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The process of technology commercialization

A case study of project CHRISGAS

Bachelor thesis within Business Administration

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Abstract

Background & Problem: Society needs to reduce its reliance on fossil energy sources. The automotive sector is significantly contributing to green house gas emissions. The European Union has set targets of 12% share of renewable energy until 2010, and 20% in 2020. Still current attempts to transition from fossil fuels have not succeeded and end users have not adopted current biofuel alternatives, mainly due to efficiency matters. New technologies must be developed. However, the majority of the European Union's multiple technology projects are still in pilot scale, and as a result far from commercialization. What are the stages and implications of technology development?

Purpose: One of the major European biofuel development projects is Swedish, public funded, CHRISGAS. Our purpose is to describe and understand the technology development process, with relation to the project's progress.

Method: We have used a qualitative case study, where multiple open ended interviews have been executed with management of CHRISGAS and related industry actors.

Theoretical framework: Theories are derived from the area of innovation management and technology commercialization, complemented with literature focusing on public research.

Conclusion: A technology commercialization effort is described as a constantly ongoing, cumulative and integrated process, covering the stages of imagining, incubating, demonstrating and sustaining its position in the marketplace. Emphasis has been placed on openess to market needs and interaction with R&D, intermediate adopters, influental opinion leaders and industry capital providers.

Project CHRISGAS has not initially, due to its government steered university structure, being developed with the commercial focus related to the commercialization model. Accordingly, we have found it to face some shortcomings which we believe represent limitations of public projects; 'The Valley of Death'. The fact that is has not collaborated and prepared private industry for its applications is now resulting in difficulties to attain industry interest and private funding for reconstruction prior demonstration. However the project is setting up a new structure, which will be commercially oriented, including management from the industry. In order to capitalize on this project and entirely commercialize it, we see a necessity for more obvious indications towards a dominant design and an opinion leader taking part in the development.

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1 Introduction

This chapter will introduce the reader to a brief background of the European biofuel situation, project CHRISGAS, and following problem discussion and purpose.

1.1 Background

We are confronted daily with signals of the global climate change, focusing on future prevention strategies. Fossil energy is said to spur global warming to a large extent, where carbon dioxide and greenhouse gas emissions are expected to peak in 2025 (Commission of the European communities, 2006). Europe is consequently faced to a challenge where efforts into energy efficiency and renewable energy are found on the top agenda. The nearby target is aiming at having 12% of the total energy consumption from renewables by 2010 (and 20% until 2020), focusing on new energy technologies and economically viable biofuels (Commission of the European communities, 2006).

The automotive sector, and particularly the transport division, is heavily dependent on fossil fuels (98% fossil). The worldwide car fleet is further predicted to expand from current 900 million to 2 billion units in a time perspective by 2050, says the president of AB Swedish Shell (K.Georgsson, personal communication, 2007-02-07). Thus a large focus is put on development of alternative fuels.

The closest EU target is aiming at a 5.75% share of biofuels by 2010 (currently 2%). The transport sector is expected to significantly increase its biofuel share in the long term, targeting approximately 25% by 2030 (Biofuels Research Advisory Council, 2006). Sweden is aiming at a 10% share in 2012 (CHRISGAS (b)).

The alternative fuels at present promoted for adoption constitute the so called 'first generation' of biofuels, foremost ethanol and bio-diesel (RME). However, the first generation is associated with low efficiency. New research projects are therefore constantly initiated in order to developing new technologies for the 'second' and later 'third' generation of biofuels, which are providing greater potential in efficiency and total economy. These 'advanced' alternative fuels, derived from a renewable biomass feedstock, include ethanol from cellulose material and synthetic fuels produced by gasification or other synthesis gas processes. However, these fuels are currently not available in full scale, spite several pilot projects set up around Europe (Edwards, Larivé, Mahieu & Rouveirolles, 2007).

Alternative fuels within the 'second generation', particularly derived from wooden biomass prove immense potential both in the track of direct biomass gasification and gasification from black liquor (waste from pulp mills). One of the most promising fuels produced through these processes is "bio-DME" (Dimethyl ether from biomass) (Edwards et al., 2007). Swedish project CHRISGAS (Clean Hydrogen-rich Synthesis Gas) is set up by the European Union and the Swedish Energy Agency to demonstrate production of synthesis gas for further upgrading to liquid fuels such as DME, methanol and synthetic diesel (CHRISGAS).

1.2 Project CHRISGAS (Clean Hydrogen-rich Synthesis Gas)

Sweden is, after Latvia, the second largest user of renewable energies in primary energy consumption, 29.5% in 2005 (European Commission). Sweden is also at the forefront in the research and demonstration of advanced biofuels (the 2nd generation) particularly from wooden biomass. There are three main pilot projects operating, CHRISGAS is one of them.

Project CHRISGAS is funded by and designed for the 6th Framework Program (FP6) of the European Community's action plan in promoting research, technological development and demonstration (CHRISGAS). Historically the demonstration plant in Värnamo, now hosting project CHRISGAS, has been used for demonstrating production of electricity and heating through gasification of renewable feedstock from wood (S. Bengtsson, personal communication 2007-04-13). In order to proceeding by decreasing the economic risk of private industry, the plant has required public funding, and steering as a non-profit organisation. Växjö University is appointed as coordinator, and the Växjö Värnamo Biomass Gasification Centre (VVBGC) established in 2003, launching project CHRISGAS in 2004.

The overall objective is to advance the existing gasification technique, and *'develop a process to produce clean, hydrogen rich gas (being an intermediate product for the production of commercial quality hydrogen, vehicle fuels and others')* (CHRISGAS proposal, p.6). Project CHRISGAS aims to fill the 'gap' of the sophisticated vehicle fuels that will be demanded in the future, currently only possible to produce from fossil fuels (CHRISGAS proposal).

The CHRISGAS technology will demonstrate gasification particularly from wood, by definition including a range of materials: farmed wood, perennial grasses, and wood waste from forestry (Edwards et al., 2007). Possible end products extracted from the CHRISGAS technology are methanol, Fischer Tropsch (FT) diesel, hydrogen, and bio-DME (Växjö Värnamo Biomass Gasification Centre).

1.3 Problem discussion

Energy related research has historically contributed strongly to an increased usage of renewable energy sources, but the magnitude of the challenges ahead requires increased efforts (Commission of the European communities, 2006).

In spite of a positive progress in reaching the target of 12% renewable energy sources by 2010, current projections (6.38 % in 2005) indicates that EU will fail meeting it. There are several issues to overcome; an economically unjust advantage to fossil sources, complexity and novelty of renewable energy applications, and difficulties in setting up a suitable infrastructure (Commission of the European communities, 2007).

New, more efficient fuel technologies must be commercialized. Even though usage of biofuels within EU has increased from a 0.5% share in 2003 to current approximately 2%, it needs to be significantly rising in order to reach the target of 5.75% in 2010 and further long term objectives. Current political attempts to spur domestic production and transition from fossil- to alternative fuels have thus not completely succeeded and end users not fully adopted the current available alternatives. That is partly explained by relatively low efficiency compared to fossil fuel and economical matters.

The EU paradigm of the 6th Framework Program (2002-2006) and now the 7th focuses heavily on supporting new technologies. However, the majority of alternative fuel projects, like project CHRISGAS, are still in pilot- and demonstration scale, far from commercialization. We are therefore interested in the process of commercializing new technologies; what is required to bring them to market? Which steps? And what implications are there?

This process extends over approximately 15-20 years according to Vijay K. Jolly (1997) professor at Harvard Business School. His work 'Commercializing new technologies – getting from mind to market' clearly displays and thoroughly describes the whole process from discovering a novelty to final adoption, and is to a large extent contributing to our investigation.

The limitation of Jolly's (1997) process is the presuming of the commercialization taken place in one single organisation, implying difficulties where several parties need to be involved in development of end products. It also implies difficulties in analysing public research, which to some extent is lacking explicit commercial objectives. The work of Braun et al. (2000) complement Jolly (1997) where providing understanding for technology transfer from public research.

However, due to the fact that project CHRISGAS is EU funded, managed by a non commercial organisation (Växjö Värnamo Gasification Centre), and currently set up only to demonstrate and develop the gasification process, its technology will not be fully commercialized until incorporated in end products. This implicates an additional entity taking over CHRISGAS project, exploiting the technology and fully commercializing the fuels. Thereby application development implies its own implications; large investment requirements and finance, political issues, subsidy matters, future supply of feedstock and end user adoption (personal communication, IVA Symposium-The Future of Forest Bioenergy, 2007-02-07). And most important, developers of fuels based on the CHRISGAS technology, are predisposed to a successful transition.

1.4 Purpose

The purpose of this study is to describe and understand the process of technology commercialization, particularly analyzed in relation to the development of publicly funded project CHRISGAS.

2 Method

This chapter starts with explaining the logic behind the approach used to fulfill the purpose. This is followed by the discussion about the case study and data collection method. The issues of reliability and, validity are considered as well.

2.1 Qualitative approach

Qualitative approach is the method used when aiming to understand a complex situation as well as social and human activities (Collis &Hussey, 2003). The qualitative method implies that a process or meaning is examined in order to understand a socially constructed reality, where relationship between researcher and the area is studied instead of quantity, amount, intensity or frequency, or meaning (Denzin & Lincoln, 1994). The qualitative approach is beneficial when there is believed to be many different truths and not just one (Shay, 2001).

In our specific case we investigate project CHRISGAS and its multifaceted development process. The complexity of the process makes a qualitative approach suitable in order to understand this broad development, which does not imply one single solution. Since the purpose is to gain deeper understanding, our means is conducting a case study of the technology commercialization process, where we again believe the angle of our study to be particularly applicable for the qualitative research method.

Mason (2002) claims interviews to be most recommended in the qualitative research method, since the describing and understanding a process, in order to answer the questions of how and what. During our study we have followed the thoughts of Mason (2002) and conducted multiple interviews in order to investigate *how* project CHRISGAS relates to the existing theories of technology commercialization, and *what* implications there are.

2.2 Case Study

Case study research is a specific form of qualitative research that is focused on providing detailed information of one or more cases; decisions or processes (Yin, 1994). It is structured in accordance with two broad options according to Yin (1994); single-case design or a multiple-case design. Single-cases studies a *certain* decision or process, while a multiple-approach studies *a set* of decisions or processes. Case studies have the freedom to adapt or use many different tools; i.e. theories, models, concepts and methods (Alvesson, 2000). The main intention of case studies is to deepen the knowledge on a *particular* individual/organization, time and location (Miles & Huberman, 1994). A case study also implies that the research is longitudal, thereby covering an extended time (Creswell, 2002).

Our case study is structured according to the single approach, aiming for a *deepened understanding of the process of technology commercialization, particularly from public research.*
We have used more of a 'case oriented' way of handling the problem instead of a full case study, where not able to fulfill the longitudinal part as Creswell (2002) argue for. This thesis therefore presents more of a *"Snap-shot"* of time according to Saunders et al. (2003).

We are interested in what stages the development goes through and the related implications. Through the literature we have found the work of Jolly (1997) 'Commercializing new technologies – getting from mind to market' to clearly display and thoroughly describe the whole process from discovering a novelty to final adoption. His model serves as the foundation, complemented with material on public research.

The limitation of Jolly's process is the presuming of the commercialization taken place in one single organisation, implying difficulties where several parties need to be involved in development of end products. It also implies difficulties in analysing public research, which to some extent is lacking explicit commercial objectives.

Our study will focus on project CHRISGAS development, and analyze it in relation to above theories. Due to the fact that it is a public research endeavour, where several intermediate actors presupposed to be involved, we will investigate for particular implications of a development process like this.

Our research guidelines in this case study could be summarized as follows: 1) Focus on describing and understanding the process of technology commercialization 2) Aiming at analyzing the commercialization process of project CHRISGAS in order to find implications for public projects.

2.3 Data Collection

This part will explain how the collection of data has been undertaken. The interviewees is introduced and described as well as how reliability and validity is gained in this thesis.

2.3.1 Primary and Secondary data

Secondary data is material that has been gathered for other purposes than the one undertaken in the current study, but can still be particularly applicable in the current research. Secondary research data is significantly beneficial due to its nature of being quick to gather at a relatively low cost (Saunders et al., 2003).

Primary data consists of material that is collected in direct connection to the purpose, e.g. interviews and observations, which has the advantage and specific ability to be tailored for investigating the particularly current problem (Saunders et al., 2003). We have particularly used primary data for our case study, consisting of interviews and conference visits aiming for observations specific for this purpose. Beyond face-to face and telephone interviews, collection of data, important observations and initiation to contacts were conducted during two particular conferences, one in Stockholm, IVA Symposium-The Future of Forest Bioenergy (2007-02-07), and one in Jönköping, Oljan och Klimatet (2007-03-29).

Our interviews have been the main source of our primary data, where the interviewees have through their knowledge and experience in the area contributed to the understanding that our work aims for. Initially the IVA Symposium in Stockholm was beneficial for us to attend as a starting point for the study. That enabled us to establish an understanding of the current market picture for forest bioenergy and implicitly verified project CHRISGAS market position. We also found it important to actually meet the influential actors and show them our interest, which we believe made them more prepared to be interviewed at a later stage. During both the IVA Symposium and 'Oljan och klimatet' in Jönköping, we had the opportunity to meet project CHRISGAS coordinator Sune Bengtsson to briefly discuss our work. During the conferences we, as mentioned earlier, also made a lot of observations which otherwise would have been difficult to get.

The secondary material foundation for this thesis consists of reports from CHRISGAS, publications from governmental agencies, mainly the European Commission, as well as information on homepages.

