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Challenges for Eco-innovative Start-Ups in Sweden

A study in the Swedish Utility Market

Master of Science Thesis

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ABSTRACT

This thesis aims to explore the field of eco-innovation by identifying and analyzing the main market barriers for eco-innovative start-ups in the Swedish utility market. Furthermore, this thesis presents the Swedish start-up's approaches to overcome these main identified barriers.

The thesis comprises a literature review section on the field of eco-innovations and related concepts, in order to introduce the reader to the field of eco-innovation and create an analytical framework to identify the main market barriers and approaches for eco-innovative start-ups. The study comprises interviews of three Swedish start-ups, finalists in the Swedish environmental innovation competition. In these interviews the identification of the main barriers and start-up's approaches is carried out using the analytical framework. A comparative analysis between the cases is used as an analysis method. Finally, from the analysis the most common barriers and approaches to these barriers are presented.

This report identifies four main barriers to eco-innovative start-ups in the Swedish utility market: the lack of market legitimization, the customer's criteria to assess the technology, the Swedish policy towards renewable technologies and the Swedish geographical conditions. The thesis also finds that the start-ups facing these barriers would: enter available niche markets, expand their network, broaden their product portfolio and enter international markets in order to overcome the barriers.

Key Words: Eco-innovation, Start-up companies, Swedish utility market, Barriers, Approach.

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1. INTRODUCTION

Chapter 1: Introduction

1.1 Justification and Background 1.2 Purpose 1.3 Scope 1.4 Disposition 1.5 Main concepts

This chapter serves as introduction for the master thesis study. First a background of eco-innovation and the justification of the study are presented. Then, the purpose and scope of the master thesis, along with the research questions are stated. Lastly, an overview of the outline of the study is presented.

1.1 JUSTIFICACION AND BACKGROUND

Sustainable development has become important in recent years because of the targets of environmental summits (e.g. the Rio conference in 1992, the Kyoto protocol, the Lisbon process, etc), these targets demand new products and services. The European Environment Agency has established the goal of making eco-innovation, the easy innovation in the European Union Innovation Systems (EEA, 2006). However, eco-innovation at this point in time is considered by no means easy, so in order to achieve this goal further research in the area of eco-innovations is required.

One of the many challenges for research in this area is to actually define eco- innovations. The definition for eco-innovation has varied some definitions include terms as sustainable development, less damaging effect to the environment, environmental burden, etc. Further research is required in this area to clearly limit and define eco-innovations.

There is a push of the society for eco- innovations to be reflected in the regulatory framework, because of the benefits they bring to the environment. Since competing products have higher external costs, it is therefore important to internalize these costs to these products in order for eco-innovations to compete (Rennings, 2000). For this point, the main specific challenges of eco–innovations are to create options that fit in the prevailing value system of society, create equitable value for the customers and stakeholders along the value chain and create innovations that fit with the carrying capacity of its supporting ecosystems (Verloop, 2004).

There is seemingly an urgency to develop eco-innovations that succeed in markets. For this purpose the environmental Forum Halland with the support of the Environmental Technology Delegation of the Swedish Government has developed the Swedish national Environmental Innovation Competition (EIC) running since 1998. The current project leader for this competition is Hans Leghammar. The main judging factors to select a winner include the cost efficiency and potential market of the eco-innovation. Winners of the competition in past years include, the following start-ups: OrganoClick, which found new

properties for the cellulose that permits a wider range of uses for it instead of other more pollutant materials, Bioprocess Control Sweden, which permits a more efficient process of biofuel production and Aureola Swedish Engineering AB, that developed a method for cooling surfaces saving substantial amounts of energy and material.

After the first competition, organizers found that a follow up of the finalists after the contest was required. The finalists needed help to access clients, to work with social opinion leaders, and to contact investors trough the different intervals of the innovation grow (Englund and Leghammar, 2004). Since 2009 these follow up and help functions have been taken by Innovatum Technology Park.

As a part of its follow up activities from the finalists of the competition, Innovatum has been interviewing the start-up companies (113 in total) that drive these innovations for the past 3 years looking for success factors by following their development. Start-up companies for Innovatum research are considered companies that had not commercialized their innovation before the competition and are in an early development phase: seed, start-up and early expansion of (Englund, 2008). Also as part of the interview, conducted by Innovatum asked the finalists of the competition what they believe to be the main market obstacles and barriers for the eco-innovation and areas of the business that require external help for further development.

1.2 PURPOSE

The purpose of this master thesis is to analyze the main market generated challenges identified by Swedish start-up companies in renewable energies field. The study will not only identify the main barriers of the market but will also explore how the start-ups approach the identified barriers. The thesis is focus on commercializing renewable energies eco-innovations in the utility sector formed by the electricity, gas and water markets in Sweden.

In order to indentify the barriers for start-up eco-innovations, we also consider the customers point of view in our study. Finally, this study will result in the identification and subsequent approaches of the sampled start-ups, developing eco-innovation, in the Swedish utility sector. Therefore the objective for this study is **to describe the barriers of start-ups developing an eco-innovation for the Swedish utility market, and how they approach them**.

Research questions

This has been operationalised by the two following RQs.

- **RQ1 What are the main market barriers for the start-ups with renewable energy eco-innovations?**
- **RQ2 How are start-ups in the renewable energy sector working to overcome these barriers in order to reach potential customers?**

1.3 SCOPE OF THE RESEARCH: RENEWABLE TECHNOLOGIES AND THE UTILITY MARKET

This research is focused on renewable technologies in the utility market. The selection of this scope is explained in this section.

1.3.1 Utility Market

An area where Innovatum is interested to focus is the electricity, gas and heating sector since this branch is among the three sectors which release the greatest emissions of GHG and also is over represented in the interview study (Englund, 2008). An important perception in this sector is the one made by the former CEO of Shell, who stated: "*Strange as it may sound, we already possess much of the technology we need to build a more sustainable energy system*." (Voser, 2009, P1) Here the main challenge, as perceived by former Shell CEO, is not the technological development but the commercialization of the technology. For this reason a study of the commercialization challenges for eco-innovations in this market will be desirable.

The utility sector is formed by electric, gas and water companies who, unlike other market segments, requires significant infrastructure and could be local or national monopolies (Datamonitor, 2009). Therefore most of utility sector is non-rivalries and non-excludable. The utility sector provides the public with electricity, gas and water services or public goods directly or indirectly. Furthermore, utility companies has higher bargain power than individual consumers or small suppliers (Markusson, 2001). Also from a market value point of view electricity utilities represent the 94.1% of the utility market in Sweden (Datamonitor, 2009), so the study of Swedish utilities will be mainly focus in electric utilities.

1.3.2 Renewable technology

From a technological point of view the results from the Innovatum study shows that the technology field with more finalists in the EIC is the renewable energy field, since 19% of the interviewed finalists are in this area, followed by 16% in energy efficiency (Englund, 2008).

Renewable technologies are the ones that can be replenished or regenerate themselves, these sources help to reduce greenhouse gases emissions and can replace the scarce fossil fuels (May & Zoe, 2009).

A deeper study of companies that are in the renewable technology field and utility market sector are desirable from Innovatum's perspective. Therefore this study will focus on the challenges faced by start-ups in formative stages of renewable energy eco-innovations in the utility market. These start-ups are all considered in an early development phase: 'seed', 'start-up' and 'early expansion'[1]. Finally, this study is primarily concerned with the innovator start-ups and its customers.

[1] Definitions according to Berggren and Gretzer (2006). *Seed*: financing to companies for research together with the facilitation of evaluation and further development of an initial concept before the business operations have reached the start-up phase. In this phase the company has been established and the first real interaction with the potential market has commenced. *Start-up*: financing to companies for product development and initial marketing. *Expansion*: Financing for growth and expansion of a company that is actively trading but which has not necessarily needed to generate a profit or positive cash flow.

1.4 DISPOSITION OF THE THESIS

The disposition of the master thesis study is shown in Figure 1. This Figure can be used as a reading guide as each chapter will be introduced by the relevant chapter schema.

Chapter 1: Introduction

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1.5 MAIN CONCEPTS OF THE THESIS

This section defines the main concepts of the master thesis. These concepts can be used as a glossary by the reader to better understand the research.

START-UP:

"A company, generally newly created, that has been operating during a short period of time, and is in a phase of product development and initial marketing." (Berggren and Gretzer, 2006; Nesheim, 2000)

Swedish Utility Sector:

"The utility market is formed by the electricity, gas and water market firms and its providers in Sweden." (Datamonitor, 2009)

Barriers:

"Barriers are obstructions on the way of a company or a new technology. It will make company or new technology difficult to enter the market." (Sullivan et al., 2003)

Approach:

"Approach is defined as 'to come or go near something or goal' or 'opportunity of drawing near the target'. It used to describe the methods of companies going near or entering into the market in our report." (Kemp et al., 1998)

2. ANALYTICAL FRAMEWORK

Chapter 2: Analytical framework

2.1 Innovation 2.2 Eco-innovation 2.3 Comparison 2.4 Diffusion 2.5 Drivers 2.6 Barriers 2.7 Success Factors

This chapter presents a framework constructed by existing theory that in conjunction with the empirical results will be used to answer the research questions. A literature review and some pre-study interviews formed the base of the framework.

The sections of this chapter are:

- Start-up definition
- Definition and types of Innovation
- Definitions and types of Eco-innovations
- Innovation versus Eco-innovation
- Diffusion of Eco-innovations
- Drivers of Eco-innovation
- Barriers of Eco-Innovation
- Approaches for Eco-innovations success

Since the research in eco-innovation is limited and the fact that there are commonalities between innovation and eco-innovation. The analytical framework is complemented by additional literature from Innovation. Also, information regarding the Swedish utility sector company reports and pre-study interviews are used as complements from the literature.

2.1 START-UP DEFINITION

For this master thesis, the definitions of start –up is made by combining Neisham (2000) main characteristics of start-up as newly created and in the stage of product development with Bergreen & Gazer (2006, p.16) definition of the start-up stage which is: "*financing the companies for product development and initial marketing, the company has been operating during a shorter period of time.*"

For this study companies will be considered start-ups if they fulfill the resulting definition:

> "*A company, generally newly created, that has been operating during a short period of time, and is in a phase of product development and initial marketing.***"**

From this definition a company to be considered as a start-up should be developing their main product and starting to reach the market. In addition, Butler (2006) explains that the term start-up is commonly typified as the creation of a company to explore a business opportunity as a result of the opportunity-

spotting by an individual. From these definitions important characteristics of a start-up are identified. It should be newly created and new in the market. Still, authors had not defined a specific time of existence for a company to be considered a start-up.

Start-ups generally are limited by "tiny" budgets, resource, labor or land if compare with incumbent firms. But they often associated with high growth, especially technology oriented start-ups, because those start-ups have more "flexible" strategy and are more sensitive to the market changes that can translate in the fact that they introduce radical innovations in the market more energetically. (Chih-Chiang Lu, 2006, Dwivedi, 2009, p.1)

2.2 DEFINITION AND TYPES OF INNOVATION

In recent years, business competition has been intensified rapidly between companies. Consequently, most firms need to continuously innovate to ensure long term competitiveness (e.g. Bjorg and Magnusson, 2009). It can be said that innovation is indispensable to companies, if they want to get advantage in the market and keep it. But what is innovation? In order to answer this question, we will now provide a review to derive a definition.

2.2.1 Definition of innovation

There are different definitions of innovation. Joseph Schumpeter (Schumpeter, 1934, p.66) described innovation as, *"Innovation means a new combination of purpose and method."*

Hauschildt (2006, p.4) described innovation as: *"Innovations are… qualitatively new products or processes, which differ significantly from the former state."* A more simplified definition stated innovation as "a new way of doing something" or "new stuff that is made useful" (Barras, 1984).

We must distinguish two similar words, innovation and invention, which are often mentioned together. Due to innovation implying the creation of something, it is often equated with invention. However, the distinction here is important as Jan Fagerberg (2004, p.4) described: *"Invention is the first occurrence of an idea for a new product or process while innovation is the first attempt to carry it out into practice."*

In the context of this study innovations will be viewed as the selection, development and commercialization of a new idea as Von Stamm (2008) defined it.

There are many theories to describe innovation and to categorize innovation. To better understand innovation's development, researchers have usually categorized innovations into a set of contrasting types. Three frequently employed sets are Product *vs.* Process, Technical *vs.* Administrative, and Radical *vs.* Incremental (Halila, 2007).The following section explores these classifications.

2.2.2 Classifying Innovation

One of the first classifications of innovations is the one made by Joseph Schumpeter, where innovation can be classified as (Schumpeter, 1934):

- *Product innovation: Includes a new good or service or significant improvements to the existing ones,*

- *Process innovation: Includes a new method of production or delivery,*
- *Marketing innovation: Includes new marketing methods as product design and packing, promotions and sell to new markets,*
- *Organizational innovation: Includes a new organization in business practices workplace or in the company's external relations.*

Both product and process innovation, are usually related to technology, in contrast with both of organization and marketing innovation are mainly related to the social structure of the organization (Draft, 1978) as table 1 shows. Organization innovation is used by optimizing different organizational elements such as human, financial, time, information and improving the management effectiveness.

Table 1: Product versus. Process versus. Organization versus. Marketing Source: Draft 1978

Categories		Characteristics
Technical innovation	Product innovation	1. Bring higher product value to customers 2. Bring higher services value to customers
	Process innovation	1. Improving the manufacturing technology level 2. Increasing manufacturing process efficiency 3. Improving product quality.
Administrative innovation	Organizational innovation	1. Optimizing different organizational elements 2. Improving management effectiveness
	Marketing innovation	1. Creative new geographical marketing 2. Satisfied new market demands 3. Creative new market segmentation

In order to differentiate the types of eco-innovation (product, process, marketing and organizational), it is useful to understand the areas and activities that will be affected in an organization by the introduction of an innovation (Halila, 2007). The difference between technical and administrative innovation is important to understand because it tells us which system is more related to the innovation the technological or the social one (Halila, 2007).

Radical vs. Incremental

Another important classification, besides the one of Schumpeter, is the one of Gopalakrishnan and Damanpour (1997), who explained that innovations can be divided as radical and incremental.

Both, radical and incremental innovations can have widespread impact on industries. Radical innovations could have revolutionary impact on firms. It produces fundamental changes in the activities of an organization or an industry and represents a clear departure from existing practices (Carrillo-Hermosilla et al., 2009). On the other hand, incremental innovation represents small-scale modifications to existing systems of products and processes (Halila, 2007). Usually as a result of innovations and improvements suggested by engineers or users. Those theories were summed up as Table 2 shows: (Bianca, 2004; Kotelnikov, 2009)

Table 2: Main Differences Radical vs. Incremental Innovation (Sources: Bianca 2004, Kotelnikov, 2009)

	Radical Innovation	Incremental Innovation
Emphasis	Development of new products / processes or new businesses	Improvements in existing products / processes, or services.
Risk	High uncertainty	Low uncertainty
Technology	Explores new technology	Exploits existing technology
Key players	Key players are cross-functional individuals	Key players are cross-functional teams
Business case	Business plan evolves through discovery-based learning	Business plan developed at the beginning
Process	Process is informal	Process is formal
Prototyping	Teaching the market about the new technology and learning from the markets how valuable that technology is in that application arena	Ironing out wrinkles near the end of the design phase
Trajectory	Sporadic and discontinuous	Linear and continuous
Idea Generation & Opportunity Recognition	Occur sporadically throughout the life cycle, often in response to discontinuities in the project trajectory	Occur at the front end; critical events are largely anticipated
Organizational Structures	Project starts in R&D → migrates into an incubating organization → transitions into a goal-driven project organization	Cross-functional project team operates within a business unit
Resources and competencies	Creative acquisition of competencies and resources from a variety of internal and external sources	Standard resource allocation; the team has all competencies required to complete the process
Operating Unit Involvement	informal at early stages → formal at later stages	Formal involvement from the very beginning

As described above, radical and incremental innovations play important roles in the companies innovation activities. Nowadays, most innovations are incremental (Kotelnikov, 2009), especially in medium or small size companies because impacts of its lower risk and lower investment. Those difficulties do not mean that radical innovation is unnecessary, quite the opposite radical innovation is necessary to create products and processes that do not replace others, but adds something new (Bessant et al. , 2004).

2.2.3 Start-ups and Incumbent Firms

This section will focus to discuss what kind of innovation strategy is common brought by a start-up company or an incumbent company. Incumbent companies have big research budgets and the resources to hire top scientists to innovate and drive the growth, success, and wealth of firms and nations (Gerard et al., 2009; Hill and Rothaermel, 2003). However, in practice, small start-ups with comparatively tiny budgets often manage to out-innovate the bigger established competitors. So it seems the selection of innovation strategy is not only affected by size of company and funds but is also

affected by the environment, as well as the structure and the management (Hill and Rothaermel, 2003).

The phenomenon above described, happens because incumbent large companies often have multiple committees. Those committees will review each new idea before determining whether or not to go further, how much budget to grant the idea and what milestones should be established. Thus the creative idea is send through multiple committees consuming time. And moreover creative ideas would be killed in the process. Often many committee members do not want to take responsibility for innovation failure, so committee members will demand more information as a stalling and reputation preservation tactic. According to Jeffrey Baumgartner's analysis and summarization (2007), the result is damaging to innovation in two ways:

1. *It takes a long time for good ideas to be approved and receive a budget for further development. Competitors with a similar idea can often get it to market much faster.*
2. *For the same reason, it takes a long time for bad ideas to be rejected. This wastes time, budget and valuable resources.* (Baumgartner, 2007, p.1)

In addition Leonard-Barton (1992) explained that incumbent firms had generated capabilities that differentiate them strategically; these capabilities can be embodied in the employees, in technical systems that codify employee's tacit knowledge in explicit knowledge, managerial systems to create knowledge and the company's values and norms. The advantage of these capabilities is that it can not be easy imitate by competitors. They normally enhance innovations in the domain of their employees, technology, management, values and norms, these innovations are normally incremental. Instead, these capabilities hinder innovations that are not in these domains as radical innovation. In this respect, start-ups present advantages to introduce radical innovations in the market. Still, compare with large company, innovation activities are limited by funds and resources in SME's (Small and medium-sized companies) (Dwivedi, 2009, p.1).

This section discusses innovation and its classification. This definition and classifications can be used for most innovations including eco-innovations (Halila, 2007). Eco-innovations will be further discussed in the next section.

2.3 DEFINITION AND CLASSIFICATION OF ECO-INNOVATION

To discuss eco-innovation, it is logical to follow the same structure as the previous section discussing innovation. For that reason this section starts with the definition of eco-innovation and then it will be followed by the classification of eco-innovations.

2.3.1 Definition

When reviewing existing literature there are a variety of definitions of eco-innovation, and some literatures quote the concepts of environmental innovation and green innovation, actually defining the same meaning as eco-innovation. It is well known that many firms devote significant resource to

develop new methods of reducing or treating air or water emission, recycle or reuse waste, finding cleaner energy source and other methods of environmental protection, all these actions are considered as eco-innovations.

Eco-innovation has been broadly defined as the process of developing new ideas, behavior, products and processes that contribute to reduce environmental burdens or to ecologically specified sustainability targets (Rennings, 2000, p.320). To better elaborate the concept of eco-innovation, the concepts of eco-design and eco-efficiency has been introduced as well (Halila, 2007). The eco-design refers to the design which addresses all environmental impacts of a product throughout the complete lifecycle of the product, without compromising other criteria like function, quality, cost and appearance (ECO2-IRN, 1995). It emphasis the design of a product, service or system with the aim of minimizing the overall impact on the environment (Carrillo-Hermosilla et al., 2009). Eco-efficiency is a management philosophy to guide and measure companies and other actor's development in environmental performance for reducing the consumption of resource and pollution, at the same time saving costs (Carrillo-Hermosilla et al., 2009). Eco-efficiency stimulates eco-innovation by the search for new way of doing things (Jones, 2001, p.57-58).

Fussler and James (1996, p.364) state the eco-innovation *"is the process of developing new products, process or services which provide customer and business value but significant decrease environmental impact."* A more complete definition, which will be used in this study, is the one expressed by Englund (2008, p.5), defining eco-innovation as:

> *"The iterative process striving to take a technology-based invention with a less damaging effect to the environment than the available alternatives to commercial success."*

Whether the innovation was initiated by environmental motivation is not important. What we care about is whether they can actually improve environmental performance (Halila, 2007). So actually all of these definitions appear to focus on the effects of innovations rather than on the intention. Intentions to develop eco-innovations can be to get advantages over competitors, due to the low cost and product difference, to find new ways of converting wastes into saleable products that provide additional revenue for the firms, to cut the emissions below the required level, make it conform to government regulation and good reputation which is so important in the market.

After the review and analysis of all these definitions, a boundary of eco-innovation for this report is identified. Eco-innovation is derivate of innovation, so it cannot be denied that eco-innovation has most of the features of innovation (Hordern et al., 2008). All forms of innovation activities that can result in significantly improving environmentally protection can be also viewed as eco-innovation. It could include new or modified process, techniques, systems, services and products which can be used to avoid or reduce environmental harms, and efficient use of resources. Eco-innovation can urge the companies to accord with the government environmental regulation and make the firm get competitive advantages.

