CHALMERS
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Biodiesel fuels in Sweden: drivers, barriers, networks and key stakeholders

Challenge Lab 2014: Sustainable Transport and Mobility Solutions

Master's Thesis in Complex Adaptive Systems and Industrial Ecology

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Department of Energy and Environment
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2014

REPORT NO. 2014:06

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The Challenge Lab 2014 takes on biodiesel. Photo "Rapsfeld 2007" by Daniel Schwen is licenced under CC BY-SA 2.5

Reproservice, Chalmers
Gothenburg, Sweden 2014

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Abstract

This thesis consists of two parts. Part I describes the Challenge Lab method, which is a method developed for students to find a thesis research question to support transition into a sustainable society. The Challenge Lab method was carried out by 12 students during Spring 2014 and contains methodologies, tools, perspectives, theories and frameworks for students to work with complex problems related to sustainable development. This years' work include backcasting, self-leadership, multi-level perspective, systems theory, systems transition, design-thinking, etc.

Part II addresses the uncertainties of the barriers and drivers for development, diffusion and use of biodiesel fuel in Sweden and as well as the networks and key stakeholders connected to biodiesel fuels. In Sweden, biodiesel fuels have the biggest market share among the biofuels, 53.4%, but only hold a small market share out of the total vehicle fuels, 4.3% (based on energy content). The aim of this report is to increase awareness and encourage development, diffusion and use of biodiesel fuels (FAME, HVO and DME). The barriers and drivers were identified with the methodology of Functions of Innovation Systems and key stakeholders were identified through Social Network Analysis. The research method was semi-structured interviews with stakeholders as well as literature studies. The the main identified drivers are i) HVO commercialisation and, ii) EU policy on emission standards; and the main identified barriers are i) high production costs of biodiesels compared to fossil diesels, ii) limited state aid (mainly tax exemption) that lacks future oriented vision, iii) low visibility of biodiesels, iv) weak market for biodiesel fuels in a high-blend form, v) petition on regulatory change for HVO, vi) environmental concerns associated with biofuels, vii) feedstock limitations and viii) lack of strong advocacy coalitions. Furthermore, important stakeholders in the Swedish biodiesel market are Preem, Volvo Group and policy makers on national level.

Keywords: DME, FAME, HVO, RME, biodiesel, functions of innovation systems, social networks analysis, technical innovation systems

Acknowledgements

In our endeavours for a sustainable world, the Challenge Lab will hopefully be a small step for mankind towards the goals we are all working for.

Daniella Mendoza is responsible for the parts with Functions of Innovation systems and Cecilia Hult is responsible for the Social network analysis parts. The rest of the report are written jointly.

Thanks

We would like to thank the Challenge Lab participants, for an unforgettable journey. We would also like to thank our examiner John Holmberg, our supervisor Ulrika Lundqvist, our project manager David Andersson and Kamilla Kohn Rådberg. You have all been very helpful in the confusion that follows a pilot project. Finally, we would also like to thank our families, friends and dear ones. Without love and friendship, the world would be a dull place.

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The photo of the wall (figure 6) is printed with the permission of the photographer Olivia Zhiyu Tang.

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Figure 5 is from the article “Backcasting - A Natural Step in Operationalising Sustainable Development” (Holmberg, 1998).

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Introduction

1 Background

Environmental concerns are what worries Swedes the most (Weibull, Oscarsson, and Bergström, 2013). This is not surprising considering the unsustainable world of the 21st century. But sustainability is not only the environmental question of pollution that the Swedes worry about. The Brundtland Commision (Brundtland, 1987) states that sustainable development mean “to meet the need of the present without compromising the ability of future generations to meet their own needs”. Future generations will not only have needs of clean air and water, but also access to good health, education, and shelter from flooding and other natural disasters. Climate change, pollution, social unrest and disease are a few of the world problems that need to be addressed so that the children of tomorrow can have a fulfilling life.

It is only natural that academia and academic scholars take on the challenge of creating a sustainable world. They have the knowledge and the predisposition to seek solutions to complex and complicated problem. However, both the private and the public sectors also face the challenge of building a sustainable society.

The Challenge Lab was created by Chalmers, and amongst others, its vice president for sustainability John Holmberg, as one answer to how to address complex societal challenges. The aims for the Challenge Lab are i) to combine diverse competencies and to bring them together to find innovative solutions to complex problems associated with sustainability and ii) to be a “neutral arena" that brings stakeholders together in dialogue on sustainability topics. Bringing academia, the public and private sector together with students as a common denominator opens up for new and innovative solutions. In the pilot of the Challenge Lab, 12 students at Chalmers wrote their master's theses during Spring 2014 on topics related to sustainability while interacting with both industry and the public sector.

For the pilot run of the Challenge Lab, the targeted subject was transportation in the Gothenburg area. The *Transport and mobility solutions* cluster is one out of five identified knowledge clusters in the Gothenburg region (Andersson, 2013). With two major vehicle manufacturers, the Swedish automotive industry has its headquarters in Gothenburg and the largest port of Scandinavia is the port of Gothenburg. City logistics, safe transport and green transport are other key areas withing the cluster.

However, apart from being a knowledge cluster the transport sector is also responsible for a major part of the greenhouse gas emissions, 33% in Sweden (Naturvårdsverket, 2014) to be precise. The environmental impact of the transport system needs to be reduced and the Swedish target is to make the vehicle fleet fossil independent by 2030 and fossil free by 2050 as stated in the investigation "Fossil free fleet" (Näringsdepartementet, 2013).

Grahn (2009) suggest four main strategies to reduce emissions and one of them is to replace current fossil fuels with low-emitting fuels such as electricity or biofuels from sustainably produced feedstock. Biofuels have the advantage of fully or partially being compatible with the present infrastructure. The car fleet has an average life span of 17 years (Edh, 2014) meaning that substituting fuels in existing vehicle must be a part of the strategy for 2030. The combination of the increasing share of sold diesel-vehicles (Statoil Fuel & Retail, 2013) in Sweden and the large biodiesel share (SPBI, 2012) of sold biofuels make biodiesel an important topic. Even so, there is a lack of research targeting biodiesel specifically and the most common topics are either all biofuels or biogas.

2 Aim and objectives of thesis

The aim of this thesis is to show how students can work interdisciplinary to solve complex sustainability problems together with stakeholders. It is also to increase awareness of the existing biodiesel alternatives and to support the development, diffusion and use of biodiesel fuels.

The objectives for the Challenge Lab in this thesis are i) to describe the Challenge Lab methodology and ii) for students to, by defining a thesis research question, find where and how to intervene in the transport system of Gothenburg in order to make it more sustainable. The defined research question in this thesis deals with the barriers of wide-spread biodiesel use and the stakeholders within biodiesel. The objectives are: i) to identify drivers and barriers for development, diffusion and use of biodiesel fuels, and ii) to identify networks and key stakeholders connected to biodiesel fuels.

3 Scope and limitations of thesis

The thesis does not provide a full theoretical background to all of the components of the Challenge Lab but focuses on the method itself and the tools used. The sustainable transport system is not the global system but restricted to Sweden.

4 Outline of thesis

The thesis is divided into six chapters. Chapter 1 is the Introduction to the thesis (this is Chapter 1). Chapter 2 and 3 can be read independently.

Chapter 2 presents the Challenge Lab (this is most often referred to as phase I), which focuses on the Challenge Lab method concluding in the "master thesis research question". This chapter deals with the concept and content of the Challenge Lab. It describes the Challenge Lab method, which includes a set of methodologies, tools, perspectives, theories and frameworks used for the students as means to deal with complex challenges related to sustainable development, specially the topic of "Sustainable transport system". A part of the results of Chapter 2 (phase I) is the "master's thesis research question" including a description of how the research question was defined.

Chapter 3 presents biodiesels in Sweden (this is the theme in focus of the research question). This chapter includes a description of Swedish situation in regards to biodiesels, and methodologies and results on barriers and drivers and the key stakeholders working with biodiesel.

Chapter 4 discuss the research made on the Challenge Lab (phase I) and biodiesel (phase II). The discussion also leads to some recommendations for further work and actions.

Chapter 5 contains the conclusions on the findings on the Challenge Lab (phase I) and the Swedish situation on biodiesel (phase II).

2

Challenge Lab

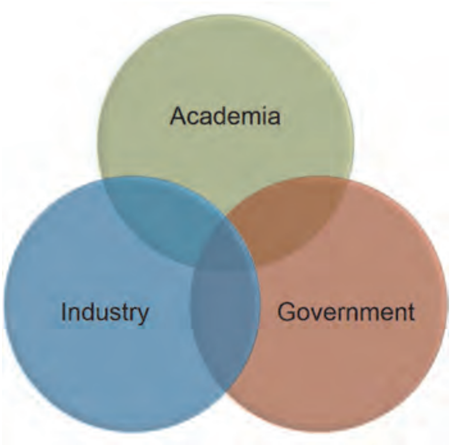
1 Introduction

The Challenge Lab is a master's thesis project carried out at Chalmers University of Technology in Gothenburg with the pilot running during the Spring semester 2014. This chapter will describe the purpose and method of the Challenge Lab and the results from the pilot students.

1.1 Background

Academia, the private and the public sector are three main parts in the society sometimes working together and sometimes not. It is often desired to increase the interaction between the three sectors. Leydesdorff and Etzkowitz (1996) describe the *triple helix* model of university-industry-government relations that is often used to describe the interactions between them (figure 1a). The model rose from economy where focus for a long time has been on the industry-government relationship. Adding the academia as en equal part can be related to the shift from an industrial economy to a knowledge economy, where new forms of working together arise.

Including academia in the triple helix raise new interest in the mission of the academic sector. One model trying to explain the mission of academia is the *knowledge triangle* and it has increasingly gained attention at both national and EU level (Högskoleverket, 2009). The three corners of the knowledge triangle are research, education and innovation, illustrated in figure 1b. The three corners



(a) *The triple helix model describes the three sectors. They intersect both in pairs and all three with each other.*

(b) *The knowledge triangle shows the three corner stones of academia: education, research and innovation.*

Figure 1: *Two models that bring different parts of society and education together(Leydesdorff and Etzkowitz, 1996); (Högskoleverket, 2009).*

have not always been integrated in Swedish universities but there is an increasing ambition to do so (Holmberg, 2014b).

As one initiative working with education, research and innovation, Chalmers started the *Areas of Advance* where the three corners of the knowledge triangle unite. The Areas of Advance span multiple departments, enabling them to work together and meet external stakeholders in one common area. The current areas are: Transport, Energy, Built environment, Life sciences, Nano technology, Materials, Information and Communication Technology, and Production (Holmberg, 2014a).

Whereas the Areas of Advance have to some some extent brought research in multiple departments closer together, not all stages of education are involved. A traditional Chalmers master's thesis is carried out in one of two ways: it is connected to one department or one professor in that department or the thesis can be connected to a company. In the latter case, there is usually a supervisor in that company and an examiner at Chalmers. In both cases, the thesis' objectives can either be given to the student(s) by the supervisor or the student(s) can make their own suggestion of a thesis topic. Either way, the thesis is generally not including all three sectors from the triple helix. In addition, there is also the innovation corner of the knowledge triangle missing in traditional thesis work.

Having identified a lack of innovation and interaction with both public and the private sector, Chalmers decided to take action. John Holmberg, the vice president of sustainability at Chalmers, is one of the initiators of a “living lab” at Chalmers. The living lab consists of student from diverse backgrounds co-working , co-creating and cooperating. It is a collaboration platform where students write a master’s thesis within academia, but also interact with the public and private sector. There are other similar projects around the world, the CityStudio in Canada and Urban Mill in Finland being two examples. Urban Mill started in 2013 as a joint project of Aalto University, a Finnish construction company and the city of Espoo and is currently dealing with urban development (Urban Mill, 2014). The CityStudio is a similar initiative between the city of Vancouver and six higher education institutions in the city (CityStudio, 2014).

One of the main thoughts behind the lab is that students do not represent any interests except curiosity. This gives them the opportunity to get closer to stakeholders without being perceived as a threat or with a hidden agenda. The students’ aim is not only to perform thesis work and to co-create amongst each other but also to work together with outside stakeholders and act as change agents.

The living lab at Chalmers was named the *Challenge Lab* because it focuses on challenge-driven innovation and research. The actual challenge is the challenge of a sustainable society inspired by Chalmers’ vision: *Chalmers for a sustainable future*. Sustainability is one of the most important topics of today and a topic that need to be addressed urgently.

In summary, the Challenge Lab is a new and innovative form of work in academia. The core is challenge-driven research and innovation towards sustainable development. Sustainability is a global systemic issue and one challenge is to understand the system of the planet. Another challenge is how to intervene in the system once it is understood. To meet these challenges, the Challenge Lab method has been developed.

1.2 Aim and objectives

The aims of the Challenge Lab are i) to combine diverse competencies and to bring them together to find innovative solutions to complex problems associated with sustainability and ii) to be a "neutral arena" that brings stakeholders together in dialogue on sustainability topics. The objectives of the Challenge Lab are i) to describe and develop the Challenge Lab methodology and ii) for students to find, by developing a thesis research question, how to contribute towards a sustainable transport system in Gothenburg.

2 Method

The Challenge Lab method contains a set of methodologies, tools, perspectives, theories and frameworks for students to use as "means" to work with complex problems related to sustainable development. The method section describes the Challenge Lab method from the perspective of the students who worked with it during the Challenge Lab pilot in Spring 2014. The set of "means" is referred to as "means-box". Some of the methodologies, tools, perspectives, theories and frameworks were theoretical means to understand the system, while other were practical means to achieve specific objectives. The "means-box" is illustrated in figure 2. This figure maps the set of methodologies, tools, perspectives, theories and frameworks according to how they were used in the Challenge Lab pilot 2014, in spacial and temporal terms and in a practical or theoretical sense. For example, dialogue tools were practical means for the Challenge Lab members to develop effective communication in the group, therefore these tools were used in the "present" (time period) and within the Challenge Lab (spacial scale). The funnel is a framework used to understand global trends, therefore it was used to have a global perspective (spacial scale) or the "past" (time period).

The methodologies, tools, perspectives, theories and frameworks are described further on in each section. Each section includes i) a description of how they could be carried out, ii) a theoretical context and finally, iii) the students' experiences of the tools and frameworks in italic writing to show how the working process of the Challenge Lab looked like during the pilot.

2.1 Overview

The Challenge Lab method is a set of methodologies, tools, perspectives, theories and frameworks divided into five steps (Holmberg, 2014a): Outside-in, inside-out, system theory, system analysis and project formation, all of which can can be seen in figure 3. Both the selection of using the entire Challenge Lab method, the choice of steps in the method and the choice of modules and tools in each step is a choice of method.

The outside-in step aims at giving students an understanding of global challenges through a sustainable development perspective. The system boundaries are wide both in space and time and thus allows for complex challenges to be placed at the heart in search for solutions. In this step, tools such as backcasting, the funnel, the sustainable development criteria and the compass are used.

The inside-out step focuses on the values and visions of the Challenge Lab students. The hypothesis is that by understanding themselves each team member can have a greater understanding of the system. It also aims at evolving the team and providing tools for the students' future work. The step consists of

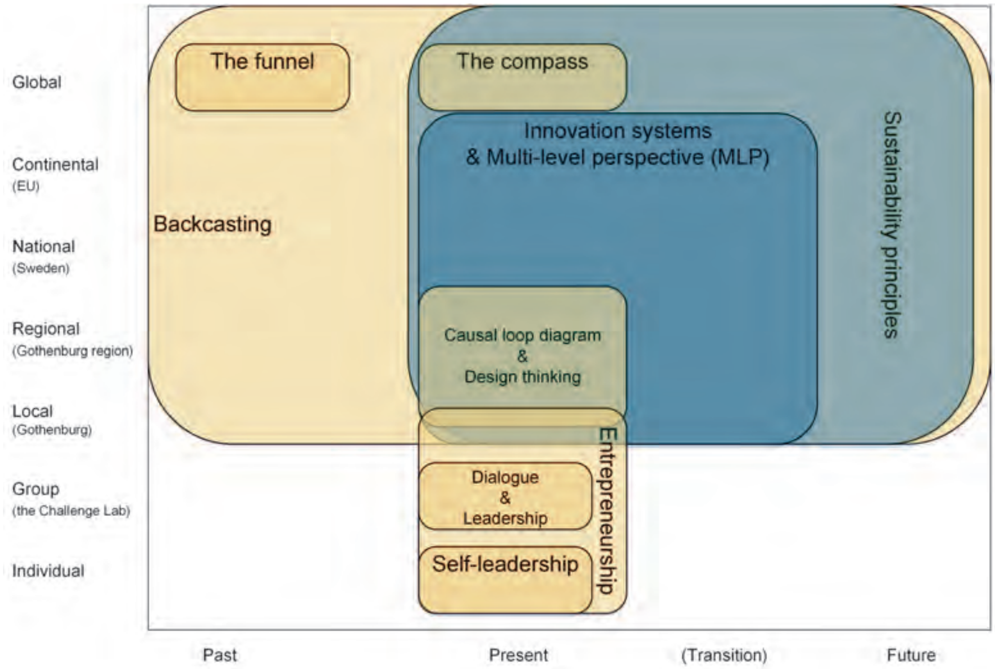


Figure 2: *Means mapped in spacial (y-axis) and time (x-axis) scale, according to how they were used in The Challenge Lab method. Yellow indicate that they were used in a practical form; blue that they were used in a theoretical form.*

three main modules: self-leadership, leadership and dialogue tools.

When both steps have been introduced, different system and transition theories are included. The knowledge aims at helping the students to understand a system with from a scientific perspective. The first of the theories is the multi-level perspective (MLP) with transitions of socio-technical systems from a niche to a regime. The details of the MLP-theory has been described by Geels (2002). The second theory deals with innovation systems.

After having a theoretical background, the students engage in a system analysis where they find hot-spots and leverage points in the chosen system that tells them where to engage. In the system analysis step, instead of using literature studies, stakeholders from many different organisations give their opinion of the topic (i.e. the transport system of Gothenburg). They provide information of hot-spots in the system and areas of interest.

Finally, with the knowledge gained in the previous steps, the students design their projects. The objective is that the projects should evolve using the Challenge Lab method and be based on information from the different steps.

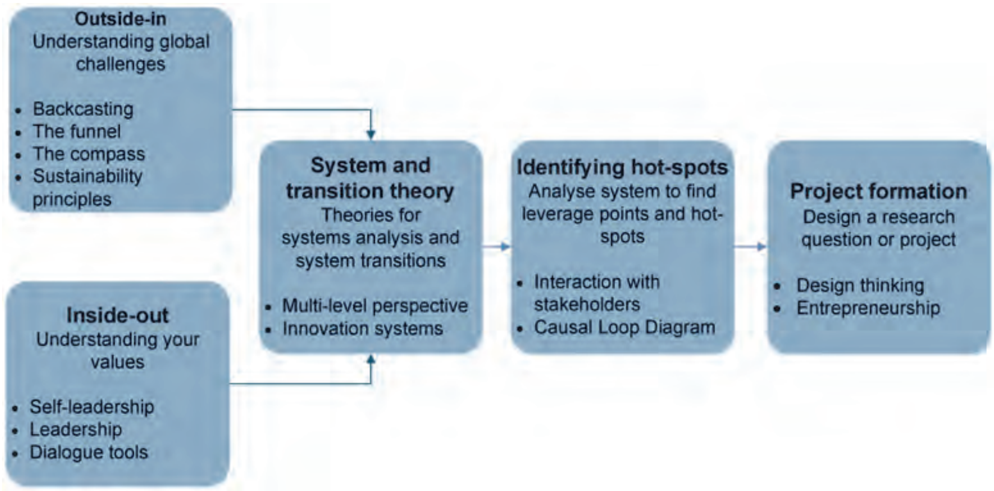


Figure 3: *The Challenge Lab method is a method for working with systems and complex issues, in particular sustainability. Each step in the method has a purpose that is fulfilled by using methodologies, tools, perspectives, theories and frameworks (Holmberg, 2014a).*

With the identified key areas, the main tool used in the projects formation is a design thinking methodology. This is used as a tool to find the right angle of the projects and to make prototypes of the results.

2.2 Outside-in

The outside-in step enables the students to zoom out and have a wider perspective regarding space scales and time periods. During this step, backcasting, the compass, sustainability principles and the funnel are used in order for the for the Challenge Lab students to understand past trends, present challenges and future plans in a scale that goes from global to local (the region of Gothenburg) 4.

Understanding the gap between the current output of the systems and the desired output has to be achieved at a system level. There is a need for fast and wide-spread change in the systems created by man. As Scharmer and Kaufer (2013) put it, human systems are creating results that nobody wants.

