. Certain combinations of resources can be thought of as more valuable than others. In order to identify what combinations that may results in a competitive advantage, a framework called VRIO is often used (Landström & Löwegren, 2009; Forsman, 2004). The VRIO framework represents the features that make a competitive advantage; and stands for: *Valuable, Rare, Imperfectly imitable and Organized.*

Valuable
The basic criterion for creating a competitive advantage is that resources have a value. The value of the resource is highly dependent on the perspective of the company as was mentioned earlier. It should however be noted that the value of a resource may change over time based on market environment and the ability of competitors to obtain the same resource (Barney, 1991, 2002).

Rare
Resources that are easily accessible will thus not be able to become competitive although they are considered valuable. As a result, resources need to be exclusive and hard for other companies to obtain. Resources that match such a description are regarded as rare (Barney, 1991, 2002). Resources and capabilities that are both valuable and rare are considered competitive advantages.

Imperfectly imitable
Resources and capabilities that are valuable and rare may, however, find competition from complementing resources presented by other companies. Imperfectly imitable indicates that a resource is complicated in nature and hard to substitute or duplicate (Barney, 1991, 2002). An example of imperfect limitability would be patents. Further, this feature enables the creation of sustained competitive advantages. Sustainability does in this case mean that the advantage status is kept over time (Reed & DeFillippi, 1990).

Organized
Resources that contain all the previously stated features may be regarded as protected from external threats. Having organized resources indicates that the resource is optimized for internal use (Barney, 2002). This feature mainly involves that the owning company of a competitive advantage not should fall in conflict with the ability to use the resource. As a result, many different aspects may be regarded as an organized feature. Some example could be: structure of the company, management and reporting system etc.

This model is, however, not universally accepted in the RBV. There is a wide Varity of models that try to address how sustained competitive resources arise (Forsman, 2004). What is common among these models is that competitive advantage becomes sustainable only if a company adapts a competitive strategy. Further it can be argued that the purpose of a competitive strategy is to establish and maintain competitive advantages (*Ibid*).

Das and Teng (2000) distinguish between two types of sustainable resources: property-based resources and knowledge-based resources. Property-based indicates that a company has secured resources by claiming single ownership; such as right by contract or patents. Knowledge-based indicates that resources have been secured by a high level of complexity that limits other to duplicate or substitute (*Ibid*).

2.3 Diffusion Theory

The previous chapter presented properties of the resource based view. This theory explains how concepts and resources can gain value and thus create competitive conditions for certain companies. The following chapter will address how changes are conducted and how new technologies and concepts are spread through populations.

2.3.1 Defining innovation

In order to understand innovation there is a need to clarify certain terms. Most people can argue that new technologies involve access to new knowledge. Further, one can argue that knowledge is, in its basic form, based on information. Information, knowledge, and technology are all terms that are closely related when speaking of innovation. In order to distinguish between them, these definitions will be explained in the following sections.

Information
Rogers (2003) describes information as a difference in matter-energy that affects uncertainty in situations where choices exist. This means that information simply aids individuals or units to make choices in a specific situation.

Knowledge
In order to make use of information one must learn to apply the information within a context. It is during this learning process that information is being converted to knowledge (Ferguson, 1995). Knowledge may also be divided into two types, formal – and tacit knowledge. What signifies formal knowledge is that it can be easily transferred between individuals. This involves generally information that can be written down. Tacit knowledge is the opposite of formal, which makes it hard to transfer; an example of tacit knowledge is experience.

There are also other dimensions to knowledge. Rogers (2003) address three categories of knowledge: Awareness -, how-to -, and principles knowledge. The awareness knowledge signifies that an individual is aware of an innovation. How-to signifies knowledge that is necessary to perform an operation. An example could be: learning by doing experiences. Finally, principle based signifies knowledge of functions and processes. In other words this knowledge explains why a certain process provides a certain outcome and thus provides understanding to the process.

Technology
When adopting a new technology it can be argued that certain levels, of the various knowledge types, are needed. It is mainly how-to- and principle based knowledge that affects the development of new technologies (Ferguson, 1995). How-to knowledge will affect the usage of the technology while principle knowledge gives room for development and new ways of applying the technology. While the awareness based knowledge is not developing new technologies directly it should be noted that the use of such knowledge is a requirement for identifying new possible technologies.

There are, however, some differences in how technology is defined. One definition of technology is: "*knowledge of cause-and-effect relationship embedded in machines and methods*" (Sproull & Goodman, 1990, p. 255[1]). Rogers (2003) on the other hand, describes technology as: a design for instrumental action that reduces uncertainty in cause-effect relationships involved in achieving a desired outcomes.When speaking of technology one should note that there is a difference between technology as a single unit and systems of technologies. Technology, as a single unit, involves combinations of knowledge that are based on cause-effect relationships (Weick, 1990). Technological systems on the other hand are seen as sets of implicit and explicit technologies that in combination provide a desired outcome (*Ibid*). The implicit and explicit nature holds the same meaning as informal and tacit nature (Nyström, 1990). It should, however, be noted that there are differences whether a technology can exist on its own, meaning that it is not built on other technologies. It is argued that all technologies build on past technologies in some extent.

Innovation

The meaning of innovation may consist of various aspects depending on the definitions used. The same issue as of technology, no common definition, applies to innovation. Some researchers use "*the search for, and discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organizational set-ups*" (Dosi, 1988, p. 222[2]). Another definition used by Nyström (1990), and others, "*the process of bringing new ideas into use*" (Nyström, 1990, p. 5). What is common for these definitions is that they are based on the gathering and applying of new technology. In order to distinguish between innovation and technology one may say that technology is a way of performing while innovation is more focused on finding different areas and methods for applying a technology. Thus one may say that innovation is the process of technological development.

When using the term "new", it may sometimes be confusing what is regarded as new based on an individual level. Rogers (2003) defines innovation as "*ideas, practices, or objects which are perceived as new by individuals or other units of adoption*" (Rogers, 2003, p. 12). This definition has been chosen for this study since it provides a good picture of how an already existing concept still can be regarded as innovative.

Using this perspective is, however, questioned since it can be argued that an adoption of an already established technology is not innovative. This argument is grounded in that no modifications are made to the technology and thus no room is given for development to the technology. This suggests that a company is being imitative instead of innovative. It should be noted that individuals or organization that considers imitating a technology will have to put the technology to use within their own situation (Westney, 1987; Sahlin-Andersson, 1992[3]). This suggests that any imitation must include some level of modification to the technology and thus an imitation cannot be non-creative (*Ibid*).

2.3.2 The innovation process

A technology can be seen as new in two ways: recently discovered or recently developed (Ferguson, 1995). The difference mirrors what was stated earlier, whether it is new to an individual or new in general. What is common to both these ways is that external information is gathered and learned and then adapted to fit the user's needs and environment.

[1] This reference was explored through Ferguson (1995).
[2] This reference was explored through Ferguson (1995).
[3] This reference was explored through Ferguson (1995).

When an innovation is being pursued, one can distinguish between high and low technology. This indicates the difficulty to adapt a technology (Calori, 1990). High technology entails significant barriers that restrict the pursuer to a certain set of resources in order to develop the technology. Such technology is generally associated with specialized labor, technological uncertainties, and large investments in R&D among other things. Low technology on the other hand is associated with low level barriers to accomplish the technology. A study by Davies (1979) highlights a similar difference between innovations. It distinguishes between expensive, sophisticated innovations and cheap, easy innovations. This is mirrored in the implicit and explicit technology that was presented earlier by Nyström (1990).

Just as there are different definitions to innovation, there are various ways of explaining how the process of innovation works. There are, however, some areas which seem to be central to this process. First, no matter how radical a technology is, it has to be built on previous technologies. Another point that is raised is that technologies are evolutionary and thus compete with the interest of the users (Tushman & Anderson, 1986[4]). This explains how technologies that have been developed for a long time suddenly can be replaced by a new rather undeveloped technology. As a new technology becomes apparent there will be a period of experimentation regarding how a technology should be designed until a dominant design has been agreed upon (Utterback, 1994). Factors that determine whether a design becomes dominant depend on the mixture of circumstances such as: immediate needs, customers, design presentation, reputation of the introducing firm etc. Once a dominant design has been reached, focus will be shifted towards developing processes rather than developing the product.

Further there is also a need of space that a new technology can grow and evolve within. This suggests that it is important to divest certain technologies in order to make new and perhaps more efficient innovations room to meet its potential (Helgesson, 1993). This suggests that a technological design may be known but lay dormant due to the lack of expansion. The reason why this occurs depends on the level of resources that the users have invested in already existing technologies and how easy it is for the user to transfer resources to the new technologies. Another factor that affects the development of a technology is the interest individuals have in existing technologies in contrast to new ones.

2.3.3 Diffusion

Diffusion of an innovation means how a technology is spread throughout a population. This process can be describes as an innovation that is communicated through certain channels over time among the members of a social system (Rogers, 2003). Within the diffusion process one can notice four elements:

1. Innovation
2. Communication
3. Time
4. Social system

Innovation
While innovation was explained earlier this element is more concerned with the aspects that improve the adoption rate of an innovation. Five aspects are being identified as significant to the rate of adoption (Rogers, 2003): The perceived relative advantage of adoption;

[4] This reference was explored through Ferguson (1995).

compability with values, experience and needs; complexity in understanding and use; triability on an experimental basis; and observability of the innovation in use elsewhere.

Communication
Communication refers to the process of creating and sharing information among participants in order to reach a mutual understanding (Rogers, 2003). Communication basically consists of four parts:

- An innovation
- An individual or unit of adoption that has knowledge of, or experience with, the innovation
- Another individual of unit of adoption that does not have knowledge of the innovation
- A communication channel that connects the two units

(Based on Rogers, 2003, p. 18)

There are generally two main communication channels that are used: interpersonal and mass media. The degree that participants in a communication understand each other is based on the level of homophily/heterophiliy – the extent to where the sender and receiver are alike/dislike (Ferguson, 1995). Further it is argued that diffusion is a part of communication which involves that a new idea is being shared from one participant to another.

Time
Time affects the diffusion process in two ways. The first one is the rate in which an innovation is being adopted (roger, 2003). This rate may vary depending on the circumstances of the innovation but it generally has an S-curve shape, which is displayed in figure 2,1 (Usha Rao & Kishore, 2010). From this S-curve one can identify certain categorize of adopters. In the beginning there are only few that have adopted the innovation. These adopters are referred to as the innovators. As time progress a few more start adopt the innovation – early adopters. These categories are dominant until the innovation reaches a breakthrough. During this period, the rate of adoption is increased dramatically – these adopters are referred to the early majority. After comes the late majority and finally comes the laggards that adopt to the innovation last.

