

**UNIVERSITY OF VAASA**  
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**UNDERSTANDING MARKETING SYSTEM FOR ALGAE BASED BIOGAS**

Master's Thesis in  
Marketing management

**VAASA 2018**



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<b>Year of entering the University:</b>	2016	
<b>Year of completing the Thesis:</b>	2018	<b>Pages: 86</b>

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**ABSTRACT**

The world's energy consumption is expected to double in 2050 with a 1,6% annual growth rate. This has led to focus on finding alternative and renewable energy sources that support sustainable development. The purpose of this research is to form an understanding how the marketing system works for an algae based biogas. Research examines the barriers and opportunities of algae based biogas. The focus is on the empirical materials (interview data) and how the marketing system elements appear in the interviewee's discussion.

This research is related to the TransAlgae project which explores the possibilities for algae cultivation in the Nordic climate. One of the objectives of the project is to implement innovative solutions for producing micro- and macro-algae based biogas. The understanding of a marketing system started from creating the theoretical framework for marketing system for algae based biogas. Main theories are marketing system (Layton 2009), sustainable business model and PESTEL which form a theoretical framework of the study. The marketing system framework was enriched by the findings in empirical data.

There are technological, economical, functional, knowledge, climate, cultural and legal barriers of algae based biogas. Algae cultivation and harvesting take more energy than the biogas can release is one example of technological barriers. There are functional, environmental and social opportunities for algae based biogas. Algae enhancing nutrient recycling is an example of environmental opportunity.

There is enormous potential to make biogas from algae. The product is not close to commercialization even though algae have great properties as being most rapidly growing biomass and the ability to clean wastewater during cultivation. With the need of new renewable energy source and the great properties of algae it is essential to continue the research of algae based biogas.

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**KEYWORDS:** algae, biogas, marketing system, sustainable business model



## 1 INTRODUCTION

Resource depletion and mitigating climate change are the driving forces to look for alternatives to fossil fuels. The world's energy consumption is expected to double in 2050 with a 1,6% annual growth rate. (Tabassum, Xia & Murphy 2017: 136.) The EU's renewable energy directive has set a target in which final energy consumption from renewable sources should be 20 % by 2020. Independent EU countries have committed reaching their own national renewable energy targets to achieve this common goal. EU has required that at least 10% of transport fuels should be from renewable energy sources by 2020. This has led to focus on finding alternative and renewable energy sources that support sustainable development. (Slade & Bauen 2012: 29–30; European commission 2017).

Algae cultivation and algae products are currently an interesting research topic around the world, because algae have great potential to be a biomass source for biogas. Algae are potentially suitable raw materials for biofuel production because useful polysaccharides (sugars) and triacylglycerides (fats) can be produced and used as raw materials for producing bioethanol and biodiesel transport fuels. (Slade et al. 2012: 29–30; Singh & Gu, 2010: 2596–2597).

One of the greatest features of microalgae is the ability to clean waste water during cultivation capturing nutrients and carbon dioxide, which is beneficial for environment and climate. (Biofuel region 2017.) Algae bioenergy is currently being researched extensively, but has not yet achieved commercialization. (Awudu & Zhang 2011: 1359–1360.)

This research is related to the TransAlgae project, which is a three-year project from 01.04.2016 to 31.03.2019, where possibilities for algae cultivation in the Nordic climate are explored. The objective of the project is to implement innovative solutions for producing micro- and macro-algae based biomass from waste streams on an industrial scale. This project includes six activities: Forming a network, cultivating algae,

harvesting algae, extracting of algae, transforming algae and system analysis. To achieve the objective, the project will develop a cost-effective and energy-efficient harvesting system and methods for transforming algae biomass to bioenergy and high value end products. (Biofuel region 2017; Botnia-Atlantica 2017).

The project also aims to create network of algae industry stakeholders in the Botnia-Atlantica area. The target companies of the network are medium-sized and small companies such as wastewater treatment plants, biogas producers, dairy farms, and power plants. TransAlgae project partners are Swedish University of Agricultural sciences (SLU) (project leader), Biofuel Region, Mid Sweden University, Nattviken invest, University of Vaasa, Novia and NIBIO.

TransAlgae's project budget is 2 209 675 EUR and EU support for this project is 1 059 646 EUR which is included in the project budget. Co-financers of this project are Regional council of Ostrobothnia (FI), Nordland fylkeskommune (NO), County Administrative Board of Västerbotten (SE), SLU (SE), Kempestiftelsen (SE), University of applied sciences Novia (FI), Arctic seaweed (NO), Mid Sweden University (SE), County administrative board of Västernorrland (SE), NIBIO (NO), Biofuel Region Bfr AB (SE), University of Vaasa (FI) and county of Bodø (NO). (Biofuel region 2017; Botnia-Atlantica 2017). The focus of this thesis will be on algae based biogas.

The TransAlgae project mindset lies in circular economy. For example, algae clean waste water during cultivation process, using the nutrients in the sewage water. Therefore there is no need to buy nutrients for algae cultivation and the nutrients in the sewage water are re-used. Hereby, algae are used as biomass for biogas and leftover from the process are used as fertilizers. (Botnia-Atlantica 2017.)

Circular economy is a very important topic, since the global resources are decreasing daily and people consume more than the world can sustain. Because of the increasing consumption and decreasing resources, there is a need for finding alternative resources, recycling materials, finding new renewable energies and exploiting the circular

economy. (Kumar, Rahman, Kazmi 2013: 601.) The goal in circular economy is to increase the use of resources and materials in a way the raw materials and their value remain in circulation. Waste of materials is minimized. In Finland Sitra has calculated the circular economy having an opportunity to add value about 1.5 to 2.5 billion euros. The greatest value potential of circular economy is not in waste and material flows but in the more valuable maintenance of machines, re-use and re-manufacturing. The circular economy requires co-operation from the operators and consumers across the field, demolishing administrative obstacles, and success of innovative experiments to achieve the full potential. (Salokoski 2017: 30). Circular economy is part of the value creation and sustainable business model in this research.

### 1.1 Purpose and objectives of the study

There is plenty of research on algae cultivation and harvesting, yet there has not been much research on marketing system or sustainable business model for algae based biogas products. It is important to conduct research about the market of algae based products before introduction to the market. When the market is defined market's exchange logics, roles, and its actors e.g. the marketing system (Layton 2009) play key roles for the product development and launch. As the end product is still in an early stage there is a need for research of the business model. Algae based biogas is a renewable energy source and therefore the emphasis of the research should be on the sustainable business model.

The purpose of this research is to form an understanding how the marketing system is defined, and which elements constitute the marketing system in the context of algae based biogas. The research aim is answered through three objectives.

First objective is to create an understanding how the marketing system works. First objective is based on theory and is answered in chapter two. This is achieved by explication the elements of marketing system defined by Layton (2009). Sustainable

business model and PESTEL are important theories as well in this research and are presented in chapter two.

The second objective is to define a marketing system for algae based biogas as well as defining a sustainable business model for algae based biogas. Social, economic and environmental aspects will be considered in this sustainable business model. Here the focus is on the empirical materials (interview data) and how the marketing system elements appear in the interviewee's discussion. Second objective is answered in chapter four.

The third objective is to determine the barriers and opportunities for algae based biogas. Third objective is also based on interviews with algae and biogas experts, articles of the field and is answered in chapter four.

## 1.2 Research approach and limitations

The research uses sustainable business model and marketing system theories. Algae based biogas as phenomenon is examined in relation to a marketing system and a sustainable business model. How the marketing system could work for the new product is the main point of view in this research.

Sustainable business model was selected as the idea of algae based biogas business is to find sustainable ways to cultivate and harvest algae biomass and create a renewable source of energy. Moreover, the sustainable business model is used since the environmental, societal and the economic aspects are considered. (Piscicelli, Ludden & Cooper 2017: 1; Teece 2010: 172–173).

The research is based on qualitative research approach which aims to explore the subject as comprehensively as possible and describe as well as create understanding of the phenomenon. In qualitative research emphasizing the point of view of the participants and the interaction of the researcher with the individual observation of participants is

essential. (Hirsjärvi, Remes, & Sajavaara 2007: 157,160.) Methodological choices in this research are hermeneutics as the paradigm, abduction logic as the research logic, interviews as the data collection method and content analysis as the analysis method.

To obtain a common and valid understanding of the meaning of a text is the purpose of hermeneutical interpretation. Reality is always interpreted in hermeneutics, therefore hermeneutics is variation of interpretivism. In research the interviews are conversations which are transformed to text that have been interpreted. Hermeneutical method focuses especially on the interpretation of text, and the interviews are used as the data collection method in this research thus hermeneutic paradigm was chosen for this thesis. (Erikson et al. 2008: 20,33; Kvale 1996: 46–47).

Primary research data was collected by semi-structured interviews with chosen algae and biogas experts in the field. Same theme was used in every interview. The semi-structured interview type was chosen, because the same questions were used in each interview, even if the order and form could vary. In this thesis both theory and empirical study are equally important, together giving a better understanding of the researched phenomenon. Hence the abduction logic was chosen as the research logic.

One of the biggest limitations of the study is the absence of the algae based biogas market. Hence, this research is based on a review of the existing biogas market, algae and biogas experts' interviews as well as articles of algae, biogas, marketing systems and sustainable business models.

### 1.3 Key terms

Essentials key terms are biogas and algae. *Biogas* is formed by the degradation of various microbes in organic matter under anaerobic conditions. Production of biogas in controlled closed reactors is called anaerobic treatment-, or digestion of biogas. The organic digestion residue is suitable for fertilizer use. (Mutikainen, Sormunen, Paavola, Haikonen & Väisänen 2016: 10).

There are two different types of *algae*. Macro-algae are cultivated in ocean (seaweed) and micro-algae are cultivated in marginal land. There are numerous species of macro- and micro-algae. Algae species differ from each other for example by colour and genetically. For example, between the brown seaweed *Fucus* and green seaweed *Ulva lactuca* there is a greater genetic difference than between an oak tree and *Ulva lactuca*. Algae can be cultivated all year round, but Nordic weather conditions complicate the cultivation process which lasts throughout the entire year. (Murphy, Drosig, Allen, Jerney, Xia & Herrmann 2015: 1,4; Singh et al. 2010: 2596–2597).

#### 1.4 Research structure

The structure of this thesis is divided into five different chapters. The first chapter consists of introduction to the subject of the research and the research approach as well as shortly describing the objectives, limitations, methods and key terms. The second chapter focuses on the theoretical framework. A marketing system, a sustainable business model and PESTEL analysis are selected as the main theoretical concepts of this research. The first objective is theoretical and therefore it is answered in second chapter.

The third chapter focuses on the methodology of this thesis. The chosen methodology chapter examines the methodological choices of the research, including the paradigm, research logic, the data collection method and the analysis method. Hermeneutics, hermeneutic circle, abduction logic, interviews and content analysis are introduced in this chapter.

The fourth chapter, which is also the empirical chapter, focuses on the results. The key findings in this thesis are introduced in the result chapter. The algae, biogas and biogas' markets are presented more profoundly in this chapter. Algae based biogas barriers and opportunities are presented with the sustainable business model. At the end of the fourth chapter the marketing system for algae based biogas is introduced. Thus, the second and

the third objectives of this research are answered. The fifth chapter concludes the research.

## **2 DEFINING MARKETING SYSTEM AND SUSTAINABLE BUSINESS MODEL**

This chapter introduces the theoretical framework of the research. Marketing system, sustainable business model and PESTEL analysis are the main theoretical concepts in this research and together they will create an understanding of how marketing system and sustainable business model work. Thus, this chapter answers to the first objective of the research. First objective is to create understanding how a marketing system works and will be answered in this chapter.

### **2.1 Development of marketing thought and practice**

This chapter introduces different approaches of marketing and how marketing has developed. Marketing inherited the model of exchange from economics and the economics' dominant logic is based upon the exchange of goods. Marketing is seen as continuous economic and social process where operant resources are paramount which unifies different areas of literature streams such as service marketing, customer orientation, market orientation, quality management, value management, supply chain management and network analysis. (Polanyi & Arensberg & Pearson: 1957: 266–267).

Theories in table 1 have been chosen because they help understanding how the marketing thoughts and practise have been changed through the years and how a marketing system has developed to its current state. This collection of marketing theories is presented in chronological order.

**Table 1.** Development of marketing thoughts and practise

<b>Timeline &amp; researchers</b>	<b>Definition</b>
Smith (1776)	Value in exchange (specialization)
Maslow (1943)	Maslow's hierarchy of needs
McCarthy (1960)	4P (product, price, promotion, place)
Grönroos (1994)	Relationship marketing (mutual benefit and satisfaction of both parties)
Lusch & Vargo (2006)	Service dominant logic (SDL)
Layton (2007)	Marketing system
Heinonen, Strandvik, Mickelsson, Edvardsson, Sundström, Andersson (2010)	Customer dominant logic (CDL)

At first the marketing focused on manufacturing products, labour and exchange of goods. Value was embedded in exchange and wealth in society were created by acquiring the tangible goods. (Vargo & Lusch 2004: 1–3; Smith 2007: 330). Smith's value in exchange idea is originally from his book "*AN INQUIRY INTO THE NATURE AND CAUSES OF THE WEALTH OF NATIONS*" which was published in the year of 1776. Hereby, the marketing idea of value in exchange has been with us for more than 200 years. Smith's thought about value in exchange is still valid and it is part of the marketing system. (Smith 2007: 330). Key to wealth was in specialization by making goods that people wanted, and at the same time increasing the productivity of workforce therefore cutting costs and creating a surplus. The main thing was getting people willing to exchange to satisfy their needs for a diversity of services and goods. (Layton 2009: 352; Smith 2007). In 1776 the economic had two objectives, they were: Firstly, to provide a revenue for an enterprise and secondly to supply the state with a revenue enough for the public services. It proposes to enrich the both ruler and people. (Smith 2007: 328).