2.2.1 Backcasting

Backcasting is a method used for planning towards sustainable development (Holmberg, 1998; Holmberg and Robèrt, 2000). It is applicable when the system

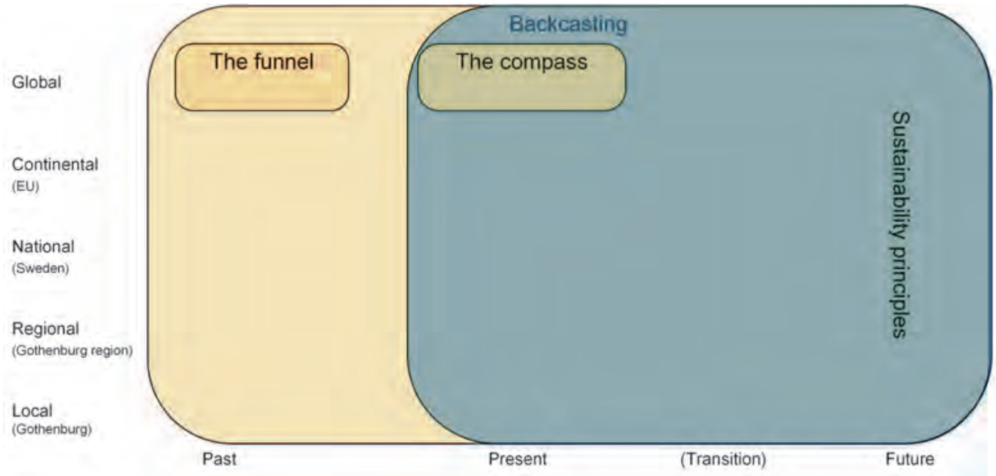


Figure 4: *The set of means in spacial scale (y-axis) and time (x-axis), according to how they were used in The Challenge Lab method. Yellow indicate that they were used in a practical form; blue that they were used in a theoretical form.*

is complex, when current trends are seen as problematic and when there is a need for a big change (Dreborg, 1996). It is an important methodology for the Challenge Lab because of two reasons: i) the system scope is wide (global) and the time horizon is long (> 50 years) and ii) there is need for innovative and creative solutions to current problems to avoid lock-in solutions. The four steps of backcasting are summarised by The Natural Step as (Holmberg, 1998):

Step 1: Define a framework for sustainability
Step 2: Describe the current situation in relation to the framework
Step 3: Envisage a future situation
Step 4: Find strategies for sustainability

and all steps are described in more detail below. The Natural Step version of backcasting can be seen in figure 5.

Backcasting starts by establishing a desired future and aims to find how it can be reached from the present. A point in the future is chosen so that it is sufficiently far away, being relatively independent from the present, thus it presents an alternative to conventional solutions that are usually blocked by current economic, social, technical and organisational structures (Dreborg, 1996). Hence, backasting is a methodology to understand i) the present situation and its main challenges, ii) the desired future by assuming that business as usual is not the path, and iii) the strategies that close the gap between the present situation and the desired future.

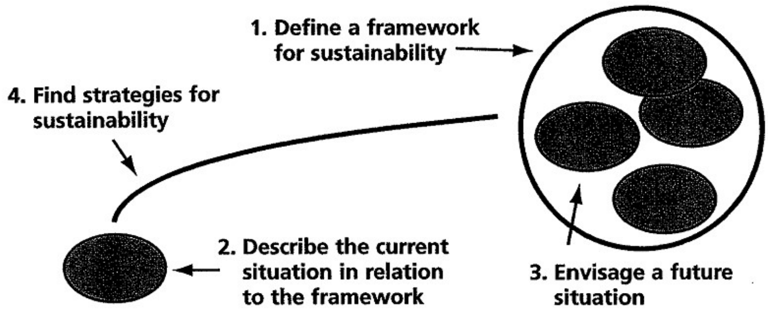


Figure 5: *Backcasting as used by The Natural Step (Holmberg, 1998) describes how to use an envisioned future as a start to set sustainable goals.*

As part of the process we mapped the results on the backcasting module in a "living document" internally called the wall *(figure 6); this as a way for us to all contribute in an orderly manner, keep regularly updated and be able to process a great amount of data. In the first step, we conducted a literature search for a suitable sustainability framework. In the second step, we used the funnel to map the current situation and the compass to find the sustainability challenges. The third and fourth step also consisted of literature studies finding existing goals and strategies for sustainability.*

Figure 6: *The Challenge Lab realisation of backcasting. The figure shows our working environment with* the wall. *To the very right of the wall is the Challenge Lab vision, to the very left is the trends of today. In between, different projects and strategies connected to the transport system are shown.* Photo: Olivia Zhiyu Tang.

Step 1: Framework for sustainability

The selection of a framework for sustainability serves as a benchmark for which future scenarios and strategies are aligned with sustainable development. A sustainability framework can either be developed for a specific situation or chosen from the existing pool.

We did a literature search guided by the Challenge Lab team to find a framework for sustainability that could serve as a benchmark. The framework found was one developed by John Holmberg (Holmberg, Robèrt, and Eriksson, 1996).

Step 2: Current situation in relation to the framework

The present situation is established and possible unsustainable trends are discovered. The description of the current situation can be done using data from primary or secondary sources, while considering the system boundaries previously defined.

The funnel and the compass were two tools employed to describe the "current situation in relation to the framework" (the framework proposed in step 1).

The funnel

The funnel a tool to visualise natural boundaries though the analysis of global trends (Robèrt et al., 1997). A funnel is small device used for fluids, similar like a pipe but with a wide, often conical entrance and a narrow exit. With this picture in mind, it is easier to explain how society once had high supply and low demand on natural resources (wide entrance of the funnel), but as time goes by the supply is decreasing as the demands are increasing (narrow exit of the funnel). Which means that society is "getting deeper into the funnel" where it becomes harder to satisfy human needs and desires. Therefore the funnel works as a metaphor for understanding the physical limits of humans. The funnel analyses global trends in six different areas: energy and material use, economy, population, land, resources and assimilation capacity. The funnel express the global challenges in physical measurements and communicates the results in a visual manner (figure 7).

The six trends all have indicators related to them. *Material and energy use* are understood as the quantity of material and energy (respectively) used to produce goods and services with the ultimate purpose of satisfying human needs. *Economy* can be measured through wealth, which is the value of owned assets. It also indicates the amount of accumulated resources and can be expressed though gross domestic product (GDP), global wealth, etc. *Population* covers the growing world population as well as the balance of where they live. *Land*, water and energy are specially important resources for humanity and the are

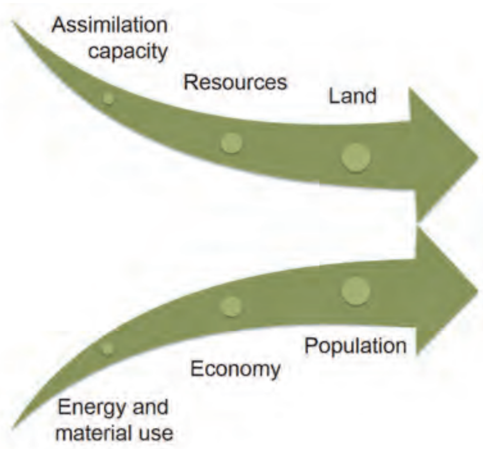


Figure 7: *The funnel is a tool to visualise current trends, where many aspects of the society are growing. At the same time the planetary boundaries puts a limit to the capacity. The combination leaves a constantly decreasing gap (Robèrt et al., 1997).*

highly interconnected (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2013). Other *resources* are oil or metals. *Assimilation capacity* is defined as the capacity of natural systems to absorb, break down, disperse or concentrate materials foreign to nature, including human "waste", at certain concentrations without itself being degraded. Assimilation capacity is limited and if exceeded, its function which is to help support life on earth, can diminish along with other ecosystem services (Cairns, 1999).

In the realisation of the funnel the team was divided into groups of two and each group researched one trend. By literature studies, the trends were put into graphs and attached to the wall where they were a visual reminder of unsustainability.

The compass

The compass is an "indicator tool", inspired by the work of Daly (1973), that evaluates the sustainability performance of a project, business, organisation, etc. according to four areas, one for each of the compass points: North for nature, South for society, East for economy and West for well-being. It is a way to map challenges and indicators of sustainability to the four areas in order to find the area with the most sustainability potential. A representative picture of the compass can be seen in figure 8.

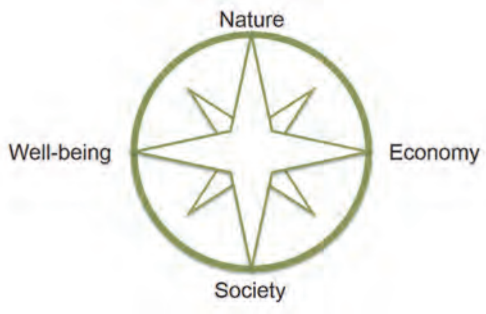


Figure 8: *The compass is a tool that evaluates the sustainability performance of a project, business, organisation, etc. It holds four compass points of sustainability: North for Nature, South for Society, East for Economy and West for Well-being (AtKisson, 2008; Daly, 1973).*

Nature refers to the health and sustainable management of ecosystems, bio-geo-physical cycles and natural resources. *Society* refers to the collective action of people reflected in social systems, structures and institutions. *Economy* refers to systems around the products and services that people want or need. *Well-being* refers to the individual health and happiness of people. In other indicator tools, e.g. the triple bottom line, well-being is considered within the society category. It is considered an individual category in the compass due to the importance of monitoring the health and happiness of people independently of the social collective performance (AtKisson, 2008).

One of the most "advanced process and technical applications" of the compass, as applied by Lee Hatcher and Alan Atkisson (2008), include ten steps. Only one of these steps was used by the Challenge Lab: consulting relevant stakeholders on what they consider challenges and a possible set of indicators related to a sustainability-related goal and vision.

We used the compass, in a partial manner, to map what we considered the main challenges and possible set of indicators related to the transport system in Gothenburg. The exercise began with a brainstorming session where the group wrote down all of the challenges that need to be addressed when designing a sustainable future. Subsequently, we classified each challenge within the four compass points of sustainability. If a challenge was entirely an economical challenge, it was placed to the far east of the compass and if a challenge was only related to society, it was placed far south and so on. Some challenges were naturally not only connected to one of the perspectives and so they were placed somewhere in between. In addition, we performed a brainstorming session for the indicators which were as well classified and mapped according to the four *compass points.*

Step 3: Envisage a future situation

A desired future is painted or envisioned based on the sustainability framework chosen in the first step. The sustainable future is a precondition for finding the strategies that will take us there.

For this step we crafted two visions with different system boundaries. The first was a global, long term vision, the second a vision for sustainable transport in Gothenburg. In this step we used our creativity and inspiration from the sustainable development criteria.

Step 4: Strategies for sustainability

When both the present and the desired future are known, the search for the path between them begins. This path consists of the strategies that need to be implemented in order to reach that desired future. The strategies can either be defined for a specific situation, be taken from a pool of existing strategies or be a combination of both.

When strategies are implemented they must be in line with the socio-economic reality. This means that there must be confirmation that each step is in line with the strategy (Robèrt et al., 2002; Quist and Vergragt, 2004). In other words, if investments are made in the name of "sustainable development" for example, there must be an assurance that there can be future investments that build upon the same strategy (towards the vision) and do not represent a dead-end (Robèrt et al., 2002; Quist and Vergragt, 2004).

Using literature studies, we found transport related strategies at different levels i.e. continental (Europe), national (Sweden), regional (West Sweden) and local (Gothenburg). The strategies were goals, policies and governing documents setting targets for what the policymakers want today. These strategies and goals were also written down and put up on the wall.

We also looked into ongoing activities like projects to see if they were related to sustainability. The projects could be projects at Chalmers, in Gothenburg City or with companies as long as they related to sustainability and transport. The projects were found either by talking to stakeholders or looking at what projects were founded by e.g. Vinnova.

2.3 Inside-out

Inside-out zooms in by putting the individual in focus. This step consists of three modules: self-leadership, leadership and dialogue (figure 9). The purpose of the inside-out step in the Challenge Lab is to enable the students to cooperate in solving complex problems while being pro-active and self-driven change agents towards sustainable development.

Figure 9: *Means mapped in spacial (y-axis) and time (x-axis) scale, according to how they were used in the inside-out step. Yellow indicate that they were used in a practical form.*

Whereas change of systems often is the focus, underneath systems lay people that perpetuate them. For this reason researchers put much interest in the behavioural dimension of change (Scharmer and Kaufer, 2013). Thus it is important to understand human beings; the first step is to understand oneself.

2.3.1 Self-leadership

Self-leadership aims at letting every member understand their goals and values. It is important for the Challenge Lab (and for sustainable development) in order for the students to i) increase self-knowledge at an individual and group level and ii) to become self-driven change agents towards sustainable development.

According to Carstedt (2014) change agents, i.e. pro-active, motivated and active people, are needed to produce change towards a sustainable future. Once people understand themselves, i.e. their own values, strengths and visions and their environment, they can challenge existing mental models and beliefs of how systems work and should work. In order for this to happen, it is valuable for people to be equipped with self-leadership skills.

Leaders are change-agents. A leadership's main function is either to cope with change or to produce change (Kotter, 2001). Goleman (1998) studies identified and grouped common leader's qualities within three groups: emotional intelligence, cognitive abilities and technical skills. Cognitive skills such as analytical reasoning and high IQ, were considered "threshold capabilities" where a certain level should be reached for successful leadership, but a surplus did not add on to leader qualities. These skills were useful for leaders to have a systems perspective and a long term vision. Technical skills like accounting and business planning were only found relevant in leaders with a low hierarchical rank. Emotional intelligence was found to be highly relevant to all levels of leadership: i) self-awareness, ii) self-regulation, iii) motivation, iv) empathy and v) social skill (Goleman, 1998). Self-awareness is the ability to identify ones' own moods, emotions, strengths, weaknesses, needs and drives and to understand how their effect on the environment (Goleman, 1998).

Awareness is the formula for successful change according to an study which was conducted during 18 years on the behavioural dimension of change conducted by Senge and Scharmer (Scharmer and Kaufer, 2013). In their words: "The quality of results produced by any system depends on the quality of awareness from which people in the system operate." Empathy is the ability to understand the emotions of a third person and to treat that person accordingly (Goleman, 1998). Self-regulation is the ability to suspend judgement and to "think before act" (Goleman, 1998).

Scharmer and colleagues (2007), created a framework called U-theory for learning, leading, innovating and profound systemic renewal. The U-shaped five-step journey aims to shift focus from a mode called "the old me-world" where conversation is shallow and listening passive to an operating mode with collective thinking and acting. In the desired operating mode, new ideas are brought forward by aware participants acting from within. The U-journey is visualised in figure 10. The first step is the co-initiating where common grounds are set. The second step is co-sensing where you seek within yourself to find your desires and driving forces. Thirdly, Scharmer uses what he calls "presencing" meaning that with the insights gathered from the previous step, new knowledge emerge. With that knowledge, the fourth step co-creation starts. This is an exploratory phase where, by making prototypes and testing new ideas, new lessons are learnt. The last step is the co-evolving. Here, institutions work together with the new knowledge on how to create a new future.

Intrinsic motivation is the propensity to do an activity with high energy and persistence guided by an internal motivator i.e. pursuing a specific outcome (Goleman, 1998). Extended research show that high (intrinsic) motivation is associated with more engagement, better performance, higher quality learning, achievement beyond expectations, etc. (Goleman, 1998; Ryan and Deci, 2000). Thus a person highly motivated (intrinsically) had the ability to 'take in' a value or regulation (i.e. internalisation) and transform it into its own (i.e. integration). It is also interesting to mention that motivation is enhanced and sustained in social environments that are able to satisfy three innate psychological needs e.g. competence, autonomy and relatedness; and that people will only hols motivation for the activities that truly interests them (Ryan and Deci, 2000).

A last part of leading yourself is to decide where you want to go. There are multiple decision tools but the one presented is here the *six thinking hats* (DeBono, 2000). The six thinking hats aims to prevent discussion from circling

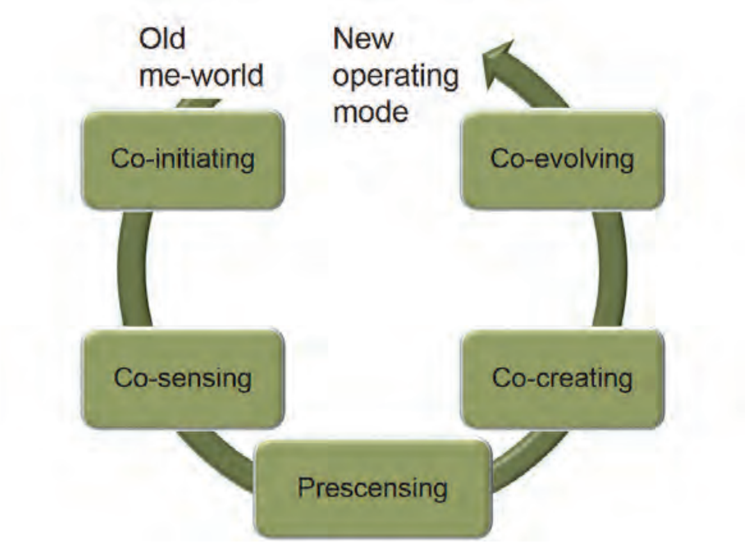


Figure 10: *The U-theory by Scharmer (2007) as an inner process to evolve from a rigid state of mind to an operating modes characterised by collectiveness. This journey is made by first going down inside your mind and to then rise with the new-found knowledge about yourself.*

and coming back to the same arguments over and over again. By using six figurative hats in different colours and letting each hat represent a perspective, an issue can be viewed from each of the different perspectives. Each hat is used for a few minutes each so that all perspectives get represented.

- The *white* stands for information. Here all facts are made clear and the group share common grounds. What do we know?
- The *blue* hat is the managing hat. This hat focus on goals, objectives and strategies. What shall be done next?
- The *yellow* hat is the positive hat focusing on the cons with every suggestion.
- The *black* hat is the negative hat focusing on problems and difficulties.
- The *red* hat is used slightly shorter than the others. That is because it is used for intuition, gut feeling and instinct.
- The *green* hat is the creative hat and while wearing this, the groups should find new ideas and solutions.

DeBono (2000) suggest that the hats should be used during the meeting, but the order of use can vary. What is important is to use the white hat in the beginning and to wait a little with the black hat. By doing this, the ambition is for the group to come to decision faster and with better results.

In the self-leadership module, we experienced a two day process guided by Dominic Martens from SelfLeaders to learn about self-leadership and enhance leadership skills by using knowledge, methods and tools (Martens, 2014). The purpose of this workshop was to understand our values, strengths and goals and to build the team with openness and active listening. We received lectures on three main subjects i) values ii) self-leadership and iii) learning. We focused on activities i) to increase active listening by hearing to personal experiences, ii) balance personal strengths, iii) create a personal vision, iv) increase sensitivity and perceptiveness.

Building trust

During our first day with the self-leadership workshop, we engaged in so called "active listening". Divided into groups of three, one person told stories linked to a value from their life for a total of 20 minutes. Another person listened to the stories and could not speak during the whole time. Instead, he or she should engage in the listening with their mind and body. The third person was the observer who watched the session and at the end shared his or hers reflections with both the story-teller and the listener.

Value mapping

Before the thesis work started, every team member filled out a survey at Value Online where we rated different values. These values were sorted into a meaning map with foundation values, focus values and vision values. As an additional task, each team member picked a handful of these values and wrote them down on a small plastic card. The card was meant to be carried with us every day and every week, one of the values on the card should be a prioritised value.

Decision making

The decision making tool of the Six thinking hats was used in a fictional case of a school board. The school dealt with the problem of students lacking motivation. During this exercise, we learnt the different colours of the hats and set aside a few minutes for each colour.

Strengths

Martens (2014) also introduced a few tools to focus on our strengths with the notion that is more common to focus on weaknesses in everyday life. One tool was a balancing tool. Firstly, we stated our perceived main strength. Secondly, *we exaggerated that strength into a weakness. Then we chose the positive opposite of that weakness. This would then be our complementary strength, i.e. one that would complement ourselves. Finally, exaggerating our complementary strength into a weakness tells us where our challenge is. To gain more of our complementary strength, we should try to cope with the challenge of the negative counterpart.*

The other exercise focusing on strengths was the "hot seat". One person in the group sat in the hot seat while the other people told that person one strength that they thought the sitting person had. The result was that each person heard a number of strengths that others thought he or she possessed.

2.3.2 Leadership

The main theoretical difference between leadership and self-leadership, is that in the former a leader is guided or guides towards a common purpose, while in the later a leader guides itself towards a personal purpose. Leadership is important to the Challenge Lab in order for the students to adopt a common vision for sustainability and collaborate towards it.

Leaders work by i) setting the direction of change through visions and strategies, (ii) gather up people who are aligned with the vision through communication skills and (iii) motivate and inspire people to work towards the vision (Kotter, 2001).

According to Carstedt (2014), everyone need to collaborate towards a common sustainable future in order to reach a sustainable development. For this to happen, it is necessary to have a common vision and coordinated actions. A common mental model (vision, sustainability framework) is the prerequisite to achieve coordinated actions towards a sustainable future, where e.g. professionals, politicians business men and general public are engaged and function effectively together (Robèrt et al., 1997).

Moreover, Wendelheim (1997) found that in order for people to collaborate there needs to be trust. As he puts it: "if a group wants to solve a complex task, there must be trust within the group otherwise they will fall back to an easier task". Good communication, in the form of openness, active listening and dialogue is a prerequisite to build trust in a groups (Isaacs, 1999).

During the leadership module we took a passive role, the role of the followers guided towards a common purpose of a sustainable future. We received a speech on sustainable leadership from Göran Carstedt who has a long experience of leading positions in international organisations such as Volvo, IKEA, Clinton Climate Initiative, the Natural Step and The Society for Organisational Learning. He is considered an expert on leadership, organisational learning and change *as well as an acclaimed speech giver. Furthermore, in regards to sustainability he is considered to have a "rigorous logic and science with an unparallelled understanding and feel for people's inner needs and motivation." (Talarforum Scandinavia AB, 2014).*

2.3.3 Dialouge

Dialogue is the art of thinking together by agreeing to disagree. This is how Isaacs (1999) defines dialogue. Debate, discussion and dialogue are three wordsoften used in the same context without any distinction. The fact is that the three ways of communicating fulfil distinct purposes and should be used in different ways. Whereas debate aims at smothering the opponent by "bombarding" them with arguments, dialogue aims at creating understanding and find solutions while listening to all partners. Discussion lies in between where each participant speaks for their viewpoint, but without the purpose of defeating the opponent. The dialogue module is meant to improve stakeholder interaction and also to enhance communication within the group.