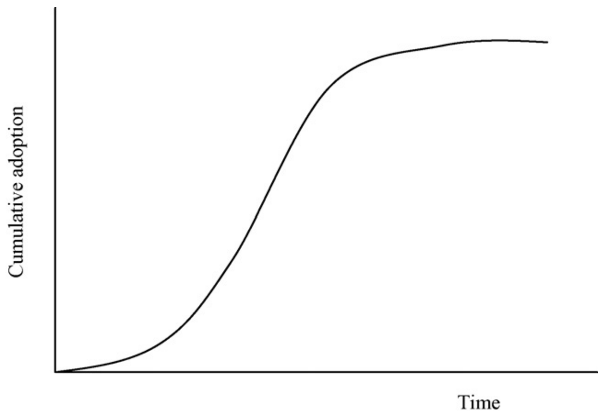


Figure 2,1: Diffusion curve – level of adoption vs time (Usha & Kishore, 2010)

The second way that time affects is the decision process of an innovation. Five stages have been identified for this way (Rogers, 2003).

- Knowledge – the stage that creates an awareness, and an understanding of a certain innovation
- Persuasion – the stage where a formation of an favorable or unfavorable attitude to the innovation
- Decision – the stage where the choice of adoption is valued against the choice of rejection
- Implementation – the stage that follows from an adoption of the previous stage, where the innovation is actively being adopted
- Conformation – the stage of seeking support and feedback on the adopted innovation

Social system
A Social system is described as a group of interrelated units that work together to reach a mutual goal (Rogers, 2003). Such units can be change agents which are representatives of a change agency that tries to influence a certain decision to potential adopters. Another example is opinion leaders, who generally influence attitudes of others in an informal way. The social system may also affect adoption through the structure and norms that exists within the system. Three types of decision that are based on the social system have been identified (*Ibid*):

- Optional – decision made by a single individual
- Collective – decision made within a group
- Authority – decision made by individuals in a position of a power that may enforce the decision upon other individuals

2.4 Choice of Theoretical framework

The theoretical frame was presented in the two previous chapters, including the resource based view and diffusion theory. This section will address why these theories were selected for this study.

2.4.1 Resource based view

The argument for using RBV is that the theory provides a good explanation to how companies improve their performances perceived both internally and externally. While improvement can be closely synonymous with success it is expected that RBV could provide an insight to the resources that affects success in the agricultural-based biogas production. Further, the RBV may also identify the resources that are common among the producers and put these in comparison to other findings of this study. As a result, it will be possible to get an indication of what factors that is important for a successful development in the agricultural-based biogas sector.

The RBV do, however, not consider how a competitive advantage is created which would provide a good perspective for development in the agricultural-based biogas sector. The theory do, however, present the properties necessary for competitive advantages which provides a guide for identifying resources that would be considered important.

Another weakness with RBV is that it mainly focuses on single company's ability to gain advantages over others; in other words creating heterogeneity within the market. While this sector is focused on findings of common factors that may enable a development, it might be considered inaccurate to use RBV. While the RBV provides a perspective applied from a single company it can be expected that some facilities will perform better than others. By categorizing what resources that these companies use it is possible gain an indication to what factors that these companies have in common. Further it is possible to use the diffusion theory, which adapts a broader perspective, in combination with RBV. As a result, it becomes possible to study factors interesting both at single facilities as well over the entire population studied.

However, since the RBV mainly focuses on finding competitive of advantages among companies, one may wonder whether performance is a good measurement for assessing success? It is argued that success becomes more complicated when applied in a context with smaller companies (Forsman, 2004). Further it can be expected that the definition of success may be different among facilities of different sizes. It should be noted that the identification of competitive advantages relies in finding resources that are considered valuable. Further, the theory argues that a resource receives a value based on the preferences of a company. While it is argued that smaller companies value success based on other factors than necessarily economical, RBV will still apply since these companies will value resources differently.

2.4.2 Diffusion theory

Diffusion theory was used since it provides a good understanding of the different properties of an innovation and the innovative decision process. This theory also provides a view of how concepts and innovations spread through a population. As a result this theory may provide a perspective of what developments that have been performed as well as finding developments that currently are being pursued.

What diffusion theory, however, lack is individual acts when there are several innovations at disposal. The theory only presents the availability of acceptance and rejection of a single technology (Ferguson 1995). If applied to the farm-based biogas production one may expect that facilities have several innovations to pursue. It will still be possible to identify the innovations that are being pursued by using RBV. From this it may be possible to see the usage rate of innovations and determine the development stage of an innovation. A high rate could be argued to hold influence on a successful development in the agricultural-based biogas sector.

3 Method

The previous chapter presented the theoretical framework that has been selected for this study. This chapter will present the methods that have been selected for the study and also argue why these choices were made.

3.1 Research approach

When gathering data in a social study, it is common to distinguish between quantitative and qualitative research. A quantitative approach basically involves the collection of data that is measurable (Robson, 2011; Bryman, 2004). Further, the findings that is presented, aim to present generalizations that could be applied outside the studied area. Based on this, one may say that a quantitative approach generally seeks to create an understanding of why behaviors and practices exist (Bryman, 2004). Using such a method often involves testing of a theory. The role of the researcher, in a quantitative approach, involves a distant stance to the respondents when gathering data. This serves as a way of not affecting the results and thus keeps a high level of objectivity in the study (Robson, 2011).

The second approach called qualitative research is more focused to creating an understanding of a topic based on the perspective of the respondent (Robson, 2011). In relation to the quantitative approach, qualitative data does not seek to create any base for making generalizations. Instead this approach is more focused on words and expressions other than numerical information and generally seeks to generate theory (Bryman, 2004). However, using a qualitative approach puts a greater stress on the role of the researcher (Robson, 2011). There is a both a need to guide the respondent to focus on the topic as well as interpreting the data that is provided.

There are several other differences between these two approaches that will not be discussed in this paper. One may, however, state that the mayor differences are oriented in the researcher's role, the type of problem that is being studied and the solution for addressing these. Further it is apparent that quantitative data is more oriented to study groups while qualitative data focuses more on individuals (Robson, 2011).

When adapting a quantitative study it is common to state that a fixed design is used (Robson, 2011). In contrast to fixed design, qualitative studies are commonly regarded as flexible designs. There are, however, ways of combining both of these approaches in a study. Such combinations can be formed in several ways using a multi-strategy research design.

Examples of a multi-strategy research would be to use one approach as a primary, while having the other approach as a complement (Robson, 2011). As an example: a quantitative approach may be used as primarily while having complementing qualitative data. This results in an alternate source that could provide further explanation to any generalizations drawn. Similarly, an opposite design may be used where qualitative data is used mainly. Such designs are labeled *Sequential explanatory design*. Further both quantitative and qualitative approaches may be used independently of each other to gather data. This enables the analysis to compare the findings from the different findings.

Using a multi-strategy research design holds benefits as it may combine the advantages of both the qualitative and the quantitative approach (Robson, 2011). Mixing qualitative and quantitative methods when gathering data complements provides both wider and deeper insight into the object nature of the study (López et al., 2012). This would result in getting a more complete picture of the studied topic.

3.2 Method for collecting data

As the overall research approach is decided, next step is to decide how data is going to be collected. Robson (2011) presents four strategies that researchers can use to acquire reliable data: Survey, interviewing, Observations or Testing.

Surveys are beneficial in gathering information from a large population of respondents (Robson, 2011). This is performed through a fixed questioner being sent electronically or by postal service. This method enables the researcher to be isolated from the respondents which may be good when applying a quantitative approach.

Interviewing involves a communication with the respondents, where information is created from the share of information in the communication. The interview is thus applied as a professional context where the interviewing party is outlining the conversation. Robson (2011) further raises three different designs of interviews that may be used depending on what level of depth knowledge that is sought for. The first design uses an interview guide where all questions are predetermined and presented in a fixed order. Questions and explanations are also very strictly presented. This design is called the fully structured interview. The second design is called the semi-structured interview, which involves an interview guide where questions follow an order. However, the presentation and explanation of these questions may differ in relation to the fully structured interview. This means that questions may be altered or changed during the interview depending on circumstances of the interview. As a result this design may also address further questions in order to follow up certain parts of the interview guide. The final design is called unstructured interview, where no real structure is used. The interview is estimated to begin at one point and depending on information that is presented questions are developed.

Observations involve the use of perception to interpret and gain understandings of the topic that is studied (Robson, 2011). Observations are commonly used in combination of any other collection methods to further enhance an understanding; an example would be actions and behaviors among respondents. Such data may provide additional information that can confirm or deny findings that was presented using another method.

Testing is a method used for studying perceptions, attitudes and opinions among respondents (Robson, 2011). This method generally involves a set of statements where respondents have to rate whether they agree or not. It is common that the respondents are given a Likert scale, these involves a ranking scale of 1 to 10 for example. Assigning the number 1 could for example indicate that a respondent do not agree at all with a statement while 10 represents the far opposite. The values presented may then be categorized or ranked to make an analysis of respondents view.

3.3 Choosing of approach and method

The method used in this study is adapted to the exploratory nature of the research question, which has resulted in an inductive approach. An inductive approach implies that the research uses empirical observation to generate hypotheses, which may eventually lead to theoretical generalizations (www, socialresearchmethods, 1, 2013). This approach was used since it is open-ended in the initial stage (*ibid*), which was considered favorable when structuring an exploratory study.

Since this study is focused on exploring and describing the factors that are important for conducting successful biogas business in the agricultural-based sector, a need for a mixture of both quantitative and qualitative data could be argued. As a result, the study has adopted a *Sequential explanatory design* where a quantitative approach is used primarily. It is expected that many variables may be interlinked with the success in agricultural biogas production. Since a quantitative approach is well suited for handling several variables (Holme & Solvang, 1991) it was chosen as the primary approach. Further it is also argued that there is a need for deeper knowledge to understand how success may be enabled in the agricultural biogas sector. While a quantitative approach lacks in creating depth it is interesting to include a qualitative approach as well.

Further, the data was collected through telephone interviews following a semi-structured interview guide. This method was chosen because it was economically efficient and also not very time consuming which are factors that have been quite limited for this study. Most of the questions in the survey used a standardized format which generally had a clear answer that not would be confusing for the respondents. Followed by the standardized questions there were more open ended questions that could capture opinions and additional information that could be of interest to the study. It was also expected that interesting discussion would arise during some interviews that would be centered to specific questions. Based on this the semi-structured interview guide was selected.

3.3.1 Structure of the Interviews

The questions in the interview guide were divided within four categories to cover different aspects that could contain factors successful for biogas production. The categories are the following:

- Organizational
- Production
- Logistical
- Economical

The **Organizational questions** were focused on geographical location, organizational structure and development level of the biogas facility. Since facilities vary from one another it may be expected that these factors hold affection on the productivity and functionality of the facility.

The **production oriented questions** focused mainly on how the facility had been constructed and what quantities of biogas it could produce. These questions were mainly aimed at giving a picture of what capacities a facility could produce.

The **logistical oriented questions** were focused on means of transporting material and energy from the facility. These questions would give a picture of the distances that the respondents would be willing to operate within. The logistical question would also present information to the methods used for transportation.

The **economically oriented questions** are focused o investment costs and factors that would affect the economic situation of the facility. Further, this section would focus on open ended questions regarding workload; factors that affect the economic situation, activities related to biogas production, *etc*., this section also consisted of two Likert scales questions where respondents can value their perceived level of utility and profitability for their biogas facility.