2.3.2 Classification of eco-innovations

From the last section, we have found that there are many theories to describe eco-innovation and to classify it. According to Brezet's (1997, p.14), eco-innovation is classified in four types based on aspects of designing. These types can be described as:

1. *Product improvements from a preventive environmental impact perspective for existing products. Product and production technology are the same.*
2. *Product redesign is meaning the product concept remains almost intact. The product and its components are further developed or replaced, for example by introducing non-toxic materials, improving distribution, recycling or energy efficiency.*
3. *The complete technological system (product, production chain, infrastructure and related institutions) is replaced by a new system.*
4. *Function innovation is not limited to existing product concepts but will be related to other 3 types of innovation mentioned in the unit. It is meaning to achieve the purpose in another way. For example, we read news from website to instead of reading newspaper. Otherwise functional innovation allows tasks to be performed more efficiently and allows an organization to save time, money or both and allows an company operation more toward environmental friendly, such as E-database instead of paper-based data* (Brezet 1997, p.14).

In this classification, the four types of innovations are driven by environmental considerations with different characters. The first type of eco-innovation is focused on environmental protection, such as avoiding pollution. The second type stands the application of environmental-friendly material, manufacturing and distribution. The third one means a new system is implemented instead of the old system. The last one emphasizes the replacement of physical products by dematerialized service.

Other classifications are the ones of Kemp (1998) and Malaman (1996). They have listed similar categories of eco-innovations, which are both classified according to differences in their use, both classifications are summarized in Table 3.

Table 3: Kemp vs Malaman Eco-innovation classification

Kemp (1998)	Malaman (1996)
• *Pollution control technologies* • *Waste management* • *Clean technology* • *Recycling* • *Clean products* • *Clean-up technology* • *Monitoring and assessments technologies*	• *Cleaner products* • *Input reduction* • *Input substitution* • *Energy saving technologies* • *Cleaner production processes* • *Recovery and recycling technologies* • *Cleaner products which modify the production process of other firms* • *Environmental diagnostics and monitoring* • *Add-on or end of pipe technology*

2.4 INNOVATION VERSUS ECO-INNOVATION

The challenges and barriers faced by start-up companies are somewhat similar for both innovation and eco-innovation. Still, there are differences between them that are important to understand which characteristics of innovations are also of eco-innovations.

The main difference between eco-innovation and innovation is the consideration of secondary stakeholder in eco-innovation compared with the focus in shareholders of innovations. This difference has its source in the double edge of eco-innovation. The double edge refers to the two kinds of spill-over produced by eco-innovations. The first one is the spill-over produced by all innovations that reach the market, and permit the competitors to copy the technology and also profit from the innovation. The second one is exclusive of eco-innovations and it is the positive spill-over that generate for society resulting in less external costs compared with competing products and services.This double edge characteristic of eco-innovations can be considered as a problem since a lot of benefits of eco-innovations do not translate in profits to the eco-innovator (Rennings, 2000, P328).

It can be inferred that eco-innovation is a derivative of innovation (Hordern et al, 2008). It can also be argued that an industry will face decreasing marginal returns on its incremental eco efficiency gains, in term of sustainability and financial improvements. Therefore it is pertinent to regularly generate eco-innovations that offer more opportunities to reduce environment pollution as radical innovations in order to push the technological system up to a new equilibrium (Murphy and Gouldson, 2002, P40).

In the long run, world resources can`t be sustained without radical innovation (Hordern et al., 2008). Now many start-ups begin to make use of this opportunity to approach the market in order to get competitive advantage.

2.5 DIFUSSION OF ECO-INNOVATIONS

As defined before, innovation is the commercialization and development of a new idea. An important process for a new idea to become an innovation is the one by which new inventions spread trough a population of potential adopters, this process is known as diffusion (Granstand, 2007). It has been presented that the innovation follows an S-shaped path for the adoption by the potential customers (Bernauer et al., 2006) (Figure 1).

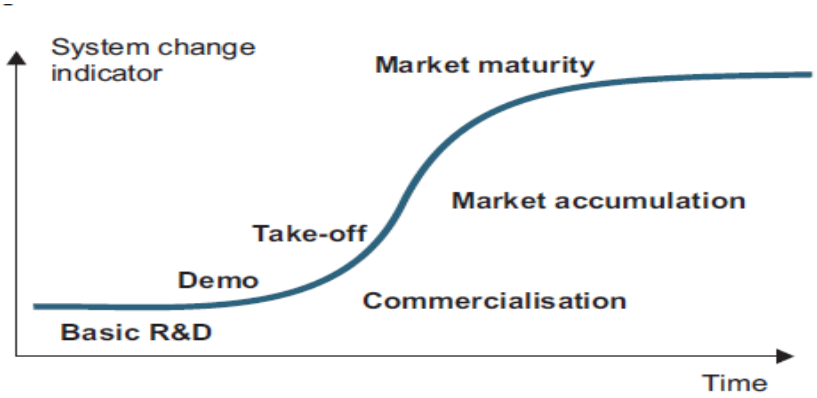

Figure 1 Stereotyped innovation path Source: (Bernauer et al., 2006)

There is a phenomenon that some customers may like to adopt innovation relatively early, to develop competitive advantage and to be early adopters, owing to be risk averse in the process of innovation diffusion. Diffusion of innovation means the process of how innovation spread through population of potential adopters. The idea of diffusion of innovation is imperative to mention here, since it is an important part of innovation commercialization analysis.

Innovation always need some time to be embraced by potential adopter. It is a general trend that best ideas are not quickly adopted and eco-innovation is no exception.

The S-curve describes the relationship between cumulative percent of adoption and the time. If the innovation diffuses rapidly, it will create a steep S-curve as reflected in Figure 1, otherwise it will have a slower rate of innovation (Rogers, 1995). When the adoption follows the S curve, the distribution curve of adopters follows a normal distribution, as we can see from the Figure 2. According to Moore, (2007). The adopters of eco-innovation can be classified into five segments: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards.

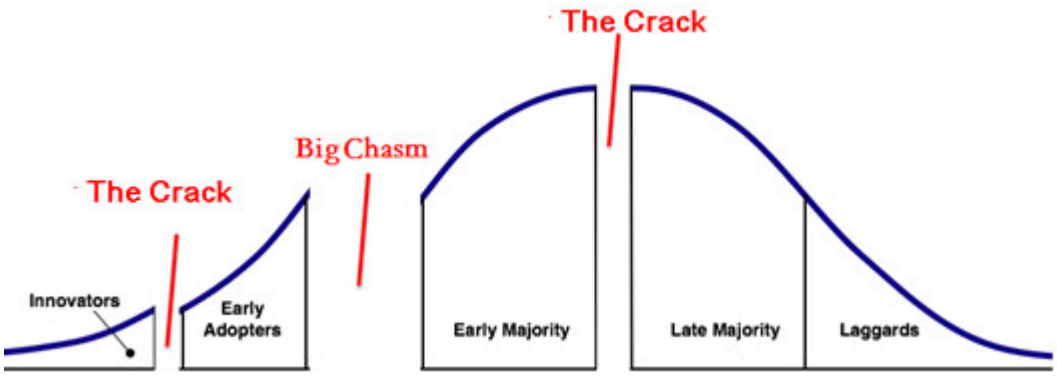

Figure 2: Bell curve Source: Moore, 2007

Only if the adopter has the ability to work with complexity and have substantial financial resources, they will like to accept the high uncertainty. Early adopters are more integrated with potential adopter than innovators and often have the greatest degree of opinion leadership, providing other potential adopters

with information and advice about innovation (Hellstrom, 2007). As time goes on the risk and cost reduces significantly, the early majority and late majority turn up and the number of adopters will surge. After many adopters gather in the market, the attraction of the innovation disappears and the market begins to subside.

However, the bell curve also shows that there is one main chasm and two small cracks in the curve. The first small gap occurs between innovators and early adopters due to the hot technology product that cannot be readily translated into a new major benefit (Moore, 2007, p.16). Sometimes the product has exciting functional technology and its performance be improved continually as well. Nonetheless, the product cannot present its commercial success because there is the barrier of no evidence yet that the product can bring the adopters benefit. . The key to win the gap is to show the potential adopters that the new technology enables some strategic leap forward, owing to its intrinsic value (Moore, 2007, p.16). However, if the marketing effort is unable to find the compelling application, the product will fall through the gap (Moore, 2007, p.16).

After the early adopters, the chasm comes into being before the early majority. Most of time, the early adopters are independent, motivated by opportunities and can quickly appreciate the benefit of innovation. However, the early majority is analytical, conformist and wants to see the proven results from other companies before adoption, which may lead them to the main chasm (Dorf & Byers, 2005). Crossing the chasm is a challenge task, sometimes the chasm will last quite a long time but if the product can get through this gap favorably, it will be purchased more and more. The main problem in this phase is the potential users do not know how to use the product because of the weak capabilities and complexity of the products (Dorf & Byers, 2005 p.264). Some firms try to educate their prospective users but it is an expensive and time-consuming task. Many firms want to transfer the education cost to the customers in order to lighten their burden. As the result, the adoption of the innovation is delayed or halted (Dorf & Byers, 2005). Actually, in this condition the firms should try their best to make their products be learned and operated easily that will impel the product go through the chasm successfully. The supporting facility of the product is another problem in this gap. In some cases, the user needs a widely available infrastructure for using the new product. However, the infrastructure is difficult to be built for just a few users that will make the customers unwilling to adopt the innovations. So the interconnection among companies is necessary that a new product`s adoption by one player depends on its systematic adoption by other player (Dorf & Byers, 2005).

The other small crack can emerges between the early majority and the late majority. This is the result of the unwillingness by the late majority to become technologically competent. The success of the continuation of company also lies in the fact that how easy their products can be adopted (Moore, 2007).

We have discussed diffusion process from the society group point of view. In order to get an overall level of understanding, we have to introduce the adoption process with a focus on the individual view. Rogers (1995, p.20) described the adoption as:

"Adoption is a process through which an individual passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of new idea, and to conformation of this decision."

And he divided the adoption process into five stages which are commonly accepted：

1. *Awareness: the individual is exposed to the innovation but lack complete information about it.*
2. *Interest or information stage: the individual becomes interested in new idea and seeks additional information about it.*
3. *Evaluation: the individual mentally applies the innovation to his present and anticipated future situation, and decides whether or not to try it.*
4. *Trial: the individual make full use of the innovation*
5. *Adoption: the individual decide to continue the full use of the innovation.*

Moreover, there are four main elements that will affect the innovation process, which include *"innovation, communication channels, time and social system* (Rogers, 1995, p.20)."

2.6 DRIVERS OF ECO-INNOVATIONS

This section outlines and discusses the drivers for eco-innovations found in the literature, with a focus in drivers for eco-innovations in utilities markets. The section begins with a description of general drivers for eco-innovations and its importance. Then different classifications of these drivers are presented and one is selected for this study, followed by a presentation of identified market drivers from the literature. Finally these drivers are discussed in the context of the utility market.

2.6.1 General drivers

The predominant drivers for eco-innovations have been identified and explained by different authors. One of the main classification for the different drivers is made by Carrillo-Hermosilla, (2009) who proposed that from a firm's perspective drivers can be classified as:

- external factors (as public policy, general situation of economy, suppliers, customers, users, competitors, civil society)
- characteristics of the firm (as financial situation, position in the value chain, multinational or local character of the firm and its sector, employees)
- Characteristics of the technology (as cost, benefits, complexity, criteria for assessing technology) this is a more specific classification of drivers.

The problem for using this classification in this study is that it could be difficult to focus in the market drivers as customers, since most of them would be consider external factors that drive eco-innovation and also important characteristic of the market (as assessing technology and sector parameters) would be in other classification. Another issue with Carrillo-Hermosilla (2009), Gonzalez & Konnola (2009) classification is that the main identified drivers by (Hordern et al., 2008) were: Economic growth and development in emerging markets, environmental regulation and preserving a good reputation. All

these drivers are mainly considered external factors thus; using Carrillo-Hermosilla (2009) classification in this study will require further division.

Another classification that could be more suitable for this study is the one presented by Rennings, (2000) where the drivers are mainly considered :

- a technological push
- a market pull
- a Regulatory push/pull

Figure 3 presents the drivers for eco-innovations. The technology push and market pull are common drivers for most innovations. Eco-innovations, because of the positive benefits to society, have also a third driver in the regulatory push/pull by governments to impulse eco-innovations in favor of their citizens.

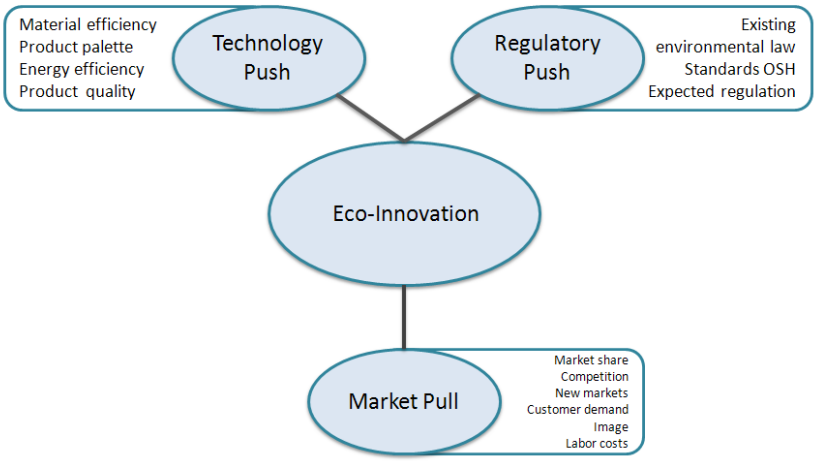

Figure 3: Determinants of eco-innovation Source: Rennings 2000

2.6.2 Interaction between different drivers

A model of how these drivers interact is useful for our study. Sartorius (2006), explains the interaction between the external drivers of political system, social-cultural system and the techno-economic system on the innovation company and its sector. The focus of Sartorius (2006) model is to explain how impulses in the three systems permit radical eco-innovations to develop by destabilizing incumbent technologies and how the absence of these impulses permit the adoption of only incremental eco-innovations . Sartorius believed that the political system is the main driver of eco-innovations since the environmental laws are emitted by the government. In order for the political system to emit these regulations a mix between internal factors (interest groups in the government, election cycle, etc) and external impulse resulting of techno-economic system (market pull and technology push) and the social cultural system influence the decision making process of law makers.

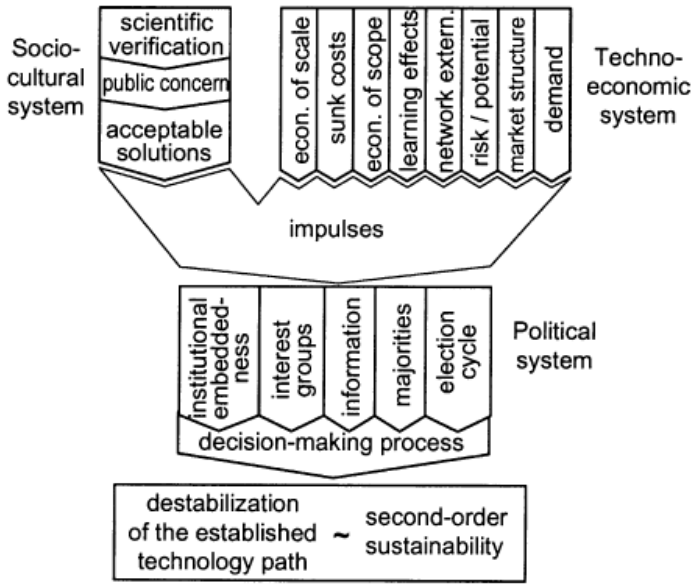

Figure 4: Determinants of support to radical or incremental eco-innovations SOURCE: Sartorious 2006

Sartorius 2006 statement, that the main driver of eco-innovation is the political system, has been challenged by different authors who believe that there is a shift towards market drivers. Markusson (2001), showed this change by a survey made in Sweden in 1995 where costumers have been considered the prime source of eco-innovations demand in 38% of the 300 manufacturing firms interviewed compared with 29% who stated that regulatory demands is the main source of eco-innovations. Competition and increasing market shares are considered the main market drivers for eco-innovations in Markusson's study. Eiadat, Roche & Eyadat (2008), stated that government environmental regulation does not work to adopt innovation strategies in companies. This result can be explained by Porter and van der Linde (1995), who explain that some companies prefer to engage in legal struggles against environmental laws instead of investing in innovations to improve their environmental performance.

2.6.3 Differences between market and political drivers

The difference between market and public policy drivers emerge from the double edge problem of innovations (explained in the eco-innovation section in this chapter as positive spill-over's in the market and positive effects in the environment). The government and the market have different impulses to support eco-innovations what results in different drivers for each of them. Porter and van der Linde (1995), proposed the win-win proposition that states that environmental regulation induce innovation by making industry aware of inefficiencies 'pollution = inefficiency'. They, also, stated that a static view of regulations made companies believed that environmental regulations translates in higher costs; but markets are dynamics and emergence of innovations can lower total costs of a product and/or improve its value to the customer compare with older technologies. Further, Porter and Van der Linde (1995) explain the relationship between market pull and regulatory push/pull stating that the regulatory push

should provide the opportunity for innovation by creating the incentive in the market to discover new profitable opportunities as a result of putting more attention and resources in technology development.

2.6.4 Market drivers

Market drivers for eco-innovations have been studied during recent years. An interesting result is the one provided by Foster and Green (2000) who identified three main situations where eco-innovations were driven by the market. These situations are:

- In the first situation the green performance is a main characteristic for the user; in this case the environmental characteristics are evaluated as any other characteristic of the product and evaluations of different products are compared. To evaluate environmental effects of the products instruments as Life Cycle Assessment have been developed. Foster and Green study showed that with this market driver both radical and incremental eco-innovations can be developed.

- In the second situation there is the creation of a new green market as a result of the government or an industry organization green agenda. For this driver more radical innovations are supported.

- In the third case the company had decided to include some green issues from a strategy or regulatory point of view considering them in a compliance list. This driver is normally for incremental innovations

Another characteristic of the market that might affect eco-innovation is market concentration. Nevertheless, authors had not reached a consensus about the effect of this characteristic. Schumpeter (1934), argued that market concentration reduces market uncertainty and motivates R&D investments. while other authors have argued that market concentration builds inertia and hinders innovation (Leonard-Barton, 1992).

2.6.5 Drivers in the Utility market

To start this section, it is important to remark that demands on environmental issues by companies and governments in the sector are originated by consumer's demands. Some of this environmental demands are passed from big utilities companies to dedicated environmental technology firms most of them of small size (Markusson, 2001). This makes the sector to be dominated by utility companies that have a high bargaining power compared with individual consumers and small technology driven suppliers.

In the utility sector the main drivers are found to be the increasing fossil fuel costs along with the requirements to reduce greenhouse gases emissions achieving air quality improvement (Nilsson et al., 2009). One of the main requirements is the Climate & Energy Package of the European Union that states the target of 20% of renewable energy consumption by 2020 in the EU. These have originated an interest in renewable energies sources (RES) and technologies that reduce emissions as carbon capture and storage (CCS). Also an energy efficiency focus had emerged in the sector as a result of the economic crisis (Markusson, 2001). These energy efficiency efforts normally result on incremental eco-innovations

but also have been a driver in the past of radical solutions, for example as the district heating system in Sweden (Nilsson et al., 2009).

New energy and environmental policies could possibly create problems for energy and utility companies. As the national targets for the share of electricity generation based on renewable resources are rising in the utility market This phenomenon could have a negative effect in current investment plans by utility companies. The return and also the investment decision in these projects generally depends on the subsidy systems (Datamonitor, 2009).

Two important instruments from the policy framework that had impulse eco-innovation (mainly renewable energies eco-innovations) in the market is the trading of CO2 and Renewable Energy certificates in order to achieve required levels for utilities companies. The other instrument that has shown increments in eco-innovations is feed-in tariffs or premiums to renewable energies that obligates utilities to buy renewable energies at a fixed price (Jacobsson & Bergek, 2004).

Another driver to develop eco-innovations in the utility market is the expectation that the Swedish utility market reach an increase of 48.1% in value from 2008 to 2013 (Datamonitor, 2009). This growth in the market will require new generation plants with the possibility to introduce renewable technologies. Also, there is an opportunity to export these innovations to other countries in the European market as companies in Spain and Germany had been done with the wind turbine technology (Nilsson et al., 2009).

2.7 BARRIERS OF ECO-INNOVATIONS

This section identifies and evaluates the different barriers for eco-innovation. There are many barriers identified for the specific characteristics of eco-innovations, which vary depending of the kind of eco-innovations (Carrillo-Hermosilla et al., 2009). The section begins with a presentation of general barriers of eco-innovations with a special emphasis in market barriers. Market barriers for eco-innovations seem to be tougher than for other innovations, as a consequence of these barriers the stage of commercialization of eco-innovations is consider a “death valley” since most eco-innovations fail this stage (Nilsson et al., 2009). In summary this section presents identified barriers found in the literature relevant to the utility market sector.

2.7.1 General barriers

Classifications of barriers for eco-innovations are similar as the ones used for drivers of eco-innovation. Moreover, the absence of drivers can also be considered as a barrier to eco-innovations (Carrillo-Hermosilla et al., 2009).