Dialogue as a tool for collaboration is described by Sandow and Allen (2005). The understanding created by dialogue begins by listening and Sandow points out that shared knowledge is created by dialogue and listening is the beginning of dialogue. Interruption is hindering the speaker in communicating and should subsequently be avoided. In order to create room for qualitative dialogue it is also important with time, or rather the experience of time, as this helps creating a listening atmosphere. Sandow also mentions the value of trust. He claims that trust is a reinforcing circle where trust leads to collaboration, collaboration leads to listening, listening leads to understanding and understanding leads to trust. He concludes that successful organisations are those that manage their human capital and those who succeed in creating a collaborative environment.

Dialogue was learnt in sessions with Martin Sande from Preera. A full day or half a day of dialogue was scheduled at intervals during the Spring. Each session started with a check-in and then different themes were addressed during the sessions. Some of the tools were later used in our dialogue with stakeholders. Two of the tools discussed were the 5R-model and the circle/triangle time.

5R model

Preera's (Sande, 2014) 5R-model contains five prerequisites for a successful dialogue: The Room, Relations, Roles and Routines of a dialogue session are essential for constructive Results. A summary can be seen in figure 11.

The *room* should have no hierarchy in the seating which could be obtained by sitting in a circle so that everyone sits eye to eye. The meeting should start

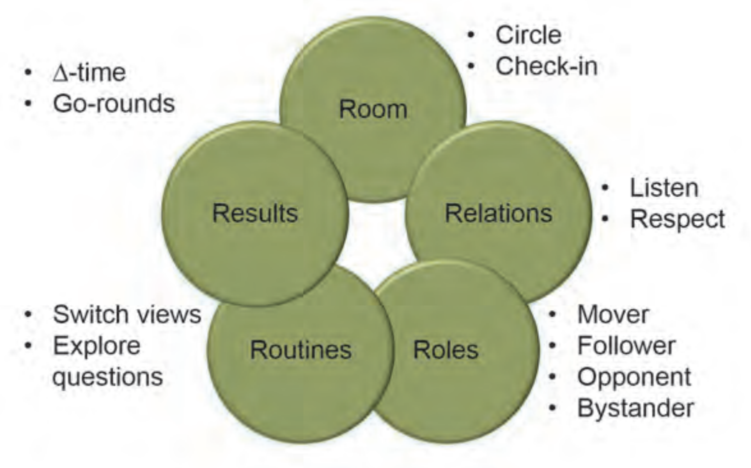


Figure 11: *Model by Sande (2014) for facilitating good dialogue. The* room *should be adapted for the dialogue and the* relationships *should be carefully established. If not all* roles *in the dialogue are filled, a facilitator could take the missing role.* Routines *should include actively switching viewpoints as well as trying to use exploratory language. Finally, by switching to decision mode, or* triangle time*,* results *can be reached.*

with a check-in so that everyone speaks out at least once before the meeting agenda starts and also finish with a check-out so that there is a proper closure to the meeting.

The *relationships* in the meeting should be characterised by respect. The balance between exploring others' views and advocating your own is important to keep.

There are established *roles* in a dialogue. As a facilitator, it is important to be aware of these so that the facilitator can take a missing role. The roles are the "mover" who pushes the dialogue forward, the "follower" who compliment the mover and support him or her. The "opponent" challenge the meeting with questions and corrections. Finally, the "bystander" listens and supply additional perspectives.

Routines for dialogue include check-in and check-out sessions that are important to make all participants feel listened to. As Sandow and Allen (2005) states, the experience of being listened to is essential for a good dialogue session. The trust is gained by the set-up of the meeting, with an effort to reduce hierarchies and the roles of the meeting participant creating a balanced meeting. All of this will help creating *results*.

Triangle/circle time

Another tool used in the dialogue process is to divide time between *triangle time* and *circle time*. The triangle/circle time tool is used to keep the balance of respect and listening while handling the need for progression and decisions. An illustration of the two types of time and the difference between them can be seen in figure 12.

Figure 12: *Model by Sande (2014) for division of time between* circle time *and* triangle time*. The purpose is to facilitate dialogue and to make sure that they both lead somewhere (taking decisions) and that the group is thinking together (communicating).*

In circle time, everyone is allowed to present their opinion and talk without judgement. Decisions are made in triangle time where the group are allowed to come to conclusions and set the way forward.

2.4 System theory

Within the interdisciplinary study of systems and their dynamic, exists many different theories and approaches. Innovation systems and Multi-level perspective were used by the Challenge Lab students in order to understand systems and system transition 13

2.4.1 Innovation systems

Innovation systems can be defined as "all important economic, social, political, organisational, and other factors that influence the development, diffusion,

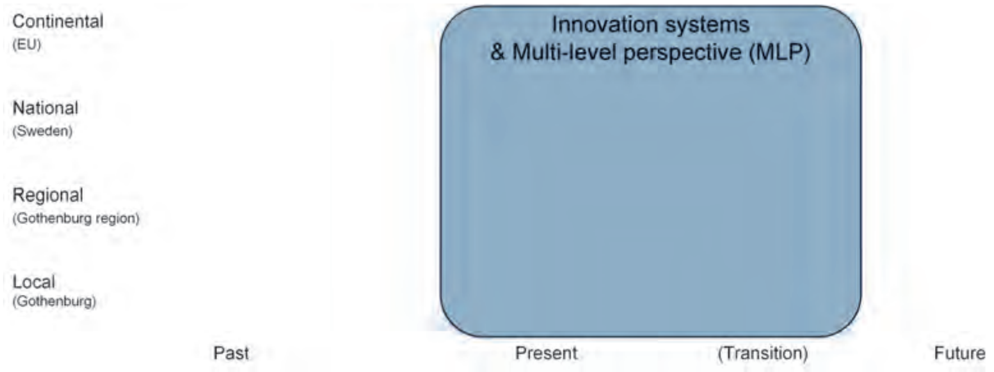


Figure 13: *Means mapped in spacial (y-axis) and time (x-axis) scale, according to how they were used in the system and transition theory step. Yellow indicate that they were used in a practical form; blue that they were used in a theoretical form.*

and use of innovations" (Edquist, 1997). As the Challenge Lab is looking for innovative solutions, innovation systems can be one way to understand innovation.

Innovations are universally recognised as the main cause of economic growth and a source of new employment. It was later recognised that innovations also are important means to generate environmental improvements (Foxon et al., 2005; Edquist, 1997). In general terms, innovations are creations of economic significance that either focus on a new process or a new product i.e. goods or services. The process can undertake either a technological and/or an organisational innovation. It is most common that "innovation systems" focus on technological innovations, therefore focusing on technological change rather than the broader concept of innovation (Edquist, 2001). Innovation systems can be categorized into technological innovation systems, national innovation systems, regional innovation systems, local innovation systems and sectoral innovation systems.

The process through which technological innovations emerge is complex. It is not influenced by one isolated organisation but rather by many interacting factors in a time consuming process. In fact, relations between many different actors is important for having a flow of knowledge, information and technology that in turn leads to innovative ideas. Therefore, in order to understand and perhaps influence innovation processes it is important to undertake a systems perspective (Edquist, 1997).

A system is made up of components, relationships and attributes. *Components* operate the system i.e. actors, organisations, institutions and technological artifacts. *Relationships* are links between the components. These are important because the system is more than the sum of the parts (Blanchard and Fabrycky, 1990 as cited in (Carlsson et al., 2002)). *Attributes* are the properties of the system which are crucial for its understanding. These can be related to the function or purpose of the system. “The function of an innovation system is to generate, diffuse, and utilise technology” (Carlsson et al., 2002).

2.4.2 Multi-level perspective

The multi-level perspective (MPL) explains technology transitions as an interaction between micro, meso and macro levels. This relates to the ability to zoom in and out in scale and address global challenges as well as local ones.

In MPL as described by F. Geels (2002), there exists three levels: the landscape, regime and niches.

Landscape consists of the structures in society. It can be economic structures, cultural values, environmental issues or legislation. The common characteristic are that they are external factors acting outside the technology.

The *regime* is the same as the dominant technology. There are many regimes coexisting and together they make up a patchwork or regimes. Dominant designs could be the combustion engine car as a mean of transport, televisions for entertainment or the shape of the electrical plug. The regimes are characterised by incremental improvement and the lack or revolutionary steps

Niches are small technologies that are in some way innovative or novel. They are the seed of technology transitions because they exist within the context of landscape and regimes. If the landscape is right a niche can rise to become a regime and either replace an existing one or add to the patchwork or regimes. Of course, there are also niches that will never become a regime.

The core of MPL is the interaction between the landscape, regimes and niches. It is changes in the landscape that affect the development in the regimes, but also niches pushing from below induce changes in the regimes. The competition with niches is important for the development of the regimes, something that has been apparent many times in history: all from the development of sailing ships in the 20th century to efficiency improvement of combustion engines in the 21st century.

2.5 Identifying hot-spots

Systems and system analysis is a field where the concept of *levarage points* are well known. These points are considered to be sensitive areas in a system where a small applied force can make a big change of the system (Meadows, 1997). With knowledge about general challenge and a theoretical background to system and transition theory, the fourth step in the Challenge Lab method is identifying hot-spot in the system. The hypothesis is that if the students can identify these leverage points, they can induce change in the system. Interaction with stakeholders and Causal loop-diagram were means for the Challenge Lab students to find the "hot-spots" (figure14).

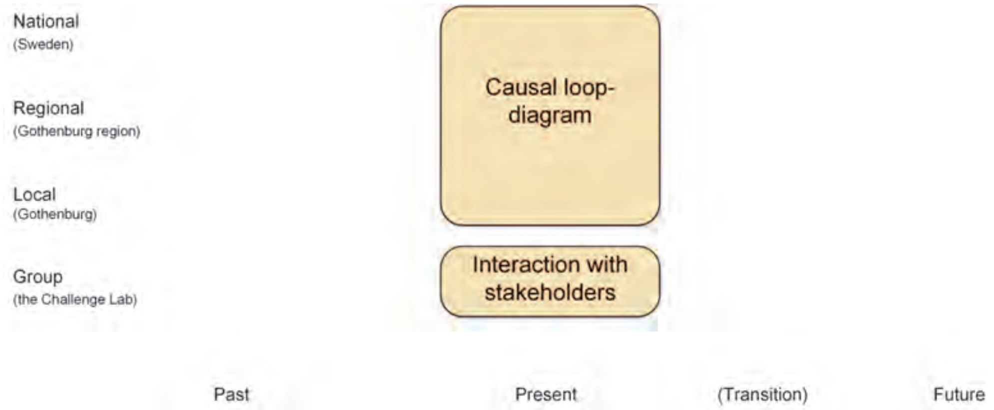


Figure 14: *Means mapped in spacial (y-axis) and time (x-axis) scale, according to how they were used in the step of identifying hot-spots. Yellow indicate that they were used in a practical form; blue that they were used in a theoretical form.*

2.5.1 Interaction with stakeholders

Stakeholders have knowledge about the system. With this assumption, there should be interaction between the students in the Challenge Lab and stakeholders for the students to gain first hand information and experience about the system. The exchange of information is done in a number of ways: personal communication, literature studies, written work or maybe creative collaborations. The main point is that the students have the opportunity to probe stakeholders and gain insights about the system.

It is preferable if the stakeholders hold a strategic position within their organisation as there are informal structures governing what the stakeholders know. As one of the Challenge Lab objectives are that the students should not represent any interests, representatives from diverse areas should be considered. There are the sectoral division of private, public and academia, but also the division of driving forces governing the interests of the stakeholders. There can also be a point to interact with multiple individuals within the same organisation, as they can have different viewpoints and access to information.

Stakeholder management is a growing field in environmental sciences connected to a growing insight of how stakeholders affect policy-making and environmental strategies. Stakeholders can be companies, institutions, governmental agencies etc. They work together and form a web of intertwined interests. In addition, there are also results that points out that there are internal networks within organisations as well as between stakeholders (Sandow and Allen, 2005).

Sandow also presents a perspective where individuals are the focus. He uses a network model with the individuals in an organisation to prove how an organisations is built up. The result is a system within the organisation where information is transferred in social collaborations. A stakeholder organisation does not only exist on its own but is dependent on its relations with other.

Taking the perspective of a system analyst, Meadows (1997) ivestigate a system and where to find the most effective point of intervention. Meadows also mention the flow of information as a medium-high effective point of intervention. Combining this with the social collaboration theory of Sandow this indicates that stakeholders and individuals can have a central position in a network and hence be a leverage point.

In the Challenge Lab 2014, most of the stakeholder interaction took place in the office at Chalmers Lindholmen. Multiple stakeholders were invited to give their perspectives on the current topic, in this case the transport system of Gothenburg. The invited stakeholders held strategic positions within their organisations and added an overview perspective. In general, the stakeholder sessions began with a presentation by the stakeholder and ended with a mix of a question/answer and a discussion session where the students posed questions to the stakeholders. A typical meeting would be 1-2 hours.

Trying to keep a balance of interest, stakeholders were invited from academia, the public and the private sector.

Academia was represented by the Transport Area of Advance and its vice president Magnus Blinge, Maria Grahn talking on biofuels and Björn Sandén talking about transition of socio-technical systems and MLP. The latter two work at the Energy and environment department at Chalmers. Frances Sprei also works at the department of Energy and environment but spoke mostly of the Fossil free fleet-investigation (the FFF).

The public sector stakeholders were Sofia Hellberg (Trafikkontoret) and Pernilla Hellström (Miljöförvaltningen) representing the municipal level. Hans Fogelberg, Västra Götalandsregionen and Jörn Bergström, Kollektivtrafiksekreteriatet both work at the regional level in Västra Götaland. Mats Rydehell, Innovationskontor Väst was also invited to speak about the transport system in general with focus on public strategies. The chairman of the FFF-investigation, *Thomas B. Johansson visited the Challenge Lab for a lunch where the students could discuss the FFF-results.*

The private sector was mainly represented by Axel Edh from Volvo Cars, but also by Sunfleet founder Per Lanevik. Axel presented the environmental work of Volvo Cars and Per shared his story of being an environmentally aware entrepreneur in the transport related area of carpooling.

2.5.2 Causal Loop Diagram

Causal Loop Diagram (CLD) is used to connect entities, or *variables*, in a system and quantify or qualify how they relate to each other. CLD can be used as a tool to identify the critical factors in a system. Before starting the CLD-analysis, there are a few things that should be declared. The first is to set a goal of the analysis: what is it that you want to investigate. The second are the system boundaries, i.e. what to include and what not to include in the system. The purpose of the boundaries is to make the system meaningful so that an analysis of the system can answer your question. If you want to investigate how a person moves in a kitchen in order to optimise the number of steps, the number of spotlights in the ceiling is probably not a useful variable. There is not one recipe for constructing a CLD, but Haraldsson (2000) suggest the following approach:

1. Define variables that can be measured and that can increase or decrease.
2. Find units for the variables found in step 1.
3. Phrase the variables so that the positive is the + and the negative the -, e.g. avoid "war is increasing" but rather use "peace is increasing".
4. Just state the relations and do not analyse loops just yet. Loops can be open as well as feedback loops.

When the CLD has been constructed, it is time to test the hypothesis. By increasing or decreasing a variable it is easy to follow the system and see what happens to the other variables. Making a rough draft of +/- links is a good way to get a grasp of the system. To quantify the links, it might be easier to use a system analysis software.

The basics of CLD is the existence of relations, dependencies and *feedback loops*. A feedback loop can either be reinforcing or balancing. The reinforcing or positive feed-back loop is a prerequisite for an avalanche where a variable grows and grows until it reaches some limit. The balancing or negative feedback loop act against any changes to the variable. The result is that negative feedback loops maintain an equilibrium state of the system and positive feedback loops pushes the system away from an equilibrium.

In the Challenge Lab, we used a heavily modified version of CLD. Instead of using the CLD to answer a question, we used it as an exploratory tool.

First, we had a brainstorming session during which we came up with possible variables that could affect the transport system. Secondly, we grouped the variables together and label the groups in some way. Examples of groups were "Technology", "Behavioural" or "Economy". We also considered drawing the links, but had to stop before doing so due to time restrictions.

2.6 Project formation

One of the objectives of the Challenge Lab method is to find a research question connected to the topic at hand and to sustainability. To ensure that the research question is relevant and well formulated, attention should be paid to the process of developing the research project. Design thinking and entrepreneurship were means for the students at the Challenge Lab to start the design the research question and the thesis project 15.

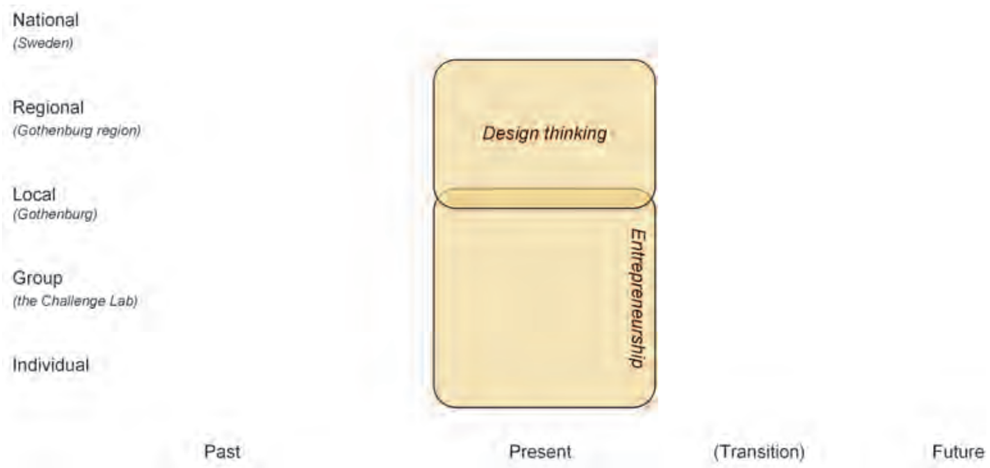


Figure 15: *Means mapped in spacial (y-axis) and time (x-axis) scale, according to how they were used in the project formation step. Yellow indicate that they were used in a practical form; blue that they were used in a theoretical form.*

2.6.1 Design thinking

A design thinking and multi-level design methodology has been developed for the Challenge Lab (figure 16) (Söderberg, 2014). The methodology is used as a tool to analyse the projects' problem situations. All the steps can be seen in the upper part of the figure.

The first step is to describe the challenge by writing a problem description where the problem is phrased. The second step is to draw the system boundaries

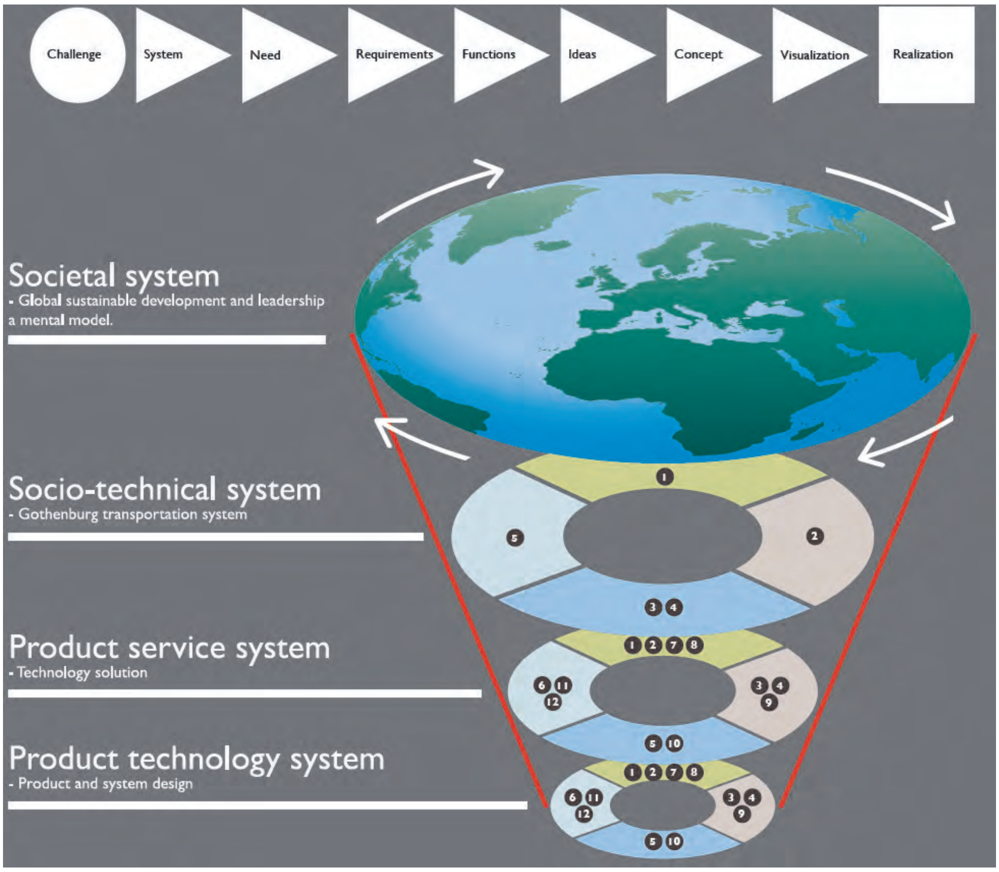


Figure 16: *A schematic overview of the design methodology adapted to the Challenge Lab. The multilevel design model is based on the works by Joore (2010) and describe the levels where a product interact. The working process consists of many steps using design thinking.*

and set limitations for what to include and what not to include in the system. Subsequently, the need and requirements that has to be met for the project are investigated. Based on the presumed users and aspects such as "economy" or "environment", requirement are listed for the project. Looking at the functions of the project, the project idea is formulated and a prototype of the results are made. The prototyped results could be anything from a start-up to a framework for decision making.