Within these areas, some questions were structured to distinguish between planned – and actual values. These values were collected to notice differences from what respondents would expected. One could also estimate that some of the interviewed facilities would be in the process of planning, deciding whether to invest or constructing a facility. Since these facilities would be unable to answer questions regarding actual values, a slightly modified set of questions were used. In order to keep the level of comparability between these two sets of question as good as possible, questions were altered as little as possible. As a result, the modified questions were mostly based on planned values from the original questions.

3.3.2 Choice of population for empirical study

Respondents for this study were selected based on a list presented by the Swedish board of agriculture. This list summarized all agricultural-based biogas facilities that had been applied for governmental support[5], which is believed to contain the far majority of the total agricultural based biogas producers. Since the investment costs of biogas facilities are estimated to be high, it is strongly motivated for anyone willing to invest in a biogas facility to apply for support funding.

3.3.3 Time frame

The interview questions were first developed based on a survey sheet performed by Svenska hushållningssällskapen. The questions was then presented and discussed with the supervisor and modification was made based on feedback from the discussion. Once ther first interview guide was completet, a pilot test was made on a governmental owned biogas facility that in some extent processed agricultural products. Modification where then made based on the feedback from the test. Based on this, the real interviews were initiated. All interviews were performed over two months and data presented by the respondents was gathered in a survey sheet or as a comment to the interview.

3.3.4 Processing of data

While some respondents could not present data in the units that the survey requested interpretations and revaluation were used to convert the information. Some respondents also had difficulties with answering certain questions. This may have resulted in data that is roughly estimated by the respondents. In order to account for the reliability within the responses a security scale of 1 – 3 was used to determine the precision of the data; 1 would indicate a high level of insecurity while a 3 would indicate a high level of precision to the data. The rating was performed by the author where impressions from the interviews and the level of recalculation were used to determine the rating. This rating was performed for each of the four sections in the survey. This does however make the rating quite subjective which also questions the validity of the findings. It can however be expected that the validity of the questions in general becomes higher from using this rating than if all values should been used for evaluation.

[5] The list contained facilities that had been applied investment funds from the Swedish board of agriculture (www. Swedish board of agriculture, 1)

3.3.5 Ethics

Ethics are concerned with rules of conduct and it very important that these are addressed (Robson, 2011). When gathering data it is important that respondents are informed about the study and what it involves. Further they should be given the time to consider participating in a study before committing. Respondents should also be given the option to participate anomalously. When such values are expressed it is the duty of the data collector to not present values that could expose the respondent.

In this study all respondents were contacted over phone and email where they were presented a brief introduction to the study and asked about participation. All respondents were given the opportunity of anonymity. Further, all respondents who chose to participate in the study were given the option receive a copy of the report once it was finished. This option was presented as an incentive for participating in the study and security were respondents would have the ability to check what information that had been presented.

Further, data that was regarded as sensitive or could endanger exposing respondents who had asked for anonymity has not been presented in the study.

3.3.6 Statistics

In order to measure any relationships that may exists between certain parameters, a correlation measurement was included. Correlation indicates that two parameters changes as a result of each other (Robson, 2011). Further, there are three different types of correlations. In order to describe these, assume that one parameter increases.

- Positive correlations indicates that the other parameter increases as well
- Negative correlation indicates that the other parameter decreases
- No correlation indicates that the other parameter remains unchanged

The rate of correlation is decided based on following interval. Having a correlation either -1 or 1 indicates that a linear relationship exists between two parameters. Having a correlation value of zero indicates that no relationship exists at all between the studied parameters (Robson, 2011). However, it is highly unlikely that perferct correlation appers in social sciences. This is also raises the issue of assessing a correlation. According to Robson (2011), a minimum correlation of 0,3 may be regarded as statistically significant. However, it is also mentioned that the minimum acceptable level is decreaed as the studied populations grows in number. To keep this parameter simple, the value of 0,3 has been adopted as minimum to state any statistical correlation.

$$-1 \leq r \leq 1$$

Further, Correlation was calculated in Microsoft excel, and using the following equation. This equation was set as the standard method for calculating correlation in excel.

$$Correl\,(X,Y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2}\sqrt{\sum(y-\bar{y})^2}}$$

Figure 3,1 Equation used to measure correlation (Own creation)

3.4 Trustworthiness

When performing a research it is important to provide a transparent view where findings are not presented outside its context, in order to pursue a cause. This section will highlight the parameters that will strengthen the report and present how these apply to this particular study. When managing trustworthiness it is common to address validity and reliability.

3.4.1 Validity

The term Validity is mainly focused around the accuracy of a result and can be divided into different types (Bryman, 2004). The most important type of validity in a quantitative study is measurement validity, which address whether the measurement provides a picture of what the study intends to study (Robson, 2011; www. Mälardalens högskola, 1, 2013). Further Validity can be divided within internal and external validity (Robson, 2011; Bryman 2004). Internal validity refers in great extent to the causality of making conclusions based on findings in a study. As an example one may ask if a factor A affects a factor B and that there are no other factors involved that may affect the causality. External validity, on the other hand, involves the level of generalizability. This type addresses the possibility of findings being applicable within other settings as well?

When addressing the level of validity in a study, it can be hard to assign any value. Unless one without doubt can state that the measurement applied is relevant for the intended study. Bryman (2004) and Robson (2011) address a number of indicators that may provide a picture to the level of validity in a report. The first indicator is called *face validity* which is a minimal level of validity. This indicates that the measurements being used give a reflection of the area that is being studied. The second indicator, *concurrent validity*, indicates that there are additional similar measurements being collected simultaneously. These measurements may then be put in comparison to each other to determine how these affect certain findings. An example, IQ test could be put in relation to academic performance. The third indicator, *predictive validity*, resembles the previous indicator. The difference is that measurements from different times are used for comparison. The fourth indicator, *construct validity*, involves the relation between a measurement and theoretical evidence. This suggests that validity is based on empirical and theoretical correlations. This indicator may be seen as similar to measurement validity as mentioned above. The final indicator, *convergent validity*, involves comparing the used measurement with studies that have tried similar measurements.

While it may be hard to find a specific method that corresponds perfectly, some studies have used complementing measures to strengthen the relevance of their findings (Robson, 2011). Using several sources for determining a statement is usually called triangulation and could be seen as a method of addressing validity. However, it should also be mentioned that using multiple methods requires a certain amount of resources which may not always be available in a study. Limitations such as time and knowledge have been limited in this particular study.

This study has been focused to finding success factors in the Swedish agricultural biogas production, looking into four areas. Based on theoretical as well as empirical findings there are good indications that factors for success exists within the four fields that have been selected for this study. By measuring factors within these fields it can be argued that *face validity* will be achieved. Further the study has collected measures in large extent within a small time interval which makes it arguable that there is potential for *concurrent validity* in the study. The findings will also be used in comparison to draw conclusion, where correlation measures will also be adapted. This would further suggest that *construct validity* and *internal validity* is assessed in this study.

Validity aspects that are lacking or have not been included in this study are *predictive validity* and *convergent validity*. Using *predictive validity* would have required collection of data at a later point which could not be performed due to time restriction. As a result it is arguable that this study only will provide a momentary picture of the agricultural biogas production. However, it should be noted that changing circumstances have progressed relatively small recently and it may be expected that such development will continue. Further, the findings of this study will only apply for Swedish farm base biogas production and thus it may be hard to apply the findings of this study to any other settings. As a result it becomes hard to compare the findings of this study to other studies performed. Only if a setting that is faced with very similar conditions as the farm based biogas production, these findings may be applied. Based on this one may also argue that the generalizability of this study becomes limited. Thus one should be careful when adopting these findings within another context.

3.4.2 Reliability

Reliability on the other hand is focused on the consistency of the data. This means that the way data has been collected is relevant for how well the study has been performed (Bryman, 2004; www, Mälardalens högskola, 2, 2013). One may state that reliability is concerns with the level of replicability (Bryman, 2004). As an example, if a study uses a measurement that results in A and a similar study results in B, it may argued that conclusions drawn in the first study could considered unreliable. Based on this one may also state that reliability is concerned with precision of the findings.

Reliability may also be divided in parameters such as stability and internal reliability (Bryman, 2004). Stability is focused around the solidity of a finding over time. Having stable findings indicate a security that findings does not fluctuate after the study is performed. Internal reliability is focused on whether findings within one area correspond to another finding and thus together give any indication based on the findings.

While it was mentioned earlier that this study have been limited in time, thus no room have been available to test the stability by repeating the study of each respondents. However, reliability of the findings has instead been compared to each other to see whether data from one respondent matches the findings from other respondents. If several respondents would assign a similar value to a question it is argued that there is a high reliability when making conclusion in this relation.

4 Background for the empirical study

The previous chapter described what choices have been made to perform this study. In this chapter, more in depth information will be presented on the process of producing biogas and what methods that exists. Further the chapter will address the areas where biogas can be applied. This chapter will in other words focus on creating a greater understanding for biogas which is needed before addressing the empirical findings.

4.1 Biogas in the agricultural sector

In the introducing chapter of this paper, a short presentation on biogas was presented. In order to make a quick review it was noted that biogas is a natural process where biological material is decomposed by various anaerobic bacteria's. As a result from this process, gas is produced which in majority consist of methane and carbon dioxide. The methane is a very energy intense substance which may be used to supply renewable energy in various areas and thus replace limited sources such as fossil fuels.

4.1.1 Elements of biogas production

When producing biogas there are some parameters that one usually distinguishes between. Since production of biogas involves living organisms that require a specific environment to function optimally it is common to distinguish between: mesophilic and termophilic; Slurry-based and dry-based production.

Mesophilic vs. Termophilic
The biogas process is either mesophilic or termophilic in nature. This gives an indication to what temperatures that are used in the biogas chamber (Biogas syd, 2010). Mesophilic digestation indicates that 37 C is used while Termophilic digestation uses 50-60 C (Biogas syd, 2010; www, bioenergiportalen, 1, 2013). These temperature levels are used to get the best possible production from the biogas chamber. The reason there are two different temperature levels is because there are different types of bacteria used in the processes. As the biogas process does not provide any heat itself it is common that some biogas is used at the farm to heat the reactor (www, LRF, 1, 2013). Mesophilic digestation uses a lower temperature than termophilic which makes it attractive since it costs less to heat. Termophilic digestation is, however, interesting to some producers since the decomposition time is lower than in the mesophilic process (www, bioenergiportalen, 1, 2013). As a result termophilic digestation makes it possible to process larger quantities of substrate with a small facility than what is possible in a mesophilic facility.

Slurry-based vs. dry-based production
Further one should also know that the production may be slurry-based or dry-based (www, bioenergiportalen, 2 & 3, 2013). This distinction indicates the concentration of dry matter in the feedstock, mixture of substrate. Slurry-based indicates that the substrate is pump able and thus the dry matter concentration is somewhere around 2-12% (www, bioenergiportalen, 3, 2013; Biogas syd, 2010). This method is generally good for substrate that has a very high water concentration but it is also possible to digest less water based substrate by shredding it. Dry-based digestion on the other hand is focused on a higher concentration of dry matter, around 20-30% (www, bioenergiportalen, 2, 2013).