During our secondary data collection process, Internet searching has been used to a large extent. The search engines of Google and Google Scholar have been used, also e- Julia, which is provided through the Jönköping University library site, where e-Julia is a tool for searching in a large number of academic databases.

Keywords used for data search:

- Energy technology commercialization strategy/ Energy technology commercialisation strategy
- Technology commercialization strategy/ Technology commercialisation strategy
- The valley of death
- Technology transfer
- Product development
- DME
- Värnamo, Växjö, Biomass gasification (VVBGC)
- CHRISGAS

2.3.2 Interviews

Interviews are a good way of finding out individuals' insight and thoughts about a certain situation (Yin, 1994). Interviews can take numerous of forms according to Yin (1994), where the most common is of open-ended nature. In this kind it is possible to discuss facts as well as respondent's own opinion in the area of interest. The information gathered from open ended interviews can afterwards be used as basis for further investigations (Yin, 1994). The advantage of open-ended interviews is that the respondent is not limited in their answer and can therefore give an in-depth view (Andersson, 1985).

A second version of interviews is the focused kind. This kind may still be of open-ended nature but the interviewer is more likely to have a certain set of questions and the main objective of this interview type is to confirm already known facts (Yin, 1994).

The final form discussed by Yin (1994) is an even more structured style of interview as formal as a survey. The advantage is that it is a time saving process as well as the answer is easier to interpret and has a higher comparability (Andersson, 1985).

During our study, open-ended interviews have been conducted with respondents, including particular focus points on their relation to project CHRISGAS development process. However we tried not to limit the views of respondents, so they clearly could state their point of view and give us new insight.

In our case we executed several telephone interviews due to the extensive geographical distance and facilitating for respondents to find time available. Telephone interviews can according to Saunders et al. (2003) be as good as face to face interviews, having the advantage of being less time consuming and expanding the possible geographical area in which they are made. However, they stress these kinds of interviews to usually being shorter than the face to face kind. In our case we considered this disadvantage, however decided that our choice was either to the telephone kind, or no interviews at all. Thus in several cases our interviewees were either on business trips (some abroad) and some very scheduled. We kept the interviews open-ended with specific focus points and prepared the respondents in advance by providing guidelines a few days in advance.

2.3.3 The Empirical Interview Base

The empirical research was conducted through 6 open ended interviews with five different persons. In addition we conducted informal interviews and contacts during the conferences, and had several initial contacts with some of our interviewees in order to grasp the biofuel market in preparation for these interviews. All the interviews were made during the period 2007-02-22 to 2007-05-09, either over telephone or face to face.

The study aims at describing project CHRISGAS commercialization process. We have thus mainly chosen persons who can describe and discuss the development from this point of view (Lennart Gårdmark, Sune Bengtsson, Ann Segerborg). In the project's background there are several partners involved, but mainly focused on technical development. Therefore we choose to interview actors close to mentioned commercial process.

In order to investigate the market attractiveness and industry interaction we have also chosen to interview participants which either have collaborated with the project historically or might be interested in future interaction (Volvo, Preem).

- **International DME Association (IDA), representative for Växjö municipality and senior advisor project CHRISGAS.**
  Lennart Gårdmark, was interviewed face to face on the 22nd of February 2007. This interview was conducted primarly to gain an overview and broad knowledge in the area of DME, in relation to project CHRISGAS. Gårdmark has a deep and genuine knowledge in the area working closely with management of project CHRISGAS. The interview took 2 hours.
- **Project coordinator CHRISGAS**
  Sune Bengtsson, was interviewed face to face on the 13th of April 2007 and one via telephone the 8th of May 2007, as well as short briefings during the conferences. Bengtsson is our main source of information when it comes to project CHRISGAS. He has been managing it since the start-up and could give us a deep understanding of the progress. Each interview took approximately 45 minutes.
- **Preem**
  Sören Eriksson, was interviewed over telephone on the 26th of April 2007. We interviewed Eriksson to find how Preem's view on commercialization of the CHRISGAS technology. Oil companies are today the supplier of fuel and they have a well working distribution network for fuel and it is therefore interesting to see their standpoint. Preem has also been in discussion to take part in CHRISGAS project and are therefore well aware of the project. The interview took 40 minutes.
- **Volvo**
  Patrik Klintbom, coordinator alternative fuels, was interviewed over telephone on the 2nd of May 2007. We interviewed Klintbom to get the information how the automotive industry (especially Volvo) is looking upon the commercialization of CHRISGAS technology and DME as a fuel. Volvo has today R&D of DME trucks, and it is therefore interesting to know their reasoning behind it. Volvo has also, like Preem, had interests in project CHRISGAS. The interview took approximately 40 minutes.

- **Swedish Energy Agency**
  Ann Segerborg-Fick, was interviewed over telephone on the 9th of May 2007. Where the agency has mainly funded and managed project CHRISGAS, Segerborg-Fick is a prominent actor currently working for industry collaboration and commercialization of CHRISGAS. She has a significant knowledge of the biofuel market and political initiatives of from her background within the European Commission.

2.3.4 Translation bias

All interviews were conducted in Swedish, later translated into English. This could be problematic since some information can be misinterpreted and distorted in the translation. To minimize this possible problem, all interviews were recorded and in written text sent back for approval and clarifications. An independent person was also selected to verify our translations before sending the questions to the interviewees.

2.4 Validity and Reliability

Yin (1994) discusses how creation of validity and reliability of case studies might be questioned. Reliability refers to in which quality the collection of data has been completed and how the analysis has been executed, according to Östbye (2004). He stresses the importance of methodical reliability in qualitative research. Validity is a measurement on how trustful the study is (Morse, Barrett, Mayan, Olson, and Spiers, 2002). Without validity in the research, it loses its utility according to Morse et al., (2002). In order to construct validity and reliability, (Yin, 1994) claims it is important to use multiple sources in establishing relevant evidence of the data collected and minimize the errors and biases of the study. Working with only one sample may imply a reduced basis for generalization, but sampling in case studies does not follow the rules for statistical generalizability. It is aimed at studying interactions of people, events etc. in depth to find a pattern or highlight a certain aspect (Yin, 1994).

To construct reliability and validity in this case study, we have aimed for using multiple sources and cross referencing throughout the work. We argue for built in cross referencing in having multiple interviewees closely related to the management of project CHRISGAS (Sune Bengtsson, Ann Segerborg and Lennart Gårdmark) which all having different perspectives and influence on the process. We have also cross examined project CHRISGAS work with industry collaboration/interaction by bringing in views from industry actors not dependent upon each other.

In order to avoid biases, we have had the opportunity to brief each interviewee afterwards and having them confirming the work. Moreover we have tape recorded each interview, and in order to extract the information, we wrote it in text format as well.
To minimize errors and biases of this work, we have both been involved in the original interview and later cross read the text. When this empirical data then have been processed and analysed, we have carefully been proof reading the other part's work compared to the original transcripts of interviews.

3 Frame of reference

The frame of reference will initiate the reader to the area of technology commercialization focused on exploiting public funded research.

There is no single solution or model suitable for all technology commercialization. Particularly not in the situation of the project CHRISGAS technology, which is based on public research. Jolly's (1997) model is the closest illustration, covering management of the whole process from insight to commercializing end products. Even though Jolly (1997) mentions how his commercialization model is particularly relevant for the lone inventor- or university transfer, project CHRISGAS is not fully applicable to this work. Thus, project CHRISGAS is not fully managing the entirely commercialization of end products It is developing an intermediate technology, a product for further upgrading to fuels. Project CHRISGAS will therefore at some point in Jolly's (1997) model have to collaborate in attracting industry partners interested in promoting adoption and commercialization of the end applications. On the other hand, those activities have not explicitly been included in the project tasks so far. Project CHRISGAS is not set to be commercializing any particular fuel. Project CHRISGAS is consequently not an ordinary, commercial organization, while funded by the European 6th framework program, actively supervised by the Swedish Energy Agency, set up by non-profit Växjö Värnamo Biomass Gasification Centre and coordinated by Växjö University. Therefore the frame of reference also includes theories from the European Commissions work in analyzing commercialization of public funded research from Large Public Research Institutes, including additional finance aspects of collaboration between public and private entities (Braun et al., 2000).

3.1 Technology commercialization process

Jolly (1997) describes a technology as an essential capability with possibilities to be used for multiple end applications. As illustrated by Markham and Kingon (2004) (figure 3.1) a single technology is a platform which has abilities in contributing to a variety of applications and providing access to several markets, which they name the TPM-linkage (Technology-to-Product-to-Market linkage). Schwartz, Yu and Modlin (2004) claim that developing and commercializing new technologies specifically focus on *creating* and *shaping* new markets. The effort is broadly focused and has multiple product options in mind. In their opinion a technology development project seeks to exploit the technical fundamentals in order to demonstrate feasibility, not always directly being committed to make instant revenue contributions.

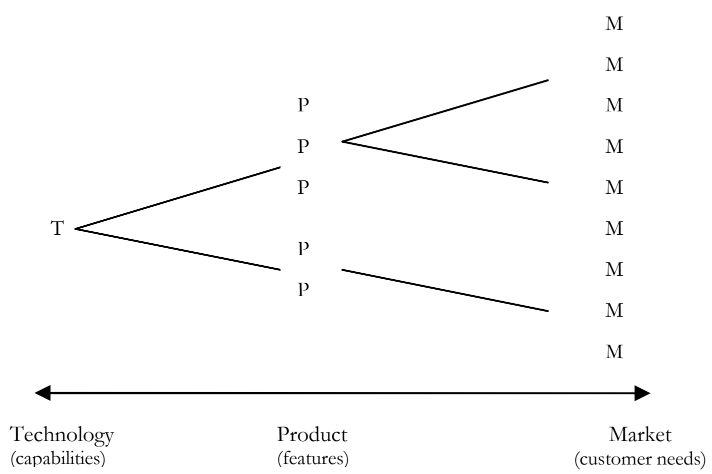

Figure 3.1 Technology-to-product-to-market linkage (Markham, 2004)

The process of bringing a new technology to market requires deliberate strategies stresses Jolly (1997). No technology based idea is intrinsically commerciable he says, it has to be made so. Value creation in a new technology is a cumulative and ongoing process, creating value stepwise as resources such as venture capital, public funds and business groups are mobilized and attracted to it. Jolly (1997) claims that a large number of activities in the process of building potential for a technology are inter related, going back and forth. It is not a linear process, as sometimes displayed in theory he points out. Each phase of development has its own implications and possibilities, where he stresses the significance of *his* model to highlight the particular importance of efforts in mobilizing resources and stakeholders throughout all stages.

Jolly's (1997) technology commercialization process (in accordance with figure 3.2), incorporates five major segments (1,3,5,7&9) which all represent main elements of the innovation process, each requiring input from a variety of functions and external sources. Each of these segments represents an independent process of value creation and offers a way of reflecting on entry, exit and alliances, all functioning with its own set of stakeholders. The stages of (2,4,6&8) are needed as mobilization phases, where stakeholders are gathered and rewarded.

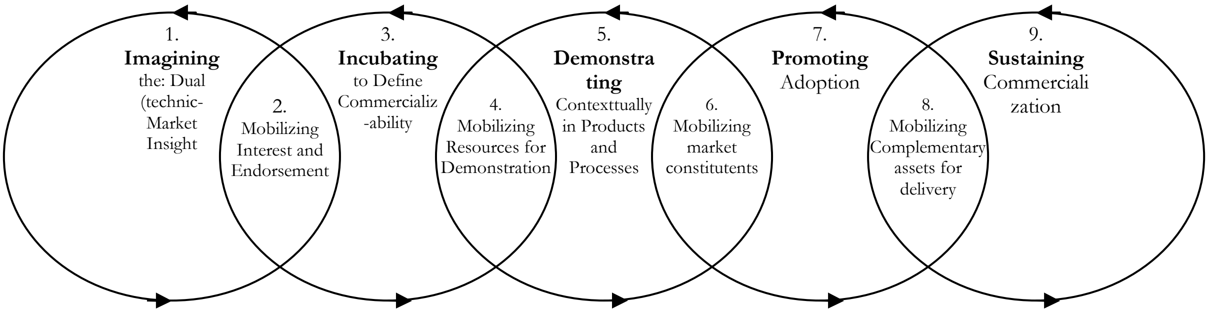

Figure 3.2 Commercializing technologies, getting from mind to market (Jolly, 1997)

3.1.1 1) Imagining insight

Most ideas evolve through constant iteration between a new technological capability and market need, triggered by customers or by a single researcher's own convictions. Jolly (1997) argues that there are several ways of creating market insight: by accelerating the rate of experimentation, intensifying contacts between researchers and the market in order to anticipate new uses, as well as encouraging brainstorms and idea exchanges.

3.1.2 2) Mobilizing interest and endorsement

An interest gap occurs between imagining and incubation stage, constituting a challenge for the inventor to identify the stakeholders whose support is needed in the initial stage (Jolly, 1997).

In most cases, Jolly (1997) claims that the research group needs to satisfy a vast variety of different stakeholders simultaneously, for example; peers, colleagues, funding agencies and outside partners.