The four levels in the multi-level design methodology are inspired by product design. Joore (2010) connects the art of designing a product with socio-technical systems and system innovation. New products are not designed in a stand-alone context but rather interacting with the surrounding socio-technical systems. With this insight Joore develops the "multi-level design model" with four aggregation levels, each representing a function of the product in interaction with other product or services at the same aggregation level. The aggregation levels are the societal systems, socio-technical systems, product-service systems and product-technology systems. The choice of four aggregation levels is a deliberate choice and other design methodologies used fewer or more levels.

The upper societal system level deals with global sustainability, cultural values and a description of the current society.

At the socio-technical system level the dominant framework is set. Values are considered fixed and proposed changes to the system concerns technical system solution interacting with the existing social system.

The product-service level mainly considers the functions of the existing technical systems. New ways to fulfil these functions can be proposed at this level and the changes could either be of services and how they can fill a function or a new product to fill the function.

Finally, at the product-technology level, the technology is considered to be fix. Improvements can be made to existing technology and the analysis focuses on operational problems and incremental development. Joore (2010) concludes that his new model can be seen as a "tentative theory" which can be applied to problem situations. The theory is used to formulate hypothesises that can be tested on the problem situation.

In our process, we followed the first half of the working process depicted in figure 16. Each group wrote a problem description and identified users, needs and functions for their projects. We did not however prototype the results. The design thinking module was started after all the stakeholder meetings were finished and we had started moving into the second phase.

2.6.2 Entrepreneurship

Entrepreneurship is about finding customer and business opportunities. As a preparation for future interaction with stakeholders, an entrepreneurship module is part of the Challenge Lab. Since the thesis projects are developed during the process it is very well possible that a project could end up in an business opportunity. Besides being useful for potential start-ups, Lundqvist (2014) also mentions that the Challenge Lab participant are selling the vision of a sustainable society. Therefore, an entrepreneurial way of thinking can be a useful tool for the Challenge Lab.

Lundqvist (2013) presents the "Packaging approach" for idea evaluation as a toolbox for package and communicating business ideas. A business opportunity in general need financing, support and maybe other collaborations and hence presentation of the idea is essential. The key point is to keep the information short suggesting a seven page report and a presentation for packaging the idea. But before presenting the idea, it has to be evaluated to see if it is worth presenting.

An idea can be evaluated in a 3D utility space, where societal utility, business utility and customer utility all have to be positive. *Societal utility* measures societal values such as safety, health, environmental use, etc and applies not only to intended customers or users but to all people on the planet. To determine the societal utility, known methods such as backcasting can be used. *Business utility* is in brief a question of whether or not one can make money from the idea. Although entrepreneurship could be social as well as economic the business utility is a requirement for investment in the idea. If the investment is monetary, the payback is probably also and the business must have a potential of making money. Finally, the *customer utility* is according to Lundqvist the most important aspect. The most apparent customer is the customer paying for the service or product, but "customer" could be extended to include people affected by the product. In the public sector, the customers are generally not paying for the specific service (roads, hospitals, etc.) but still use it. In short, the customer must have some need satisfied by the product for the product to have a customer utility.

The entrepreneurship module was relatively small and consisted of a half-day lecture with Mats Lundqvist. In preparation, we also did some reading (Lundqvist, 2013).

3 Results

The results from the work in Challenge Lab take varying forms: literature research, visual results from tools used, ideas that emerged during the process, information from stakeholders, among others.

3.1 Outside-in

The main finding relates to the steps of backcasting. They include the chosen framework for sustainablity, a description of the present situation via the funnel and strategies that different institutions in society have decided upon.

3.1.1 Step 1: Framework for sustainability

The system principles, also often referred to as the "four system conditions"(Holmberg, 1996), selected from a literature study are presented below. The sustainability principles serve as guidelines for every person who wants ask relevant questions related to sustainable development.

Principle 1: "Substances extracted from the lithosphere must not systematically accumulate in the ecosphere"

Principle 2: "Society-produced substances must not systematically accumulate in the ecosphere"

Principle 3: "The physical conditions for the production and diversity within the ecospehere must not be systematically deteriorated"

Principle 4: "The use of resources must be efficient and just with respect to meeting human needs".

The system principles, which are system requirements or restrictions, hold the potential of being a shared mental model that serves as a guide towards sustainable development. Because they are general principles rather than detailed guidelines they can focuses on the essential things, they are "more engaging and easier to reach consensus on" (Robèrt et al., 1997). They are based on a scientifically based view of the world and on the common definition for sustainable development. Sustainable development means "to meet the needs of the present without compromising the ability of future generations to meet their own needs" as stated in the World Commission on Environment and Development (Brundtland, 1987) also known as the Brundtland Commission. The word sustainable contain respect for inter-generational equity, dynamic systems equilibrium, and the maintenance of the adaptive capability. Development, on the other hand makes reference to the creation of possibilities and opportunities (Holling, 2001). The sustainability principles can be implemented at all scales and within the current economic reality. They acknowledge that environmental problems originate from society and thus focus on the cause of the problem i.e. society, rather than the consequences such as environmental problems. They do not assume that individuals will act against their self-interest and they are easy-to-understand principles and simple to disseminate (Robèrt et al., 1997).

Step 2: Current situation in relation to the framework

The funnel shows dominant trends of the current situation and the compass indicates where the sustainability issues lie.

The funnel

One representative graph for every trend (population, economy etc.) is presented here. Overall, growth has been a common theme during the 20th century and some of the trends predict a continuous growth even in the future.

Population

According to the United Nations' estimate of the current and future population, the world population is growing although the growth is slowing down (figure 17). In 1950, there were just over 2 billion people on the planet, today, in year 2014 there are about 7 billion. In the future, we will be even more with an estimated population of nearly 10 billion people in 2050. The estimates are based on the medium fertility dataset (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2013) meaning that there are slightly more people born than dying.

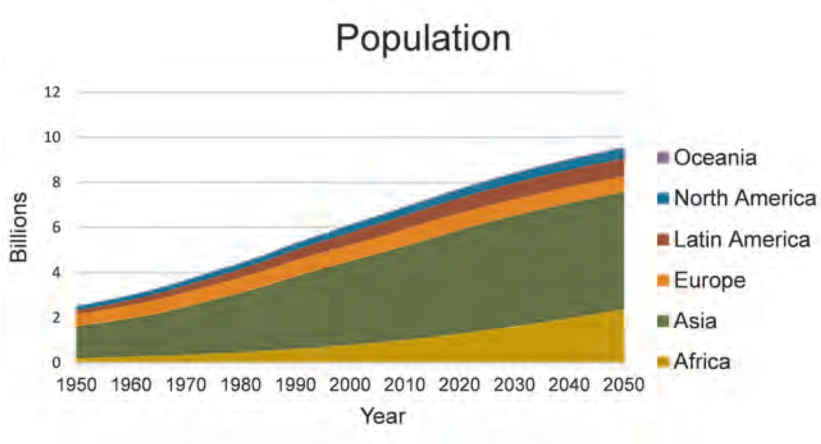


Figure 17: *The world population is growing and is estimated to reach nearly 10 billion by 2050 (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2013).*

Economy

Wealth tends to increase through time due to the economic structure where economies aim at a percentage of growth. Economic growth is a major EU policy objective (Commission of the European Communities, 2005) but other parts of the world are also growing economies. This can be seen in figure 18 which shows the GDP for different regions of the world over time.

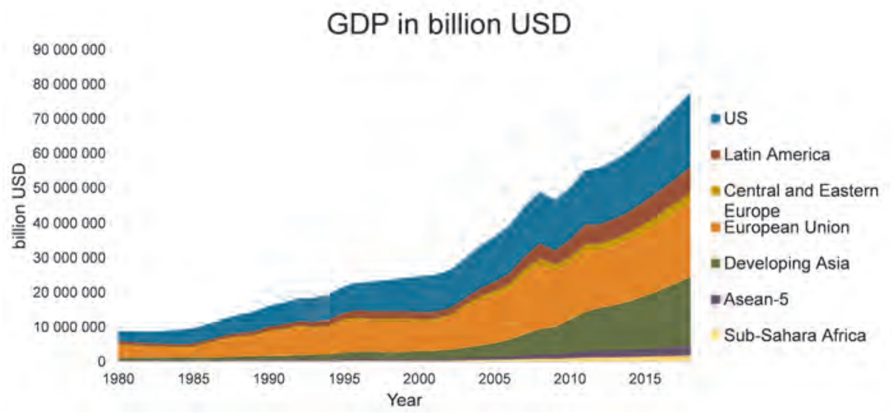


Figure 18: *GDP by regions and time (International Monetary Fund, 2013).*

Material and energy use

Focusing on energy use, the energy intensity increased between 1980 to 2010 in 28 OECD-countries out of 30, according to a study done by Liddle (2012). This can be seen as an example of a worldwide trend shown in figure 19, where the primary energy use between 1965 and 2012 har increased in all parts of the world (p.l.c, 2013).

Resources

Natural resources are increasingly extracted and transformed thus altering the concentration and structure of matter. In the energy sector a good example of how resources are getting scarcer is seen in the analysis of oil trends. The world energy use in the transport sector comes almost entirely from oil (International Energy Agency, 2008). Although there are enough remaining proven reserves of oil and natural gas liquids (NGLs) (about 1.2 to 1.3 billion barrels) to supply the world for a range of 40 to 45 more years considering the consumption rates of 2008; it is evident (figure 20) that volume of production has surpassed the volume of discoveries (International Energy Agency, 2008)

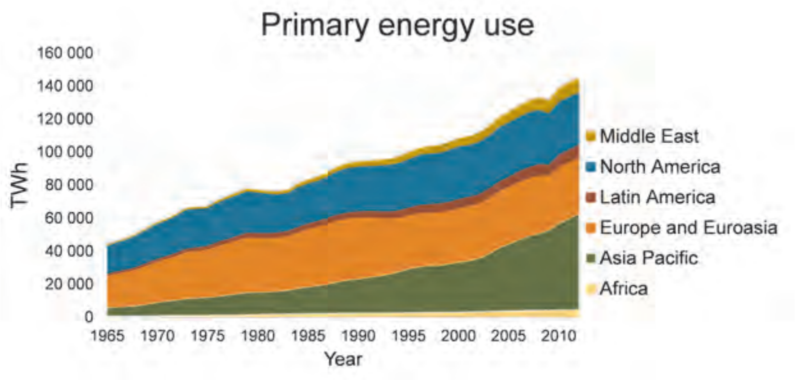


Figure 19: *Primary energy use in the world (p.l.c, 2013).*

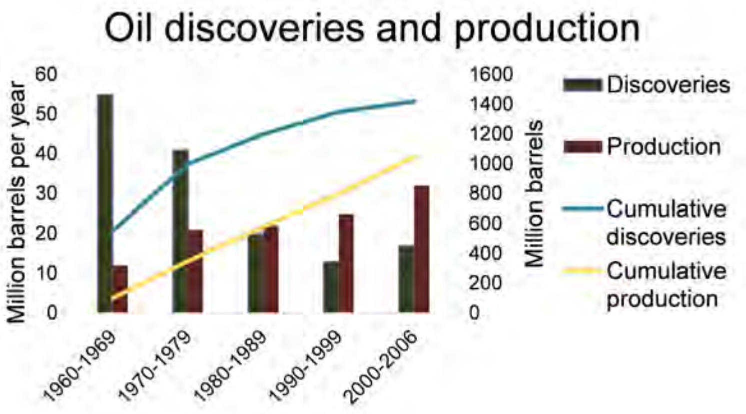


Figure 20: *Oil discoveries and production from 1960 to 2006, showing that in recent years the volume of oil production surpassed the volume of oil discoveries (International Energy Agency, 2008)*

Land area

The planet Earth is limited in space with a total land area of 149 million km^2 (Central Intelligence Agency, 2013). Hooke, Martín-Duque, and Pedraza (2012) describes how the ice-free land area is used at present day (numbers for 2007). Figure 21 shows that about half is land that has been directly modified by man and half is natural land. The numbers are modest approximations and the real impact by man might be larger due to second-hand impact following building or a few transformations that are not included (coastal modification, wind plants or power grids). Out of the 46.5% natural land, 18.7% is land that are mostly unsuitable for agriculture. This includes mountainous areas, arid regions and tundra. Left untouched is 27.8% of natural forest. Cropland is land where food or goods are grown. Permanent meadows are uncultivated land, used for e.g. pasture. Eroded sediment areal is where sediment from man-made activities has been deposited. Land marked as "logging operations" are areas near forests (natural or planted) that have been affected by the logging activity. In total, about two thirds of the useful land available have been modified by humans, and the last third consists of e.g. rainforest.

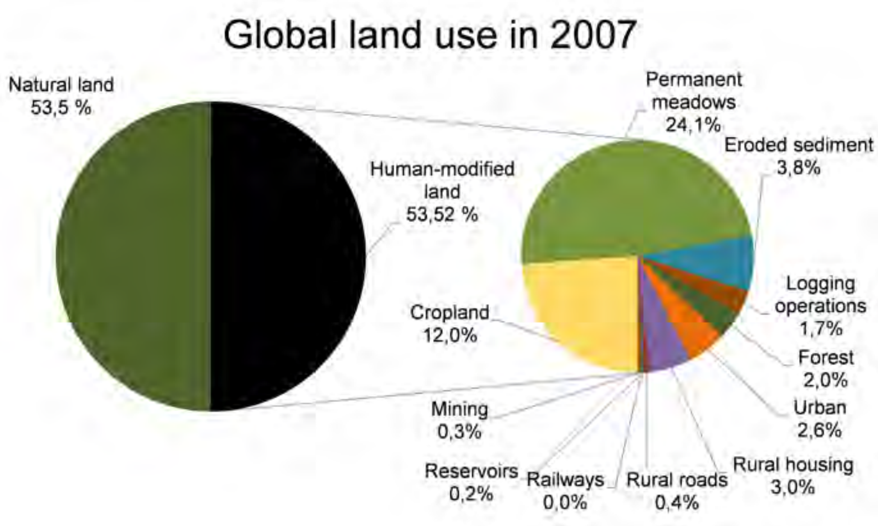


Figure 21: *How the total ice-free land area is used today (2007). About two thirds of the useful land available have been modified by humans, and the last third consists of e.g. rainforest (Hooke, Martín-Duque, and Pedraza, 2012).*

Assimilation capacity

Carbon is one of the elements highly monitored and investigated due to its relation to climate change. Over the last 800 000 years the normal range of variation has been roughly between 180 and 300 ppm ((Lüthi et al., 2008) as cited in (Grahn, 2009)). The atmospheric CO_2 concentration has followed a steady increase over the last 30 years, reaching unusually high concentration of 393 ppm in 2012 (Le Quéré and al., 2013). Carbon emissions, which mostly originate from burning fossil fuels, cement production and land-use changes are not only absorbed by the atmosphere, about 30% of the CO_2 emissions from the year 1940 to 2000 were absorbed by oceanic and terrestrial sinks (Intergovernmental Panel on Climate Change, 2007). Carbon accumulation has resulted in changes in global temperature, sea level, ocean acidification and snow cover (Le Quéré and al., 2013).

In summary, natural resources are decreasing, in the sense that they can be found less and less in their natural concentration and structure. The assimilation capacity is limited (or even decreasing), meaning that "waste" is being increasingly accumulated in nature. Population is increasing. Economy, in the form of wealth creation (GDP) is increasing. Material and energy intensity, considered as the amount of resources and energy to satisfy needs, are increasing per capita.

The funnel allegory explains how global mega trends increase the pressure on human and natural systems. Following these trends in the future is equivalent to going deeper and deeper into the narrow part of the funnel, where the degrees of freedom to act will be considerably less. This might manifest itself as resource scarcity, severe contamination, loss of ecosystem services, increasing costs and harder competition due to stricter legislation, etc. (Robèrt et al., 2002).

The compass

The results from the compass are inconclusive in identifying the most important indicators. It does however show that most challenges are related to Society or Economy rather than Nature.

Identified sustainability challenges were e.g. consumption, fossil fuel usage, resource scarcity, growth decoupling, stakeholder commitment, behavioural change and cross-cultural interaction. Identified indicators were e.g. punctuality, particle concentrations, GDP, fuel price, polulation density and happiness index. The realisation of the compass can be seen in figure 22.

3.1.2 Step 3: Future situation

The global normative vision is to have a sustainable future where the human population is able to meet their needs without compromising the ability of next generations to meet their own (based on Brundtland Commission's definition of sustainable development (Brundtland, 1987)). The Challenge Lab team made a vision based on this:

"A sustainable future where the population (10 billion people is able to meet their ow needs, within the planetary boundries, without compromising the ability of future generations to meet their own."

The vision for a sustainable transport sector in Gothenburg is to have a transport system that satisfies the needs of the complete population where the complete system (as well as each individual part) i) is efficient, ii) the materials used are enclosed within the techno-sphere and iii) the source of energy is

Figure 22: *The indicators and challenges identified in the Challenge Lab. Most of the challenges relate to Economy or Society rather than to Nature. Photo: Cecilia Hult.*

renewable produced with minimum impact to the environment i.e. zero fossil carbon emissions to the atmosphere.

Sweden has established visions and targets that are aligned with the Challenge Lab's vision: "[To have] a resource-efficient energy supply system with zero net emissions of greenhouse gases into the atmosphere by 2050" where a step towards that vision is to have an fossil fuel-independent vehicle fleet by 2030 (Näringsdepartementet, 2013).

3.1.3 Step 4: Strategy

The transition towards the established vision must be done gradually but with full security that the most urgent targets will be reached. The strategies that are in line with the four sustainability principles follow two basic mechanisms: de-materialisation and trans-materialisation (Karlsson et al., 1997). At a EU level transport strategies include the use of low or zero emission vehicles, substitute motorised vehicles by more environmentally friendly modes of transport i.e. walking, cycling and public transport, efficient logistics, etc. (European Commission, 2011). The Swedish transport strategies are presented in th Fossile free fleet-investigation (Näringsdepartementet, 2013) and the strategies include biofuels, energy efficiency and a reduced need for transport.

Ongoing projects that relate to sustainable transport in Gothenburg include

GoBiGas, a biogas pilot plant, *Green Campus Chalmers*, *Ubigo*, a mobility service system for transport, *DriveMe*, a self-driving car by Volvo and many more.

3.2 Inside-out

If the findings from backcasting are visual or can be seen as the hard reality, the results of the inside-out module mainly relates with soft values such as trust and confidence.

A leaders role is to set the direction of change, gather up the people and motivate and inspire people. This is how Göran Carstedt fulfilled his role in the Challenge Lab as a leader for sustainable development. According to Carstedt in order to have a transition towards sustainable development there is a need for people to share a meaningful purpose worthy of peoples fullest commitment and a learning organisation. The meaningful purpose is to retain "the ability of our own human society to continue indefinitely within the natural cycles". The origin behind sustainability challenges is how flows of matter in industrial age systems are linear, while those in natural (closed) systems are circular. The conception of how a sustainable society should function is followed by setting goals towards that direction. Carstedt emphasised that once ambitious goals are set, these act as magnets attracting the means to achieve them. Organisational transformation is consequently needed to achieve a sustainable future. Carstedt gives great importance to organisational change by stating the possibility of not having "an environmental problem, school, health care, or a business problem [. . .] but [rather] an institutional problem [due to the fact that] our organisations are not capable to deal with the complexities we are now meeting" (Carstedt, 2014). On the other hand he states that "there is no organisational transformation without personal transformation" (Carstedt, 2014). Therefore individual change is essential but difficult to achieve because usually people resist to change as they overestimate the value of the known situation while underestimating the value of alternative possibilities. Resistance to change manifests itself in different ways e.g. fear of making mistakes.

On the other hand massive transformations such as the industrial revolution happened in relatively short time periods. What drives people to change is an idea, a dream or a desire of something, as opposed to a plan. Therefore there in order to "liberate human creativity people need a meaningful cause to believe in" (Carstedt, 2014)

Activities to encourage active listening in the group helped develop self-awareness, self-regulation and empathy. The Challenge Lab group also showed openness and trust to each other, possibly contributing to the exercises in the beginning of the process. A manifestation of learning about dialogue is the Challenge Lab work space where a circle of chairs is used as a meeting space.

3.3 System theory

One of the main points in MLP-theory is the existence of transition technologies. This means that in history, the transition from a niche to a regime has not been a single journey for a few isolated regimes. Instead, the competing between niche technologies is a precondition for the development of the niche technologies. Even the niche technologies that did not turn into a regime sometimes played an important role for other niche technologies which made the transition. This point is important when evaluating transport solutions because this means that even though a technology may not have the potential to be a world wide solution for all transportation it can still play a role in the transition to a more sustainable transport system.

3.4 Identifying hot-spots

The Challenge Lab students identified several areas that could be considered leverage points in the Gothenburg transport system.

City planning

Gothenburg is a low-density city with roughly 1/3 of the population density of Stockholm or Malmö (Hellberg, 2014). Many of the issues related to transport (congestion, local emissions, etc.) are results of the need for transport. One way to meet this need is densification of the city. There are currently strategies for the public transport system being formed with the target to have local nodes and a more grid-like system than today (Hellberg, 2014).

Low-emitting fuels

Regarding the large share of the road transport and its emissions, both Grahn (2014) and Edh (2014) focus on the need for alternative vehicle fuels. Both biofuels and electricity for transportation are parts of the strategies in Sweden (Näringsdepartementet, 2013). One ongoing project on biofuels is the GoBiGas project run by Göteborg Energi where biomass (waste, woodchips) is transformed into biogas. One on electricity is the ElectriCity-project where PH-busses from Volvo will be tested in Gothenburg City (Fogelberg, 2014).