4.1.2 The production process

In Sweden it is most common that slurry-based, mesophilic production is used (Energimyndigheten, 2012; www, LRF, 1, 2013; Biogas syd, 2010). When producing biogas from such a facility the first stage is that the substrate is mixed, into the preferred feedstock, and gathered in a silo next to the biogas facility. Within this silo the feedstock is being warmed to match the temperature in the digestion chamber. Once the reactor is ready, feedstock is being pumped in. The feedstock will then go through four different process stages: Hydrolysis, acidogenesis, acetogenesis and methanogenesis (www, LRF, 1, 2013; www, bioenergiportalen, 4, 2013; biogas syd, 2010). For each of these steps different bacterial cultures are used.

Hydrolysis
The first stage is the hydrolysis where enzymes, produced from some of the bacteria have, split the feedstock into smaller pieces (Biogas syd, 2010).

Acidogenesis
Once the feedstock has been split bacteria's will start to break down monomers to short fatty acids.

Acetogenesis
The fatty acids will then be consumed by bacteria's that in turn produce acetate.

Methanogenesis
In the final stage of the anaerobic digestion, acetate and carbon dioxide is converted to methane.

For slurry based facility it is common to have water pipes along the walls of the reactor chamber filled with heated water to. The temperature is then equally distributed as a large rotator mixes the feedstock in the chamber. The process is also affected by pH levels in the chamber. Like many other organic processes it is required that these levels are maintained at 7,0 for optimal performance (www, Bioenergiportalen, 1, 2013). The pH level is much dependent on what composition of feedstock that is being used. Generally there has to be a mixture of easily digested material such as starch and more time consuming material such as content with vegetable fiber threads in order to maintain a suitable level.

The time interval for the digestion may vary based on a number of factors. One may however expect a slurry based feedstock that mainly consists of manure to require around 20 days of processing (Biogas syd, 2010; www, LRF, 1, 2013). Once gas is being produced it will gather at the top of the chamber where it is pumped to a storage container. The initial gas that is produced in the reactor chamber will contain traces of water and hydrogen sulphide. These substances will need to be cleansed out or they may damage pipes and other equipment. Gas that is produced but finds no use will have to be destroyed by combusting it in a flare. This may occur when there is too much biogas produced in contrast to what can be stored and transported.

The remains of the feedstock that is not converted during the process, also referred to as digestate, is extracted from the chamber and stored in a sealed area (www, LRF, 1, 2013). It is important that the process is disabled before the digestate can be extracted. This can be done by altering the temperature or expose the content to oxygen. Once this is done, the digestate may be applied to the crop fields.

4.2 The market for biogas in Sweden

In order to understand how production of biogas looks today it is of interest to create an understanding of the energy market in Sweden. The energy market in general is very similar to any other market in its characteristics; prices are based on supply and demand (www, Energikunskap, 2, 2013). While major energy sources such as oil, coal and natural gas is affected in great extent by the world market price, bio fuel sources are affected more by local markets within the Scandinavian countries (www, Energikunskap, 3, 2013).

There is however one market that differs slightly from the other energy markets in Sweden. The electricity market was at first regulated to a monopoly until 1996 (www, Energikunskap, 2, 2013). As this regulation was terminated, consumers were free to choose what electricity supplier they wanted. However, the monopoly was only terminated for the production of electricity while it still applied to the electric grid. The electricity grid functions like a transport network for electricity and it also affects the price the consumers pay for electricity in some extent. As an effect there are a limited number of companies that are allowed to operate the electric grid. Each producer of electricity is thus bound to use these companies in order to sell electricity.

The most basic principal when addressing energy is that energy cannot be generated or destroyed within a closed system; this means that energy only can be transformed.
Based on this principle it is important to distinguish between energy carriers and energy sources. Energy sources are the substance that is consumed in order to produce energy (www, Energikunskap, 1, 2013). Energy carriers, on the other hand, is described as that which transport or store energy (*Ibid*). This can be exemplified by using the biogas. The biogas that is produced in the facilities (energy source) can be consumed to produce electricity, heat and vehicle fuel (energy carriers).

While the energy sector is large this presentation will only focus on certain aspects that are of interest to this particular study.

4.2.1 Areas of application for biogas

Biogas can be applied within several areas of energy production. One of the more common areas is heat production where the gas is simply consumed in a gas turbine engine (www, LRF, 1, 2013; Lantz et al., 2007). Biogas can also be used for a combined heat and power production, referred to as CHP. This method is similar as it also involves that the gas is being consumed in a turbine engine. CHP generally results in that 35% of the energy is produced as electricity while the rest is becomes heat (*Ibid*). While these two methods use renewable source and are more environmentally healthy it is estimated that they only will hold a small potential of reducing the levels of greenhouse gases. One reason is that there are already other renewable sources available that are cheaper than biogas, for example wood chips (Lantz et al. 2007). The biogas can also be used for vehicle fuel where it is argued that the gas holds a high potential for making environmental improvements. This requires that the gas becomes upgraded, which means that the gas is cleansed from all substances but the methane. This results in that all gas can be combusted and thus there will be slim to none emissions from gas vehicles.

The digestate that is leftover from the production may be used for fertilizing crops. It is argued that the digestate is a better fertilizer than manure or artificial fertilizers (www, LRF, 1, 2013). Some of the benefits with the digestate are: greatly reduced odor, less chance of carrying pathogens or weed seeds and greater soil penetration which results in less eutrophication.

4.2.2 Incentives and barriers

Incentives
The main incentive with using biogas is that it is a renewable source of energy that can be used to within several areas and thus replace fossil sources and other limited sources. This is goes in line with several national environmental objectives that the Swedish government has agreed on reaching by 2020 (Lantz et al., 2007). Further there are also targets presented by the European Union that favor solutions to renewable energies in different sectors.

The digestate that is produced from the biogas is another incentive that can be applied on both a national level and on a farm level. On the national level the euthropication is reduced since the digestate is better applied to the soil and also penetrates that soil better than conventional fertilizers (Brown et al., 2007; Wünsch et al., 2012). On a farm level this digestate may prove a valuable complement to other alternatives. One example is that the digestate can applied for fertilizing organically crop production.

Biogas is also different from many other renewable sources since it can be run on biomass in general and does not need any crop fields or other products that otherwise would limit production within other areas. This do also makes biogas a promising method for handling energy production and waste treatment. An expansion within biogas may actually result in a waste treatment of biological products that is cheaper than incineration plants (Lantz et al., 2007).

Barriers
A big problem with the biogas production is the economic profitability. Since its low usage in past years there have been small developments in the production method (Lantz et al., 2007). This makes the biogas unable to compete with the established fossil fuels without external interventions.

Another barrier is technical competition on various levels. One such area is that other treatment methods may prove cheaper than using biogas production (Lantz et al., 2007). This will affect the level of interest that the government will devote to biogas production. Another level is the availability to substrate. Energy crops are a substrate that holds a high potential for biogas production. There is however more profitable ways of using this crop than biogas.

4.2.3 Interventions to biogas

In order to meet environmental- and energy targets, certain interventions has been introduced to the energy market (www, biogasportalen, 1, 2013). Such interventions consist mainly of taxes and subsidies on various energy sources. The taxation consists of three types today: energy tax, sulphur tax and carbon dioxide tax. The rates for each of these taxes vary between the energy sources depending on the levels of emissions. These taxes affect the energy production in the following way.

Heat
Production of heat in general is subject to energy-, carbon tax and sometimes even sulphur tax and nitrogen tax (www, biogasportalen, 1, 2013). However, biogas production that is used for heating is exempted from both energy tax and carbon tax.

Vehicle fuel
Fuel that is classified as carbon neutral is exempted from all taxes (www, biogasportalen, 1, 2013). Biogas that is used for vehicle fuel will however lose this position and become subject to certain taxes. These taxes may, however, become neutralized through tax deductions in the declaration. It should however be noted that biogas will have an advantage over natural gas that will increase over the coming years.

Electricity
In relation to heat and vehicle fuel, electricity production is taxed differently using an electricity tax (www, biogasportalen, 1, 2013). In some cases, however, electricity can become subject to sulphur or nitrogen taxes. The energy sources used for electricity production are being subject to a reward system called elcertifikatsystemet, Electricity certificate system. This system is used to favor renewable energy sources. This system gives the producer a certifiticate for each of MWh that is produced. These certifiticates can then be sold in order gain extra revenues. In combination with these certifiticates, government has established regulation that states that all, but energy intense companies, have to purchase a certain percentage renewable energy; creating a demand for renewable energy. The price of the energy certifiticates is determined based on the amount of users.

5 Results

This chapter will present the data that was gathered through interviews. The data will be presented in four sections: Organizational-, Production-, Logistical- and economical data.

The studied population of this paper consisted of 50 facilities in total. Out of these there were 31 facilities that were interviewed, 12 facilities were contacted but decided not to participate or could not participate within the time frame and the remaining seven facilities was not able to contact. This gives the report a response rate of 62%.

5.1 Organizational data

The first area of the interview survey was devoted to the organizational aspects of the facilities.

5.1.1 Organization of facilities

Based on the interviews it became apparent that 27 facilities had chosen to invest in a biogas facility while four respondents were considering investing, this is presented in table 5,1. Further, Three facilities were under construction, three were in the process of testing their facilities before starting a real production and three were facing a production stop. The remaining 18 facilities were all running and producing biogas. Facilities that stated that they were under construction or planning were given the modified survey which amounted to seven respondents. This has created some differences in response since these facilities would not be able to answer the exact same questions.

Table 5,1 Stage of development and organization of interviewed biogas ventures

Stage of development	Company Structure	Ownership
Planning	Corporation	Sole
Planning	Farm enterprise	Sole
Planning	Farm enterprise	Sole
Planning	Farm enterprise	Sole
Construction	Corporation	Shared
Construction	Corporation	Shared
Construction	Corporation	Shared
Start-up	Corporation	Shared
Start-up	Farm enterprise	Sole
Start-up	Farm enterprise	Sole
Stopped	Sole preprietor	Sole
Stopped	Corporation	Shared
Stopped	Sole preprietor	Sole
Operational	Corporation	Sole
Operational	Trading company	Sole
Operational	Sole preprietor	Sole
Operational	Corporation	Shared
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Corporation	Shared
Operational	Farm enterprise	Sole
Operational	Corporation	Sole
Operational	Corporation	Sole
Operational	Farm enterprise	Sole
Operational	Farm enterprise	Sole
Operational	Corporation	Sole

When asked about how the facility would be organized, the common answer was as corporations or as farm enterprises. Further it could be mentioned that facilities organized as farm enterprises would be an expansion of previous farm operations, where biogas was included.

It can also be noted that all facilities with shared ownership was structured as corporations while the sole owned facilities mostly was structured as farm enterprises. It could also be noted that the three facilities under construction had a shared ownership. This may indicate that there amount of share-owned facilities are developing. Further, Respondents were asked about the shares in ownership. However, no summery will be presented on such information due to two reasons. First, this information could reveal certain respondents that had wished to be anonymous. Second, some respondents had great difficulties in determining the share of each owner involved. As a result there may be great errors to the findings presented in this study.