3.1.3 3) Incubating to define commercializability

According to Jolly (1997), defining commercializability is about deciding if and how to take project further and creating the expected value in the eyes of those who support the effort, in terms of potential payoffs and probability of realizing the idea within a reasonable time. Many early stage scientific discoveries have according to Markham and Kingon (2004) the potential to be used in a variety of applications. Therefore early exploration of the different uses of an innovation and how they should be pursued is a key aspect of defining its commercializability. Hence Jolly (1997) also argues for early interaction between R&D and product development teams, while the researchers might seek to solve a particular technical aspect but do not have the view of finding multiple applications or ambition and drive needed for proceeding commercialization (Jolly, 1997). This stage also involves significant effort, especially for single inventors, of making the idea attractive to resource providers and other stakeholders who can contribute in taking it further. Jolly (1997) mentions how many companies and an increasingly number of universities and research institutions establish 'incubators', attached to the R&D function. They could be groups researching the technology further, incorporating it in a pre-commercial product or process, building prototypes and testing them with lead customers

What is central in establishing commercializability is achieving certain technical milestones and to demonstrate future progress by visualizing and plan for pursuing an attractive set of applications. Jolly (1997) claims that the greatest leverage in bringing the judgement of commercializability forward comes from assembling as much information as possible about market potential and proposing a credible action plan that takes into account the uncertainties likely to be encountered.

3.1.4 4) Mobilizing resources for demonstration

After the incubating stage, a technology transfer gap may appear, where many inventors either success or fall behind and loose stake in their technology. To be successful in demonstrating, Jolly (1997) argues that the best strategy is to assemble as much capital as possible initially. With the interacting interests of providers as governments, resource providers, venture capitalists and partnering companies, the R&D organisation might set up a wide range of options.

Jolly (1997) further stresses that among the key things are to look for the interests and time lines for each stakeholder. To reduce the stakeholders' perceived risk and try to show rapid progress in the demonstration in order to sustain interest is of great importance. Furthermore, success of new products is usually a function of type of launch and delivery says Jolly (1997). He argues that the more radical a technology is, the greater the need for mobilizing a wide range of market constituents.

Technical specifications are driven by the 'early adopters' who are the customers that are prepared to work with prototypes which are in constant state of evolution says O'Connor et al. (2004). The commitment of these prospective customers is the drive of plans for transitioning projects. Early users of the product are helping in assessing the transition readiness. The authors further claim that the complexity of moving from a prototype, designed for learning, to a product meeting manufacturing requirements are often not understood and unforeseen by the initial R&D team.

We believe CHRISGAS to enter this stage when allowed funding from the Swedish Energy Agency to rebuild the facility for demonstration in a larger scale. They are still running smaller tests and are therefore assumed to still be partly in the Incubating stage.

3.1.5 5) Demonstrating contextually in products and processes

When demonstrating the technology conceptually in end products, there are according to Jolly (1997) two significantly important aspects to consider: 1) only conceptualize products required on the market and 2) assuring that the technology itself is ready to be incorporated in them at the right time. Product development is hereby to be seen as an important, but independent sub process in commercialization. In Jolly's (1997) opinion, the technology development effort turns into the process of product development where concrete product ideas are recognized and made concrete.

In the transition process from R&D to product development, O'Connor et al. (2004) describe a 'middle ground' of innovation activity, where nobody "owns" the projects. This is a discontinuity displaying potential implications for further progress. The problems derive from the requirements of operating units focus on generate revenues and returns on investment, while the technology itself is under development for these commercialization purposes. Markham (2004) illustrates this relation as the 'valley of death', the gap between the technical development of an innovation and the commercializing process. The somewhat contradictory expectations of the R&D team and receiving unit must be discussed during the transition period claim O'Connor et al. (2004). Jolly (1997) claims that transferring technology is notably a matter of communication.

To promote adoption and interest among stakeholders consequently requires a well communicated business case. He states recipients of a new technology to being fundamentally interested in a business opportunity and not just in the technology in itself. This incorporates that defining it to be able to convince them of its economic benefits and superiority by being concrete and bringing the technology close to the context of the recipient as possible is central. Cooke and Mayes (1996) also argue for information as the means of technology transfer. It is essential that information flow is facilitated throughout the organisation, from both formal and informal networks, they argue.

3.1.6 6) Mobilizing market constituents

To avoid a transfer gap when launching a new product, an analysis of the entire business system and identification of the important actors is beneficial, according to Jolly (1997). Developing a market for novel products involves coordinating the contribution of several areas and stakeholders; notably partners for the delivering the technology's full benefit. Partners in delivery can be intermediate adopters, manufacturing partners, distributors for promotion and independent suppliers of complementary products (Jolly, 1997).

3.1.7 7) Promoting adoption

Jolly (1997) mentions how completed innovations tend to diffuse through two types of networks: established communication channels of an industry and interaction with third parties, for example suppliers and government agencies. The ultimate judge of a new concept is the end user. While several intermediate adopters and market constituents may have earlier accepted to help promote a technology, it is end customers buying the product or service incorporating it who decide how valuable it is.

Technology based products have to be "adopted" by different categories of stakeholders. Which feature of the technology that is offered, the way it is configured, and the bundle of benefits it provides, all need to be adapted to what customers require at the time of launch. Generally, Jolly (1997) argues that products must conform to existing patterns of use and offered features should be fitted to nature of demand at current point in time.

Jolly (1997) stresses that for many technologies that customers wait for other to adopt before committing themselves. Hence demonstrating the technology on its own facility is seldom enough. Customers want to be reassured of its superiority, where Jolly (1997) emphasises the role of 'Opinion Leaders' as credible actors leading to valuable and influencing demonstration. These Leaders might for example be universities and prominent companies. According to Capon & Glazer (1987) a technology which includes new processes may be difficult for the market to accept and identify with, even though having real value in itself.

3.1.8 8) Mobilizing complementary assets for delivery

Profiting from certain technological innovations depends on early made decision in mobilizing demonstration or collaboration with various market actors, if not a diffusion gap may appear. Another aspect is whether to produce and promote the end product in house or licence the technology. To successfully capitalize on a realization of a technology, is according to Jolly (1997) a function of having the technology commercialized as quickly and widely as possible and to allow to benefit from profits made.

3.1.9 9) Sustaining commercialization, realizing long term value

Some revenues have been realised during the latter sub processes of technology commercialization but the real pay off comes after the launch, argues Jolly (1997). The value of a new technology is not realized at launch or market penetration, it is realized when sustaining commercialization. Sustaining refers to the effort of establishing its use in the marketplace, in relation to competitors. The technology must lead to a dominant design, where the attractiveness is enhanced and an increased number of users have adopted it, thus creating dependence of the technology.

3.1.10 Time to market

A technology is said to be near term commercialization when impact expected within 5-10 years, medium 10-15 and long term 15-25 years according to Cassedy and Grossman (1990).

Jolly (1997) argues that the process of developing a new technology might take 10-20 years, where 10 years is the average. However, he stresses that the overall time to market for innovations varies depending on how the starting and ending points are defined and successfully functioning processes in the commercialization effort. It is also a question of nature of competition and first-mover strategy or not. Jolly (1997) stresses that there is not much to do in accelerating the development of a new technology itself, but what organisations *can* do is engage in more collaborative research and assign a greater number of researchers to the project.

3.2 Commercializing public research

Historically governments, motivated by socio-political and macroeconomic perspectives, have traditionally supported mainly basic research in universities and other specialized institutes (Braun et al., 2000). The primary objective was aiming at advancing in knowledge and theoretical understanding. But government involvement has expanded says Jolly (1997) now also playing a role in the demonstration of new technologies as partners to private industry, mainly by funding private research which is commercially oriented and making government laboratories and institutions available to private industry.

Government funded, Large Public Research Institutes (LPRI's) are significantly contributing to most countries' national Technology and Innovation Policy structure (Braun et al., 2000).

Beyond the traditional role of furthering science and generating know-how in advanced areas, their tasks increasingly include promotion and diffusion of advanced knowledge and support of its conversion into successful new products and services (Braun et al., 2000).

Through their work of analysing (LPRI'S), Braun et al. (2000) have identified several key fields particularly impacting the innovation and technology transfer process of public research (figure 3.3).

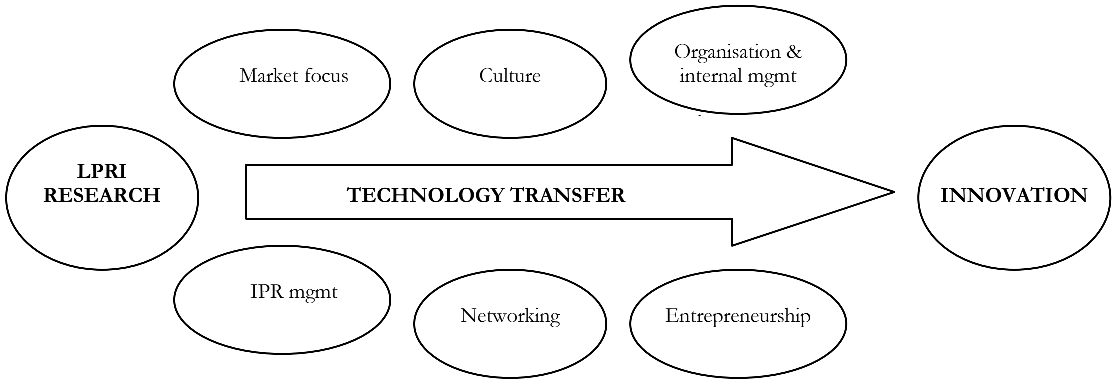

Figure 3.3 Technology transfer framework of LPRI: s, Braun et al. 2000 (p. 18)

Market focus and Networking: Building active relationships

According to Braun et al. (2000), each group of stakeholders surrounding research institutes has different expectations, which needs to be balanced individually. Generally the *Government*, as the main financing body, seeks to maximize the economic and social impact by enabling knowledge dissemination and wealth creation. *Industry* use LPRI's for assistance in accessing and mastering new technologies which they would not be able to develop and implement by their own means. *Other transfer partners* like other institutes, business support organisations, incubators, technology brokers and partners are important where collaboration can bring significant breakthrough.

Braun et al. (2000) state how LPRI's, in order to be effective technology transfer agents, need to be complemented with a commercial sense for customer focus. It requires each research institute to systematically identify and integrate customer requirements and expectations into the development process, in order to early promote the innovation/technology on market (Braun et al., 2000).

Culture and Organisational/ Internal management

In order to successfully transfer research results, some research institutes might benefit from changing the culture from being specifically engaged in advancing science and technology to also being market oriented and gaining recognition and awareness of their work according to Braun et al. (2000). The culture within a public research institute needs to be a mixture of scientific excellence and business relevance. Successful technology transfer missions also require an open, entrepreneurial, flexible and tolerant organisation. Cooke and Mayes (1996) emphasise the management attitude to be crucial for successful commercialization and transfer, if not allowing for change in products and processes lagging the organisational progress.

Intellectual Property Rights (IPR) Management

Working with IPR management from public research includes the balancing of protection and exploitation of intellectual assets, as well as decisions on possible protection methods, technology sourcing (licence) and exploitation (sale/licence out), timing and pricing. Effective management handles both internal and external processes. The internal includes: valuation of technology, pricing, forecasts and patent portfolio management. The external processes are: patents, licensing, managing exploitation (technology life cycle), PR and marketing (Braun et al., 2000).

Entrepreneurship: Create "win-win"situations in new business creations

The strategic decision of finally finding the future organisational "home" for a major innovation which is ready to be transferred, has several paths: transfer to an existing operating unit, create a new business unit, form a joint venture or place it outside the organisation as a spin-off. Braun et al. (2000) highlights MIT (Massachusettes Institute of Technology) in the US as particularly successful, where Shane (2002) is particularly studying selling university inventions from MIT. He argues that however university licences have increased and many universities have adopted specific policies and procedures to encourage technology development, these activities might benefit from an even more systematic approach. He argues that the best solution for university technology commercialization requires that actors who have comparative advantage in that activity commercialize it, while the process requires a wide set of skills which are not often possessed by the single university.

3.3 Valley of Death

Funding requirements needs to be addressed at the start of transition effort emphasises Braun et al., (2000). Lack of funds slows down the project commercialization efforts dramatically, and considerably impacts the ability to produce a smooth transition according to O'Connor et al. (2004). Funding of a commercialization can derive from a combination of internal and external sources such as value chain partners and government. In the case of transferring projects from the public to private sector, Murphy & Edwards (2003) discuss several implications and barriers to success, defined as the 'Valley of Death'. Difficulties might arise in collecting sufficient amounts of capital to make transfer of the technology as smooth as possible. These problems might originate from the fact that public sector is most focusing on funding *creation* of new technology and not supporting the following product development stages. The private investors' on the other hand are reluctant to invest until reaching the early commercialization stage, when solid initial sales have been established.

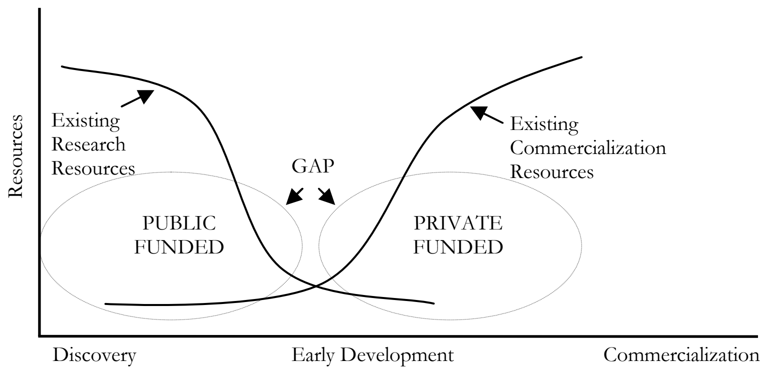

Figure 3.4 Combined model of 'The Valley of Death' from Markham (2004) and Murphy & Edwards (2003)

Thus, according to Murphy & Edwards (2003) the problem is that when private alignment and capital is needed at most, risks are unfortunately high, and the organization may be unable to attract resources needed. This is a problem that illustrates the classic 'chicken-and-egg scenario'. In many cases the public organization actually needs significant private support in turning the new technology into a marketable product. Murphy, Brokaw and Boyle (2002) emphasize the involvement and understanding of the financial sector early in the development process, further strengthened by Jolly (1997) and Krishnen et al., (1997). They also highlight customer focus and early market consideration.