Abraham Maslow developed a five level hierarchy for human needs on 1943 to understand people's personal growths and marketers have later adapted it to understanding consumer motivations. This Maslow's hierarchy of needs is presented in figure 1. Marketers embrace this five-level model because it might indicate what kind of product benefit consumer is looking for which depends on the level the consumer is on, consumer's level of spiritual or mental development, and on their economical situation. Maslow's five level model is standard marketing knowledge, but contains many problems, such as the same product or activity can satisfy dissimilar needs. For example, gardening can make consumer feel safe (level 2) and it can be a source of self-fulfilment (level 5) at the same time. Other problem with Maslow's hierarchy is culture-bound, the levels can be seen as rational, individualistic and materialistic in western culture, but people in other culture may change the order of the levels. For example, in Asian culture the welfare of the group is higher in the hierarchy than individual's needs. Therefore marketers need to keep in mind consumers having different cultural background and in different consumption situations the consumers have different priorities for needs. (Solomon, Marshall, Stuart, Barnes & Mitchell 2013: 206 – 207).

According to Maslow's hierarchy, basic needs must first be satisfied before the consumer proceeds to the next level of need. A consumer who has not eaten or drunk, does not go looking for new experiences or is not interested about a status symbol. Maslow's first level of needs contains physical needs such as food, water, and sleep which are needed to live. When these needs are met, the people need a sense of security, and safety needs are met through security and protection. Next people want to satisfy social needs, such as finding love, friends, and becoming accepted by others. The following level of needs is the need of appreciation, things that give value to people. For example, reaching a certain status in a workplace or in the eyes of others in the same social group. The last level of needs is the need of self-development. (Maslow 1943: 370–386; Solomon et al. 2013: 206–207). For example, painting, where people can develop their technical skills and artistic vision. This algae based biogas could be seen in this hierarchy on level four. The customer could buy this renewable energy to fulfil their status, hereby it could be seen as a need for ego. The end product could be on level

two as the world needs new renewable energy sources which can secure the energy supply and, in this case, secure the supply of gas. Thus, this could be a need for safety.



**Figure 1.** Levels of needs in the Maslow's hierarchy of needs (Solomon et al. 2006: 207)

Jerome McCarthy first introduced the four Ps of marketing in his book of Basic marketing, A Managerial Approach (1964). The four P's is also called marketing mix and is still used as a marketing tool. The marketing mix defines the marketing as a functional activity and is seen as marketing strategy. The four P's stand for product, price, promotion and place. The first P of marketing mix is product. The product can be intangible or tangible good that fulfils the need or want of a consumer. The second P of marketing mix is price. Price is the cost of the product which customer transfers in exchange of goods. Demand, supply, profit and marketing strategy of the product will impact on the price of the product. The third P of marketing mix is promotion. Promotion is about promoting the product and has its own mix called promotion mix. Advertising, personal selling, sales promotions, public relations and direct marketing are included in the promotion mix. The fourth P of marketing mix is place. Place can be

the location where the customer buys the product or the product's distribution channels for example store or e-commerce. One of the deficiencies on this marketing mix is that it does not include any interactive elements between seller (the company) and buyer (customer). Other deficiency presented by Kotler is that the marketing mix only presents the seller's views and not the buyer's. (Baker & Saren 2010: 14,16; Constantinides 2006: 408–409). The product element in 4 P is the assortment in the marketing system and the place where the algae based biogas is sold or distributed and an important part of a marketing system. The price is one tool for competition and an important one when the algae based biogas is introduced to the market. The price is commented in the result chapter. The promotion is of course important but as the end product is not ready for the market promotion is not included in the marketing system.

Since marketing mix does not include the customer's views or any interactions between seller and buyer relationship marketing was developed. Grönroos defines the relationship marketing: *“Marketing is to establish, maintain, and enhance relationships with customers and other partners, at a profit, so that the objectives of the parties involved are met. This is achieved by a mutual exchange and fulfilment of promises”*. In previously described relationship marketing creating, maintaining, and improving a relationship between seller and buyer is vital for marketing and selling the products for customers. Mutual satisfaction and benefit with both parties (seller and buyer) via exchange is important. Giving and keeping promises for customers are integral elements of a relationship marketing. Achieving customer satisfaction, long-term profitably, retention of the customer base is equally important as fulfilling promises that company has been giving to the customer. Trust is one of the key elements in relationship marketing. (Grönroos 1994: 9).

Earlier the marketing dominant logic focused on embedded value, tangible resources and transactions. New perspectives have emerged regarding the marketing dominant logic and today they focus on the co-creation of value, intangible resources and networks. The goods have been the center of the marketing thinking and over time the focus has shifted from goods-focused approaches to customer- and service-focused approaches. According to Vargo and Lusch this new perspective in marketing dominant

logic makes service even more important than goods for the economic exchange. It is called Service dominant logic (SDL). The classical division between services and goods is outdated. Today customers do not buy services or goods, the customers buy offerings which create value for them. In SDL exchange processes, intangibility and relationships are central. (Vargo et al. 2004: 1–3).

According to Heinonen, Strandvik, Mickelsson, Edvardsson, Sundström and Andersson (2010) the customer dominant logic (CDL) is focusing more on the customers than the goods-dominant logic (GDL) OR SDL in marketing. Both GDL and SDL stand for a provider-dominant logic and the CDL is separated from them because it is focused on the customer's practices, life and experiences, in which of course the service is embedded naturally. Thus, the CDL is a wider logic where the SDL is part of the CDL. The marketing logic is looked from a customer's perspective and which the service is naturally part of, because the service is what the customer gets from the company when the customer for example, buys a car. CDL has five major challenges to marketers: visibility of value creation, scope and character of customer experience, company control in co-creation and involvement. (Heinonen & Strandvik, Mickelsson & Edvardsson & Sundström & Andersson 2010: 531 –532; Vargo et al. 2004: 1–3).

Roger Layton's (2007) marketing system is more recent theoretical frame of marketing. Layton suggests that marketing system starts with specialization and ends with growth and well-being. It includes exchange logics, flows, roles, networks, governance, assortments and buyers. Marketing system could be described as a process. First is specialization, following the social matrix that effects on specialization and the end of the process is the profit. Marketing system responds for customer's demand by providing assortments of products or services via exchange and creating value for customers or other participants and creates a network for individuals, entities or groups. Marketing system is a wider concept than four P's, relationship marketing, SDL and CDL and therefore it is chosen for this research. As the algae based biogas product is not ready for the market, it is crucial to define the whole marketing system hereby this marketing system works for theoretical approach in this research. (Layton 2009: 354). Marketing system is presented more thoroughly in the next chapter.

## 2.2 Marketing system

Marketing system is a theoretical model and created by Roger Layton. The marketing system model provides fresh and comprehensive approach to marketing so that all the different actors are included in the marketing system. Marketing system is a process that starts with specialization and ends up with growth and well-being. The marketing system is a network where buyers, sellers and other actors meet and where the exchange happens. The decision to trade involves much more than a single commodity for both parties. Partly marketing system thinking started from trade imperative, where individuals realized that through specialization the profits were possible. Primary function of marketing system is to offer an assortment consisting of a heterogeneous set of goods, service, experiences and ideas for customers. For a marketing to function, there needs to be supply, demand, assortments, sellers and buyers. (Layton 2011: 260,262; Polanyi et al. 1957: 266–267). Layton's marketing system was chosen for this research for being comprehensive approach and including all different actors and together they form marketing as whole.

Consumers are looking for and purchasing assortments that match their needs and producers desire to put together product combinations that increase returns by specialization. The trade networks linking sellers and buyers with specialization become more and more dense and marketing system as a macro structure for embedded exchange becomes more likely. Technology, emergence of supporting institutions and the growth of knowledge play relevant roles in decreasing or managing transaction and coordination costs for the system to operate. (Layton 2009: 354; Layton 2011: 260–261).

**Table 2.** Definition of a marketing system. (Layton 2009: 354.)

1. *A network of individuals or groups and or entities*
2. *Embedded in a social matrix*
3. *Linked directly or indirectly through sequential or shared participation in voluntary exchange of value*
4. *Which jointly creates, assembles, transforms and makes available*
5. *Assortments of product, services, experiences and ideas*
6. *Provided in response to customer demand.*”

Table 2 explains the marketing system by Roger Layton. Functional marketing system needs network or individuals that exchange value to each other. The elements of marketing system are embedded in a social matrix. This marketing system provides products, services, ideas or experiences. Marketing system can only work properly if there is demand. The elements of a marketing system are specialization, exchange logics, flows, roles, networks, governance, assortments, buyers, growth and well-being. (Layton 2011: 259–260,267.) Marketing systems are everywhere from exchange in tribal societies to western mature economies. (Layton 2011: 259–260,267.) The elements are depicted in the figure 2.

**Figure 2.** The elements of a marketing system. (Layton 2011: 267.)

In a marketing system consumer’s needs meet producer’s supply. In other words, consumers are looking for and purchasing assortments that match their needs and producers desire to put together product combinations that are based on the ability to specialize and therefore increase returns. The structure and functioning of embedded marketing systems shapes and is shaped by social matrix. (Layton 2011: 261–262, 267–269.)

According to Layton all exchange takes place in the social matrix, a context where the marketing system operates. Economic, social, cultural and physical are the characteristics of a social matrix and these affect the marketing system's exchange logics, roles, flows, networks, governance, assortments and buyers. In marketing system, the economic characteristics are seen as parts which make a marketing system work economically. For example, how a product coverage is formed or what are the fixed costs of a company. In marketing system the cultural characteristics are viewed as cultural norms that affect the marketing system. For example, how the culture of the country affects exchange logic or roles. In marketing system the social characteristic is seen as a social structure between actors of a marketing system. It is a relationship between actors and is guided by the rules of a society. In marketing system the physical characteristic is considered as physical infrastructure of a marketing system. Interactions between the elements of a marketing system will define both effectiveness and efficiency of the marketing system. (Layton 2011: 261, 268.)

Layton's marketing system is usually used for existing markets therefore use of the model for a non-existing market is a challenge. Layton's model does not consider the sustainability factors and thus needs modifications.

Growth and well-being aspects in the marketing system are not in the focus of this theoretical discussion therefore they are not included in this chapter. The end product is still not close to commercialization and hence it is not crucial to focus on the growth and well-being in the marketing system. Moreover, the focus is on how the marketing system could work for algae based biogas. When the end product is closer to commercialization and the market is created for this product the growth and well-being aspects will be more important and need to be focused on. Next all the aspects of marketing system are introduced except for the growth and well-being aspects.

### 2.2.1 Specialization, exchange logics, flows and roles

Specialization is the first element in the marketing system. The marketing system starts with producer's specialization where the producer gains increasing returns by product or service specialization. In this marketing system the specialization means that a firm offers their product to the buyer, the buyer buys the product and a firm makes a profit. Firm's business model, its capability to make profit with value creation, value delivery and value capture are included in specialization. (Layton 2011: 261, 268; Shomali & Pinkse 2015: 3831–3832.)

Exchange logics form the second element in marketing systems. Exchange logics can vary from planned or unplanned choices from simple grocery shopping to complex multi-party negotiations. Marketplaces can vary from shopping malls to sophisticated offices. Since increasing returns are available and exchange is not cost-free, further specialization in trades related functions and roles are viable. (Layton 2011: 261, 268.) The marketing system exchange logics include the exchange between a firm and a customer. In this stage firm offers a product to the customer including the value creation, then the firm delivers the product to the customer thus including value delivery. Finally, the customer pays for the product and gets the product and its value, the firm makes a profit including the value capture.

Division of exchange and labor contribute to social well-being. (Vargo et al. 2004: 6.) The viability of an exchange context is influenced by safety, hygiene, access and communication factors. (Layton 2011: 268,269; Layton 2009: 355). Value-in-exchange is the value potential embedded in products or services provided by a company which through sales is realized as value for the company. Value-in-use is both determined and created by customers. The value for customers is created during their usage of products or services. (Grönroos & Gummerus 2014: 209.)

Value propositions made by sellers and expressed through products, services, experiences and ideas are the content of these exchanges. The co-creation of value outcomes will usually require close co-operation between sellers and buyers. The values can be economic and /or non-economic in nature sought by the participants in exchange.

The exchange can be bilateral, multilateral, once off, repeated, fully or partially informed. Much depends on whether the exchange is seen as a single event or a part of a longer pattern or relationship. Exchange can be an obligation, gift, barter or sale. Exchange can be auction, fixed price or negotiated. (Layton 2011: 268, 269; Layton 2009: 355). In the algae based biogas marketing system the exchange is seen as a sale and prices can be fixed and negotiated.

Flows are the third element in marketing systems. In a marketing system there are different flows such as ownership, possession, finance, risk and information. Flow is between a seller and a buyer. Every flow has different tasks in marketing system to keep it running. For example, there needs to be flow of information between a seller and a buyer for the exchange to take place. For example, the flow of risk is transferred from seller to buyer when the exchange takes place. Economic, social and cultural factors in the social matrix affect flows of a marketing system. (Layton 2011: 270; Layton 2009: 355.)

Roles are the fourth element in a marketing system. There are different participants that can vary from individuals (households) to entities (agencies, firms) to marketing system (clusters, networks, markets, partnership, alliances etc.) and each of one fills one or more roles in the functioning of a marketing system. The participants provide relevant support services associated with the flows of information, risk, finance, possession and ownership. For example, firms can act as buyers or sellers or both, individuals can be part of information flows as controllers, providers or gatekeepers. (Layton 2011: 270, 271; Layton 2009: 355.) In algae based biogas's marketing system the company who cultivates the algae has the role of provider of biomass and also a role of seller of biomass. They sell the biomass to a biogas refinery company who transforms the biomass into biogas. The municipal waste water plant can have the role of buyers of the service where algae clean the waste water or the role of provider as they provide the waste water with nutrients that algae need for cultivation.