5.1.2 Geographical dispersion

It is also possible to determine the geographical dispersion of the respondents. Based on the findings, it can be revealed that the regions Hallands – and Västra götalands län were containing the highest concentration of farm based biogas facilities in this study. Västra götaland contained the highest concentration with nine facilities while Hallands län contained six facilities. The remaining regions would not have a higher representation than 3 facilities per region in this study.

5.1.3 Age of facilities

Some of the facilities that were running also provided information to the time that they had been active in the biogas business. This parameter was not actively asked for and thus there are missing values for many of the respondents. 12 facilities presented their age which showed that the age is relatively young for the facilities. The average age amounted to 3,15 years while the highest stated age was 15 years and the lowest age was 0,5 years.

5.1.4 Developing of biogas facilities

When exploring how facilities had been developed, it became clear that respondents would seek information by visiting other facilities before investing in their own facility. Based on the data collected in this study, it is possible to state that a majority of the respondents had performed visits within Sweden. However, some respondents also stated that they had searched for knowledge internationally. Table 5,2 displays the countries that had been visited and the amount of respondents that had made visits to any of these. Further the table distinguishes between the respondents that had performed visits in one country only and those that had visited multiple countries. No respondent would, however, visit more than three countries before investing. One respondent did not present any value and thus there are only 30 responses registered. Based on the findings, one could note Germany a relatively interesting country to agricultural-based biogas producers in Sweden.

Table 5,2 Countries visited before investing in a biogas facility

	Amount of countries visited			
Countries	One country	Two countries	Three countries	Total
Sweden	16	5	5	26
Germany	2	6	5	13
Denmark	0	2	4	6
Finland	0	1	0	1
Italy	0	0	1	1
Total	18	7	5	30

Based on the respondents who choose to invest in a biogas facilities, it became apparent that the majority choose to hire a supplier over self construction. From the 27 respondents that had invested in a biogas facility, five respondents choose to build their own facility. The remaining 22 facilities hired one out of ten suppliers.

Further it was also present that the far majority of respondents used mesophilic temperature over termophilic. Out of the 31 facilities, 27 stated that they used or planned to use mesophilic temperature while only three respondents stated that they used/planned to use termophilic temperature. The data also presented that slurry-based processes was dominant among the respondents. All of the termophilic facilities used/ planned to use a slurry-based process which may be somewhat different from what is suggested.

During the development stage it was apparent that respondents had faced several types of troubles. It is shown that construction problems was the most frequent followed by administrations and governmental issues.

For the facilities that had been constructed one could state that eleven facilities had faced troubles with construction and reconstructions. By comparing the assigned method of construction with the facilities that had faced troubles, it was possible to note that the problems were distributed well among the various construction alternatives. Further, this showed that the rate at which problems had occurred were similar for facilities that had been constructed without a supplier in relation to those that had used a supplier. It may also be noted that the suppliers that had been used mostly had the highest amount of facilities with troubles. The highest amount of troublesome facilities per construction category amounted to two. This value applied to four suppliers as well as to those that had constructed their own facility.

5.1.5 Reliability level: organizational values

For this section, the reliability of the responses was estimated to be very high. Respondents had little problem providing the requested information and in almost all cases without doubt or insecurity. The Average level for this section was rated to 3.

5.2 Production oriented data

This section will present the production oriented findings of the study.

5.2.1 Biogas production

When perceiving the various digester sizes used, it became apparent that there are great differences. The average value for digester sizes amounted to 1900 M^3 while the highest value amount to 10 000 M^3 and the lowest value amount to 165 M^3. Among the respondents there were great variations in digester volumes used, which resulted in a grouping based on the sizes. These are presented in table 5,3 along with the amount of respondents that each group would represent.

Table 5,3 Production and further use of raw gas divided on categories of digester volumes

	Groupings of digester sizes						
	< 1000 M3	1000 - 2000 M3	2000 - 3000 M3	3000 - 4000 M3	> 4000 M3	Unassaigned	Grand Total
Count of Respondents	11	6	5	3	3	3	31
Average of Planed rawgas production (M3)	162144,7	223846,2	1639250,0	1650000,0	14323064,1	30769,0	2144607,1
Average of actual rawgas production (M3)	145323,1	183648,7	1295170,3	1300000,0	1650000,0		579071,3
Average of planed rawgas/digester vol. (M3)	359,5	177,0	612,7	322,4	2376,6		577,7
Average of actual rawgas/digester vol. (M3)	217,6	84,5	483,6	114,0	122,2		215,3
Count of respondents, planed heat produktion	10	5	4	2	1	2	24
Count of respondents, actual heat production	6	3	3	2	1		15
Count of respondents, planed electricty production	8	4	3	2	1	1	19
Count of respondents, actual electric produktion	5	3	2	2	1		13
Count of respondents, planed cleansed gas production	1		2	1	3		7
Count of respondents, actual cleansed gas production	1		2		1		4

Further, respondents also presented planned and actual values of gas production over the latest year. The average values for each digester size group is presented in table 5,3. While it may be expected that the production depends on the digester sizes used, the produced quota was also put in relation to the digester volume. This made it possible to see how much gas that had been created per cubic meter of digester volume. Based on this it was shown that the largest gas production in relation to digester size occurred in the third group and the first. It can also be noted that respondents were facing troubles reaching their planned production quota. One may, however, note that several respondents could not assign any value to the actual production of raw gas. A possible reason is that many facilities do not possess the instruments for measuring raw gas production. It should also be mentioned that the differences in response security in large extent fluctuated from these questions. Respondents, in general, seemed to have problems with providing accurate values regarding production.

Based on the produced raw gas, the study continued by looking at the areas where respondents would use the raw gas. This is summarized in table 5,3 which displays the amount of respondents that would use a share of their raw gas to produce heat, electricity or cleansed biogas. From these findings it was possible to state that heat is the dominant production form followed closely by electricity. It is also possible to state that values for producing cleansed biogas seemed to be more interesting for the larger digester sizes. Further, facilities were mainly diversified between those that only would produce cleansed biogas, those that produced a very small proportion or those that did not produce at all. In contrast to cleansed biogas, heat and electricity were more common in the smaller facilities. However, one has to be careful when drawing any conclusion from these findings since many respondents seemed to have difficulties to provide accurate answers when asked. As a result one should expect a low level of reliability. These values do, however, fill a function by providing a perspective on the areas that biogas is being used within.

5.2.2 Consumption of energy

From the energy production of the raw gas, the study continued by looking at the consumption of energy for the respondents. However, there were also great variations in response when asked about the consumption of energy. 17 respondents presented that they were planning to consume a proportion of the energy within the farm, the average share for these values amounted to 63,5%. When asked about actual consumption within the farm, only 13 respondents could present values which had an average share of 62,3%.When asked about the share that would be used for selling, 22 respondents presented that they planned to sell a proportion of energy. Based on the values presented by these respondents, the average share amounted to 66,3%. When asked about the actual share that had been sold, 15 respondents presented values which had an average share of 44,7%. As different sets of respondents provided values to these questions, one should be aware of a high probability of errors to these values. When asked, respondents would mostly state that no instruments for measuring such levels are present. These values may however indicate that there is an interest to diversify the production between consuming and selling energy.

5.2.3 Digestate

When perceiving the digestate production one could see that a majority of the respondents used the digestate within their own farm. Only a few respondents would sell or share their digestate. Further it could be noted that the respondents that did share their digestate, in most cases, had entered an agreement with other farmers, where provision of substrate was paid with an equal share of digestate.

When asked about the storing capacity of digestate the values would differ in great extent. 26 respondents provided answers where the highest value amounted to 60 000 M^3 and the lowest value amounted to 300 M^3. Further the average value for the storage capacity amounted to almost 11 700 M^3. From the interview it was also possible to state that the storage capacity would have small effect on the biogas production. Several respondents stated that if the operation would result in more digestate than what there is capacity for, there are possibilities to purchase storing capacities from other farmers. As an effect, storage capacity may not be considered a greater limitation in biogas production.

5.2.4 Reliability level: Production values

For this section, the reliability of the responses fluctuated to some extent. Some respondents had problem providing information and some doubt could be noted when answers were presented. The Average level for this section was rated to 2.

5.3 Logistical oriented data

This section presents the logistical findings of this study.

5.3.1 Distances

The report has further examined the longest distances that respondents would travel when transporting substrate and digestate. One may note that there is a greater spread in distances for substrate while digestate is mostly concentrated to 1 – 10 km radius of the farm. Only a few would make travels longer than 20 km to dispose of digestate. It may be noted that the longest distance for transporting substrate amounted to 400 km and the shortest amounted to a few meters. A possible reason to the difference in distance is the type of substrate used in the digester. While some respondents would only use substrate present at the farm, the transportation becomes very short. The Average distance used for transporting substrates amounted to 29 km. In the case with digestate, the longest distance amounted to 35 km and the shortest amounted to 0,6 km. Further, the average value amounted to 9 km.

5.3.2 Transportation methods

Further the study examined the transportation methods being used for substrate, digestate and cleansed biogas. From the interviews it became apparent that three transportation methods are being used for substrate and digestate: Contraction, pipeline and transportation through own vehicles. The values from the interviews are being presented in table 5,4 where 24 respondents provided values. It may be noted that there are more values than respondents in the table; this is caused by some respondents who used more than one transportation method. Based on this it can be noted that pipelines were most commonly used when transporting substrate. One should, however, note that respondents assigned pipeline even though they would transport substrate within a short distance. As a result any pipe system of transporting substrate to the digester reactor may have been regarded as pipeline by the respondents. 13 respondents that had assigned pipeline transported their substrate within a radius of 0 – 10 km. Further it could be noted that using contractors was an interesting alternative for transporting both substrate and digestate. Further, it was not very common for respondents to handle the transports of substrate on their own. However, it was more common to transport the digestate by one’s own machinery.

Table 5,4 Transportation methods used for substrate and digestate

Methods	Substrate	Digestate
Pipeline	14	7
Contractors	11	13
Transport by self	3	10

When asked if raw gas or cleansed biogas was transported, it became apparent that the cleansed gas would be transported through a pipeline. The raw gas would instead be consumed at the farm to produce another form of energy. Four respondents stated that they transported cleansed biogas while the remaining 20 facilities converted the gas to another energy form.

5.3.3 Reliability level: Logistic values

The reliability levels were in general high for this section. Respondents had little doubt when presenting values. The average value amounted to 2,9.

5.4 Economical oriented data

This section will present the findings from the economical oriented data.

5.4.1 Costs and funding

The initial part of the economic oriented question was concerning the investment costs for the facilities. The investment costs were divided in the initial costs for the facility and any additional costs that would arise from the biogas facility. Such additional costs could be reconstructions, increased employment, new machinery, *etc*. From the interviews, 29 respondents presented their initial investment costs. The highest investment registered amounted to 75 000 000 SEK while the lowest amounted to 2 400 000 SEK. The average investment cost amounted 14 225 000 SEK. From these, 16 respondents stated that they would need to make additional investments. The highest additional investment registered amounted to 12 000 000 SEK while the lowest amounted to 100 000 SEK, the average value of additional investment amounted to 1 778 000 SEK. It should be noted that respondents who were in the process of planning or constructing a facility presented their estimated investment costs.