Governments tend to support new technologies where private investors and companies either find the technology to complex and uncertain, and/or require large initial investments. Governments could also be interested in signalling endorsement of the technology and thereby motivate private companies to confidently join the effort more (Braun et al., 2000). Cassedy & Grossman (1990) claim technologies of the long term perspective to significantly requiring government sponsoring to overcome financial and risk obstacles. This programmed sponsorship might retain on medium term level as well. On short term and in the final commercialization stage, investors from the private sector are helpfully invited.

The first three stages of Jolly's (1997) model, (imagining, incubating and demonstration) are according to him all requiring and benefiting from Government R&D support finance. It is at the earliest in the stage of promoting the technology and the end products commercial lending organizations come into place. But Gompers & Lerner (2001) argue that the large amount capital that is needed for an investment in the energy sector is beyond the scope of any private company and business angel investors to fund. Murphy & Edwards (2003) finally recommend developing a joint public/private partnership where the private sector should lead and provide the overall direction for the investment.

Markham (2004) illustrates another aspect of the 'Valley of Death', the gap between the technical development of an innovation and the commercializing effort preceding it. On one side the initial lab and R&D resources for technology development are found, on the other the marketing, sales, promotion and distribution resources. O'Connor et al. (2004) discuss it as a 'middle ground' of innovation activity, where nobody "owns" the projects. Markham (2004) mentions multiple reasons for the existence of 'Valley of Death', where differences in background (technical vs. market orientation), objectives and requirements on reward structures might be obvious.

These problems derive from the operating units' requirements of generating instant revenues and returns on investment, while the technology itself often in that stage is under development for these commercialization purposes, according to him.

3.4 Theory conclusion

Bringing a technology to the market requires a cumulative and ongoing process, displayed by Jolly (1997). In his opinion no technology is fully commercialized until adopted in saleable end products. Jolly's (1997) model includes five main stages; (Imagining, Incubating, Demonstrating, Promotion, Sustaining commerciability) which require 4 sub stages of mobilizing stakeholder endorsement.

Early exploitation of the different uses is a key aspect when defining a technology's commercializability says Jolly (1997). Thus he also argues for early interaction between R&D and product development teams. The researchers might seek to solve a particular technical aspect but do not have the view of finding multiple applications, or ambition and drive needed for proceeding commercialization.

The commitment of 'early adopters' is the drive of plans for transitioning projects, says O'Connor et al. (2004). . To promote adoption and interest among stakeholders consequently requires a well communicated business case. Jolly (1997) states the recipients of a new technology are fundamentally interested in a business opportunity, and not just in the technology in itself. Accordingly, defining and convincing about economic benefits and superiority by being concrete and bringing the technology close to the context of the recipient as possible is central.

Furthermore, during the demonstrating stage it is important to conceptually test the technology in end products and there are two significantly important aspects to consider: 1) only conceptualize products required on the market and 2) assuring that the technology itself is ready to be incorporated in them at the right time. In the transition process from R&D to product development, O'Connor et al. (2004) nevertheless describes a 'middle ground' of innovation activity, where nobody "owns" the projects. The 'Valley of Death'. This is a discontinuity displaying potential implications for further progress.

To avoid a transfer gap, an analysis of the entire business system and identification of the important actors is beneficial, according to Jolly (1997). Funding transfer can accordingly be problematic, particularly when the public sector has supported research and creation of new technology, but not supporting the following product development stage. The private investors' on the other hand usually start investing when initial sales have been established (Murphy & Edwards, 2003). Jolly (1997) stresses the increased role of Government support in the research and demonstration of new technologies. They function as partners to private industry, mainly by funding research which is commercially oriented. Braun et al. (2000) stress a need for commercial sense and customer focus of public research institutes in order to successfully promote innovations and new technology on the market (Braun et al., 2000).

Jolly (1997) argues that the process of developing a new technology might take 10-20 years, where value is not realized at launch or market penetration, thus when sustaining commercialization. Sustaining refers to the effort of establishing its use in the marketplace, in relation to competitors. Shane (2002) argues that commercializing university technologies requires that actors who have a comparative advantage in that activity commercialize it, while the process requires a wide set of skills which are not often possessed by the single university. Murphy & Edwards (2003) recommend developing a joint public/private partnership where the private sector should lead and provide the overall direction for the investment.

4 Empirical findings

In this chapter the empirical findings of the qualitative research are presented. The work is divided into sections on CHRISGAS initiation, current status and further outlook for commercialization.

4.1.1 The CHRISGAS technology

Production of end products from fossil based synthesis gas is currently a known and confirmed process. However, no proven and commercial method to generate the synthesis gas from renewable sources exists for the purposes of producing methanol, hydrogen, DME or Fischer Tropsch Diesel. The uniqueness of CHRISGAS technology is consequently the: "*generation of a **hydrogen rich** gas by **gasification cleaning** through steam reforming and upgrading*" (CHRISGAS proposal p8). A large degree of hydrogen provides high conversion ratios when upgraded to fuel. The cleaning process is critical where gasification of wood biomass yields tar particulates, which the used catalysts are vulnerable for (CHRISGAS proposal).

Moreover project CHRISGAS' synthesis gas demonstrates a major strength when upgraded to fuels. It provides as high as a 55% conversion ratio (55% fuels yielded), and even higher if plant is integrated and exploiting waste energy from heating production. Ethanol production from wooden biomass (also an advanced biofuel of the 2nd generation) yields approximately 20% (S. Bengtsson, personal communication, 2007-04-13). The overall aim with this project is to *demonstrate* production of synthesis gas from wooden biomass, at a level of 4ton/h dry biomass, 18MWth (CHRISGAS).

The synthesis facilitates a broad spectrum of potential products: DME, FT-Diesel, methanol and hydrogen. These can be used in a number of markets;

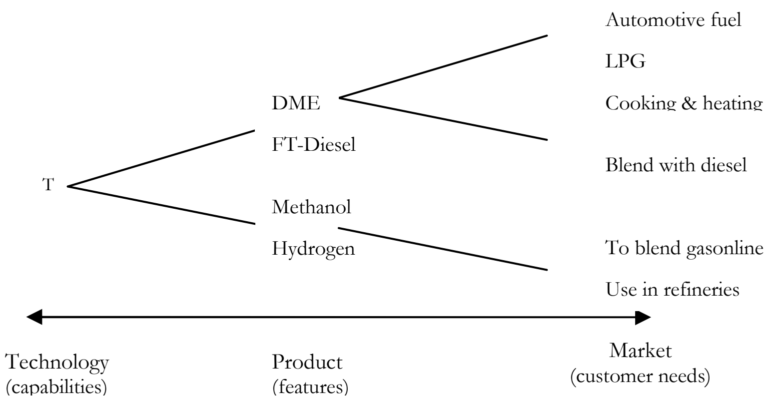

Figure 4.1 Adapted TPM-linkage, Markham (2004)

4.1.2 Initiation

The background leading to launch of project CHRISGAS has been quite winding describes CHRISGAS project coordinator, Sune Bengtsson (personal communication, 2007-04-13). What has been significantly influencing its way, is the political background of the European Union and Swedish energy directives. Ever since the 1980's, when Sweden had main discussions on nuclear power supply, the plant played a role in demonstrating alternative energy production.

The conversion of wood into energy in the Värnamo plant was originally a major project of the energy company Sydkraft, today e.on. It was also partly financed by the Swedish Energy Agency (STEM). Sydkraft successfully demonstrated production of electricity through conversion of biomass to synthetic gas (syngas) through an IGCC process (Integrated Gasificaton Combined Cycle (CHRISGAS proposal).

However, after successful completion, and due to economical reasons, Sydkraft decided to close the facilities in 2000. Several discussions were initiated in how to use the plant in the future; nonetheless it remained closed until 2004. Project CHRISGAS was then proposed to further develop the gasification process for demonstration of alternative fuel extraction, with the background of the European Union's increased discussions on decreasing the heavy reliance on fossil fuel within the transport sector.

The project was accordingly financed within the 6th Framework Program, and supported by the Swedish Energy Agency. The project was given 9.5 million EURO in support, initiated September 2004, extending until 2009.

4.1.3 Project management and incubation

Ann Segerborg-Fick (personal communication, 2007-05-08) from the Swedish Energy Agency, describes how the launching of project CHRISGAS was quite convincing. Its technology demonstrates the most cost-effective way of extracting fuels from renewable feedstock according to her, where supply will be the most critical parameter for success in future. She illustrates an imminent demand for commercializing the second generation of biofuels with outlook for significant rapid future adoption. 'The European target of 5, 75% of alternative fuels is more manifested than ever' she says.

The project has currently reached the third year of progress, beginning the actual pilot scale tests and socio economic studies (WP4 & 16) (CHRISGAS proposal). The CHRISGAS project is also faced with a new financing discussion, where the Swedish Energy Agency allows 182 million SEK for rebuilding to make a demonstration facility, with the reservation for a 70 million SEK contribution from new industry partners which must be drawn together.

The management of the overall project is executed through a project committee, where project coordinator (Sune Bengtsson) manages all activities. The project manager shall also be responsible for reporting activities included in the European Commission (FP6) contract and all communication between the EC and other participants. The activities has been divided into 19 work packages (WP) (see below), the majority conducted in the Värnamo plant and coordinated by Växjö University.

1. Project Coordination
2. Plant modification
3. Plant alteration
4. Pilot scale tests
5. Off site fuel supply and management
6. On an off- site fuel drying
7. Pressurised fuel feeding
8. Gasification
9. Gas Characterisation
10. HT Gas filtration
11. Applied catalytic steam reforming

12. Steam reforming catalyst characterisation
13. Ancillary and novel processes
14. Process system studies
15. System studies
16. Socio economic studies
17. Exploitation/dissemination
18. Training
19. IPR

The CHRISGAS project consortium (see appendix 5) consists of 19 partners, significantly contributing as in developing the technical aspects (CHRISGAS proposal). Some of the work packages (4,8,11,13,14,15) have also been independently managed by one participant; TPS (Termiska Processer AB). They are significantly knowledgeable in gasification of biomass, working with this area since the 1980's. CMA (the Spanish Research Centre for Energy, Environment and Technology) has contributed to 'off site fuelling', TKE Energi with 'pressurised fuel feeding' and S.E.P (Scandinavian Energy Project) with 'on site drying' (CHRISGAS proposal).

The Demonstration activities of the CHRISGAS project are included in WP no 2,3,4 and 6 (Plant modification, Plant alteration, Pilot scale tests, and On site fuel drying). The other packages are aimed at research, technological development and innovation activities. The pilot scale tests (4) Off site fuel supply management (5) Pressurised fuel feeding (7) and socio economic studies (16) form the 'core' of the project (CHRISGAS proposal).

WP 17 (Exploitation & Dissemination) ensures that knowledge in project is protected, disseminated and exploited to its full potential. Dissemination shall include exposure of project status, technical reports on individual WP's, published technical papers, conferences and seminars and information on CHRISGAS website (CHRISGAS proposal). According to Sune Bengtsson (personal communication, 2007-05-08) the project team works with dissemination by continuously posting publications on website, and offering lectures and activities. The organising of the exploitation part, which aims to utilize knowledge gained, is currently dependant upon the future plant structure and financial matters (S. Bengtsson, personal communication, 2007-05-08).

4.2 Commercializing CHRISGAS

This part will focus on project CHRISGAS present situation and towards commercialization. It will discuss the work with mobilizing resources, promotion, future organization, collaboration and outlook for end products.

4.2.1 Mobilizing resources for demonstration

At current date, the technology of project CHRISGAS has been developed to the extent of requiring reconstruction of the plant for demonstration in larger scale. The management of the project is particularly working on attracting private investors interesting in funding further progress.

The coordinator, Sune Bengtsson (personal communication, 2007-04-13), describes how this project is quite unique in its situation of both being government funded and actively managed by a government agency;

'The usual procedure when investing in new research projects, is that industry trigger discovery but needs significant financial support, normally given approximately 20-30%'. 'In this case, the project is not managed by a strong industry conviction, instead almost 100% government managed' he says. 'This situation might to some degree being novel for the authorities' (S. Bengtsson, personal communication, 2007-04-13).

Ann Segerborg-Fick (personal communication, 2007-05-09) from the Swedish Energy Agency is functioning as the government director for project CHRISGAS strategies. She has a background within the European Union, describing a situation where there are no formal guidelines from the European Commission on how to work with commercialization of government projects. 'Though the government agencies are faced with that on a daily basis' she says.

In order to work on overall European government strategies in attracting industry, Segerborg-Fick (personal communication, 2007-05-09) is currently involved in the creation of a common, international platform. She believes a visible and united commitment to create larger industry interest. 'Project CHRISGAS as the example, could definitely benefit from having for example oil companies and automotive industry supporting it'. 'It makes it easier for investors to grasp and forecast the future scenario' she says. 'The European Platform for Biofuels' is trying to create and communicate a general agenda for which fuels to support the development of in future'.