One of the main barriers for eco-innovations emerged from the double edge of eco-innovations (Rennings, 2000) (explain in this chapter in the eco-innovation section). Eco-innovations are subject to a double market failure:

- The first one is common for all innovations; spill-overs of an innovation can be used by other firms reducing the innovation efforts and investments in these advantageous firms (Carrillo-Hermosilla et al., 2009).
- The other one is that negative environmental costs of other competitor's products/process are not internalize eco-innovations could be to costly for customers making difficult to adopt and develop them (Carrillo-Hermosilla et al., 2009).

Eco-innovations face barriers for business development and capturing commercial opportunities. Some of these barriers have been identified by Smith (2001), finding in his study of English companies that they are the provision of information for business and consumers, regulations and standards and financial intervention. It is important to identify that these obstacles come from different sources as business and consumers, the UK regulatory framework and the UK innovation system.

Hordern, Borjesson and Elmquist (2008) found barriers to eco-innovations in their literature review, which include, economic sources, lack of knowledge, lack of experience and technology and capability lock-in and underdeveloped regulation. From the perspective of Smith (2001) Economic resources can also be a major barrier since start-ups experienced difficulties to obtain capital even in modest amounts for R&D and other purposes.

2.7.2 Market barriers

This study is mainly focused in the market barriers for eco-innovations different authors have studied these market barriers. Innovatum's study results showed that innovators consider the market barriers as the most important barriers (Englund and Leghammar, 2004). This view can be explained by innovator's common believe that consumers demand cannot be changed and so they cannot manufacture products for which is no clearly articulated demand (Kemp et al., 1998). A study of the market barriers is the focus in this research. Market barriers found in the literature are the following; some are specific of the market and others of the perceptions between the market and the eco-innovation. The ones emerging directly from the market are: the technological lock in of customers and the technology standard support by the policy. The barriers that emerge from the relationship between the market and the eco-innovation are: lack of market legitimization, customer's criteria to assess new technologies, customer's lack of information about the eco-innovation, low availability of the eco-innovation and high costs to customers.

Customer characteristic

The Swedish utility market is formed by incumbents, normally international companies as Vattenfall, E.On and Fortrum benefiting from economies of scale) and small municipal utilities such as Skara Energi AB, Udevalla Energi, Halmstad Miljo, etc. The incumbents companies are vertical integrated being part of all the value chain from generation to distribution and customer sales. Municipal utilities differ in their level of integration, mainly depending on the size of the municipality. Normally heat municipal utilities are vertical integrated (Datamonitor, 2009).

- **Technological lock-in of customers**: Customers already have technologies that perform the same functions as the eco-innovation and/or complementary devices that are incompatible with

the eco-innovation. Costumers can be locked-in in these technologies due to the existence of increasing returns as result of economies of scale, learning curves, complements and networks. These factors can lock-in markets in an environmentally inferior technology since the costs of transition are difficult to be absorbed by customers (Carrillo-Hermosilla et al., 2009). The technological lock-in can also be a result of customer's behavior on the search of information about an investment to maximize their utilities stopping the search when they feel comfortable with their knowledge about , people also tend to choose options that many people has choose at the moment (Hamberg, 2004).

An effect that magnifies this barrier, is the "sailing ship effect"[2], that is the effect of increase efforts by companies with the existent technology to improve it, as a reaction to a new technology being introduced in the market. This effect is a barrier during the development phase of start-ups with a new technology (Kemp et al., 1998)

- **Policy technology standard:** can be a barrier for eco-innovations if the public policy prescribed a technology standard for the industry. It can limit the introduction of eco-innovation, regulation should foster continues improvement and do not lock in on a particular technology or the status quo (Porter and van der Linde, 1995). In the other hand, the lack of a clear vision of the future, towards sustainable development, by policy makers translates in uncertainty of market developments to business customers (Kemp et al., 1998).

Also the costs to verify compliance are consider high by small firms who prefers the option of self-declaration taking the responsibility of compliance. Small business feels that regulatory authorities are unresponsive to their needs since it is difficult for start-ups to influence regulatory processes (Smith, 2001).

Relationship between customer and eco-innovation

- **Lack of market legitimization:** There are negative market's perceptions for eco-innovations quality and price (Bonini & Oppenheim, 2008). Lack of legitimization translates in wary capital sources, the need to educate customers and suppliers, difficulties to recruit personnel and hostile policies (Jacobsson & Bergek, 2004). Also eco-innovations may not meet the specific demands of customers requiring first a shift in these demands to introduce them to markets (Kemp et al., 1998).

- **Costumer criteria assessing new technologies**: evaluation of technologies is usually undertaken with the criteria used to evaluate the old ones. Customer's inertia is the unwillingness to move as a result of tension between stability and risk, and the tension of short term efficiency/performance and long term competitive advantage (Hordern et al., 2008). Also in an

[2] As the effect was first explained in the ship industry, when steamships enter the market and sailing ships manufacturers increased their efforts to improve their ships. These efforts resulted in improvements in sailing ships that permit them to survive competition for a while. As explained by KEMP, R., SCHOT, J. & HOOGMA, R. (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management,* 10**,** 175-195.

early phase of development innovations had not been tested by customers in a large scale and need to be optimized to pass must customers tests, large-scale use will lead to redesign improvements and changes on customer's assessments of the technology(Kemp et al., 1998).

- **Customer's lack of information:** Information about environmental problems and the existence of the eco-innovations and its benefits could not reach the customer. Many attempts to label innovations as eco-innovations are meaningless and confusing for consumers (Bonini & Oppenheim 2008). Customers can have impulses to improve the environment but are not sure how to do it. The barrier is that customers distrust the environmental claims of firms, instead they trust claims of scientists and environmental groups (Bonini & Oppenheim, 2008).

- **Low Availability**: Costumers cannot find eco-innovations. This is mainly originated because distribution channels for new technologies are not as good as those for established technologies (Carrillo-Hermosilla et al., 2009). Customers complain about the availability of local eco-innovations which make them to import them compromising their environmental goals by the impact of transport (Smith, 2001).

- **High costs to customers:** A new technology normally means high capital investments. Price was the largest barrier to buy green products as found by the U.K. Department of Environment, Food and Rural Affairs in 2007. Customers want shorter returns of investment that the ones eco-innovations offer (Bonini & Oppenheim, 2008). Costumer's focus on static cost impacts of green products ignores the benefits of eco-innovations. Many costumers do not account the learning curve and the economies of scale, that makes cost to decline over-time current costs should represent an upper limit (Porter and van der Linde, 1995).

Analytical framework for market barriers

Finally to create an analytical framework to identify these barriers, the main concepts (symptoms) related with each barrier were identified. Table 4 shows these concepts related to the barriers that will be used to identified the presence of the barriers in the start-up's interviews.

Table 4: Literature review resulted chart of market barriers and its symptoms

Market Barrier	Symptoms
Technology lock-in of customers	• Have technologies for the same function • Increasing returns by the same tech • Search of information in the same tech • Invest in same technologies
Policy technology	• Lack of market legitimization • Lack of a clear vision • Regulations are resource consuming • Not enough support to their needs
Customer's lack of information	• Confusing for customers • Distrust the environmental claims • Customer's don't believe the technology reduces the environment burden
Low availability of the product/service	• Customer's not reach the eco-innovation • Lack distribution channels • Not local service/products
Lack of market legitimization	• Lack of large projects • No standards for the technology • Wary Capital sources • Hostile policies • Need to educate customers
Customer's criteria to assess the technology	• Focus on static costs • Absence of tests • Costly to demonstrate • Tension between short and long term goals • Small number of possible customers
High Costs	• Difficult to finance by customers • Large times of return of investment • High costs for the industry

2.7.3 Evidence of the existence of these barriers in the Utility market

- **Policy technological standard:** In the Swedish utility market, policies that regulate the industry are considered one of the main barriers by Jacobsson & Bergek (2004). They explained the origin of the barriers from the so called 'Swedish nuclear power trauma'. This trauma has it roots since the 1970's when discussions about safety issues in nuclear plants started, then in 1980 after the Harrisburg nuclear plant accident a referendum proposing to dismantling Swedish nuclear plants appeared. Powerful groups formed by energy intensive industries and the two dominant Swedish utilities opposed the referendum.

This referendum started the Swedish nuclear power trauma. During these period of time renewable energies were only seen as substitutes to nuclear power, creating a fierce resistant to any policy that supports renewable energies and assessing renewable energies in terms of how many nuclear reactors could replace, which was just a small fraction (Jacobsson & Bergek, 2004). Swedish policy makers did little to increase the legitimacy of renewable energies since support of renewable energies was weak in the Swedish political system. Inconsistent and weak policies have resulted in the increase of customer's uncertainty (ibid).

Even in our days some companies and policy makers keep similar views about renewable energies, as example is the lack of policies to support solar collectors in the constructions and renewal of houses as other countries do (e.g. Spain) (Jacobsson & Bergek 2004).

- **Technological lock in of customers:** The utility market is considered a high volume mature sector. This kind of market is normally resistant to changes and present high lock-in barriers (Datamonitor, 2009). Energy production plants are expected to have a long productive life (60-100 years hydro, 50 years thermal, 20 years wind) and have high upfront costs (Rising 2010). Adoption and diffusion of innovations in this market is slow. For a new technology to reach 1% of the global market, it can take 25 years. *"In the energy sector, the scale of investments and new projects is massive, and 18 months feels more like 18 minutes….. It will take three more years to build a demonstration plant, one year to start it up, and two to five years to achieve a reliable operation"*, as Shell President Peter Voser, (2009) stated it. The perspective in the sector is very long term. Instead incremental innovations for monitoring and process controls that improves efficiency of old technologies are common (Markusson, 2001).

- **Lack of market legitimization:** Other important barriers are the size of the projects in the sector and the low cots of fossil fuels compare to renewable energies. The eco-innovation's capability to scale-up without reducing their environmental benefits or bringing additional environmental pollution is consider a barrier (Rising, 2010). It seems that companies in the sector require technologies that can be applied to generate large amounts of electricity or heat. Additional start-up's challenges identified by (Jacobsson & Bergek 2004) in the Swedish utility sector are their disconnection with large scale applications that are the main receivers of government subsidies and their underdeveloped division of work.

- **High cost to customers:** The market shows a tendency of being price sensitive mainly because of the undifferentiated commodities that are heat, electricity and water. The price sensitivity in the market can become a barrier for eco-innovations (Datamonitor, 2009). Another barrier for the Swedish market is the reliance on imports for components to production processes from developing countries. Eco-innovations in these supplies are competing with companies that have lower labor rates and raw materials costs. Governance and regulations for the eco-efficient economy may become a burden especially for SME's (Nilsson et al., 2009).

- **Customer criteria assessing new technologies:** Also for the users is difficult to predict prices, what makes difficult to estimate price advantages of new technologies. In the other hand

incumbent energy technologies had received a high amount of direct subsidies in past years and indirect subsidies since negative externalities had not been added to their costs (Jacobsson & Bergek, 2004).

An interesting fact of the Swedish utility market is their R&D Investments. Rising (2010), stated that Vattenfall (a major player in the Swedish utility market) investments in R&D from 2008 were mainly in Carbon Capture and Storage, CCS (43%) and Nuclear Power (30%) compared to Renewable (10%). The main reason stated by Rising (2010) to explain these investment percentage, was that CCS and nuclear power are not mature technologies and for that reason required higher investments compared with wind and biofuels that are considered to be mature technologies.

Another reason to maintain a high investment in nuclear power was the results of the Life Cycle Assessments developed by the company (Figure 6), that shows that Nuclear Power and Hydropower had the less emissions of CO2 than other renewable energies as wind and solar. These results also explained Vattenfall's generation portfolio where more than 95% of the power generation uses Nuclear or Hydro power (Vattenfall, 2005).

The investments in CCS technology in the industry can be considered as 'sailing ship effect', that improves fossil fuel plants as a reaction to renewable energies technologies.

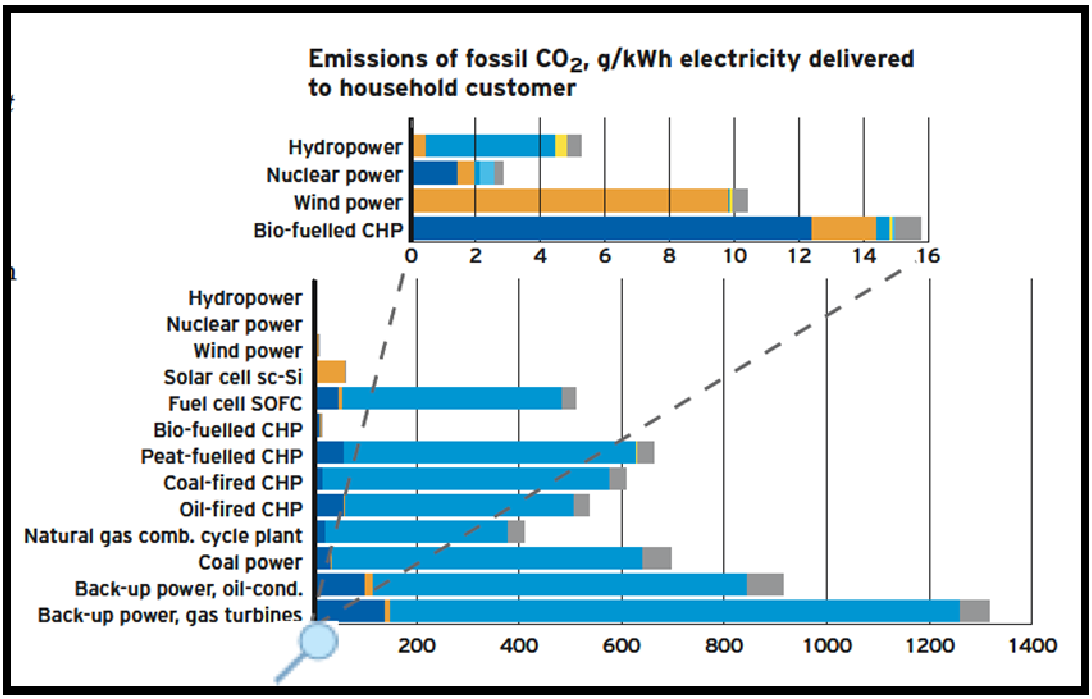

Figure 5: Vattenfall's LCA results Source: (Vattenfall, 2005)

The decision of technologies to deploy by the company is also the result of the cost of abatement graphic developed by the company. In this graphic the ratio of the cost of technology compared with the

reduction of CO2 by deploying the technology is presented (Figure 7), the lower the result of the ratio the more appealing the technology (Mogren, 2007). As seen in the figure technologies that improve efficiency are the more appealing ones because offers cost savings and also reduce the CO2 emissions. Still, there is only a limited amount of efficiency that can be improved, other appealing technologies already have been applied in Sweden (District Heating) and others are difficult to deploy because of the country conditions (Sugarcane biofuel). As seen in the figure below small Hydro and nuclear are considered more appealing than others renewable as wind and solar.

The use of these measures, in the Swedish utility sector, to evaluate investments and technologies can became a barrier for eco-innovations since the technology is not mature enough. The current evaluation methods can be too static to evaluate eco-innovations. Costs of eco-innovations are expected to be reduced significantly in the future and the production methods would be more efficient reducing both cost and emissions (Porter and van der Linde, 1995). Also continues investment in the same technologies makes these technologies to become in the company's own domain which creates the perception that the risk of investing in them is more controllable than the risk of technologies outside the company's domain (Hamberg, 2004).

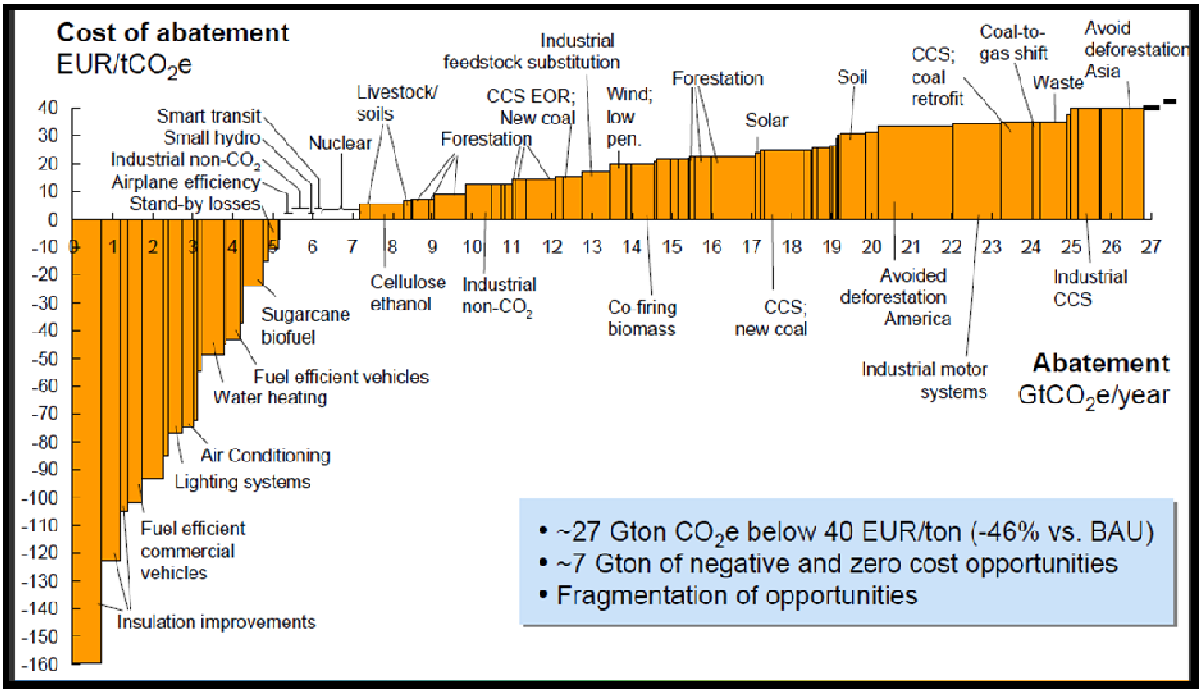

Figure 6: Technology cost of abatement Source:(Mogren, 2007)

2.7.4 Summary of the barriers of eco-innovation

Table 4 is used as a summary for this section. It presents the main market barriers identified in the literature and its evidence in the utility market.

Table 5: Market barriers Literature versus Utility Market using the analytical framework

Main market barrier mentioned in the literature	Presence of the barrier in the utility market
Technological lock-in of customers	• High volume mature sector • Incumbent technology's plants have a long productive life • High upfront costs
Policy technology standard	• "Swedish nuclear power trauma"
Lack of market legitimization	• Skepticism in eco-innovation capability to scale-up • Absence of large scale applications
Customer's criteria assessing new technologies	• Incumbent technologies received a high amount of subsidies • Use of static life cycle assessments and cost of abatement graphic
Customer's lack of information	None
Low availability	None
High cost to customers	• Low cost of fossil fuels • Price sensitive market • Reliance of imports from developing countries

2.8 APPROACHES FOR ECO-INNOVATION SUCCESS

This section analyses and discusses the approaches for eco-innovation's success found in the literature, with a focus in the utility market. The section begins with a description of general strategies for eco-innovations to approach a market, followed by a presentation of identified success factors from the literature. Finally these drivers are discussed in the context of the utility market.

The commercial success of an eco-innovation is a reflection of the institutional innovations in the political, economical and social systems in its environment (Kemp et al., 1998).

For an eco-innovation to succeed the existence of a potential market for it is compulsory, it is even better for the eco-innovation if the market already exists (Foster and Green, 2000) Also, successful eco-innovations are driven to fulfill identified needs. Seeking out information about green issues from customers both also other stakeholders in the market is one of the best ways to succeed with eco-innovations (Foster and Green, 2000).

Also external factors are important for eco-innovations to succeed as internalization measures in the market, support to technology research, development and demonstration, market engagement programs and deployment policies (Hordern et al., 2008).

2.8.1Market approach

From a market perspective different factors have been found to be important to reach market success. Halila (2007) found the main factors in the realism when evaluating one's own innovation, access to capital and the utilization of the network. Other authors (Bonini & Oppenheim 2008, Smith 2001,Van De Ven, 1993, Kemp et al., 1998) found additional factors as educate consumers, get customer's trust and the availability of niche markets. The factors identified in the literature for successful marketing of eco-innovations are:

- **Realism when evaluating one's own innovation**: It is important to maintain a realistic view of the product. Most eco-innovators believe that their product/process would revolutionize the market. Still assessing the product from a customer point of view and comparing to competitors is required for the eco-innovators (Halila, 2007). The two main criteria that costumers look in a product/process can be divided as must have to be consider by costumers call qualifying and order-winning criteria which are the aspects of the product/process that permits the customer to make a buy decision (Hill, 1995).Traditional selling points as price, performance and quality should still be used to reach customers (Hordern et al., 2008).Consumers should be able to track the advantages of the eco-innovations. Additional activities carried on by customers to less green products should be identified as handling, storage and disposal of discharges. Including the savings of pollution-wasted resources, wasted effort and diminished product value to eco-innovations marketing is a key factor (Porter and van der Linde, 1995). Also to build trust companies should inform customers about the true environmental impacts of its products (Bonini & Oppenheim, 2008).