In order to get an understanding of how these investments are covered, the interviews continued with exploring the sources used for financing. Based on the respondents, these investments mainly consisted of subsidies and bank loans. It would, however, be strange if some respondents did not use any subsidy. The population had been selected on a list that summarized the facilities that had applied for governmental funding. What should be noted regarding these subsidies is the impact they have on the investment. While many facilities had subsidy levels around 33%, some facilities manage to find interesting partners that would be willing to support facilities with 50%. It should be noted that the subsidies only would cover the initial investment cost. Further, these values were considered sensitive by the respondents. This has caused a risk for high unreliability when summarizing these values which is reflected in the reliability index. 25 respondents in total presented values to the shares of subsidies that they had been granted. From these, 23 respondents stated that they also had used bank loans and further 13 stated that they also would use their own capital to finance a facility. Based on this one could see that priority at first is given to subsidies, then loans and finally the use of private capital.

5.4.2 Incentives to start a biogas venture

The respondents were also asked about the reasons to why they would invest in a biogas facility. The responses were gathered in certain categories that are presented in table 5,5. From this one can see that economical arguments such as business opportunities are high but also other non economic values such environmental care and entrepreneurial spirit. The argument that was most frequent, belief in future improvements could entail both economical and non economical aspects based on the perspective of the respondent.

Table 5,5 Arguments for starting a biogas business for the studied facilities

Reasons to invest in biogas		
Areas	Respondents	share of total
Business opertunities	11	35%
Belief in future improvements	14	45%
Improved fertilizers	9	29%
Environmental care	11	35%
Become selfsufficient	4	13%
Intresst and entrepreneurial spirit	9	29%
Not invest	4	13%

Some respondents also stated that they currently would not invest in a biogas venture if presented with such a decision. The argument to this was mainly centered on bad profitability. This is further mirrored through the main factors that influence the economic situation of biogas production, perceived by the respondents, is the operational costs and the current prices of gas and electricity. Another argument for not investing regarded the workload that follows from a biogas facility.

5.4.3 Workload

When asked about the time that respondents would have to spend on a biogas facility per month, one could note large differences between facilities. The highest time spent on a facility amounted to 175 hours/month while the lowest value amounted to five hours/month. The average time spent on facilities amounted to 42 hours/month. It could be noted from the facilities, which had high time consumption, that problems such as reconstructions or dysfunctional systems were perceived as the main reasons. Several respondents stated that their facilities had been subjected to high concentrations of sulphur which in turn would corrode equipment inside the facility. As a result the operators would often have to stop the production and repair the damages.

The respondents were then asked whether they are satisfied with their workload. This question was used give an indication of what levels that would be considered acceptable. As a result 14 respondents stated that they were satisfied, three stated that they were uncertain and six said that they were unsatisfied. One should be aware, however, that a high workload could be expected by some respondents. Some respondents stated that they were expecting troubles when dealing with new technology. As a result they felt that the work load matched their expectations, however, they would still wish for a lower workload.

5.4.4 Perceived utility & profitability

The study then continued by examining the overall perceived utility and profitability with the facilities. For these questions, the respondents were presented a Likert scale ranging 1 – 5 where 1 was regarded as a very low level and 5 a very high level. In the case with profitability, values 1 – 2 were considered as unprofitable, 3 was considered breakeven or weak profitability and 4 – 5 were considered as profitable. The findings are displayed in table 5,6 which shows that there are only a few examples of facilities in the studied population that had experienced profitability. The majority assigned unprofitable values and only five respondents stated that they had experienced a breakeven or a weak profitability.

Table 5,6 Perceived levels of utility and profitability by respondents

Level of percieved profitability	Count of respondents
Unprofitable	18
Breakeven or weak profitability	5
Unassigned	8
Level of percieved utility	
Low utility	5
Medium utility	4
High utility	15
Unassigned	7

When studying the level of utility, value of 1 – 2 was regarded as a low level of utility, 3 was regarded as a medium utility and 4 – 5 were seen as a high level of utility. Based on this it became apparent that respondents was relatively happy with their facility despite the bad profitability.

5.4.5 Reliability level: economical values

Reliability levels in this section varied to some extent but provided a general high value. Respondents had some troubles providing values to shares used within the finance sources. It may, however, be expected that some respondents did not want to present such information since it is regarded as sensitive. The average reliability value amounted to 2,5.

6 Analysis

The previous section presented the empirical findings of the study. This chapter will analyze the empirical findings using the theoretical frame presented in chapter 2. The chapter will use the research questions presented in chapter 1 as basis for conducting the analysis.

The research questions of this study are the following:

- *What factors are significant for the successful development of farm based biogas ventures in Sweden?*
- *What practices are being used in farm based biogas production in Sweden today, including technical aspects, resources and organizational aspects such as collaboration?*

6.1 Assessing success

From the study it may be noted that there are various factors that affect the outcome of a biogas operation in the agricultural sector. As a result one may expect both economical and non economical aspects to be involved in the success of agricultural-based biogas ventures. A parallel may drawn to Forsman (2004) who stated that not all factors for successful development are dependent on economical values. Using RBV, it is argued that the value of a resource is dependent on the perception of a company. This would suggest that, even thought a value is not economically oriented it may still be regarded as valuable to a company. This is further apparent when combining the perceived profitability with the perceived utility. Calculating the correlation between profitability and utility results in 0,59 which indicates that there is a correlation between these parameters. As a result one may argue that economic profitability is dependent on the utility in some extent; which is also displayed in table 6,1. Based on this it is possible to state that the perceived level of utility and profitability can be used to assess factors for success in this study. The question that follows is what factors that determine the levels of utility and profitability?

Table 6,1 Perceived utility in relation to perceived profitability

	Level of Profitability		
	Unprofitable	Weak profits or Break-even	Total
Level of Utility			
Low level of Utility	5		5
Medium level of Utility	3		3
High level of Utility	10	5	15
Total	18	5	23

6.1.1 Motives to start a biogas venture

One may start by looking at the reasons to why respondents choose to invest in a biogas venture. Based on this study, it was shown that the most common arguments are: business opportunities, belief in future improvements, environmental care and entrepreneurial and technical interest. While these arguments inspire people to begin biogas ventures, one may considered these as intangible values. While it is mentioned in RBV that intangible values are hard to measure, it becomes somewhat complicated to determine to what extent these values affect the development of success. However, what is common to these arguments is that they present a motive to start producing biogas. As an example one may look at the argument business opportunities, it can argued that any respondent who assign such an argument is interested in expanding their business activities. From this it is arguable that there is an economic motive that inspires persons to invest in biogas. However, other arguments such as the care for the environment may not be interesting from an economic perspective but instead it is interesting to the owner of the facility. What is common to both of these arguments is that they motivate the owners to get involved in biogas. Depending on the value of the motive, one may also argue that an economic loss could be considered acceptable in order to fulfill a motive. Using the diffusion process it is arguable that motives are important for the development of biogas production. The first element of a diffusion states that the rate at which an innovation is pursued is, in part, dependent on the perceived relative advantage of adoption. In this case the relative advantage would be the fulfillment of the motive. Further it can be argued that when people start adapting to a concept, it is possible for knowledge to spread and enlighten people that have similar motives but are unaware of a method that enables fulfillment. However, an adoption also requires that the conditions are satisfying. While the biogas sector has been struggling with bad conditions in terms of profitability and production, some people may consider their motives too costly to pursue. As a result, there is need for external support which may be achieved from networking with external actors.

6.1.2 Relations and networking

From the study it could be noted that there are different aspects of relations that affects the development differently. It could be noted that several respondents choose to perform visits to facilities in Sweden and in some cases internationally before investing. When studying the perceived value of utility and profitability in relation to the visits performed, it could be noted that respondents who had made visits to multiple countries generally had a high perceived levels of utility. The relation between profitability and visits in multiple countries was not as significant. However, these findings may suggest that there is a relationship between external partners and a successful development. Using the RBV, one may state that such a resource could be regarded as valuable and rare using the VRIO model. As a result one may regard external alliances as a competitive advantage that presents the firm with important feedback and knowledge for managing production.

Applying a broader perspective, one may argue that external contacts are important for a further development in the Swedish agricultural-based biogas production as a whole. This becomes apparent in the process of innovation which suggests that the technological development is based on the refinement of old technology. By combining technology from external producers with the existing technology one may expect opportunities for a stronger development as well as the creation of new innovation methods of performing biogas operations. As a result the one could expect shortcuts in innovative process.

Further, one should also note the importance of crafting relations with national actors. Several respondents stated that there is a need for better prices in current biogas production. Such prices can be affected in large extent by actors such as government and other organizations with influence in the biogas sector. An example would be governmental interventions in the form of production subsidies. Further it is also noted that the investment costs for constructing a biogas facilities generally is high. While the government has provided construction subsidies to cover up investments, one may expect that the amount of agricultural-based biogas producers would have been much less if no such subsidies had existed. Based on this one may argue that the government is an important actor for the future development of biogas production. This would indicate that a factor for successful development in the agricultural based biogas sector as a whole lies in creating better connections with governmental actors. Since governmental actors do also have an interest in an expanded biogas production. While governmental actors are concerned with environmental targets, an increased investment in biogas would benefit the motives of producing biogas. As it was mentioned above, an increased relative advantage of an innovation will benefit the rate of adoption. This would in turn enable larger potential for handling biowaste and a larger production of renewable energies. In total both parties would benefit from each other which could be regarded as a valuable competitive advantage, using a RBV perspective. The only problem with achieving such a relation is risks associated with biogas currently. From the findings it was apparent that the production of biogas currently was below the planned values in a majority of the facilities. As a result the production of biogas has to improve and become more stable. The question is only if there is potential to achieve improvement with current conditions?

6.1.3 The potential of Production

When addressing the production of gas one may expect such values to have a high correlation to utility and profitability. Since the gas produced is somewhat synonymous to the performance of the facility. When calculating the values for raw gas, correlation with profitability amounts to 0,322 and the correlation with utility amounts to 0,589. Both of these values indicate that the production of gas is relevant, in some extent, to the success in agricultural-based biogas production. However, since respondents of this report had great troubles assigning production values, it can be expected that this correlation is not fully truthful. To expand on the impact of production, digester sizes were also compared to the perceived levels of utility and profitability. Based on this the one could notice that nearly any correlation exists between these parameters. Correlation between utility and digester size amounted to -0,0016 and correlation with profitability amounted to 0,178. Based on these findings, there are no guarantees that production would have any effects on the successful development of agricultural-based biogas production.

Despite the uncertainties in correlation between production and development, there are other aspects that may provide a view on this relation. In the findings of this study it was apparent that several facilities had faced either construction or production problems which in turn would disturb the gas production. Using RBV one may argue that an early adoption in biogas could be regarded by some as a competitive disadvantage. Since the early adopters would have to test and fund the development towards a stable solutions. From the innovation process one may argue that technology has to be built based on current technology and adoption will occur once conditions are satisfying. Based on this it may be suggested that biogas facilities are in the process where they need to be developed which makes technological an interesting parameter for a successful development in the agricultural-based biogas production.