Segerborg-Fick (personal communication, 2007-05-09) suggests that governments should try to solve industry attraction and collaboration by reducing risks for private companies. Public funded demonstration is thus definitely necessary, thereby convincing applicability before attracting private investors interested in financing further progress of projects (A.Segerborg-Fick, personal communication, 2007-05-09).

4.2.2 Valley of Death

Segerborg-Fick (personal communication, 2007-05-09) describes how the governments' largest problems arise when public funded projects in demonstration reach the stage of being handed over to private industry. 'Attracting private actors is definitely a deadlock', a phenomenon I recall to be named 'Death Valley" she says. 'Actors like investment banks are a bit novel about the energy sector, which is a major problem for the European Union, without any current solution' Ann Segerborg-Fick claims (personal communication, 2007-05-09).

Consequently, the Swedish Energy Agency and project CHRISGAS management have constantly investigated how to attract the industry into the project. The solution became reinforcing a condition of 70 million SEK industry capital contributions, before allowing its 182 million SEK further support to the project (CHRISGAS). 'To force a project to private industry collaboration has actually not been initially included in our agenda' says Ann Segerborg-Fick (personal communication, 2007-05-09). Thus the aim of the Swedish Energy Agency is not commercial. 'My work in finding industrial partners has extended far beyond what is normal she says'.

However, in order to attract capital, Ann Segerborg-Fick (personal communication, 2007-05-09) believes they have an attractive solution in Värnamo. 'The only way to attract industry finance is to 'compress' the initial investment and also sharing and reducing risks' she says. The project is allowed 182 million SEK additionally, where the industry should contribute with 70 million SEK and gain access to a project worth 1 billion SEK.

Sune Bengtsson (personal communication, 2007-04-13) describes the uniqueness and industry attractiveness of project CHRISGAS as its readiness to upscale without any 'test factory'. He stresses that the plant is *currently* not commercial, but just slightly modified the equipment could be used in full scale production.

4.2.3 Promoting and 'selling' the technology

'Marketing of the CHRISGAS project aims at displaying technical feasibility in order to illustrate a foundation to solve climate problems trough renewable sources' says coordinator Sune Bengtsson (personal communication, 2007-05-08). 'However the marketing effort is challenging, where not commercial in its traditional sense' he says. 'Project CHRISGAS synthesis is not a product package in itself. The project demonstrates and creates the synthesis gas to generate awareness, provide information and create interest. It is therefore *not* included in the project to promote any particular end product' (S. Bengtsson, personal communication, 2007-05-08).

However, Bengtsson (personal communication, 2007-05-08) describes how the project is constantly diffusing its information towards the market, but not focused towards any specific user. 'I would say that is more spin-offs and municipalities working with that, since it is *not* in the specifications of project CHRISGAS to do so'. 'This is a synthesis gas which is flexible for *all* kinds of usage' he says.

Ann Segerborg-Fick (personal communication, 2007-05-09) discusses how to promote project CHRISGAS synthesis gas in future. 'It is extremely important to have the right 'packaging'', she emphasises. 'You have to put efforts in a selling case, not always the situation in university steered projects'. 'I am currently working on how to 'package' project CHRISGAS' she says, stressing that it is not an easy task. 'The fact that project CHRISGAS currently might be positioned too far away from end products complicates marketing and selling of this case'. 'Other projects have come much further'. Ann Segerborg-Fick (personal communication 2007-05-09) believes that industry interest actually could have decreased in relation to the strategy where project CHRISGAS has never been locked into promotion and production of one single alternative.

4.2.4 Outlook for end products

Ann Segerborg-Fick (personal communication, 2007-05-08) believes the most viable future scenario includes remaining existing vehicles, fuel distribution infrastructure, instead improving and blending bio material with current fuels. 'We can not change everything' she says, 'but we can utilize our capabilities to the fullest'.

During the IVA symposium in Stockholm, February 2007, the CEO of AB Swedish Shell, Karl Georgsson (personal communication, 2007-05-09) emphasizes four energy policy drivers that are important for selection of their future fuels; energy security, economic development, environmental impact and ease of implementation (C.Georgsson, personal communication, 2007-02-07).

Subsequently he claims that petrol and diesel will remain as the main fuels for the predictable future, however more advanced. The biofuels will become increasingly important, but primarily as blends with fossil fuels. On the longer term Shell considers hydrogen as the potential to be a viable fuel option. Shell is currently investing in R&D and bio-technology companies to commercialize the second generations' biofuels within projects such as IOGEN (cellulose ethanol) and CHOREN (Fischer Tropsch Diesel) (C.Georgsson, personal communication, 2007-02-07).

Ann Segerborg-Fick (personal communication, 2007-05-09) believes that the product with highest market potential when produced from project CHRISGAS synthesis gas might be hydrogen. 'All refineries consume a great deal of hydrogen, currently produced from fossil natural gases' according to her.

'Hydrogen produced from biomass is more efficient and environmentally friendly'. 'We think this is the best usage for the CHRISGAS technology' (A. Segerborg-Fick, 2007-05-09). Nevertheless, some DME projects have been supported by the European Commission and the Swedish Engergy Agency; 'it is a question of market demand' says Segerborg-Fick (personal-communication, 2007-05-09). 'Even though DME has proven great results in different analyses and reports; that is not enough'. 'DME will for sure be applicable to heavy vehicles, like buses, but compared to all the possibilities for project CHRISGAS synthesis gas, it is a niche application'.

'There will for sure be future regulations enforced in substituting and improving for example diesel' says Segerborg-Fick (personal communication 2007-05-09). 'That is where the project CHRISGAS synthesis gas proves its greatest contribution to substituting fossil fuels; its flexibility' she says. 'Even if it is not fully substituting any fossil fuel, there could be a blend of lets say 10-20% bio mixture'. 'That is where hydrogen is so special' she says, 'you can for example blend it with diesel and eliminate the sulphur percentage' (A. Segerborg-Fick, personal communication 2007-05-09).

4.2.5 Industry collaboration

This part pictures project CHRISGAS's work with future organization of industry partners (Company A), as well as provides reflections from the automobile and oil industry.

4.2.5.1 Organizing for 'company A'

Bengtsson (personal communication, 2007-05-09) expects the project CHRISGAS synthesis gas to be ready for full scale production in 2010 or 2012, dependant upon current progress and authority formalities.

In order to facilitate commercialization of the CHRISGAS technology, the Swedish Energy Agency are slightly changing the organisation structure, setting up 'Company A' consisting of the '70 million SEK industry partners'. 'Company A' will be allowed 11% ownership in the CHRISGAS project, independently managing commercialization. Where the former part of project CHRISGAS has been focusing on research, Ann Segerborg-Fick (personal communication, 2007-05-09) stresses how 'Company A' will focus more on exploiting the technique for market purposes. 'Virtually the original project CHRISGAS will be divided, where the new project area thus has more investment focus' she says. 'All IPR management and know-how will serve as the foundation and core of the new 'Company A'' according to Segerborg-Fick (personal communication, 2007-05-09).

The facilities in Värnamo will be jointly owned by Växjö University, KTH (Royal Institute of Technology) and the 'company A' (11%) (S. Bengtsson, personal communication, 2007-04-13). ''Company A' will be exploiting the technique by creating additional plants and commercializing the gasification technique in future' says Bengtsson (personal communication, 2007-04-13). 'The facilities in Värnamo can then be used also for other projects and further research within the area' (A. Segerborg-Fick, personal communication, 2007-05-09). 'Company A' will be a mixture of specialists, consisting of technical companies, venture capitalists and so forth' (S. Bengtsson, personal communication, 2007-

05-09). 'Our main aim is to remain and emphasise the 'core' in project CHRISGAS, the gasification technique' (A. Segerborg-Fick, personal communication, 2007-05-09).

Which companies to include in 'Company A' are not decided yet, but several actors interested. However, TPS, a prominent and driving actor who has been interested in 'company A' and responsible for several work packages in the project is currently in an unstable situation (A.Segerborg-Fick, 2007-05-09). 'They have serious financial problems, where the parent company, Talloil, is selling out the company' says Bengtsson (personal, communication, 2007-05-07).

The project team has historically also discussed future 'Company A' collaboration with for example AGA-Linde and Preem says Segerborg-Fick (personal communication, 2007-05-09). 'The technique is significantly compatible with a refinery, therefore suitable for oil companies'. 'However, these companies are not undertaking any particular R&D and to some extent reluctant to collaborate in these efforts' she says. 'We think is better that other actors are setting up the plants and in the next stage selling them to interested actors' (A. Segerborg-Fick, personal communication, 2007-05-09). 'Therefore we have considered selling a 'turn key facility', where the customers receive access to a complete concept'. 'We have had some interested actors in that'. 'Industry partners are attracted by the fact of having a completed plant that they can get rapid access to' says Ann Segerborg-Fick (personal communication, 2007-05-09).

The desirable future, collaborative scenario of 'company A' working for commercialization of CHRISGAS technology is described by coordinator Sune Bengtsson (personal communication, 2007-05-09); "Company A' will focus on setting up production units. Moreover it could be beneficial to involve distributors (oil companies) and having concurrent development from automotive industry' (S.Bengtsson, personal communication.

4.2.5.2 Fuel Distribution

Sören Eriksson (personal communication 2007-04-26), managing supply, trading and product development at Preem, describes the main demand for alternative fuels spurred by the transport sector. 'It utilizes approximately 70% of diesel sold by Preem today' he says. Preem describes how they are continually bringing in renewable fuels in the program, which is still assumed to remain mainly fossil based, due to supply reasons. 'However we develop it towards a rich blend of renewable fuels' says Eriksson (personal communication, 2007-04-26). 'We estimate that current viable biofuels will not cover the demand'.

Eriksson (personal communication, 2007-04-26) describes how Preem currently has not an overall explicit strategy for working with new technologies. They have for example historically been interested in collaboration with the CHRISGAS project, but after consideration decided not to be involved (S. Eriksson, personal communication, 2007-04-26). Eriksson (personal communication, 2007-04-26) believes the investment still is experienced too risky. Preem is not either used to participate to that extent in R&D, where normally acquiring already developed technologies and production plants. 'Thus it is not currently included in Preem's business plan to work with collaborative R&D, and particularly not in university projects' says Eriksson (personal communication, 2007-04-26). He questions whether universities should actively lead technology development projects. 'Maybe they are more beneficially managed by industry actors' (S.Eriksson, personal communication, 2007-04-26). Preem finally puts forward the importance of setting up common political guidelines for new technologies, which has to be accepted in the entire Europe.

4.2.5.3 Automotive industry

Representing the automotive industry during the IVA symposium in February, Anders Röj (personal communication, 2007-02-07), fuel coordinator at Volvo technology, explains which aspects Volvo look into when new alternative fuels are evaluated; The foundation is to evaluate the sustainable availability, well-to-wheel efficiency and degree of emissions. Energy density, economy and infrastructure are also important aspects, as well as safety and health when it comes to handling the fuel.

Other aspects to consider are those of political environment and customer perceptions according to Röj (personal communication, 2007-02-07).

Volvo is involved in the European 'renew'-project, funded by the European Commission's 6th Framework Program. It seeks to share knowledge and results on an international basis, aiming at defining the best possible solution for future fuels from renewable feedstock. Volvo has within the 'renew' project set up tested engines fuelled with DME. However, the restriction of that fuel is the need of a completely new distribution structure. 'The infrastructure is admittedly similar to LPG, which has 14 0000 filling stations in Europe'. 'But a transport sector requires approximately 2 500 centers and the private fleet 20-25 000' (P.Klintbom, personal communication, 2007-05-02).

In order to support the development of Black Liquor gasification, Volvo Technology Transfer AB, which is focusing on supporting new ventures, has recently acquired ownership in Chemrec, a Swedish pilot plant for black liquor gasification (P.Klintbom, personal communication, 2007-05-02). 'Volvo has formerly been interested also in the CHRISGAS project' says Klintbom (personal communication 2007-05-02), however decided to withdraw the involvement. Volvo believes in the CHRISGAS technology and its synthesis gas potential, says Klintbom (personal communication, 2007-05-02).

When asked upon whether the project might have been delayed since it has been steered by a university Klintbom said that this might be one reason out of many other possible reasons. Another aspect which he believes restricts project CHRISGAS is that it is not aiming at a certain end product. 'This is understandable' he stresses since good quality synthesis gas is the key issue, 'but may have lead to that industry (particularly automotive and oil) have not seen its full potential as they may have done in other similar projects' (P.Klintbom, personal communication, 2007-05-02).

How to speed up the time to market for new technologies is according to Patrik Klintbom (personal communication, 2007-05-02) a matter of financing. 'Setting up production plants requires large investments and guarantees of applicability, where extensive risks involved'. 'Government could reduce risks in the fuel sector by setting up production plants to demonstrate proof of technology' according to Klintbom (personal communication, 2007-05-02). He describes how Volvo definitely benefits from government support in development efforts. 'Even though our company covers the majority of investments, the support significantly reduces financial risks' (P.Klintbom, personal communication, 2007-05-02).

5 Analysis

The analysis is arranged in accordance with Jolly's (1997) commercialization model. Initially the three steps project CHRISGAS has gone through are presented, followed by the three steps that the project is considered to be in right now. The last section discusses future commercialization activities required.

5.1 Project CHRISGAS Development up to today

This part will, in accordance with Jolly´s (1997) model, analyse the stages of 1, 2 and 3, in which CHRISGAS already have developed through

5.1.1 1) Imagining

According to Jolly (1997) technologies are not fully commercialized until incorporated and adopted in end products. We would therefore, in his terms, define project CHRISGAS as completely commercialized when the synthesis gas is used for full scale production of any of the end applications, for example DME.