- **Access to capital**: Capital is required in order to succeed in the development process of an eco-innovation. Dealing with venture capital is a challenge for eco-innovators since eco-innovators require a high level of control of their company and normally venture capital firms want to have a large influence in the eco-innovation start-up. Eco-innovations companies with a more diversified ownership tend to be more successful (Halila, 2007). Alternative solutions can be proposal of subsidies or incentive based schemes (Smith, 2001).

- **Utilization of network**: For start-ups a high quality (strong ties between members) and large number network is one of the main resources (Englund, 2008). Normally, eco-innovation start-ups relationships are with family and friends that would support them in good and bad times. But an addition of market actors to the networks is required even if these relationships are weaker. Eco-innovations require a mix of members of its network that includes individuals with strong marketing financial and technology knowledge of the eco-innovation. The members of the network start to isolate themselves from other industries and technologies developing the unique know how of a new technology (Van De Ven, 1993).

The network has been found to need to be both horizontal and vertical:

- Horizontal relations permit eco-innovators to benefit from ongoing work (Hordern et al., 2008). Even firms competing with a similar product must cooperate to educate consumers, develop

institutional arrangements and generate critical mass to the new technology in some cases becoming a new industry.

- Vertical relations permit the network to perform most of the functions required to commercialize a line of new products/ services (Van De Ven, 1993).

When the innovation moves forward the network should increase in size and strength in its ties (Halila, 2007). Learning is the base for eco- innovation to develop and normally takes place in interactions between eco-innovators and other actors. Absorptive capacity of start-ups is important to acquire this knowledge. Linking with different organizations and actors permits innovators to appropriate competences and resources to develop and commercialize their technology (Van De Ven, 1993). Successful eco-innovators are characterized by a correct management of external relations (Markusson, 2001).

- **Educate customer**: Normally eco-innovators should first consider themselves as educators before being salesman. Customer's decision making uncertainty can be reduced if more information about the eco-innovation is available to them (Hamberg, 2004). Government and environmental organizations can help eco-innovators to diffuse knowledge about its innovation and the environmental problems (Bonini & Oppenheim, 2008). Maintaining a position of gatekeeper regarding eco-innovation is crucial to succeed. To provide reliable data eco-innovators need to have access to relevant business and environmental material (Smith, 2001).

- **Gaining customer's trust:** Uncertainty in the innovation is one of the main market barriers. Innovators need to win customer trust. Some of the mechanisms to achieve this objective are guarantees, licensing practices, industry regulations and endorsements by trusted institutions. Also trust in a new technology is fundamental to enter a market and achieve legitimization (Van De Ven, 1993).

  The creation of technical standards for the new technology is a factor that increases customer's trust. The eco-innovation has fewer uncertainties once a dominant design has emerged. These standards can be developed by government agencies, by firms in the industry or by a dominant producer (Van De Ven, 1993).

- **Availability of niche markets:** *"Niche market is a targetable portion of a market sector."* (Kroeger et al., 2008, p.4). Niche markets play a key role in new technology's take-off and development. Niche markets are important to demonstrate and finance innovations, also help to start learning processes of customer's needs and institutional adaptations (Kemp et al., 1998).

  Niche markets can be made by policy that creates protected spaces for a certain application of a new technology niche markets also can be early markets form by industry's visionaries or can be formed by NGOs. Governments should work as facilitators of niche markets that develop eco-innovations (Kemp et al., 1998).

The customers in these niche markets can provide the first stimulus to eco-innovate in the form of a market pull (Carrillo-Hermosilla et al., 2009). This first market can have the characteristic of being proactive firms that see the adoption and investment in eco-innovations as a reduction of risk by developing competences and resources that will be required in the future (Hordern et al., 2008).

Additional success factors present in the literature are the improvement in the productivity, bring customers additional revenues, cut customer's emissions, make products/services available and improve customer's reputation are other ways to succeed with marketing eco-innovations.

One of the main priorities in the energy industry sectors is to reduce CO2-emissions, helping costumers to increase efficiency is where most eco-innovations have found a market (Voser, 2009).

2.8.2 Summary of the section

From existing theory the main approaches used by eco-innovators to reach the market seem to be: Evaluate own eco-innovation, get access to capital, expansion and utilization of their network, educate customers, gain customer's trust and enter available niche markets. Following these approaches offers a better opportunity to overcome barriers by eco-innovation start-ups.

The following section presents the methods used in this master thesis.

3. METHODOLOGY

Chapter 3: Methodology

3.1 Scientific approach & research strategy 3.2 Research design 3.3 Research methods 3.4 Validity & Reliability

This chapter describes the methods used for the study. First, the scientific approach, the research strategy and design are presented, followed by the explanation of the research methods used to collect data and to analyze it. Finally validity and reliability considerations of the methodology are discussed.

The following diagram explains the process of the research that would be further explained in detail.

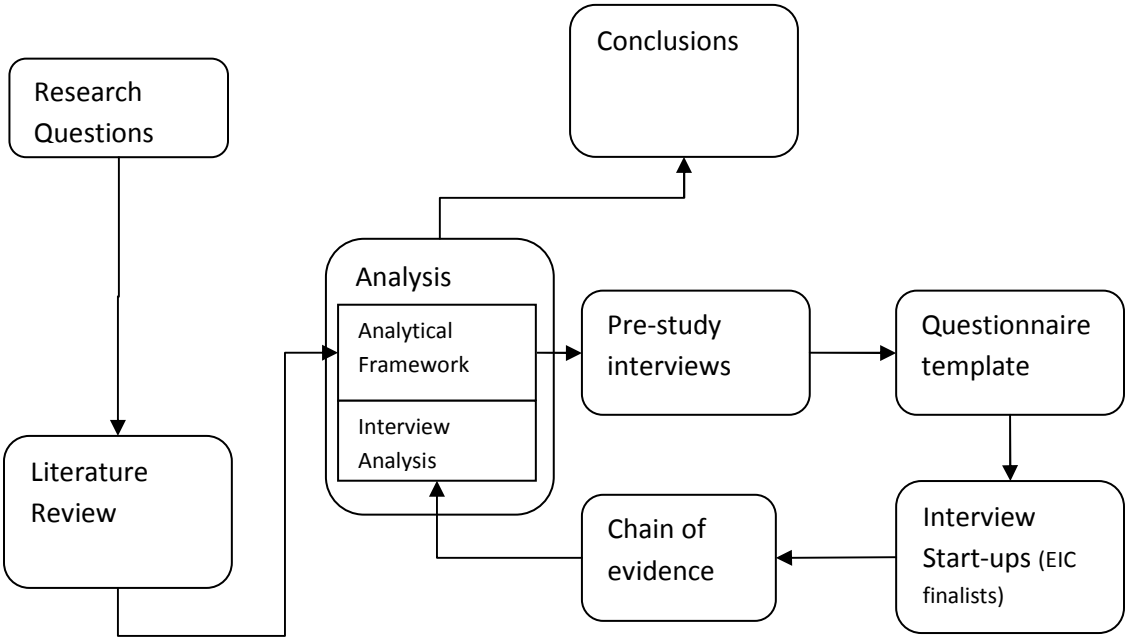

Figure 7: Research steps for this study

3.1 SCIENTIFIC APPROACH AND RESEARCH STRATEGY

The approach for this research is exploratory since the aim of the project is to define and identify problem areas (Kinnear and Taylor, 1996). The relevance of the resulted knowledge can be classified as a description, since it answers the questions of how and what of a problematic situation (Van De Ven and Johnson, 2006).

A studied variable is quantitative if it can be measured or qualitative if it cannot be measure and is subjective, quantitative techniques are normally used to answer what questions and qualitative techniques are used to answer how questions (Bryman and Bell, 2003). Since both types of questions form part of the research, the data collected would be a mix of quantitative and qualitative techniques, with a dominance of qualitative data. This approach has the objective to permit facilitation, triangulation and complementation of both types of data (Bryman and Bell, 2003).

3.2 RESEARCH DESIGN

The research design is a multiply-case study, since more of one case will be studied during a single point on time, each case focuses in an extensive examination of a single organization (Yin, 1981). The distinctive characteristics of case studies are that the phenomenon to examine is contemporary and it is in a real-life context, case studies are especially useful when the boundaries between a phenomenon and its context are not clear (Yin, 1981), as in eco-innovations.

This study is predominant qualitative, so the cases have an inductive approach; an inductive approach means that the researcher infers the implications of his results to generate/complement theory (Bryman and Bell, 2003).

The type of cases, as classified by Yin (1998), presented in this research are representative or typical cases, since the selected cases represent a common start-up with an eco-innovation in the renewable field in the utility market. Case studies can mix both qualitative and quantitative evidence. Main sources of case studies data is fieldwork, record reports and observations (Yin, 1998).

A multiple-case study research allows comparing and contrasting the results of each case. Case studies are considered adequate methods for exploring areas in early phases of research, as it is the case of eco-innovations. The research design of a case study offers advantages to answer what and how questions and to improve theory building establishing the circumstances in which a theory is valid or not (Yin, 1998).

The level of analysis of the research, the primary unit of measurement and analysis of the study (Bryman and Bell, 2003), is consider to be companies with an eco-innovation in the renewable energy field and the utility market.

3.3 RESEARCH METHODS

It is important to emphasize that each of the steps in this study have the research questions as point of origin. For the different steps of the research: literature review, pre-study interviews, start-ups interview and analysis different methods are used (Bryman and Bell, 2003). The following paragraphs explain the research methods use for each step.

3.3.1 Literature review

A literature review is necessary as a part of the research project. The literatures were selected carefully by the authors based on the research questions. The literatures review focuses on "challenges of eco-innovation developed by start-ups" and "how this start-ups approach the market". The literature resources include existing books, reference materials, journals, website information and so forth.

In order to search useful and relevant information efficiently, a search strategy was developed. Compiling keywords or phrases is a very useful way to generate a search strategy, so several keywords were defined for this project: "eco-innovation/environmental/sustainable innovation", "start-up/Micro-enterprises/ small-enterprises", "challenges/ obstacles/barriers".

The identified challenges, then, where classified in general barriers for eco-innovations and market barriers for eco-innovations. Also drivers of eco-innovations were identified from the literature and classified in general and market specific. The reason to also study the drivers of eco-innovations is the fact that the lack of these drivers is considered a barrier (Carrillo-Hermosilla et al., 2009).

There is a problem to translate theory to practice, because practice knowledge normally is used to deal with issues encountered in a particular case, instead, theory knowledge try to explain a general case (Van de Ven and Johnson, 2006). Included in the literature review, there is not only theoretical knowledge but also there is practical knowledge. Also drivers and barriers of eco-innovation related to the Swedish utility market are included; the main sources of this information were utility company's reports. To complement the information about the Swedish utility market two interviews to Swedish utilities were carried out. The results of these interviews were added to the analytical framework. The companies interviewed were selected one to represent international actors present in the Swedish utility market (Vattenfall) and the other one was selected as a local Swedish utility (Halmstad Energi och Miljo).

3.3.2 Pre-study interviews

The literature review was conducted with the aim of becoming familiar with the subject of eco-innovation and to develop an analytical framework, as part of the analytical framework a questionnaire was developed. To complement and to asses this first draft of the questionnaire interviews with start-ups that did not form part of the population objective were carried out.

To select the sample companies to be part of the pre-study, the advice of Bryman and Bell (2003) was followed which established that a pilot study should not be carried out with members of the sample of the full study instead it should be carried out with respondents that can be comparable to members of the population of the full study. Two pre-study interviews were conducted, one with a company with an eco-innovation in the rail industry and one with an eco-innovation that did not reach the market.

The results of the pre-study interviews help to find extra questions to be included in the interview, provided experience to interviewers, identified tendencies from respondent's interest to be lost, identified questions that can be misunderstood and tested how well the questions flow (Bryman and Bell, 2003). Some of the information of these pre-study interviews was used in the analytical framework chapter, mainly to identified eco-innovations barriers.

3.3.3 Questionnaire template

A questionnaire template (See appendix 1) was developed focusing in answering how start-ups face the obstacles identified in the literature review. The experience of the pre-study interviews was used to polish the questions. In addition, a review of the challenges identified on theory in the literature and in Swedish utilities information was part of the questionnaire. The main aims of the questions were to:

- Establish the background of the company and its eco-innovation
- Establish the market of the eco-innovation
- Identify the main market barriers of the eco-innovation
- Understand the approaches of the firm to face these market barriers

With these aims the data was obtained by semi structured interviews to start-ups with eco innovations. Semi structured interviews are considered to use an interview guide form by a series of general questions were the interviewer is able to vary the order of the questions (Bryman and Bell, 2003). The questions mix both open questions and closed ones. The interview template begins with the background questions. Followed, by the personal perception of the interviewee of the main barriers and how the company face them. Then, there are more specific questions about how the company entered its market and reached customers. Finally, concrete examples of how the company entered the Swedish market were asked.

3.3.4 Start-up interviews

Once the questionnaire was finished, deeper and empirical information from three companies in the renewable energies technology field was collected. The selection of three as the number of companies to be interviewed is to offer variability and, at the same time, maintain the research in the time and resources boundaries (Bryman and Bell, 2003).

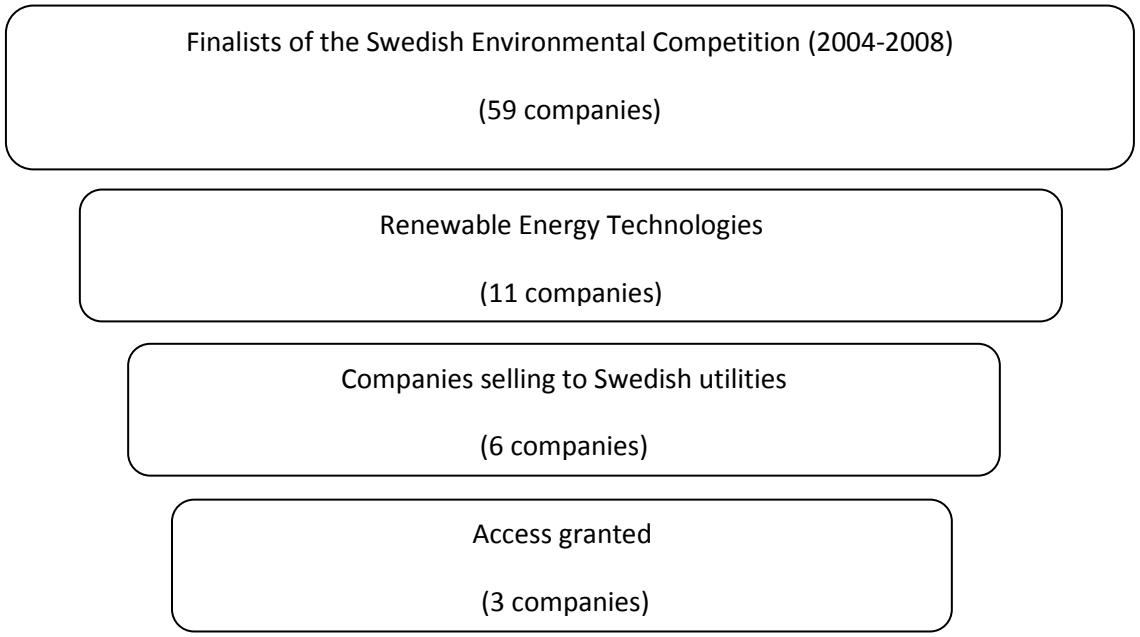

Figure 8: Illustration of the selection of start-ups for the study

The selection of these three companies is shown in the above figure. From the pool of 59 companies (Appendix 2) finalists of the Swedish Environmental Innovation Competition[3] between 2004-2008, a filter is made for companies that their technology is in the renewable energy field. Then, with the help of Innovatum's personnel, a filter to separate these 11 companies was made. The companies were separated in companies that no longer exists, or had not reached the market, or sell to different markets that the Swedish utility one and the ones selling to the Swedish utilities. From the companies selling to Swedish utilities a convenience sampling is used, where the authors contact the company's resulted in the filter (around 6) and interviewed the ones more accessible (Bryman and Bell, 2003).

It is also important to emphasize, that even if a convenience sample was used, the companies that form part of the study are from different renewable technologies (solar, biomass gasification and biogas). This strategy helps the study because none renewable technology is overrepresented (Englund, 2008).

The CEOs or Marketing Directors of the companies were selected for the interviews, because are considers as the main responsible of the market entry strategy in start-ups.

After the interview analysis, follow up questions were sent by email to interviewees to clarify some of their responses. Van De Ven and Johnson (2006), stated that repeated interviews provide better opportunities to penetrate more deeply the research subject.

[3] The list of finalists can be found in the website of the competition: http://www.miljoinnovation.se/ServiceMenu/English

The results of the interviews are presented following the recommendations of Yin (1981), who stated that results should be organized around specific questions and the data, interview segments, that address the same topic should be assembled together.

3.3.5 Chain of Evidence

The chain of evidence is defined by Yin (1981, p.63) as "*the explicit citation of particular pieces of evidence, as one shifts from data collection to within-case analysis to cross-case analysis and to overall findings.*" The chain of evidence of this report permits the reader to understand how the authors reached conclusions and made the analysis. To better follow the chain of evidence, the main evidence found during the start-ups interviews is presented in a table in the end of the empirical observations and results chapter.

3.3.6 Interview Analysis

Based on interviewee responses, parameters that will affect the eco-innovation in the market can be identified (McQuarrie, 2005). The challenges will be verified or refuted base on the interview data. Quantitative analysis method helped to identify the main parameters that are mentioned by startups (Bryman and Bell, 2003). For the interview most of the responses were qualitative parameters.

The explanation of these responses is based on the analytical framework making a qualitative analysis. A technique to build explanations in exploratory case studies is the one presented by Yin (1981) which divides the process in 3 phases:

- Rendition of the fact of the cases (chain of evidence)
- Considerations of alternative explanations
- Selection of the most congruent explanation based in the facts

The qualitative analysis was developed by the authors, and consists on categorizing the responses in different concepts of the analytical framework and the research questions. This is made by presenting the analysis as answers to the research questions.

Finally a cross-case analysis between the three companies studied is done. Yin (1981) proposed two approaches to make a cross-case analysis.

- The first one is **the case-survey approach**, which requires two conditions. First that the isolated factors of each case should be worthy of substantive attention and, second the number of cases should be enough to warrant cross-case tabulations (Yin, 1981).
- The second approach is **the case-comparison approach** that consists in two parts (Yin, 1981):
    - Build an explanation for each case singly
    - Identified the levels of modification for each case

In our study the number of cases is not enough to carry a case-survey approach, also the significant factors for each case are not present in all the cases, for these reasons a case-survey approach cannot be selected. So, a case-comparison approach is better suited for our study.

It is important to emphasize that the aim of the analysis is to answer the research questions for the three studied cases and not to generate a general explanation for the research questions.

3.4 VALIDITY AND RELIABILITY OF METHODS USE

The construct validity of the research specifies that the research design should measure the right concepts to answer the research questions (McQuarrie, 2005). The research and data collection method had been designed to answer these questions and fulfil the internal validity criteria, also triangulation with secondary sources are made in the research.

One of the main disadvantages of case studies is the external validity, how a single case can be used to generate a general theory, external validity is not possible to be achieved by a case study (Bryman and Bell, 2003). Moreover, the study of more than one case and the selection of typical cases in the sample permit this research to reach a higher degree of generalizability than single case studies.

The interviewees were not only asked what are the main market barriers but also a set of questions that permitted to identify other barriers mentioned in the literature and confront the ones perceived by interviewees. Also the research avoids a coercive style of imparting knowledge and self-interested recommendations.

Reliability records of the interviews and questionnaires were part of the research document, which permit the research to be replicable (Bryman and Bell, 2003). Still there is the risk of interviewers influence the answer of interviewees.

The researchers also took the responsibility of explaining how the resulted knowledge can be applied in practice by including a section with the managerial implications. Also the four main suggestions of (Van de Ven and Johnson, 2006) to develop a conjoint research between academics and practitioners were follow up by:

- Confronting questions and anomalies existing in reality
- Organize the research project as a collaborative learning of scholars and practitioners
- Conduct research that examines alternative models and practical formulations of the question of interest
- Frame the research to contribute knowledge in both academic and practice domains

4. EMPIRICAL OBSERVATIONS AND RESULTS

Chapter 4: Empirical Observations and Results

4.1 4.2 4.3 Case studies 4.4 Main differences of cases studied 4.5 Summary of evidence

This chapter presents the results of the interviews of start-ups companies in the renewable energy field. First a background of each start-up is presented. Then, the answers of the interviewee's are grouped using a similar layout as the one used in the analytical framework's sections about barriers and market approaches of eco-innovations.

These case studies are followed by a summary of the main characteristics of each company. Finally, a summary of the main evidence from the results and empirical data that will be carried to the analysis chapter is presented as a summary of the section.

4.1 CASES STUDIED

The results of the three cases studied are presented in this section. A background of the company is used as introduction for each case; the data for the background has been mainly collected from the webpage of the company[4]. Then, the interview results are presented using the following method to present the answers. Each time an interviewee mentioned an aspect found in the literature this data was grouped under the literature barrier or approach. Additional data that is not related to a specific barrier or approach of the literature, but was mentioned by the interviewee is grouped under the titles perceived barriers and approaches of the company.

