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Cleantech System Solutions

A case study on how to manage the necessary knowledge to prepare for a transaction

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Abstract

Climate change and a growing awareness from governments, industry and citizens have led to an increased growth of the cleantech sector, with the goal to reduce the industrialized world's impact on the environment. There are a number of Swedish system solutions based on clean technologies which to a large extent are at the forefront of the industry. The Swedish government has put forward an ambitious goal that Sweden should become a role model in cleantech system solutions and is striving to increase the export of these system solutions. There is a large amount of knowledge in cleantech system solutions that is important to manage and prepare before a solution can be transacted and commercialized. With the development of the knowledge based economy, knowledge transactions become essential. This cannot be ignored in the knowledge intensive cleantech sector and to strategically manage the valuable knowledge is necessary in order to appropriate the value of celantech system solutions in the commercialization. The aim of the study is to increase the understanding of the relevant factors that influence the management of the necessary knowledge in cleantech system solution. Thus, the main research question for this study is:

> *How can necessary knowledge in a cleantech system solution be managed to prepare for a transaction of the solution?*

The method used to investigating this research question is a qualitative case study with interviews, observations and review of relevant documents from an in-depth case study of BIOAGRO ENERGY AB, a system solution in the field of biomass-pellet production. The focus of the thesis has been to combine previous research in the field with the gathered empirical data to generate a theory over the relevant factors that affect how the necessary knowledge can be managed and prepared. In the theory construction process, systematic combining has been used to develop the theoretical framework with insights from empirical data and vice versa.

The results from the study show that in order to manage the large bulk of knowledge in a cleantech system solution it is necessary to deconstruct the knowledge parts that create the complete system solution. The knowledge parts vary in their nature, type and application. The research also show that assessing the knowledge parts based on the uniqueness, optimization stage, imitability, substitutability, IPR based control, secrecy-based control and ownership clarity is important, since all these criterions are found to have relevant impact in a potential transaction of the system solution. The results also show that managing the relationship between the actors involved in the development of the system solution is essential to control the knowledge. By using a combination of legal structures, such as IPRs, trade secrets and contractual measures as well as alternative supporting actions, can the necessary knowledge in a system solution can be controlled and managed in a transaction.

Acknowledgements

We came during November of 2011 in contact with David Andersson, CEO at Ecoera AB, who offered us the opportunity to do a case study on the BIOAGRO Energy AB system solution and to write our master's thesis based on the experience. Naturally we were excited to get this chance as the project presented an opportunity to be involved in the preparation for commercialization of an interesting cleantech system solution.

The experience of writing this thesis has been both rewarding and educational. We have drawn and built upon the skills we had developed during the master's program Intellectual Capital Management (ICM) as well as from the knowledge from our different educational backgrounds, with Martin Warneryd having studied Industrial Engineering at Chalmers University of Technology and Johan Larsson studying Law at Gothenburg School of Economics, Business and Law.

We are grateful for the support from our academic supervisors Magnus Eriksson and Christoffer Hermansson and our project supervisor David Andersson on which we have relied on for valuable input. Without their continued support, guidance and advice the process would not have been as rewarding, educational or enjoyable.

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1 Introduction

This chapter presents the motive for the conducted study. The section aims to build up the argumentation by which the research question and sub-questions rest upon. Furthermore, it will present the research questions in relation to the background motive of the study. Finally, the chapter will define the scope of the thesis with delimitations and definitions.

1.1 Background

The industrialized world is already exploiting natural resources at a pace that requires several earths to cover the increased demand from the growing population. At the same time, awareness over the impact that the industrialized world have on the environment increases. Scientific evidence indicates that the time in which we have to act to reduce these human impacts on environment are decreasing and that it will soon be too late to reverse the effects. (Azar, 2009)

Environmental technology has its origin in the environmentalist movement that begun developing in the post war era. (Guha, 2000) Early insights and crisis, such as the oil crisis in the seventies, lead to development of the development of alternative energy production. The term environmental technology was developed in the 80s, to categorize technologies that lessen the impact on the environment. The term was replaced by clean technology, cleantech, which was introduced in the beginning of the 21th century.

The cleantech industry has grown significantly in the recent decade. Pernick and Wilder (2008) discuss the cleantech revolution that is taking place today. When the industry begun developing in the 70s it was considered alternative and did not gain broad support from policymakers and established companies. The climate has since then changed, both literally and metaphorically speaking, and today clean technology is viewed as a source of economic growth and potential solution to the environmental damages. (Pernick and Wilder, 2008) This has led to that investors, governments and firms are starting to realize the potential in the industry and investments has grown substantially. Evidence supporting that clean technology industry has become mainstream is that governments increasingly, with different stimulus programs, reward green initiatives. (Adriaens, 2010) There are according to Pernick and Wilder (2008) some significant factors that drive the fast growth in the industry: high energy prices, depleted natural resources, volatile sources of foreign oil, record deficits and unprecedented environmental and security challenges.

Sources that drive the development of the industry is firstly costs, as increased energy prices and uncertainty over natural resources lead to increased costs. Secondly, increased investments that provide capital has had significant impact on the growth of the sector. Thirdly, governments are competing to become the top performer in using clean technology and building the jobs of the future. Fourthly, China, perhaps the fastest growing super economy in the decade, is faced with substantial challenges in providing energy and transportation over the country. Both sectors are said to use lots of fossil fuels such as coal and oil, making them uncertain for future demands and it can be argued that China will not continue growth in this pace without adapting clean technologies for their increased demands. Fifthly, consumers are becoming more aware and are in a higher degree demanding products made from renewable sources. Sixth and lastly, the climate itself and its evidence of manmade change, contributes substantially to how the cleantech industry is being shaped. (Pernick and Wilder 2008)

Both the nature of cleantech sectors, e.g. energy, transport etc and the changing environment provide for state interference in the development of the industry. Pernick and Wilder (2008) present a strategy that will allow the state to seize the opportunity in cleantech industry by forming clusters and building regions with collected strengths around certain clean technology sector. These clusters should collect strengths from University, industry and municipality and together form a knowledge center.

Knowledge has always played a significant part in the economy. The difference with the knowledge economy from previous economic systems, such as the industrial economy, is that knowledge per se is the main driver of the economy. The development of IT infrastructure has played a key role as to make possible the different knowledge transactions for its instant access to different types of knowledge. (Houghton and Sheehan, 2001) As with every transition towards a new discourse in economic growth the society demands a structural transformation and every transformation has its catalysts that play a significant part in forming the structures. Together with the ICT and biotech sector, the cleantech sector is considered to be a knowledge intensive sector and thus, catalyzes the increased knowledge transactions that found the knowledge economy.

When knowledge is the driving factor of the economy, previous physical products has been deconstructed and the idea and research behind the products becomes the important valuable assets which customers are willing to pay for. However, compared to a physical product transaction the knowledge product transaction is more complex in its characteristics. Knowledge based products are intangible, making them infinitely scalable as opposed to tangible products that are made from scarce resources. (Granstrand, 2009) Further, an intellectual product lacks the natural protection a physical product automatically has. (OECD, 2011) Hence, there is need to manage the results from knowledge creation since knowledge as Granstrand (2006) explain demand a large initial investment to create but is cheap to imitate.

In the new economy more firms, both large corporations and SMEs, act as innovation bridges. Instead of being solely the exploiters of new technology, they are also sources of new technology and use innovation to interact with other actors as knowledge purchasers, providers and partners. This was mainly done by larger corporations in the past; however, the new foundations of the economy opens up for SMEs since key drivers of the knowledge economy are not based on limited resources and economies of scale in the same way and today small firms insted often drives new innovation and business models based on intangibles, open innovation, networking and interactive learning. (OECD, 2011) As described previously, the cleantech sector is considered to be knowledge intensive. A large number of small niche firms are active in this sector. These small firms are the key players in driving innovation and development of the sector. (OECD, 2011) In order to provide a cleantech system solution, collaborations with other supplying firms take place and often state or the municipality is the head actor in these collaborations. (SWENTEC, 2008)

In line with the growth of the sector as such, countries globally make investments to make a shift into a more sustainable growth in industry and public domain. This creates a large opportunity for companies in the cleantech sector to provide solutions that will lessen the environmental impact. At national level, Swedish authorities are aware of the development and declare in a press release from September 2011, that Sweden will strive to become a role model for cleantech solutions around the world. The government indicates with this press release that they seek to capture the opportunity to export the Swedish cleantech system solutions which are at the front line of the industry. Governmental investments in this sector will aim to provide further development of cleantech solutions, however also enhance commercialization of existing solutions. (Regeringen, 2011)

There exist a large number of these cleantech system solutions today in Sweden. The successful cleantech solutions create a need for new and tailor made business models that fit the potential global customer when exporting system solutions. By highlighting the case with SymbioCity CleanWater Offer, Swentec points out the need to gather and package the knowledge around a certain field and by this keep a more collective offer as the basis in the relation with the customer. (SWENTEC, 2008)

As awareness increases in the global forum around clean technology and increasing knowledge transactions, the policies and regulations are likely to be updated in order to better suit the new economic setting. The OECD (2011) states that in order to rightfully appropriate intellectual assets there is a need for governments to establish functional macroeconomic, and framework conditions which follows the development of intellectual assets and the creation of value.

Commercializing a system solution is complex both due to the technical aspects and the different actors that are involved when developing the system solution. A potential export has to include the knowledge behind the solution in order to make it functioning. In order for Sweden to gain the ambitious goal of becoming a role model in providing cleantech system solutions there is a need to manage the existing bulk of knowledge integrated in the system solution to extract value from it.

1.2 Research aim and Research Question

1.2.1 Research Question

How can necessary knowledge in a cleantech system solution be managed to prepare for a transaction of the solution?

The aim of this thesis is to advance the understanding of relevant factors when managing necessary knowledge in a transaction of a cleantech system solution. In order to answer the research question, it is required to understand what makes knowledge necessary in a system solution. Hence, there is a need to identify and assess the necessary knowledge. In order to prepare for a transaction there is also a need to understand the control aspects of necessary knowledge.

1.2.2 Sub-questions

1. What factors and actions/aspects are relevant in order to identify the necessary knowledge?
As stated in the background of the thesis, the need to gather necessary knowledge in relation to a cleantech system solution requires some identification procedure. Therefore, the first sub-question relates to the identification of the necessary knowledge and factors that are specifically relevant for the system solution within the cleantech industry.

2. Which assessment categories are relevant to assess in order to determine the degree and nature of the value in the identified knowledge?
An export of a cleantech system solution includes transaction of knowledge connected with the solution. In order to appropriately manage this knowledge there is a need to create awareness over the nature of the knowledge since, as stated in the background, knowledge is expensive to create but cheap to imitate. The question aims to capture the characteristics of the knowledge in the system solution leading up to criterions that are relevant to assess.

3. How can the necessary knowledge be controlled?
When the necessary knowledge has been identified and assessed, it is possible to transact. However, in order to be able to appropriate the value of the system solution, the necessary knowledge must be controlled. In this sub-question we aim to investigate how the necessary knowledge that has been identified can be controlled. We will investigate both the legal structures and alternative methods that can be used to control knowledge and evaluate the benefits and limitations of the identified options.

1.3 Delimitations

1.3.1 Knowledge in the system solution

A system solution is made up from several assets, both tangible and intangible. The scope of this thesis aims to capture relevant factors how to manage the knowledge in the system solution, hence the focus will be on the intangible assets.

1.3.2 Prepare for a transaction

By preparing for a transaction we mean that the knowledge that is necessary should be identified, assessed and controlled with the aim of performing a commercial transaction. There are of course further steps needed, e.g. package and communicate the knowledge in the solution, creating a value proposition, customize the product for a potential customer etc, in order to prepare the knowledge for a transaction. However due to the time constraints of the thesis we have chosen to limit the scope to relevant factors in general of the knowledge in the system solution since further steps requires extensive information over, e.g. market, customer etc, which is impossible to gather and analyze within the time frame.

1.3.3 Focus on an EU perspective

In order to achieve a sufficient depth in the research we will focus an EU perspective in the thesis. This focus has been chosen in order to present an overview of the legal structures that are relevant to manage and prepare knowledge for a transaction.

1.3.4 Focus on codifying knowledge into assets that can be transacted

The capabilities of the workers/stakeholders involved and their experience and knowledge is an important factor that contributes to the value of a company and their products. These capabilities are sometimes referred to as intellectual assets of a company. However, when intellectual assets are discussed in this thesis it is always the type of knowledge that can be codified and "objectified" into an asset that can be transacted.

1.4 Definitions

1.4.1 Background (BG)

The Background knowledge is knowledge that is brought into collaborations by the parties. (European Commission, 2002)

1.4.2 Foreground (FG)

The Foreground knowledge is the results of the collaboration. The collaboration agreement between the parties set the framework for what is included in the Foreground and how the ownership and rights are divided and dealt with. (European Commission, 2002)

1.4.3 Intellectual property

Intellectual property (IP) are legal constructions that provide legal protection to creations of the mind, such as inventions, literary and artistic works as well as symbols, names, images, and designs used in commerce. These can be owned and controlled through patent, copyright, trademark and design rights, and are obtained through either registration, assignment of rights or automatically. (WIPO, 2008)

1.4.4 Intellectual property rights

Intellectual property rights (IPRs) refers to the rights provided to IP by laws and regulations.

1.4.5 System solution

According to Tillväxtverket (2010) there are three different levels of system solution. Level one is that several components make up a product. Level two is that several finished products are integrated in one system. The third level is that different companies and state actors are involved to provide a system solution. The way EU defines a system solution is that they can be described as whole systems that includes know-how, procedures, products and services, equipment as well as organizational routines and leadership routines. The focus in this thesis is not on the organizational features or leadership features and thus, these will not be included in the study.

1.4.6 Clean technology

One important issue to address when defining clean technology is whether the technology is eco-efficient or eco-effective. Eco-efficiency is making technology more environmental friendly, however there is still a negative impact from the technology. It is making technology "less bad" for the environment; it can include reduction of greenhouse gases from diesel engines or applying filters that reduce pollution from factories. Eco-effectiveness is on the other hand when, as Bill McDonough who claims to have coined the term says, the technology is designed in order to provide an alternative to eco-damaging technology, e.g. instead of taking the car to a scheduled meeting one uses the IT system to have the meeting instead. (http://www.sdearthtimes.com/et0699/et0699s6.html) The general definition of clean technology that the OECD and the EU are using:

> *"Clean technology is the installation or a part of an installation that has been adapted in order to generate less or no pollution. In clean as opposed to end-of-pipe technology, the environmental equipment is integrated into the production process."*
> (stats.oecd.org/glossary/detail.asp?ID=2988)

This OECD definition is strictly from an environmental perspective which is natural considering its origin. It is also strictly eco-efficient with regards to the discussion above. However, looking at the growth of the industry and the increased number of investments made in recent years, professional associations often describes the industry in combination with economic gains which is more suitable for an investment market. For instance, the Cleantech group, based in San Francisco, defines clean technology as:

> *"knowledge-based products and services that add economic value by raising productivity and/or product performance, while minimizing the use of natural resources and impact on the environment and public health"* (http://articles.latimes.com/2011/aug/28/business/la-fi-leckey-20110828)

With this definition they captures both the turning point in economy development, from the product based to the knowledge based, as well as capturing the economic benefits that the industry has the potential to induce. There is a clear difference in this definition which is interesting when regarding the sustainability and development of the industry as such. However, the main aim for this thesis is, as being discussed in other definitions, to create value in the broad sense and the relevance of cleantech for society and sustainability of the earth is therefore highly valued.

Viewing the overall motive to this thesis, that Sweden are to become a role model in cleantech solutions worldwide, we believe that the brand equity of Sweden as a cleantech system solution provider will be better when focusing on solutions that are eco-effective before eco-efficient. In this thesis we will refer to the definition provided by the OECD and will regard the eco-effective solution as an asset that adds more environmental value to the cleantech solution than an eco-efficient solution would do.

1.4.7 Controlling knowledge

We have defined the concept of "controlling knowledge" or having "control over knowledge" as follows. An actor is controlling knowledge when the actors:

- Can access the knowledge
- Can make decisions on how to use the knowledge

- Can decide whom has the right to use the knowledge
- Can grant or deny access to the knowledge, and
- Is able to leverage value from the knowledge in, e.g. a commercialization and/or collaboration

2 Research method

This sections aims to present the method used for studying the objectives put forward in the different research questions stated previously.

In the process of performing empirical research there are generally three different research approaches used: deductive, inductive or abductive. The deductive research take its approach in formulating a hypothesis, e.g. test a framework in a specific setting, and investigates if the hypothesis is true or false during the analysis of the collected data. When performing an inductive research the researcher does not use an existing theory, instead the theory is evolved from the findings of the study. The abductive approach is a combination of these two approaches, where the researcher takes a standpoint in the existing theories and use empirical data to test the theory and modify it to fit the specific research context. (Patel and Davidson, 1991)

The research question in this thesis aims to capturing significant factors of analyzing necessary knowledge in a cleantech system solution. We will use a theoretical foundation for our investigation, although the theories will evolve when testing them with empirical data and literature review. Hence, our research is best described with an abductive approach.