6.1.4 Technology

It is possible to state that new technology and innovations are important in a successful development. While some respondents stated their company age, it became apparent that company age and perceived profitability of the respondents correlated well. The calculated correlation amounted to 0,519 which indicate a relatively high correlation. Since it could be concluded from the findings that the facility ages within this study was relatively low. This would suggest that the agricultural-based biogas sector still needs to be developed. Using diffusion theory one may argue that the concept of agricultural-based biogas production still is in the initial phase of the S-curve and thus needs to be developed. As an examples, the production of biogas from agricultural-based biogas facilities have increased in production over the years but is still very small in relation to other energy sources on a national level. One may also argue that the concept could be in the end of the S-curve despite its small affection of energy production. This would suggest that the concept never reached its potential. However, there is still a great potential for further production in the agricultural sector which suggest that the former is more likely to be true. In this case it might be that the concept of biogas is being developed and thus successful factors are about to become developed.

6.2 Practices within the Swedish agricultural biogas production

From the facilities studied in this report, one may note that there are certain factors that are common when looking at the practices used in biogas production.

6.2.1 Facility structure

Looking to the organizational structures of the facilities one could note that the far majority of respondents would use mesophilic temperatures levels with a slurry based process. Only a few respondents stated that they would use the thermophilic temperature. One may expect termophilic temperatures to be more common in the larger biogas facilities since this temperature is able to process substrate faster than mesophilic solutions. One explanation could be that this temperature still needs testing and thus there are risks associated with investing in a thermophilic solution. Since there have been a similar expansion for dry-based processes it could be expected that this process is subjected to the same uncertainty.

Further it could be noted that majority of the facilities were sole owned. Only three facilities of the established facilities were share-owned and one of these was facing a production stop. However, what is interesting is that all facilities under construction and one that was about to start up were share-owned. Based on this one may expect the beginning of a new concept. Using Diffusion theory it can be argued that the concept of producing biogas in share owned facilities is in the initial stage of the adoption curve. Although the findings of this study cannot present sufficient data to investigate the performance of such facilities one may speculate that this concept could have potentials for handling the currently bad profitability. As more farmers gather in a joint venture, one may expect more resources available and fewer costs per shareholder.

6.2.2 Transportations

From the logistical oriented questions one may note that there are differences in transport patterns and methods when comparing substrate and digestate. When perceiving substrate, it was noted that the transport distances used varied in large extent among the respondents. Digestate on the other hand, used distances that were more centered within a certain radius. The fact that respondents would use longer distances may indicate that the substrate is a factor for competitive advantages. Since different substrate affects production differently, one may expect that certain substrate is worth the trouble long distances.

Further it may be noted that the means of transportation in great extent consists of pipes and contractions for substrate while the methods are somewhat more mixed for the transportation of digestates.
What is interesting is that contractors are being used in a large extent for both transportations of substrate and digestate. This would suggest that the outsourcing of transportation is an

interesting alternative which in turn could be described as a valuable resource. It may be expected that using contractors, creates other resources such as time for the facility operators. Depending on where facilities are localized and what substrate that the facility need, contract transportation may differ in value. While these values cannot be estimated it should be noted that transportations through contractors is commonly used among the studied facilities which would indicate that these could be relevant for successful operations.

Continuing with the logistics it should be noted that only a few facilities decided to transport biogas or vehicle fuels which indicate that most of the biogas is being processed at the farm. This may be a result of the low production of vehicle fuel that exists in the farm-based biogas facilities.

Instead the production is mainly focused around heat and electricity which are expected to be cheaper production methods. The reason why this expansion has occurred may depend on several aspects. While production mainly is focused on heat and electricity, an interesting thought may be whether an expansion in vehicle fuel would improve the situation for biogas. At the same time it is apparent that many facilities have appointed the price levels, of both gas and electricity, as insufficient for performing economic profitable biogas operations.

6.2.3 Workload

For the respondents of this study, it was noted that hours/month on the biogas facility would vary in great extent. The average value amounted to 42 hours/month which is relatively high in relation to the values that some of the respondents mentioned that they would like to have. This would indicate that average workload would amount to 1,4 hours a day which may not be seen as very heavy. A possible explanation to the differences in workload may be oriented in the construction problems that have been mentioned earlier in this study. However, despite the varying workload, a majority of the respondents stated that they were satisfied with the workload on the facility. Using RBV one may argue that the extra time being spent on the biogas is not constraining the farmer in any way and thus time becomes a resource that is less valued than the perceived value respondents get from handling their facility.

7 Conclusions and discussion

This chapter will address the findings of this study in relation to the aim presented earlier in this report. Further the findings will be discussed and thoughts of future research will be presented.

7.1 Conclusion

The aim of this study is to investigate factors that are significant in the development of agricultural-based production ventures in Sweden.

Based on the data that was gathered for this study one can summarize farm based biogas production as a relatively unstable concept. However, there are potentials for improving the situation. These will be presented in the following sections.

7.1.1 Impact of organizational aspects

When looking at the facilities studied, one could identify several similarities in structure. Most commonly, facilities are structured as mesophilic slurry based facilities. Only a few facilities are using termophilic digestion but all of these use a slurry based method. Further, a majority of the facilities are organized as a sub-enterpreise within the farm concept.

It is also shown that respondents mainly had been performing visits to Germany and within Sweden. Some respondents also made visits to Denmark and some other European nations. Further one could see that respondents that performed trips outside of Sweden could be expect to gain a more successful facility. Comparisons between respondents showed that those who made international visits had higher perceived value of utility in general than those that only stayed within Sweden. This suggests that relations with international partners are relevant for successful development. One may expect feedback and support to be interesting benefits from these connections.

7.1.2 Impact of Production aspects

Based on the values presented by the respondents of this study, it was shown that there are problems to manage production. In most cases, facilities would have troubles living up to their estimated production levels of biogas. This inability to perform is also mirrored in the economical values presented by the respondents as it was shown that the perceived level of profitability and gas production correlates well.

It was also apparent that the facilities were subjected to several challenges in the form of creating stable facilities and dimensioning these to the conditions of Swedish biogas production. Parameters such as time spent on the facilities could vary greatly among the respondents. One explanation to the variation could be the level of construction problems that facilities had been subjected to. Such problems would affect the performance of the facilities by delaying production and also increase invested costs in some cases. However, some facilities that would have no problem with construction could still become subjected to other problems that would affect performance. An example of such problems would be high concentrations of sulphur in the reactor chamber. This would in turn put a heavy corrosion on parts of the reactor and result in replacements having to be made sooner than estimated.

Further it could also be concluded that it is hard to protect oneself from these problems. The study showed that the rate at which these problems occurred were quiet equally distributed between facilities that had hired a supplier or been built independently. Going one step further would be to evaluate how different suppliers perform in relation to one another. While such data has not been gathered in this report it should be mentioned that the choice of supplier might be an important aspect for farmers. This is also mirrored by a majority of the respondents who stated that a large share of the time was used to serve and repair the facility. This indicates that there are troubles in finding solutions that works practically. By getting a supplier that can deliver a stable facility from the start, one may save costs and increase the overall production time.

One respondent actually stated that solutions in Sweden are based on technology from the rest of Europe where manure is not digested in such a great extent as in Sweden. This would indicate that the technology still needs to be developed in Sweden to become more effective. Further, some respondents presented that the age of their facilities were relatively young. This may also strengthen the fact that there is a need of market development in Sweden.

7.1.3 Impact of Logistical aspects

It was also possible to see similarities in the use of transportation methods. Most commonly, transportation was performed through sub-contractors. This finding could be applied on transportation of substrate as well as digestate. Thus it may be arguable that the high use of contractors could provide facility operators with a greater capacity that could be applied elsewhere. Although contractors may be costly, the time that the respondents save by hiring such, may be considered as beneficial.

This is also mirrored in the workload presented by the respondents. The majority of the respondents stated that they would only want to spend seven to eight minutes a day on their facilities. However, due to a high level of problems associated with farm based biogas facilities it could be noted that the workload in some cases would fluctuate heavily between respondents. As most facilities would be a part of agricultural business concept one may expect that time is very important and thus explain the high usage of contracted transports.

7.1.4 Impact of Economical aspects

Based on the perceived profitability from the respondents it was shown that a majority of the respondents valued the economic output as unprofitable. Only a few facilities managed to obtain small profits or a breakeven result. This expansion within the biogas sector may be the result of several aspects and the ones that was raised by the respondents of this study was mainly the price levels for gas and the support from society. Several respondents stated that profitability would not be possible without interventions from the society.

This makes external actors, such as the government, important for a further development in farm based biogas production. One can think of various areas that external partners may affect the development. Using the government as an example, they are able to influence price levels on a national level while on a regional level they may decide how investments support funding are to be divided. This indicates that there is good ground for alliances and networks to affect the success in farm based biogas production. An interesting topic among the respondents was the implementation of a biogas subsidy to stimulate production of renewable energies. While many respondents stated that a small subsidy could make a great difference for the future development of biogas, it is important that external actors lift the topic and argue for such changes.

Despite the generally negative attitude to the economical outlook for biogas, some respondents mentioned that they had experienced profits or a breakeven result. Some of them stated that there are other benefits that arise from biogas production that affects the overall economy. These values are however hard to measure since their effects may vary differently depending on the context being applied. This would suggest that there are different perspectives on how biogas is evaluated by respondents. While some look at the biogas facility as a single unit others look at a broader perspective where the biogas could be included as part of a farm concept. From this argument it is possible to state that the potential of success in biogas in some extent depends on other agricultural activities.

It could also be noted that many of the arguments for entering the biogas sector, did not necessarily have any business orientation. This was also mirrored by several respondents who claimed to have a medium to high level of utility with their facility despite a bad profitability. Examples of popular arguments were: environmental friendly activity, entrepreneurial & technical interest and becoming self sustained. This relates back to forsman (2004) which indicates that not all factors for successful development are dependent on economical aspects but also the values of the owner. In the case with environmental values, the argument is more focused on a belief to create beneficial conditions for all people. The technical interest, on the other hand, is more focused on a personal level. Thus one may note that motives are important for the development of biogas production. This would also explain why the perceived level of utility in general is higher than the perceived level of profitability. One may expect that the extra costs associated from a bad profitable venture are worth the level of satisfaction that respondents get from pursuing their motives.

Another possible explanation to the arguments for investing in biogas is a belief in future developments. This would indicate that there are hopes among respondents for achieving first mover advantages by investing early. If it should be assumed that the conditions for biogas production changes, resulting in a profitable business, the already established facilities would be able to cover market shares and thus exploit a profitable development from the very start.

7.2 Discussion

This sub-chapter will present a discussion based on the findings above. Two areas have appeared frequently in the findings and will be put in focus.

The value of development
One aspect that appeared several times in the findings was the indication for further development. It was possible to see that the Swedish biogas facilities struggle with construction problems, unstable reactor solutions, reduced production and unsustainable prices. As an example, some respondents claimed that they were having troubles with high concentrations of sulphur in their reactor chambers. This would in turn result in corrosion on certain equipment and thus require replacements to be performed sooner than anticipated. Another example is the gas price which has been stated to be at an insufficient level which would indicate that the market for biogas not yet stable.