### 2.2.2 Networks and Governance

Networks are the fifth element in the marketing system. Networks are the core of a marketing system. Participants in networks vary from individuals, groups, or households to entities as firms, agencies or alliances. These networks are linked in exchange transactions. Networks create together economic value in response to customers' demand by offering a range of products, services, ideas and experiences. (Layton 2011: 271.) Networks involve actors, structure, dynamics, entry and exit flows. Moreover power, trust and influence are important factors in a network. How value is contributed between actors and which role each actor has in a network are important questions, when creating a new network. (Layton 2009: 355.) A biogas refinery company is one example of the network in an algae based biogas marketing system.

An optimal network for a biofuel supply chain will ensure that biofuel can be delivered effectively and efficiently to the end user market. Sourcing and locations of production facilities include supply chain network decisions. The networks' critical and strategic decisions in a biofuel supply chain affect the biomass flow, the associated costs, procurement of biomass, sourcing, allocating and capacity of intermediate warehouses, distribution, purchasing and location of the plants. (Awudu et al. 2011: 1362.)

Demand and supply contracts contain decisions of agreed terms of payment and delivery between the producer and the supplier. These contracts might include standard regulations and some contain feed in tariffs, tax cuts and exemptions, R&D programs, investment subsidies and mandatory biofuel quotas. Demand and supply contracts measure the fusion and intensity of having some level of conviction to entice the investors. (Awudu et al. 2011: 1362.)

Governance is the sixth element in the marketing system. In a marketing system the governance is the overall governance of the marketing system meaning how the elements of a marketing system are managed and by who. How the networks are agreed upon on ownership or risk and who has the final liability for debt for example.

### 2.2.3 Assortments and Buyers

Assortments are the seventh element in the marketing system. Assortments are what firms provide and customers want to fulfill their needs with. There are distinct types of assortments such as offered, accessible, sought, acquired and accumulated. Assortments produced by marketing system are visible indicators of society's values, nature and commitments. (Layton 2011: 272–273; Layton 2009: 356.) In this marketing system the assortment is algae based biogas and the service is cleaning the waste water.

Buyers are the eighth element in marketing system. The process begins with identifying buyers who are associated within the marketing system. There are several types of buyers such as individuals, households, firms and agencies. Customers can be end-users or intermediate users. It is good to notice that customers may not be the end users of the assortment. Their exchange role can be passive, active co-producer or co-creator of value. They can make single or multiple purchases at a time and their participation can be self-sufficient or market dependent. (Layton 2011: 272; Layton 2009: 356). In this marketing system buyers could be municipal waste treatment plants, who buy the service where algae clean the wastewater. The end-customers for the biogas could be individuals, or firms such as bus companies using biogas as transport fuel.

A market providing assortments which fulfill customers' needs and wants will determine the success or the failure of the marketing system. On one level customers can be seen as households, individuals, managers or buying groups and on another level they are considered in aggregate as groups, segments, regions or communities. Important factors for system functions and structure are heterogeneity of the resource capabilities and endowments of buyers, including the capability to pay. The review of demographics and decisions making of the customers is very important. (Layton 2011: 272; Layton 2009: 356). Marketing system is now thoroughly discussed. Next chapter introduces a sustainable business model.

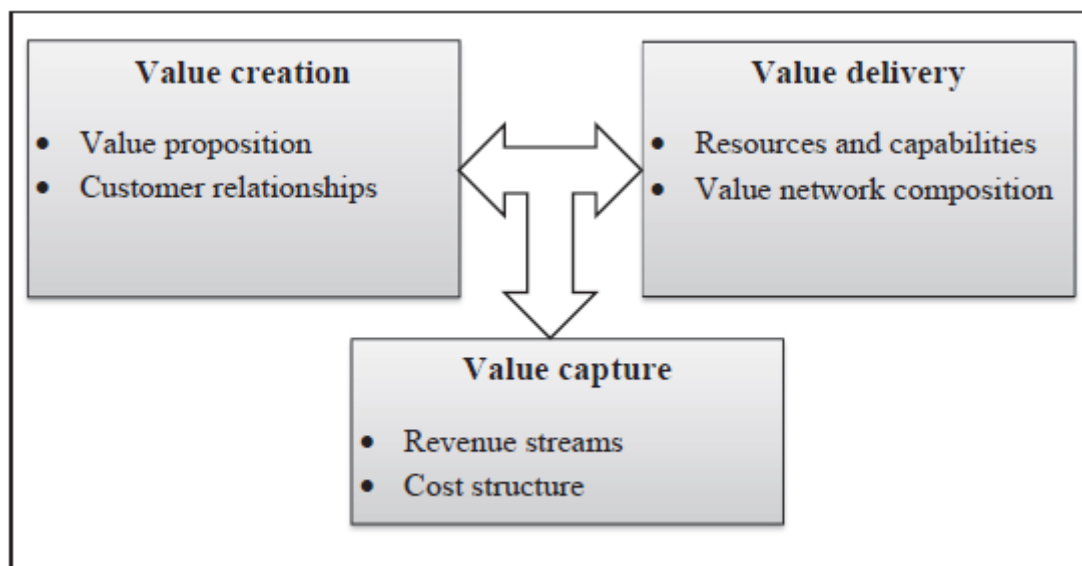
### 2.3 Sustainable business model

Sustainable business model is relevant because the algae based biogas is renewable energy source and the business model's focus is to make more environmental friendly and renewable energy. The global warming has made people and firms to think more about the environment and sustainable choices such as recycling and decreasing the carbon footprint. Hereby, the sustainable way of making business has increased in recent years. Environmental challenges such as climate change and resource depletion have impact on environment, economy and society. Natural resources are decreasing day by day and their sustainable use needs to improve or there will be a need to find alternatives for them quickly. These environmental challenges are forcing actors to find sustainable ways to practise business. (Kumar et al. 2013: 601; Piscicelli et al. 2017: 1).

According to United Nations Economic Commission for Europe (UNECE) the term sustainable development was defined by the Brundtland commission at 1987 and it is defined as *“development which meets the needs of current generations without compromising the ability of future generations to meet their own needs”*. This definition is still used to defining a sustainable development and it is used in this research. (Unece 2017.)

Firm uses a business model to simplify its operations and to be analysable, manageable and visible. (Teece 2010: 172.) Business model helps to understand, visualize, capture, share and communicate the firm's business logic. (Osterwalder, Pigneur & Tucci 2005: 12.) The business model's essence is in determining how the firm delivers value to the customers, makes customers willing to pay for this value and change these payments into profits. A firm's business model reflects management's hypothesis about customers' needs, what they want and how they want it, and how the firm can meet the customers' needs, get a paid for it and making a profit doing so. Innovators will fail to either capture value or deliver value from their innovations without well-developed business model. (Teece 2010: 172.)

The core of a business model lies in how business model creates, captures and delivers value for the customers. (Teece 2010: 172–173.) Figure 3 demonstrates the business model with three components. First component is value creation which includes the value proposition and customer relationships. The second component is the value delivery where firm's resources and capabilities with the value network composition are included. The third component is the value capturer holding revenue streams and cost structure. (Shomali et al. 2015: 3832.)



**Figure 3.** Business model framework. (Shomali et al. 2015: 3832.)

The value creation answers to customers' actual needs and in value proposition the firm makes a proposition for the customers. How to manage the relationship with the customers and how the firm is answering the customers' shared needs or more customized needs, are the choices that the firm makes in value creation component. Value delivery answers how the firm delivers the value for its customers. Firm needs to decide which resources and capabilities are going to be used and what kind of resources and capabilities it already has, when delivering the value proposition to its customers. Moreover is the firm going to develop these resources and capabilities internally or externally. (Shomali et al. 2015: 3832; Teece, 2010: 172.) The value network is about how the firm organizes the value chain with its assets internally or externally, and with

the relationships with stakeholders such as distributors and competitors. (Shomali et al. 2015: 3832; Teece, 2010: 172.)

Value capture is the business model's financial foundation explaining how the firm gets customers to pay for the value that the firm has created and how these payments transform into profit. Value capture answers the question how value proposition influences cost structure and how this leads to a new revenue. (Shomali et al. 2015: 3832; Teece, 2010: 172.)

As new technology emerges, business models can help firms determine how to benefit from implementation of modern innovations. Business models can be mediators between economic value creation and technological innovation. Thus, a business model provides an analytical tool that identifies challenges of a new technology and helps the firm to recognize which acquisitions they need to obtain and which changes are needed to achieve their wanted economic value. (Shomali et al. 2015: 3831.)

The emergence of disruptive technologies is one of the main reasons for firms to rethink their business model. There are two different views on how to define disruptive technologies: market-based and capability-based. In the market-based view disruptive technologies change the performance of a product in the eyes of the customers. In the capability-based view, disruptive technologies demand the firm to make comprehensive changes to its capabilities. (Shomali et al. 2015: 3831.)

Thus, a business model is about value creation; how the model creates, captures and delivers value for the customers. There is no difference between a traditional business model or a sustainable business model. Value creation is the essence for both business models. (Teece 2010: 172; Piscelli et al. 2017: 1–2.) Sustainable business models vary from traditional business models in a way that sustainable business models consider the environmental and social aspects as well as the economic aspect. The firm has a potential to create competitive advantage through sustainable business model and at the same time provide societal and environmental benefits. Sustainability benefits are usually accomplished for example creating value from waste or to deliver functionality

and change the processes for more natural or renewable processes. (Piscicelli et al. 2017: 1).

A sustainable business model also creates, delivers and captures value that profit the firm and its stakeholders (customers, suppliers and investors) together with the society and environment. All the stakeholder groups' interests are aligned, and the society and environment are key stakeholders in this model. According to Porter and Kramer (2011: 66) sustainable business model is concept of shared value where the competitiveness of a company is enhanced through operating practices and policies while improving the economic, social and environmental conditions.

Sustainability addresses the firm implementing the environmental, social and ecological requisites in all its activities and across the whole value chain. Having an environmental aspect in the business model, a firm should improve the product's eco-friendliness by for example using recycled materials and improving its eco-efficiency regarding energy consumption, resource intensity and waste per production. The social aspect in a business model means improving quality of health services and care, quality of human life and individual wealth. One of the challenges in ensuring the success of sustainable business models is about increasing the economic value while improving the environmental and social benefits. The economic aspect in a business model is the profit that a company makes. (Rosca, Arnold & Bendul 2015: 1–2.)

### 2.3.1 Biofuel supply chain

Supply chain resembles a business model a lot since both manage a chain. The business model managing the chain of value from firm to the customer or end user and supply chain managing the chain of supply from manufacturer to the customer or end user. In both similar decisions (strategic, tactical and operational) are made about the chains. As the end product is biogas (biofuel), hereby the biofuel supply chain management has been chosen for this research.

Generally, a supply chain consists of a network of manufacturers, suppliers and end users. Managing the supply chain involves managing all the activities of the supply

chain to ensure effectiveness and efficiency of the supply chain. (Awudu et al. 2011: 1362.)

Three main decision-making processes in biofuel supply chain management are strategic, tactical and operational. Strategic decisions are long term decisions and after five or more years might need a revision. Tactical decisions include sourcing, scheduling, production, transportation, inventory and logistical contracts. Tactical decisions are medium term decisions and they are between six months to one year. Operation decisions are made to achieve the tactical decisions and they include decisions such as demand forecasting or transportation. Operation decision are short term decisions and are made daily or weekly. (Awudu et al. 2011: 1362–1363.)

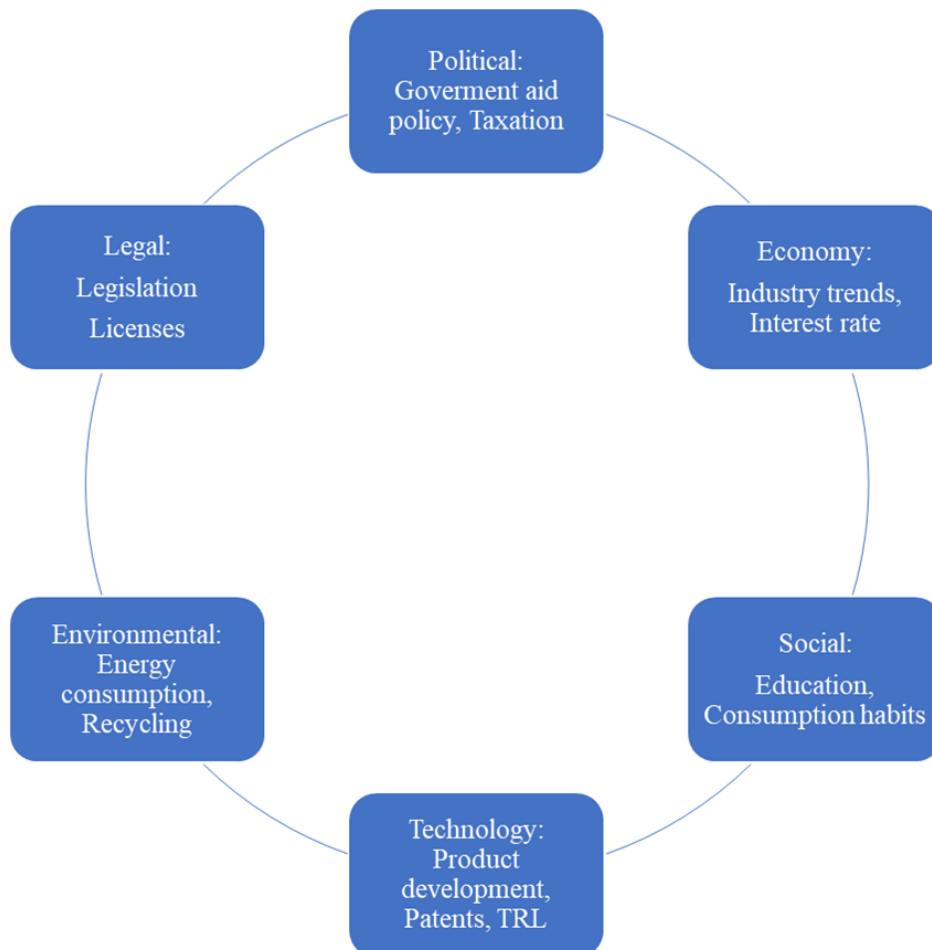
The biofuel supply chain's strategic decisions are energy production technologies, networks, demand and supply contracts and ensuring sustainability selections. While beginning of planning the production of biofuel the energy production technologies should be selected first since the technologies do not change in a short time period. Energy production technologies contain: transforming the waste biomass and organic substrates into energy, conversion options, requirements of infrastructure and end user implementations. Cost of building and maintaining the plants, sustainability and environmental issues, raw material type and availability are important factors to consider when making strategic decision regarding the biofuel supply chain. Managing the biofuel supply chain involves managing all the activities of the supply chain to ensure effectiveness and efficiency of data flows, material flows and cash flow efficiency. (Awudu et al. 2011: 1362.)