A common way to divide different research methods is to distinguish between qualitative and quantitative methods. The type of paper and the research focus, aim and question of the thesis dictates if the qualitative or the quantitative method is the appropriate method for the thesis. Generally, the quantitative method answers the *how* questions while the qualitative method focuses on the *why* questions. (Biggam, 2008)

A qualitative research method does not focus on gathering a large quantity of data and numbers in the same way as a quantitative does and is not used to generate one absolute answer. Instead, the qualitative method is primarily used for in-depth research which makes the method suitable for studies where the aim is the understanding of a certain phenomenon, i.e. to start from existing theory and build from them using empirical data that is collected. (Biggam, 2008) Based on our research question we have concluded that the qualitative method is the most appropriate research method for this thesis. By applying the qualitative method we can increase the understanding of relevant factors by performing in-depth studies and collecting qualitative factors from the empirical data.

2.1.1 Research design

As a way of studying contemporary phenomena where the boundaries between context and phenomena are not clearly evident, Yin (2009) describes case studies as an appropriate method. Flyvbjerg (2001) adds that if context dependent knowledge is seen as important the case study can contribute to this understanding. The case study is also a way of studying a phenomenon where little previous theory exists. (Eisenhart, 1989)

The subject of the thesis, cleantech system solution, is indeed a contemporary phenomenon. It is also not clearly evident where the boundaries between context and phenomena are drawn, due to its linkage with the cleantech industry. Theories on how to manage the knowledge of a firm exists extensively. There is however a lack of theories on knowledge management in the specific setting of the thesis. Hence, the case study appears to be an appropriate research design for the purpose of this thesis. The case study will allow us to gain an in-depth, investigative study of how system solutions can be structured and we will base our conclusions in the thesis on the methods and processes that we develop and use within the case.

Gadde and Dubois (2002) introduce the term systematic combining as an abductive research approach to case research. Figure 1 below illustrates the approach:

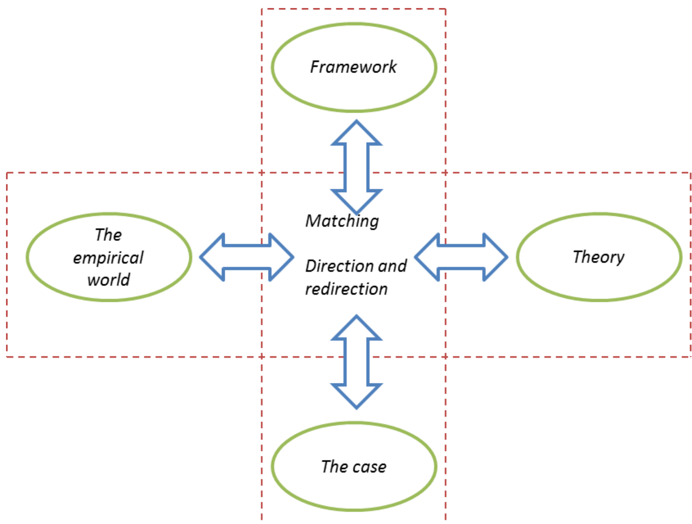


Figure 1: Systematic combining

The systematic combining is a structured way of performing an abductive research and bases its logic from the intertwined nature that a case study research most often includes. Often, research approaches tend to describe the case study as a linear process which can be structured in different stages or phases in the process. However, moving back and forth between the elements of the research, empirical data and the theoretical framework will expand the researchers understanding of the phenomena studied. In essence, systematic combining is performed by matching theory with empirical data which directs and redirects the researcher throughout the whole research process. Instead of only using different sources of information for triangulating the empirical data, Gadde and Dubois (2002) argues that the different sources can help revealing aspects of the research previously unknown to the researcher. These discoveries will redirect the research from previously theoretical framework and provide new dimensions and interview questions for the continuation of the research. (Gadde and Dubois, 2002)

2.1.2 Case study description

2.1.2.1 Choice of case

According to Yin (2009) a single case study which includes a representative case is often used in research designs. With the time limits and the scope of the research question a single case were considered the best available alternative. The research questions aims to capture relevant factors for managing knowledge in system solutions in the cleantech industry. Hence, the choice of case was aimed at being to some extent representative for the general population in Sweden. Certainly, no fully representative case exists, however bringing in the aspect of a successful case could provide more insights on the practical application of the findings, albeit being to some extent normative. The BIOAGRO case is representative in the meaning that it is a complete system solution within the cleantech industry. It has gained attention as being a successful case with rewards from authorities. It is also incorporating the elements desired to investigate, e.g. several technologies and actors, both public and private, which is usually the case in Swedish cleantech solutions.

2.1.2.2 Research steps

Figure 2 below illustrates the research steps we have performed in the study:

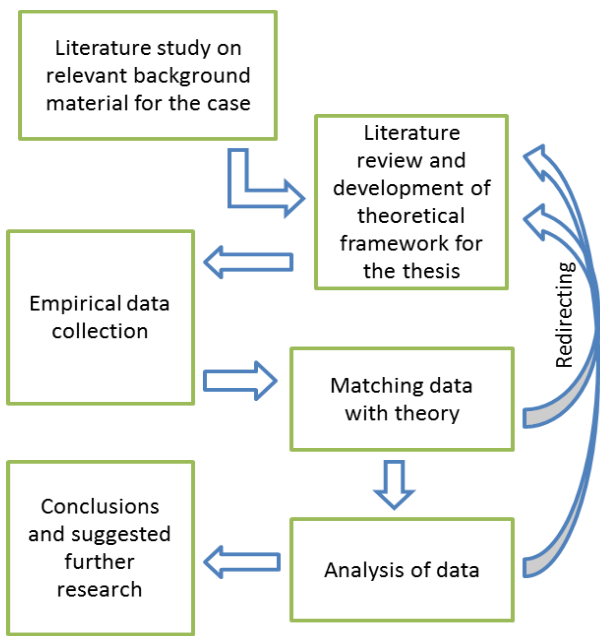


Figure 2: Research steps

According to Bryman and Bell (2007) the first step in a case study is to understand the fundamentals surrounding the case. In our study we began by reading existing material related to the case such as project reports and also technical descriptions to understand the technology in the system solution. After understanding fundamentals relating to the case we developed our theoretical framework by reviewing previous theories and literature on the subject. The study was performed on a single case; hence the theoretical framework is important for generalizing the findings with existing theories. (Yin, 2009) It also contributes to the preconceptions of the research which is then developed through the study process. (Gadde and Dubois, 2002) After developing the theoretical framework we began the planning process for collecting empirical data. Yin (2009) states that when performing a case study it is important for the researchers to bear in mind the research questions and objectives of the study, since a case can reveal a substantial amount of data and it is easy to miss out on specific clues or ideas. In this paper the data collection is conducted through interviews, observations and by studying reports and documents related to the case. Several sources of data increase the quality of the study since these different sources can be triangulated and has also the effect of providing new dimensions to the research which was previously unknown. (Gadde and Dubois, 2002) After collecting the data, the data was sorted and analyzed. The analysis took its basis in structuring the empirical data and the detection of relevant structures. Results from the analysis were used as a basis for matching previous theory and to give directions for development of the theoretical framework. Then the iterative process begun again with collecting further data, analyze and match with the developed theoretical framework. When the data collection was decided to be sufficient and the theoretical framework construction had seized to provide new aspects, the final analysis took place. Finally, our analysis was summarized and conclusions were drawn from the findings of the research. The conclusions were complemented with examples for further research in the area.

2.1.3 Method for the gathering of empirical data, data collection

The raw data is in this study comes from interviews and observations at the BIOAGRO facility. In addition to interviews and observations in the form of raw data, we will also study sources such as reports and documents relating to the BIOAGRO case.

2.1.3.1 Interviews

Since the subject of the investigation, the system solution was the main interest in performing the interviews, the focus were not on the respondents' opinion and experience as much as their expertise in the field. Flick (2009) names the type of interviews described as expert interviews. When performing an expert interview the objective can be to generate a new theory from reconstructing the knowledge from various experts in the field. (Flick, 2009) This objective is similar to this study's objective in that it aims to increase understanding over relevant factors when managing knowledge in the system. From the factors identified it is possible to draw conclusions for theory generating purposes. An expert interview puts pressure on the researcher to be able to understand the field of research. Hence, the interviewer must possess a degree of expertise himself to be able to understand often complex processes and to be able to asking relevant questions and to understand the answers. (Flick, 2009) Similar to the prerequisites of performing a case study, it was important to read up thoroughly on the subject before performing the interviews.

Interviews were conducted mainly at the BIOAGRO facilities with some additional interviews in Göteborg. The majority was conducted in person. However, due to geographical restraints, some interviews were conducted over the phone.

The following people have been interviewed in relation to the case study:

Interview person	Company	Position
Mattias Persson	Skånefrö/BIOAGRO	Technical staff
Alf Eriksson	Skånefrö/BIOAGRO	Technical staff
Sven-Olof Bernhoff	Skånefrö/BIOAGRO	CEO
David Andersson	Ecoera/Chalmers	CEO
Sten Petterson	Rejlers	IT consult

Table 1: Interview persons

The interviews lasted between 45 min and 1 hour. An interview template was used and during the interviews extensive note taking was performed.

2.1.3.1.1 Interview template

The interview template was constructed in order to derive information necessary to answer the stated research questions. The case study in itself was supposed to provide underlying information to support the process in increase understanding over relevant factors when preparing a system solution for a transaction. Hence the interview questions dealt with understanding technology and the process of knowledge creation in the system solution at BIOAGRO. With this information it was possible to analyze important factors that related to knowledge in the system. The answers from the interviews and observational data were analyzed according to factors relevant for capturing value in knowledge based assets described in the theoretical chapter.

2.1.3.2 Observations

In addition to the interviews observations at the facilities of BIOAGRO were made. The observations were mainly for the purpose of understanding the complexity of the system. Observations can be both participating and non-participating. The main reason for choosing the non-participant observation is to avoid influencing the subject of investigation. (Flick, 2009) Since there was no risk that the authors would interfere with the studied subject by participating at the facilities, the participating observation was chosen. Spradley (1980) distinguishes between three stages of participating observations: descriptive, focused and selective. Descriptive observations are used in order to provide orientation to the researcher in the field of study. Focused observations narrows the field to suit the scope of the research question. Finally selective observations are used to add complementary details to further proof findings in the previous stage. At BIOAGRO we followed the stages of the participating observation by first getting an overview of the system at place. Secondly we looked at specific parts relating to necessary knowledge of the system. In combination with interviews, observations of further details were made to fully grasp the complexity of the system which was needed in order to answer the research question. Observations were made during a two day visit at the facilities of BIOAGRO. Notes were taken by both authors during the observation.

2.1.3.3 Reports and documents

In addition with interviews and observations, reports and other relevant documents were studied to provide further insights into the subject. Documents handled included:

- Technical reports
- Business plan
- Contracts
- Test reports
- Project reports

These were used to both gather new empirical data, and also as a mean of triangulating the other data gathered from interviews and observations.

2.1.4 Sorting the empirical data

Since the amount of gathered data was rigorous made it necessary to sort and filter the gathered data before presenting the data in the thesis. The method for sorting was based on answering the research questions. Both a topological sorting as well as chronological sorting as proposed by Merriam (1994) was used in this process. The reason for this was that the empirical data collected showed both topological differences and chronological differences. Hence, a description over different technology ingredients (topological) in the cleantech system solution and construction phases in which knowledge was created (chronological) and which actors were involved in the creation (topological) was needed to capture the extent of knowledge and its connection to carriers in the studied subject. The main focus for the presentation of the empirical results was to as readily as possible describe for the reader of the thesis in what way the system solution incorporated different technologies and how these technologies were created.

2.1.5 Analysis of the data

As the objective for the study was to find relevant factors in order to manage necessary knowledge in a cleantech system solution, the analysis was based on the identification of themes and categories which connected to the topic. Merriam (1992), states that qualitative analysis should be performed by finding common categories or themes to draw conclusions from. Already in the phase of sorting the empirical data, structures were identified which was then further analyzed what specific categories or themes the structured data best fitted within. After finding relevant themes and categories, the analyzed data was reviewed in combination with the theoretical framework of the thesis. The whole process was iterative and if some empirical data suggested slightly new approaches, the theoretical framework was reviewed and updated. All in accordance with what Dubois and Gadde (2002) refers to as “systematic combining”.

The presentation of the analysis follows the structure of the stated research questions. In order to provide the reader with a better understanding, examples from the empirical setting was used where the analyzed factors were implemented. However, the authors are fully aware that identifying the best way of implementing the findings from the analysis is not within the scope of this thesis and the choices presented are merely examples of how to capture previous theories with the empirical data. The choices taken are also inspired by our previous educational experiences; mainly from the Master program Intellectual Capital Management (ICM) given at Chalmers and University of Gothenburg during the years 2010-2012.

2.1.6 Method of evaluating regulatory frameworks

The study includes an analysis of how the necessary knowledge in a system solution can be controlled. We based the research of this aspect on three questions: (1) how can the legal frameworks, structures, tools and constructions be used to control the necessary knowledge in a cleantech system solution? (2) How can the identified legal constructions and supporting actions be implemented in order to meet the identified structural and legislative challenges relating to controlling necessary knowledge in system solutions in the cleantech industry? And (3) how can the knowledge that cannot be codified into the legal constructions could be controlled and protected?

The study of these aspects was done through applying a modified version of the conventional legal method, as the goal has been to identify how knowledge can be codified and controlled through IP law and other methods. Therefore, the legal history of legal acts will not be analyzed in the research. The focus has instead been to analyze the legal structures that can be used to create control structures based on the specific context of cleantech system solutions. In order to analyze the relevant legal frameworks it has been required to take an interdisciplinary approach and we have therefore used the IAC Model, see chapter 3.5, during the research. This model is based on the methodology taught in the Applied ICM course of the Intellectual Capital Management master program and the aim has been to build upon this methodology to include the legal tools that can be used in the specific setting of cleantech system solutions. As there is no single legal act that regulates how knowledge can be controlled it is required to analyze different legal acts that could be used. IP law naturally becomes important to include in the research of controlling knowledge, as knowledge is intangible and IP law creates rights to intangible between individuals, see chapter 3.4.3.1. There is literature and other material available regarding how knowledge can be controlled. However, there is no previous study of controlling knowledge specifically in cleantech system solutions. The available material is also to a large extern general in nature since knowledge is a general term. Therefore, reports from global organizations, such as OECD, European Commission and WIPO are important to analyze as well as literature and national laws of the Member States.

The methods for controlling knowledge that have been identified and that are discussed in the theoretical framework are evaluated in relation to the BIOAGRO case in order to identify relevant factors that affect how knowledge can be controlled. By analyzing the empirical data from the BIOAGRO case, such as the available contracts between the actors, and comparing these to the theoretical framework we aim to identify specific factors relevant to controlling knowledge in cleantech system solutions.

2.1.7 Validity discussion

Qualitative research is concerned with the credibility of the research, as oppose to quantitative research where it is usually easier to test the quality of the research since replication of the research is possible. There is however measurements to judge the quality of the research also within the qualitative strategy. Qualitative research is often measured according to the following criterions:

- Construct Validity
- Internal Validity
- External Validity
- Reliability

Construct validity refers to in which way the research has incorporated operationally sound measurements for analysis, i.e. to what extent the research has measured what it is supposed to measure. Internal validity is usually used in descriptive and causal studies and aims to establishing a causal connection where certain things lead to other things as opposed to occasional or false connections. External validity refers to that the study is delimited to the specific area in which the results can be generalized. Reliability refers to whether the method of the study can be replicated with the same results. (Yin, 2009)

2.1.7.1 Construct validity

The aim of the thesis is to increase the understanding over relevant factors when managing knowledge in a cleantech system solution. The empirical data is collected from an in-depth case study performed at a case which is considered as a representative case in the scope of the research question. Hence, the discussion over what is relevant and how does one measure this creates the foundation for construct validity in this research. First as part of collecting the data needed, several sources were used. Interviews, observations and document reading, was all used and developed during the research in order to found a thorough empirical ground for the analysis. All empirical data is stored in a folder along with results from the analysis in excel sheets etc. The authors have also continuously during the process discussed the relevance of the empirical data with the project supervisor, David Andersson. David has also been involved in the development of the thesis and provided reflections from the case setting perspective. Hence, the authors argue that the construct validity has been considered and fulfilled to the extent possible within the scope of the thesis.

2.1.7.2 Internal validity

Since the aim of the thesis is to find relevant factors and not derive causal connections between manipulated variables, the discussion on internal validity is less relevant. One action one might perform is to test rivaling explanations to observed phenomena. (Yin, 2009) However, since the focus always have been on the existing solution, and the exploring nature of the research, factors found are strictly drawn from the empirical data gathered in relation to the system solution. Hence the authors argue that the internal validity, to the extent it is necessary for the type of research, is taken under consideration.

2.1.7.3 External validity

Generalizing results from one case study is complex. The research has been designed to review the collected empirical results in combination with theory. Hence, the empirical data has been tested against existing theories and therefore the external validity of the research has been considered.