However, no technology based idea is intrinsically commerciable according to him; it has to be made so. Project CHRISGAS has on the one hand not being designed to be commercial, described by Sune Bengtsson (personal communication 2007-04-13), and could therefore questionable be applied to the commercialization process of Jolly (1997). However, we recognize the development progress of project CHRISGAS to relate to his statement of *making* it commercial. The project also relates to the thoughts of Schwarz et al. (2004) who describe a technology development project as exploiting technical fundamentals in order to demonstrate feasibility, not directly related to instant revenues. Even though not initially for profit, we believe project CHRISGAS development towards the future 'Company A' industry structure and its commercial structure, implicitly indicates a progress in the direction of Jolly's (1997) commercialization process.

Moreover Jolly (1997) argues that most ideas are initiated and triggered by iteration between a market need and a new technological capability, also discussed by Markham (2004) which mentions the Technology-to-Product-to-market (TPM) Linkage aimed at converting technical advantages into required product features. Project CHRISGAS was initiated in 2004, triggered by society's need for renewable energy sources. The foundation for wood gasification was already set in Värnamo (Sune Bengtsson, personal communication, 2007-04-13). We can therefore conclude the launching as *mostly* triggered by political influences at the European Union level. Project CHRISGAS is thus notably a non commercial research project, since it is Government funded (EU 6th framework program) and actively supported and managed by the Swedish Energy Agency. This implies that its ideas are not necessary developed with clear market focus. However, the potential end products are faced with great market interest which necessitates interaction, possibly further than normal.

5.1.2 2) Mobilizing interest and endorsement

Since project CHRISGAS is a public triggered research project, we have found the stage of mobilizing interest in taking it further as somewhat being integrated with the latter. We argue that CHRISGAS passed this stage in 2003-2004 when receiving a go for the project and initial funding for setting up VVBGC and the project CHRISGAS consortium structure.

Jolly (1997) admittedly claims that the research group benefits from satisfying a vast variety of different stakeholders simultaneously in this stage; for example peers, colleagues, funding agencies and outside partners.

But all stakeholders of the CHRISGAS consortium are contributing to secure the technical development and not set to satisfy any particular other stakeholder or market actor.

5.1.3 3) Incubating

Jolly (1997) describes the effort of defining commercializability as deciding *if* and *how* to take the project further.

If project CHRISGAS was given a go for further progress was already decided in its initial stage of 2004, where allowed government funding for 48 months. The project team had already defined the future uses of the synthesis gas, in accordance with Jolly's (1997) emphasis on early exploitation of different uses. He also discusses 'incubators' who takes the technology further. We believe the creation of the CHRISGAS consortium relates to an incubating function.

We also recognize the importance of the active involvement from the Swedish Energy Agency, particularly Ann Segerborg-Fick, who describes her extensive involvement and how the launching of CHRISGAS was particularly convincing due to its most cost-effective way of extracting fuels from renewable feedstock (A. Segerborg-Fick 2007-05-09).

How the Swedish Energy Agency and Växjö University decided to take the project further was defined in the project description/application for government funding. The work was defined in the 19 Work Packages, where several important milestones and technical progress goals were identified and emphasized (CHRISGAS proposal). Jolly (1997) stresses the importance of achieving certain technical milestones and to demonstrate future progress by visualizing a plan for pursuing an attractive set of applications when establishing commercializability. Project CHRISGAS constantly works with dissemination of results through published technical reports, project status reports, conferences and seminars (S.Bengtsson, personal communication, 2007-05-08). On the other hand, we can not see that the project exploits and works towards any specific set of applications. Instead its flexibility and possibilities to be incorporated in a vast range of products are emphasized in 'marketing'. This fact is a deliberate strategy, where project coordinator Bengtsson (personal communication, 2007-05-08) strongly emphasizes that promoting any particular end product is not included in the structure. We believe this in fact could be both project CHRISGAS advantage – and disadvantage.

Jolly (1997) claims that what is important for incubating is assembling as much information as possible about market potential. He also emphasizes early interaction between R&D and product development teams. Researchers are on the one hand specialists on technical aspects, but might lack drive for commercialization he says. We believe the project CHRISGAS team at Växjö University to be very aware of the market potential for the synthesis gas and the end applications, but could have benefited from earlier market integration. This project has been focusing on technical feasibility from the initiation and somewhat ignored the market aspects of potential users. The project *has* on the one hand early defined its uses according to what Markham and Kingon (2004) says about the TPM Linkage, and early exploring the different uses, but they have *not* defined strategies for commercial development. We therefore agree with Braun et al.'s (2000) statement that public research needs to be complemented with a commercial sense of customer focus, in order to be effective technology transfer agents.

5.2 CHRISGAS current position and implications

In accordance with Jolly's (1997) model (figure 5.1), we believe the stages of 4, 5, and 6 to be particularly interrelated in the case of CHRISGAS. We would define project CHRISGAS to currently function across these processes;

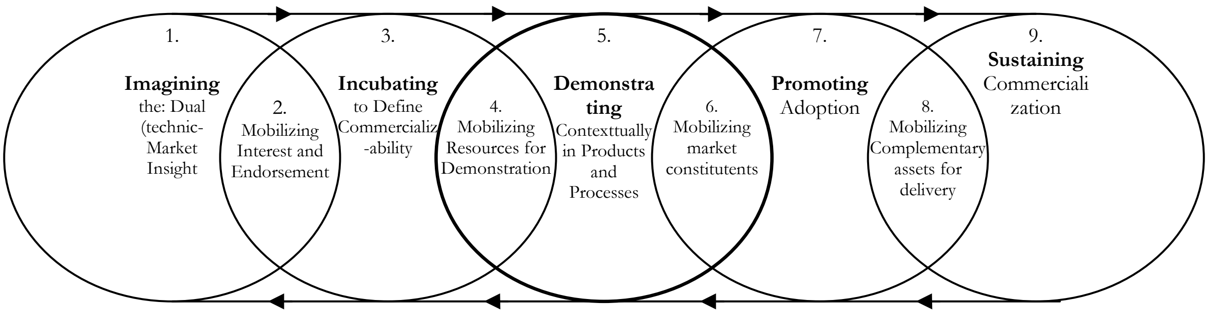

Figure 5.1 Adapted technology commercialization model Jolly (1997)

Additionally we argue for a slightly different view of the model than originally. According to above illustration, we claim that all steps must be even more combined in a *specific* process aiming towards an explicit goal. That admittedly *is* the case with Jolly's model, but we believe the overall picture must be clearer and focus even larger towards an end product in order to avoid disturbances and interruptions. Currently, when talking of 'independent sub processes', we believe there is a risk in having to narrow advance planning and to much focus on the current stage. Government projects and research efforts like project CHRISGAS in particular, might significantly benefit from having an initial explicit strategy for future commercialization. Research in its own sense is crucial, however if aimed to be commercialized it has to be complemented with market focus, as a suggestion in accordance with above model.

5.2.1 4) Mobilizing resources for demonstration

Project CHRISGAS is according to us currently working in stage no 4 with mobilizing resources for demonstration, they are in position to demonstrate in larger scale after rebuilding of facilities (no 5) and also working more towards the market through Ann Segerborg's work with industry attraction, partners and 'packaging' (no 6) (A. Segerborg-Fick, personal communication, 2007-05-09).

Jolly (1997) believes that value creation of technology development is an ongoing cumulative process, growing when resources such as venture capital, public funds and business groups are mobilized and attracted to it. We believe that is exactly what is currently happening in project CHRISGAS. It was admittedly not initially commercial, but has developed towards a more marketable state. It has created significant value along its development, now ready to being more commercial in its sense. This might recall the 'change of culture' Braun et al. (2000) propose, and a more open and flexible management attitude like Cooke and Mayes (1996) discuss.

Demonstrating in the case of project CHRISGAS is not completely similar to the demonstration Jolly (1997) describes in his model. The CHRISGAS project aims to set up a large scale demonstration of *synthesis gas production*, and not demonstrating conceptually in end products. Our analysis will put focus on CHRISGAS current situation.

To be successful in this phase, Jolly (1997) argues it beneficial to assemble as much capital as possible initially. The organization should be able to choose from a wide range of interest from resource providers, venture capitalists and partnering companies. Gompers & Lerner (2001) argue that the large investments in the energy sector *require* government sponsoring. Private, industrial funding comes into place late in the process. In accordance with Jolly's (1997) and Gompers & Lerner's (2001) thoughts we have seen that project CHRISGAS has been mainly government funded throughout the whole process up to today. The project received initial funding of 9,5 Meur in 2004, and are now in the process of receiving additionally 182 million SEK aimed at rebuilding the plant for larger scale of demonstration and exploitation (S. Bengtsson, personal communication 2007-04-13).

5.2.2 Project CHRISGAS Valley of Death

We believe Jolly's (1997) picture of the wide range of options of resource providers, might be to optimistic, particularly for government projects which to some sense lack commercial attraction. Project CHRISGAS, which has not being particularly market focused during the initial progress, was consequently faced in a situation of 70 million SEK *enforced* industry contribution when needing additional funding in order to proceed (A. Segerborg-Fick, personal communication 2007-05-09).

Ann Segerborg-Fick (personal communication 2007-05-09) from the Swedish Energy Agency describes the difficulties and 'deadlocks' for government projects in general when attracting private funding. A phenomenon she mentions as 'Death Valley'. Murphy & Edwards (2003) discuss this incident, which actually *is* referred as the 'Valley of Death' (as Segerborg-Fick mentioned). They describe it as a function of the public sector mostly focusing on *creation* of new technology and not supporting the subsequent product development stages. Consequently, the private investors' are reluctant to invest until solid initial sales have been established and the concept verified. We believe that is exactly what is happening for project CHRISGAS, which only develops the intermediate synthesis gas and not supporting end products.

Murphy & Edwards (2003) stress that public organizations in many cases significantly needs private support in turning the new technology into a marketable product. But unfortunately risks are high during early stages, and therefore seeming unattractive to industry resource providers. We find that project CHRISGAS *is* definitely and currently facing the position of 'Valley of Death', since Segerborg-Fick (personal communication, 2007-05-09) describes severe difficulties in attracting industry capital. She mentions how her extensive work in finding industry partners for this project has reached beyond the traditional. Actually no explicit guidelines from the EU-level governmental perspective exist according to her.

Finally the Swedish Energy Agency decided to reinforce a condition on its 182 million SEK allowance, as mentioned earlier. Ann Segerborg-Fick (personal communication 2007-05-09), stresses that this enforcement was *not* included in the initial agenda of the agency, but necessary for lowering government risks and securing of further commercialization. She still claims that this kind of deal (where the industry can contribute with 70 million SEK and have access to a project covering 1 billion SEK) is attractive and would receive significant interest. It could be a future 'model' according to her. Project CHRISGAS has also an additionally advantage which would attract the market according to Sune Bengtsson (personal communication, 2007-05-08); it is ready to upscale to full scale production, and do not require a 'test factory'. This somewhat indicates to reduce the time of demonstrating, and instead focusing on full scale production within reasonable time.

In order to reduce and bridge the 'Valley of Death', we have seen that Ann Segerborg-Fick (personal communication, 2007-05-09)/ the Swedish Agency has described several ways to go; 1) A common platform to create a larger interest and focus on which applications to develop 2) Public demonstration of production in order to convince partners, and 3) Compress the initial investment, reduce and share risks. That also relates to the thoughts of Jolly (1997). He emphasizes responsiveness for each stakeholder's timeline, reducing of perceived risks, and having a clear communication of benefits.

In the situation of project CHRISGAS we have found that the management has decided to integrate the industry in a 'independent' 'Company A', allowed 11% ownership, where all know how and IPR will be put, according to Ann Segerborg-Fick (personal communication 2007-05-09). 'Company A' should therefore from current date and onward be responsible for demonstration, further commercialization and in the end also the construction of additional plants. We have seen that this company is up to now not fully developed, thus we know less about the final outcome. What we *do* know from both Sune Bengtsson (personal communication 2007-04-13) and Ann Segerborg-Fick's (personal communication 2007-05-09) interviews is that the team aims to bring in a mixture of technical specialists, venture companies etc. That could facilitate the problem Markham (2004) discusses, where moving a semi-developed to product development might seem unattractive.

We argue that this effort also strongly relates to the thoughts of Shane (2002). He argues that the best solution for university technology commercialisation requires that actors who have comparative advantage in that activity commercialize it. The process accordingly requires a wide set of skills which are not often possessed by the single university. It furthermore follows the ideas of Murphy & Edwards (2003) who recommend developing a joint public/private partnership where the private sector should lead and provide the overall direction for the investment.

However there is a possible problem which could at this point restrict 'Company A' from progress; the unstable situation of TPS, the knowledgeable and driving actor who has been prospected for ownership and also responsible for several work packages in the project (A.Segerborg-Fick, 2007-05-09).

5.2.3 5) Demonstrating

According to Jolly (1997), there are two significantly important aspects to consider when working towards commercialization of applications: 1) only conceptualize products required on the market and 2) assuring that the technology itself is ready to be incorporated in them at the right time. A problem for the CHRISGAS project, as well as other industry actors, is that no solution is currently dominant. Both industry and the management of project CHRISGAS would like to see a common agenda or platform community from the government perspective, which would communicate which options that are most interesting (A. Segerborg-Fick, personal communication, 2007-05-09, S.Eriksson, personal communication, 2007-04-26, P.Klintbom, personal communication 2007-05-03).