4.1.1 CASE STUDY: BIOPROCESS CONTROL SWEDEN AB

Bioprocess Control provides technologies and services to design and operate biogas plants. It was founded in 2006, as a result of the research in anaerobic digestion process in Lund University. In the same year the company participated in the Swedish Environmental Innovation Competition (EIC) winning the first prize with their first product (Biogas Optimizer). This product was the first one of the company and was first sold in 2008.

Biogas Optimizer is a software program based in an algorithm that by measuring in real time biogas flow, pH and gas composition, regulates the pump that feeds raw material to the digester tank, maximizing and stabilizing the production of biogas per time unit. The company had added other products to their portfolio in 2009, as the Automatic Methane Potential Test System (AMPTS) to measure the energy capacity of the raw material in the biodigester and the Intelligent Process

[4] Company websites: http://www.bioprocesscontrol.com/, http://www.absolicon.se/, http://www.cortus.se/

Automation System (IPAS) that permits an automation solution to operate the biogas plant (Bioprocess Control Sweden AB, 2010). Also, in 2009 Bioprocess Control opens an office in China.

In 2009, the sales revenues reach 2 million SEK, mainly in services carried out by the company and sales of the AMPTS product. The company is form by 9 members in Sweden and 3 in China.

4.1.1.1 Interview results

The data from the Bioprocess Control Sweden's interview is:

Perceived barriers

The interviewee stated: "*The main barrier has its source in the market. The maturity in the market place is the main barrier to deploy our technology. We see the maturity of the market as the required development of the biogas industry.*" The technology of Bioprocess Control is most useful for companies that developed high automated biogas plants and also have an important amount of production of gas. The interviewee stated: "*Our technology has almost no application in low efficiency anaerobic digester, as the ones made by just membranes.*" The production of biogas plants in Sweden is rather limited. The development of better policies and a better deploy of biodigester technologies in the market can help the market to develop faster.

Market characteristic

The customers of the company include biogas plant developers firms (SvenskBiogas and Swedish Biogas), electricity and heat utilities (E-On, Kappala local utility and Kalmar Biogas),universities (Lund University) and research institutions (the Korean office of Swedish Biogas International, SYVAB).These customers have bought the diagnosis service implementing the Biogas Optimizer software and some the AMPTS. The only sale of the IPAS system has been to China. Challenges that generate from the customer characteristics are presented below.

- **Technological lock-in of customers**: The interviewee stated: "*We have competitors with similar systems and some competitors can lock in customers because their high investment costs. Our system requires the installation of sensors and control mechanisms for the feeding system. The product is compatible with most high efficiency plants and can be added to existing production plants and naturally also when new production plants are built-up.*" But as refer before to it is not use in low efficiency biodigesters.

- **Policy technology standard:** "*The policy is focused in the reduction of emissions mainly using taxes*" as the interviewee said it, "*We would prefer a feed in tariff for biogas, to help the sector to mature faster.*"

Relationship between customer and eco-innovation

In this part, the focus is on how the interviewed company deals with the challenges that arise from the interactions between the customer and the eco-innovator firm.

- **Customer's lack of information:** The information is diffused to customers mainly by internet and direct contact by the salesman of the company. Customers are highly informed about the importance of an efficient process in the biogas plant.

- **Low Availability**: "*Our engineers can installed the system in Sweden and China in a timeframe of 12 months, for the services they normally take around 4 months to be carried out*" the interviewee said. It is important to emphasize that one of the main barriers of biogas growth is the availability since there is a limited amount of biogas that can be produced without affecting food production or other industrial activities. Bioprocess Control believes that their products/services improve the availability of biogas.

- **High costs to customers:** The price strategy of the company is to price their products with the benefits they deliver to costumers warranting at least an increase in a 10% of the production of biogas of the plant. The return of investment for the costumers is expected to be around 2 years. The price is also maintained around the ones of the competitors.

- **Lack of legitimization**: The immature market can be an evidence of the lack of legitimization.

- **Costumer criteria to assessing new technologies**: Bioprocess control, the interviewee stated: "*Permits real time monitoring of the production of biogas which permits the costumer to easily asses the potential increases in the biogas productions for their plant by using our product.*"

Market approaches for success factors

- **Access to capital**: Bioprocess control had been granted a 1.9 MSek from Vinnova to develop new sensor products also the Dutch company DSM Venturing, a unit of Royal DSM, has invested and become a shareholder in Bioprocess control.

- **Utilization of network:** Bioprocess Control has developed a partnership network with different companies. Their main partner is the Dutch DSM a company in the material and life science industries which has net sales of 9.3 billion Euros, also the interviewee said: "*We have several co-operations with Swedish biogas developer as Swedish Biogas, Simbiente, Gaia group, Ecoregon and Tricorona.*" These companies have partnerships with Bioprocess Control and offer bioprocess control's service/products to their customers.

- **Gaining customer's trust**: Bioprocess Control interviewee stated: "*We guarantee that the production gets at least ten percent higher with our technique, which gives a maximal pay-off time of two years.*"

- **Continues improvement in the products/services and increase customer's revenue:** Bioprocess control keep developing better products and services since its creation, as example is the IPAS product. The company develops solutions that permit the plants to operate at 100% efficiency assuring optimum performance and design. Once the plant is installed, the company provides support to operators to ensure a high efficiency process and true benefits of products.

Bioprocess controls interviewee said: “Also our state of art solution increases the reputation of our customers.”

- **Availability of niche markets:** Research institutions have been the main customers of the company, for this reason new sensors had been developed to be part of the product portfolio.

Approaches of the company

During the interview, the interviewee also told us how they approach the market, to overcome the barriers he perceived.

- **Broaden the technology portfolio**: In order to face the challenge of an immature market the interviewee stated: “*We have taken the approach to broaden our technology portfolio from just applications to applications, lab equipment and sensor technology.*” This means that Bioprocess Control has expanded its offer from just the software application to lab equipment and sensor technology (AMPTS).The interviewee said: *“With lab equipment, we have decided to launch several products in this year and future years.”* This strategy permits them to reach universities and research institutions that play an important role in an immature market.

- **Sell to multiple markets**: The Company considers spreading immature market risk by entering different markets. Interviewee said: *“We also decided to sell the products we had to multiple markets to spread the risk.”* Biogas technology could evolve faster in other companies other than the utility ones as in water treatment plants, food & beverage producers, ethanol and bio-diesel producers, pulp & paper companies and farmers, as stated by the interviewee “Sell to multiple markets help to overcome products whit maturity in some markets.” Also the investments on China show that the company believes that other countries could develop a biogas market faster than Sweden .

4.1.2 CASE STUDY: ABSOLICON SOLAR CONCENTRATOR AB

Absolion Solar Concentrator AB sells systems to produce heat and electricity from solar energy. It was established in 2007, as a result of the research project in solar concentrators by universities of Borlänge, Lund, Uppsala and the KTH in Stockholm. In 2005 the research project in these universities finished and the resulting, product the Solar 8 (a solar concentrator) was presented in the EIC, being one of the finalists that year. This product will evolve to become the main product of Absolicon Solar AB the solar collector X10.

The solar collector X10 includes a photovoltaic panel, a cylinder parabolic reflector that concentrates sun light in the panel and a solar tracking system that turn on and down automatically avoiding overheating, and a web server to connect to the internet. It generates both electricity and heat the surface size and outputs can be user customized. By having integrated all these devices the X10 reduces cost and simplifies operation. The name X10 comes from the fact that it concentrates the light of the sun ten times, the name of its antecessor (Solar 8) was from the fact it concentrates the sun light 8 times in the receiver.

In 2009, the sales revenues reached 200 000 Euros, mainly in sales of the X10 product. The company is formed by 9 members in Sweden, where the X10 is assembled. Also the company has a small assembly facility in Spain.

4.1.2.1 Interview results

The data from Absolicon Solar Concentrator's interview is:

Perceived barriers

The interviewee stated: "*The main barrier is the licensing part and obligations when entering the market with a combined system because all standards and certifications are designed for, either power systems or thermal systems, but not for a system that combines both technologies, so we have to rewrite the map of how these tests are done."* The X10 is an integrated system that produces both heat and electricity and also use a heat concentrator. These characteristics make the product difficult to test by certificate authorities and customers. Being an innovation there are not standardized tests for the X10. Still customers require a government or European Union institution certification to get subsidies or other kinds of support from the government (mainly in Spain). In addition customers also want to be sure that the X10 will not be damaged by hard environmental conditions and by overheating in the long run. Using a concentrator (with almost unique characteristic) makes the X10 works at higher temperatures than normal solar light collectors, company personnel stated: "*Meeting temperature requirements for all components of the system was a big challenge for the X10."*

Another perceived barrier is the customer finance for the product and its installation. Interviewee said: "*Project financing is a big issue mainly in Spain, because banks are not willing to lend so much money to the customers we have.*"

Customer characteristic

The customers of the company include Hotels, Museums, and District Heating systems in Sweden. Still, the largest installations of X10 have been carried out in hotels in Spain (Centro Forestal Sueco in Marbella). The company is expecting to sell the X10 to the hospital sector in Sweden and Spain. The interviewee stated: "*That the marketing of the product is much more about the customer's savings and revenues in Spain, instead of Sweden where both financial and environmental benefits of the product are important."*

- **Technological lock-in of customers**: The interviewee stated that Absolicon Solar has competitors with similar solar systems without the concentrator. The high initial investments and large return of investment of solar light collector systems make difficult to customers to change to other systems. The only requirement to install the X10 is a surface (in the roof or in the ground) of at least 100m2.

- **Policy technology standard:** The interviewee said: "*Emissions of CO2 should be taxed more harshly that they are currently that would drive technology advances in the renewable energies field.*" Policy supports the technology but requires the certification of the product. These certifications require investment in test facilities and development. Especially in Spain there are

policies to support solar collectors, as solar energy is mandatory in all new houses the government gives an average subsidy of 30%, also renovations of buildings required that 80% of the energy consumption of the building comes from renewable energies. Interviewee said: "In Sweden we do not have this kind of laws. To apply for this subsidy the product should have the Solar Keymark certification."

Relationship between customer and eco-innovation

- **Customer's lack of information:** The information about the eco-innovation is diffused to customers as the interviewee said "*Almost only through the web, we focus a lot in Google and web ads.*" Universities that form the project also play a part in the education of the customers. The product is mainly market by its new revenues for customers and its environmental performance.

- **Low Availability**: Absolicon has established a small assembly facility in Spain that makes easier for Spanish customers to reach the product. Also, Absolicon offers and installation service and the start-up times for the system are short.

- **High costs to customers:** The price strategy of Absolicon as stated by the interviewee is: "*We look at competing products in the market and put the price of the product similar to them.*" The return of investment for customer varies according the size and the country of the installation. For Swedish customers it is between 8 – 15 years, instead for Spanish costumers is between 3-8 years. The price strategy of the product is highly related with the price of the competitors.

- **Lack of legitimization**: The market still does not have a standard to asses heat and power systems. Solar energy is a low scale generation technology compared with other technologies in the energy systems as fossil fuels.

- **Costumer criteria to assessing new technologies**: Since X10 is an innovation interviewee said: "*it is difficult for customers to asses the technology, mainly its lifetime.*" This is a big concern from the customer even if it has the knowledge of solar collectors the addition of a concentrator makes difficult to compare. Also it is costly to carry on the test that customers require before buying the product.

Success factors

- **Realism when evaluating one's own innovation**: Absolicon has a high confidence in its product and believes it will make possible solar energy to reach a share of the electricity and heat production market in Sweden and Spain, also they believe is the best solution for solar collectors.

- **Access to capital**: The CEO of the company is part of the family behind Logosol, a company that sells portable saws and has a turnover of more than 60 million Seks. Exoro capital has invested 4 millions in the company.

- **Utilization of network:** Absolicon has made a partnership with Grupo Solar Kuantica, a solar project developer in Spain, to make most of the sales of X10 in this country. Also from the Logosol Company, Absolicon has got the knowledge of assembly and logistics of the X10 product following a similar system as the one used with the portable saws. From Exoro, Absolicon acquired the business competence and its marketing director**.**

- **Gaining customer's trust:** Absolicon offers a 15 years warranty of 90% electricity production and 25 years warranty of 80% electricity production. Absolicon has the solar keymark certification.

- **Continues improvement in the products/services and increase customers revenue:** One of the main goals, as stated by the interviewee is "*to be able to compete with fossil fuels to do that we have to reduce prices*" by R&D. The evolution from the Solar 8 product to the X10 shows the constant improvement in Absolicon's product.

- **Availability of niche markets**: Absolicon's customers are mainly hotels. Also the company has sold to museums and hospitals.

Approaches of the company

- **Work in close contact with certification bodies**: The interviewee stated: "*We work a lot with certified bodies and institutions in Europe*." In the past year Absolicon work closely with the Swedish National Testing and Research Institute to get the Solar Keymark Certification. Finally at the end of 2009, this collaboration showed to be fruitful resulting in the issue of the Solar Keymark by this institute. This certification would bring further advantages to the product in the European market.

- **Sell and offer credit to international markets**: Absolicon faces a strong challenges in the time of return of investment in the Swedish market. Focusing in countries where there is better physical and regulatory conditions is the selected option to overcome this challenge. "*Spain is the most important market for the X10 product right now*", as the interviewee stated: "*Spain has better laws than Sweden supporting renewable energies and higher solar radiance.*" Even to overcome financing problems in countries outside Sweden, Absolicon exports credit from Sweden as the interviewee stated: "*For the financing part of customers, we try to see if we can get part of the financing from Sweden, from the Swedish government*."

4.1.3 CASE STUDY: CORTUS AB

Cortus was started in 2006 to commercialize a new gasification technology WoodRoll. Cortus develops, produces and delivers a supply of clean renewable synthesis gas to energy intensive industries, through WoodRoll, an advanced patented gasification system.

Cortus AB sells clean renewable synthesis gas to energy intensive industries and offers a new biomass gasification technology call WoodRoll, to Swedish utilities. It was established in 2006 and has more than 20 years of experience in the energy and process field. Cortus AB was a finalist of the Swedish Environmental Competition in 2008.

The WoodRoll patented gasification system consists on three steps, drying, pyrolisis (gasification without oxygen) and gasification of biomass. First, biomass is dried. Then it enters the pyrolisis chamber where gas tar and volatiles are carried out of the process to an indirectly heated reactor and finally a gasification process using the residual tar is conducted. This gas tar is not mixed with the char and steam.

The result is a synthetic gas with a mixture of hydrogen and carbon monoxide free of nitrogen and carbon monoxide is the result of the process. The biomass fuel can be any biological material as wood waste and industrial sludge.

In 2009, the sales revenues reach 400 000 SEK, mainly in sales to the process industry of synthetic gas in the mineral industry in Sweden. The company is form by 3 members in Sweden.

4.1.3.1 Interview results

The data from Cortus AB's interview is:

Perceived barriers

The interviewee stated that "*The main barrier for the technology is mostly financial.*" Costs to develop the plants to produce the synthetic gas and offer it to the intensive energy industries are high.

In the Swedish utility market this is not such a big barrier since, as interviewee stated: "*Utilities normally own the gas production plant. It is in their hands, instead of our hands*", the utilities are the ones that finance the plant. In the other hand in the utility market an identified barrier as stated by interviewee: "*It is also a financial matter to demonstrate the technology; currently it is difficult for us to demonstrate the technology to customers. Demonstration facilities and tests are too costly and are difficult to finance.*"

Market characteristic

The company has sale only to one customer in the mineral industry by signing a contract of 12 years to supply synthetic gas to this customer. The requirements of customer in this industry are high temperatures (1200 C) that in the past only fossil fuels could be used. Approaches to Swedish utility companies have been made by the company and they expected to reach an agreement in a short period of time as said by the interviewee, "*With a first customer the pilot plant would increase its production and demonstration of the technology would be easier.*" Also, Cortus technology can be used to sequestrate carbon dioxide and CCS which could be interesting for Swedish utilities. Still, a concrete process needs to be developed by the company to offer carbon sequestration and CCS techniques.

Cortus AB offer different products to each market the energy intensive firms and the utilities. As the interviewee said it: "*To intensive energy companies we sale a supply contract to utility companies we sale a complete system.*"

- **Technological lock-in of customers**: The Swedish utilities are lock-in more mature and proven technologies. Still, the market is expected to grow and further gas supply would be required.

Also incumbent technologies are preferred because as interviewee stated: "*Is easy to make the same decision as other companies, is easy to follow someone else lead.*"

For intensive industry customers, there is almost no lock in since the synthetic gas can be used as natural gas so; the process is the same for them.

- **Policy technology standard:** The interviewee stated his view about environmental laws as: "E*nvironmental laws are not a barrier, but they are time consuming. To follow the protocols, to present in the right way you need a lot of money before you can get any money from the market. Regulations delay the starting point of commercialization of the technology*."

Relationship between customer and eco-innovation

- **Customer's lack of information:** Cortus AB uses internet, seminars and personalized customer's contact to diffuse the information about their technology to customers.

- **Low Availability**: The availability of the synthetic gas depends on the capacity of the plant which depends on the investment made on the plant. The test facility has a capacity of 150kW that is expanded to 3Mw.

- **High costs to customers:** The prices for the supplies and systems offers by Cortus as stated by the interviewee: "*Our prices are similar to the ones offered by renewable energy sources in the market*."

  The return of investment for customer is difficult to calculate as the interviewee stated: "*The plants time of return of investment depends of the size, government subsidies and government loans, normally is between 3 – 5 years. For the supply contracts the investment is profitable from day one for customers.*"

- **Lack of legitimization**: The Swedish utility market as said by the interviewee: "*required several demonstrations of the technology before investing in it*." There is not a standard for the company's technology plant. The interviewee believes that there are skeptics in the market but he still stated that "*Even with the skepticism and without fully explaining what you are doing there are always companies interested in the technology*."

  The technology has only been tested in small scale (3 MW) but the interviewee believes that there is no problem for larger plants until 50MW.

- **Costumer criteria to assessing new technologies**: It is difficult for customers to asses the technology, even more in the long run. There is only one test facility plant of the technology that started in 2009. The expected life for the plant is to be 15 years as interviewee stated what means a long term investment perspective for customers.

  From the interview, the interviewee stated that: "*Customers have a short term goal by being more profitable and a long term goal of building a greener company*." So, the assessment should reflect these goals.

Success factors

- **Realism when evaluating one's own innovation**: Cortus AB believes that there technology is more efficient (an overall 80% efficiency) that other renewable using biomass. Also, Woodroll has advantages to other technologies in process industries with high calorific demands as is a green process.

- **Access to capital**: Cortus AB has been part of different competitions as the EIC and had been finalist in most of them getting capital represented by grants. Also the first contract sale by the company assures as said by interviewee: "*A decent cash flow*."

- **Utilization of network:** Cortus AB had collaborations with the Royal Institute of Technology, KTH, in Stockholm to develop the process and still has some contact to further develop other processes. Also a Norwegian company was part of the development of the technology mainly the gas separation process. These partners help Cortus to develop their technology.

  From a market perspective Cortus has developed a collaboration with the Swedish company Nordkalk . Nordkalk dedicates to the extraction of limestone and its processes to made lime based products. Nordkalk cooperation result in the buildup of the test facility for WoodRoll product of 150 kW.

- **Getting customer's trust:** The creation of the test facility and the demonstration plant would help to increase customer's trust in the product. Also the existence of the first customer is expected to increase the trust in the market.

  Cortus AB also offers product guarantees to customers. For intensive energy companies Cortus guarantee the supply of synthetic gas that means that in the case of a shortage in the production by the company facilities the company would require to buy the gas from other company.

  For the utility market Cortus offers a guarantee in the performance of the plant based as stated by the interviewee: "*It is hard to give an answer for the power companies, usually the guarantees are the customer's required specification*."

  At least the first company's customer believes that by buying gas from Cortus he improves his company's reputation as the interviewee stated: "*Our first customer really believes that by buying our synthetic gas he improves his corporate image by greening his operations*."

- **Continues improvement in the products/services and increase customer's revenue:** Cortus is developing better solutions and processes for its customers. Examples of this are the development of the CCS technique and the process to produce renewable hydrogen production.

  Also, Cortus is working to reduce production costs and plant costs. To maintain a competitive price since the interviewee stated "*I expect biofuels to increase their prices in the future*."

- **Availability of niche markets**: Even with the barriers to demonstrate the technology, the interviewee believes that there is a high interest by different companies in different markets for the technology. As he stated "*We have more opportunities (potential customers) that we can chew on for the next 4- 5 years.*"

  Currently, Cortus has focused in intensive energy industry companies specifically in the mineral process field. But they expect to reach other industries as the metal & steel production, pulp & paper industry, cement production, glass manufacturing and the power companies.

Approaches of the company

- **Get capital for competitions and financial firms**: As the interviewee stated "*Our approach to overcome the financial barrier is going to every possible financial institution and venture capital firm.*" Also the participation of the company in a loft of environmental competition is evidence of the approach to get capital for as many sources as possible.

- **Get customer to invest in facilities**: Possible customers have been collaborating with Cortus AB investing in the demonstration and test facilities. Cortus expects to integrate Swedish utilities to these collaborations.