Also the subject of the thesis aims to increase understanding over relevant factors for managing knowledge in a cleantech system solution. This objective needs an in-depth study of a representative case. The representative case is chosen from the definitions of the cleantech industry and system solution. Hence, the case fulfills these criterions.

2.1.7.4 Reliability

Reliability in qualitative research is focused on that researchers are careful and precise in their documentation of how the data is collected and interpreted. The more precise, the easier it is for an external person to control the method of the research. (Yin, 2009) In this thesis we have provided an interview template as well as descriptions of how the analysis was performed. Also, the general approaches and design of the research has been presented and what factors have influenced the methodology decisions taken. Thus, the authors argue that reliability of the research has been taken into consideration in a conscious manner.

3 Theoretical framework

This chapter aims to present the theories behind managing knowledge that are relevant in the scope of this thesis. The chapter will follow the stated research questions. The chapter will begin by investigating theories relating to the identification of knowledge that contribute to the firm or organization's profitability. Then next section will address theories relating to the assessment of the identified knowledge and the third section will present the theories regarding controlling knowledge, including logic behind the control of knowledge and existing tools. The final section will present the IAC-model to summarize the author's view of the presented theoretical framework.

3.1 Managing knowledge in system solutions

In the last decades the world has undergone a shift from traditional industrial economy, where factors that drive growth are products and labor, towards a knowledge economy where the knowledge per se is the key driver of growth. (Teece, 2008) As described in the background of the thesis, the cleantech sector along with mainly the ICT and biotechnology/nanotechnology sectors functions as catalysts that drive the development of the knowledge economy. In a system solution, the fact that several technologies and competencies together form the solution creates an amount of knowledge which is related to different parts in the solution such as specific technology, processes and integration.

3.1.1 Nature of knowledge

Not all knowledge is connected with direct value creating potential. To be more detailed in the knowledge expression Nonaka (1994) distinguishes between "tacit" knowledge and "explicit" knowledge. With tacit knowledge he refers to the type of knowledge that is connected with a person's mind and needs to be codified in order to be explicit. Explicit knowledge is codified and possible to transact between actors. The increased rate of knowledge based transactions stemming from the development of the knowledge economy also relates to finding new ways of codifying the knowledge in various ways. This development has decreased the amount of tacit knowledge for the benefit of explicit knowledge. (Houghton and Sheehan, 2000)

3.2 Identifying relevant knowledge in the system solution

Identifying specific knowledge in order to appropriate value from it gained increased awareness during the described shift from traditional economy to knowledge economy. There are several views on what knowledge is contributing with in terms of increased profitability of the firm and some general thoughts on the importance of knowledge from the late 50s and forward will provide the foundation for the role of knowledge in today's knowledge based economy which is essential for managing knowledge in a cleantech system solution.

3.2.1 Knowledge in relation to firm's profitibility

Knowledge was first mentioned for its strategic role in the firm by works from Nelson (1959) and Arrow (1962). However, back then knowledge was viewed as a *public good* that provided value to the society as a whole, not the specific firm. This view did not create incentives for firms to invest in knowledge creation since this would not provide sufficient return on investments. Changing the strategic role of knowledge, making it more connected with the firm's specific profitability, Wernerfelt (1984) introduced the resource based view (RBV) on the firm or organization. This perspective views anything that can be thought of as a strength or weakness of the firm as a resource. In a more formal way the resources can be defined as assets, intangible and tangible, that at a given time are tied to a firm over a relatively long period of time. A firm that carries resources superior to its competitors holds competitive advantages which lead to higher profitability. This is in essence different from the previous view, which stated that the firm's competitive advantage stems from superior products or production processes. However, the views can be merged since a superior resource often leads to competitive advantage in the shape of a superior product on the market, hence the resources can be viewed as roots of the competitive advantages. Wernerfelt (1984) gives examples of different resources, e.g. brand names, in-house technology, trade contacts etc. Wernerfelt (1984) also argues that it is possible to find attractive resources that can be the subject for creating a resource position barrier. If a firm finds a resource that creates a competitive advantage towards another firm on the market it can use the resource in order to cement that lead.

Barney (1991) further builds on the resource based view and argues that the main differences between the previously dominated traditional view of the firms competitive advantage and the resource based view is that firms may be heterogeneous within an industry. The specific resources that build up this heterogeneity may not be mobile throughout the industry as the traditional view would argue and thus the heterogeneity is sustained. Barney gathers the insights of his studies in the VRIN framework (valuable, rare, imperfectly imitable and no substitutability) that can be used to analyze whether a firm's specific resources can be used in order to create sustainable competitive advantages.

The RBV has a static view of the means for profitability of the firm. Later authors argue that this static view is not sufficient to create the sustainable competitive advantages of the firm. Instead the dynamic capabilities through which knowledge can be created, replicated, transferred and integrated, is the key to firms ability to create sustainable competitive advantages. (Teece and Pisano, 1994; Nelson, 2004; Teece, 2008) The actual processes of extracting value from the resources, which can be linked with the dynamic capabilities of the firm, are outside the scope of this thesis. However the management of knowledge proposed in the research question is similar to the dynamic capabilities of the firm, in its overall aim to prepare for a transaction of the system solution.

The way firms excel their businesses through the management of competencies that are considered core relates to the foundation of the knowledge economy in which knowledge assets are the key drivers of economic growth. Prahalad and Hamal (1990) describes the concept of core competencies as the collective knowledge stemming from both individuals and organizations within a firm. In this case the core competencies are the sum of the identified necessary assets in the solution and its link to the knowledge that created them. Instead of focusing on the conquering of different markets the firm should focus on defining its core competencies and continue to develop these in order to sustain a competitive advantage. In this way it is actually possible to shape the market after its own competencies.

3.2.2 Identify the right knowledge

Knowledge can have different attributes and when identifying the necessary knowledge in order to prepare for a transaction there are certain attributes with the knowledge that one should look after. Diefenbach (2006) suggests different attributes of knowledge assets:

- Linked to a particular individual
- Between two or more individuals
- Transferability

The two first categories relate to human or organizational capital which is not within the scope of this thesis. However the last category of transferability relates to knowledge in a system solution which is supposed to be transacted. Examples of knowledge assets within this category are:

- Data (symbols, signs), information
- Explicit knowledge
- Intellectual property (company's name and logo, trademarks, drawings, formulas, software programs, copyrights, patents, licenses, quota, internet domains, portals)
- Contractually regulated aspects of formal relations between parties (rights and duties)

The main characteristic of this category is that the knowledge asset can be isolated and exist without a personal carrier. (Diefenbach, 2006) By using a categorized system for identifying knowledge assets there is a possibility to locate them more precise and efficiently. This leads to clarity on how to manage the resources more appropriately. (Diefenbach, 2006)

Also Harrison and Sullivan (2006) discuss the importance to identify a firm's collection of knowledge assets since these assets often are tacit and diffuse. If done correctly the finding of the knowledge assets can provide meaningful returns for the firm. They suggest that the assets are described in an inventory list and categorized accordingly to what make sense for the firm or organization that possesses them. By identifying the relevant transferable knowledge assets which is believed to contribute to the value of the cleantech system solution in a potential transaction, it is possible to create a list of assets and describe them in a manner that makes sense within the context.

3.3 Assessing knowledge assets

Not all identified knowledge assets are equally important in relation to what value they bring to the system solution. In order to manage the knowledge assets efficiently there is a need to assess which of the assets that is more important and which are of less importance in the system solution.

3.3.1 Knowledge assets contribute unequally to firms profitability

As previously discussed Barney (1991) suggests four different attributes that the knowledge assets of a firm must have in order to be competitive advantageous: valuable, rare, imperfectly imitable and no substitutability.

3.3.1.1 Valuable resources

The basic feature of a resource to be competitive is that it is valuable. It must in other words have the ability to exploit opportunities or neutralize threats in a firm's market. A resource can show fulfillment of any other attribute while lacking the valuable attribute and thus have no effect on competitive advantage.

3.3.1.2 Rare resources

Although a resource might be valuable it is not generating a competitive advantage as long as several competing firms also possess the valuable resource. It is therefore important that the resource is relatively rare in order to create competitive advantage against competing firms. The attribute is not mandatory to survive and thus, common valuable resources might be the key to survive economically in a condition of creating competitive parity in an industry. However rareness, as long as it supersedes the common factor that creates perfect competition in an industry, will contribute to the competitive advantages of a firm.

3.3.1.3 Imperfectly imitable resources

A resource can be imperfectly imitable from three different sources. First a firm's unique historical condition can generate imperfectly imitable resources. Barney (1991) argues that what most traditional models assume wrong is that a firm’s historical development is not relevant to its performance in the industry. On the contrary, these historical aspects can create imperfectly imitable resources solely for their presence at a specific time and place in history. Secondly, a resource can be perfectly imitable through its causal ambiguity meaning that firms in the industry, including the firm who possess the resource, do not fully understand the linkage between a specific resource and its contribution to the competitive advantage. As long as this information is ambiguous it can be kept as a sustainable competitive advantage for the firm who possesses it. Thirdly, a resource can be the result of a complex social phenomena occurring in the firm. For instance the specific relationship between managers can create competitive advantages which relates to personalities and other context specific attributes. Such relations are imperfectly imitable as long as they are not subject to direct management.

3.3.1.4 No substitutability for the resource

Even if the identified resource is considered valuable, rare and imperfectly imitable there is always a risk that a competing firm can accomplish the same strategic measurements although using a different resource. Since the result from the resource is what creates the firm’s advantage this attribute is mandatory in order to keep sustained competitive advantage of the firm.

Albeit Barney’s attributes often include knowledge assets drawn from human capital, e.g. management skills, which is not part of the scope in this thesis his insights contributes in the way that he points out the need to assess the different resources (knowledge assets) since not all knowledge is considered as important. Sullivan (2001) further suggests that all assets may be categorized generically as unique, differentiable or generic assets.

3.3.1.5 Unique assets

The complete set of assets in an organization is a unique set of assets, as no other firm has the exact same skills, abilities, innovations, knowledge, patents, copyrights, trademarks and trade secrets. The unique assets are also difficult to duplicate and requires a considerable amount of resources and time for other firms to duplicate.

3.3.1.6 Differentiable assets

Differentiable assets are the assets that are similar to those found in competing firms, such as manufacturing and distribution. These assets are often not unique, however also not identical to other firms as the systems are not identical. Together with the unique assets, the differentiable assets set the firm apart from the competition. Complementary business assets are a special classification of differentiable assets that complement the firm's innovation and are important to KBB for generating and maintaining profits.

3.3.1.7 Generic assets

The generic assets are the assets that are not differentiable or unique.

These categories show similarities with the VRIN framework. However, Sullivan (2001) chooses to include difficulty to imitate in the unique asset, something that Barney (1991) describes in an own category. In a cleantech system solution there is a need to assess the previously identified knowledge from criterions that are thought to contribute to the value of the solution.

3.3.2 Contextual dependency

The firms identified knowledge assets are always contextual and does not exist without a purpose or a point of view. (Stewart, 1997) The context can be defined as the firm's internal and external realities. (Sullivan, 2000) An internal reality of a firm is based on their direction, resources and constraints, whereas the external realities are concerned with the strengths and weaknesses of the firm as well as the capabilities to compete in the external world. These realities and the context are often expressed in the company vision and strategy for reaching the vision. Since different companies have different visions the knowledge assets of companies are used in different roles and thus, valued accordingly to the specific role it carries. Harrison and Sullivan (2006) add that all assets should be filtered according to what make sense to the firm or organization. This filtering is context specific and should serve as a foundation for the development of a business model which can leverage the assets in the most efficient way. In a cleantech system solution this reasoning could be implemented in what specific context the solution exists and is thought to be utilized within, will have an effect on the assessment of knowledge assets.

3.4 Controlling the necessary knowledge

3.4.1 The importance of controlling knowledge

Through the Identification and Assessment a wide range of necessary knowledge is defined and structured. Controlling the necessary knowledge is essential in a transaction in order to not lose control over necessary and valuable knowledge and to appropriate the value of the knowledge. However, the intangible nature of knowledge poses various challenges and the appropriation of value is difficult since knowledge in general is expensive to generate but cheap to imitate and reproduce. (OECD, 2011, p. 17)

System solutions in the cleantech industry can be dependent on different technologically complex parts that require adaptation and integration to function in a single system. Due to this complexity, a single actor does not usually possess all the knowledge necessary to develop a complete system solution single-handedly. There is a need to gain access to and acquire the proprietary knowledge of several actors with different fields of expertise. Getting access to proprietary knowledge can be done in a number of different ways. One option is to develop the necessary knowledge in-house through investments in R&D. Another option is to acquire the knowledge externally through supply, license or joint development agreements. The knowledge can also be acquired by hiring additional employees with the relevant expertise, acquisition of other firms or use consultancy services to train current staff. (Caenegem, 2002, p. 13; Slowinski, Hummel and Kumpf, 2006, p. 30; Kyläheiko et al, 2010, p. 274) However, Caenegem (2002) suggests that structural acquisition is not the most efficient way of acquiring knowledge. Instead, collaborating with actors that have expertise in the relevant areas is far more effective. While this is an effective way of acquiring knowledge, it also leads to an increase in human capital rather than physical capital. Human capital falls outside the IP-based legal structures making the knowledge more complicated to manage and control. (Caenegem, 2002, p. 12)

3.4.2 Introduction to controlling knowledge

Due to the intangible nature of knowledge, creating control becomes complex and no single solution can be applied in every situation. There are however a number of methods, or knowledge protection mechanisms, that can be used to create control layers. Norman (2001) divides knowledge protection mechanisms into three areas: human resources, legal structures and processes. Human resources include educating employees about proprietary knowledge and the importance of protecting the proprietary knowledge. The Legal structures available are, among others, IPRs and contractual mechanisms. Using agreements, such as Non-Disclosure Agreements (NDAs), to control knowledge as well as contractually create consequences if a partner accesses off-limits information or uses proprietary information without permission is also highlighted by Norman (2001). The Processes focuses on controlling knowledge flows, such as limiting certain proprietary knowledge to one person, the so-called gatekeeper, and the collaboration partner’s access to the facilities. (Norman, 2001, p. 51-52)

3.4.3 Relevant legal structures for controlling knowledge

The intangible nature of knowledge makes it easy to transact over borders all over the globe. However, the rapid technology development and different national systems give rise to conflicts and difficulties when transacting knowledge across borders. (Seville, 2009, p. 1) IPRs are not the only legal structures that are relevant in order to control knowledge and in this section Trade Secret Law, Contract Law, Competition Law as well as IPRs and IP law will be discussed.

3.4.3.1 Intellectual Property law

Intellectual property (IP) laws are legal constructions that provide legal protection to creations of the mind, such as technical inventions. (WIPO, 2008, p. 3) The knowledge that fulfills the strict requirements of IP law can be controlled through patents, copyrights, trademarks and design rights, and are obtained through either registration, assignment of rights or automatically. (Caenegem, 2002, p. 13) Intellectual property rights (IPRs) refers to the rights provided to IP by laws and regulations.

The laws of intellectual property can be used to create rights between individuals that are vested in knowledge. Knowledge is abstract and inherently difficult to define and specify, so in order to use IP law to control knowledge the characteristics that make knowledge 'intellectual property' in the eyes of the law must first be analyzed. Christie and Pryor (2005) describe IP as "an intangible subject matter emanating from the human intellect in respect of which a legal right of exclusivity may be granted". (Christie and Pryor, 2005, p. 9) This is based on classifying the two words in "intellectual property". IP is as defined creations of the mind, see the definition in 1.4.3. Therefore, knowledge that constitutes IP is derived from human intellectual activity, primarily innovation and creativity. The novelty criterion in patent law is an expression of this, as creativity and innovation results in novel ideas. This leads to the conclusion that knowledge that is an innovative or creative product of the human intellectual activity can be eligible to be IP. The concept of "property" can be viewed as rights to knowledge from a law perspective. Thus, the right of exclusivity is a hallmark of property according to Christie and Pryor (2005). (Christie and Pryor, 2005, p. 7-9)

3.4.3.1.1 Benefits and limitations of using IPRs to control knowledge

IPRs have the benefit of being accepted as property by both the legal structures and other actors. There are legal rules, courts and offices that can be used to enforce the rights and stop infringements. IPRs provide these rights to the rights holder in return for knowledge diffusion. For instance, in order to obtain patent protection, the underlying idea must be explained in the patent application which is published, disclosing the knowledge and making it accessible for the public, which is likely to create a more rapid diffusion of the knowledge.

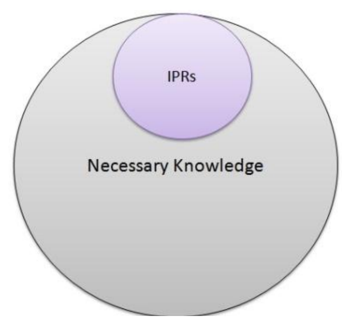


Figure 3: Discrepancy between IPRs and the necessary knowledge.

The strict requirement of what can be controlled through IPRs creates a discrepancy between the knowledge that can be controlled through IPRs and the necessary knowledge in the system solution, illustrated by Figure 3. For instance, patents require novelty, and copyrights only protect the expression of a work and not the underlying ideas in that work.