Awudu and Zhang recommend collaboration between agricultural, consumer and governmental organizations to reach the objective of providing renewable energy to answer the changing market demand for bioenergy. These decisions also support the main objectives and functions. Sustainability ensures that environmental, social and economic aspects of this supply chain are sufficiently addressed. The main uncertainties in biomass supply chain are production and operation, transportation and logistics as well as demand and price uncertainties. Factors of uncertainty will affect on supply

chain performance and should be included in decisions making. (Awudu et al. 2011: 1362–1363.)

### 2.3.2 PESTEL analysis

Marketers use PESTEL analysis to analyse the macro-environmental factors that influences the firm or organisation. PESTEL analysis is a framework and it is an acronym from the words political, economic, social, technological, environmental and legal. Dividing the different factors into categories makes it easier to perceive and to interpret. The information produced by the analysis can be utilized in the firm's strategy. (Vuorinen 2013: 220).



**Figure 4.** PESTEL analysis. (Vuorinen 2013: 222.)

As the figure 4 illustrates the PESTEL analysis has six different categories; Political, Economy, Social, Technology, Environmental and Legal. Government position and its

aid policy, taxation, customs, wars, conflicts, terrorist attacks, relative strengths of political parties are included in the political category. In the political category the firm writes down how different matters affect the political aspects of the firm, for example a new tax for ice cream. Economic cycle, gross national product (GNP) trends, industry trends, interest rates, inflation, investments and unemployment are included in the economy category. In the economic category the firm elaborates how the economic aspects affect the turnover, for example what the future industry trends are. (Vuorinen 2013: 222).

Demography structure, education, consumption habits, life style changes, attitudes towards work and leisure time and ethnic factors are included in the social category. In the social category the firm forms an understanding how the social aspects such as the consumption habits have effect on the demand of service of product. Product development, research, technical readiness level (TRL), patents and findings of parallel fields of industries are included in technology category. In technology category the firm explains how the technical aspects such as patents will affect the firm and its operation. (Vuorinen 2013: 222).

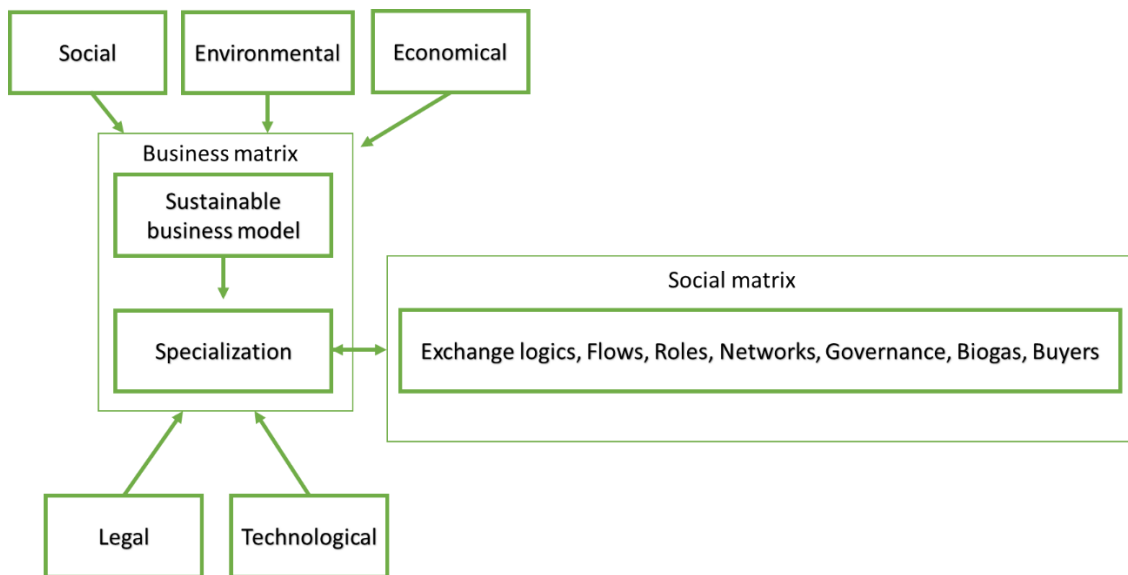
Environmental protection, energy consumption, waste treatment, carbon dioxide emissions, effects on green values, recycling and emission trading make up environmental category. In the environmental category the firm lists how the environmental aspect such as energy consumption affects processes. Legislation of competition and labour, product safety, licenses, immaterial rights and EU:s regulations are included in the legislation category. In Legislation category the firm describes how the legislation aspects such as EU:s regulations affect the operating environment. (Vuorinen 2013: 222).

PESTEL analysis does not aim to list every possible thing in all categories. With themes that have no presumable changes, there is no need to take them into the PESTEL analysis. It is essential to find the most important themes for the firm, which have a clear impact on the firm's operations. (Vuorinen 2013: 220). The purpose of the PESTEL analysis is not to write down only probable factors but also to find signs of changes and

weak signals. (Keinonen & Jääskö 2003: 143.) When the factors are divided into various categories, it is reasonable to consider the factors strength and probability. (Vuorinen 2013: 223).

## 2.4 Theoretical framework

This chapter demonstrates the theoretical framework of this research. This framework consists of theoretical elements that have been introduced earlier.



**Figure 5.** Theoretical framework of the study

Theoretical framework is made of models of marketing system, PESTEL and sustainable business model. As mentioned before the Layton's marketing system was chosen for the main marketing theory, because it was a wider concept than others presented earlier. Together sustainable business model and marketing system's element specialization form the business matrix in this theoretical framework.

Sustainable business model was chosen for this research as the end product is renewable energy and the production is benefitting the environment (cleaning waste water). Algae based biogas business model aims to create economic, environmental and social

benefits. PESTEL analysis' social, environmental and economical parts are included in sustainable business model as these are the three core values that sustainable business model wants to achieve. Therefore, the social, environmental and economical aspects of PESTEL are in this theoretical framework. A sustainable business model also creates, delivers and captures value that profit the firm and its stakeholders (customers, suppliers and investors) together with the society and environment.

Sustainable business model and specialization form a business matrix. This is presented in the theoretical framework of the study. First the firm creates a sustainable business model, a business plan how they are going to make profit and at the same benefit the environmental and social surroundings. Specialization is the sustainable business model put in to practice. A marketing system starts with the specialization, the firm has described the business plan and if they are going to make a profit by product or service specialization. Hence, the firm's business model, its capability to make profit with value creation, value delivery and value capture are included in specialization. Sustainable business model with specialization creates a comprehensive view of how a firm could be operating profitably. Business matrix is the most important part in this research and the theoretical framework.

PESTEL analysis examines political, economic, social, technological, ecological and legal effects of the firm's operation surroundings. (Vuorinen 2013: 220.) When the business idea is relative new it is good to examine the surroundings of the business idea and define which matters affect algae based biogas business model and the marketing system. PESTEL analysis is a comprehensive framework for the examination. As the product is renewable energy the business matrix needs to consider the EU and local environmental laws and regulations. PESTEL's legal part is included in specialization as firm needs to function legally. Especially when the company is producing renewable energy there are many EU regulations that the firm needs to follow. As the product - alga based biogas - is at experimental level the technology needs to develop so that in the future the algae based biogas is profitable. Hereby the technological aspect of PESTEL is included in this theoretical framework.

For the specialization to work the company must make decisions about the exchange logic, flows, roles, networks, governance, assortments and buyers. These elements are included to this theoretical framework and they are influenced by a social matrix. The elements: exchange logic, flows, roles, networks, governance, biogas (assortment) and buyers together with specialization and sustainable business model form a marketing system for algae based biogas as the product is still developed. When the product is ready for commercialization then the theoretical framework needs to adapt.

In the empirical part the research examines marketing system in the context of algae based biogas. Next chapter introduces the methodology choices for this research.

### 3 METHODOLOGY

This chapter examines the methodological choices of the study, including the chosen research approach, the paradigm, the data collection and the analysis of the material.

#### 3.1 Research approach and research paradigm

The qualitative research method was selected as a research method because it aims to explore the subject as comprehensively as possible, describing the phenomenon and creating more understanding. The starting point for qualitative research is the complex and detailed examination of the material. (Hirsjärvi et al. 2007: 157,160).

Obtaining a common and valid understanding of the meaning of text is the purpose of hermeneutical interpretation. (Kvale 1996: 46–47). The purpose of this research is to define sustainable business model for algae based biogas and create an understanding of how marketing system could work for algae based biogas.

Abduction is a research logic which combines both deduction and induction in one research. In abduction logic the theory and empirical research are having a dialogue with each other through the research. (Tuomi et al. 2002: 99.) In this thesis both theory and empirical study are equally important, moreover together they are giving a better understanding of this researched phenomenon, thus abduction logic was chosen as research logic. (Eriksson et al. 2008: 21,23.) Moreover, the abduction is related to interpretivism and reality is always interpreted in hermeneutics, thus the paradigm supports the choice of abduction logic. (Kvale 1996: 46, 47).

One of the key paradigms of qualitative research is hermeneutics. The paradigm refers to the researcher's worldview or beliefs that guide the researcher in her research work. Paradigms can be imagined to be the essence of the study. Friedrich Schleiermacher is the founder of hermeneutics. Reality is always interpreted in hermeneutics, therefore hermeneutics is variation of interpretivism. The purpose of hermeneutical interpretation

is to reach a general understanding of the purpose of the texts, therefore interpretation is strongly present in qualitative research. Hermeneutics is an important paradigm in research-interviews because interviews are conversations about people's lives and the world and conversation is transformed into a written form that the researcher interprets. The concept of text in hermeneutics also includes discourse and action research. The hermeneutical method focuses especially on the interpretation of text, thus this method was chosen for this research. (Kvale 1996: 46,47).

The hermeneutic circle is originally from Schleiermacher, Heidegger and Husserl have later developed it. (Eriksson et al. 2008: 33.) The interpretation process is described in the hermeneutic circle. (Kvale 1996: 47) Primary information has been interpreted by the researcher and as the process continues, this knowledge is adapted and changed. The objects are interpreted and conditional. The hermeneutic circle is one way of conceptualizing the understanding of the process of interpretation. When a person interprets, it involves the human gender identity, experiences, culture and expectations. (Eriksson et al. 2008:32 –33.)

The hermeneutic circle is like a spiral where it is continuously possible to deepen knowledge and understanding the meaning better. Primary information has been interpreted by the researcher and as the process continues, this knowledge is adapted and changed. The hermeneutic circle is one way of conceptualizing the understanding of the process of interpretation. When a person interprets, it involves the human gender identity, experiences, culture and expectations. The objects are interpreted and conditional. (Eriksson et al. 2008: 32–33; Kvale 1996: 46-48.)

### 3.2 Interviews

One of the most common qualitative research data collection methods is an interview. Interview differs from other methods of gathering information as it is having a direct linguistic interaction with the subject. Interview's basic idea is that the questions provide material that will help answer the research question thorough analysis. Interviewing is

often chosen in situations where researcher wants to emphasize a person in a research situation as a subjective that creates meaning and is an active party in research. (Hirsjärvi et al. 2007: 199–204; Eriksson et al. 2008: 79, 82).

Interviews are often chosen as a data collection method when exploring a slightly mapped or unknown area, or if it is known in advance that interviews will provide answers that are complex and need interpretation. An interview usually aims to clarify or deepen the answers. One of the strengths of the interview is the flexibility in collecting the data, because the interview can be controlled, and interview can be flexible and adapt the interview situation along with interviewee. (Hirsjärvi et al. 2007: 199–204; Eriksson et al. 2008: 79, 82).

The benefit of the interview is that people who have experience in the phenomenon or knowledge of the subject can be selected for the interview. In quantitative questionnaires researchers cannot influence so much on who answers the questionnaire because the respondents are not selected one by one. (Tuomi et al. 2002: 76–77.) That is one of the main reasons that the qualitative method and interviews were selected to be the data collection method.

Primary data was collected by interviews with chosen algae and biogas experts in the field. Interviews are individual interviews, so interviewee's point of view is transmitted naturally. Same theme was maintained in every interview. Semi-structured interview type was chosen, because this type of interview allows to change the question order and vary the wording in each interview. There was also some structure that helps keep the material comprehensive and systematic. Other advantage of the semi-structured interview is that the material is unified, although the nature of the interview is debatable and casual. In this case, the analysis of the results is easier and more comprehensive. One of the benefits of the interview is moreover that it is possible to reach the desired respondents later if, for example, a follow-up is required. (Hirsjärvi et al. 2007: 199–202; Eriksson et al. 2008: 82). Table 3 present the chosen interviewees of this study.