4.2 CHARACTERISTICS BETWEEN THE STUDIED COMPANIES

From the observations, we found that the studied companies had common characteristics between them. First of all, the companies studied are start-ups. They commenced their operations in recent years, are researching different markets and have few employees. Additionally, they are all Swedish companies in the field of renewable energy. They all identified the Swedish utility market as a focus market for their products. The number of their customers is still limited as the amount of their sales. Lastly, all of the companies participated in the Swedish Environment Innovation Competition (EIC) and other competitions and trade shows in the last year. Their main products are based in the eco-innovation presented in the EIC.

However, the studied companies also present a set of characteristics that are not common to all. After presenting the results and empirical observations for each company a table comparing the main different characteristics of the three cases is presented in this section. This table will be use to analyze the differences in the market challenges and approaches of each company in the analysis chapter. The differences were identified from each case. The main characteristics are:

- Type of eco-innovation e.g, (Brezet, 1997): Product improvement, product redesign, function redesign and system (See eco-innovations classification in the analytical framework chapter)
- Renewable technology field
- Start-up's background from (2004-2010)
- Number of customers
- Strategic focus markets

The following table (Table 6) shows the variances of the three start-ups in terms of the characteristics mentioned above:

Table 6: Main observed characteristics between the studied start-ups

Characteristic	Bioprocess Control Sweden AB	Absolicon Solar Concentrator AB	Cortus AB
Type of eco-innovation (E.g. Brezet, 1997)	Product improvement: • Improvement of existing products	System: • Change product, production chain and infrastructure	System: • Change product, production chain and infrastructure
Renewable technology	Biogas	Solar	Gasification of biomass
Start-up's background (2004 - 2010)	University	Industry and University	Industry
Number of customers	10<	10<	1
Strategic focus markets	• Research institutes and universities • Swedish utilities • Waste treatment plants	• Hotels and hospitals • Swedish utilities (DH)	• Intensive energy industry • Swedish utilities

4.3 SUMMARY OF MAIN EVIDENCE FOR THE RESEARCH QUESTIONS

This section presents a table with the findings of the empirical observation and results chapter. These findings will be further discussed in the next chapter. The main objective of the table is to clarify the chain of evidence from the results to the analysis.

Table 7 presents the main empirical observations to discuss the first research question**:** what are the main market challenges for the start-ups with renewable energy eco-innovations? The evidence is classified in the perceived barriers stated by interviewees, the barriers that have their source in their customer characteristics as found in the analytical framework and the barriers that result from the relation between their products and their customers mentioned in the analytical framework.

Table 7: Main empirical observations and results of the market challenges for the studied start-ups

Important observations	Bioprocess Control Sweden AB	Absolicon Solar Concentrator AB	Cortus AB
Perceived barriers by the interviewees	1. Small number of possible customers a. No mature market b. Required high efficient plants	1. Absence of test for the technology 2. Customer lack of financing	1. Lack of capital to develop production and demonstration plants 2. Costly to demonstrate the technology
Market characteristics	1. Presence in different markets 2. Largest sale in China 3. Prefer a feed in tariff	1. Certifications required to get subsidies 2. Larger sales in Spain 3. Not enough support laws in Sweden	1. Customer's tendency to invest in the same technologies 2. Regulations are time and capital consuming
Relationships between customers and eco-innovation	1. ROI 2 years 2. Swedish utilities had only buy services not products	1. ROI varies depending of the received sunlight a. More in Spain than Sweden 2. Difficult to develop tests for the technology because is a new technology	1. ROI 3-5 years 2. No standard for the technology 3. Customer's lack knowledge to understand the technology

Table 8 presents the main evidence of the presence of the approaches mentioned in the literature for eco-innovations to overcome market obstacles and the approaches of the studied companies to the market. This evidence is used to discuss the second research question: How are start-ups in the renewable energy sector working to overcome market obstacles in order to reach potential customers?

Table 8: Main empirical observations and results of the success factors and approaches to overcame market obstacles by the studied start-ups

Approaches Research question 2	Bioprocess Control Sweden AB	Absolicon Solar Concentrator AB	Cortus AB
Factors considered successful in overcoming perceived barriers by the literature and interviewees	• Investment of DSM Dutch • Offer guarantees • Network includes biogas projects developers	• Investment of Exoro • Offer guarantees and has the Solar Keymark certification • Network includes solar projects developers and certification bodies	• Investment of customers in demonstration facilities • Offer guarantees • Network is mainly form by possible customers
Approaches of the company	• Sell to international market China • Diversified by selling to different markets • Expand offer to lab equipment and sensor technology	• Sell and offer credit to international market Spain • Sell mainly to the hotel industry	• Approach most venture capital firms • Customer in the mineral industry

5. COMPARATIVE CROSS-CASE ANALYSIS

Chapter 5: Comparative cross-case analysis

5.1 Market barriers 5.2 Company's approaches 5.3 Discussion differences 5.4 Relationships

In this chapter the analysis of the cases is presented. Comparative cross-case is used as analysis method, this method is based in building an explanation for each case and identified the levels of modification for each case (Yin, 1981).The selection of this method is made in the methodology chapter, section 3.3.7. The section begins with a diagram that presents the causal relations between barriers and approaches and their empirical data. The diagram is formed by these three different components: evidence from the empirical observations and results, market barriers from the analytical framework and interviewees and approaches from the literature and results. Then, each of the three types of diagram components is further explain, first the identified market barriers and its evidence is shown, followed by the approaches to these barriers and its empirical data.

5.1 RELATIONSHIPS BETWEEN EVIDENCE, MARKET BARRIERS AND COMPANY'S APPROACHES

This section presents the relationships between market barriers, its approaches and the empirical data. A diagram (Figure 9) is used as a tool to present these relationships. Each of the relationships of the diagram is explained in sections 5.2 and 5.3. The diagram serves as an explanation of the relationships between the identified barriers and its evidence. As example the absence of standards for the technology would result in an absence of tests resulting in the use of incumbent technologies tests by the customers to assess the technology. Using these assessment methods will result in the customer's wary to invest in the eco-innovation. All the relationships are better explained in this chapter.

The stated terms in the diagram are divided in three categories evidence, market barriers and approaches. The evidence statements are explained in the section of the barrier or approach to which are related.

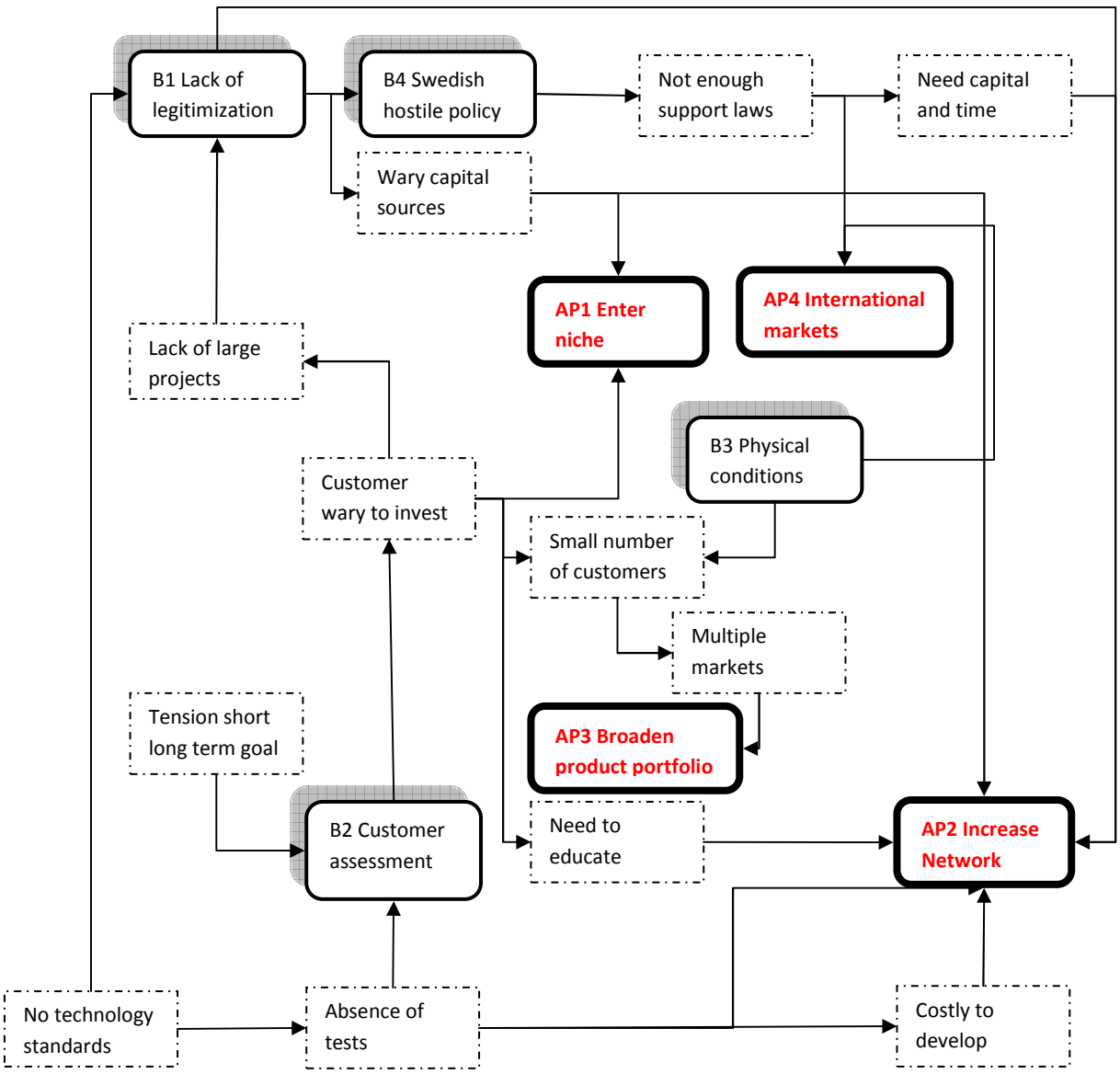

Figure 9: Diagram company's approaches to overcome market barriers # = Barrier AP# = Approach = evidence

The following components are market barriers from the analytical framework identified in the empirical data of the studied cases, and will be discussed in the following sections:

- Barrier 1: Lack of market legitimization, section 5.1.1
- Barrier 2: Customer's assessment, section 5.1.2
- Barrier 3: Physical conditions, section 5.1.3
- Barrier 4: Swedish unsupportive policy, section 5.1.4

The following statements are company's approaches from the analytical framework identified in the empirical data of the studied cases:

- Approach 1: Enter niche markets, section 5.2.1
- Approach 2: Expand their network, section 5.2.2
- Approach 3: Broaden portfolio, section 5.2.3
- Approach 4: Enter international markets, section 5.2.4

5.2 ANALYSIS OF THE MARKET BARRIERS USING THE ANALYTICAL FRAMEWORK

The empirical observations and results chapter shows the main data from the studied companies. The section identifies the main market barriers mentioned in the analytical framework that are present in the studied companies. The section states each barrier identified and relates the main market barriers and its empirical data.

5.2.1 Barrier 1: Lack of Market Legitimization

The lack of legitimization of a technology is considered as a barrier for eco-innovations by various authors (Jacobsson and Bergek, 2003, Kemp et al., 1998, Van De Ven, 1993). For the efficient operation of a market, the legitimization of a new technology is fundamental, its absence often take high quality products out of the market because of the uncertainty in the technology (Van De Ven, 1993). The cases presented in the study show evidence of the causes and effects of the lack of market legitimization. The main evidence of the causes is the absence of start-up's large projects in the Swedish utility market and the fact that there are no standards for the start-up's technology. Evidence of the lack of legitimization in the market is the lack of capital for the start-ups and the perception in our results that current Swedish laws do not offer enough support for the start-ups.

- **Absence of large projects**: Utility companies and government subsidies are mainly focus in technologies that can be applied in large scales (Rising, 2010). Technologies that had not been demonstrated in large scale applications and projects in the market decrease their legitimization (Jacobsson and Bergek, 2003). To gain market legitimization and satisfy customer's demands innovations required large scale use (Kemp et al., 1998). The evidence of the absence of large projects in the market is that the largest sales in Absolicon and Bioprocess Control had been in international markets. Additional evidence of the lack of large projects in Sweden is the fact that Cortus has only one customer and an income of 200 000 Sek last year and the fact that Bioprocess Control has only sold services and not products to the Swedish utility market. These facts show the absence of large scale projects and applications of the start-ups in the utility market.

- **No standards for the new technology**: The creation of a technical standard for the technology is a factor that increases legitimization of a technology (Van De Ven, 1993).The emergence of standards permits to develop a dominant design for the technology that eliminate other designs and decrease customer's uncertainty in the technology (Van De Ven, 1993, Grant, 1995). The

evidence of the lack of technological standards is exemplified by the cases studied. There is no standard for the Cortus AB's plants because is a pilot plant and they are still developing it, and also the lack of standardized test for Absolicon and Cortus technology.

- **Lack of capital for the start-ups**: Lack of legitimization translates in wary capital sources (Jacobsson and Bergek, 2003). Venture capital firms and investors, used experts from the market to assess investment opportunities (Thampy, 2010) .A lack of legitimization in the market would diminish their desire to invest on the technology. The lack of capital by the companies is heavily evident in the studied companies. Both, Absolicon and Cortus perceived the capital to develop demonstration facilities and tests as a main barrier. Cortus interviewee, even, mentioned the difficulty to get capital and the need to contact "*every possible financial institution and venture capital firm*."

- **Not enough support laws in Sweden:** Lack of legitimization translates in hostile policies, if a technology is not legitimize in the eyes of policymakers, the resulting policies would be inconsistent creating uncertainty in the market (Jacobsson and Bergek, 2003). The three companies interviewed stated their preference for different policies in the market that would decrease the uncertainty of the benefits of their technology. Specifically, Absolicon mentioned a feed in tariff for the energy generated by the eco-innovators technology. Knowing that all the energy, heat and gas, generated by the renewable technologies presented in this study would be bought at a premium price would be a major driver for Swedish utilities to become customers of these companies, the absence of this driver is a barrier, because generates uncertainty to customers.

- **Need to educate customers**: To change the lack of legitimization in customers eyes eco-innovators should considers first as educators before being salesman (Bonini and Oppenheim, 2008). The participation of the studied companies in shows and market fairs could be consider evidence of the need to educate customers. Also, the need to educate customers is reflected in the statement of Cortus interviewee that customer's seems interested in the technology even If most of them lack the knowledge to understand them.

5.2.2 Barrier 2: Costumer's criteria to assess new technologies

Costumer criteria to asses new technologies can be an important barrier for eco-innovations, mainly if the assessment criteria is based in incumbent technologies (Jacobsson and Bergek, 2003). Evaluation of technologies is usually undertaken with the criteria used to evaluate the incumbent technologies (Hordern et al., 2008). Incumbent technologies had important advantages if the assessment criteria is based in their technologies main criteria instead of new technologies criteria (Bonini and Oppenheim, 2008).

The cases presented in the study showed evidence of the use of incumbent technologies to assess the company's technologies. Both evidence of the causes and effects of this assessment exist in the companies, evidence of the causes is the absence of tests for the start-ups technology and the high difficulties, the costs to demonstrate these technologies (e.g. Cortus), the customer's lack of knowledge

to understand the technology and the tension between customer's short term goals and long term goals. In addition there is evidence of other factors that make customers to use incumbent technology's criteria to assess the new technologies; these factors are the Swedish Nuclear Power Trauma, the long term perspective on the industry, the exclusion of improvements in renewable technologies and the subsidies received by incumbent technologies. In the other hand, there is also evidence of the effects of using incumbent criteria to assess the technology. This evidence is the tendency to invest in the same technologies in the market and the small number of customers for the new technologies in the Swedish utility market.

- **Absence of tests for the technology**: The absence of tests for the technology makes customer to use the ones of incumbent technologies. Innovations in development phases had not been tested by customers (Kemp et al., 1998). The evidence for this cause is mainly in the Absolicon and Cortus companies. Absolicon required to "draw the map" of how tests are done for their product. Cortus tests and demonstrations are not "*100% developed*" as interviewee stated. Both companies required to elaborate their own test for the technologies since market current test did not apply for their technology.

- **Difficult and costly to demonstrate the technology**: If a technology is difficult to demonstrate to customers it would be difficult for customers to assess the categories where they have advantages compared with incumbent technologies. Also, the three eco-innovations can be considered to be complex, this fact made them more difficult to demonstrate and generate customer's trust (Van De Ven, 1993) . Bioprocess eco-innovation is a complex algorithm that controls the feed rate to the biodigester, Absolicon is a solar system that includes a concentrator, a tracker system and a photovoltaic cell and Cortus is a new gasification process with a series of steps. Cortus AB stated that it is difficult for customer to test their technology because of the lack of demonstration facilities.

- **Customer lacks knowledge to understand the technology**: Customer's uncertainty in the assessment to invest in a technology reduces proportionally with the amount of information that the customer has (Hamberg, 2004). Cortus stated that some of the possible customers do not completely understand the technology. Also, all three companies mainly use internet and direct contact to diffuse their technology these channels make difficult to reach customers and to be trusted by customers (Bonini & Oppenheim, 2008).

- **Tension between short term and long term goals**: Inertia in customer's selections of technologies is the unwillingness to move as a result of the tension between stability and risk, short term performance and long term competitive advantage (Hordern et al., 2008). Both, Absolicon and Bioprocess interviewees stated that the customer is focus in a medium term strategy, the perception of customer's medium term strategy by both companies could mean that their customers face the tension between short and long term goals so they are focus in neither. Still, the best evidence of this fact is the statement of Cortus CEO that customers have "*the short term goal of being profitable and the long term goal of being greener."*

Additional causes present in the market for using incumbent technology's assessments for the eco-innovations were identified by different authors. These causes are:

a) The Swedish Nuclear Power Trauma: Results in Swedish utilities assessing renewable energy technologies in the term of how many nuclear reactors can replace (Jacobsson and Bergek, 2003).
b) Long term perspective in the industry: The market is resistant to changes and requires long period of times to understand how to asses a new technology, the view is that for a new technology it takes 6-9 years to demonstrate, start-up a plant and reach reliable operation (Voser, 2009).
c) Customers do not account the learning curves and economies of scale that would improve and reduce the cost of eco-innovations in the energy market (Porter and van der Linde, 1995).
d) Incumbent energy technologies had received large amounts of subsidies in past years and also indirect subsidies from the fact that costs of externalities had not been add to their costs (Jacobsson and Bergek, 2003).

- **Tendency to invest in the same technology**: Companies are used to invest in technologies that are considered to be in their own domain because the investment risk is considered more controllable than the risk of technologies outside company's domain (Hamberg, 2004). In addition, incumbent technology improves as a result of the entry of a new technology in the market (Kemp et al., 1998). Cortus interviewee perceived the presence of this tendency in the market. Also the results of Vattenfall assessment (Vattenfall, 2005, Mogren, 2007) showed the tendency in the company to invest in similar technologies(nuclear and hydro) and the existence of the sailing ship effect.

- **Small number of possible customers**: Assessing new technologies in terms of incumbent technologies is a big disadvantage for eco-innovations to be selected by customers (Bonini and Oppenheim, 2008). The evidence is the limited amount of sales of all three companies studied in the Swedish utility market. As Bioprocess Control shows it there are not many Swedish plants that had developed efficient biogas plants which can use their technology.

5.2.3 Barrier 3: Physical conditions

When reviewing existing literature physical conditions of Sweden were not identified in the analytical framework as barriers to eco-innovations. However, there is evidence that Swedish physical factors affect the market for eco-innovations in Sweden and can be consider as a barrier. The main reason is the possibility to increase revenue for customers in other countries. Evidence of the effects of these conditions was mainly found in Bioprocess Control and Absolicon as:

- **Small number of potential customers**: The small number of potential customers in Sweden for Bioprocess Control can be explained as an effect of the lack of animal farms to produce manure/sludge that can be feed to biodigesters. Investment in biodigester plants benefit for economies of scale (Olsson, 2010), the larger the plant the less the construction cost by energy generated. Also, a larger plant generates a larger amount of biogas that translates in more

revenues generated for the customers. The absence of these farms is related with the conditions in Sweden. China has showed to be able to have larger projects for the product, this is evidence of the presence of better conditions, mainly more dung/manure produced by farms in that country than Sweden.

- **Geographical characteristics in Spain compared with Sweden**: The amount of sunlight received in Spain compared with Sweden translates in almost the double of energy generated by Absolicon Solar concentrators and, as consequence, higher revenue from this energy. This fact permits customers in Spain to recover their investment in shorter periods of time compared with Sweden customers. An investment with less time of return reduces customer's uncertainty (Hamberg, 2004).

5.2.4 Barrier 4: Lack of policies to support eco-innovations technology

Swedish policies are not perceived as a barrier for the companies in this study. Still, the three of them would like more support from the policy makers. This is evidence that there is a lack of policies as driver of eco-innovations. Market pull is inoperable unless government policies increase the value of renewable technologies (OECD, 2008). Also hostile policy or absence of supportive policy is considered as a barrier by various authors (Smith, 2001, Jacobsson and Bergek, 2003, Kemp et al., 1998). Evidence of the presence of sources of hostile policies in the studied cases is the lack of market legitimization. The evidence of the presence of the effects of hostile policies is the fact that regulations are time and capital consuming and the perception of not enough support from Swedish laws to eco-innovator's technology.