Registering IP is still to a large extent based on local systems and many IP applications are restricted to a single jurisdiction and must therefore be made to each single relevant area with an uneven proprietary protection and expanding costs as a result, with patents being the most expensive. When an IP, e.g. a patent, application is granted there are also costs connected with controlling that the patents are respected. Furthermore, enforcing the claims can be both expensive and have uncertain results. (Caenegem, 2002, p. 14-16)

3.4.3.1.2 The need for proactive actions

The structure of IP law requires that the actors are proactive in order to meet the specific requirements that must be fulfilled in order to obtain IPR protection. Failure to observe these requirements from the start of the development of a system solution may result in irrevocably losing the option of IPR protection, e.g. by revealing information on a technical development before filing the patent application and thereby destroying the novelty. By being proactive, the firm retains the option to complete or abandoning the application depending on the value of the knowledge for the final solution. (Caenegem, 2002, p. 19)

3.4.3.2 Trade secret law

In the EU there is not a harmonized system for the protection of trade secrets. All Member States offer some form of protection, although in some jurisdictions the protection is limited. Common law countries, such as the UK and the Republic of Ireland, have effective trade secret protection despite having no specific trade secret legislation. Thus, the lack of specific legislation dealing with trade secrets is not necessarily an indication of whether effective action can be taken in a country. Trade secrets are not generally viewed as IPRs, however is recognized as being closely related to IPRs. Trade secrets are also closely related to contract law since contractual liability is often are used to protect trade secrets. (Hogan Lovells, 2011, p. 1-2)

3.4.3.2.1 Knowledge that can be protected

The knowledge that can be protected through trade secrets varies in the Member States. In the common law countries the law of confidence can protect all types of knowledge whether it is commercial, industrial or personal. In other States there is specific protection against disclosure from employees regarding manufacturing or process knowledge and separate protection for commercial knowledge. Some States apply the definition of "undisclosed information" provided in Articles 39(1) and (2) in Agreement on Trade Related aspects of Intellectual Property Rights (TRIPS), there is however no single definition of "trade secrets" in the EU. (Hogan Lovells, 2011) Norman (2001) presents a series of steps on how to create trade secrets. These include specifying proprietary information, what information and capabilities can be shared and what information and capabilities that cannot be shared and to contractually create consequences if a partner accesses off-limits knowledge. It is also important to establish consequences if a partner use proprietary information in the wrong way and to sign Non-Disclosure agreements. (Norman, 2001, p. 52-55)

3.4.3.2.2 The reach of trade secrets

The individuals whom trade secret law can be used to take action against also vary in the EU. Employees, both current and former, licensees and competitors are some of the possible defendants. Trade secret regulations in some countries allow that actions are taken against anyone that has received confidential knowledge. In other States, actions can only be taken against those with whom some contractual relationship exists.

Employees can in most Member States be bound by contracts of employment during the employment, however the possibility to control the knowledge that ex-employees have gained during the employment varies. Third parties, with whom there is no current contractual relationship or a contract is not concluded, and where confidential knowledge is disclosed, can have serious outcomes. In some Member States the third party will be open to action through other regulations, such as unfair competition or duly confidence may be implied by the circumstances and in some jurisdictions there are no actions that can be taken if the recipient is in good faith. If knowledge is received through no fault of one's own, e.g. a wrongly addressed mail, nothing can be done in a number of countries. (Hogan Lovells, 2011, p. 2) However, in Sweden the Trade Secret Act states that the recipient of the confidential knowledge will be liable to compensate the owner if he willfully or negligently reveals a trade secret which he understood, or ought to have understood, to have been revealed contrary to the statutory provisions, unless the information is received in good faith. (Act (1990:409) on Trade Secrets)

3.4.3.2.3 Benefits and limitations of using trade secrets

Due to the difficulty of detecting and proving infringements of IPR protected processes, it can be more effective to keep the process as a trade secret instead of patent protection. The use of trade secrets is also an effective way to appropriate the returns generated by the necessary knowledge that is developed. It functions as a layer to protect knowledge that is possible to keep secret in a potential transaction. However, trade secret protection is not suitable for all knowledge, as the knowledge that is controlled by trade secrets must be secret in a transaction as well. (Caenegem, 2002, p. 16)

The codification and packaging of knowledge into a patent application and the costs connected to the application and the maintenance of a patent can be avoided through the use of trade secrecy. Furthermore, knowledge kept as trade secrets can be protected for an indefinite period of time, as opposed to IPRs that have a limited time-span of protection. However, trade secret protection only extends to information specific enough that it can be proven not to be in the public domain. It is not possible to "register" a trade secret and there is no way to exclude others from using the knowledge, making unintentional diffusion of the knowledge a great risk. Unlike patent protection, trade secret law offers no protection against reverse engineering. The time to reverse engineer can also be much shorter than the time period which a patent protection is valid, due to the fact that the competitors will have additional information because of its existence. (Friedman et al, 1991, p. 62-65) The effectiveness of legal procedures to enforce trade secrets can also be questioned, as the local procedure in countries in EU is not always effective in providing the continued protection of trade secrets. In some jurisdiction the public can only be excluded from court proceedings, which is necessary in order to keep knowledge secret, for reasons relating to security, public order or decency. Furthermore, there can be considerable difficulties in obtaining sufficient evidence of misuse of trade secrets, similar to the issues of proving infringement of process patents, even though there is a reversed burden of proof in TRIPS Article 34. (Hogan Lovells, 2011, p. 3-4)

Trade secrets can be used to control a wider range of knowledge than patents due to the strict requirements of patent protection discussed above. Thus, trade secrets can be used to create a control layer on necessary knowledge that cannot be covered by patent protection, see Figure 4. There are a number of strategic factors to take into consideration if patent protection is available, e.g. the firm's market position, the risk of reverse engineering, the integration of the technology in the system, development stage etc. These factors must, according to Caenegem (2007), be taken into consideration when deciding whether to apply for patent protection of the knowledge or to keep the knowledge secret though trade secret law. (Caenegem, 2007, p. 26)

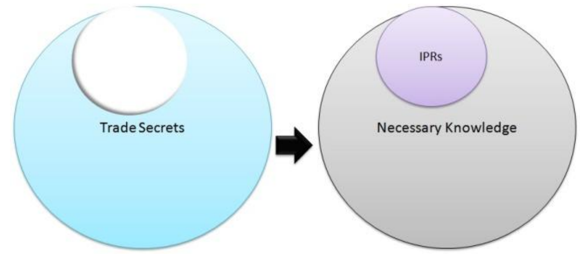


Figure 4: Trade Secrets can be used to control a wider range of knowledge then IPRs.

3.4.3.3 Contract law

A contract is an agreement between two or more parties that has been entered into voluntarily with the intent of creating a legal obligation. The contract provides freedom to the actors to structure their interaction in the way that suits them the best while courts provide a last resort to settle disputes and enforce the obligations. (Petrusson, 2005, p. 163-164) Well-crafted legal agreements are important in order to regulate collaborations and other relationships, such as a Non-Disclosure Agreement and a Joint Development Agreement, provide the foundation of controlling knowledge. (Slowinski, Hummel and Kumpf, 2006, p. 30-31)

3.4.3.3.1 Collaborations

The development of system solutions is characterized by several different technologies being combined into a single system, creating a need for collaborations and joint developments. Many challenges arise in collaborative settings due to the complexity in terms of technology, activities, actors and outcomes. Collaborations therefore require agreements to regulate the rights and responsibilities of the actors involved and to define and clarify the roles, interests and obligations as well as the rights and ownership of the results from the collaboration. (Slowinski, Hummel and Kumpf, 2006, p. 30-31)

3.4.3.3.1.1 Managing the Background and Foreground knowledge in collaborations

Managing the Background (BG) and Foreground (FG) knowledge is important in all external collaborations. Failing to manage both the FG and BG knowledge in a collaboration not only limits development opportunities, it can also destroy potential value of developed knowledge and technology as well as result in unintended ownership or control rights being granted to external actors. Liability for infringement, breach of confidentiality and other obligations can all result from poorly designed collaboration agreements. (Slowinski, Hummel and Kumpf, 2006, p. 36-37; Telles, 2011, Transaction Information and Analysis)

The BG knowledge is the knowledge that is brought into a project and can include all knowledge that is contributed to the project in relation to the purpose of the collaboration. The FG knowledge can be both specific knowledge from a particular project and all knowledge that arising out of general research/collaboration efforts between two or more parties, upon which the FG is dependent on. In order to effectively regulate the BG/FG in collaborations, the BG and FG must be defined and specified in each situation and relationship. The concept of BG/FG is not automatically linked to a specific context and must be defined in relation to the knowledge itself or the rights associated with such knowledge. The knowledge that is included in either BG and FG knowledge is either defined by contractual provisions, or is determined by legislative regulations, such as Employment law. (Telles, 2011, Rights Management)

Collaborations involve the contribution and creation of knowledge by different actors, each with different value, rights and obligations. In order to control the necessary knowledge that is created as well as brought into the collaboration the rights to the knowledge must be managed. There are a number of key factors to regulate in a development agreement, which raises a number of issues that need to be managed from a strategic and legal perspective. When entering into collaboration, the existing IP and other necessary BG knowledge must be identified, defined and evaluated. The licensing rights to existing knowledge/IP, confidentiality and secrecy obligations for knowledge are issues that are regulated and managed in the agreement. Actively managing these aspects before, during and after the collaboration ends is necessary in order to regulate the rights and ownership of the BG and the FG which is part of controlling the necessary knowledge for a future transaction. Entering into collaboration without defining and regulating the BG and FG can lead to losing control over the results and the necessary proprietary BG knowledge that is brought into the collaboration. (Expert Group Report to European Commission, 2002, p. 35-36; Telles, 2011, Rights Management)

3.4.3.3.2 Collaborations with academia

Academia can hold the relevant proprietary knowledge that is necessary to access. (Caenegem, 2002, p. 10-11) There are different ways to interact with Universities and University researchers in order to gain access to proprietary knowledge. Pries and Guild (2004) discuss the three primary methods that Universities use to capitalize on the research: (1) creating a new business based on the innovation, (2) ongoing development and marketing of the innovation to firms that will use the innovation in their business, and (3) disposition of the innovation to an established firm. There are also several licensing options that can be used, where a firm can acquire the rights to proprietary knowledge through exclusive or non-exclusive license, corporate partnerships or sponsored research funding. (Pries and Guild, 2004, p. 1-7) Slowinski, Hummel and Kumpf (2006) explain the importance of ensuring that everyone involved in the collaboration understands the terms in the agreement, especially regarding confidentiality, in order to protect the knowledge that is developed since Universities often want to have the right to disclose the results of the collaboration in thesis papers and academic journals. (Slowinski, Hummel and Kumpf, 2006, p. 37)

The first method of interacting with academia presented by Pries and Guild (2004) is to form a collaboration partnership with one or several Universities or University researchers. Another option is to collaborate with a specific research team, which would allow a closer collaboration with the team. A long-term collaboration has several benefits, such as that the company will be able to maximize the value and the results from the partnership and have a better control over the research. The downside is of course that research collaborations requires a high degree of involvement from the firm in terms of time and money both in the set up phase as well during the process.

Another method discussed by Pries and Guild (2004) is Disposition of knowledge, which is when knowledge is either sold outright or licensed on an exclusive basis to a firm. In these situations, the firm also acquires substantially all the risks, however also the ownership and rights to the proprietary knowledge. The University/researcher typically retains no ongoing rights to the knowledge or its future enhancements. However, the University/research may in some cases retain very limited rights to the innovation, such as the right to use the innovations in their research. The transfer of the knowledge to an established firm in exchange for equity is similar to disposition of the knowledge to an established firm, except that the University retains an equity right in the proprietary knowledge. The firm will have the right to use the asset and thus is able to commercialize the system solution. However, the equity the University gets in return represents a residual interest in the assets of the firm and can be used to identify the right to appropriate returns from the knowledge. The residual rights to the knowledge might provide a concern for the firm in the future as it can affect the right to change and develop the results if not regulated. (Pries and Guild, 2004, p. 1-7)

3.4.3.3.2.1 Comparison of Intellectual Property Management models used by Universities

There are differences in legislations regarding the rights to knowledge and innovations in EU which affect the Intellectual Property Management models of Universities. Technology transfer offices are used in most of the EU countries, however not in Sweden. In Sweden the “Teachers’ Exemption” (1 § section 2, Act (1949:345) on the Right in Inventions by Employees) grants the researchers, instead of the University, at Swedish Universities the right to the inventions. Thus, the researchers owns the rights to the results of research they perform at the Universities and are free, or become responsible, to patent and choose when and where their research results should be reported. Denmark had a similar regulation as Sweden until the year 2000 when “Act on inventions at public research institutions”, commonly referred to as the “Law on University Patenting” was implemented. (Act no. 347 of 2 June 1999 on inventions at public research institutions) This legislation allocates ownership of an invention to Universities when it is made as part of the work of employees. This also applies to knowledge resulting from collaborative work with third parties, such as private companies, however in these cases the University may upon prior agreement with the party concerned, renounce, in full or in part, the right to the knowledge made in the project. (7 § and 9 §, Act no. 347 of 2 June 1999 on inventions at public research institutions)

Thus, collaborating with academia in Sweden requires that the rights and ownership of the knowledge created in the collaboration is regulated with the researchers involved directly. In the rest of the EU there are Technology Transfer Offices that facilitate the knowledge transfer.

3.4.3.3.3 Agreements

Contracts are necessary in order to have successful collaborations and the Non-Disclosure agreement (NDA) and Joint Development agreement are essential in most collaboration. NDAs can be used to create protection and control over the knowledge that is shared in the early discussions and raise awareness of the importance of confidentiality. Three areas are essential to address in NDAs: (1) what confidential knowledge is being disclosed, (2) each firm's rights to use the disclosed knowledge and (3) the timing of confidentiality (both the disclosure and confidentiality period). The Joint Development agreement is used to regulate the results, the FG knowledge, of the collaboration. A clear description of the joint development, clear boundaries in the agreement and defining each firm's rights to use both BG and FG knowledge are important aspects of a well-crafted Joint Development Agreement. (Slowinski, Hummel and Kumpf, 2006, p. 32-34)

As mentioned above in chapter 3.4.1, collaboration is one way of accessing proprietary knowledge. Another method is to instead enter into a supply agreement, where one actor, "the buyer", specifies the needs of a certain part of the system solution and purchases this from the "supplier". The function of a Supply agreement is to specify the obligations to sell and buy, e.g. a technical solution and the terms in a Supply agreement usually focus on regulating the obligations to sell and buy. However, if development and modifications are needed to incorporate the technologies in the system solution, the supply agreement is not likely to regulate the aspects highlighted in chapter 3.4.3.3 regarding the rights and ownership of BG and FG in that development.

3.4.3.3.3.1 Framework for analyzing agreements

Analyzing contracts is an important aspect of controlling knowledge. Andrew Telles presents a framework for analyzing contracts. The framework consists of four main steps: (1) reading the entire agreement including all attached documents, (2) break down the agreement into "blocks", (3) define the context and (4) run different scenarios. The first step of reading the whole agreement allows the reader to grasp the intent, structure, style and the type of provisions that are included. This provides an overview of what the agreement covers, what is missing and the overall purpose of the agreement. The second step involves breaking the agreement down into specific blocks that define the parties obligations and rights. Another "block" to specify is the object of the agreement, e.g. IP, know-how, money, results etc. The fourth block is related to how the other blocks are regulated in the present and in the future. The third step involves defining the context of the agreement by identifying the parties and their rights and obligations. It is also important to identify any questions that the terms of the agreement raise. The fourth and final step in the framework is to run different scenarios in order to evaluate consequences, answer risks and determine opportunities and identify risks. (Telles, 2011, Transaction Information and Analysis)

3.4.3.3.4 Competition law

In collaborations with the aim of developing a system solution and commercializing it, through e.g. an exclusive license, it is important to take Competition law into consideration. Art. 101, previously art 81, in the Treaty on the functioning of the European Union (TFEU) regulates joint conduct and can impact on IP license agreements, technology transfer agreements and other IP pooling arrangements. The EC rules apply to any relationship that affects the trade between member-states. If it does not affect the trade between Member States the national laws applies instead. However, the fact that two firms are based in the same country does not mean that trade between member states is not affected. The relation between firms is always important when evaluating Competition law. It is important to analyze the restraints and what sort of restraint does the firm have on the partner. Companies that are not directly competing with each other have a vertical relationship. These are important to separate from horizontal relationships, or inter brand relationships, as horizontal relationships can have a much worse effect on competition and thus the rules regarding these are stricter. Development agreements, which include all agreements between actors regarding R&D, are normally horizontal agreements, which is why they are important to discuss from a Competition law perspective.