**Table 3.** Interviewees

<b>Interviewees</b>	<b>Profession</b>	<b>Length of the interview</b>	<b>Day of the interview</b>
I1	Project Leader in Anaerobic Digestion Research	1 hour 3 minutes	7.6.2017
I2	Assistant professor in energy technology	22 minutes	16.10.2017
I3	Research manager in energy technology	39 minutes	19.10.2017
I4	Coordinator in energy technology	21 minutes	16.10.2017
I5	Research assistant in TransAlgae	31 minutes	17.10.2017
I6	Research scientist in Arctic agriculture	47 minutes	18.4.2018

There are different methods to record the interview for documentation and later analysis such as note taking, remembering, audio recording and video recording. Recording the interview allows the interviewer to concentrate on the interview, its topic and dynamics. When interview is recorded it allows re-listening for the interview and it helps writing the transcript of the interview. (Kvale et al. 2009: 179). Therefore, the interviews were audio recorded, because this helped to concentrate on the actual interview and it was easier to write the transcript when one could return to the interview and play back and forth every ambiguous part. Moreover, notes were made during the interviews about the high lights of the things that the interviewee was telling.

### 3.3 Content analysis as analysis method

Content analysis is basic analysis method than can be used in all qualitative researches. Content analysis can be a single method or a loose theoretical reference framework. Table 4 presents the content analysis framework. Interviews give the researcher a lot of material and going through all the material is time-consuming. There is also a lot of irrelevant information in the materials and with the content analysis the researcher makes a decision which information is relevant, and which is not. (Hirsjärvi et al. 2007: 199–204; Eriksson et al. 2008: 79, 82). Table 4 presents the framework of content analysis.

**Table 4.** Content analysis framework. (Tuomi et al. 2002: 93.)

- |  |
|--|
| <ol style="list-style-type: none"><li>1. Choose, what is interesting in this study and stick with it, make a strong decision.</li><li>2. Go through the material, separate and mark the things that are interesting</li><li>3. Leave everything else from the research</li><li>4. Collect the mark things together and away from the other material</li><li>5. Categorizes, make themes and types.</li><li>6. Write a conclusion</li></ol> |
|--|

The framework has six different steps. Following every step will give good framework to write a content analysis. In every qualitative study there is a possibility to find multiple interesting things in the collected material such as interviews and this can make the researcher confused because the researcher might want to study all the interesting things and report them in the research, but this is impossible. Therefore, the researcher needs to make strong decision on what are the most interesting things that he or she is going to research and report in the study. This is the first step in the content analysis framework. The second step is to read the material many times and marking and separating the interesting things what can be found in the materials. The third step is to leave everything else from the research and only focus to the things that the researcher has found. The fourth step is to collect the found and marked things together. The fifth step is to make categories, themes and types from the things that were found in the material. The sixth step is to write conclusion about the findings. (Tuomi et al. 2002: 94–95).

Content analysis' weakness is the uncertainty if the researcher has selected the right things from the material and found all the interesting things. Therefore it is important to go through the material carefully and many times and make sure that all the right things are found from the material. Choosing the themes, categories and types are the things that need to be done precisely. Content analysis' strength are the multiple times research materials are looked through and selecting good categories helps making the analysis.

In this research the categories were from the theoretical framework such as assortments, flows, roles and networks. During the analysis focus was directed into the issues that

the interviewees brought up about the algae based biogas market, products and elements of marketing system. After collecting data of elements of marketing system, markets, products and the algae based biogas barriers and opportunities from the interviews, categories were made and every relevant data was put under the right category. When all the relevant data from interviews had been categorized and made into themes conclusion and results of the research were to be done.

### 3.4 Evaluating the research

Qualitative approach emphasizes the subjectivity of the information that comes from the research and it is good to consider the limitations of the study. In qualitative research, it is essential to emphasize the point of view of the participants and the interaction of the researcher with the individual observation. (Hirsjärvi et al. 2007: 157, 160).

One of the challenge in qualitative research is how to assure the reader about the validity and reliability of the research. Hereby, adopting strict evaluation criteria for the research will increase the transparency and will also provide ways to highlight the limitations and strengths of the research. Lincoln and Cuba (1985) have created validity and reliability evaluation criteria for qualitative research. It is a concept of trustworthiness which contains four following aspects: conformability, transferability, credibility and dependability. (Eriksson et al. 2008: 290, 294)

*Conformability* refers to the interpretations and findings which are linked to data in a way that others can easily understand it. *Transferability* idea shows that the similarity of the research can be found in previous studies, making a connection between with your study and the previous studies' results. This research has used previous studies by making linkages to the existing articles of the field and a discussion between this research's results and previous studies' results can be found. However, the idea of *transferability* is not about replication hereby, this research has used new marketing system framework for algae based biogas's theory which is a collection of marketing system, PESTEL and sustainable business model theories. This research can be used for

algae based renewable energy sources studies and marketing system studies for renewable energy. Because the algae based energy is a niche this research can't be transferred for other purposes than algae based energy source studies.

The key thing in *credibility* is the requirement for another researcher to get the same results and claims when he or she is using the same data of the research. Further, has the researcher made logical and strong links between data and results and credible claims from the data. This research's findings of interviews are linked to data and the interpretations are made from these findings. These research results are quotes from the interviews thus the reader can see the links between data and results. The findings of this research and interpretations are linked to data in a way that every reader can easily understand it. *Dependability* refers to the process of the research being well documented, logical and traceable. (Eriksson et al. 2008: 290, 294). All the interviews of this research are well documented, as all the interviews were transcribed hereby, all the data is traceable in this research. Different researcher can interpret the same material in different ways and choose different themes to follow therefore, there can be themes in this research that other researcher would have taken into account and researched more.

## 4 RESULTS

Algae biofuel energy has received much attention recently. Algae based biofuel is called a third generation biofuel. Algae bioenergy is currently being researched extensively, but it has not yet achieved commercialization. (Awudu et al. 2011: 1359–1360). In this chapter the marketing system for algae based biogas is formed by empirical analysis and the barriers and opportunities for algae based biogas are discussed. The findings of the interviews and possible linkages to the articles are discussed on the base of the empirical analysis and the theoretical framework in this chapter. Thus, the chapter answers to the second and third objectives of the study. First, however, the algae and biogas industry are described to form a preliminary understanding of the topic.

### 4.1 Background of algae and biogas industry

There are two different types of algae, macro-algae which is cultivated in ocean (seaweed) and micro-algae which is cultivated on marginal land. There are numerous species of macro- and micro-algae. Algae contain sulphur, carbon and nitrogen and the carbon-to-nitrogen (C:N) ratio varies between species. Macro-algae's C:N ratio tends to be higher than micro-algae's. The availability of nutrients, growing conditions, time of the year of cultivation and harvesting and the algae species affect the algae's C:N ratio. (Murphy et al 2015:1,4).

Algae has rapid growth rate. Its capability to double its biomass in time periods as short as hours makes up one of the reasons why algae is a potential biomass source for biogas. Algae can be cultivated all year round. (Slade et al 2012: 29-30 & Singh et al 2010: 2596-2597). Microalgae has enormous potential to be biomass source for biogas as it has higher growth rates and better capability to accumulate lipids than for example oil crops. (Schlagermann, Göttlicher, Dillschneider, Rosello-Sastre, Posten. 2012: 1.) One of the greatest features of microalgae is to capture nutrients and carbon dioxide enabling

the algae to clean waste waters during cultivation making it beneficial for environment and climate. (Biofuel region 2017).

There are two alternative ways to cultivate algae, open pond system and photo bioreactors. Open pond system is placed outside and receives the light and temperature naturally from the environment. Photobioreactors are closed systems where light and temperature are regulated. (Slade et al. 2012: 29–30).

Technology readiness level (TRL) is used to describe the technological maturity of a process. RTL is a parameter and ranges from 1 to 9. On the scale, one means very basic research of a new technology and nine means that the technology is ready for commercialization. For seaweed the TRL number is 5 during the research of this study. More research is required before seaweed can be used as biomass for biogas. TRL level is even lower for microalgae, as it needs to be refined before it is suitable biomass for biogas. The microalgae's cultivation methods need more research as well. (Murphy et al. 2015: 31). While writing this thesis, the cultivation of microalgae is not cost-effective. (Borowitzka 2013: 743.) Both microalgae and macroalgae hold a great potential to be biomass for biogas, but the potential needs to be researched more.

Biogas consists mainly of methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ). Biogas can be used for same purposes as natural gas as they have only slight difference in percentage ratios of carbon dioxide and methane. Biogas is renewable energy that can be used for example heating and transport. (Makisha 2016: 1093). Biogas is formed while various microbes disintegrate organic matter in anaerobic conditions. Controlled close reactors for biogas production are called anaerobic treatment or digestion. Leftover from the process of digestion can be used to make fertilizer. Biogas process can be fed with for example, sludge from waste water treatment plants and manure of farmed animals. (Mutikainen et al. 2016: 10).

According to European biogas association there were 17 376 biogas and 459 biomethane plants in Europe in 2015. (EBA 2017). Finland has 86 biogas plants and they produced biogas 630 GWh /year in 2014 and this is about half a percent of renewable energy

produced in Finland. Since 2013 biogas production had increased (ca 4%). In 2014 one agricultural digester and three co-digestion plants started production.

**Table 5.** Biogas plants in Finland 2014 (Huttunen & Kuittinen 2015.)

Plant type	Number of plants	Energy production* (GWh/year)
Sewage sludge, municipal	16	149
Biowaste, codigestion	14	151
Agriculture	13	5
Industrial wastewater	3	4
Landfills	40	304
Total	86	630
*=Produced energy as electricity and heat excluding efficiency losses. Vehicle fuel production 17 GWh is added to total energy production		

Table 5 shows different biogas plant types in Finland in 2014. Landfills remain to be the main biogas plant type. Compared to 2013 the use of biogas as a transport fuel has increased by more than 50%.

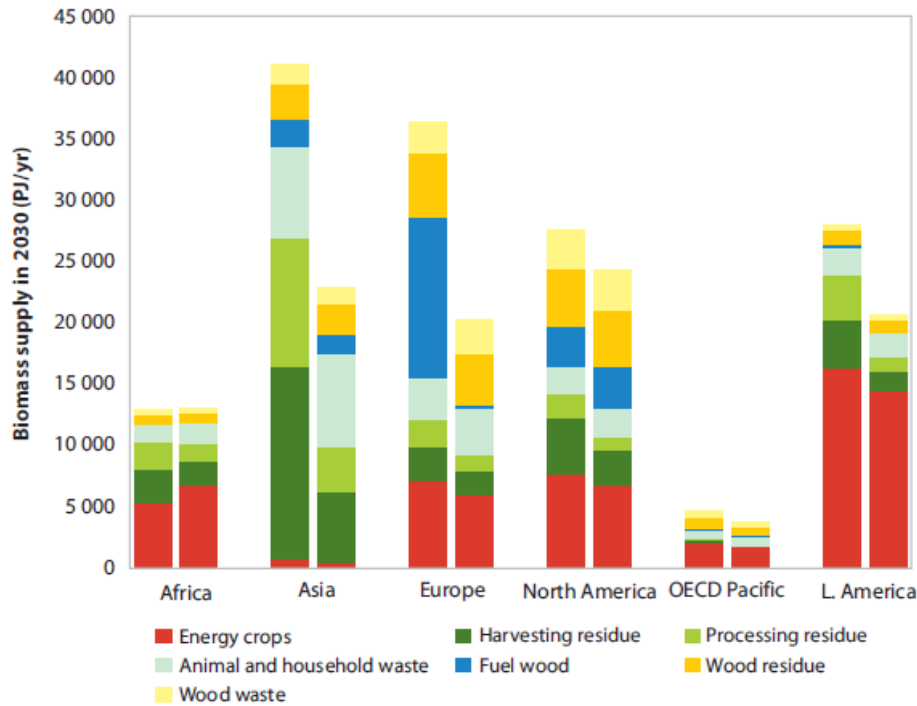
**Table 6.** Biogas utilization type in Finland 2014 (Huttunen et al. 2015.)

Utilization type	GWh	%
Electricity	159	22
Heat	455	62
Vehicle fuel	17	2
Flaring*	101	14
*=excluding efficiency losses		

Table 6 shows different biogas utilization types in Finland in year 2014. As the table shows most of the biogas is used in heating and then electricity. Biogas was utilized to generate 454.7 GWh heat and 158.6 GWh electricity. Biogas utilization rate increased from 81 % to 84.5 % of the biogas production volume. (Mutikainen et al. 2016: 12).

Goals of the renewable energy productions have been tightening and timetable for their usage have been quickened with the Paris climate agreement. The share of sustainable bioenergy is estimated to be around half of all renewable energy in 2030. International renewable energy agency (IRENA) predicts that the use of sustainable bioenergy could

increase by 70% from today to 2030. This requires that especially biofuel use in transport, including shipping and air transport, will increase. Carbon neutral transport is realized first with the use of biofuels. Therefore, it is important that biofuel use in transport is already being promoted. (Salokoski 2017: 23–24).



**Figure 6.** Biomass supply in 2030. (Salokoski 2017: 23)

Figure 6 shows IRENA's scenario how the biomass supply would divide in year 2030. In Europe the fuel wood and energy crops would constitute the biggest supply for biomass in 2030. For example, easy availability of wood in Europe affects this scenario. Algae as a biomass is studied in 2018 worldwide and when the cultivation and harvesting can be made more energy efficiently and cost-efficiently the harvesting residue as biomass supply will increase in the future. The raw material base for bioenergy will be further expanded. Sustainability is a key factor, but the raw bio material's availability, acquisition and transportation are also significant factors in increasing the use of bioenergy. The growing part of raw material for bioenergy will be waste based which increases biogas production. (Salokoski 2017:24).