- **Lack of market legitimization:** As explained before in this section the technologies studied lack legitimization this results on hostile policies (Jacobsson and Bergek, 2003). The evidence of the lack of legitimization in the cases has already been presented. It is mainly the lack of large projects in Sweden and the lack of a standard for the technology.

- **Regulations are time and capital consuming**: Start-ups feel that regulatory authorities are unresponsive to their needs since that there is costly and time consuming to verify compliance and applied to subsidies (Smith, 2001). There is evidence mainly in the cases of Absolicon and Cortus of the time and capital consuming processes needed to apply for subsidies and to comply with regulations. Both interviewees perceived this fact as a main barrier.

- **Not enough support laws in Sweden**: The three interviewees stated that they would like more support from Swedish laws to their technologies. A clear example of the insufficient support is the absence of niche markets created by regulations. Laws that required the use of the technologies studied in specific situation would help the adoption of the company's product/services by creating niche markets (Kemp et al., 1998). An example of this regulation is the law of renovated buildings requiring having solar panels in Spain, which creates a niche market for solar energy.

5.2.5 Summary of the analysis of market barriers

Table 9 relates the evidence from the last chapter and the analytical framework from chapter 2. The evidence of the result chapter can be a cause or an effect of the market barrier mentioned in the literature. From the above section we have identified the following market barriers:

Table 9: Summary of the analysis of market barriers

Identified Market Barrier	Empirical data causes	Empirical data effects
Barrier 1 Lack of Market Legitimization	1. Lack of large projects in Sweden *a.* Larger sales are in other countries *b.* Customer's only buy services 2. No standard for the technology	1. Lack of capital 2. Customer's lack of financing 3. Not enough support laws in Sweden 4. Educate customers: a. Expos & trade fairs b. Customer lack knowledge
Barrier 2 Customer's assessment	1. Absence of test for the technology 2. Difficult and costly to demonstrate the technology 3. Customer lack knowledge to understand the technology 4. Difference in short and long term goals	1. Tendency to invest in the same technology 2. Small number of possible customers 3. Lack of large projects
Barrier 3 Physical Conditions	None	1. Small # of potential customers 2. More sunlight in Spain than Sweden
Barrier 4 Lack of Policy's support	1. Lack of legitimization 2. Lack of a clear vision	1. Regulations are time and capital consuming 2. Not enough support laws in Sweden

5.3 COMPANY'S APPROACHES TO OVERCOME MARKET OBSTACLES IN ORDER TO REACH POTENTIAL CUSTOMERS

The last section identified the market barriers of the studied sample. This section will relate these barriers identified and analyses the approaches of the companies in overcoming these barriers. Also, the empirical and literature review data is related to these approaches. The section begins by explaining each one of the approaches identified: Enter niche markets, increase the start-ups network, broaden the company portfolio and enter international markets. Then, a table that relates the approaches with the market barriers is presented at the end of the section as a summary.

5.3.1 Approach 1: Enter available niche markets

The high importance for eco-innovators to enter available niche markets has been stated by various authors (Kemp et al., 1998, Carrillo-Hermosilla et al., 2009). The main benefits from these markets are to better understand customer's needs and industry trends and a source to finance in early stages (Kemp et al., 1998, Grant, 1995). The evidence that studied companies are entering available niche markets is the main customers of the company, as it is explained in the next paragraph.

- **Main customers of the companies:** The main customers of the three studied companies are not in the Swedish utility market. Bioprocess Control is mainly focus in universities and research institutes, Absolicon in the hotel industry and Cortus in the intensive energy industry specifically the mineral industry. These niches markets seems to be form by industry's visionaries of each market and industries were the advantages of eco-innovations are more important than their disadvantages as Kemp, Schot & Hoogma (1998) referred to.

- **Customer's criteria to asses new technologies**: Niche markets are important to demonstrate innovations and start learning processes of customer's needs (Kemp et al., 1998). To enter the Swedish utility market eco-innovations technology required to be long tested (Voser, 2009). Niche markets provide a market to test the technology before entering the Swedish utility market.

- **Wary capital sources**: Wary capital sources are an effect of legitimization. Niche markets finance eco-innovations in early stages (Kemp et al., 1998). Niche markets had an effect of market pull stimulus to eco-innovations (Carrillo-Hermosilla et al., 2009). An example of the market pull that niche markets can have in start-ups is the case of Cortus where the customer is so interested in the technology that he invested to develop the demonstration plant of the WoodRoll technique. This approach by Cortus customer can be a result of the customer's view that investing in eco-innovations is a reduction of risk through the development of future required resources mentioned by Hordern, Borjesson and Elmquist (2008).

All three companies had entered different markets outside the Swedish utility market. This can be explained as the utility market is a mature market where changes take times and investments are long term. These characteristics make difficult to be consider a suitable niche market.

5.3.2 Approach 2: Expand the start-ups' network

Expansion and utilization of a network is considered to be a success factor by many researchers, as an approach to acquire competences and resources required to commercialize and diffuse the eco-innovation (Halila, 2007, Van De Ven, 1993, Hordern et al., 2008, Englund, 2008). The evidence that the studied companies are expanding their network is their various partnerships with other companies and the strength of these partnerships. The main identified barriers that are overcome by this approach are the lack of market legitimization, the need to educate customers and the absence of tests.

- **Partnerships with other companies**: When eco-innovations moves forward their network should increase in size (Halila, 2007). Bioprocess Control, Absolicon and Cortus have a high

number of collaborations with different companies as stated in the results chapter which had increased each year since its foundation.

- **Strengthen collaborations**: When eco-innovations move forward the network should strength in its ties (Halila, 2007). An example of the stronger ties between the companies and other companies are the investment made by other companies in the technology.DSM Dutch has become a shareholder of Bioprocess Control. The venture capital firm Exoro has invested in Absolicon and has provided the marketing director for the company. Finally, Nordkalk, the limestone company, has invested in the demonstration facility of Cortus. The results of these collaborations had helped the companies to overcome their barriers as need of capital, development of tests and educate customers.

- **Lack of market legitimization**: To gain legitimization, technologies required various companies to enter their field to develop a critical mass. A new industry is born when the members of the network start to isolate themselves from other industries developing the new technology (Van De Ven, 1993). Increasing the network permits the companies to reach a critical mass for the technology.

- **Need to educate customer**: Government and environmental institutions can help eco-innovations to be diffused (Smith, 2001). All three companies have this type of members in their networks.

- **Absence of tests**: Linking with different organizations permits eco-innovators to appropriate resources and competences required to commercialize the technology (Van De Ven, 1993). To develop tests innovators require resources and competences. An example of members of the network helping an innovator to develop tests is the Absolicon's collaboration with the Swedish National Testing and Research Institute.

5.3.3 Approach 3: Broaden Portfolio

Even if this factor has not been found in the analytical framework, the interviewees had mentioned (e.g. Bioprocess Control & Cortus) it as an approach to face the market barriers. This is explained by Grant (1995) who said that first customers assist in the development of new products to better fulfill their needs. The evidence of this statement is the customers in multiple markets by the companies, the more different customers the more products that form the start-up's portfolio. Broaden the portfolio helps companies to increase their number of customers.

- **Possible customers in multiple industries**: Bioprocess Control and Cortus are stated to be focused in various different markets. Bioprocess sales to biogas plant developers, research universities and Swedish utilities. They had found a niche market in the universities and research products, to better serve this market they needed to develop additional products as sensors and measurement systems in addition to their innovation. Cortus is focused in the intensive energy industry but is also interested in other markets as the utility market and the transport. With the intention of better reach these markets Cortus is assessing the possibility to develop a CO2 sequestration method and a hydrogen generation process.

- **Small number of possible customer**: Small number of customers in the Swedish utility market is a result of the utilities assessment methods. The effect of the small number of customers in this market is the entry of innovators in other markets. To fulfill the needs of these different markets the product portfolio should be increased.

5.3.4 Approach 4: Enter international markets

Other approach that was found during the interviews of the companies is to enter international markets. This approach was taken by two of the studied companies (Bioprocess Control and Absolicon). The evidence of this approach is the sales and representative units in other countries. The barriers that are expected to be overcome by this approach are the Swedish physical conditions and hostile policy.

- **Sales and representation units in other countries**: The main sales of both companies had been in other countries, Absolicon in Spain and Bioprocess Control in China. Companies had installed a facility in these countries, Bioprocess control has a subsidiary in China and Absolicon has an assembly facility in Spain.

- **Physical conditions**: Both countries offer better physical conditions for the eco-innovator's technology. China has more and larger animal farms than Sweden. Spain receives a higher amount of sunlight than Sweden. Companies want to entering international markets that expands more rapidly that the local ones (Hafstrom and Max, 2009).

- **Policy to support technology:** In the case of Absolicon Spain offers a better support from the policy to the solar cell technology. Feed in tariffs, laws to ensure the use of solar panels in new and renovated constructions are examples of the Spanish support policies.

5.3.5 Summary of the analysis of company's approaches

Table 9 relates the evidence from the empirical observations and results chapter and the analytical framework from chapter 2. In addition, it also relates the barriers identified in the last section to the success factors and approaches of the companies.

Table 10: Summary of the analysis of start-up's approaches

Barriers	***Approach***	***Empirical data***
Barrier 1 Lack of Market Legitimization	*Approach1:* Enter available niche markets. *Approach2:* Expand the start-ups network	• Their first customers are research institutes, hotel, and mineral industry, instead of Swedish utility market. • Partnership with other companies and strengthen collaboration
Barrier 2 Customer`s criteria to assess new technology	*Approach1:* Enter available niche markets. *Approach2:* Expand the start-ups network	• Go to niche market to test the technology before entering the Swedish utility markets • Linking with different organizations to commercialize the technology • Collaborating with other organization to develop tests.
Barrier 3 Physical condition	*Approach3:* Broaden product portfolio *Approach4:* Entering international markets	• Find possible customers in multiple industries • Development of new product • Development of new products for different market. • Sale and representation units in other countries
Barrier4 Lack of policies to support eco-innovation technology	*Approach4:* Entering international markets	• Go to international markets

6. DISCUSSION

After having identified the main market barriers and companies approaches in the analysis chapter, these barriers and approaches are discussed in this chapter. First, the variations in market barriers and approaches between the studied cases are further discussed and explained by the characteristics of each company. Then, a discussion of the main challenges and barriers that may result of the companies approaches is carried out.

6.1 DISCUSSION OF THE DIFFERENCES IN MARKET BARRIERS AND APPROACHES FROM THE STUDIED COMPANIES

The identified market barriers and approaches of the last sections showed some differences between each company. In this section the authors explain these differences by using the characteristics of each company, stated in Table 6. Start-up's characteristics are presented and its effects in the variations of market barriers and approaches for each company are discussed, a table relating the company characteristic and its effects on companies and barriers is showed at the end of each section.

6.1.1 Type of eco-innovation

Brezet (1997) presented a classification of eco-innovations dividing them in product improvement, product redesign, function innovation and system innovation. The studied companies have different types of eco-innovations. Bioprocess Control can be classified as a product improvement because it is an improvement for biogas plants. Instead, Absolicon and Cortus eco-innovations can be considered as system innovations. Absolicon solar concentrator is a complete system that requires infrastructure changes for the customers to use the heated water, also is a new process to produce and supply power and heat to customers. Cortus process requires new plants to use the system for Swedish utilities customers, is a new process and the synthetic gas is a different product compared with the natural gas or other fossil fuels that substitute. Both companies had developed complete system to convert a raw material in an energy product, electricity and heat by Absolicon and synthetic gas by Cortus. The main market barriers affected by the difference on the type of company's eco-innovation are the lack of market legitimization and the costumer's criteria to assess the technology. In addition the expansion of the start-up network was also affected.

- **Lack of market legitimization**: The absence of standard becomes more important for system eco-innovations as the ones of Absolicon and Cortus. Since, the eco-innovation is a complete system most of the standards and designs need to be developed by them. Both companies will require developing all the processes and devices for the systems and establishing them as the standards in the market.

  Instead, Bioprocess product is an improvement of biogas plants, so, the company does not require to develop all the standards of biogas plants and devices (as biodigesters, manure mixers, etc). The cost to develop the standards for the product is less, since is just a part of the process of a larger system. Still, the company requires the legitimization of the technology

compared with other similar solutions that biogas plants need. Anyhow, it would be of great interest for the company to be part of the development of a dominant design of biogas plants in the market. This might be possible by forming alliances with companies that offers complementary devices and processes. These partnerships will permit Bioprocess Control to be a part of the dominant design and reduce the resources required to develop standards.

- **Costumer's criteria to assess new technologies**: There is a difference in the costs and resources required to demonstrate and fulfill customer's evaluation and tests as a result of the type of eco-innovation.

  The system eco-innovations (Absolicon and Cortus) both perceived the test and demonstration of their technology as the main barrier in the market. This can be explained by the fact that they need to build the facilities and develop their own test to certificate their technologies for government regulations and customers. Their technologies cannot be added to other systems and they need to test each process and device of their complete systems. This fact results in high costs to demonstrate the technology and comply with regulations. Also, demonstrate the technology required longer periods of time and a larger amount of tests resulting in longer times to reach the market.

  The improvement eco-innovation (Bioprocess) studied in this research showed to be easier to demonstrate the technology to customers. The interviewee did not perceive the customer and regulation tests as a barrier and believes that is easy to demonstrate the technology to customers.

- **Expand the start-up's network**: The expansion in the network by companies with a system eco-innovation has included strong ties with members that help the companies to develop their tests. In the case of Absolicon, it had worked closer with certification authorities as the Swedish National Testing and Research Institute. Cortus has highly involved their customers in the development and design of the synthetic gas demonstration plant.

Table 11: Effects of the different type of eco-innovation in the market barriers and company's approaches

Type of eco-innovation	**Product Improvement**	**System**
B1: Lack of legitimization	• Influence standard	• Create standard
B2: Customer's assessment	• Less costs and resources • Easier to demonstrate • Less time to market	• More cost and resources • Difficult to demonstrate • Larger times to market
AP2: Expand the start-up's network	• Stronger links with distributors	• Strong link to test developers

6.1.2 Renewable technology

Each of the studied cases has a different renewable technology (biogas, solar, gasification of biomass). The main market barriers affected by the difference on renewable technologies are the Sweden physical conditions. These barriers are highly linked with the approach to enter an international market.

- **Physical conditions**: These conditions affect each company differently, specifically the inputs required by each company's technology to generate energy. For solar and biogas technologies, it showed to be a barrier for the development of the technology and for biomass gasification technologies showed it to be beneficial.

For Bioprocess Control and Absolicon Solar, Sweden have less of the required inputs for their technologies compared to other countries. Bioprocess Control requires manure/dung for large animal farms that are not many in Sweden because the physical conditions required by animals which results in a small amount of biogas projects developed in the country. Instead, Absolicon suffers from the low amount of sunlight in Sweden compared with other countries that result in less heat and power production for the customers translating in smaller revenues from Absolicon's products for their Swedish customers.

On the other hand, the physical conditions in Sweden may benefit Cortus AB. Mainly the abundance of forests and wood companies that have a large amount of biomass residues that can be used as raw material in the WoodRoll process. Also Sweden's physical conditions permit the country to have large energy intensive companies (mainly in pulp and paper and mineral industries) that can be used by Cortus as a niche market.

- **Enter international markets**: Solar and biogas technology companies had entered international markets that offered better physical conditions.

Table 12: Effects of the different renewable technologies in the market barriers and company's approaches

Renewable technology	Biogas	Solar	Biomass Gasification
B3. Physical conditions	• Less biogas plants	• Less sunlight	Beneficial physical conditions
AP4. Enter international markets	International markets present more advantages	International markets present more advantages	Sweden present more advantages

6.1.3 Founder's background

The studied companies have different backgrounds. Bioprocess is the result of a University research spin-off. Absolicon Solar and Cortus had an industrial background. Cortus has been founded based on the experience of its founder in industrial services mainly high temperature combustion processes. Absolicon has a mixed background; the product is the result of a project between different universities. In addition, their CEO and founder is part of the family behind the Logosol Company. The background of the companies mainly affects the following approach of the companies:

- **Enter available niche markets**: There are differences in the types of niche markets entered by the companies. Cortus AB has approached the mineral industry where high energetic gases are required to provide high temperature to processes. It can be argue that because its background Cortus has a better knowledge of this type of customers and also a network in this sector. Absolicon has contacted hotels that require large amounts of hot water and are located in zones that receive large amount of light annually. Probably, this market was not part of the founder background, but, the 20 years experience of the CEO in Logosol corporate strategy team could make him able to acquire the knowledge required to select a suitable niche market. This kind of customers can be considered to be market visionaries because they have the insight to match a new technology with a strategic opportunity (e.g. Moore, 2007).

  Bioprocess Control is the result of a University research spin-off, because of this, it can be argue that have a better knowledge of this type of customers and also a network in this sector. Universities and research institutes can be consider as technology enthusiast since technology is a central interest in their functions and tend to explore new technologic devices (Moore, 2007).

Table 13: Effects of the different start-up's background in the market barriers and start-up's approaches

Start-up's background (2005-2010)	University	Industrial
AP1: Niche Market	• Technology enthusiast	• Markets visionaries

6.1.4 Number of customers

The number of customers of the innovation is highly related with the phase of the eco-innovation. Cortus only have one customer and can be considered to be in the test and demonstration phase of their eco-innovation. Instead, Bioprocess and Absolicon can be considered to be in the early commercialization of the technology phase (Halila, 2007). This difference affects the following company's approach:

- **Expand the network**: As stated by Halila, (2007) the focus in the early stages is on solving technological problems and testing the technology. Instead, in further stages the focus is on the market.

  Companies in a further stage, Bioprocess Control and Absolicon, had integrated biogas and solar project developers to their networks. Strong relationships with this type of companies have helped both companies to expand their sales.

  In the case of Cortus, which is in an early stage, possible customers in the mineral industry had helped with the development of demonstration and test facilities. These customers would be the final users of the synthetic gas produced by the company.

Table 14: Effects of the different amount of customers in the market barriers and start-up's approaches

Number of customers	1 customer	More than 1
AP2: Expand the Start-up's Network	• Mainly form by technology testers	• Mainly form by Distributors

6.1.5 Strategic focus markets

The different strategic focus markets of the company had highly affected one of the approaches:

- **Broaden portfolio**: The difference on the strategies to broaden the portfolio is a clear evidence of the type of markets that the companies had enter or are interesting on. Also, these strategies showed the focus that companies had in their respective markets.

  Bioprocess Control has broadened their portfolio in order to fulfill the needs of their niche markets. Research institutes and universities used a large amount of products to measure their research projects and experiments. This need is reflected in the sensors developed by the company. These sensors can be useful in the early phases of development of biogas plants to measure the potential of the dung.

  Absolicon Solar has not increased its product portfolio. It has two different products a solar system that produces only heat and one that produces both heat and power. Here, the additional product is based in the first product but includes additional features. This strategy helps the company to focus in a specific product and a specific market.

  Cortus AB offers two main products: a complete system to generate synthetic biogas and the supply of biogas. These different products are for different markets. Still, they are part of the integrated process and are highly related. However, the company has plans to expand their technology to develop CO2 sequestrating solutions and hydrogen generation. It seems that the company future strategy would be a economies of scope one using one technology to develop different products (Granstrand, 2007). Also these new applications show the desire of the company to enter the Swedish utility market, because these two additional applications (specially the CO2 sequestrating system) are solutions of high interest in the industry.

Table 15: Effects of the amount of different strategic focus markets in the market barriers and company's approaches

Strategic focus markets	One market:	Multiple markets:
AP3: Broaden product portfolio	• Maintain same products	• Broaden portfolio

6.2 DISCUSSION OF CHALLENGES CAUSED BY COMPANY'S APPROACHES

The approaches of the companies could result in further challenges for the eco-innovators. A wrong management of the different challenges of the approaches can became a further barrier. In this section the main challenges for each company's approach would be discussed.