This would suggest that there are several types of development that needs to be pursued in order achieve more successful biogas operations. One may think of two initial ways to expand development. Either new concepts or innovative methods of producing biogas are established or the conditions for current biogas production have to change. It may be expected that both alternatives have to be pursued simultaneously. In time one may expect that innovative methods will be developed enough to make biogas production profitable, using current conditions. However, it may also be argued that the producers in the farm based biogas production will not be able to produce under bad conditions for all too long.

The value of external partners
As it was shown in the findings, external suppliers may provide important benefits within the farm based biogas sector. By using the RBV, relations with parties that may influence politics could be regarded as capabilities that can be used to create future competitive advantages. Governmental support was mentioned as one important partnership that may enable a stronger position of influence when new policies, subsidies, taxes etc., are to be formed. In the case with government, a strong support would affect the entire farm based biogas sector and thus influence the level of success. However, to get a stronger support from governmental actors it is also important to establish networks with influencing partners. Diffusion theory addresses four elements that affect the adoption of an innovation where the final element is social systems. Partnerships with the governmental, or other, actors could form the basis for social system that in turn could improve a further adoption of farm based biogas production. This correlates also with the study of success in the Danish farm based biogas sector. A major factor that enabled a good expansion of facilities was the connection between various actors.

An interesting thought is whether problems, which exist in Sweden, can be found in other cultures as well. Other European nations such as Germany and Denmark, with high biogas production, are currently well develop in the farm based biogas sectors. Since both these nations are relatively close to Sweden, it may be thought that solutions to Swedish problems could be found in their developments. This becomes more apparent when combining the perceived level of utility with the various countries that respondents had visited before building their own biogas facilities. It was shown that respondents who had made visits in one to two nations, other than Sweden, would have a higher perceived value of utility than those that only made visits in Sweden. Based on this, it could be suggested that international relations could result in valuable and rare resources. Such resources would become interesting for facilities that would wish to compete with other facilities but also to further improve the situation for farm based biogas. One may argue that such relations would benefit the diffusion process. In this case the communication would take place on a larger population than only the Swedish biogas production.

7.3 Further research

Based on the findings of this paper, one may find several areas that would need further studies. In order to present a few interesting examples it would be interesting to study the affection of using different substrates. It was presented by this study that a majority of the respondents could not deliver the production quotas that they initially had planned. While one solution is to develop the reactor chamber another one would be finding the substrate types that work in the Swedish climate.

It may be expected that different substrates are hard to come by and thus it may be expected that facilities have to import substrate over long distances. Thus it would be interesting to study how transports of different substrates affect the performance of a biogas operation. By providing some indication to what distances that could be used for certain types of substrates, practical guidelines would become available to further help farm based facilities to achieve a profitable business.

Another interesting approach is to study differences between other nations such as Germany and Denmark. By identifying what norms, conditions and methods that are being used in these countries it would be possible to distinguish whether Swedish facilities could improve by adapting their methods or if there is a need for Swedish facilities to develop their own strategy. It may be expected that some aspects could be adapted while some are unique within the country and thus have to be developed.

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Appendix 1: Summery open questions provided during the study

Table 1 Facilities response to open questions presented in this study, percentage of respondents who assigned a certain value is also presented

Question	Response (categorized)	Respondents	Share (%) of total respondents
Troubles that occured during the development stages	No troubles	4	12,9%
	Administration	7	22,6%
	Construction & reconstruction	11	35,5%
	Planning before construction	3	9,7%
	Resistence from society	1	3,2%
Additional investments	None	8	25,8%
	Installation of energy systems	4	12,9%
	Increased production capacity	4	12,9%
	Construction & reconstruction	11	35,5%
Investment subsidies that have been used	Ananymous	1	3,2%
	Jordbruksverkets investeringsstöd	20	64,5%
	Ananymous	1	3,2%
	Stöd från energimyndigheten	2	6,5%
What are the major activities when handling the biogas facility	Controlling, supervising	22	71,0%
	Handling substrate	13	41,9%
	Service of facility	16	51,6%
	Checking facility	10	32,3%
	Reconstructions	1	3,2%
	Switching containers	1	3,2%
	Handling external visits	1	3,2%
What factors has the greatest affection on economical situation on your facility	Cost for governmental supervision	2	6,5%
	Operational costs	9	29,0%
	price of gas	8	25,8%
	price of electricty	10	32,3%
	price electricty certifiticate	2	6,5%
	Support from society	6	19,4%
	Choice of substrate	4	12,9%
	Production volume	6	19,4%
	Rate to which gas can be used	3	9,7%
	Cost of chainging equipment	5	16,1%
	Capital costs	8	25,8%

Question	Response (categorized)	Respondents	Share (%) of total respondents
Why did you invest in a biogas venture	Business opertunities	11	35,5%
	Belife in future benefits	14	45,2%
	Improved fertilizer	9	29,0%
	Environmental care	11	35,5%
	Not invest	4	12,9%
	Enterpreneurial spirit and technical interest	9	29,0%
	become self supported	4	12,9%
Are you happy with your facility?	Generally happy	10	32,3%
	Happy with current conditions	3	9,7%
	Not happy with current conditions	5	16,1%
	Happy except for the economic situation	2	6,5%
	Happy except for governmental interventions	2	6,5%
	Generally not happy	1	3,2%
Do you consider the biogas venture as profitable?	High capital costs	1	3,2%
	Generally bad	3	9,7%
	Will improve in the furture	5	16,1%
	Weak profits or breakeven	3	9,7%
	Profits need to increase	13	41,9%
	Need similar conditions as rest of Europé	2	6,5%
	Profitable when including alternate products	1	3,2%
If not invest: What needs to change to make it worth investing	Production subsidy	3	9,7%
	reduced workload	1	3,2%
	reduced costs of changeable parts	1	3,2%
	better support from governments	1	3,2%

Appendix 2: Interview guide

This is the main interview guide used in this report. All interviews were conducted in Swedish.

Frågor till Intervju studie 2013

Examensarbete om Biogas

Organisatoriskt orienterad:

- Namn på gård: ______________________
- Gården finns i län: ______________________
- Vad för slags företags struktur tillämpas hos biogasanläggningen?

Verksamhet inom gården ☐
Enskilt bolag ☐
Handels bolag ☐
Ekonomisk förening ☐
Aktiebolag ☐

Ägaren av den gård där anläggningen ligger	%
Andra lantbrukare	%
Andra leverantörer av substrat	%
Andra förbrukare av anläggningens energiprodu	%
Andra aktörer i biogasförädlingskedjan	%
Andra intressenter (Skriv nedan)	%
Summa	%

- Vilka är ägare i biogasanläggningen?
- Vilken utvecklingsfas befinner sig anläggningen i

Under planering ☐
Under konstruktion ☐
Under inkörning ☐
Under uppehåll ☐
Är i drift ☐

  - Om anläggning är i drift: vilken delfas var jobbigast?

Produktions orienterade

1. Vad för slags biogasanläggning tillämpas

   1.1. Processtyp (Slurry, enstegs eller två stegs?)

   1.2. Vad för slags rötning används (Mesofil eller Termisk)

   1.3. Vilken leverantör anlitades?

Våtrötning/Slurry ☐
Torr, kontinuerlig ☐
Torr, satsvis, en stegs ☐
Torr, Satsvis, två stegs ☐
Mesofil ☐
Termisk ☐

   1.4. Vilken sorts lösning bygger anläggningen på?

Standard lösning ☐
Bygger på standardkomponenter ☐
Utnyttjar standardkomponenter kompletterat med en hel del unika lösningar ☐
Anläggningen är unikt utvecklad på plats ☐

2. Har ni varit i kontakt med andra biogasanläggningar? Ja ☐ Nej ☐

2.1. Om ja: Var och hur ofta? ________________________________

3. Hur stor är rötkammaren? ____________________ M^3

4. Hur mycket gas produceras på ett ungefär under ett år?

	planerad produktion/år	Faktisk produktion/år
Obheandlad biogas		
Värme		
Elektricitet		
Renad biogas (fordonsgas)		

5. Var förbrukas gasen angivet i %

	planerad användning	Faktisk användning
Egen energi		
Såld energi		
Facklad energi		
Summa		

Har haft problem att få avsättning för gasen Ja ☐ Nej ☐

6. Var kommer substratet ifrån?

Animaliskt gödsel från egna gården	%
Animaliskt gödsel från andra gårdar	%
Växtrester från egna gården	%
Växtrester från andra gårdar	%
Särskilt odlat växtmaterial	%
Industriavfall	%
Summa	%

6.1. Om industriavfall: Har det varit några problem med att använda dessa?

____

7. Hur stort utrymme finns det för att ta hand om rötrester? ____________________ M^3

8. Vad används rötresterna till?

Gödsling av egen gård	%
Gödsling av andra gårdar	%
Andel som går till försäljning	%
Summa	%

Logistikt orienterade

1. Hur långt transporteras substrat som längst? ____________________ Km

2. Hur långt transporteras rötrester som längst? ____________________ Km

3. Hur ser transporter för substrat, rötrester och biogas ut?

Substrat

Transport egen bil ☐
Transport någon annans bil används ☐
Transport ledning ☐

Rötrest

Transport egen bil ☐
Transport någon annans bil används ☐
Transport ledning ☐

Biogas/Fordonsgas

Transport egen bil ☐
Transport någon annans bil används ☐
Transport ledning ☐
Omvandlas till annan energi gården ☐

3.1. Om via lastbil: hur mycket ryms (som mest)? Biogas: ________ Subs./Rötr. ________

3.2. Om via ledning: Hur lång ledning? ____________________ Km
samt vem står som ägare för ledningen? ____________________

Ekonomiskt orienterade

1. Hur stor var kostnaden att investera i biogasanläggningen? ____________________ SEK

1.1. Andra investeringar som uppkom som följd av biogasanläggningen?

____ ____________________ SEK

2. Med vilka medel finansierades biogas anläggningen?

Ägarnas egna insatser	%
Bank eller andra lån	%
Offentligt investeringsstöd	%
annan finansiering	%
Summa	%

2.1. Om offentligt investeringsstöd: vilket? ____________________

2.2. Om annan finansiering: På vilket sätt?

____

3. Vem hanterar biogasanläggningen? (Gården/ägarens ansvar eller någon annan part)

Ägaren/anställda vid gården där anläggningen ligger	%
Andra delägare och deras anställda	%
Särskilt anställda	%
Summa	%

4. Ungefär hur många timmar i månaden läggs på skötsel av biogasanläggningen?
___________ timmar/mån

4.1. Vilka sysslor består arbetet mest av?

____

4.2. Motsvarar arbetet med biogasanläggningen era förväntningar? Ja ☐ Nej ☐

5. Vilka faktorer anser ni har den störst påverkan på ekonomin?

____

6. Av vilken anledning valde ni att investera i biogasproduktion?

____

7. Anser ni att ni är nöjda med biogas anläggningen? Missnöjd 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Nöjd

____

8. Anser ni att biogas anläggningen är ekonomiskt lönsam? Mkt olönsamt 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Mkt lönsamt

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