Development agreements and licensing agreements that are horizontal inter brand relationships cannot result in cartels, price fixing, market sharing, quotas and colluding as this is not compatible with a common market. The block exemptions are safe havens and by following them the firm will be acting in accordance with Competition law. The block exemptions include: vertical agreements, technology transfer, specialization and research and development. (Colston and Galloway, 2010, p. 20-29)

3.4.3.3.5 Strategies for managing the knowledge of the employees

The employees involved in the development of the system solutions possess important knowledge related to the system solution in the form of tacit knowledge; know-how, skills and experience. This tacit knowledge is necessary and important to control. Tacit knowledge is however difficult to control as long as it is only carried in the minds of the employees. The law ensures that the tacit knowledge employees carries stays mobile making it difficult to control through legal means. Several authors and theories explain the need for identification and codifying of the tacit knowledge within a firm suggest that in order to capture the economic potential of the knowledge and to control the knowledge, there is a need to codify the knowledge. (Brooking, 1996; Granstrand, 2000; Stewart, 1997; Teece, 2000) Granstrand (1998) and Stewart (1997) Teece (2000; 2008) states that the essence of the firm lies in its ability to create, transfer, assemble, integrate, protect and exploit its knowledge. He also suggests that the more a given item of knowledge or experience has been codified, the more economically it can be transferred. Caenegem (2002) also discusses the importance of codifying, or "externalizing knowledge", tacit knowledge. Externalizing knowledge involves codifying tacit knowledge in order for the firm to control and manage the valuable knowledge assets. Externalizing knowledge is the first step in controlling tacit knowledge through legal means, such as IPRs. Externalizing knowledge also puts the firm in a better position to control the knowledge; both in a transaction and if e.g. a dispute with employees regarding trade secrets or confidential information would arise. The firm can also build, organize and manage a knowledge inventory connected to the system solution. The externalizing of knowledge can be encouraged by informing the employees of the reason, value and importance of externalizing the knowledge. (Caenegem, 2002, p. 21)

3.4.4 Degunkificaton

Degunkification is a term used by Petrusson (2005) to describe the process of creating structural order by systematically identifying all claims that could be made on knowledge. (Petrusson, 2005, p. 161-162) Degunkification consists of two components, Title Clearance and Background/Foreground Claims Analysis. Title clearance is a static analysis, i.e. focused on a specific point in time. The aim of the Title Clearance is to clarifying the title (ownership) of the knowledge as well as to determine who has the right to use the knowledge, the ongoing obligations etc.

The Background/Foreground Claims Analysis is dynamic as the analysis focuses on knowledge of specific actors over time. The Foreground knowledge created in the one collaboration becomes Background knowledge in the next, so the relevant actors and contracts vary depending on the time in history. (Telles, 2011, Degunkification and Information Gathering)

3.4.4.1 Title Clearance

Title Clearance is a tool used to identify existing and potential claims on specific knowledge at a specific time. The first step in performing a Title Clearance is to define the specific knowledge on which the Title Clearance is to be performed, e.g. a copyright protected work or a patented technical solution. There may be several actors involved who have made creative contributors to the developed knowledge, allowing them to make claims regarding e.g. ownership and rights to the knowledge. By identifying the existing and possible claims it becomes possible to establish who owns what and how the knowledge can be used.

The goal of performing a Title Clearance is to be able to make informed and proactive decisions, take proactive measures, rectify risks and make strategic planning. To be able to do this it is necessary to map the existing claims, perform a risk assessment, identify the need for further actions and identify and clean-up risks. The process of making a Title Clearance involves five steps: (1) defining the specific knowledge on which to perform the Title Clearance, (2) Identify and collect the necessary information, (3) analyze the legal and contractual rights, (4) assess existing and potential claims and (5) manage the existing and potential risks. (Telles, 2011, Degunkification and Information Gathering)

3.4.4.2 Background/Foreground claims analysis

Unlike the Title Clearance, which is static, the Background/Foreground Claims Analysis (BG/FG Analysis) is dynamic as the focus is on identifying relational claims on knowledge over time. The analysis is based on the information provided from the Title Clearance and expands on a broader range of knowledge, such as know-how and specific adaptations. The BG/FG Analysis facilitates the monitoring and managing development results, contracts in collaborations and knowledge.

The goal of the BG/FG Analysis is to actively manage, control and monitor rights to developed knowledge as well as to maintain control for future developments made by others and to track claims of development partners and employees. The process of the BG/FG analysis consists of five steps: (1) identify the relevant transaction strategy, (2) determine the developments that have taken place, (3) determine what knowledge assets contributed to the results and (4) analyze the legal and contractual rights to the results and existing knowledge. These rights include ownership, right to use, confidentiality and limitations. The final step (5) is to map the development over time and link it to the knowledge. Through this process the parties involved in collaborations can be linked to the necessary knowledge over time to clarify that the rights to commercialize the system solution exist. (Telles, 2011, Degunkification and Information Gathering)

3.5 Theoretical summary

The IAC Model, see Figure 6, is an illustration of how the authors view the theory on how to prepare the necessary knowledge in a system solution for a transaction. The overall view of the theoretical foundations is that each part of the process is dependent on the information that is produced in the step before. Therefore, in order to control the necessary knowledge, it must first be assessed. In order to assess the necessary knowledge, it must be identified.

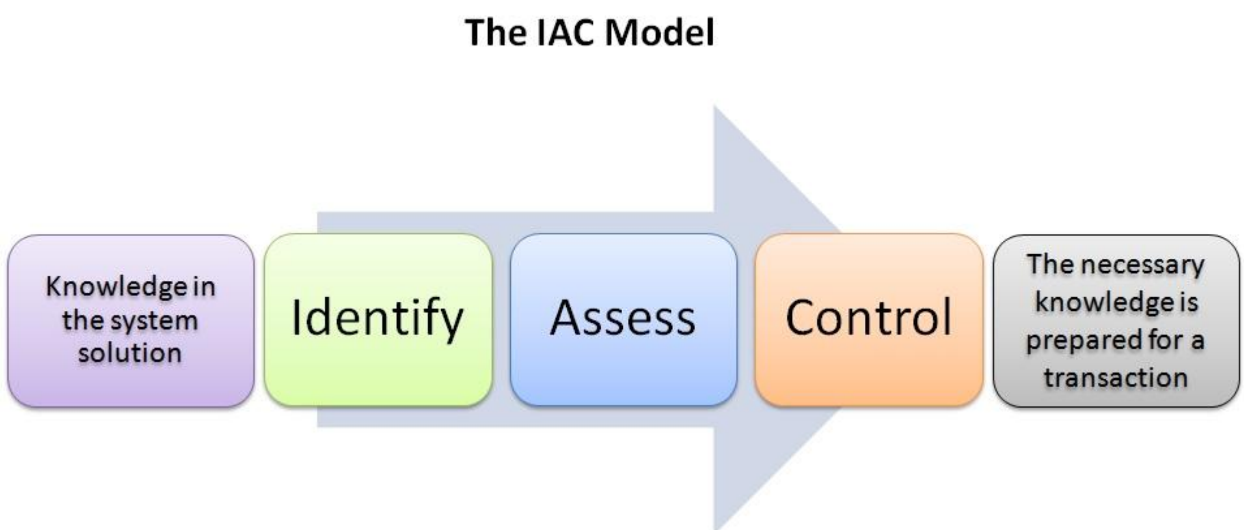


Figure 5: The IAC Model

Identify

Identifying the valuable knowledge in the system solution can provide profitability for the firm. By valuable we mean the necessary knowledge which has to be included in a potential transaction of the system solution. These knowledge assets should make sense in the context of preparing for a transaction of the system solution. Thus, it is important to identify transferable assets, i.e. explicit assets or tacit assets that have the potential of being codified and become explicit, since these can be capitalized on. Further assets should be described so that they make sense to the context they exist and will be utilized within. This means describing the assets in the form that they can be understood for what value they bring in a potential transaction of the system solution. Knowledge assets must also be controlled to fully capture the potential value from the knowledge, hence description of the assets should link to control means of the assets identified. It also means that whatever is relevant from the system solution point of view, i.e. what are specifically important characteristics in a system solution, this will be included when describing the assets.

Assess

To provide value for a potential transaction of the system solution, certain assets are more valuable than others. Assessing the previously identified knowledge assets can detect key assets in the system solution. The assessment of the knowledge assets is dependent on the identification of the assets. It is important to distinguish which assets are considered unique and valuable and which are differentiable or generic since it will have an effect on how to manage the knowledge assets. Assessment criterions must provide measurement sufficient enough for the described distinction. These criterions must be based on the contextual setting the system solution exist and will be utilized within. This means that in order for the system solution to be transacted there is a need to identify the key assets which are more important in order to create value in the transaction. These key assets will also need more careful control and hence, the criterions should provide insights over how to manage and control the identified knowledge assets.

Control

Control is required in order to appropriate the value of the system solution in a commercialization and to keep control over the knowledge. The control is dependent on the identification and assessment of necessary knowledge, since without clearly defining the necessary knowledge it is not possible to effectively control. There are a number of methods that can be used to control the necessary knowledge. These include the legal frameworks: IP law, contract law and trade secret law. There are also alternative strategies in order to control tacit knowledge and tools for controlling knowledge. Furthermore, clarify the existing and potential claims that can be made on the knowledge and the ownership and rights to the knowledge are important steps in creating control over the necessary knowledge. How to control knowledge is influenced by a number of different factors, such as the type of knowledge, in what form the knowledge is and the context in which the knowledge exists and will be utilized.

4 Results

In this section we present the results from the data collection. The aim is to provide significant details for the analysis of the results. The chapter begins with an historical overview of the BIOAGRO case. Then it continues with specific results from the investigation of the system solution. Lastly it presents collected data over the actors involved in the system solution.

4.1 History

BIOAGRO is a project with a large network of collaboration partners that aims to provide a system solution in the field of biomass created from by-products in seed production. The project begun in 2006 after the head partner Skånefrö AB, sent in an application for an EU LIFE grant in 2005. With the application, Skånefrö AB asked for funding of a facility that turned the residuals from the seed production into biopellets in order to extract energy to the own facilities and the community nearby. The BIOAGRO project was a complex project with many partners providing their respective knowledge. HOTAB was approached in order to develop a solution for the combustion of pellets. In order to avoid toxic substances in the waste material from burning the biopellets there was a need to optimize the recipes for creating biopellets, which resulted in the collaboration with Chalmers. This collaboration in turn resulted in the start-up company Ecoera AB. ÄFAB was also brought on to perform the pilot scale testing of the recipes. (Technical Report, BIOAGRO)

Today BIOAGRO has finished the EU funded project and has become a commercial entity with the purpose of extracting value from the developed solution. Interest has been huge and over one thousand visitors, representing forty five countries, have been to the facilities. The project was also awarded Best of the Best from the EU commission in 2011 where they outcompeted hundreds of other Life projects. (Layman's report, BIOAGRO)

4.2 Technical solution

The technical system in BIOAGRO is the result of all incorporated knowledge, thus a description over the complexity of the system is the base for an analysis which will be done afterwards.

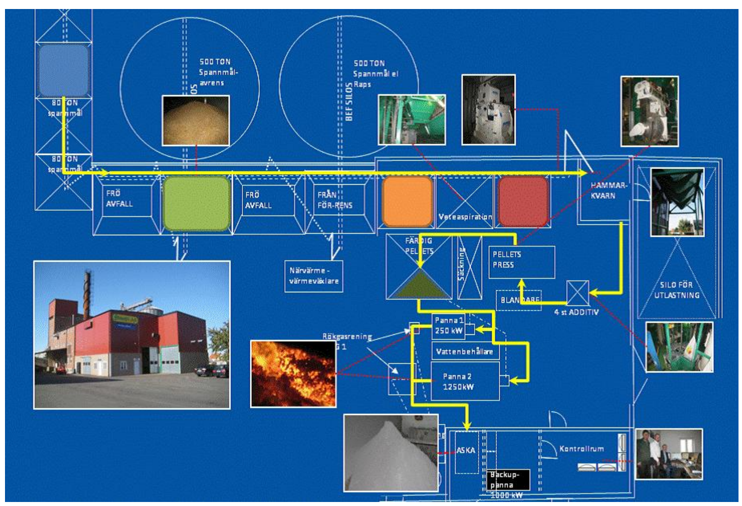


Figure 7: Overview system at BIOAGRO

4.2.1 Several technologies

The system at BIOAGRO is made up by combining a number of different subsystems which all incorporates their specific technology. (Interview Mattias

Persson, BIOAGRO) In Figure 8 the different technologies are listed and described briefly.

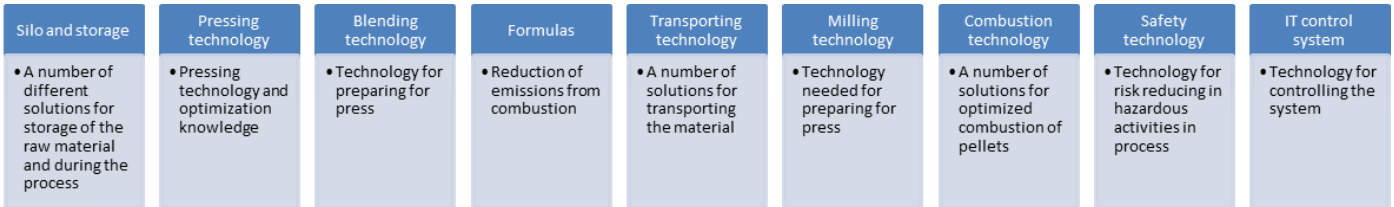


Figure 8: Technologies incorporated in the BIOAGRO system solution

Each of the technologies shown in the picture above contains a large amount of knowledge which all can be seen as significant in order to make the system function as desired.

4.2.2 Modification of technologies

The technologies are standalone results from vast amounts of research and development. However, the exact utilization in the BIOAGRO facilities was for the majority of the technologies never the sole intent for originally developing the technologies. Instead the technologies has been tested and modified in order to meet the specific requirements of the raw material used in the facilities. (Interview Mattias Persson, BIOAGRO) The process of constructing the plant and system has been a series of utilizing the expertise from the suppliers of the hardware and the knowledge stemming from handling the different raw materials that the system aims to process. (Technical Report, BIOAGRO; BIOAGRO Life report) A conceptual model of knowledge creation for a specific technology type used in BIOAGRO is shown in Figure 10.

Figure 9: View over system solution at BIOAGRO

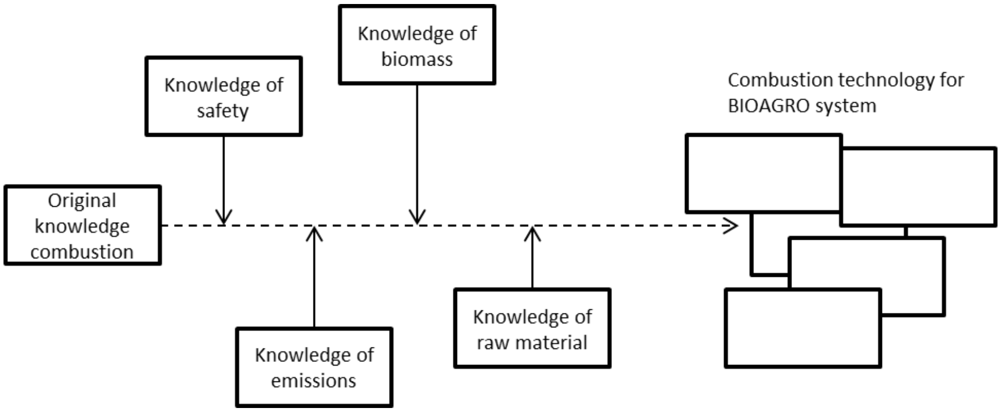


Figure 10: Knowledge creation - modifying

The original knowledge combustion square is to be understood as the original equipment from the supplier. However during the implementation of the original combustion equipment a number of solutions are created in order to make it feasible in the specific context of BIOAGRO. Hence the result of the implementation creates a technology that is more developed, i.e. constitutes more knowledge, than its predecessor it originates from. The same applies to all above described technologies that originally were created for a different purpose then the process at BIOAGRO.

4.2.3 Integration of technologies

The previous paragraph presents the technologies as stand-alone knowledge containers. The next task in the creation of the system solution was to integrate the different parts in the system. (Interview Alf Eriksson, BIOAGRO) These actions resulted in the creation of an additional bulk of knowledge. Building on the conceptual model described above we can add the knowledge that is created in the integration part of the system building process, see Figure 11.

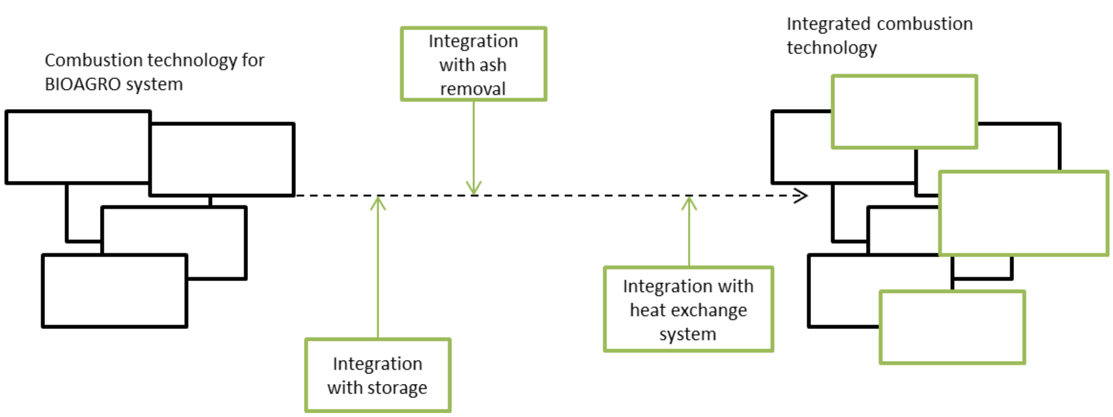


Figure 11: Knowledge creation - integration

The result is a more thorough knowledge block that is niche for its specific utilization, the BIOAGRO process. The integration of all different technologies in the BIOAGRO system was a time consuming and difficult task and the knowledge created in the integration part stems from problem solving among the different expertise persons available. (Technical Report, BIOAGRO) Integration was both performed between different technologies and also sometimes within a technology group, for instance the transporting technology. (Interview Alf Eriksson, BIOAGRO) As described, the task of integration was a time consuming and difficult task and it is also here the main challenges were, resulting in the creation of necessary knowledge and future improvements.