In *which* products to develop, the oil- and fuel distribution industry is attracted by security, profitability, environmental impact and ease of implementation (K. Georgsson, personal communication 2007-02-07). The automotive industry indicates an interest in fuels which have sustainable availability, well-to-wheel efficiency, low emissions, suitable infrastructure needs and economy (A.Röj, personal communication 2007-02-07). We believe all possible applications of project CHRISGAS have the advantage of significant environmental potential, low emissions and well-to wheel-efficiency.

More uncertain are the ease of implementation and initial profitability. In order to launch for example DME, a completely new infrastructure must be implemented on petrol stations. We also believe the initial costs for new alternative fuels could be marginally higher than for fossil fuels, before fully benefiting from economics of scale. Project CHRISGAS *has* on the one hand knowledge about the potential for its end applications, and is on right track in terms of hydrogen and discussion about blending alternative fuels with current standards. *But,* there has not been any selling case. The market has accordingly not been convinced of its abundance and advantages. Either it has been provided with strategy suggestions to share and reduce risks.

If project CHRISGAS is ready to incorporate the technology in end products at the right *time*, is uncertain due to the fact of no common dominant product to put efforts in. With Sune Bengtsson (personal communication, 2007-04-13) describing the possibility to upscale production by 2012, the technology is near term commercialization in accordance with Cassedy and Grossman's (1990) description. Patrik Klintbom (personal communication 2007-05-03) believe project CHRISGAS technology is one of the nearest technologies for commercializing the second generation of biofuels, but why the market responds in that way is because of vague communication. The users have not had full insight in its progress.

5.2.4 6) Mobilizing market constituents

Setting up a commercialization effort requires significant market knowledge and focus. Jolly (1997) claims that the more radical a technology is, the greater the need for mobilizing a wide range of market elements. The technology of project CHRISGAS is to some extent radical, where some of the applications would require significant changes in fuel distribution infrastructure and changes in vehicles. Jolly (1997) further argues that developing a market for novel products involves coordinating the contribution of several areas and stakeholders. That could be partners in delivering the technology's full benefit, intermediate adopters, manufacturing partners and so on. These efforts have not originally been planned to be included in the CHRISGAS project structure Sune Bengtsson (personal communication, 2007-05-08). Its marketing aims at displaying technical feasibility in order to illustrate a foundation to solve climate problems. However Bengtsson (personal communication, 2007-04-13) and Segerborg-Fick (personal communication 2007-05-09) manifests a vision on concurrent development of the distribution- (oil companies) and automotive industry in parallel with the work of 'Company A'. They mention that there have been several interests from the private industry in collaborating, but all have withdrawn their attention. We believe that this has happened just for the reason that project CHRISGAS has not spoken the 'industry language', thus difficult for a research organization like this to coordinate involvement from additional industry partners within the business system.

Jolly (1997) argues that attracting contribution from market elements in the commercialization effort is a matter of successfully convincing future recipients of the economic benefits and superiority of technology. That is fulfilled by being concrete and bringing the technology close to the context of the users he says. The recipients of a new technology are thus fundamentally interested in a *business opportunity*, not just the technology itself.

This agrees with the thoughts of Ann Segerborg-Fick (personal communication, 2007-05-09), where she claims it extremely important to have the 'right packaging' when attracting industry. She further describes that the CHRISGAS project is not at present 'packaged' to the fullest, but the team is working on it.

There *have* been market actors both from the oil- and automotive industry interested in co-development with project CHRISGAS. However these have withdrawn their interest. Volvo who has worked with DME-vehicles can even be seen as an 'early adopter' in the sense of Jolly's (1997) description, but they have not *developed* the application in collaboration with project CHRISGAS. Why the project has not completely succeeded to sell its case to either the oil- or automotive industry might particularly relate to O'Connor et al.'s (2004) description of 'Valley of Death'. Project CHRISGAS is facing this 'middle ground' of innovation activity, where the project is positioned in a transition process from pure R&D, requiring contact with product development entities. The complexity described by O'Connor et al. (2004) is that the technology itself is under development, and industry put focus on instantly generating revenues, not willing to collaborate in development. That might be the situation in project CHRISGAS.

Preem has explicitly said that oil companies invest in completely developed technologies and not taking part in any collaborative R&D (S.Eriksson, personal communication, 2007-04-26). Both Preem and Volvo are discussing significant risks as the major determinant for withdrawal; a failure for the project in accordance with Jolly's (1997) emphasis on reducing stakeholders' perceived risk and try to show rapid progress in order to sustain interest (S. Eriksson, personal communication 2007-04-26, P. Klintom, 2007-05-03).

5.3 Future challenge

This part discuss and put forward the future challenges for project CHRISGAS.

5.3.1 7) Promoting adoption

Which product that mainly should be produced from the CHRISGAS technology is open and flexible according to Ann Segerborg-Fick (personal communication, 2007-05-09). She claims the product with highest potential when produced from the synthesis gas to be hydrogen, initially aimed at refineries and for blending with fossil fuels. DME which has been demonstrated within the renew program (renew) is also particularly promising, particularly for the transport sector. As fuels, these products yet require significant changes in distribution infrastructure and vehicles. She also claims the project CHRISGAS technique to be particularly compatible with a refinery, but no such are yet interested in collaboration (A. Segerborg-Fick, personal communication, 2007-05-09).

Jolly (1997) stresses that the ultimate judge of a new concept is the end user. While several intermediate adopters and market constituents may have helped in promoting a technology, it is end customers buying the product or service incorporating it who decide how valuable it is. Therefore products must conform to existing patterns of use, and offered features should be fitted to the nature of demand at current point in time. In the situation of end applications of project CHRISGAS, we currently find it too early and uncertain to discuss whether the technology successfully will lead to wide adoption. We find nature of demand unstable and somewhat roaming. That is mainly due to the uncertainty in which new biofuel technology is going to be dominant.

We would argue that the fact where project CHRISGAS today being positioned as a broad technology with multiple outlooks could be its shortcoming, possibly positioning it to far from the market. Its flexibility might instead diffuse the technology and making it difficult to grasp the business opportunity in it for recipients.

Actually Segerborg-Fick (personal communication, 2007-05-09) herself points out that since project CHRISGAS has never been locked into promotion of any particular alternative; it could have decreased industry interest and brought the project away from market.

5.3.2 8) Mobilizing for delivery

Jolly (1997) claims that successfully capitalizing on technological innovations depends on early made decisions in mobilizing collaboration with various market actors. In this case of project CHRISGAS, we find it not early integrating industry cooperation. But it is in current position to working with a larger degree of market collaboration. If project CHRISGAS is unable of setting up an open and collaborative structure, it might lead to adoption problems in future.

Jolly (1997) argues that convincing the market by demonstrating the technology on its own facility is seldom enough. Capon & Glazer (1987) further strengthen that and argue a technology which includes new processes to be difficult for the market to accept and identify with, even though having real values in it self. Customers want to be reassured of its superiority, where Jolly (1997) emphasises the role of opinion leaders; credible actors leading to valuable and influencing demonstration. We have mentioned that project CHRISGAS has not up to today worked in close collaboration with intermediate and early adopters (even though the renew project with Volvo in forefront helps market awareness (renew)). The industry has to some extent known about project CHRISGAS benefits, but being rather reluctant to involvement. Since all market elements are closely interrelated and important for adoption, we believe the project definitely would benefit from integrating fuel producers, distributors and the automotive industry. We also believe a significant market actor, with great influence, decides to go in forefront for the development. There will for sure also be crucial with government guidelines and sanctions, putting forward *the* future alternative.

5.3.3 9) Sustaining commercialization

Referring back to Jolly's (1997) initial statement of no technology to be fully commercialized until adopted in end products, we can see that project CHRISGAS has a major challenge to overcome.

The number one issue is to convince the industry to work with prototyping and promote adoption. Thus project CHRISGAS will have to come close to industry (distribution and vehicles) in order to *create* market demand, as Schwartz et al. (2004) argue. That is to promote and demonstrate production of end products which convince of its superiority. Thus importantly, the real pay off comes after launch, and is not realized until sustaining commercialization by establishing a position in the marketplace (Jolly, 1997).

6 Conclusion

The conclusion responds to the purpose of the thesis and is followed by a discussion about possible future studies as well as limitations of the work done.

Jolly (1997) describes the technology as a multifaceted capability which can create and enable access to multiple markets. We have learned that commercializing a new technology is a deliberate, cumulative and constantly ongoing procedure (Jolly, 1997). It incorporates and integrates the broad processes of; (*Imagining, Incubating, Demonstrating, Promoting adoption, Sustaining in the marketplace*). To be successful, Jolly (1997) argues for early exploitation of the technology's different uses and interaction between R&D and research teams. He moreover states the recipients of a new technology being fundamentally interested in a business case, and not just the technology in itself. Therefore integrating intermediate adopters, early users and influential opinion leaders is crucial.

Project CHRISGAS is accordingly *currently* working with mobilizing resources for demonstration, in position to demonstrate in larger scale after rebuilding of facilities, and functioning more promotional towards the market through industry attraction attempts (A. Segerborg-Fick, personal communication, 2007-05-09). However, in relation to what project CHRISGAS development process has displayed, we have concluded public projects in particular to face two major limitations;

- *Progress slows down when unable to attract private funding (Valley of Death)*
- *They need a model to attract and incorporate private industry*

In order to avoid gaps and disturbances, we argue for a slightly different view of the process than originally by Jolly (1997). We believe the process of technology commercialization must *early* be aimed towards a more specific segment. We also believe the overall focus must be clearer, and government projects, like CHRISGAS, complemented with a market sense. Moreover there could be more obvious strategies for development processes requiring several intermediate actors involved.

In relation to above implications, we have concluded project CHRISGAS to currently facing the 'Valley of death', due to its public structure. It is having difficulties in attracting industry capital for demonstration, and potential product co-developers are reluctant to collaboration. We believe these difficulties have arisen partly because demonstrating an *intermediate* technology and not focusing at convincingly signifying applicability in any end product. The broad range of options available might have diffused the technology and perplexed the market actors.

As Markham (2004) says; moving a semi developed technology to product development is not attractive, and project CHRISGAS has not prepared the market by early integrating intermediate adopters and product development in its activities. In relation to its university nature, project CHRISGAS has accordingly not either spoken the 'industry language', which has resulted in inability to provide a 'selling case', and the market eventually being unconscious of its lucrative potential and rather close time to market. Thus in order to bridge the 'Valley of Death' and fully commercialize for example DME; project CHRISGAS will have to gain industry attractiveness and collaboration with producers, distributors and automotive industry. We see a necessity for more obvious indications towards a dominant design and an 'opinion leader' taking active part in the development.

6.1 Reflection upon study

We find the purpose of this study (*to describe and understand a technology commercialization process, analyzed on project CHRISGAS*), to have revealed a number of factors which to some extent move away from the original literature views presented. Though a number of factors agree, the complexity not sufficiently covered is how to find a model suitable for commercializing *public* research. Also how to manage a process where several intermediate actors are included.

The theories mainly review a development processes which is ultimately commercial, not covering a transition from initially non commercial research efforts of public institutions and universities (like project CHRISGAS) further to commercialization. As a consequence we have applied an explicitly non commercial project to a commercial model, which obliged us to sometimes reason on a hypothetical level, foremost in the late stages of the process.

We believe that the example of project CHRISGAS have revealed problems which are significantly illustrative for projects which require involvement both from government and private perspectives. This study admittedly emphasizes CHRISGAS to a large extent, where we believe there could have been interesting to also look into other public projects to benchmark the development process against.

Our work could be illustrated as a foundation for further progress. Given the aspects we have learned during this study, we believe it could be further enhanced by trying to reveal the *specific* problems involved and provide suggestions for solutions. Where we believe the number of interviews have provided a foundation suitable for our purpose, an enhanced study would require more extensive studies of participants involved; particularly in project CHRISGAS, potential adopters, end users and multiple views from government and private industry perspectives.

6.2 Suggestions for further studies

The commercialization process we have displayed has just briefly touched upon the area of including several parties for commercialization. Jolly's (1997) picture is therefore significantly simplifying the process, by implying one organization to follow the whole process through. We believe the true picture is that actually most technology commercialization efforts are like project CHRISGAS, complex networks of stakeholders and co-developers dependant upon each other. Overall coordination must be solved, and we therefore believe it would be significantly interesting to map these networks and analyze crucial factors for collaboration. That would include setting up a framework of how to facilitate a joint development effort.

It would definitely ease public technology transfer projects with studies focusing on models for how to attract and integrate private industry. From the public view, the Swedish Energy Agency pose a wish to study how governments or/and the European Union can help companies to be less risk averse (A. Segerborg-Fick, personal communication 2007-05-09). This may involve how to reduce risks, provide warranties, and improve loan conditions. That could be executed by searching for transfer efforts in a wide range of industries to benchmark against. Finding a model for university and government technology transfer would probably decrease time to market for a majority of crucial new technologies and research discoveries.

We would also find it important to go deeper into the phenomenon 'Valley of Death'. As illustrated in our empirical findings, this is a major problem particularly for public projects. We would therefore recommend studying this incident in depth and analyze it from different views; (public sector, private sector, lending institutes, and angel investors). That could provide a picture of each entity's expectations and provide a guide for transferring projects.

Postscript;

Comments by T Lennart Gårdmark

This addendum publish a set of final remarks written by mr Gårdmark, where he states some opinions, clarifications and depended comments about project CHRISGAS and VVBGC.