## 4.2 Business matrix for the algae based biogas

The business matrix is defined as a part of marketing system including the specialization and sustainable business model. First there is sustainable business model, which illustrates how the company makes a profit with the algae based biogas. Specialization is the sustainable business model put into practice. The value creation and value delivery are included in the business matrix. This chapter presents a sustainable business model and specialization for algae based biogas on the base of the empirical data. This chapter answers the second objective.

*“Biogas production is growing all the time. Globally I think biogas has big future.” (I3.)*

Biogas industry is growing every year globally and it has a demand as renewable energy source. (Salokoski 2017: 23–24.) The literature and interviewees agreed that biogas production will increase in the future. This finding supported the sustainable business model. Value creation, value delivery and value capture are included in the part of the sustainable business model of the marketing system. (Shomali et al. 2015: 3832.) As the algae based biogas is still in an early phase, the value capture which includes the revenue streams and cost structure is not involved with this marketing system. Below is explicated how the interviewees evaluated the value creation for algae based biogas.

*“It is mostly that you will remove the nutrients from the wastewater so they don’t end up in the cleaned water, because if they end up in the water or they would cause nitrification and that is the main reason why you do the waste water treatment and we don’t just let it go out to the sea. So there, then it is a cost, to clean out the nutrients and you still do not really use them but you could use them to cultivate algae. Because algae even if you cultivated them, they need nutrients, to combine them you have a possibility to have a win-win situation with the algae.” (I1.)*

Algae is using the nutrients from the wastewater and cleaning it during cultivation. This could be a win-win situation between wastewater treatment plant and a company that

will use wastewater for algae cultivation. There would be co-creation of value between wastewater treatment plant and the algae cultivation company. The values could be economic or non-economic in nature sought by the participants in exchange. They could exchange services or exchange products to each other. For example, wastewater treatment plant would give portion of wastewater to the company and company would give the cleaned water back to the wastewater treatment plant or they would sell these to each other. This is the value creation and value delivery in the marketing system of algae based biogas.

*“There is already added value when you clean the wastewater. This biomass could go for biogas production this is a good initiative.” (I6.)*

Value creation is happening when algae cultivation cleans the wastewater. The created value can be delivered to the wastewater treatment plant. Together the cultivation company and the wastewater treatment plant could have value network composition. Another value creation is happening when the company offers algae based biogas to the market. The customers have an opportunity to buy renewable energy that is made from algae. This has value for the environmentally conscious customers.

*“First is founding cost, they are quite high, they are at the beginning, you have to build whole system before you can sell any product. It is a lot of money to invest before any income. How to avoid this, it is the same with solar energy and wind energy. It would be need some support from state.” (I3.)*

The investment for this algae based biogas production is very high. The algae cultivation and harvesting are very expensive and building the whole production system is a costly investment. The company needs to invest a lot of money before they can sell any products. As the production is still in progress and needs more research the company would need financial support from the government. This algae based biogas is a new renewable energy source and it would be a more sustainable choice for energy and

therefore there is a possibility to get aid from government. For example, the government gives aid for the wind energy.

*“Somehow I think there can be some decentralized production. So it is good if it is close to biogas plant of course. So somehow it is always a question how a transportation is going on. We can also think that we can grow algae close a place that we have the nutrients and we have heat, then we would move algae. It would be less effective in economic if we separate the heat and separate the nutrients and transport them. It would be best to grow, cultivate algae on this cleaning plant.” (I3.)*

*“There would be an own company for growing algae. and they are buying nutrients and they are buying heat.” (I3.)*

*“We think that you have to let say use wastewater so it is very likely to or at least I think that municipality or the municipal companies are some way involved. Like for example now Vaasan vesi are involved with this and are interested what happen because it would be them perhaps that cultivated the algae at their waste water treatment plant. Stormossen is a company owned by municipality they would make the biogas most likely out of it. It so that would be the case its like a co-operation between with both municipal companies like Vaasan vesi and so on.” (I1.)*

Thus, there are different business model for this algae based biogas production. Below it is explicated how the interviewees evaluated different business models for algae based biogas. One model is that the algae cultivation would happen near wastewater treatment plant. This is a question of having the wastewater near the cultivation place and there would be no need for transportation. It is wise in economic sense not to have many transportations for the biomass. The company x would buy the wastewater from the wastewater treatment plant and the wastewater treatment would buy the cleaned water or they would make an exchange. The wastewater treatment plant would give company x some wastewater for cultivation and when the water is cleaned the company x would

give the water back. Some exchange would happen between wastewater treatment plant and company x. When the algae biomass is ready it would be transported to the biogas refinery. The company x would pay for the biogas refinery company for making the biogas out of algae biomass. The company x would sell the biogas or the biogas refinery would sell it.

In another business model the wastewater treatment plant would do the algae cultivation and harvesting. There would be a company which would do the transportation between wastewater treatment plant and biogas refinery. It would do the selling of biogas. Another model works in a way where the wastewater treatment plant would do the algae cultivation and harvesting and biogas refinery company would transport the biomass and make the biogas. In both models where the wastewater treatment plant would do the cultivation there would be financial aid from government or from municipality as wastewater treatment plants are owned by the municipality.

Building a separate wastewater treatment plant or getting rights to do the cleanings is out of question for being too expensive. Building an individual biogas refinery is not wise because it is very expensive. Therefore, the service of making biogas would be bought. What is certain is that there would be co-operation with both wastewater treatment plant and biogas refinery company or during the start at least.

*“Idea of 11-13 km tube that start here wastewater cleaning plant and goes to stormossen. Now days they are saying it is not build because tekes or state did not give any money for that.” (I3.)*

One idea for the biomass transportation is a tube between wastewater cleaning plant and biogas refinery company. TransAlgae project had this plan but it was cancelled because there wasn't enough money. Definitely this is one option for biomass transportation.

*“When we develop this perfect technology, the price has to be competitive, then you have a business for biogas and biofuel otherwise if the price is not competitive it not matter how we perfecting the technology it will not sell.” (I6.)*

The price of algae based biogas needs to be competitive with fossil fuels. Otherwise there exists this amazing end product that no one will buy because the price is too high. One solution is to make the production as economic as that is possible. Another thing is to develop more energy efficient cultivation and harvesting systems and a way to increase the algae concentration.

*“Biogas is the same substance, it does not differ from what it is made.”*  
(I5.)

Since the biogas is the same when it is from the waste or algae, the value of algae based biogas is in the production of algae based biogas. As in sustainable business model and specialization the key is to make value from the algae based biogas. The value is transformed on the algae based biogas production. Making co-operation with companies that aim to have win-win solutions is the key of value creation and value delivery in this business model and specialization. Economical, environmental, social, technological and legal aspects are introduced in the next chapters.

#### 4.2.1 Economic, social and environmental aspects

Economic, social and environmental aspects are included in the sustainable business model. (Rosca et al. 2015: 1–2.) At the beginning of the algae based biogas production the economic and environmental aspects are the most important ones. The next quote shows how sustainability and economic aspects go hand in hand.

*“You know that algae is cultivated for purpose for example to make pigments you use part of the algae for that not the whole algae, then you can use rest of the algae for anaerobic digest to make biogas out of it. This*

*increase the sustainability for both that you produce biofuel and that you make the profit by taking care of the waste.” (I1.)*

The algae cultivation in wastewater has environmental benefits. This is illustrated in the next quote:

*“you have a lot of nutrients in wastewater, you could use the microalgae to suck up all the nutrients from the waste water then you will have a clean water. you have some environmental credit or ecological credit or what ever you called it.” (I6.)*

While cultivation of the algae cleans the wastewater the production sustainability increases when growing the biomass at the same time when the wastewater is cleaned. Environmental aspect presents itself in this production when developing more energy efficient ways for cultivation and harvesting, recycling the nutrients and cleaning the wastewater. The whole circular economy thinking does support the environmental aspect in this business model.

The social aspect comes in later, when the end product is closer for commercialization, the companies are starting to be established and more manpower is needed, as illustrated in the next quote:

*“I think it would be absolute possible to create new jobs by in introducing or getting this industry started.” (I1.)*

When the obstacles are overcome, and the end product is close to commercialization there is a possibility to create new companies and jobs. Creating new jobs is the social aspect for this sustainable business model.

#### 4.2.2 Technological and legal aspects

Technological and legal aspects are parts of PESTEL. For example, TRL, patents and product development are included in technological aspect. For example, Legislation of biogas and different licenses are included in legal aspect. (Vuorinen 2013: 222.) The technological and legal aspects are in this research part of the theoretical framework of marketing system and they affect the business matrix. As mentioned earlier the TRL is five for the seaweed therefore, more research is required before seaweed can be used as biomass for biogas. For the microalgae the TRL is even lower. The microalgae's cultivation methods need more research as well. (Murphy et al. 2015: 31). These TRL numbers represent the algae as biomass being still in early phase, needing more research and more developed technology before the TRL rises and the algae as a biomass is ready for the market.

*“So in the future maybe it would be more cheaper to cultivate algae seaweed for example, that it would be automated that it would be automatically done, because in Norway and in Scandinavian countries the manpower is very expensive.” (I6.)*

Automated cultivation is one of the technological aspects in this marketing system. One of the interviewees mentioned (I6) that the automation of cultivation could decrease the cost as the manpower is expensive in the Nordic countries. Development of automated cultivation system is a good idea for future research. For example, now the seaweed cultivation is done by hand.

The interviewees had difficulties commenting about the legal aspects of algae based biogas, as they do not work in the business environment. On the contrary they work with algae cultivation and biogas production. Many of the interviewees share common line that the Finnish government should support the algae technology and biogas production.

*“I feel like the government need to do something for algae technology and maybe reduce taxes if the product is renewable and ecological friendly and*

*courage people to do something and try to aware population to about the benefits of the algae and what algae really brings to the society.” (I5.)*

*“If government is really interested for algae I think it will go faster to the market.” (I5.)*

Interviewees saw the government support as a power that would increase the algae end products' commercialization and introduction to the market. The Eu's legislation of renewable energy will have effect on the algae based biogas's production. For example, directive 2008/98/EC is about waste management requirements. (Eur-lex 2018.) Now the technological and legal aspect are discussed, and the next chapter introduces the social matrix of the marketing system.

#### 4.3 Social matrix for algae based biogas

Social matrix is the context where the exchange between company and customer takes place. Cultural, social, physical and economic are the elements of a social matrix and these affect the marketing system's exchange logic, roles, flows, networks, governance, assortments and buyers. (Layton 2011: 261, 268.)

The social and cultural elements did not come up from the interviews and thus they are not included in these following chapters. The following chapters present the algae based biogas marketing system's exchange logic, roles, flows, networks, governance, assortments and buyers which are based on the findings from the interviews. The marketing system's elements are presented in the same order that they are in the theoretical framework. First elements are exchange logics, flows and roles and they are presented in the next chapter.

#### 4.3.1 Exchange logics, flows and roles

Exchange logic in this marketing system takes place when the company x will exchange services or products with the wastewater treatment plant, biogas refinery plant and while selling the end product (biogas) to the customers. Exchange between wastewater treatment plant and biogas refinery plant is a relationship or they could form a network together. The exchange would be planned, fully informed and with fixed or negotiated price. There would be exchange between the company that sells the biogas and customers. That exchange would be economic, and it could be a single event or multiple events.

There are different flows in marketing systems such as ownership, finance, risk and information. The company x would cultivate, transport and sell the biogas in this marketing system. The company x would have the ownership of the algae biomass and biogas. The risks of this whole production would be with the company x. The contracts and government financial support would dictate who would have the finance flows. It would make sense that the company x would have the main finance flow of this marketing system but could have some finance aid from the government and municipal. This could be joint venture between company x, wastewater treatment plant and biogas refinery plant. Then the ownership, risks and finance flows would be divided equally. Of course, there would be information flows between all these three companies and with the customers.

*“If the algae production would be part of cleaning the waste water then I supposed that responsible lies 100% for wastewater treatment plant so I suppose that they have a system that is working really very well and back up systems but I suppose that this might not be the work that they would outsource to another company because they have the responsibility of for fulfilling the permits that they are having” (I2.)*

The ownership flow of the wastewater would be all the time with the wastewater treatment plant. Treatment plants are responsible for the wastewater to be cleaned properly.

In this marketing system the company x cultivating the algae has the role of provider of biomass and also the role of seller of biomass. The biomass is sold to a biogas refinery plant who transforms the biomass into biogas. The municipal waste water plants can have the role of buyers obtaining the cleaned wastewater or the role of provider as they provide the waste water. This marketing system of algae based biogas is still just in an early phase therefore, it is difficult to say how the exchange would happen, how the flows would be divided and which are the roles of the participants.

#### 4.3.2 Networks and governance

In this marketing system networks exist, and these networks are linked in exchange transactions. At least one network is linked with the wastewater treatment plant and one with the biogas refinery plant. The value contributions by each actor and their roles in this marketing systems will affect the depth of network.

*“We think that you have to let say use wastewater so it is very likely to or at least I think that municipality or the municipal companies are some way involved. Like for example now Vaasan vesi are involved with this and are interested what happen because it would be them perhaps that cultivated the algae at their waste water treatment plant. Stormossen is a company owned by municipality they would make the biogas most likely out of it. It so that would be the case its like a co-operation between with both municipal companies like Vaasan vesi and so on.” (I1.)*

The municipals own the wastewater plants in Finland so if a company wants to clean the wastewater some networking with municipal is needed or the cleaning is done together as partners.

Governance means how the elements of a marketing system are managed and by who. How the networks agree on ownership or risk and which party has the final liability for debt for example. As the algae based biogas is still researched because the product is not yet close to commercialization, the interviewees could not comment how the

governance of the marketing system could happen. Therefore, there is nothing to be said about the governance of the marketing system.