4.2.4 Automation of the system

The BIOAGRO system is an automated system. Therefore, a thorough IT control system was created during the development of the system solution. This task included many challenges and the final result was a complex IT control system. (Technical Report, BIOAGRO) Adding this aspect to the conceptual model we can illustrate the knowledge creation in this part of the system build up, see Figure 12.

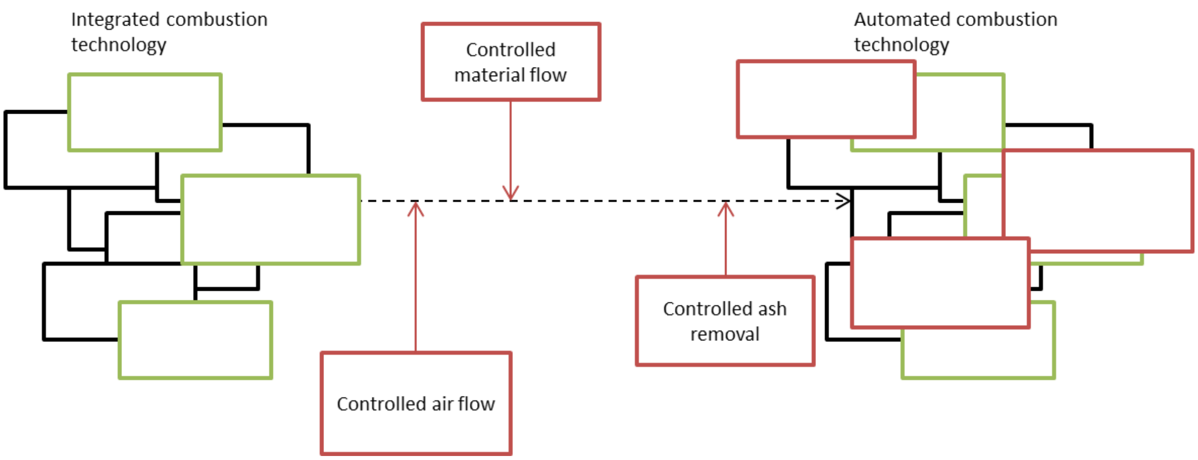


Figure 12: Knowledge creation - automatization

Once again the knowledge block surrounding the combustion process has grown and now consists of knowledge created from three different challenges: modification, integration and automation.

4.2.5 Exceptional knowledge or common knowledge

Both technologies developed in the creation stages of the solution and technologies that already existed which have been included in the solution varies in their degree of uniqueness in relation to existing technologies on the market. (Interview Mattias Persson, BIOAGRO) Some technologies are entirely standard solutions, some are customized and others are new innovations. In the formal project plan, the objectives were to build a system solution with 90 percent existing technologies and 10 percent innovations. (Project plan, BIOAGRO Life) The results was that innovations superseded the original thought of 10 percent and in the system solution at BIOAGRO innovations are to a higher degree represented than 10 percent. (Interview David Andersson, Ecoera AB)

4.2.6 Knowledge type

Not all knowledge implemented in the system solution share the same characteristics. There is knowledge relating to:

- Hardware
- Software
- optimization tests

In the different subcategories of the knowledge parts there are similar types of knowledge. Some formal optimization tests at BIOAGRO generate data that are stored in a database or summoned in reports. Other more ad-hoc optimization trials, generates raw data without a formal structure. There is also knowledge incorporated in generating new solutions for technical requirements of the system. Similarly, knowledge is incorporated in software code and algorithms for the automated system. The software system also incorporates lists of relevant data to control the system. Some knowledge assets have already been formalized in Intellectual Property rights. (Interview Alf Eriksson, BIOAGRO; Interview David Andersson, Ecoera)

4.2.7 Optimization level

The system solution at BIOAGRO is under constant improvement. Significant efforts have been taken to provide for a functioning solution. However, the complexity creates room for improvements and constant knowledge creation in optimizing the system functionality. At the moment, several improvement updates are aware of and will thus, be integrated in the following versions of the system solution. (Interview Alf Eriksson, BIOAGRO) These blocks of knowledge are spawning over the entire set of modification, integration and automation as well as the entire set of different types of knowledge.

4.3 Actors

In the BIOAGRO system solution there are several different actors that have been involved in the development, see Figure 13. The company BIOAGRO Energy Österlen AB is owned by the Swedish seed company Skanefrö Förvaltnings AB and there are five partners; EcoEra AB, HOTAB, ÄFAB, Westrup A/S and Rejlers. There are also six technology providers: SANPRO, Schneider Electric, Pannpartner, Andritz Sprout A/S, Firefly AB, KL-Industri AB. The partners and technology providers were approached by Skånefrö AB and provided with detailed information about their assignment and the needs and requirements of what they were expected to deliver. (Technical Report, BIOAGRO)

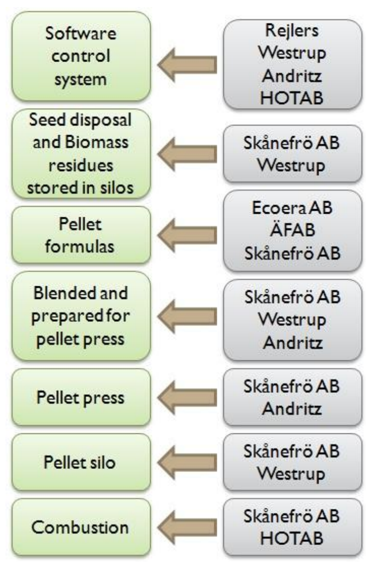


Figure 13: Actors involvement in the specific technologies

4.3.1 Partners in the BIOAGRO system solution

4.3.1.1 Skånefrö AB

Skånefrö AB is the main actor and owner of the system solution and was responsible for the installation of the equipment except for the boiler units. Skånefrö AB has an extensive expertise in seed processing and was responsible for the construction of the BIOAGRO facility as well as the installation of the equipment except for the boiler units. (Layman's report, BIOAGRO)

4.3.1.2 Westrup A/S

Westrup A/S is responsible for supplying peripheral equipment for the BIOAGRO Energy system solution. They also contributed with strong know-how related to contracting and the integration of the hardware.

Westrup has expertise in the designing and manufacturing of high-quality machinery and equipment for the seed and grain conditioning and processing industry.

4.3.1.3 HOTAB Group

The HOTAB Groups contribution to the project was the design, construction and installation of the furnace units. The BIOAGRO furnaces prototypes were designed to prevent ash melting; a challenge that burning agro-residues has compared to woodchips or wood which generates a low amount of ash. The HOTAB Group has expertise in the latest combustion technology and can design, construct and manufacture complete combustion solutions. (Layman's report, BIOAGRO)

Figure 14: Boiler unit BIOAGRO

4.3.1.4 Ecoera AB

Figure 15: Chalmers Lab, Pellet formulas

When developing the BIOAGRO system solution proprietary knowledge from academia was required regarding developing the pellet formulas. The BIOAGRO project group approached Chalmers University of Technology with the research project to develop formulas that would "mix biomass and environmentally friendly additives to form a renewable pellet fuel for heat production". The parties referred to the project stemming from business as a "Reverse tech transfer". The Department for Inorganic Environmental Chemistry in Chalmers University of Technology where part of channeling knowledge and research results towards implementation in a biofuel production system in the BIOAGRO Energy production facility. (Alänge and Lundqvist, 2010) To perform the research and transfer the knowledge to the BIOAGRO project, the Chalmers School of Entrepreneurship (CSE) became involved and a CSE project was started for the development and commercialization of the fuel in collaboration with the BIOAGRO project. Ecoera AB was created and incorporated the CSE project, becoming a technology provider to the BIOAGRO project as well as an independent firm, owning the pellet formulas. Ecoera AB performed tests and evaluations of different mixtures of raw material and additive developed the pellet formulas for the BIOAGRO Pellet. (Layman's report, BIOAGRO) Ecoera has expertise in pellet fuel formulas and can also contribute with expertise related to future developments, innovation and are a marketing partner. The formulas for the Bioagropellet are licensed from Ecoera AB to BIOAGRO Energy Österlen AB, the company created to commercialize the BIOAGRO system solution, through an exclusive license agreement. (Alänge and Lundqvist, 2010)

4.3.1.5 ÄFAB

ÄFABs contributions to the project are as consultants and lab providers on renewable energy and biomass. Small-scale combustion trials were done in the laboratory at ÄFAB and Ecoera and ÄFAB worked together to develop optimized formulas for bio-pellets. ÄFAB's contribution was focused on "biomass fuel pellets small-scale grate-fired combustors". They have expertise in environmental- and resource economizing, with a main focus on bioenergy and had BG knowledge on producing pellets by mixing oats and barley with other waste products and bringing it through a fodder pellet machine. (Technical Report, BIOAGRO)

4.3.1.6 Rejlers

Rejlers contributes with leading expertise when it comes to construction of the IT control system for the BIOAGRO system solution and the PLC infrastructure system. They have extensive expertise in engineering consultancy within the areas of: infrastructure, industry, energy, and construction and property. Rejlers also has a strong expertise in the field of programming the system to tailor and optimize the functions to enable maximum efficiency of the system. (Interview Sten Petterson, Rejlers)

4.3.1.7 ENCUBATOR

The final partner's ENCUBATOR which enabled the transferring of the IPRs created through the collaboration with Chalmers University of Technology to Ecoera AB. Encubator has experience from venture start-up and financing from the 10 years of operations within the Swedish innovation system. Encubator, owned by Chalmers University of Technology, has formed ventures stemming from high-tech innovations from university and industry. It serves as a commercialization partner to BIOAGRO Energy Österlen AB and is using its network of partners to leverage the competence of the whole BIOAGRO consortia. (Interview David Andersson, Ecoera AB)

5 Analysis

The aim of this chapter is to analyze the empirical data and discuss the relevance of the results according to the theoretical framework which has been used in the thesis. The analysis and discussion will follow the stated research questions: identify, assess and control.

5.1 Identify

As presented in the empirical part we can see that the system contains a large bulk of knowledge with various characteristics and types. This knowledge has been created during various stages of the project which is illustrated in the previous chapter. In order to properly manage this bulk there is a need to identify the specific parts, or assets, of the bulk of knowledge that is necessary for a potential transaction of the whole system.

5.1.1 Choice of necessary knowledge assets

The choice of relevant knowledge assets are derived from the context in which the system solution exist and will be utilized within. The knowledge assets found in the BIOAGRO system is varied in a number of ways, stemming from different creation processes and contributing more or less to the functionality and value of the full solution.

To exemplify, the silo system in the BIOAGRO system contains knowledge stemming from modifying the silos to suit the characteristics of the raw material used in the pellet production of the system. Silos were originally created to suit raw material with different characteristics and problems occurred when trying to use them with the bi-products in the BIOAGRO facilities. Thus, modification was needed and knowledge in the form of implemented new technical solutions and test data for the different substances was created. This knowledge is considered necessary in order to make the system function. It is also the type of explicit knowledge, i.e. through tangible representation in technical solution or saved as test data in a database, which can be transacted and hence, possible to extract value from. (Diefenbach, 2006; Granstrand, 2001) The knowledge stemming from modifying the silo system is an example of knowledge assets which should be identified and provided in an inventory list (Harrison and Sullivan, 2006) over relevant knowledge in the system solution.

The silos were integrated with the transport system that transported the raw material to the next part of the system solution. However, transport conveyors were also created with other types of raw material in mind; thus, modification was needed for conveyors as well and resulted in knowledge creation. Then integrating the silos with transporting conveyors needed some control system for release of substances. The integration system, based on software, needed to take into account the characteristics of the raw material and was developed for that specific purpose. This software system is also an example of necessary knowledge since without the integration there would not be a system with the different technologies. It is also explicit since it is captured in a software code and hence, possible to transact. Due to the necessity of the knowledge and its transferability this knowledge also needs to be identified and provided in the inventory list.

The above examples show that there is a need to be detailed in order to extract relevant knowledge from the bulk of knowledge in the system solution. There is a need to deconstruct the system into subsystems and take into considerations the aspects of creation processes and problem solving in the construction of the system. In this way it is possible to identify necessary knowledge in order to prepare for a transaction of the system solution.

At this stage we have only analyzed factors that are relevant in picking out the right knowledge assets. The next factors should be linked with how to describe the knowledge assets so they can be understood in the way that they make sense to the context in which they exist and will be utilized within. (Harrison and Sullivan, 2006; Barney, 1991; Stewart, 1997)

5.1.2 Describing the knowledge assets in relation to the context

In order to enable an easy reference to the type of technology the knowledge asset in the BIOAGRO system falls within we have chosen to describe the knowledge asset with a title that captures the technology type. In this way the context in which the system solution exists in is described. (Harrison and Sullivan, 2006) Furthermore, in order to capture the balance of being specific and accessible we have chosen to provide a more explanatory definition of the knowledge asset. In this way the assets are described in relation to the functionality in the system solution, i.e. contextually described, in a both specific and yet easily understood way for laymen. Below is an example which relates to the type of solution found in the BIOAGRO system, however the example is just an imaginary and not an actual asset due to the sensitive information regarding valuable knowledge in the system solution:

Asset Title	**Definition**
Cyclone-facilitated blending mixer	Solution which creates a desired mixture of raw material in order to facilitate the pellet pressing and create a desired texture of finished pellets

Table 2: Title and Definition of Asset

In the context of preparing the system solution for a transaction, this information will provide an easy reference to the technology, i.e. blending technology, and specificity to which underlying technique, i.e. cyclone technology, that make it possible. It is also accessible in that it explains the benefits of the knowledge asset, i.e. facilitate pellet press and create desired texture, which can be linked with what value the potential customer in a transaction would benefit from.

5.1.2.1 Relating knowledge asset to technology type

The empirical data illustrates that the system solution holds many different technologies. By relating the assets found to a specific technology, it is possible to see which technology part of the solution holds most assets. This can give a hint on where to identify the key knowledge assets of the system solution. (Pralahad and Hamel, 1990)

At BIOAGRO this was done in order to provide an overview of the assets. Figure 16 illustrates the assets in relation to technology type.

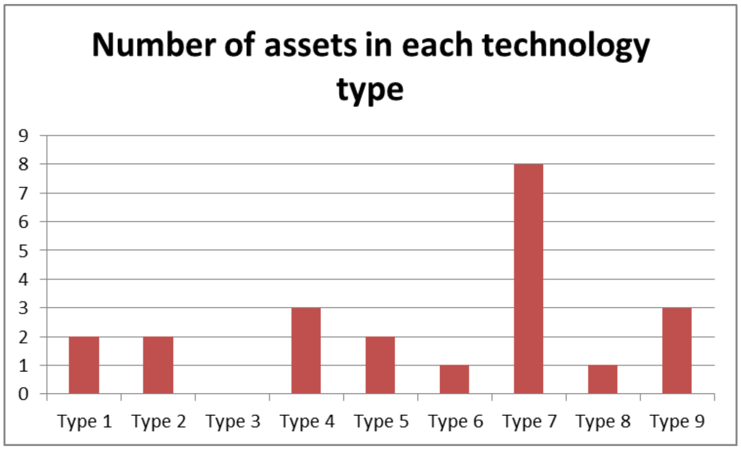


Figure 16: Number of assets in each technology type

As can be seen from the diagram some technology types include more assets than others. When linking the assets with specific technology type it is easier to see in what parts the system holds the most assets.

5.1.2.2 Knowledge creation stage

Looking at the nature of the system solution, several development stages are apparent, and these stages can be linked with creation of knowledge assets. In order to transact the solution, linking the knowledge assets with the creation stages can provide meaningful information on where to locate the key knowledge assets in the solution. (Pralahad and Hamel, 1990) This is drawn from the fact that certain creation stages at BIOAGRO demand more knowledge creation and problem solving than others and thus, it can further provide information over how the knowledge assets should be managed in the possible transaction, i.e. manage and control measurements. At BIOAGRO the three different creation stages were: modification, integration and automation. Figure 17 describes the amount of knowledge assets in respective creation stage category and illustrates in which creation stage most knowledge assets were created.