Driving force: The European Union and Swedish directives have NOT been the driving force, but we have used them to secure public funding to reach our goals. The parties involved in the creation of Bio-DME Project and CHRISGAS had various motivations. For Växjö and Växjö Energi the goal is a 170 000 ton bio-DME per year plant in Växjö supplying fleets of DME heavy vehicles (lorries and buses) in Växjö initially and in Sweden.

For TPS the drive was to develop their biomass gasification techniques and commercialize it. For Ducente the goal has been first, as an agent for Sydkraft/Bioflow, to sell the pilot plant and, as a personal goal, to get a major role in the further development of the pilot plant. For the Swedish Energy Agency, to create a platform for Swedish companies to develop various processes, the sales of which could create jobs in Sweden. For Växjö University the goal is to create new niche research program.

What to commercialize: The lack of interest in DME in Europe in the early 2000 caused us to leave the Bio-DME Project concept, which included the well-to-wheel demonstration of bio-DME, in CHRISGAS. Instead we agreed that CHRISGAS, which only covers the first step of automotive fuel production, would open up possibilities for the marketing of VVBGC as a very flexible research and demonstration plant. The rebuilding of the plant will be done in a way that allows both full- and slip stream use of the synthesis gas for down stream research and pilot demonstrations. Several pilot plants of various kinds could be built at or near the site. This is confusing and requires a prospect for each type of client aimed at their specific, individual interest.

Each CHRISGAS participant has the right to his prior IPR and to the result of his work in the project. The EU rules regarding the use of the results by others are also clearly stated. However, Bioflow claims that they have the rights to anything that is developed in the pilot plant. This is, as I understand it, a major reason that other companies hesitate to invest in the so called "Company A", which will be a co-owner of VVBGC during the CHRISGAS period.

In order to exploit the results from CHRISGAS marketing efforts should be directed to;

- Companies that already have synthesis techniques for fossil synthesis gas and that want to produce bio-versions of their current products.
- Companies that use these fossil-version products as base for their production
- Companies that use these fossil-version products, as is, in their products
- Companies that could use the CHRISGAS type synthesis gas as is

All of these are examples of companies that should have an interest in or could influence the building of biomass gasification plants.

In order to secure the future of VVBGC other, separate marketing activities should be initiated; to financiers, companies wanting to build pilot plants, research institutes and universities, etc. The better result of the VVBGC marketing the greater chance for the individual partners of CHRISGAS to land orders for their technique.

Several companies and institutions have visited VVBGC and its pilot plant, but VVBGC has no capacity to follow-up these contacts. VVBGC has limited my activities to contacts with companies with synthesis techniques – excluding contacts with their end-customers, who could initiate market pull. Local banks, organisations and companies have donated funds for the employment during three years of a qualified marketing person with technical or research background with potential to become director of VVBGC. For VVBGC to survive it is necessary to attract more projects to the pilot plant.

However, since the financing of VVBGC and CHRISGAS is not clear and money from the Swedish Energy Agency only paid out for a few months need at a time the VVBGC management has not deemed it moral to employ a person on such frail grounds. This is very unfortunate since the marketing person could have helped attract companies to "Company A". However, the Swedish Energy Agency has taken it on them to find partners for "Company A" with out the interference of VVBGC. VVBGC is left sitting in the Valley of Death.

Some potential builders of pilot plants have not yet taken decisions because they have no other activity in Sweden. They do not want long transports of synthesis gas or synthesised gas to their premises for tests. The location is thus a problem as well as the pending new co-ownership of VVBGC. The Swedish CHRISGAS companies are much smaller than any of these potential builders of plants.

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Appendices

Appendix 1 DME

DME (Dimethyl ether) is physically similar to LPG (liquefied petroleum gas), currently manufactured from natural gas-derived methanol, but can also be produced from coal or biomass. Besides usage for automotive fuel, DME could also be used in gas turbines for power generation, household purposes (cooking, heating) and as a hydrogen source for fuel cells. DME is also successfully used to replace CFC propellants (International DME Association).

DME prove significant potential for fossil fuel substitution, with almost a 10% ratio in Europe, compared to conventional biofuels (first generation) of approximately 2, 5%. Synthetic diesel covers approximately 7% and ethanol 5%. Furthermore, DME produced from biomass is providing more efficient results in energy output and reduction of green house gas emissions than other fuels derived by current Gas-to-liquid (GTL) or biomass-to liquid (BTL) processes (Murphys et al., 2007). A hybrid vehicle with a DME fuel system leaves a minimally negative influence on climate, where nitrogen oxide could be lowered up to 94% (L.Gårdmark, personal communication, 2007-02-22). However, spite large interest, bio-DME is not currently fully commercialized and available in large scale. According to Lennart Gårdmark, member of the International DME Association, the knowledge about DME's advantage is spread among researchers and specialists, but not in public, where lots of the development is executed within the transport sector (personal communication, 2007-02-22). DME as automotive fuel would require modified vehicles, fuel system, and infrastructure similar to LPG.

In Sweden there are two routes in developing DME from biomass, however two different processes: gasification of black liquor (waste product from paper industry) in CHEMREC, Piteå, and direct gasification of woody biomass in CHRISGAS, Värnamo.

Appendix 2- Hydrogen

Hydrogen is seen as the fuel for the future, due to its good performance. Hydrogen is one of the two elements in water and when hydrogen is used as a fuel, it will only give water/ water steam as emission. Hydrogen is not an energy source but instead an energy carrier, since it require a lot of energy to produce it. Hydrogen can be produced out of great variety of feedstock, everything from water to coal (Hydrogen Fuel). CHRISGAS technology can as well produce a hydrogen rich gas (CHRISGAS).

There are today many different automotive producers that work with research and test production of hydrogen cars. One major limitation is the production of hydrogen, since it so energy consuming. Another negative aspect that hydrogen has is that it is gaseous which requires a special distribution network. The industry is working with hydrogen as the fuel for the future. Still there are quite many years until hydrogen will be the main fuel in the market, but there quite a few tests in the market, for example the 3 hydrogen driven buses in Stockholm (CUTE).

Hydrogen can be used in oil refineries when crude oil is refined to diesel and the quality of the diesel turn out to be very high and with out sulphur (Preem, 2005). Today the hydrogen comes from production out of nature gas (fossil fuel), which is not optimal. According to Sören Eriksson (personal communication, 2007-04-26) the CHRISGAS process would be possible to connect to the refinery and produce the necessary hydrogen, which then would come from a renewable resource instead of a fossil fuel.

Appendix 3- Methanol

Methanol is a liquid in normal temperature and pressure and can easily be blended with petrol. This makes methanol easy to introduce in large quantities rapidly in the current fuel infrastructure. Methanol is today produced from natural gas, but CHRISGAS technology gives the opportunity to produce it out of wooden biomass. A drawback methanol has is the low contain of energy compared to gasoline, approximately half. Possible ways of introducing methanol as motor-fuel

Low blending 3%

High blending 10-20 %

Methanol 85 % (M85)

Pure methanol 100 % (M100)

Low blending in gasoline is no problem for the cars used today. High blending requires dedicated engines or confirmation from engine manufactures that the actual level of methanol level can be used without any risks of damage. Most cars today can technically already use a blending level of 10-15% methanol but as long older cars are in use it is difficult to introduce such a blend. High blending is not permitted in existing regulations and might also lead to increased NOx-emissions. M85 can be used in flexible fuel vehicle and M100 in dedicated conventional engines and fuel cells (BioMeeT II).

Appendix 4– Fischer Tropsch Diesel

FT-diesel is one of the clean fuel options and is also called synthetic diesel or Fischer-Tropsch-Diesel. The fuel can be produced in different ways, one way through Gas-to-liquid (GTL), then nature gas is used and the technology which CHRISGAS use is Biomass-To-Liquid (BTL). When producing FT-Diesel through BTL, there are four steps to go through:

1. Convert biomass into synthesis gas through gasification
2. The synthesis gas has to be purified from sulphur and tar.
3. Convert the clean synthesis gas to a synthetic crude oil through a Fisher-Tropsch-synthesis
4. Convert the synthetic crude oil to a synthetic diesel or NAFTA.

The only step that is not commercial is step number one, and this is the step which project CHRISGAS is working with.

FT-Diesel has some positive aspects, it is free from sulphur and it is directly interchangeable with traditional diesel or to blend with. The synthetic diesel contains a little bit more energy then traditional diesel and therefore the fuel consumption is comparable with traditional diesel (Biofuelregion).

Appendix 5– Partners to CHRISGAS

	Name of Partners	Short Name	Country
1	Växjö University	VXU	Sweden
2	TPS Termiska Processer	TPS	Sweden
3	Kungl.Tekniska Högskolan	KTH	Sweden
4	Pall Schumacher	PSG	Germany
5	Forschungszentrum Jülich	FZI	Germany
6	TK Energi	TKE	Denmark
7	Centro de Investigaciones Energéticas Medioambientales y Tecnológicas	CMA	Spain
8	TU Delft	TUD	Netherlands
9	Valutec	VAL	Finland
10	Växjö Värnamo Biogas Gasification Centre	VVBGC	Sweden
11	Università di Bologna	BOL	Italy
12	Catator	CAT	Sweden
13	S.E.P Scandinavian Energi Project	SEP	Sweden
14	KS Ducente	DUC	Sweden
15	Linde-Linde Engineering Division	LIN	Germany
16	Växjö Energi	VEAB	Sweden
17	Södra	SÖDRA	Sweden
18	Perstorp	PER	Sweden
19	Cornelissen Consulting Services BV	CCS	Netherlands

Appendix 6 Interview Guide

International DME Association (IDA) - Lennart Gårdmark

Broadly focusing on introducing us to the development of DME and its relation to CHRISGAS. Conducted 2007-02-22

Questions:

1) Could you please describe the historical development of DME?
2) What is special about bio-DME?
3) Market potential? Time to market?
4) What is required in terms of distribution infrastructure and modified vehicles?
5) DME from CHRISGAS?

CHRISGAS – Sune Bengtsson

Interview 1
Focusing on CHRISGAS initial discovery and development process. Conducted 2007-04-13

Interview 2
More into depth than Interview 1, further analysing parts of the process, market focus, collaboration and organistation. Conducted 2007-05-08

Questions:

1) Which important stakeholders did you initially identify and brought along (funding agencies, outside partners)? In what way did they contribute?
2) In order to take CHRISGAS further, did you early explore the different uses?
3) Did you involve application development at an early stage? If yes in what way?
4) Did you initially create an action plan that takes into account the uncertainties likely to be encountered?
5) Are you synchronising your technology development with market signals and assuring transition to incorporation in end products at the right time?
6) Have you analyzed the entire business system of the potential applications in order to identify influencing actors?
7) How would you define the market and environment?
8) Have you identified and particularly worked with partners of delivery of technology's full benefit, such as intermediate adopters, manufacturing partners, distributors for promotion, and suppliers of compliments?
9) Have you worked in any particular way to promote adoption? If yes, which groups and how?

10) Have you identified any groups of 'opinion leaders', credible actors influencing adoption? If yes, how have you worked with them?

11) How are you organised? Any particular to facilitate transition?

12) What's the future "home" of the project? (new business, joint venture)?

13) Have you identified or argue for any actor with comparative advantage who could be responsible for finally commercializing the technology?

14) How was it with the financing when Project CHRISGAS started? Was it easy or hard to get?

15) How will you work with IPR management and protection of the technology?

PREEM – Sören Eriksson

Focusing on their development of alternative fuels and potential relation to CHRISGAS. Conducted 2007-04-22

Questions:

1) We are daily confronted with media signals about fuels that will decrease our oil dependence. How would you describe nature of demand for alternative fuels?
2) How do oil companies work with the development of alternative fuels? Are they active/ passive?
3) Do PREEM have any guidelines for investment or involvement of development of new fuels?
4) How do PREEM hypothetically use new technologies, e.g. CHRISGAS?
5) How do PREEM look upon CHRISGAS in investment and collaboration? Why/Why not? What is the main point for final decision?

Volvo – Patrik Klintbom

Focusing on their development within alternative fuels and potential relation to CHRISGAS. Conducted 2007-05-03

Questions:

1) How do you in general work with development of new alternative fuels?

2) How would a commercialization process be outlined from your perspective?

3) Where CHRISGAS is developing the technology for producing DME, we have seen a relation to your company. Could you please tell us more about that?

4) As an 'early adopter', do you find CHRISGAS market focused and keen to early bring the market into the development process?

5) Technology transfer from CHRISGAS, how do you consider it to look like? What could facilitate the process?

6) Hypothetically, Why/Why not attractive to be involved in CHRISGAS?

7) Potential of DME? What is required for you to invest in development of this product?

8) What is required to commercialize DME? Time aspect?

Swedish Energy Agency – Ann Segerborg Fick

Focusing on two perspectives; government work with commercialization, and particularly the project CHRISGAS case. Conducted 2007-05-08

Questions:

1) You write:”*the possibility to commercialization should be considered in all planning of efforts”* on your website. Could you please describe how public projects (like CHRISGAS) are steered to commercialization?

2) *Is* it possible to combine public research with commercialization? Which implications are there?

3) What is significant in commercializing a university steered project?

4) Who is managing project CHRISGAS most actively? Is it the Energy Agency? In which way?

5) Do *you* have contact with external financiers and industry participants who will manage commercialization? How is that working?

6) To which actor/s would it be interesting to transfer the technology of project CHRISGAS for further commercialization?

7) Are there any guidelines for when *you* end to be involved in supporting, for example CHRISGAS?

8) We would like to know the current main focus of project CHRISGAS? What is the next step?

9) In our opinion, which end product proves greatest potential?