Politics, legislation and strategies

There are a vast number of strategies related to transport at all levels. EU has it own goals e.g. Horizon2020, Sweden has goal of the fossil free fleet in 2050. At the same time, local politicians like the ones in Gothenburg put large amount of money into biogas projects while Volvo Cars does not develop biogas cars at all (Edh, 2014).

According to Rydehell (2014), the lack of a clear leadership is one additional problem in the Gothenburg region. The overall impression is that there is a need for coordination of strategies at different levels.

"Causal Loop Diagrams"

The CLD analysis was, overall, inconclusive. The identified clusters of critical factors in the transport system from our CLD analysis are: "urban factors", "technology", "behavioural", "economy", "environmental", "transport", "industry" and "change". These factors were listed by us, but by listing the critical factors, no factor has been identified as more important than the others.

3.5 Project formation

Using the Challenge Lab design thinking model, each team made an analysis of our topics. The main findings include the functions and the users of the two phases of this thesis: the Challenge Lab and the Project.

3.5.1 Research question

The final result from the research is the research question:

What are the drivers and barriers for the use of biodiesel as a vehicle fuel and who has the power to overcome them?

3.5.2 Story behind the research question

After completing the Challenge Lab process the groups or individuals had as an outcome very different research questions. We had few restrictions for the research question, one of which was that it had to relate to sustainable transport in Gothenburg, which resulted in every group or individual having a many degrees of freedom to craft their own project as result of the (common) process. How every group or individual used the process to craft their research question was highly subjective thus we will only present the story of how we came up with our research question as an output of the Challenge Lab process.

During the inside-out step we experienced an environment that promoted creativity, freedom, openness and self-confidence. The freedom and self-confidence encouraged us to find a research topic that truly motivated us. The creativity and openness helped us in crafting our research question by interacting with the rest of the members e.g. each member proposing their own ideas and obtained meaningful feedback in return. During the process we discovered that a research *topic related to biofuels and stakeholders highly motivated us due to personal and professional reasons.*

During the outside-in step we understood that the sustainability challenges are global and complex. However, we should focus the research question not on the end-point impacts but rather early on in the causal chain i.e. in human behaviour. Given that sustainable development was at the heart of our project, we assumed that our research topic should either focus on finding a solution that fulfilled the sustainability criteria (four system conditions) or was part of a strategy that aimed at doing so i.e. through de- or trans-materialisation. Biofuels are an option for substituting fossil fuels with renewable fuels. We deemed them as an important research topic because fossil fuels, including the oil used for the transport sector, are one of the main contributor to the climate change.

During the system and transition theory step we took into consideration that human systems are complex and their transition is slow; in other words there are many controlling factors that influence the system and it takes many small stepping stones to influence its development. Some biofuels are already produced at a commercial scale and used in existing infrastructure. Biofuels can also be combined with or complement other solutions; thus we consider biofuels as an option that can contribute to the transition of the transport system, acting as a stepping stone, towards a more sustainable future.

During the step of finding hot-spots we realised that key stakeholders in the transport sector hold major knowledge on the problems and challenges. Thus they greatly influenced our decision of a research topic. Thomas B. Johansson, the leader of the FFF-investigation, commented to the Challenge Lab that the two main energy solutions to reach this target are electricity and biofuels. And that work is needed to promote biofuels. He also made an additional meaningful observation that 2030 is 16 years away, thus the existing vehicle technology is an important part of reaching that target. In our meeting with Axel Edh, one main takeaways was that emission regulations only apply to newly registered vehicles. At the same time, the average life span of a car in the Swedish car fleet is 17 years. This means that even if all new cars were for example electric cars run by electricity produced by renewable energy sources, there would still be cars emitting GHG on the Swedish roads. This in combination with the fact that a few stakeholders were recurrently mentioned by many guests (e.g. Volvo), we drew the conclusion that stakeholders play an important role in a sustainability change. In addition to this, invited stakeholders emphasised that there is need for research on liquid biofuels in Sweden.

Maria Grahn presented different biofuels and future scenarios. One striking feature was the wide variety of biomass that could be used for fuel production, *as well as the broad spectra of biofuels. Some, such as ethanol, are more known to the public than others and some, such as Fischer Tropsch diesels, were new to us. Supprisingly enough, the biodiesel usage in TWh was roughly as large as the ethanol usage in Sweden. Biogas is also used a vehicle fuel, but to a lesser extent. We learnt about the "pump law" and how many distributors chose to have an ethanol pump because it was cheaper than a gas pump due to its physical similarities to petrol.*

All of this made us focus on biodiesel as a vehicle fuel.

3

Biodiesel

1 Introduction

1.1 Background

The world energy use in the transport sector comes almost entirely from oil. In 2010, 93% of the global transport energy was supplied by oil (European Commission, 2011) and the European Union is a net importer of crude oil (European Commision, 2013). If the transportation sector continues to rely heavily on oil, then the most serious threats include oil scarcity, economic and geopolitical instability and negative environmental impacts e.g. climate change (European Commission, 2001; Olsson and Eriksson, 2007). One of the major sustainability challenges at the moment is climate change, from which greenhouse gas (GHG) emissions are the main cause. Anthropogenic emission sources exist in many sectors.

Transport is guilty of a major part of GHG-emission although to what extent varies between regions. Figure 23 shows the GHG-emissions by sector at a world, EU and national level and in Sweden, as much as 1/3 of the GHG-emission arise from the transport sector. While emissions may come from transport making it a climate issue, Europe faces at the same time a growing demand for transport (Schäfer, 2005). Apart from GHG-emissions, there are also many social, environmental and economic problems associated with the business-as-usual transport system.

The road transport is the main contributor of GHG-gases in the transport sector, accounting for 93% of the total GHG emissions in the EU-15 countries

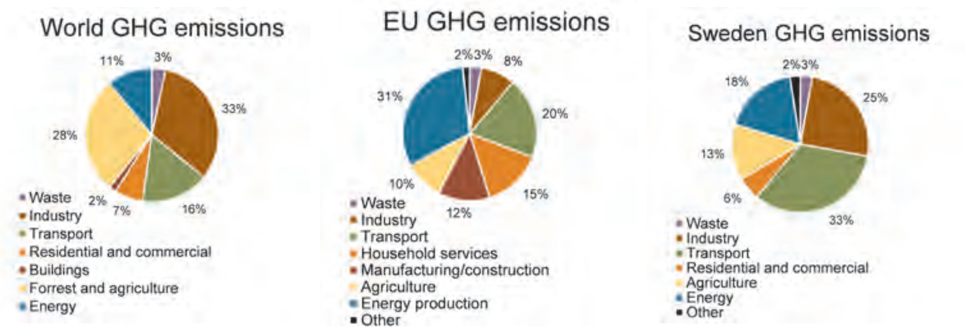


Figure 23: *Green house gas emission worldwide, EU and in Sweden by sector (Intergovernmental Panel on Climate Change, 2014),(European Energy Agency, 2011),(Naturvårdsverket, 2014)*

(European Environmental Agency, 2005). Figure 24 shows GHG-emissions in the world, Europe and Sweden for different modes of transport. In Sweden, a massive 2/3 of the GHG-emissions come from road transport.

Figure 24: *Transport emissions worldwide, EU and in Sweden (OECD/ITF Working Group, 2010),((European Environmental Agency, 2005) as stated in (European Energy Agency, 2006)),(Trafikverket, 2014)*

In response to the social, political and economical pressures there is a strong need to influence both speed and direction of innovation and technological change in the transport sector. Main strategies to reduce carbon emissions from the transportation sector are (Grahn, 2009):

1. Replace current vehicles with more energy efficient vehicles
2. Select modes of transportation that emit less CO_2 emissions per person, e.g. rail instead of aviation, bicycle or public transport instead of cars
3. Build cities that reduce transportation needs and

4. Introduce low CO2 emitting transportation fuels.

Efforts (i.e. research, financial capital, policy instruments) are put into many technological options because it is an urgent matter to limit ourselves to a two degree Celsius increase in the global average temperature, and because there is no certainty of which technologies will succeed. No single technology will be able to replace fossil fuels used for vehicles within a significant period of time. Therefore, there are many alternative technologies that are supported.

In the overall strategy, as presented in the fossil free fleet-investigation (FFF) (Näringsdepartementet, 2013), two sources of power will be electricity and biofuels. However, electrical vehicles have electrical engines instead of combustion engines. Since it takes a country approximately 20 years to (almost) completely renew its vehicle fleet, biofuels that can be used in existing infrastructure are a strategy for the short term. Additionally, since electrification (which is a more efficient technology than biofuels) is better suited for short-range travels, then it is assumed that heavy goods vehicles will have a low degree of electrification by 2030 which represents an area or opportunity for biofuels (Näringsdepartementet, 2013). A Swedish report on biofuels done by the Stockholm Environment Institute during 2009-2011 on the topic of innovations for sustainable transport, specifically low-carbon road vehicles and fuels concluded that:

"[...] later, when wider sustainability concerns entered the debate, biofuels were generally disfavoured, while other alternatives gained ground, such as vehicle electrification and so-called clean diesel technology." (Hillman, 2011).

Among the fuel alternatives, biofuels are an attractive option because they are considered carbon neutral and renewable. Therefore, biofuels are desired fuel alternatives as expressed by several official documents at European and Swedish levels. The EU has a target of reaching 10% share of biofuels or other renewable fuels for transport (European Commission, 2009), but the European Commission gives freedom to each member country to find their own solution for reaching the target. Sweden has set as a strategy to have a clear and long-term goal for biofuels, recognising that there is potential, in terms of technology capability and resources, to produce biofuels with "good climate performance of agricultural products and waste". The calculated (mean) potential is 20 TWh to be achieved between 2010 and 2030 (Näringsdepartementet, 2013).

Today, there are different categories of biofuels for vehicles. The main division is between gaseous and liquid fuels. Gaseous fuels are biogas (methane), synthetic natural gas (SNG) and syngas. Liquid biofuels are mainly divided into biodiesel and bioethanol. There are also small amounts of methanol.

In Sweden, liquid biofuels play a major role, since liquid biofuels hold an 88% market share (based on energy content) out of the total biofuel energy used in 2012 (SPBI, 2012). Furthermore, the Region of West Sweden (Västra Götalandsregionen) expressed interest in research on the current situation and development of liquid biofuels, this with the intention on taking informed decisions and actions in this matter. This interest was expressed through personal communication with a current employee in the research and development department.

Biodiesel, as other technologies in formation, could grow into a mature technology but not before going through a “lengthy (several decades long), uncertain (in terms of market, technology and policy) and painful (many obstacles and failures) process of development and diffusion” (Bergek et al., 2008a). Technologies in formation (or technological niches) are able to grow if ”if visions (and expectations) become more precise and more broadly accepted, if the alignment of various learning processes results in a stable configuration (‘dominant design’), and if social networks become bigger (especially the participation of powerful actors may add legitimacy and bring more resources into niches)” (F. W. Geels, 2012).

Hence, biodiesel is the most used biofuel in Sweden but is still a technology in formation thus there is a need for strategic actions that lead to an increase of use. There is also a lack of research with specific focus on biodiesel and additionally, there is an expressed interest (from the Region of West Sweden) to increase the body of knowledge in bioliquids (including biodiesel) in order to make informed decisions and activities in this matter.

1.2 Aim and objectives

The aim of this report is to increase awareness of the existing biodiesel alternatives and to support the development, diffusion and use biodiesel fuels. The objectives include i) to identify drivers and barriers for development, diffusion and use of biodiesel fuels and ii) to identify networks and key stakeholders connected to biodiesel fuels.

1.3 Scope and limitations

This report focuses on commercially available (or soon to be) biomass-based fuels for diesel engines, mainly FAME, DME and HVO. The geopolitical limitation is Sweden. Therefore, the report only considers stakeholders in Sweden and not European biodiesel stakeholders.

2 Theory

This section includes both a description of biodiesels and a theoretical background to the two methods used to reach the objectives: functions of innovation systems and social network analysis.

2.1 Biodiesels

Fatty acid methyl ester, abbreviated as FAME, is made from a variety of vegetable oils and animal fat such as rapeseed oil, sunflower seed oil, used frying oil or offal. FAME is produced though esterification of (extracted, filtered and purified) oil with methanol used as a catalyst. The most common oils are rapeseed, soy and palm oil, although in Sweden, only FAME from rapeseed (RME) is used due to its physical properties. Both soy and palm oil have undesired properties in low temperature (Hansson and Grahn, 2013). FAME has been used as a vehicle fuel in Sweden for at least 10 years (EEA as stated in (Näringsdepartementet, 2013)).

Hydro-generated vegetable oil, HVO in short, is another type of biodiesel. HVO is produced through fatty acids reacting with hydrogen. It is produced from the same feedstock as FAME (vegetable oils and animal fat). It can also be produced with other commodities such as tall oil although tall oil, a residue from the pulp and paper industry, requires a more extensive pre-treatment during the production (than other vegetable oils). HVO is more chemically similar to regular diesel than FAME and has been used as a vehicle fuel in Sweden since 2011 (Näringsdepartementet, 2013).

Dimethyl ether, DME, is a synthetic, gaseous diesel fuel that is liquid under moderate pressure. Hence, it is transported as a liquid and can be used in slightly modified diesel engines. All synthetic fuels are obtained from synthesis gas. Gasification is a process that converts either coal, natural gas or biomass into synthesis gas also called syngas. Synthetic fuels include synthetic diesel, synthetic petrol, DME, methanol, ethanol, biomethane (bio-SNG) and hydrogen. Biomass-based feedstocks used for gasification include lignocellulosic biomass i.e. forest residues, straw, some energy crops; and liquors from the pulp and paper industry. DME is produced from the dehydration of methanol (obtained from syngas). Fischer-Tropsch synthesis is another process known to produce synthetic fuels from biomass (Näringsdepartementet, 2013; Per Salomonsson, 2014).

The term biodiesel most commonly refer to FAME because it was the first fuel introduced. It is important to state that throughout this report the term “biodiesels” is used to refer to all commercially available (or soon to be) biomass-based fuels for diesel engines, mainly FAME, HVO and DME.

Biodiesel, as most biofuels, is often classified according to the feedstock used for production. The terms used to classify them is “generations”. There is no universally accepted definition of biodiesel generations, but the classification used throughout this report is the most common one.

First generation biodiesels, also called conventional biodiesel, are those produced from edible vegetable oils i.e. rapeseed oil, palm oil or soybean oil. FAME is an example of a first generation biodiesel.

Second generation biodiesels, also called advanced biodiesels, are produced from lignocellulosic materials i.e. wood, agricultural residues, black liquor (byproduct from the kraft pulp process), etc. DME is an example of second generation biodiesel. HVO could be a first or second generation biodiesel depending of the feedstock used for its production.

The *third generation* renewable fuels are even less well defined than the previous generations, it is not even certain that they derive from traditional biomass. They could for example be derived from algae in different forms. At the moment, there are no third generation biodiesels commercially available (Grönkvist et al., 2013).

FAME, HVO and DME are suited for diesel engines which includes most heavy goods vehicles, urban buses, delivery lorries and diesel engine passenger vehicles. The biodiesel can either be *low-blend* meaning blended with fossil diesel, or *high-blend* meaning that is more or less pure biodiesel. Low-blend biodiesel uses a system to track the percentage of the amount of biodiesel, called “B-factor” i.e. 100 vol.% of biodiesel is B100.

FAME blended in low volume percentages ($<$ 7 vol.%) with diesel can still be used in conventional diesel engines while dedicated engines are required for higher concentrations i.e. B85 or B100 (Grönkvist et al., 2013). HVO up to 70-100 vol.% can also be used in conventional diesel engines (Neste Oil, 2014) where fuel standards for e.g. diesel density or the engine set the limits. DME requires separate distribution and special vehicles (Näringsdepartementet, 2013) and cannot be blended into conventional diesel (Nyström, 2014).

Market

In 2012, the total amount of biofuels used for transportation in Sweden was 6.92 TWh. This represents 8.1% of the total energy used for vehicles in Sweden (85.4 TWh). Biodiesel, mainly HVO and FAME, holds the largest share of the biofuel market: 53.4%. Nevertheless, biodiesel holds a small share of the total vehicle fuel market: 4.3% (table 1). In 2011, HVO was introduced into the market (111 000 m^3 approximately). While DME has been used since 2011 it was until recently (2013) only used for test purposes (SPBI, 2013). The market for biodiesel is held mostly by fossil fuel companies that have diversified into renewable fuels i.e Preem, Statoil, OKQ8 and ST1 (figure 26) (SPBI, 2013).

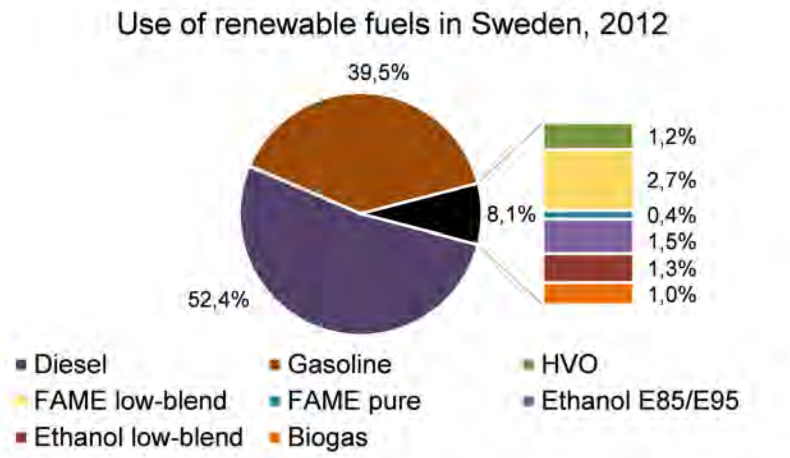


Figure 25: *Calculations of fuel usage made by SPBI (SPBI, 2012)*

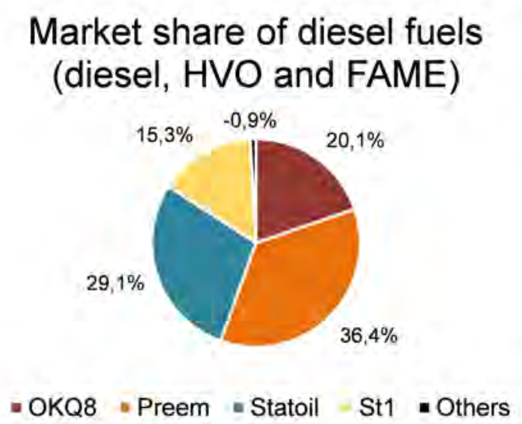


Figure 26: *Market volumes of diesel engine fuels (diesel, HVO and FAME) from major companies. Only market in Sweden is taken into account therefore, deliveries to foreign companies are excluded (and contribute with a negative share) (SPBI, 2013)*

Table 1: *Biodiesel market shares*

Fuels for transport	Market share %	Volume 1 000 m^3	Energy TWh
Diesel fuel	52.4	4561	44.7
Gasoline	39.5	3710	33.76
Biofuels	8.1	84,130	6.92
	100	**92,401**	**85.38**
HVO	1.2	111	1.02
FAME low-blend	2.7	251	2.29
FAME pure	0.4	42	0.39
Ethanol E85/E95	1.5	215	1.27
Ethanol low-blend	1.3	191	1.13
Biogas	1	83320	0.82
	8.1	**84,130**	**6.92**

Legislation and policy instruments

Legislation at European and Swedish levels that influence the biodiesel system is described in this section. The political context of biodiesels, and other fuels, is helpful for understanding further research done on the subject.

EU legislation on biofuels, mainly in the form of Directives, aim to achieve energy security and mitigate climate change. In the case of Directives it is left to each member state to decide how to achieve results with aid of policy instruments i.e. administrative, financial, support to research and development and information.

The EU ”Energy and Climate package” from 2007 includes three targets: 20% reduction of GHG, 20% renewables on average in gross energy supply in the EU and 20% energy efficiency improvement, all by 2020.

Adopted in 2009, the Directive 2009/28/EC, also known as the *Renewable Energy Directive* (RED) states a target to reach at least 10% biofuels in the transport sector by 2020. RED considers the following: i) the minimum GHG reduction for biofuels and bioliquids' life cycles should be at least 35% (at present) and at least 50% (starting from January 2017), ii) the contribution of biofuels based on residues, waste, non-food cellulosic material and lignocellulosic material counts as *double* for the target than those from other sources and iii) no biofuels should be produced on carbon rich or biodiverse land (European Commission, 2009). RED also states that the emission standards on new passenger cars should not exceed 130 g CO_2/km by 2015 and 95 g CO_2/km by 2020 (Grönkvist et al., 2013).

In 2011, Sweden implemented the fuel quality EU Directive 2009/30/EG which currently allows a maximum of 7 % FAME in diesel (Näringsdepartementet, 2013).

In October 2012, the European Commission proposed an amendment for RED including the following: i) cap on food-based biofuels at 5% share (energy content) of the total fuels, ii) the contribution of biofuels based on residues, waste, non-food cellulosic material and ligno-cellulosic material counted as *four times* (towards the target) compared to other sources and iii) a 60% minimum GHG reduction in installations with productions starting on July, 2014. However, the decision has been postponed to mid or end 2014 (Grönkvist et al., 2013).

The Directive 2003/96/EC on energy taxation regulates tax exemptions on biofuels. It is currently (2013) under revision (Grönkvist et al., 2013; SFS2013:859, 2014). The energy tax has previously been lower on biofuels, but will in the new law be taxed according to energy content. According to the Swedish Energy Agency this mean that the share of FAME will not exceed the quotas (Energimyndigheten, 2013).

In addition to the EU directives, Sweden has its own political goals to increase energy independence, to reduce greenhouse gases and to support the development of domestic industries (Grönkvist et al., 2013).