#### 4.3.3 Assortments and buyers

Assortment in the algae based marketing system is the “service” of cleaning the wastewater, refining biogas, making fertilizer and other algae products such as pigments.

*“Energy is worth so little. Even though we talk about energy is so important and we should have biofuels and so on. Relatively speaking energy is too cheap so just now even though I have the European project where they calculate the energy balance they still find out that it did not look too bad to only make biofuels out of it, but I don’t think that is realistic to only cultivate algae for biofuels purposes because energy is worth so little.” (I1.)*

As the energy is not worth much it makes sense to use part of the algae biomass for biogas and other parts of the biomass for other algae end products, such as collecting pigments and sell them forward.

*“It is all that is I know as far, food or cosmetics, pharmaceuticals or nutrients supplements and development of biofuels from algae.” (I2.)*

Companies are making different products from algae globally. For example, there are food supplements, cosmetics, pharmaceuticals that are made from algae.

*“If you cultivate algae in wastewater its for energy or biofuels because if you want to cultivate algae for some high value product you cannot grow it in waste water then you need to grow it in clean water.” (I4.)*

When the algae are cultivated in wastewater one needs to consider what other type of end products could be made from the same algae biomass to get better profit. For

example, the algae biomass can't be used for food supplements, because it is cultivated in wastewater instead of clean water.

In the algae based marketing system different buyers such as individuals and companies exist. For example, the company buyer could be the municipal waste treatment plant, who buys the service where algae cleans the wastewater. The end-customers for the biogas could be individuals who drive cars using biogas as transport fuel or firms converting biogas to electricity. The next chapters present the barriers of the algae based biogas.

#### 4.4 Barriers of the algae based biogas

On the base of data different kind of barriers for algae based biogas are present at the moment. This chapter answers for the third objective. There are many important things needed to be solved before algae based biogas production is closer to commercialization and making profit. First barrier is technological:

*“At the moment making algae based biogas, algae cultivation and harvesting are consuming more energy than the biogas can give energy.”*  
(I5.)

*“I would say harvesting techniques and of course it is too energy demanding. It is not okay to produce energy that demands more energy that you can get out of it. That is the situation so far.”* (I4.)

At this point algae cultivation and harvesting are not reasonable as the harvesting and cultivation take more energy than the biogas can release. As the algae cultivation and harvesting is consuming so much energy there is a need to develop more energy efficient way to cultivate and harvest algae. Algae cultivation and harvesting technologies need more research before the algae based biogas can be commercialized. When the advanced technology is in use, making biogas from algae becomes possible. This is only from the

energy balance point of view. Current energy consumption of cultivation and harvesting in 2018 are the biggest barriers in algae based biogas production. The technological barriers do not stop here. This is illustrated in the following quotes:

*“The harvesting that problem is universal. It is the same problem everywhere.” (I4.)*

*“When using microalgae, the challenge is always the harvesting. Microalgae it is very hard to harvest because it’s floating in the water so you need to centrifuge them.” (I6.)*

Harvesting microalgae out of water is globally challenging. Microalgae is so tiny and can’t be seen with naked eye. Microalgae floats in the water and needs centrifuging to be collected. There is a need to develop more efficient way to harvest the microalgae, which is very challenging. As the quotes below show, there are functional barriers:

*“There are things which are not yet fully solved and most of them have to do with the processing the algae like harvested and dewatered, because the concentration is so low.” (I1.)*

*“Specially, when one liter water contains only milligrams of dried algae biomass. It is so little.” (I4.)*

The harvesting and dewatering technologies need to be more advanced. Low algae concentration is a functional barrier. For example, one liter of water only contains milligrams of dried algae biomass which is a very low amount. The concentration of algae biomass needs to be higher than some milligrams in one liter. When the algae concentration in water can be increased more of the algae based biomass can be extracted and space requirement diminishes. The less space needed the better, because finding a location for algae cultivation becomes easier and of course smaller space is

more inexpensive than bigger space. There are more functional barriers illustrated in the next quotes:

*“If you want to treat to all that wastewater that of course needs a lot of space for having this algae growing. If one wants to use the wastewater to produce the algae biomass and it is a different story to what you want to optimize. If it is the optimizing the cleaning the wastewater then you need to treat the all water. but if you want to just to have the nutrients from the wastewater to produce algae biomass then it is sort of smaller scale.” (I2.)*

*“I don’t personally believe that we are here going to clean the wastewater by using algae. That is something that could be done in developing countries because the technology is not so developed. It is done there and here we have already functional systems.” (I4.)*

Treating all the wastewater needs a lot of space and of course more investments. Therefore, it would be more logical at this point to use portion of wastewater to cultivate algae by extracting the nutrients from wastewater, but not to use algae to clean all of the wastewater as it takes time, money and space. On the other hand, treating all the wastewater is not wise because we already have functional systems in every municipal. Cleaning the wastewater with algae could be more helpful in developing countries which do not have functioning systems such as India or countries in Africa. Algae cultivation in wastewater could be the solution for having clean water globally and should definitely be researched more in the developing countries. There is a knowledge barrier as the quote shows:

*“I have done trials, so I know how much we get out of biogas for example micro-algae that I show you, but the thing is that it is not so easy say. One thing it is not very simple answer on that question. Is that even in the wild the algae both micro- and macro-algae they change their composition naturally with season and cultivation.” (I1.)*

The problem how much biomass or biogas can be gotten from algae is the naturally occurring change in algae composition with season and cultivation which complicates the planning of the algae production. There are great economical barriers illustrated in the next quotes:

*“Right now the economy of algae, which cannot compete with fossil fuels. It is not a cheap product to buy.” (I5.)*

*“I would not recommend you or somebody to cultivate seaweed which cost a lot of money for biomethane production this would be more useful for food or rather than biomethane production but if there would be some waste that can not be used for food then please use for biomethane production” (I6.)*

*“I don’t think that is realistic to only cultivate algae for biofuels purposes because energy is worth so little.” (I1.)*

One of the barriers for commercialization of algae based biofuels is the high production cost. (Borowitzka 2013:743.) The interviewees agreed that the algae based biogas production costs are expensive. Regarding to the energy market price and interview’s findings energy is not worth much. The production of fossil fuels is done cost effectively and the end product is cheaper than the algae based biogas could be, because the manufacturing process for algae based biogas is very expensive and energy consuming. Algae cultivation and harvesting technologies and production process need to be more energy efficient and economical in the future. The algae based biogas needs to make a profit or otherwise no company will start manufacturing algae based biogas. The biogas as energy is not worth much and being energy consuming to manufacture makes sense that the algae are used for more than just biogas or renewable energy. Thus, the company could make better income with algae products.

The end product price of algae based biogas has to be competitive with the fossil fuels or otherwise the customers will buy the fossil fuels because of the lower price. There is

a need for new renewable energy source, but production has to be done so cost effectively that some company will start making algae based biogas. The price must be competitive that it has a chance to do well in the competitive markets.

*“If you want to cultivate algae for some high value product you cannot grow it in waste water then you need to grow it in clean water.” (I4.)*

As the algae is growing in wastewater one needs to consider what kind of products can be done from the algae biomass. For example, the biomass cannot be used as food supplements. Thus, one of the possibilities to use the algae for something else than raw material for renewable energy is collecting pigments. There lies a better possibility to make profit out of algae. As the quotes below show the algae cultivation is so expensive at the time of writing this thesis that return on investment (ROI) is very poor. This is an economical barrier.

*“If you cultivate algae, harvest seaweed for biomethane production primary maybe this is not the right way to do it maybe this not give you a good return on investment. If you want to target to get more money or income from cultivation macroalgae or microalgae or collecting seaweed you should go for more high value products.” (I6.)*

The cost of cultivation and harvesting algae are so high that one of the interviewee recommended not to make biogas or biofuels from algae, because the energy is worth so little and therefore a company would not get a good return on investments. The interviewee (I6) recommend that a company should make other high end products from algae. This way the company would get a better return on investment. This research is about algae based biogas as the end product but quoted comments tell about the high cost of algae biomass production and the general attitude in the markets. The algae cultivation and harvesting are expensive hereby it is economical barrier as the next quotes show:

*“you can have this system run outside in any building then again you have to face the climate, the light, the temperature conditions but if you have this system inside the building then you can of course control the temperature and the light. If you grow in close system inside I would say no challenges in Nordic countries.” (I2.)*

*“In the close photobioreactors the investments are high for start, higher than in the open pond system. (I2)”*

*“You can cultivate all year round in photobioreactors. The limitations there is the volume.” (I6.)*

A company needs to think the investments and the production cycle. The open pond system has less expensive starting investments than the closed system, but the company could cultivate algae only for four months. While using the open pond system the light and temperature conditions can't be controlled versus photobioreactors where light and temperature conditions can be controlled. The limitation for photobioreactor is the volume. The company can cultivate only as much as the tank size permits in photobioreactor. Since the pond system is so much less expensive than photobioreactor at the same investment the company could buy more ponds and make more algae in the same time. The company needs to think how much money they are going to invest, what are their volume goals, and do they want to cultivate all year round. These answers will determinate their choice for cultivation system. Using sustainable production method is expensive and therefore an economical barrier. This is illustrated in the next quote:

*“Pre-treatment is needed for algae biomass to produce biogas, which increases the production cost. Using sustainable production methods, making the production methods burden the globe as little as possible is one of the challenges faced by the industry.” (I1.)*

One of the challenges faced by the industry is to develop sustainable production methods. Cultivation, harvesting and cleaning the wastewater which will use less energy and will burden the globe as little as possible are needed. The circular economy is

important in algae based biogas. The goal is to make algae based biogas in a way which the materials are used efficiently by minimizing the use of materials and recycling every possible part. For example, using wastewater for algae cultivation, the nutrients from the wastewater are used as “food” for algae. Without the process the nutrients would just be disposed from wastewater. The algae need nutrients for growing and clean the wastewater by using the nutrients and no fertilizer is needed. The algae cultivation faces climate barriers in Nordic which will be obvious in the next quotes:

*“In Nordic countries our limitations are that we have short window when we will able to cultivate them. In summer we have too much light. The perfect cultivation time is spring time and early summer.” (I6.)*

*The weather in Nordic is not ideal for cultivating algae, because of the cold winters and lack of light in the winter time. Ideal weather for cultivation algae is at least +15 C and enough light throughout the year. (I2.)*

There are two ways to cultivate algae, open pond system outside and closed system in a photobioreactor. The algae cultivation in Nordic is problematic. In summer time there is too much light and too hot for cultivation and during winter time areas are cold and lacking light. The best months for cultivation are March, April, May and June according to interviewee six, hereby the growing season in Nordic is very short when using the open pond system outside. If the company wants to cultivate algae all year round it needs to choose the closed system photobioreactors. There are also cultural and legal barriers as the quote shows:

*“It is two different things. First one is attitude of people. There are lot of people that not accept biogas perhaps, people are afraid of smell. If I want build biogas plant here, people are saying no, not in my backyard. Another one is more serious. Administrative people, minister or Tekes that kind of institutes, they have said even lately that there is no future in biogas.” (I3.)*

One major barrier for algae based biogas is the attitude against it. Some people do not support biogas because of the images they have. People only see biogas as a disadvantage and therefore do not give their support. Another factor is the lack of support for biogas from Government or Tekes or similar institutes. This is a legal barrier. Many people would change their opinion about biogas and give more support if the government would give its approval. The laws and regulations could then be more preferential for biogas. As the founding cost are high for the algae based biogas production a need for financial aid from government exists in the beginning. It would decrease the risk for starting production when the company would get outside financial aid.

*“I would not say it is not possible, but it needs further research.” (I6.)*

Algae based biogas holds a lot of potential, but needs a further research concerning algae cultivation and harvesting.

**Table 7.** Barriers of algae based biogas.

<b>Type of barrier</b>	<b>Barrier of algae based biogas</b>
Technological	Harvesting and cultivation are too energy demanding
Technological	Harvesting problems
Functional	Algae biomass's low concentration
Functional	Need for space
Knowledge	Algae change naturally its composition with season
Economical	Energy is worth so little
Economical	High establishing cost
Economical	High production cost
Climate	The weather in Nordic is not ideal for cultivation
Cultural	Attitude for renewable energy
Legal	Government does not give support

Table 7 is a summary of the barriers of algae based biogas. There are many barriers for the end product commercialization. In conclusion the greatest barriers for algae based biogas are technological for example, algae's biomass low concentration, algae's harvesting and cultivation are too energy demanding. The second greatest barriers are economical such as the high establishing and production cost. All these barriers must be solved before profitable production of algae based biogas. Solving these problems needs further research, technological development, changing attitudes towards renewable energy especially towards biogas as well as legislation that supports renewable energy. Next chapter presents the opportunities of algae based biogas.

#### 4.5 Opportunities of the algae based biogas

The current data show that there are great opportunities for algae based biogas. This chapter answers for the third objective. Theoretically algae hold a lot potential as raw material for biogas. (Borowitzka 2013:743.) There is varying potential opportunities for algae based biogas. First one is functional opportunity which clarifies in the next quotes:

*“There is no biomass that grows as fast as microalgae.”* (I1.)

*“Most rapidly growing biomass”* (I3.)

Microalgae have rapid growth rates for example the algae biomass can double in hours. (Slade et al. 2012: 29–30.) The literature and interviewees agree that algae hold exciting potential for being biomass for biofuels because of rapid growth rate. There are more functional opportunities as the following quote shows:

*“Algae can be grow in wastewater it really doesn't need agricultural land. that makes algae very interesting biomass for biogas or biofuel.”*  
(I5.)