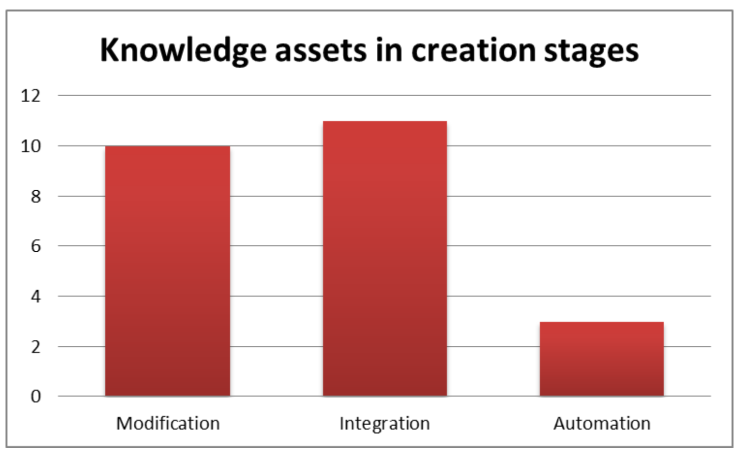


Figure 17: Amount of assets in creation stages

5.1.2.3 Type of asset

The knowledge assets found in the BIOAGRO system are different in their nature, i.e. the type of knowledge they relate to. Hence a topology of the different assets can add more information on how to manage the assets properly. Categorization of assets should make sense to the firm, and reflect the contextual setting in which the asset exist and will be utilized in. (Harrison and Sullivan, 2006) Transacting a system solution includes the transaction of relevant knowledge assets and these are important to control in order to capture the value from them. (Barney, 1991; OECD report, 2011) In the BIOAGRO system the different assets relate to different characteristics. To exemplify, the hardware have a physical representation of the knowledge, e.g. some technical solution to a physical problem in the system. Hence using a category of *technical solution* captures the type of knowledge represented in the hardware. There can also be technical solutions that are not represented in any hardware, e.g. ideas or early proof of concept prototypes. However a technical solution should have the possibility to be represented in a product. It is also the type of knowledge that can be protected with a patent provided that it fulfills the criterions for patentability.(WIPO, 2004) In this sense the knowledge is described both for its representation in the BIOAGRO system solution and for its link to possible control measurements which is significant in a potential transaction of the system solution. Further, the software in the system solution consists of a series of algorithms and connections between various lists and databases written in code that captures the solutions provided with the IT system. Hence both the type *software code* and *database* are relevant to address when describing knowledge created and utilized in the software. Both the types can be linked with protection measurements such as copyright and database protection. The knowledge assets can also be linked with how they are represented in the system solution by using the types described. Then there are other knowledge assets that are represented in the optimization data from the system solution. These knowledge assets are in the form of *data, database* and *description* which also make up relevant categories in the topology of the knowledge assets. They are all linked with copyright protection and provide information over their representation in the system solution. Figure 18 illustrates the amount of knowledge assets found in the BIOAGRO system in respective type:

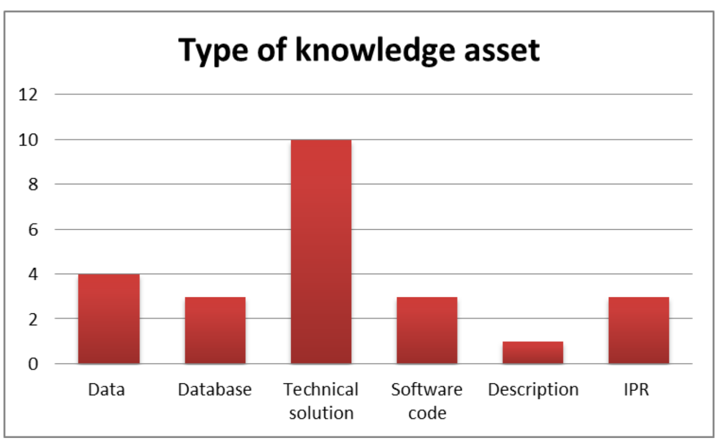


Figure 18: Knowledge types

The diagram also includes IPR knowledge assets since these are actual judicial documents that can be used directly in a transaction. (WIPO, 2004)

5.1.3 Summary of identification and description of knowledge assets

To summarize, the proposed information can be captured in a spreadsheet such as in **Figure 19**

Title	Definition	Type	Creation stage
Technology type 1			
Technology type 2			
Technology type 3			

Figure 19: Knowledge asset inventory list

As can be seen from the excerpt, the top row includes the previously mentioned contextual description categories whereas the technology types separate the following rows according to the number of assets in each specific technology type.

If the list is completed in accordance with previously described manner it will provide the reader with identification and information regarding valuable assets in the system solution. With this information it is possible to make decisions regarding management of the identified intellectual assets.

Viewed in this manner the list is a comprehensible tool to prepare for a transaction. There is however important to remember that no exact definition of this kind of list exists. Harris and Sullivan (2006) speak about the inventory list of intellectual assets as a tool for extracting value from knowledge assets. This list is our interpretation of that inventory list where we seek to implement previously literature on identifying intellectual assets. There is no scientific evidence that this list is the single choice for identification of intellectual assets in a system solution within the cleantech industry. The room for interpretation over how to present the identified assets is still open.

5.2 Assessing the identified knowledge assets

The quest for identifying key knowledge assets begun by identifying the necessary knowledge assets and describing them so that they can be understood for the contribution they make in the context they exist and will be utilized within. (Harrison and Sullivan, 2006; Barney, 1991; Stewart, 1997) The descriptions used in the previous chapter is however not sufficient to know which knowledge assets within the system solution to put focus on more specifically in order to capture value when transacting the solution. (Pralahad and Hamel, 1990) The assets found in the BIOAGRO system are both different in their nature and contribute more or less to the value of the full solution. The assets also rely on control measurements when transacting them between actors and hence, they need to be managed and controlled properly to reduce the risks associated with transacting knowledge. (Stewart, 1997; Granstrand, 2006; WIPO, 2004)

5.2.1 Choice of criterions

The system solution at BIOAGRO incorporates a large bulk of knowledge which has been deconstructed into knowledge assets from the previous step. The knowledge assets relate to different creation stages and different technologies as described earlier. There is also a different level of innovativeness in the development of knowledge parts. Some are more standard while some are more customized in relation to what exists on the market. Adding to this, some challenges were more difficult to solve while some were more straight on, resulting in different difficulty in developing the knowledge assets. The assets found in the BIOAGRO system relate different to how unique they are compared to other knowledge assets on the market. (Barney, 1991; Sullivan, 2001) A *uniqueness* criterion seems relevant in the BIOAGRO system solution context since it can provide information which assets that are developed directly for the system solution or has been modified heavily from its original state.

Some knowledge assets found in the BIOAGRO system are unique, however not difficult to imitate for someone with knowledge in the field. This is significant in the transaction of the knowledge since knowledge that is easy to imitate need more rigorous control measurements. (WIPO, 2004; Caenegem, 2002) Hence assessing the knowledge assets for *imitability* can provide information on how to further manage and control the knowledge assets.

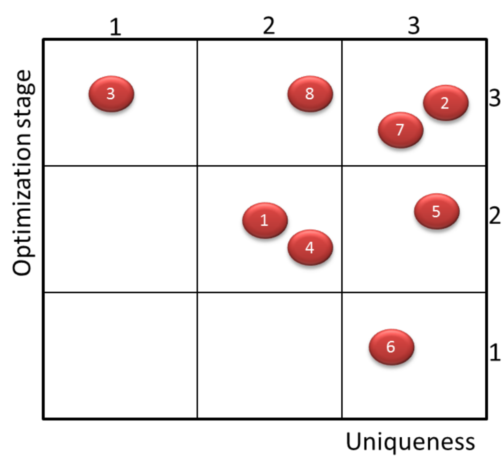
In the BIOAGRO system several different solutions were incorporated and the choices of which solution to develop and incorporate were often being influenced by the preference of the actor or actors providing it. For example, the company Westrup which delivered transport and silo solutions in the system, suggested different solutions since they had knowledge in the field. Some of the solutions could however be replaced by other solutions. This leads to the question whether the identified knowledge asset is easy to replace by another technology, software code etc. This information has also a large impact when transacting the solution and protecting the knowledge in the transaction. Hence, assessing also the *substitutability* of the knowledge asset can provide relevant information how to manage the knowledge assets in the system solution. (Barney, 1991; Sullivan, 2001)

Some knowledge assets in the BIOAGRO solution have just been developed, meaning that there is still further development and optimization possible of the specific knowledge asset. This can have an impact on a potential transaction of the system solution. An assessment of the *optimization stage* will provide information over the development potential of each asset. Thus, this information is regarded valuable since updates in the system can have impact on efficiency and costs of the solution. Also as an indicator of what protection strategy is best suitable for the specific asset, optimization stage provides important information. (Caenegem, 2002)

The different types of assets shown in the empirical data have different implications for control which is apparent in the type and development stage of the knowledge asset. In order to create control over the assets in a potential transaction, information over existing control will provide fundamental insights. Each asset can be controlled in different ways.(Caenegem, 2002; Foray, 1995; Levin, 2007) With relation to that discussion, an assessment over the two control dimensions secrecy and IPR based control will provide relevant information for existing control status of each asset.

There are several actors involved in the system solution and their contributions differed in relation to the creation process. For example, ÄFAB was involved only to test the pellet formulas while Rejlers were involved almost every integration and automation part of the creation processes. This leads to the question whether the information over what specific contribution a specific actor did in the development of the system solution, is explicit. This creates a need to investigate ownership clarity in the collaboration between actors. (Petrusson, 2005) Assessing ownership clarity in relation to formal documents will provide important information for a more thorough investigation, "degunkification", leading to information on how to manage the knowledge assets for control. The "degunkification" is part of the control analysis and will be discussed thoroughly in that section.

With the dimensions assessed it is possible to communicate the identified assets in relation to assessment criterions. A modified example from the BIOAGRO assessment is shown in Figure 20.



1	Title asset 1
2	Title asset 2
3	Title asset 3
4	…
5	…
6	…
7	…
8	…

Figure 20: Assessment view

In this communicative way it is possible to easier find the key assets, the ones that are high on both scores. This is not always true since depending on the assessment criterion, some knowledge assets can be considered key assets despite scoring low on that criterion. However, it is possible to plot either two criterions that make the most sense for the specific context the assets was assessed for. (Harrison and Sullivan, 2006) Note that the matrix is only one way of presenting the assessed assets in relation to assessment criterions.

5.2.2 Suggested assessment management

Neither Barney, nor Sullivan mentions the subjective dimensions in assessing assets in this way. Since the method has not been tested against a different method scientifically, we can only rely on the foundation for each assessment. Hence, we suggest transparency in what lies behind each assessment. This can be done by first describe the scoring criteria for the example Optimization stage, which is shown in Figure 21.

Optimization stage

Assessment score	Description
1	The asset is functioning but in an early stage with a high potential optimization level
2	The asset is optimized to a certain extent but has potential for further development
3	The asset is optimized to suit the specific context it is being used in

Figure 21: Assessment score criterions

Then by explaining the sources and give a brief motivation for the assessment score and the confidence level for the score, it is easier to judge quality on the assessment, see Figure 22.

Optimization stage

IA title	Score	Motivation	Confidence level	References
IA 4	2	The asset is tested and optimized for flow levels at 3 tonnes/hour. However increased flow requires further testing and optimization	3	1 Interview: Alf 2 Technical report BIOAGRO

Figure 22: Assessment motivation

Again this is only one way of many to perform the assessment.

5.2.3 Summary of the assessment of knowledge assets

Adding the scores of the assessment to the proposed list will provide further information over the assets within the system solution:

Title	Definition	Type	Creation stage	Uniqueness	Optimization stage	Imititability	Substitutability	IPR based control	Secrecy based control	Ownership clarity
					Technology type 1					
					Technology type 2					
					Technology type 3					

Figure 23: Inventory list including assessment criterions

With this list it is possible to create matrices such as the ones demonstrated previously. This list aims to provide the reader with information that can reduce insecurity regarding decisions how to manage the individual assets and which ones that is most important to focus on. The list comprises the theory put forward by Sullivan (2001) and Barney (1991) with addition from the analysis of the gathered empirical data. Again we emphasize that the list is only one way of presenting the assessment scores. However it follows the format used in the previous task, identifying the assets, and can function as a collected list to use as a tool to make decisions regarding management of assets available.

5.3 Controlling knowledge

The previous sections described the relevant factors for identifying and assessing necessary knowledge assets, which is fundamental in order to be able to control the knowledge. In the following section the results regarding controlling knowledge from the BIOAGRO case study and theory are analyzed.

5.3.1 Controlling the knowledge developed in collaborations

In the BIOAGRO case study we observed that a large network of actors was involved in the development of the BIOAGRO system solution, see Figure 24. In the previous two processes, the identification and assessment, a total of 24 individual necessary knowledge assets were identified. The knowledge assets had in many cases been developed by collaborative efforts from several actors. In order to determine the control of each of the identified necessary knowledge assets it was required to clarify the ownership and the rights to the knowledge, as these two aspects influences the control of the knowledge assets. (Petrusson, 2005; Telles, 2011) Due to the involvement and creative contribution of different actors in multiple knowledge assets in the BIOAGRO system solution, the existing and potential claims on the necessary knowledge also became important to clarify. In order to clarify these factors the tools presented in the theoretical framework was utilized, i.e. the Title Clearance and BG/FG Analysis. These where helpful to organize and map each actors creative contribution to the innovations in the system solution and to identify all existing and potential claims regarding ownership and rights that could be made on the necessary knowledge. (Petrusson, 2005; Telles, 2011) Investigating these issues in the BIOAGRO case study revealed that, e.g. three actors had been part of the development of the pellet formulas, combining their different areas of expertise to develop the final formulas. This indicated that the involvement of several actors in the development and integration of knowledge in a system will result in that multiple actors had made creative contributions to several of the necessary knowledge assets. It also became evident that this would not have been possible to identify from only studying the agreements between the actors. Instead, interviews with all actors involved combined with studying the written contracts are required due to the complexity that is created by the involvement of a large number of different actors.

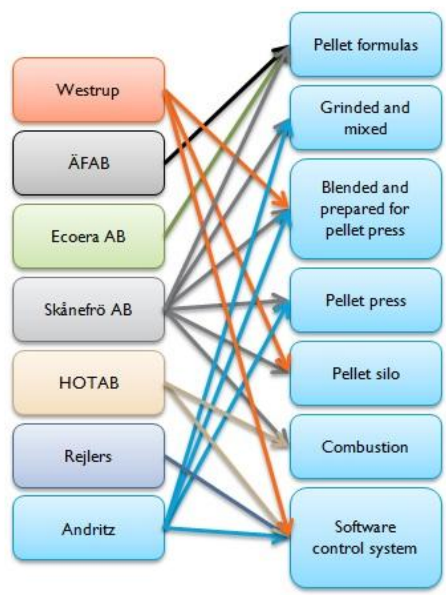


Figure 24: Network of actors involved in the development of the BIOAGRO system solution

5.3.2 Contractual control

During the development of the BIOAGRO system solution the acquisition of necessary proprietary knowledge from industry was done through hiring expert firms to complete specified tasks. Skånefrö AB, which had the primary need for the solution and was head applicant of the EU funded project, approached the partners and technology providers with detailed information about their assignment and what each actor were expected to deliver, setting up standard Supply agreements. Many of these relationships evolved during the development of the system solution into joint developments/collaborations, due to the requirement of integration and specialized adaptations of the technologies in the system solution. Thus, the standard Supply agreement was no longer sufficient as it did not cover how the jointly developed knowledge would be owned and the rights to the knowledge. Therefore, in order to prepare the knowledge for a transaction it was necessary to create new agreements that regulated these issues, as the theory suggests. (Petrusson, 2005; EC, 2002)

5.3.2.1 Interacting with Academia to access proprietary knowledge

The interaction between the BIOAGRO project group and the Dept. of Inorganic Environmental Chemistry at the Chalmers University of Technology for the development of the pellet formulas resulted in the creation of Ecoera AB that is now owned/controlled by both interests from the University as well as BIOAGRO Energy AB. This solution combines the Development collaboration model, Commercialization collaboration model and the University start-up model presented by Pries and Guild (2004) for how firms can interact with academia.

A contract was set up between Ecoera AB and the lead researcher to transfer the rights from the University setting into the commercial setting. The “Teachers exemption” allowed for an agreement to be made directly with the lead researcher, transferring the knowledge created in the research to Ecoera AB. In the contract between Ecoera and the lead researcher both the confidentiality and transfer of knowledge to Ecoera was regulated. The lead researcher wanted to publish the results from the study, something that is not uncommon in collaborations with Universities. (Slowinski, Hummel and Kumpf, 2006) This was facilitated in the contract in order to create a win-win situation between the parties. Strict confidentiality applied to all knowledge the lead researcher received from both Ecoera’s activities and other activities that occurred in Ecoera’s environment, ensuring that all BG knowledge as well as FG knowledge within Ecoera was controlled and protected. The concepts that are used, e.g. “Ecoera’s environment”, were defined and explained which is important in a well-crafted agreement as well as to educate and explain them to the parties involved. (Slowinski, Hummel and Kumpf, 2006) The results, FG knowledge, generated from the project that was initiated by Ecoera accrue Ecoera. Ecoera also had the right to first refusal, i.e. having the option to obtain ownership of the results, to the results generated from the thesis project tutored by the lead researcher that did not fall in line with the aim of the lead-researchers defined research. Therefore, by clearly regulating the ownership of both the BG and the FG knowledge, Ecoera managed to control the knowledge that was created in the collaboration. The way the agreement was set up in the Ecoera case follows the arguments presented by Slowinski, Hummel and Kumpf (2006), providing a good example of knowledge management in collaborations with academia.