One of the policy instruments used is a so called *super-green car premium* (supermiljöbilspremien) where a private buyer can get 40 000 SEK for buying a car emitting less than 50 g CO_2/km. The subsidy for super-green cars can be used between 1 Jan 2012 and 31 Dec 2014 (Hansson and Grahn, 2013).

Other policy instruments are tax exemptions and bio quotas. The government suggested in their proposition, which was accepted as Swedish law (SFS 2013:984, 2013), a new quota system for biofuels. The law was originally meant to start at May 1st 2014, but on April 10th 2014 the Ministry of Finance announced that the law has been postponed until further notice while waiting for approval according to EU state aid regulations (Finansdepartementet, 2014). The main component in the quota law is that everyone who is energy taxable has to provide a share of biofuels in their fuel supplies. The share is counted per year and not for every sold volume unit of fuel. The total share of renewables in diesel should be 9.5% whereof 3.5% should be specially assigned biodiesels that are considered to have special benefits (second generation biofuels) (Grönkvist et al., 2013).

Actors and networks

There are a number of biodiesel actors. Some produce biodiesel or biodiesel feedstock, while others distribute the fuel. The main identified producers and distributors of biodiesels in Sweden are Ecobränsle, Energifabriken, Perstorp, Preem, OKQ8, Neste Oil and Statoil.

Fuel distributors in Sweden mainly include OKQ8, Preem, Statoil and St1. ST1 is a company producing and distributing fossil fuels and renewable fuels. In 2006, they launched a product called Eco-diesel with B5 RME (St1 Energy AB, 2014). OKQ8 have both RME under the name of DieselBio+ and HVO in the name Diesel BioMax (KNEG, 2013). Their HVO is produced by Neste Oil. Statoil, a Norwegian oil company, distributes B5-B7 RME in Sweden since 1993. It also offers B100 RME, and a 30% renewable fuel containing 5% RME and 25% HVO (in 150 stations). Statoil distributes HVO under the name Diesel+ (Statoil Fuel & Retail, 2013). Preem Petroleum AB is Sweden's largest oil company, with activities ranging from refinery of crude oil to customer sales. In 1994, Preem (previously under the name of OK) was bough by a Saudi businessman Mohammed Al-Amoudi (Pahl, 2008). Preem's diesel contains B5 low-blend biodiesel as a standard for all vehicles, but they have expressed aspirations to increase it up to 10 vol.%. Preem also offers diesel with B15, B50 and B100 RME for adapted vehicles (Preem AB, 2014).

Actors that are involved in RME fuels in Sweden include Scania, Volvo, Mercedes, Ecobränsle, Energifabriken, Perstorp, plus the fuel distributors. There are three truck brands with vehicles that can run on pure RME (B100): Scania, Volvo and Mercedes (Ecobränsle, 2014). There are also a number of companies that deliver pure RME. Ecobränsle AB was founded in 1993 as a farmers' company selling RME primarily for the Swedish market. Today owned by Energigårdarna, Ecobränsle is Sweden's second largest manufacturer of RME with a production capacity of 50 000 m^3 per year. Its main supplier of rapeseed oil is AAK (Ecobränsle, 2014). Energifabriken AB is a distribution company for RME B100 (4 500 m^3 per year) as well as other products. Perstorp Bioproducts AB is a chemical company that currently (2014) offers RME for low blending purposes (B5-B7) and high blend purposes (B100). It also had plans to launch a partly non-crop based biofuel in 2013, but there has been no news of this since (Perstorp Holding AB, 2014). In 2011, Perstorp produced 1.7 TWh of RME (Energimyndigheten, 2013).

Actors that are involved in HVO fuels in Sweden include Preem, Statoil, Sunpine, Neste Oil, OKQ8, plus other fuel distributors. Preem is producing HVO under the name of Evolution Diesel (Energimyndigheten, 2013). Sunpine AB, owned by Kiram, Preem, Sveaskog and Southern Forest Owners and started in 2010, has a production capacity of 100 000 m^2 tall oil used in Preem's HVO-production per year (Energimyndigheten, 2013). Neste Oil AB is a Finnish company (50.1% ownership by the Finnish government) dedicated to the production of vehicle fuels, including fossil fuels and renewable fuels, and petroleum based products. Neste produces biodiesel through a patented process (NExBTL) that consists of the direct catalytic hydrogenation of vegetable oils. Neste produces around 2 million tons HVO every year (Kuronen, 2013).

There are formal networks at EU and Swedish levels where topics related to biodiesel are handled. The European Biodiesel Board (EBB) has two Swedish members: Perstorp and Ecobränsle (European Biodiesel Board, 2013; Ecobränsle, 2014).

Svebio is a Swedish bioenergy network that holds 300 companies that have an interest throughout the value chain or as users of bioenergy plus interested individuals. Biodiesel members include: Ecobränsle, Energilotsen Sweden AB (bio-oil supplier), Perstorp and Vegoil Energy Provider AB (RME supplier). Svenska Petroleum & Biodrivmedel Institutet (SPBI) is a non-profit organisation that helps its members deal with stakeholders, mainly authorities, other organisations and the public. Its members include Lantmännen, Nynäs AB, OKQ8, Preem, St1 and Statoil (SPBI, 2014). Swedish Standards Institute (SIS) is a non-profit member based organisation that sets standards. SPBI woks with SIS in the standardisation of fossil fuels and biofuels in Sweden and with the European Committee for Standardisation (CEN) at an EU level.

2.2 Functions of Innovation Systems

The study of how technologies emerge, diffuse and develop is studied within the concept of *Technological Innovation Systems* (TIS). TIS differs from other Innovation System tools in that it centres on a specific technology (in terms of knowledge, product or both), in this case biodiesels (Bergek et al., 2008a).

According to TIS, technological change has a systemic character that cannot be simplified by describing solely the technology but rather include how the technology is embedded in socio-economic systems i.e. the institutions, economic structures, relevant actors, etc. A TIS is defined as a "network(s) of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology" (Carlsson and Stankiewicz, 1991, as cited in Bergek et al. (2008a)). As implied in this definition a TIS has four structural components: actors, networks, institutions and technology (Bergek et al., 2008a).

The presence and interaction of these structural components determine if the system is either propelled forward or if it breaks down i.e. denominated "system failure" (Carlsson and Jacobsson, 1997 as cited by Bergek et al. (2008a)). Once the TIS shifts from a formation phase to the growth phase it becomes a self-enforcing reaction chain of powerful feedback.

Therefore it is of great interest to locate and understand the barriers in any of the components that may block the development of the system. Nevertheless, experts in the area argue that it is difficult to locate system barriers only by studying the structural elements, as they give little information on how the system is performing. Therefore, attention shifts towards analysing the *functions* in the system rather than the structure of the system thus allowing to separate the structure from the content. As Jacobsson (2011) puts it, the "functions are intermediate variables between structure and system performance; it is through the functions that components contribute to the overall 'goal' of the system, i.e. to the development, diffusion and utilisation of new technologies." The systems barriers and drivers are thus expressed in functional terms and then linked to the structural elements of the TIS (Jacobsson and Bergek, 2011; Hekkert et al., 2007; Bergek et al., 2008a).

The Function of Innovation Systems (FIS) methodology assesses the functionality of the system by identifying the barriers and drivers in order to influence the direction and speed of the technology. The FIS framework consists of key processes, called "functions" that have a direct or indirect impact on the overall aim of the system i.e. the development, diffusion and utilisation of innovative technologies. The weaknesses and barriers (as well as the drivers) in the system are understood in terms of these functions. It is in these weaknesses where it would be valuable for policy makers to intervene. Johnson (1998 as cited in (Bergek et al., 2008a)) proposed a first set of functions. The list has been laboriously revised and refined by researchers including Bergek, Jacobsson, Hekkert, who state that the final set includes all functions that allow for a "systematic identification of policy problems". The functions are (Bergek et al., 2008a):

1. entrepreneurial activities
2. knowledge development and diffusion
3. influence on the direction of search
4. market formation
5. legitimation
6. resource mobilisation
7. development of positive externalities

which are all described in the following sections.

2.2.1 Entrepreneurial activities

Entrepreneurs have an important role in society because they reduce uncertainty (in terms of technologies, applications and markets) in a TIS by conducting many experiments. Entrepreneurs convert potential knowledge, networks and markets into concrete actions by trying to create and profit from new business opportunities. Most entrepreneurs fail while some succeed. Knowledge is then collected on the functioning of the technology under different circumstances, and the success paths, thus creating social learning (Hekkert et al., 2007; Bergek et al., 2008a).

Entrepreneurial activities are mainly in-firm processes although they can also perform activities external to the firm when trying to influence the system around them; this as consequence of the acceptance that firms influence and are influenced by the larger system. Entrepreneurs can be either new entrees or existing companies that diversify and take up new developments. The later ones, are the most likely to do activities to influence the system i.e. lobbying activities (Hekkert et al., 2007; Bergek et al., 2008a).

2.2.2 Knowledge development and diffusion

According to Lundvall (1992, as cited by Bergek et al. (2008a)) "the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning". Thus this function is placed at the heart of the TIS. Knowledge is very diverse, thus there can be knowledge generation on a technology or product or knowledge about the system i.e. markets, government, competition, etc. Learning can also be done in different ways, including research, learning-by-doing i.e. users learn to use a product or technology, and learning-by-interacting i.e. actors learn by interacting in a network. Thus networks are essential for knowledge diffusion (Hekkert et al., 2007; Bergek et al., 2008a).

2.2.3 Influence on the direction of search

The development of the TIS requires a wide spectrum of actors to be involved. Firms and organisations are either lured to participate in the new system through incentives or induced to do so through pressure. Within the TIS there is also a gradual, interactive and cumulative selection process. In evolutionary terms knowledge development creates variety while the "influence of the direction of search" is the selection of the fittest (within the TIS). The direction of the search is a process done by many interacting components and factors (which are beyond the boundaries of the technology in focus) that collectively influence the selection of competing technologies, applications, markets, etc. (Bergek et al., 2008a; Bergek, Hekkert, and Jacobsson, 2008)

2.2.4 Market formation

During the emergence or the development of a TIS the markets may be non-existent or underdeveloped. This, in turn, means that the technology is badly adapted for its (potential) use and that there is nearly no articulation of demand from (potential) customers and there is poor price and/or performance of the new technology. Market formation undergoes three phases: “nursing markets”, “bridging markets”, and “mass markets”. Nursing markets are small learning spaces where entrepreneurs can develop the new technology. Nursing markets can either be niche markets for a specific technology, markets with temporary competitiveness through regulations, among others. Bridging markets give way to the mass markets which addresses the largest amount of consumers for a specified technological product (Bergek et al., 2008a; Bergek, Hekkert, and Jacobsson, 2008).

2.2.5 Legitimation

Legitimation is a matter of social acceptance of the technology in development. The TIS needs to be considered accepted, desired and appropriate in order for resources to be mobilised, for the actors within the TIS to gain political strength and for the TIS to be aligned within the institutional framework (Bergek et al., 2008a).

2.2.6 Resource mobilisation

The development of a TIS requires a range of different resources: human capital, financial capital and complementary assets. Human capital and its quality depends on people educated or prepared for relevant scientific and technological fields, as well as in entrepreneurship, management, finance, among others. Financial capital consists of seed and venture capital, diversifying firms, and so on. Complementary assets refer to infrastructure and complementary products or services (Bergek et al., 2008a; Bergek, Hekkert, and Jacobsson, 2008).

2.2.7 Development of positive externalities

“Positive externalities” is a concept used in neoclassical economics to describe the way in which companies often cannot “grasp” all the beneficial outcomes of their investments. These benefits, also called “free utilities” or “spillovers” are available to other actors in the system. Examples of positive externalities include reduction of uncertainty, strengthening of legitimacy, knowledge development, alignment of institutions, and so on. The cumulative development of positive externalities means that the functional dynamics of the TIS is strengthening. Therefore, “development of positive externalities” is sometimes used as an indicator for the overall dynamics of the TIS (Bergek et al., 2008a; Bergek, Hekkert, and Jacobsson, 2008).

2.3 Social network analysis

Social network analysis (SNA) has previously been used to exposed power structures in water management (Lienert, Schnetzer, and Ingold, 2013; Stein, Ernstson, and Barron, 2011) in order to improve water management planning. One of the reasons the water management sector has been targeted is that it often involves a number of actors on different vertical levels (local, regional, national) and actors from different areas (waste water, fresh water). It has also been used in coastal zone management (Ernoul and Wardell-Johnson, 2013) where there are also stakeholders on many vertical levels involved. Prell, Hubacek, and Reed (2009) is one of the most cited papers in natural resource management and gives an overview of how different network concept affect resource management.

The central theme in *social network analysis* is the network with nodes and edges. A node is any sort of person, actor or object in the network and the edge is the relationship between two nodes. The relationship could be of any kind: collaborational, mutual, dependent, formal, informal, etc. The analysis of the edges does not only give information about whom is connected to whom, but also can be regarded as properties of the bounded network.

Networks are normally characterised by a few network metrics, which can be used to classify or understand the network. Many of the discovered important metrics originate from the field of social network analysis (Newman, 2010). They are now also used in other applications such as information networks, technical networks or citation networks but still remain meaningful for social network analysis purposes. Newman (2010) has a fully mathematical derivation and definition of the metrics used for SNA and readers who wish to know more is recommended to read a standard book in the area. Following, a selection of metrics will be introduced.

Metrics of a social network

A network have different metrics measuring properties. Some are metrics of the network as such and others are measures of the nodes or edges.

Degree centrality is the number of edges connected to a node. If the edges are directed, there is both an in-degree and an out-degree where in-degree is how many edges are pointing at that node and out-degree how many edges are pointing out from the node.

Betweenness centrality is a measure of how interconnected a node is, i.e. to what extent it lies on the path between two other nodes. Newman suggest that the betweenness is a measurement of how the node influence the information passing through the node. The betweenness can be used both for directed edges and undirected edges, with our without correction depending on the definition of betweenness (Newman, 2010). It only differs with a factor 2 and is in most cases irrelevant since the relative betweenness of nodes in the same network is most interesting. There also exists modified measurements of betweenness like flow betweenness and random walk-betweenness but they tend to roughly the same results according to Newman. Unless it is obvious that another definition is more suitable, the simplest definition can be used without regret.

Closeness centrality, C_i, is the same as the inverse mean path length, or the inverse average distance, between a node and other nodes. The reason for using the inverse is that it generates a high number for a central node which is more intuitive. One of the downsides with the closeness measure is that the path lengths in a network generally do not vary much. Subsequently, the closeness might not differ much for a central node and a distant node (Newman, 2010).

Graph density is a measurement of how many of the theoretical number of edges that exist in the network. It is defined as the number of existing edges/possible edges. However, if a density should be classified as sparse or dense requires a computation with the number of nodes $n \to \infty$. As this is not very practical, in reality the density is also mostly used as a measurement of comparison rather than a fixed classification of sparsity.

3 Method

Two methodologies are used to achieve the objectives of this thesis: functions of innovation systems and social network analysis. The first is a qualitative method mainly addressing the question of “what” are the main drivers and barriers are and the second is a more quantitative approach mainly addressing the question of “who” can overcome these barriers. Data was collected from both primary sources such as interviews and secondary sources such as annual reports, published investigations, newspaper articles etc.

3.1 Functions of Innovation System

The scheme of analysis followed throughout the FIS is a combination of the proposals of two researchers Bergek (2008a) and Jacobsson (2011). The steps followed are enlisted below:

1. Gathering secondary data on the structural components of the biodiesel TIS: Actors, networks, institutions and technology (the results of which

are included in the “Theory” section).

2. Gathering primary data and secondary data to map the activities related to the seven functions in order to “portray a picture” of how the system is functioning. Specific information of what type of data was gathered is further explained below in each of the functions of innovation. The primary data was gathered though semi-structured interviews to actors in the private sector, the public sector and the academic sector. The list of interviewed actors is presented in appendix A, and the questions in appendix B.
3. Assessing the functionality according to its phase of development, in other words evaluating if the TIS is in a formative phase. The criteria that served as guidance for the evaluation is presented below.
4. Identifying if there are barriers and drivers for each of the functions of innovation.
5. Identifying key recommendations to address the system barriers.

3.1.1 Function 1: Knowledge development and diffusion

The search for primary and secondary data was specifically on R&D, investments in R&D, workshops, conferences, and learning networks (Bergek, Hekkert, and Jacobsson, 2008).

3.1.2 Function 2: Influence the direction of search

The search for primary and secondary data on the actors, mechanisms or factors (either external or internal to the TIS) that influenced the direction of search, with specific attention to actors visions, beliefs or expectations in potential growth, “actors perceptions on the relevance of different types and sources of knowledge”, product prices, regulatory pressures, governmental or industry targets, “articulation of interest by leading consumers” and technical bottlenecks (Bergek et al., 2008a).

3.1.3 Function 3: Entrepreneurial experimentation

The search for primary and secondary data was specifically on entrepreneurial experiments or trials, new entrants, existing companies being diversified, different types of application for the technology and complementary technologies (Bergek et al., 2008a; Bergek, Hekkert, and Jacobsson, 2008).

3.1.4 Function 4: Market formation

For the analysis of the market development phase, the market size and market drivers are taken into account. Effective procurement procedures, articulated demand and institutional changes are examples for market drivers. The search for primary and secondary data was specifically targetting market size, users and customer groups, purchasing processes, articulation of the demand and by whom, institutional change that affects the market and available standards (Bergek et al., 2008a).

3.1.5 Function 5: Legitimation

The search for primary and secondary data was specifically on attitudes towards the technology, interest groups, lobbying activities, alignment between the TIS and current legislation and stakeholders who influenced legitimacy and how (Bergek et al., 2008a; Bergek, Hekkert, and Jacobsson, 2008).

3.1.6 Function 6: Resource mobilisation

The search for primary and secondary data was specifically on sources and volume of financial capital and presence of human capital and complementary assets (Bergek, Hekkert, and Jacobsson, 2008).

3.1.7 Function 7: Development of positive externalities

The search for primary and secondary data was specifically on degree of (political) power of the TIS actors, existence of division of labour and specialization, and information and knowledge flows (Bergek, Hekkert, and Jacobsson, 2008).

3.2 Social network analysis

Three collected data set has been used in this thesis: data from semi-structures interviews, data from published debate articles in Swedish newspapers and participant lists of Swedish conferences and seminars. The purpose is to identify key stakeholders within the biodiesel area. By using three different data sources the aim is to have a more certain identification, using a sort of triangulation. The open source graph visualisation tool *Gephi* was used for the analysis och making of figures.

In the semi-structured interviews, the participants were asked to name organisations, companies, etc. that they thought could overcome the barriers the interviewees had previously identified during the interview. The question worked as a simple name generator. Stakeholders that could overcome barriers were also manually identified based on the whole interview. Whereas the first question is based on the interviewees word, the second method of collecting key stakeholders involves interviewer bias. Interpretation of the data was also made to some extent: when a interviewee said that “the municipalities” must take a bigger responsibility, it was registered as “Göteborgs kommun”. The “oil production companies" were interpreted as all of the oil companies mentioned by other stakeholders, e.g. Preem, Exxon, St1.

In the debate article data set, Swedish newspapers and magazines were manually searched for debate articles promoting biodiesel, either as a main topic or a subtopic. The time limit for articles was set to only include articles published between January 1st 2012 and April 20th 2014. Either using a Google-site search or the publications own web search four keywords, "HVO","RME", "FAME" and "biodiesel", was searched for on the publications web site. All daily news papers with an edition of > 50 000 copies were included (for a full list, see Appendix C). Other sources included magazines with an edition of > 10 000 copies in related areas such as logistics, automotive, technology. If a debate article had authors from two or more stakeholders, the two authors were assigned an undirected edge. If the same two authors had written more than one articles together, the weight of the edge was increased by one for each co-authorship.

The last set consists of speakers and discussion panel members of Swedish conferences or seminars between January 1st 2012 and Autumn 2014. The names were collected from participant list opublished nline and without checking if the scheduled speaker attended or not. The conferences and seminars all had biofuels for transportation or biodiesel in their descriptions, but could also be broader and cover sustainable transportation in general. The selection of conferences and seminars was made by convenience sampling and they were either mentioned by stakeholders in the interviews, appearing in the calendar of stakeholders previously mentioned or found using an online search engine. Seminars with only local or regional stakeholder were left out on purpose. There is no guarantee that the list covers all biodiesel-related seminars or that there is no bias toward certain stakeholders.

3.3 Interviews

Semi-structured interviews were used for collecting data for both the FIS and the SNA analysis. This section describes further details of the interviews.

3.3.1 Sampling

We interviewed 13 actors with different interests in the biodiesel sector. They were initially selected from recommendations by Challenge Lab supervisors. We then applied snowball sampling, getting names from the interviewees of other people that might be of interest. We simultaneously kept a record of in what sector the interviewees worked and contacted persons in the sectors that had less interviewees. Therefore, all samples were not from snowball sampling. The respondents who were not sampled by recommendation were selected because their names had come across reading of published reports or because they appeared in mainstream media.

Selection was made by the authors (as opposed to a reference group etc.). In SNA, it is common to first have a reference groups that select stakeholders to interview and then the interviews for data collection are made with the stakeholders identified by the reference group.

The sectors covered in the selection process were: private, public and academia. There was also some consideration given to include stakeholders from different levels i.e. local, regional and national levels.

The respondent frequency of contacted stakeholders was 13 out of 19 who were interviewed. The rest did not respond or did not find a time slot for us during the interview period. 8 out of 13 persons came from recommendations i.e. snowball sampling.

3.3.2 Interview format and content

The interviews took place between March 27th and May 9th 2014. Each interview lasted between 30-60 minutes. Most of them were face to face with both authors participating, but 5 were phone interviews. 2 interviews were made by only one of the authors present. The phone interviews were in general shorter.