Algae do not require agricultural land and can be grown in waste streams thus, requiring less water. (Biofuel region 2017.) One advantage is that algae do not need agricultural

land to grow but grow in water. For example, macroalgae can be cultivated in the sea and microalgae can be cultivated in wastewater. Algae have environmental opportunity as can be seen in the next quotes:

*“We us here have been able to connect it to wastewater cleaning. In many sense circular economy too, that is one point.” (I3.)*

*“If you want to produce algae biomass you have to provide them with nutrients, so you still have to have some phosphor and nitrogen and carbon. but if you use of course wastewaters where you need to diminish these nutrients then you have of course added effect so you produce algae biomass at lower cost because you do not have to buy nutrients to be added your water to produce the algae biomass.” (I2.)*

*“Algae can enhance nutrient recycling.” (I2.).*

One of the greatest features of microalgae is the ability to clean waste waters during cultivation since algae is a capturer of nutrients and carbon dioxide which is beneficial for environment and climate. One property of algae is the ability to use the nutrients from the wastewater during cultivation. When algae take the nutrients from the wastewater, there is no need to buy spare nutrients. The nutrients are recycled, which takes the production closer towards circular economy. Algae can be used for different purposes which is explained in the next quote:

*“Another reason why it is so interesting is that, it has, you can use it in a lot of things, as you have probably to notice that they are talking to extracting different parts of it, because the products are worthy more than the energy, they will always be.” (I1.)*

Makes sense to use part of the algae biomass for biogas and other parts for different end products since the worth of energy is low. Algae can be used for many things for example collecting pigments or as food supplements. Algae cultivated in waste water has limited options for other uses. Material which is left after burning the biogas can be used as fertilizers. In the future bio-fertilizers could be able to replace artificial fertilizers

and improve productivity as well as soil quality. (Biofuel region 2017.) Recycling or using every algae production waste possible is another step closer to circular economy. Algae have many environmental opportunities shown in the next quote:

*“It is mostly that you will remove the nutrients from the wastewater so they don’t end up in the cleaned water. Because if they end up in the water or they would cause Eutrophication and that is the main reason why you do the waste water treatment and we don’t just let it go out to the sea.” (11.)*

Algae cultivation can solve a problem (Eutrophication) with too much nutrients going into seawater through land. (European biogas 2017.) Using waste water for algae cultivation could be the key for solving the problem of eutrophication. Stopping or hindering eutrophication is definitely a good side effect of using algae to clean waste water. Another environmental opportunity is the possibility of algae cultivation done in circular economic way as the following quote states:

*“There is connection between circulation economy and energy. We have terrible need to get really rid of waste. We need to give technology to developed countries to get energy and get rid of waste. they must be connected together.” (13.)*

Cleaning waste water during algae cultivation is the future. At the same time the waste water is cleaned, and the algae biomass is formed. This kind of system could help the developing countries to clean their waste water and get algae biomass for biogas. There is a new business opportunity as the next quote shows:

*“I would say if you have waste algae like for example you have seaweed that is on the beach, that is only rotting on the shore and this could be collected and used for biomethane or biogas production.” (16.)*

Part of the solution for sourcing algae biomass could be collecting seaweed (macroalgae) sitting on the beach. Algae is not used for anything hereby the useless seaweed could be used as an extra source for algae biomass for biogas. A lot of seaweed would be needed and therefore would be wise to use manpower to collect the seaweed from the beach. Some research must be made about how much seaweed is laying on the beaches and about the rationality of collecting all for biogas production. There is an economic opportunity as well illustrated in the next quote:

*“No one is selling liquid biogas. That is something we should go on.” (I3.)*

New product could be liquid biogas which no one is selling on the market at the time of writing this study. New form of biogas could be a competitive advantage in the biofuel markets. Liquid biogas is a great subject for further research.

When the algae based biogas production starts new companies will be created or at least one company in the beginning which will need employees. New energy production will create new jobs in the market.

**Table 8.** Opportunities of algae based biogas.

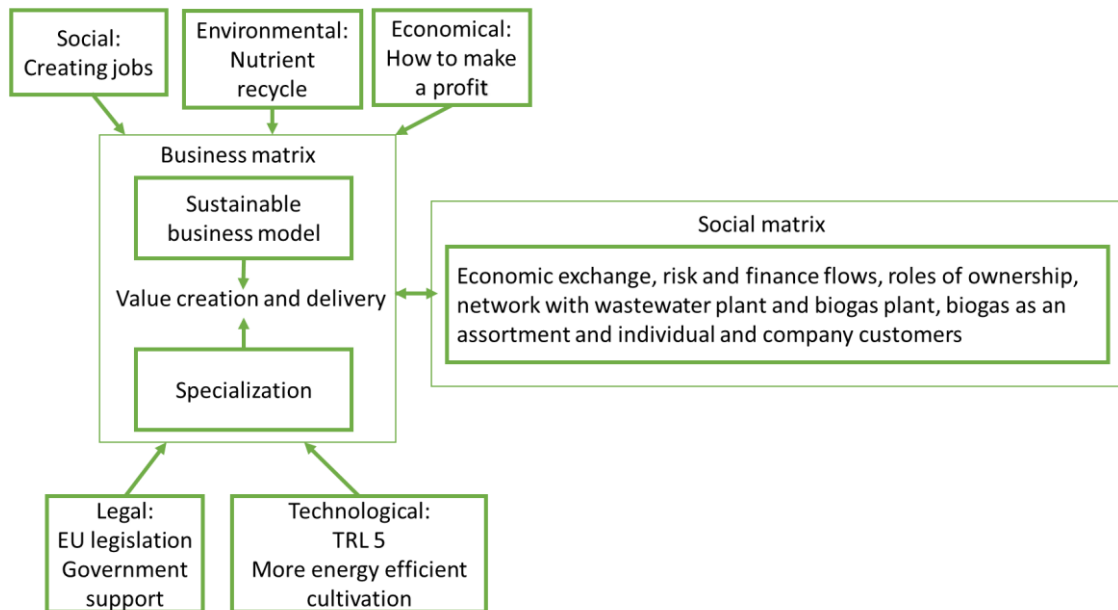
Type of opportunity	Opportunities of algae based biogas
Functional	The most rapidly growing biomass
Functional + Environmental	Cleaning the waste water
Functional	Algae can grow in water and does not need agricultural land
Environmental	Algae based fuel is more environmentally friendly than fossil fuels
Environmental	Circular economy
Environmental	Algae can enhance nutrient recycle
Environmental	Algae cultivation can solve a problem (Eutrophication)
Economical	Liquid biogas
Social	Creating new companies and jobs

Table 8 is a summary of algae based biogas' opportunities. Algae based biogas production holds a lot of potential. Algae has many notable features which makes these

presented opportunities possible. In conclusion the algae's greatest opportunities are functional such as the most rapidly growing biomass and the environmental opportunities such as cleaning waste water during cultivation and enhancing the nutrient recycle. Now the opportunities of algae based biogas have been thoroughly discussed. Next chapter is the conclusion of the research.

#### 4.6 Marketing system for algae based biogas

The results show that algae based biogas has great potential to be a new renewable energy source. However there are many barriers which need to be solved before the algae based biogas can be commercialized. The findings are summarized in the figure 7.



**Figure 7.** Marketing system framework for the algae based biogas.

Together the specialization and sustainable business model form a business matrix. The algae based biogas production methods, value creation, value deliver and networks combine the specialization and sustainable business model in this marketing system. The co-creation of value is one major aspect in the business matrix.

The economic, environmental and social aspects are important in the sustainable business model which aims to create economic, environmental and social benefits. The production will enhance the nutrients recycle and supports the idea of the circular economy in this marketing system. The social aspect in this marketing system is creating new jobs. The environmental aspect is the nutrient recycle. The economical aspect in this system is how a profit can be made with the algae based biogas. The technological aspect in the marketing system is the TRL which is five on seaweed and even lower on microalgae. There is a need for more energy efficient algae cultivation and harvesting systems which now consume more energy than the biogas can give release. The legal aspects are the government support and the EU legislation which affect the production of biogas. These five aspects affect the business matrix.

The sustainable business model is the same as the business plan: how a company is going to make a profit and environmental and social benefits with algae based biogas. For achieving profit and benefits the company needs exchanges, flows, roles, networks, value creation, value deliver, customers, assortments and to beat all the meaningful barriers of algae based biogas. The value creation and deliver influence the specialization. When the algae clean waste water the value creation is formed and the value can be delivered to municipal waste water treatment. Specialization is the business plan put into practice. When the business is practiced the specialization is in use.

All the exchange is happening in the social matrix. The business matrix and social matrix influence each other in the marketing system which is a process where each element has its own part and together they combine a functioning marketing system. There could be different business models which explain how the marketing system could work, but with the findings from the interviews there was one sustainable business model in the social matrix that stood out.

There would be a company x that would do co-operation with the municipal waste water plant and biogas refinery plant. The company x would not have to buy nutrients for the algae cultivation and the waste water plant would get clean water. The algae cultivation and harvesting would happen near the waste water plant, because waste water is hard

and costly to transfer. Costs would be saved. There would be co-operation with the wastewater treatment plant, but the company x would have the ownership of the algae biomass, the main risk flows and finance flows.

The company x would for example, transport the algae biomass to the biogas refinery plant via tube. There would be co-operation with the biogas refinery plant. The biogas refinery plant would transform the algae biomass to biogas. The company x would buy the service of making the biogas from an already existing company, because of the cost-effectiveness versus making a whole new biogas refinery. Then the company x would sell the biogas to individual customers or companies or do the selling together with the biogas refinery plant. There would be economic exchange between company x and customers.

At least two networks would exist for the company x, one with the wastewater treatment plant and one with biogas refinery plant. The three participants would exchange value between each other in this co-operation. Described scenario would be the most rational, because neither the municipal wastewater plant nor the biogas company has the resources for the cultivation of the algae. To make this marketing system work good networks; co-operation between a municipal waste water treatment plant and a biogas refinery plant are needed.

This end product's value is not only counted in the profit because so many additional values such as sustainable values are present: during cultivation the algae can clean the waste water and the residue from the biogas can be used as fertilizer. Therefore, sustainable factors need to be considered as values of algae based biogas.

Assortment in this marketing system are the "service" of cleaning the wastewater, biogas, fertilizer and other algae products such as pigments. Buyers in this marketing system are the end buyers: individual consumers and companies. Municipal wastewater treatment plant could be the other buyer while buying the cleaned water.

As the algae based biogas production is in an early stage, the TRL of the algae as a biomass is low. There are many barriers for algae cultivation and harvesting and the end product is not close to commercialization. Hereby, all the elements of the marketing system could not be fully researched. When the end product is close to commercialization there could be a more specific research for the marketing system of algae based biogas.

## 5 CONCLUSION

The purpose of the research was to gain an understanding of the marketing system for an algae based biogas. The understanding was also the first objective of the study. The understanding of a marketing system started by creating the theoretical framework for marketing system for algae based biogas. The theoretical framework for marketing system was made by combining the theories of marketing system, sustainable business model and PESTEL analysis. The marketing system framework has two main matrix blocks: business matrix and social matrix. Sustainable business model and specialization are included in the business matrix. Social, environmental, economic, legal and technological aspects affect the business matrix. The elements of marketing system: exchange logics, flows, roles, networks, governance, assortment and buyers are included in the social matrix. The first objective was achieved with the theoretical framework of marketing system.

The second objective was to define the marketing system for algae based biogas. The findings of the five aspects which affect the business matrix are presented in the next sentences. The new job places that the algae based biogas production could create are the social aspect for this business matrix. The recycle of nutrients is the environmental aspect of the business matrix. The profitable production method is the economical aspect. EU legislation and the government support are the legal aspect. The low TRL for algae biomass and lacking the energy efficient cultivation and harvesting methods are the technological aspects of the business matrix. The economic exchange, finance flows, roles of ownership, network with municipal wastewater treatment plant and biogas refinery plant, biogas as an assortment and individual customer as the buyer are elements of the marketing system's social matrix. The marketing system framework was enriched with the findings of empirical data hereby the second objective was achieved.

Third objective was determining the barriers and opportunities for algae based biogas. There are technological, functional, knowledge, economical, climate, cultural and legal barriers. For example, algae cultivation and harvesting is consuming more energy than the biogas can release and the algae concentration is too low while this study was written

and the cultivation and harvesting algae is expensive. Hereby there are great barriers for product commercialization. These barriers must be solved before profitable production of algae based biogas and commercialization are possible. Solving these problems needs further research, technological development, changing attitude towards renewable energy, especially towards biogas and legislation that supports renewable energy.

Algae based biogas production holds a lot of potential, which cannot be denied. There are environmental, functional and social opportunities for algae based biogas. For example, algae are most rapidly growing biomass. Algae holds a lot of potential with its great properties: it cleans the waste water during cultivation, it can double its biomass quickly and it exploits circular economy. Therefore, it is important to continue research on algae as biomass source.

The limitation of the study is the inability to generalize these findings since they are based on a couple of experts' opinion. The findings are interesting but preliminary about the subject of which market potential cannot be researched yet.

To answer the question how the marketing system could work for algae based biogas in the future, answers to the following questions are needed first: Who are the producers, how to cultivate the algae, which species of algae have the best qualities for biomass and for biogas, where is the cultivation happening, how to get waste water, who are the customers and what is the product price? Answers to these questions will be gotten from further research. Further studies could be about the networks of marketing system, the social aspects of algae based biogas and the market potential of algae based biogas.

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## APPENDIX

### Interview questions

1. Why is algae so interesting raw material for biogas / biomethane?
2. Why is algae better choice for source of renewable energy than what are already in the markets for example crops?
3. What are algae's potential in future?
4. What are the challenges in algae production (cultivation/ harvesting) in Nordic countries?
5. How do algae end products create value?
6. Who would buy algae based end products (bio oil, bio gas)? and why would they buy it?
7. How will the algae production will work in the future? Who will do the algae cultivation in a wastewater plant or harvest or cultivate the algae? What kind of contract would be in there?
8. What could be the algae based end products' price?