5.3.3 Methods for controlling necessary knowledge assets

The identified necessary knowledge assets in the BIOAGRO system solution consisted of various types of knowledge, assessed and organized into different categories: technical solution, data, database, algorithm, description and IPRs. The different categories provide an overview of the necessary knowledge, making it more manageable. In order to analyze how to control the necessary knowledge, it was required to analyze each category and each asset individually. Below are examples of the methods for controlling the necessary knowledge assets discussed.

5.3.3.1 Control through IP law and Trade secrets

One of the main categories of necessary knowledge assets that were identified in the BIOAGRO system solution was technical solutions. Technical solutions include unique adaptations and innovations that had been developed in order to incorporate the different technical solutions provided by the actors. For instance, HOTAB and Skånefrö AB had adapted and customized the combustion technology in order to meet the specific requirements and effectively burn the bio-pellets. Technical solutions are also a category of necessary knowledge assets that could potentially be controlled through IPRs, mainly in the form of patents, if the strict requirements are fulfilled. However, a large portion of the necessary knowledge assets were not possible, and/or not desirable, to protect and control using patents due to the strict requirements of the patent system. (Caenegem, 2002; Hogan Lovells, 2011)

Data regarding, e.g. optimization of technical solutions in the system, was another important type of necessary knowledge assets that were identified in the BIOAGRO system solution. This category includes data that is in tacit knowledge form, i.e. knowledge that had not been codified. Optimization of the components in the pellet press is an example of this category of data and the method of control for data was trade secrets. In order to create an additional layer of control, we identified a few important factors of creating a strong trade secret protection. The first step is to define what knowledge that needs to be protected, which is always an important step. (Caenegem, 2002) The next step is to codify and package that knowledge. The data which had been structured and organized into databases therefore had a stronger control position, e.g. the pellet formulas. The pellet formulas could be, because of the externalization through the codification, controlled by Ecoera AB though IPRs, in this case copyright. Another aspect that proved to be important in the BIOAGRO case was to identify and codify future improvements. This knowledge was tacit knowledge in the minds of the people involved in both developing the system solution and involved in the day to day operation of the BIOAGRO system solution. Codifying this knowledge is important in order to externalize the knowledge and to strengthen the control over the knowledge. (Caenegem, 2002) We identified that this could be done by creating manuals with the future improvements of the system solution. In order to describe and motivate the improvements they should be both defined in terms of what needs to be done and also why this should be done. Finally, by also including the intended effect of the modification/improvement will make it easier to decide if the investment is worth the reward and to prioritize between the improvements.

The software control system in the BIOAGRO system solution was also identified as a necessary knowledge asset. IPRs, such as copyright, can be used to protect software code. However, the protection is weak since a third party having access to source code can use it to produce software with the same functionality as the original software, by only making it different enough to avoid infringing the copyright, as copyright only protects the specific expression of the code and not the underlying idea. Therefore, taking actions to keep the software control system in the BIOAGRO system solution secret is more effective. (Hogan Lovells, 2011)

The decisions made during the development of the BIOAGRO system solution determine how the secrecy has been governed and maintained. In the BIOAGRO case study we found that there where many different factors that influenced the secrecy, such as the need to report to the EU Life project in the form of technical reports, as well as show and present the system solution to potential customers in order to raise awareness. It was therefore important to track the dissemination of necessary knowledge in order to evaluate and determine the strength of secrecy and the secrecy control over the necessary knowledge in the control assessment. Necessary knowledge in the BIOAGRO case, such as the blueprint of the facility, was important to analyze from this perspective, as it was determined to be most effectively protected through trade secrets. Knowledge dissemination can occur in several different ways, e.g. being published in articles, being part of presentations, being part of research collaborations and commercial transactions to name a few. Through interviews and analyzing the publicly available material we evaluated and assessed the secrecy control in order to rated the secrecy control in the assessment. It also became evident that it is necessary to take actions to keep this knowledge secret in order to prevent that the knowledge becomes accessible to the public and thus losing control over the knowledge. These actions include limiting who gets access to that information and informing the employees and other actors that are in contact with that knowledge that it is secret to name a few examples. (Norman, 2001)

5.3.4 Summary of controlling necessary knowledge

To conclude the analysis of controlling knowledge, a strategy that incorporates both IPRs as well as alternative methods is required in order to manage and control the necessary knowledge assets. In the case study IPRs were used as part of the control of the knowledge, and by using IP law together with other legal structures and alternative methods, it is possible to create control layers on the necessary knowledge.

6 Conclusions

This chapter concludes the result and analysis in the previous chapters. The aim is to answer the stated research questions.

Managing and preparing the necessary knowledge in a system solution for a transaction in the cleantech industry is both complicated and involves several challenges. There are a wide range of aspects to consider, such as different knowledge types, collaborations and claims that must be identified and regulated. These aspects are part of the nature of a system solution, as system solutions integrate different technologies in order to create a complete system. In Figure 25 the IAC Model shown in chapter0 is presented with the main factors for each step.

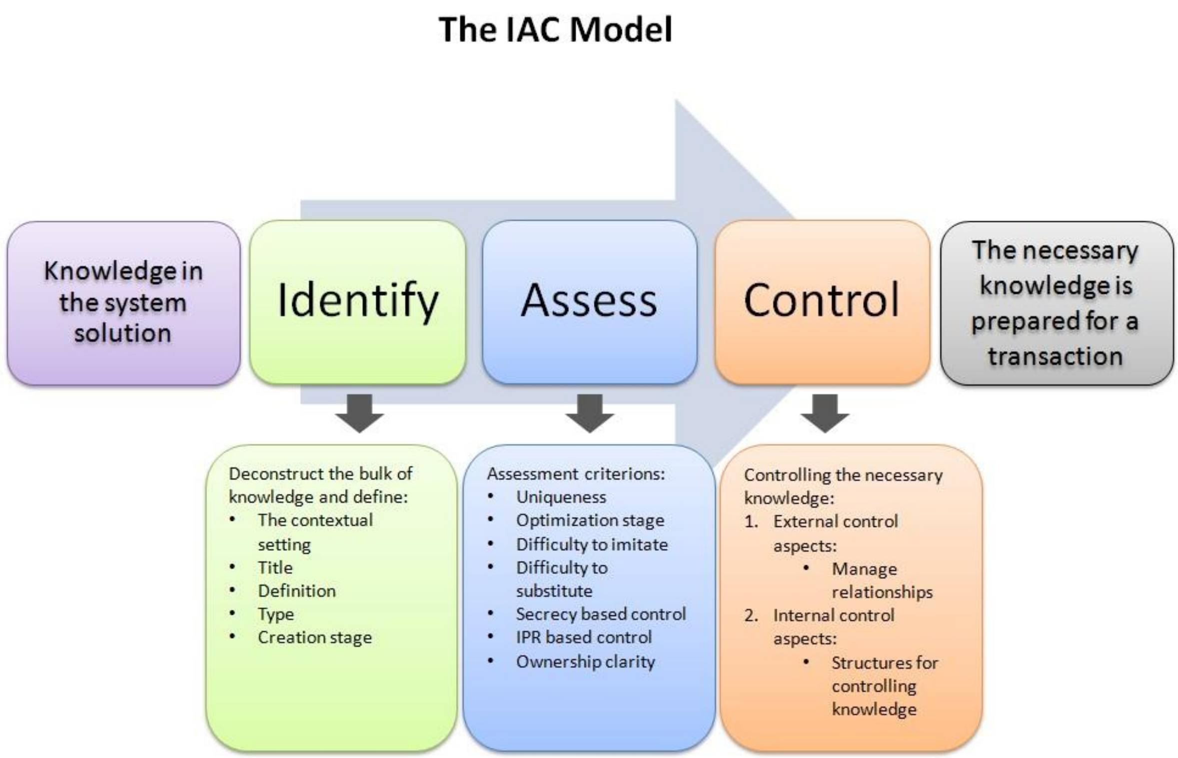


Figure 25: The IAC Model with identified factors

The bulk of knowledge incorporated in the BIOAGRO system solution is disparate and has several origins and representations. In order to manage this bulk of knowledge properly there is a need to deconstruct the bulk of knowledge so that it can be understood for what specific parts add specific value to the full solution. Aspects to consider when deconstructing this bulk of knowledge are that it should provide the contextual setting the system solution exists, and will be utilized in. Hence, the need to describe the knowledge assets so that they relate to the context is important. A title, definition and type that reflects the context on each asset gathered in a list, can be a way of structuring the identification of the valuable assets in a cleantech system solution. Adding that linking the assets with technology type and creation stage provide further insights on where to extract key assets of the solution. However to finally find the key assets, the described identification is not sufficient in itself, instead a qualitative assessment of the assets are needed.

Assessment categories are contextually dependent and the main reason for performing assessment is to link the assets to value and control. The assessment criterions which are found significant for system solutions in the cleantech industry are the following: *uniqueness, optimization stage, difficulty to imitate, difficulty to substitute, secrecy based control, IPR based control and ownership clarity.*

As is clear, some criterions coincide with previous theory, albeit slightly modified to suit the context. However, these are not alone sufficient in order to prepare for a knowledge transaction. Our analysis points out the need to assess the assets more thoroughly with further sub-dimensions relating to control since a transaction of the necessary knowledge is dependent on controlling the assets included. This is also where previous theory lacks a clear connection between the assessment and control dimensions of the knowledge.

Managing the necessary knowledge assets in a system solution to prepare for a transaction is an interdisciplinary process. The detailed information of the necessary knowledge assets provided by the Identification and Assessment process described above is essential processes to create control structures for the necessary knowledge. We have identified that it is required to manage both internal and external control aspect of the necessary knowledge. The external control aspects focus on managing the relationship between the actors involved in the development of the system solution, while the internal aspects involve controlling the necessary knowledge in the system solution.

The external aspects of controlling knowledge focuses on regulating the relationships between the actors involved in the development of the system solution to secure the right to transact and commercialize the system solution, i.e. the right to transact and commercialize the necessary knowledge. The degunkification is performed to clarify BG/FG knowledge, existing and potential claims and the rights to the necessary knowledge in the system solution over time. Since actors have both brought knowledge into the system solution as well as contributed to the development of new knowledge and technology in the system solution the BG/FG knowledge must be managed in terms of ownership and rights, both during and after the relationship has ended. Only after the system solution is fully developed and finalized is it possible to identify the different creative contributions that have been made to the necessary knowledge assets. This is however possible to structure and regulate in the agreements between the actors in the beginning of the interaction, before the development starts. To clarify if there is a creative contribution from the different actors involved in the development of the system solution we found it necessary to perform interviews with all actors involved combined with studying the written contracts, as the complexity that is created by the involvement of a large number of different actors is not always captured in the written agreements. If the current agreements do not regulate these aspects, new agreements are needed in order to manage, control and prepare the necessary knowledge for a transaction.

The internal control aspects include creating control structures and layers on the necessary knowledge in the system solution. This involves the codification, objectification and packaging of necessary knowledge into controllable knowledge assets. As describe in the BIOAGRO case, objectifying the knowledge regarding the improvements into manuals codifies this necessary knowledge and objectifies the knowledge into manuals that can be controlled by BIOAGRO. The internal aspect of controlling the necessary knowledge thus focuses on the codification, objectification and packaging of the necessary knowledge in the system solution.

These external control aspects are important to manage before the internal control aspects are performed, as the external control aspects directly affect the internal control aspects. IP law, contract law and trade secrets, together with supporting actions should be used to create a control structures for the necessary knowledge assets in the system solution. Due to the complexity of both creative contribution and knowledge types in the system solution the identified control mechanisms must be used in combination. It is only by being fully aware of the benefits and limitations of both legal control methods and the alternative methods that the necessary knowledge assets in a system solution can be managed, controlled and protected in a transaction. Using IP law as a means of controlling necessary knowledge assets in the system solution requires pro-activeness, are more difficult to use after the actual solution is finished. A conclusion can thus be drawn that being aware of the requirements for controlling knowledge in the system solution through the different methods allows the actors involved to be proactive throughout the development. The findings of this research suggest that any actor with the goal of commercializing a system solution will benefit from being proactive in the way the relationships are regulated and control structures are created.

7 Discussion

In this section we discuss the results and conclusions of the study and the aim is to critically review the study. The section will end with implications for further research drawn from the findings of this study.

The market for knowledge transfer is global. However, it would have been impossible to regard all national legal system, and hence, the scope was limited to an overview of the EU. We however believe that the EU is representative since knowledge transactions within the EU are common and there are differences between the legal systems in the Member Stat in the EU which to some extent have been taken under consideration during the research. In a transaction of a system solution an analysis of the laws and regulations of the nation to which the system solution is transacted to is of course always necessary in order to prepare and manage the necessary knowledge.

No previous studies in the field of managing knowledge in a system solution have been found that includes all aspects discussed in this thesis, and a general model incorporating these aspects has previously not existed for this type of investigation. Previous literature has discussed the different aspects, i.e. identify, assess and control, however focusing on only one of the dimensions identification, assessment or control. In the research of this thesis it was required to investigate and incorporate all the aspects and to create a holistic view over the knowledge management to be able to answer the research question. The lack of previous research entails that the results of this study can be questioned since no comparisons can be made. We however argue that in the development of the theoretical framework we have found common denominators between the authors that are presented in the theoretical framework used in the thesis. This, we argue, in combination with the thorough in-depth study of the case at BIOAGRO, is enough to support the conclusions presented in this study.

The way we describe the identified knowledge assets in the thesis is mainly drawn from the fact that they should be understood in the way they exist and will be utilized within. How the descriptions of the identified knowledge assets should be presented in detail has not been the subject for previous research, hence a best practice for this does not exist. This is why we have been very clear when describing the assets that the descriptions presented are contextually based. However, since the background of the thesis clearly states a desire to export, i.e. transact the system solutions, we conclude that in the context of transacting the system solution, the aspects motivating the descriptions of the assets are generally applicable. Should there however be another utilization strategy of the system solution, one need to include that strategy when describing the knowledge assets identified.

How to manage the assessment, described in the assessment part of the study, has not previously been researched. This is also why we included an example of how an assessment actually can look like. This is of course only one way of conducting the assessment and should therefore not be interpreted as the usual practice in the field. We however believe, as stated in the analysis chapters, that by being fully transparent in the assessment process, there is an opportunity to regard the quality of the assessment and hence, make an informed decision over the applicability of the assessment.

When it comes to the generalization of the research we believe that the findings should act as a stepping stone for further research. The identified factors are drawn from an in-depth study based on a single case. The complexity of the studied object made it necessary to focus the research on a single case in order to extracting relevant data within the time frame of the thesis. With the results it is however possible to conduct studies on both populations within the cleantech sector and populations with different sectors in order to validate the general applicability of the research results of this thesis.

In order to extract the relevant information that is discussed in this thesis from the system solution involves many challenges and difficulties as there is a need to fully understand the technology behind the solution and to define the contribution to the unique characteristics of the solution. To fully grasp the uniqueness of a technical solution the technology must be compared to the existing technology in the field. Thus, a thorough literature review and a range of expert interviews and observations need to be undertaken in order to fully extract information over the necessary knowledge in the solution. This in itself can have an impact on the implementations of the research since the resources for conducting this type of investigation is usually limited. It is also required that that the individuals performing this analysis has an understanding of law, technical and business logic in order to fully grasp the knowledge management of the system solution and to successfully perform this investigation. We however believe that the benefits in terms of reducing risks and potentially capture more value in a transaction of the system solution make the investigation essential.

7.1.1 Implications for further research

There are several implications for further research that can be drawn from the results of this study. In order to generalize the findings in a more sufficient way it would be informative to test the findings with more populations, i.e. other cleantech system solutions, in Sweden and in the EU. It would also be possible to test the results across other sectors which are known to provide system solutions.

To build further on the specific findings of this study would be to identify transactions or series of transactions for generating value of the necessary knowledge that makes the results of this study. Relevant questions can be to review what leveraging opportunities are possible, and how apply them in the best possible way.

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9 Appendix

9.1 Interview template

Technical solution

Describe the different modules in the system solution:

- What technology is incorporated?
- When was it created?
- What characteristics does the technology show?
- Is the technology developed for the purpose of the system solution or not?
- Is the technology possible to develop further?
- What knowledge is linked with the described technology?
- Is the knowledge captured in some explicit representation?
- Is there any control measurements linked with the technology or knowledge, e.g. IPR, contract etc?

Actors

Describe the actors' contribution in the project

- Which technology (ies) did the actor contribute with/to?
- Describe your relation with the actor:
    - supplier
    - partner
    - consult
- Are there any agreements or contracts with the actor?