The interviews were semi-structured with two sets of questions (one for each methodology) that were answered during the interview. The TIS questions were individual and changed for every respondent. If one of these questions were answered in an interview before we asked it, it was left out. The SNA questions were the same for all interviews (Appendix B) and asked to all respondents (when applicable).

In all interviews, the respondents were asked about the main barriers and problems for biodiesel. They were also asked directly who could overcome these barriers.

Notes were taken during the interviews and almost all of them were tape recorded for personal use. There were no confidentiality promises made.

4 Results

The Functions of innovation System identifies the drivers and barriers for the development, diffusion and use of biodiesels, while the social network analysis targets the important stakeholders.

4.1 Functions of Innovation Systems

In this section the relevant barriers and drivers will be presented (as headlines) including possible explanations of the mechanisms and reasons behind them as well as how they affect the systems functions. It is assumed that if a TIS functions properly, according to the seven functions, then the TIS is "healthy" and growing. A barrier is understood as an activity or occurrence that restrains the process of one or more functions of innovation. It is also understood as the lack of activities or occurrences within one of the functions. Only the main drivers will be emphasised throughout this section. A drivers is understood as an activity or occurrence that propels or gives force to one or more of the functions of innovation. The barriers and drivers are normally presented within each function of innovation, nevertheless in this section they will be presented in a different way as it was deemed important for the reader to understand the biodiesel system and its barriers and drivers without the labels of the seven functions. The reason behind this is to place the results within a more realistic context rather than the framework of the methodology. At the end of this section results are presented on the phase of development of the TIS, to confirm or refute the assumption that it is in the formation phase.

Historic drivers: In search for possible drivers by an overview of Swedish biodiesel history

An analysis of the historic overview facilitates the identification of historic drivers. Many activities favour biodiesel in Sweden although some of these activities were more successful than others in propelling the system forward.

Between 1970 and 1980 the *drivers* for biodiesel (FAME) were mainly the oil crisis and the surplus production in the agricultural sector. In 1990, the Swedish government exempted RME from CO_2-tax. In 1993, the first Swedish RME company, Svenskt Ecobränsle, emerged due to government stimulation of domestic production. In 1995, the first RME pilot factory by the farmer company Lantmännen Energi AB was established. Oil distribution companies that engaged in pure RME distribution were Statoil and OK. The main customers in the RME pilot were municipalities, taxi companies and delivery firms.

Before 2000 the use of biodiesel was insignificant. The use of biofuels for vehicles between the years 2000 and 2011 is illustrated in figure 27. In 2000, the use of biodiesel (FAME) was approximately 0.1 TWh per year, while in 2011 it increased to approximately 3.1 TWh per year. There are especially two years when the biodiesel use noticeably increased: 2005 and 2010. Activities that happened around these years are possible key drivers for increasing biodiesel use.

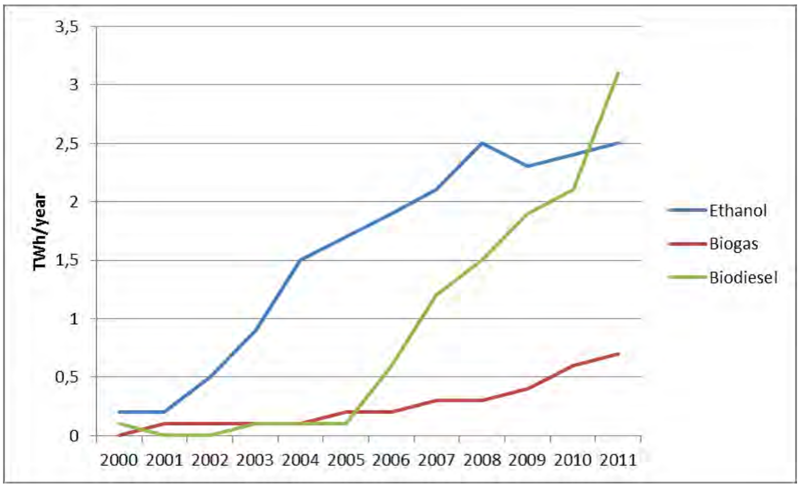


Figure 27: *Use of biodiesel (green line) in TWh/ year from 2000 to 2011 (Swedish Energy Agency, 2012 as cited in (Grönkvist et al., 2013)*

In 2004, the Swedish Parliament adopted a national target of 3% renewable transport fuels calculated as a proportion of total energy use in the transport sector in 2005 (Riksrevisionen, 2011). In 2005, the Swedish government announced its plans to be fossil fuel independent by 2020, this was followed by many activities set off to accomplish this goal (figure 27) (Pahl, 2008). In 2006 the allowed percentage of low blend FAME in sold diesel was increased from 2 vol.% to 5 vol.%. Statoil consequently announced that it would offer a 5 vol.% biodiesel blend in all of its stations.

In 2010, the EU allowed low-blends of up to 7 vol.% biodiesel in diesel (Statoil Fuel & Retail, 2013). In the same year two new biodiesel factories were inaugurated: Ecobränsle for RME production and Sunpine for tall oil used for HVO production (Pahl, 2008).

Hence, the main identified historic drivers are two institutional changes (the increase in percentage of biodiesel blend, in 2006 and 2010) which led to a *market formation* for low-blend biodiesel.

Driver 1: HVO commersialization

HVO was released into the Swedish market in 2011. SPBI (2013) and Lind (2014) from Perstorp Bioproducts AB, claim that the use of renewable fuels grew significantly between 2011 and 2012 mainly due to the rise of HVO. Although used as a low-blend (up to 20 vol.%) a major driver for HVO is that it can be blended up to 70 vol. % and used in conventional engines.

Driver 2: EU policy on emission standards

New diesel vehicles will have an advantage over new petrol vehicles in the next few years. The reason for this is the EU policy on emission standards (Directive 2009/28/EC), which states limits on average emissions on new passenger cars. According to Grönkvist et al. (2013), it will be difficult to meet the target set by 2020 (95 g CO_2/km) therefore diesel vehicles will be prefered over petrol vehicles due to their higher energy efficiency (Grönkvist et al., 2013). *This represents a driver to increase the use of diesel engine fuels i.e. biodiesels.* In 2006, 20% of all newly registered passenger vehicles were diesel cars, in 2011 the share increased to 60% and it continues to increase (Statoil Fuel & Retail, 2013; Näringsdepartementet, 2013). As an opposite, the volumes of used gasoline are decreasing (SPBI, 2013)

Barrier 1: Biodiesels are more expensive to produce than fossil fuels

Biodiesel production is more expensive than conventional diesel production, therefore it relies on political support for it to compete in the market. The production cost of petrol is between 5 and 6 SEK (figure 28). The biodiesels that currently (2013) have low estimated production costs (compared to other biodiesels) are RME and tall oil-based HVO (figure 28). The production costs for RME production is 7 SEK per litre of gasoline equivalent. HVO from tall oil has a low cost potential of 7 SEK per litre of gasoline equivalent. The uncertainty increases in estimating costs of future commercial plants. Future lignocellulosic DME production costs are estimated to less than 7 SEK per litre of gasoline equivalent, while FT-diesel costs are judged to be significantly higher, around 10 SEK per litre gasoline equivalent. Börjesson et al. (2013) believe that gasification from black liquor for the production of DME and synthetic diesel could mean a significant reduction in the production costs, but the estimations were not carried out.

Luleå University of Technology (in parnership with Chemerekc and Haldor Topsö) has a pilot plant for DME production from pulp and paper black residues through FT. Going on since the 80s and 90s, the technology is “mature” but it is still expensive. The experiment was considered unsuccessful but they continued anyway (Ulmanen, 2014).

Hence, the market development of biodiesel is highly dependent on the policy instruments in order to have a *market formation* and *resource mobilisation* (figure 30). The policy instruments in place by 2011 for biofuels were tax exemptions (state aid), Pump Act and the green car-subsidy (Riksrevisionen, 2011).

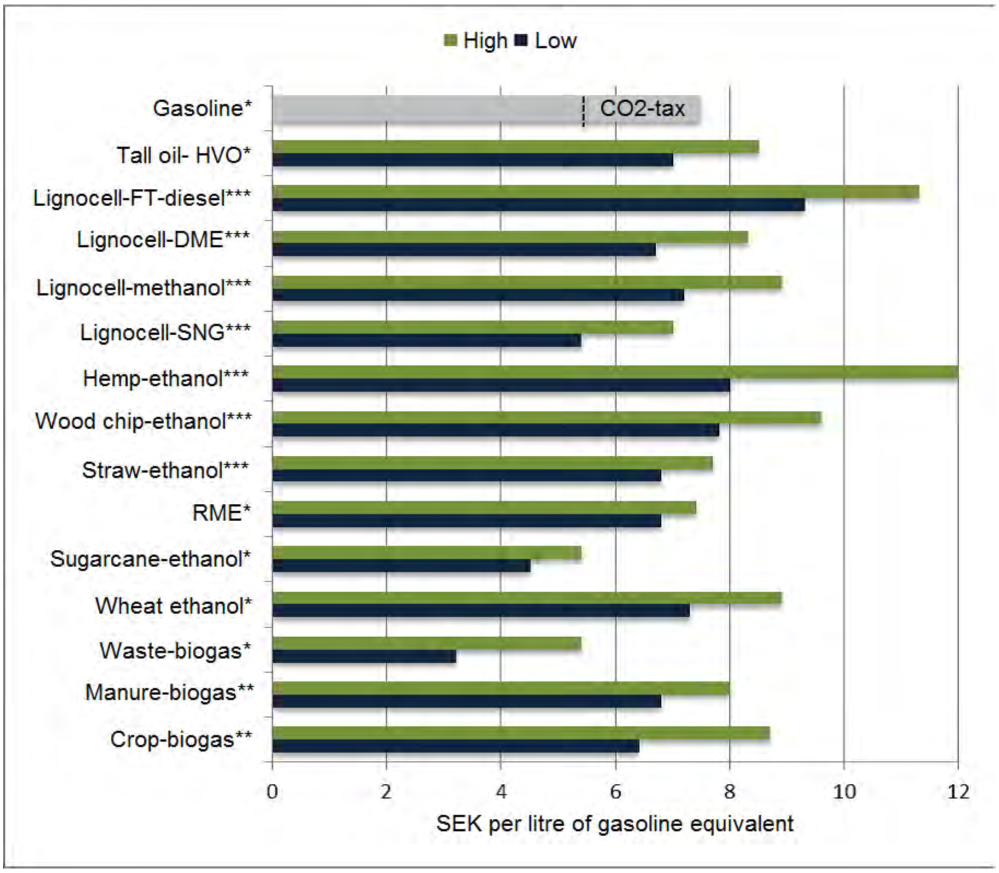


Figure 28: *The biodiesel systems are at different development stages, including some who are not yet at a commercial scale. Price variations, illustrated as low (blue) and high (green), are due to raw material costs o process design. The degree of uncertainty is illustrated with the asterisk: *=small uncertainty, **=some degree of uncertainty and ***=significant uncertainty (Börjesson et al., 2013)*

Barrier 2: Limited state aid that lacks future oriented vision

Taxes added to conventional diesel i.e. carbon tax, energy tax and VAT constitute about 55% of the price of diesel. Tax exemptions to biodiesel are set to even out differences of the costs of biodiesel production and conventional diesel production. Tax exemptions are costly to the government, as they mean a loss of income from tax charges from conventional diesel. Diesel taxes provide around 60 billion SEK to the public treasury (Statoil Fuel & Retail, 2013). Therefore, the budget for tax exemption grant is limited. During the last decades taxes has been an important instrument to influence consumers towards achieving environmental goals. Presently, 15 vol.% low-blend HVO is free from carbon tax and energy tax and 5 vol.% low-blend FAME is 100% free from carbon tax and 84% free from energy tax (Näringsdepartementet, 2013). Pure RME (100 vol.%) is completely exempted from energy tax and carbon tax (Perstorp Holding AB, 2014).

Producers have to apply for tax exemptions, which are usually granted for a period of 1-2 years in most cases and 3-5 years in a few cases, after which the producers have to re-apply. One major barrier for biofuels is the limit on the budget and the lack of future oriented policy-making in regards to biofuels (Hansson and Grahn, 2013; Riksrevisionen, 2011). Hence, current tax exemption represents a limitation to *resource mobilisation* and great uncertainty to entrepreneurs, which in turn blocks *entrepreneurial experimentation*. The final outcome from this barrier is a limited market (*market formation*) (figure 30).

Barrier 3: Low visibility of biodiesel fuels

Biodiesel has low visibility because it has been mainly blended in conventional diesel with no need for modification in vehicles and sometimes without users even realising it.

For many years biodiesel (RME) was used in vehicles in its pure form (100 vol.%) (Pahl, 2008). In 2006, the Alternative Fuel Commission recommended using low-blend biodiesel in order to reduce GHG emissions (Ulmanen, 2013). FAME blending was limited to 5 vol.% by CEN due to technical reasons (Schnepf, 2006). Since 2009, it is allowed to blend 7 vol.% biodiesel into diesel according to the new Fuel Quality Directive (Riksrevisionen, 2011).

In 2012, most of the biodiesel was used in a low-blended form, 85.5% of the FAME was used as low-blend (5-7 vol%) while most of the HVO was also used as low blends (up to 20 vol%) (Energimyndigheten, 2013; SPBI, 2013). Diesel distributors incorporate low blend biodiesel fuels to all their "biodiesel customers". Jacobsson from Volvo Cars commented that it is possible that diesel users are not aware that they are consuming biodiesels in a low-blended form (Jacobsson, 2014).

Therefore the *articulation of demand* is not typically done by the users directly but through intermediary organisations. These intermediary organisations facilitate the use of biodiesel to the users though standardisations (biodiesel fuels) and certifications (biodiesel vehicles). Decisions on standardisation in Sweden involve relevant stakeholders, such as oil companies, vehicle manufacturers, biofuel producers, etc. (Jacobsson, 2014).

Hence, *low visibility of biodiesel* leads to poor *legitimation* by users, and to an articulation of demand mostly managed by intermediary organisations whom are *influencing the direction of search* (figure 30).

Barrier 4: Weak market for biodiesel in a high blend form

As stated before, in 2012 most of the biodiesel was low-blend. The market for biofuels in its low-blended form is close to being saturated. Some interviewees think that there are no more obstacles for biodiesel use in the low-blend form, yet there are many identified obstacles for the high-blend biodiesel (Jacobsson, 2014).

Additional resources are needed for the use of medium or high-blend biodiesel, mostly in the form of *complementary assets*. FAME requires dedicated engines or vehicle certification if it is used in a blend-in volume greater than 7 vol.% (Grönkvist et al., 2013) while DME cannot be blended into conventional diesel as it requires separate distribution and special vehicles (Näringsdepartementet, 2013; Nyström, 2014). The European Emission Standards states that exhaust emissions of new vehicles have to be under acceptable limits. Therefore vehicle have to be tested for all fuels, including biofuels, and certified only if the emissions comply with the limits. The certification process is done by the vehicle manufacturers which have do new tests for the introduction of a new engine or a new fuel. However, “a large portion of the cost of development of engines consists of adapting to the increasingly stringent regulations for exhaust emissions and fuel consumption within the EU” (Näringsdepartementet, 2013). An employee at Volvo Group stressed during the interview that certification takes time and money, without guarantees that the biodiesel suited vehicles would be sold (Röj, 2014). This means that although some novel fuels are technically possible to use (emission testing procedure is not required for experimentation), there are operators that are not interested their use. In order to introduce the fuel into the market, it is first necessary for society to “believe” that the fuel would contribute to solving climate change and energy problems and for vehicle manufacturers to “believe” there is enough of a market for the biofuel (Näringsdepartementet, 2013).

Blend in regulations by the Fuel Quality Directive represent an additional obstacle as they limit the use of biodiesels (Nyström, 2014). If the blend in regulations on blending limits are surpassed, users run risks on losing validity of the vehicle warranty.

According to an employee from Volvo Group, tax exemptions on high-blended forms could present an economic incentive big enough to drive the market and this could represent a strong driver (Röj, 2014). Tax exemption is only granted to the fraction of biodiesel used (only if this fraction complies with the sustainability criteria as stated in RED). Therefore, a higher blending volume "translates" into higher economic incentives. Nevertheless there is a limit to the economic incentive. As stated in the Article 107 of the EU Treaty, the government is not allowed to over-compensate biofuels over conventional fuels. Therefore, the economic incentives are limited and controlled.

Vehicle manufacturers, mainly Volvo, which pay much attention to fuel properties prefer other biodiesel types over FAME when increasing the blend-in percentage over 7 vol.% (Röj, 2014; Jacobsson, 2014). An employee at Volvo Group stated that although FAME complies with the standard EN 14214, the "standard is not taking care of everything" in matters of quality and its use demands "higher service costs".

Hence, there are no barriers for the use of biodiesel (FAME and HVO) in its low-blend form, but there are many barriers that prevent the *market formation* of high-blend biodiesel. Many of the barriers are intrinsically related to *resource mobilisation*. High-blend biodiesel require more resources in the form of special vehicles, vehicle certifications, different distribution infrastructure, and so on. They also require *legitimation*, which means that they require for society and vehicle manufacturers to "believe" in them. Present regulations also restrict the use of biodiesel in its highblend form: blending in regulations (Fuel Quality Directive) and vehicle certification (European Emission Standards). These barriers impact the *market formation* of high-blend biodiesel and the entrepreneurial activities such as *entrepreneurial experimentation* (figure 30).

Barrier 5: Petition on regulatory change for HVO

HVO can be blended in conventional diesel in high percentage, nevertheless it it has different barriers than other high blend biodiesels. Drop-in biodiesel are those that can be added in high percentages to conventional diesel without requiring modification of the engine or the fuel system. HVO is the only commercially available drop-in biodiesel in Sweden. HVO is more similar to regular diesel (Hansson and Grahn, 2013). According to Eriksson (2013) as stated in the Näringsdepartementet (2013) HVO can be blended in diesel up to 70% and the diesel will still be at a acceptable quality standard. According to the FFF investigation Näringsdepartementet (2013) the obstacles for drop-in fuels are not so much in the "motor side" but rather in the supply of raw materials, technological maturity of the production process and the final cost of the product. According to Jacobsson, HVO production requires higher investment costs than FAME production (Jacobsson, 2014).

A strong obstacle for HVO is the (SFS2013:859, 2014) proposal which intention is to classify HVO as a conventional diesel due to its similarity (in terms of chemical formula and/or CN number) with diesel. However Sedin Sedin (2014) argues that HVO is a biofuel within the meaning of the Renewable Energy Directive. If the proposal enters into force HVO would be the only high blend biofuel in Sweden taxed with full energy tax. This will discourage use of HVO as a biofuel according to the Swedish Energy Agency (2013). Hence HVO requires additional *financial capital* in the form of seed and venture capital, and governmental funds in the form of tax exemption. The *Petition on regulatory change for HVO* represents a barrier for *resource mobilisation*, *Entrepreneurial experimentation*, and *market formation* 30.

Barrier 6: Environmental concerns

Environmental concerns refer to concerns of the environmental impacts of the biofuel life cycle, compared to conventional fuels. The main concerns are the GHG emission reduction from biofuels and the increased need of resources for biofuel production.

According to RED, biofuels have to be produced in accordance with the sustainability criteria. The aim of the criteria is to ensure reduction in GHG emissions. Biofuel GHG emissions are compared to those of the conventional fuel they are replacing. GHG emission reductions of using biofuels rather than the conventional fuel is presented as percentage (by using GHG emissions of conventional fuel as the divider). This partially means that GHG reductions from biofuels have to be at least 35% today, at least 50% in 2017 and at least 60% in 2018. Biodiesels commercialised today barely fulfil the requisites set for 2018, e.g. Perstorp offers pure biodiesel with emission reductions of 60% emissions reductions. Furthermore, biodiesels have poorer performance compared to other biofuels (figure 29).

Today, there are many efforts to “steer” biofuels towards second generation biofuels mainly due to the environmental impacts related to agricultural based biodiesels i.e. indirect land use change impacts (iLUC) and the food versus fuel dilemma. This represents a barrier for first generation biodiesels (FAME), but a advantage for second generation biodiesels, such as HVO and DME produced from non-edible sources. First generation biofuels are considered to have a limited role in decarbonising the transport sector, according to the European Commission (2014a). The amendment to RED (October 2012), proposed three modifications i) a cap on food-based biofuels at 5% of total fuels, ii) the contribution of biofuels based on residues, waste, non-food cellulosic material and ligno-cellulosic material counted as *four times* (towards the target) compared

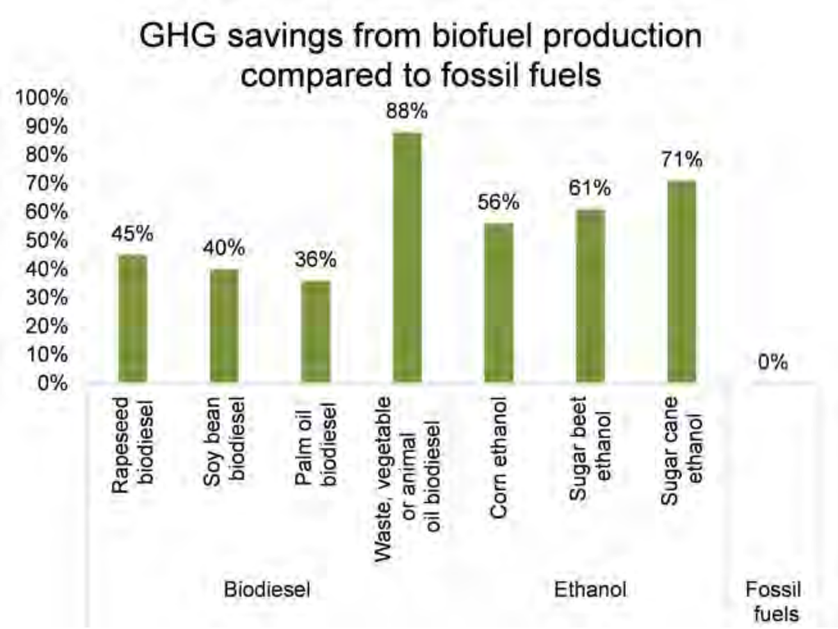


Figure 29: *Biofuel GHG emissions are compared to those of the conventional fuel they are replacing. GHG emission reductions of using biofuels rather than the conventional fuel is presented as percentage. The figure includes the conventional fuel which has an emission reduction of zero percent. Calculations were made in RED according to the life cycle assessment methodology described in the Directive appendix (European Parliament and the Council, 2009a as cited in Grönkvist et al. (2013))*

to other sources, and iii) a 60% minimum GHG reduction in installations with productions starting on July 2014 (instead of 2018), (Grönkvist et al., 2013). The proposal for amendment to RED, undecided until mid or end 2014, is likely to restrain investments on biofuels and this is a barrier for their development (SPBI, 2013).