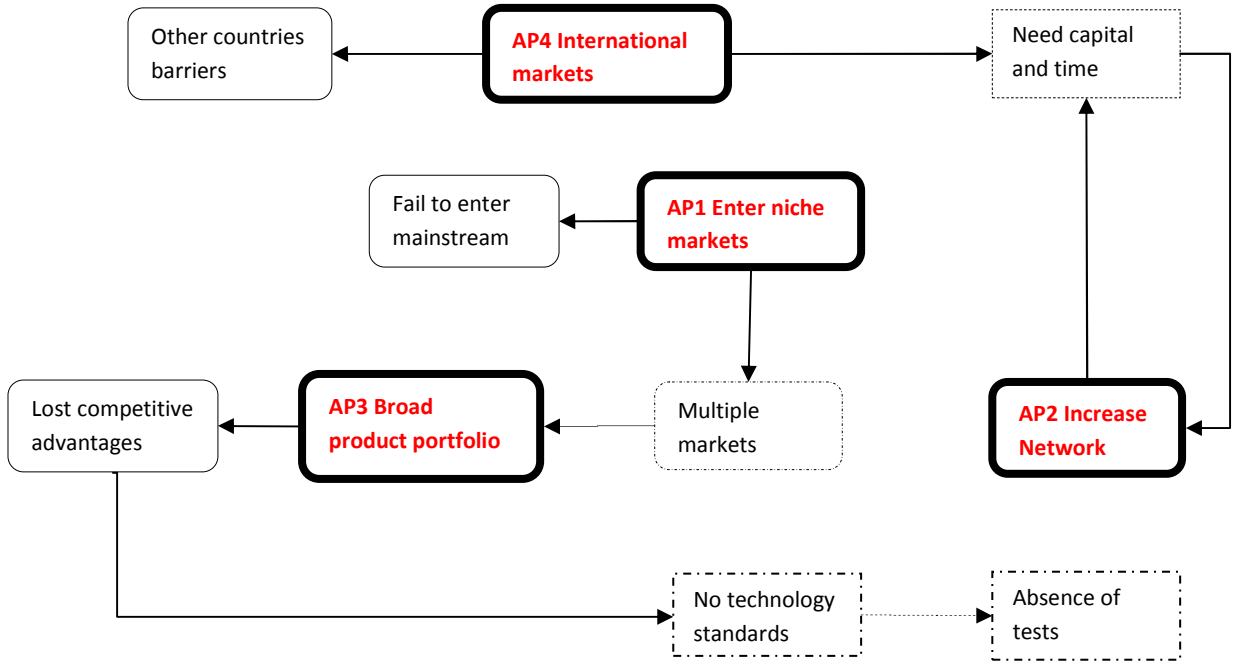

Figure 10: Challenges caused by company's approaches AP# = Approach = Evidence

- **Main challenges and success factors of entering niche markets**

Even, when a company has reached a niche market, the possibility that the company disappears or being bought by a bigger company is high. Kroeger, Vizjaket and Moriarty (2008) stated that around 80% of the companies are niche players and less than 1% of these companies become a global market leader. Most of them will disappear as a result of the consolidation of market leaders in their niche markets. Sooner or later another company with a more innovative product will enter these niche markets, by then start-ups should have enter a mainstream market or otherwise they will disappear (Moore,2007).

Without the focus in the needs of a niche market the further development of the eco-innovation would be difficult to differentiate for other products. So, it would be more difficult to become a dominant design in any market segment. Faulting on becoming the dominant design in a niche market will result in no standards for the product and a feedback loop for the absence of standards barrier.

The main success strategies to move from a niche market to a mainstream global market is to focus company's product in the needs of a specific niche market or customer (Moore, 2007; Kroeger et al., 2008). Leverage the product of the company and its competences and selecting a fast growing segment of the mainstream market as a niche market are factors that help to create a critical mass in the market and became the differentiated dominant design (Kroeger et al., 2008).

- **Main challenges and success factors of increasing the network**

Increasing the network is a key approach when looking to the literature and the interview's results to overcome market barriers. In order to benefit from collaborations and partnerships with other companies, it is important to have a clear view of the objectives of the members of the collaboration and that all members have incentives to do their best effort to achieve these goals (Granstrand, 2009). Without these factors collaborations can result in a waste of time and capital. It can be argued that efforts to increase the network could result in the entry to multiple markets by eco-innovators with its consequent challenges.

Another vital action for the innovator is to strengthen relationships whit parties who posses' complementary knowledge and resources (Halila, 2007). Stronger ties bind organizations in long term and intense relationships and also play a key role for the innovator to acquire the required competences to move from the initial stages to a successful company development (ibid).

Keeping weak ties in the network could result in failing to acquire the competences and resources to overcome the market barriers of customer's lack of information, need of capital and test development.

The time and capital needed to expand the network can create a feedback loop to increase the capital and time barriers. Also, increasing the network can magnify the importance of a correct management of multiple markets and its products.

- **Main challenges and success factors of competing in multiple markets & broaden the product portfolio**

Entering different markets could result in a lack of focus in a market and a difficulty to differentiate in one specific market segment (Moore, 2007). Broaden the product portfolio will also increase the need to develop the standards and tests for the new product. It is important to develop products that fulfill 100% the needs of the first customer to solidify the market segment of the company before approaching other markets and/or increasing the product portfolio.

From this perspective the product line strategy of Absolicon seems better fitted to focus in the first customers and niche markets. In the other hand, Bioprocess Control is broaden their product portfolio to focus in their niche market but this could become a problem since they could decrease the attention in their applications and control products to the Swedish utility market. Entering multiple markets is seen as a good strategy to diversify the risk to depend of only one customer but in the early phases customizing the product to the first customer and solidifying the company position in a niche market is a key factor. Keeping the balance between diversified customers and customer focus is a main challenge for start-ups. For Cortus, solidifying its position in the energy intensive industry would be important before developing additional applications as carbon sequestrating and hydrogen generation.

The lack of focus in a niche market, competing in multiple markets and broaden the product portfolio can increase the need for standards and product tests as a response of the increase in the number of products. In addition, there would be a need to overcome most of the barriers found in the utility market. A success factors is to identify the main competitive advantages of the product in the current niche market and further leverage them (Kroeger et al, 2008).

- **Main challenges and success factors of entering international markets**

Entering international markets is an approach that requires capital and other resources to carry on. Both studied companies that enter an international market required to install a permanent business unit in the foreign country. Evaluating the advantages of establishing international units to enter these markets against the required resources to follow this strategy is a challenge for eco-innovators. In the studied cases, companies identified important advantages in foreign countries for their products.

Entering international markets bring additional barriers that may not be present in the Swedish market, as in the case of Absolicon with their Spanish customers who have problems to get loans to buy Absolion's product. An approach to this barrier could be the one taken by Absolicon, to offer credit from Swedish institutions to their customers. Mixing the advantageous factors of different countries market could be a success factor to enter international markets.

Table 16: Damaging and success factors of start-up's approaches from the literature (1) and the cases (2) (See figure 11)

Approaches	**Damaging factors**	**Success Factors**
Approach 1: Enter niche markets	Unfocus in one niche market(1) • Lost competitive advantages • Fail to establish the product as the dominant design Select a not growing niche market(1) • Difficult to reach a mainstream market	Focus in a niche market were customers have the same needs for the product (1) • Leverage their product and competences • Become the dominant design in the niche Select a growing niche market(1)
Approach 2: Expand the start-up's network	Lack of clear goals for partnerships(1) Lack of commitment by partners(1) Form by weak links (1,2) • Waste of resources	State clear goals for partnerships(1) Ensure commitment of partners(1) Form strong links(1,2) • Acquire resources
Approach 3: Broaden portfolio	Unfocused in one market (1) • Lost competitive advantages • Fail to establish the product as the dominant design Too different products(2) • Lack of standards • Need of resources	Develop additional features for products to fulfil current niche demands(2) Diversify with different clients with similar needs(2) • Increase competitive advantage
Approach 4: Enter international markets	Unfocused in niche market(1) Enter countries with other market barriers(2)	Align with current niche markets(1) Use Sweden success factors for other countries(2)

7. CONCLUSIONS

Chapter 7: Conclusions

Answers to the research questions

For the conclusion chapter of the master thesis, first each research question is answered. Then, suggestions for further research are stated. Finally, managerial implications of the study are discussed.

7.1 ANSWERS TO THE RESEARCH QUESTIONS

In this section the research questions stated in the first chapter of the study are answered. To answer these questions, a literature review focused in the main market barriers and market success factors of eco-innovations was carried out. Moreover, interviews and reports from companies of the Swedish energy utilities were added to the literature review to create an analytical framework. In addition interviews were carried out to three companies in the renewable energy field. The empirical data of the interviews and companies report was analyzed using the analytical framework. Finally a discussion of the different market barriers and approaches and its effects in the companies was developed.

- **RQ1 What are the main market challenges for the start-ups with renewable energy eco-innovations?**

The results are that the main challenges that affect the market diffusion and adoption in Sweden for the start-ups with renewable energy eco-innovations are:

- The lack of market legitimization
- Biased customer's criteria to assess the technology
- Sweden geographic conditions
- Absence of support by regulatory policies

These barriers have been shown to vary depending of the characteristics of the companies. The main identified characteristics that affect these barriers are: the type of eco-innovation and the kind of renewable technology. If the product is a system eco-innovation the lack of legitimization and the customer's criteria to assess it, will be more important barriers than in the case of improvement eco-innovations. The type of renewable technologies will relate mainly to the favourable or unhelpful conditions and policies on Sweden mainly in the case of solar and biogas technologies compared with other countries.

Most of the evidence from the interviewed companies is related to the costumer's criteria to assess the eco-innovations, using incumbent technologies parameters to asses them is the main barrier in the market.

- **RQ2 How are start-ups in the renewable energy sector working to overcome market obstacles in order to reach potential customers?**

The study results show how start-ups in the renewable energy sector are working to overcome market obstacles in order to reach potential customers. These main approaches used by start-ups are:

- Enter available niche markets
- Expand their network
- Broaden their product portfolio
- Enter international markets

These approaches can vary depending on the characteristics of each company. The main characteristics that affect these approaches are: the kind of renewable technology, the background of the eco-innovator, the number of customers and the strategic focus markets. The kind of renewable technology affects the entry to international markets; there are renewable technologies that had more favourable physical conditions and policies in other countries, as the solar and biogas technologies. The background of the eco-innovator behind the company affects the selection of a niche market; eco-innovators are more comfortable with markets that are linked to their background. The number of customers affects the type of companies integrated to their networks. With more customers eco-innovators look mainly for distributors instead with fewer customers eco-innovators look mainly for technology testers. Finally, the number and focus of start-ups strategic markets affects their product portfolio.

Enter more advantageous niche markets, before entering the Swedish utility market is common in all studied cases. Another common approach for all cases is the expansion of the network and strengthens of network's links.

7.2 FURTHER CONTRIBUTIONS OF THIS STUDY

In addition of answering the research questions, this thesis also discusses suggestions for further research based on the findings of this study and managerial implications that emerge from it.

7.2.1 Managerial implications of the study

In addition to the theoretical contributions of this thesis there are also practical contributions from this study. Management implications are in the level of awareness to start-ups managers about the main market barriers and their possible approaches. The implications for managers are focused in the following areas:

- Strategies to enter the Swedish utility market
- Creating value from relationships between the company and external actors
- Understand the relationships between the utility market and their environment

In the topic of strategy, the main market barriers were identified. In addition at least one approach to face each barrier is mentioned in the thesis. Each approach can be a part for start-ups strategy to enter the market. Managers can analyze the presence of the main market barriers found in the literature in their companies by using the presented analytical framework. Also they can get a better idea of these

barriers by identifying the type of eco-innovation and the type of renewable technology. If the main barriers found are the ones mentioned in this study, managers should start to approach the market by following the two approaches mentioned in the literature and present in the empirical result of this thesis: enter available niche markets and expand their company's network.

This research helps managers to identify the main point to focus hen entering niche markets and increasing their network. Identifying an available niche market is important this identification should be made by using the advices in the discussion section selecting a niche market where the advantages of the eco-innovation are more significant than their disadvantages compared with the incumbent technology, the niche market should be a growing one and should offer to enter a mainstream market in the future. Then, understand the needs and evaluation methods by the customers in this market and start the creation of standards and tests for the eco-innovation. An important part of the resources and capabilities to enter these niche markets should be acquired by increasing the eco-innovative start-up network. Understanding the main goals for each partnership created and focusing in how this goal would translate in a better position in the market without consuming excessive resources is a main aspect of the approach of increasing the network.

The research explains the importance to focus in becoming the dominant design in the niche market to successfully reach a mainstream market.

Also, the identified barriers and approaches help managers to be aware of the main resources and competences required for their eco-innovations, once they are in the market. The study states the need of start-ups to develop a network to acquire these resources and competences.

Finally, the research can be also used to build a snapshot of the Swedish utility market. The study identified the main barriers in the market and its main characteristics.

7.2.2 Suggestions for further research on eco-innovations

This study has identified and described basic concepts in the area of eco-innovations, as part of its literature review, helping to better understand this research field. In addition, the developed analytical framework can be used as a tool to frame and identify the market barriers and approaches of start-ups with eco-innovations. Further studies to identify these market drivers, barriers and success factors presented in the analytical framework in other start-ups are required. Also the use of this framework to evaluate all types of companies with an eco-innovation not only start-ups would be desirable in order to optimize it. Eco-innovation is a research field that is in exploratory phase and development of analytical frameworks for this field is highly needed.

During the study the interactions between individual eco-innovators and the Swedish utility market and other markets where presented from the eco-innovator's point of view on a micro level. The presented interactions can be taken as a point of departure to identify the interactions in macro and meso level by further studies. Also, policy is viewed as a main factor that affects the market barriers and approaches of the start-ups, further studies to better explain the effect of renewable energies policies and its effect in start-ups strategies should be carried on to complement this research.

The result of this study aims to explain what market barriers exist in the Swedish utility market and how eco-innovations in the renewable energy field face these barriers. Answering these questions help to build on the theory of how technology and innovation influence the competitiveness of firms. However, before the contributions of this research can be part of a theory further studies should be carried out with eco-innovators in the renewable energy field entering the Swedish utility market. Three case studies are far away to build a theory but can be a start and contribute for further research. Special focus should be used to explain the variances between each studied case in the area. Also, explanation should be given why the companies take these approaches and why some approaches are more successful than others in order to develop theory in the area.

The research methods used in this thesis are an example of how an exploratory research can be carried out to study a new theoretical field as the case of eco-innovations. Further studies are required to validate the use of these methods in this kind of researches and in the eco-innovation field.

There is a lack of quantitative data and longitudinal studies in eco-innovations. Further evidence of the market success of the studied companies and eco-innovations in the Swedish utility industry will complement this research and be a big step to develop theory and help eco-innovations in this market.

Finally, this research has provided a snapshot of eco-innovative start-ups in the utility market. Eco-innovations seem to be the only option to reach the goals of reducing global warming, the pollution and the use of fossil fuels in the world and achieve sustainable development. Start-ups play a key role to introduce these eco-innovations mainly the radical eco-innovations that offer a higher upside. Still, the research of eco-innovations is in the exploratory stage. This study reaches the goal of explaining the main barriers and approaches of eco-innovators and helps to build theory about the subject of start-ups driven by eco-innovations.

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APPENDIX 1: QUESTIONAIRE TEMPLATE

Company :

Name:

Position:

Before the interview starts

Present myself
Describe the research project
Definition of Eco-innovation
Why their company was choose to be interviewed
How the data collected will be used
Company level perspective
Are there any questions before we started?

Background

How long have you worked at the company?
Which are the main products of the company? Is only the innovation?
Sales revenue 2009? The year before (2008)?
How many employees are part of the company?
In which sectors and industries are current clients? And potential clients? And users?
Which are your main business partners?

Obstacles General

What are the main obstacles in the market for the innovation to be introduced and to spread?
How the obstacles are approach?
Is there any main challenge in this approach?
Which are the main challenges to introduce a new technology in the energy field?

Innovation Difussion

How you diffuse the information of the innovation to the customers? (Main characteristics)
How difficult is to get a first customer?
Do you consider Environmental laws and standards as a barrier? (permits, taxes, law)
What are the means of diffusion for the company? (Scientists, environmental groups, the government the media or own company)
Do you market to different niches differently?

Price and costs

Do you market your product primarily on price, quality, performance or environment?
What is the price strategy of the company?(Benefits that the product brings, operative cost, similar products in the market, proportion of the costs)

You add a premium price from being an environmental product?
How long takes for the customer to recover an investment in the innovation?
Is it possible to highly reduce costs of the product if the quantity of products sales increases?
Do you think the costs of the product would reduce in the future? Why? (Learning curve)

Product characteristics

How difficult is to scale up your products?
Do you offer guarantees or compensation fees to your customers?
What is the availability of the product?
Is easy to trail the product before buying it?
What your products/services offer than others don't?
Do they bring additional revenues to the customer?
The innovation can help to cut emissions well below required levels?

Customer relationship

Are you involve with the customer since design or is more an add on product?
Do your products reduce the cost of electricity generation for the customer? How much?
How costly is to demonstrate the innovation and its benefits?
Which are the risks of investment for the customers?
Does the innovation solve a higher priority problem of customers?
Is there Skepticism from the customers?
The customers in the sector that you are focusing have been lock-in other technologies? How easy is to change to yours?
The customers improve their reputation by using your products?

Customer characteristics

Your costumers are focused in short term or long term goals?
Your Costumers fight environmental standards and taxes?
Is a lack of importance of sustainable trends for the customers?
Is there a tendency to invest more of the same in the market?
Is there an unwillingness to finance technologies in the bottom of the business cycle for the market?
How the decision to adopt the product is made by customers? it includes outside experts, internal specialists and/or top management of the customer ?

APPENDIX 2: SELECTION OF THE THREE STUDIED COMPANIES

The table has represented the companies' information of finalists of the Swedish Environmental Competition (2004-2008). Furthermore the 3 companies, which were selected in our study were highlighted in this table.

Company	Eco-innovation summary	Type of eco-innovation Englund, 2008	Utility market	Access	Year
OrganoClick	Cellulose properties	Substitution of hazardous			2008
Applied Nano Surfaces	Reduce friction by coatings	Energy efficiency			2008
Sondero Technologies	Measure new parameters	Traditional Env Tech			2008
Solar Water	Purified water using solar	Traditional Env Tech			2008
NAYVOC	Sand moulds greener product	Substitution of hazardous			2008
Rerail	Extend the use of rails coat	Material efficiency			2008
Woodroll	**Use of fat gas from firewood**	**Renewable energy**	**Yes**	**Yes**	**2008**
Baggis	Organic waste in a bag	Renewable energy	No		2008
Heliospectra	Plant illumination	Energy efficiency			2008
Cefibra	Plastic composites less weight	Boundary transgresion			2008
Buble Expasion Valve	Heat exchange coolers	Energy efficiency			2008
Kuzmin	Skis scrap iron wax	Substitution of hazardous			2008
Soottech	Soda pan of pulp plants	Traditional Env Tech			2008
Viogard	Protect ships of grow bodies	Boundary transgresion			2008
NordIQ	DH at an even temp	Renewable energy	Yes	No	2008
Bioprocess control	**Control Biogas**	**Renewable energy**	**Yes**	**Yes**	**2006**
Rapid Slurry forming	Die cast metal process	Material efficiency			2006
El-forest	Vehicle to transport wood	Substitution of hazardous			2006
Flying doctors	Pesticides using bees	Substitution of hazardous			2006
Weed cutter	Weed mech. Cutter	Substitution of hazardous			2006
Accumulator tank	Water div in a tank	Energy efficiency			2006
Green&Cool	CO2 use to cool	Energy efficiency			2006
Smarter	Accesorie for pneumatic	Energy efficiency			2006

pneumatics					
Toxic Substance Meter	Measure mercury	Traditional Env Tech			2006
Stridsberg	Power transmission	Energy efficiency			2006
CAPEE	Sotware for pulp	Material efficiency			2006
Sunano	Solar absorber	Renewable energy	Yes	No	2006
Helium balls	Hydrogen gas cars	Renewable energy	No		2006
Chip electricity	Chips trans heat in elect	Renewable energy	No		2006
Kari	Fish debonned machine	Energy efficiency			2006
Aureola Swedish	Cooling method	Energy efficiency			2005
Noda Intelligent systems	DH load control	Energy efficiency			2005
New generation CVT	Gear box less friction	Energy efficiency			2005
Formation Master	Paper fabri method	Material efficiency			2005
MAN concentrator	Micro gold wash machine	Substitution of hazardous			2005
Elgocell AB	District heating method	Renewable energy	Yes	No	2005
Senitec SEA	Clean water from oil	Traditional Env Tech			2005
The slyp	Clean water oil algaes	Traditional Env Tech			2005
Nolson system	Seawer management	Recycling and waste manag.			2005
Svenska Aerogel AB	GHG gel filter	Traditional Env Tech			2005
Solar 8	**Focus sun energy to a cell**	**Renewable energy**	**Yes**	**Yes**	**2005**
AHE exchanger	New heat exchanger build	Energy efficiency			2005
CFC	Recycling material from tyres	Recycling and waste manag.			2005
TopCote	Repair damage sewage	Recycling and waste manag.			2005
Northern Lighting Sys	Replece bulbs with leds	Energy efficiency			2004
Vibisol	Chushions of gas to reduce vibr	Traditional Env Tech			2004
Greeb SH ethanol	Microorganism to produce ethanol	Renewable energy	Yes	No	2004
Kjell floor	Recycle floor avoid epoxy	Recycling and waste manag.			2004
Stump cultivator	Stump hauling roots	Renewable energy	No		2004
Amide Insect stopper	Protect trees from bugs	Substitution of hazardous			2004
Sealing cracks method	Recycle amterial	Substitution of hazardous			2004
Concrete joints	To construct reduce	Material efficiency			2004

	cement				
De-ionized water	Used to clean facades	Substitution of hazardous			2004
Good nicotine	Avoid acorns	Substitution of hazardous			2004
Turbo	Best combustion points	Energy efficiency			2004
Smoke gas condenser	Attach to a boiler	Traditional Env Tech			2004
Tube with a screw	Get every paste	Material efficiency			2004
Vasasensor	Sensor for paper	Traditional Env Tech			2004
KAS comfort sys	Measure water and indor t	Energy efficiency			2004
Case studied		Pass filter	Pass	Pass	