It was established on April 2014 that public state aid (tax exemption) to biofuels would be granted in favour of advanced, "sustainable biofuels", while support to "food-based" biofuels would only be limited and granted no later than 2020 (European Commission, 2014b; European Biofuels Technology Platform, 2014). Other opponents to first generation biofuels are private companies with interest in agricultural crops, such as Nestle (Röj, 2014).

Research is focusing on second and third generation biofuels and on ways to substitute edible crops for non-edible alternatives for the production of first generation biodiesels. Potential feedstock that are in focus are lignocellulosic feedstock and waste, as well as algae and microorganisms. Perstorp, for example, is doing research on how to substitute rapeseed oil for oil-rich algae for the production of FAME (Näringsdepartementet, 2013).

Hence, environmental concerns represent a barrier for the *legitimation* of biodiesel, mainly on "first generation" biodiesels, which at the same time serves to *influence the direction of search* of biodiesels towards second and third generation biodiesels (figure 30). Therefore it is mostly environmental concerns which drives R&D towards the search of new options i.e. biodiesel based on non-edible feedstock.

Barrier 7: Feedstock limitations

There are limitations to feedstock acquisition in the sense that feedstock is either produced outside of Sweden or it is difficult to scale up. In Sweden, commercially biodiesels include FAME, mainly in the form of RME produced from rapeseed oil, and HVO. In 2010, 95-97% Swedish rapeseed production was allocated to the food sector, consequently most of RME used in Sweden is imported in the form of RME, rapeseed oil or rape seeds (Shahin, 2012 as cited in (Brandin, 2013)). A study carried out by Börjesson and colleagues (2010) shows that Swedish conditions are not particularly favourable for the production for RME, therefore it is considered not to be possible to increase the RME production in Sweden. Ulmanen suggests that the lack of rapeseed production is attributed to the fact that rapeseed is a temporal and low yielding crop (Ulmanen, 2014). These two arguments explain the limitations on scaling up rapeseed production, nevertheless, do not explain why rapeseed is currently cultivated for food purposes and not for energy purposes. Research is focusing on finding alternative feedstocks for the replacement of edible crops. Perstorp, for example, is looking into ways to replace rapeseed oil for algae oils in the production of FAME (Lind, 2014).

Currently (2014) HVO used in the Swedish market is based on tall oil, rapeseed oil and animal fat (Näringsdepartementet, 2013). Tall oil is also used to produce DME, however this resource is limited and almost completely used up. Jonas from Sunpine states that SunPine uses a considerable part of the tall oil available in Sweden (Naydenov, 2014). Regarding HVO, Nyström from f3 commented that there is not much research and development on HVO (Nyström, 2014).

Regarding DME and synthetic biodiesels, Sweden has the know-how for gasification, since a pilot plant for methanol (precursor of DME) started in the 80's (Ulmanen, 2014). Nevertheless, it remains a challenge to commercially produce synthetic biofuels from biomass feedstocks, therefore there is still no commercial scale production (bio-DME or other synthetic biodiesels) using gasification or FT-processes (Näringsdepartementet, 2013).

Hence, *feedstock limitations* are a barrier to *resource mobilisation*, as well as *influence the direction of search* 30.

Barrier 8: Lack of strong advocacy coalitions

Advocacy coalitions are defined as "people from a variety of positions (elected and agency officials, interest group leaders, researchers) who share a particular belief system" and "who show a non-trivial degree of coordinated activity over time" (Cairney, 2013). Advocacy coalitions are weak due to small and fragmented networks and competition relationships among the actors in the biodiesel community.

There are small networks in Sweden where stakeholders discuss biodiesel topics. Svebio is a formal network used for knowledge diffusion and lobbying (Kåberger, 2014). Swedish Petroleum and Biofuels Institute (SPBI) is a network that only involves petroleum based industry that have diversified into renewable energy. Their major task is lobbying. European Biodiesel Board is a formal network used for knowledge diffusion and lobbying. f3, the Swedish knowledge centre for renewable transportation fuels, is a non-lobbying research organisation that does system oriented R&D and fosters interdisciplinary collaboration between relevant stakeholders i.e. politicians, government authorities, research groups, and industry. SIS is an important identified organisation where discussion and decisions on biofuel properties take place.

The standardisation organisations (CEN and SIS) are identified as fora where cooperation between producers, users and distributors already exists (Röj, 2014). This means that stakeholders from different parts of the value chain already work together with some aspects of biodiesel Kåberger (2014), former chairman or Svebio, stated that it easy for anyone to block the development of the coordination processes throughout the value chain.

Additionally, there are informal networks characterised by alternation of cooperation and competition depending on the situation and the actors interests (Ulmanen, 2013). One of the stakeholders stated that the biodiesel community is small enough for everybody to know each other yet there is competition against different biofuels instead of against fossil fuels (Lind, 2014).

Overall, the actors are fragmented into small formal networks or informal networks characterised by alternation of cooperation and competition. Therefore, it is assumed that the degree to which the group of actors are aligned in views and coordinate for learning or lobbying purposes is intermediate or even poor.

This represents a barrier for *knowledge development and diffusion*, *legitimacy diffusion* and *development of positive externalities* 30.

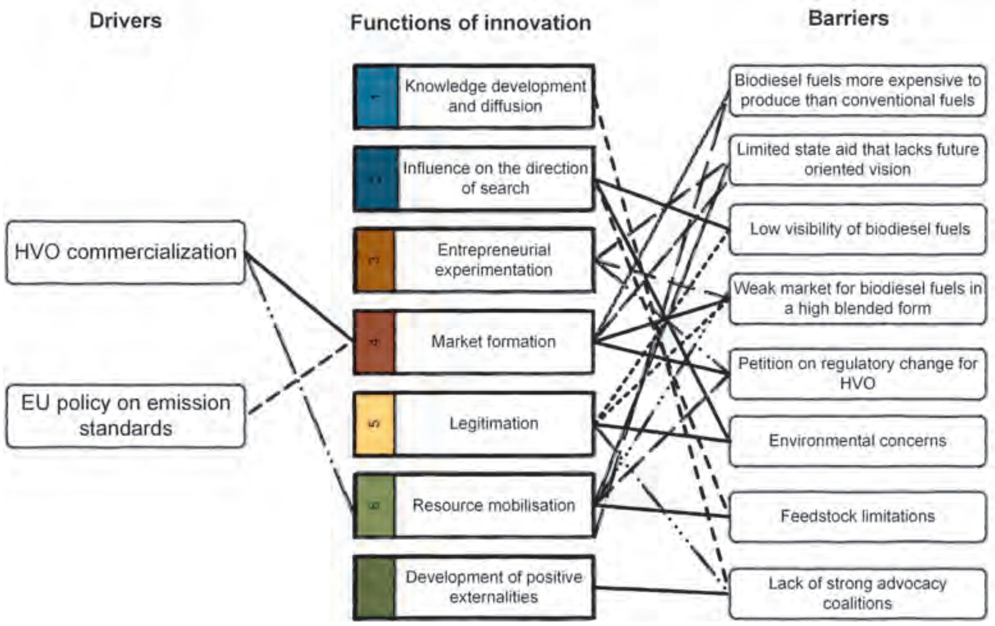


Figure 30: *The methodology on functions of innovation systems (FIS) was used for the identification of two drivers and eight barriers. These divers and barriers either block or enable one or more of the seven functions of innovation. The 'well functioning" of all of the functions of innovation within the biodiesel system (composed of actors, networks, institutions and technological artifacts) enables the achievement of the final outcome: the development, use and diffusion of biodiesel fuels.*

Phase of development

Biodiesel in Sweden is considered a technology in formation. According to Bergek et al. (2008b) the formative phase has the following characteristics, most of which are fulfilled:

- The formation phase of a TIS is rarely shorter than a decade, although it can sometimes last for several decades.
- There are large uncertainties in terms of technologies, markets and applications.
- The price and/or performance of the products are not well developed.

- The volume of diffusion and economic activities remain a fraction of the estimated potential.
- The product demand is not well articulated
- There is absence of self-reinforcing activities i.e. lack of positive feedback and there is weak positive externalities.

Biodiesel is a technology that has been present for the last couple of decades in Sweden. Between 1970 and 1980 appeared the first two drivers for biodiesel (FAME): the oil crisis and the surplus production in the agricultural sector. If the appearance of these drivers mark the beginning of biodiesel in Sweden, it can be consequently said that biodiesel has been in Sweden for more than four decades. Therefore it is not a 'new' technology although the market for biodiesel was insignificant before 2000.

Within the biodiesel TIS in Sweden there are large uncertainties in terms of technologies, markets and applications. Many production process, for example, are being explored to produce biodiesels with different feedstocks, the prices of which are not yet defined. In regards to the market, low-blend biodiesels for personal and freight conventional vehicles is a defined market. Other markets are not well defined, and are still being explored such as the use of biodiesels with conventional diesel vehicles for ''drop-in" HVO, among many others.

The volume of diffusion and economic activities of biodiesel in Sweden remain comparatively low to those of conventional diesel. In Sweden, 2012, biodiesel fuels had only 7.6% of the market share among the total vehicle fuels for diesel engines (based on energy content) (SPBI, 2013). Therefore it is assumed that the potential for biodiesel is much greater although there are still several barriers for growth of biodiesel that could significantly limit the potential.

The product demand is most often than not articulated but actors other than the user of biodiesel. Therefore it can be said that the product demand is not well articulated due to poor involvement of the final customers.

For the biodiesel system in Sweden there is presence of self-reinforcing activities and positive externalities mostly when biodiesel (FAME or HVO) is used as a low-blend in conventional vehicles. For the use of biodiesel in other applications, markets or technologies there are little positive externalities.

4.2 Social network analysis

The SNA gives an indication of which stakeholders are considered most important by other biodiesel stakeholders. It also shows to some extent which of the stakeholders that are already connected and, on a more general level, if there are any clusters or patterns in the biodiesel community.

4.2.1 Interview-based network

The results of the stakeholder interviews mainly reflect which organisations are considered important by other stakeholders when it comes to overcoming the barriers previously identified. The interview network can be seen in figure 31. The number of nodes, which is the same as stakeholders interviewed or mentioned, is 32 and the number of edges, that is connections between them, is 40. Hence, the network is considered sparse since the number of edges is low (a graph density of 0.04). This is partly because not all stakeholders in the network have outgoing edges (no interview data), resulting in fewer connections.

The actor mentioned by most stakeholders is Preem. This is partly because they are an HVO-producer and HVO is considered a promising biodiesel, but also because Preem are seen a success story of starting biofuel production while being an oil company. The importance of Preem is represented by the size of the node which is proportional to the in-degree (number of edges pointing at the node). Another important actor is Perstorp Bioproducts AB which is producing FAME. Perstorp is considered to have a high credibility making good-quality FAME, although FAME itself is not always considered a good fuel option.

Volvo Group is the third most important stakeholder together with the government. The notation of Volvo Group is here used for all companies within the Volvo group, e.g. Volvo Technology, Voluo Bus and Volvo Powertrain. It is also important to note that Volvo Cars is not a member of the Volvo group. The importance of Volvo is an expression of the importance of cooperation between vehicle manufacturers and fuel producers (Lind, 2014).

The government, *Regeringen*, have the same in-degree as Volvo Group but if they are merged with the Ministy of Treasury, *Näringsdepartementet*, the Ministry of Finance, *Finansdepartementet* and the Swedish tax Agency, *Skatteverket*, to one node the in-degree is even higher (6 instead of 3). The reason to consider merging these nodes is that two of the main barriers mentioned by stakeholders were taxation and legislation. However, when speaking of which stakeholders that could help overcome these barriers, the interviewees mentioned different ones. Hence, the government, the Ministry of Treasury, the Ministry of Finance and the Swedish tax agency could all be considered as one stakeholder representing political interests.

The municipality of Göteborg, *Göteborgs kommun*, can be seen as a representative for the public sector on a municipality level. Their position was mentioned in relation to public procurement and the possibility to create a market for green transportation.

It can also be noted that academia was never mentioned as an influential partner. The main focus was on private actors and in particular oil companies.

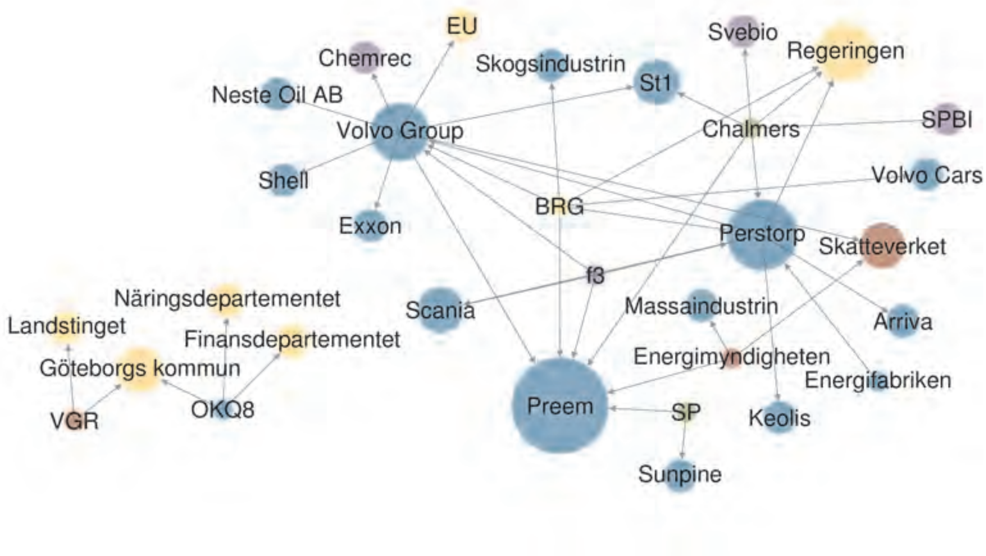


Figure 31: *Network of stakeholders and whom they have identified as a possible actor that can overcome biodiesel barriers. The colours represent in which sector the stakeholder is mainly working: green-academia, blue-private, red-public, yellow-political and purple-mixed.*

Vehicle manufacturers were also mentioned and are represented by Volvo Group and Scania.

The in-degree of all nodes with a degree > 1 can be seen in table 2. Apart from the ones describes above, the oil company St1 also has a in-degree of more than 1.

4.2.2 Article network

The article network shows which stakeholders that have published articles mentioning biodiesel together with other stakeholders and is shown in figure 32. The interpretation is that writing and publishing together is voluntary and shows how willingly two stakeholders work together and if they are prepared to have some sort of public connection.

The network consists of 38 nodes and 222 edges, making the graph density 0.316. This means that there are more connections between those who write

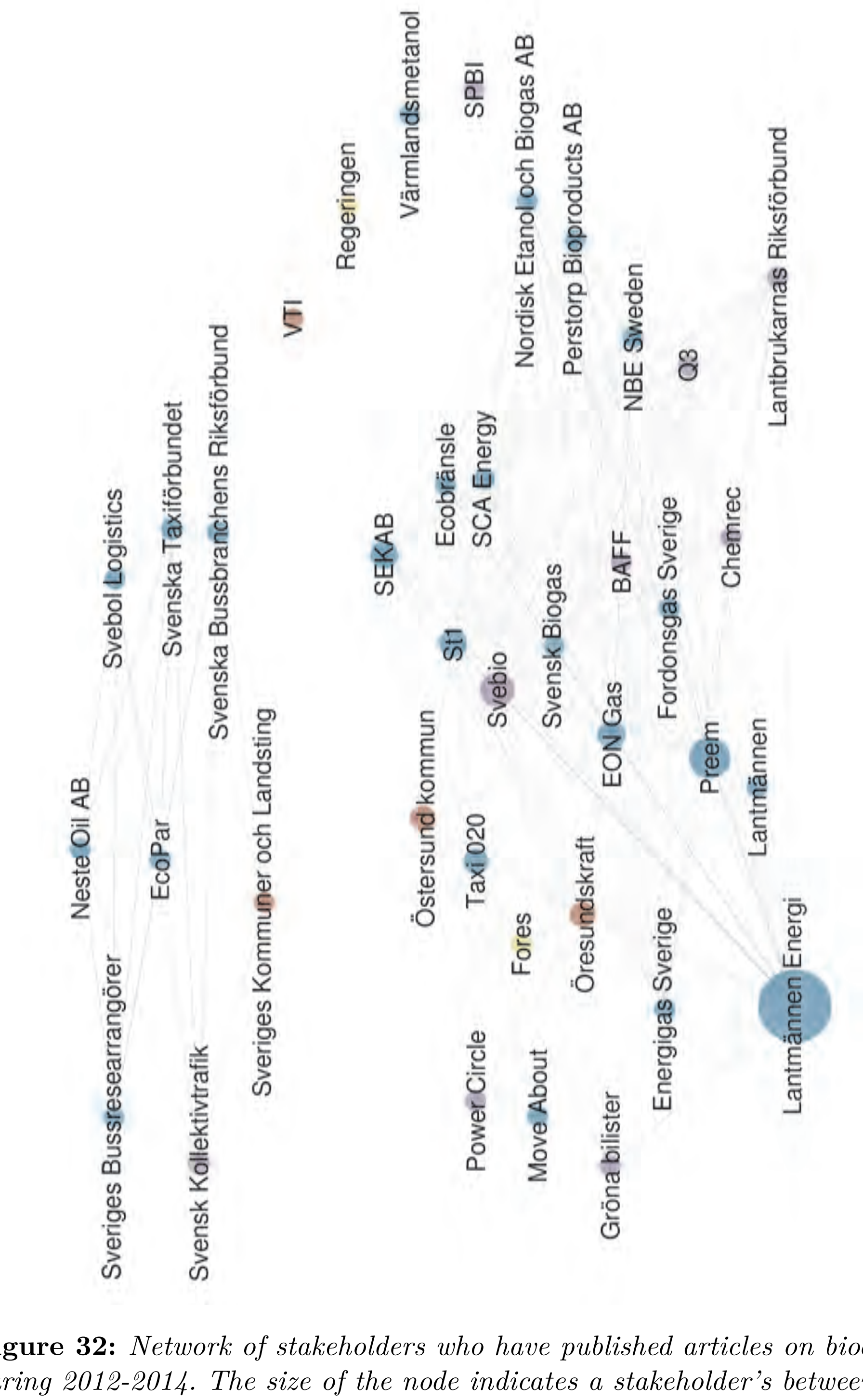


Figure 32: *Network of stakeholders who have published articles on biodiesel during 2012-2014. The size of the node indicates a stakeholder's betweenness centrality.*

Table 2: *The in-degree (how many times they have been identified as key stakeholders by others) for all nodes with an in-degree > 1. All figures are based on stakeholder interviews.*

Stakeholder	In-degree
Preem	6
Perstorp	4
Government	3
Volvo Group	3
City of Gothenburg	2
Swedish tax agency	2
St1	2
Scania	2

debate articles than from the interview based connections. As can be seen in the figure, there are two separate clusters of stakeholders. One contain e.g. Lantmännen Energi, Preem and Svebio.The other cluster contain Finnish HVO producer Neste Oil and a number of organisations for Swedish public transport, Swedish taxi companies etc.

In addition, a few stakeholders have only published articles without co-authors. The size of the nodes reflect their betweenness centrality which is a measurement of how likely the node is to lie on a path between two other nodes. Another way to put this is that a stakeholder that connects other stakeholders to a higher degree has a higher betweenness centrality.

Lantmännen Energi is the most frequent co-author with a degree of 24 (number of co-authors) and a betweenness of 62.5. Lantmännen mainly deals with ethanol and own ethanol plant, but they also represent Swedish farmers that grow rapeseed for RME and use RME. Others significant nodes in the article network are Preem, SEKAB and Svebio. Preem has already been introduced in the previous section. SEKAB is a Swedish ethanol producer and mainly co-author articles that touch upon both ethanol and biodiesel. Svebio is an organisation with 300 members with bioenergy interests. They have a subdivision called *Biodriv* of Svebio that only deal with biofuels for vehicles. Biodriv started in November 2013 (Svebio, 2014) but are here included in articles authored by Svebio.

Not all of the stakeholders work with biodiesel. Some work with other biofuels such as ethanol and biogas, but are co-authoring articles where biodiesel is also promoted.

The values of the betweenness centrality for nodes with a betweenness > 0 can be seen in table 3. The table also shows the degree and closeness of the nodes. Overall, the betweenness centrality correlates well with the degree in the article network. This can be expected as nodes with many nearest neighbours (high degree) are likely to have next-nearest neighbours and so on. This makes them more likely to be on the path between two other nodes (high betweenness).

However, Lantmännen Energi who has the highest betweenness centrality also has one of the lowest closeness centrality values. This can be seen as the fact that they are connected to many other nodes, but that a few of them lie further away resulting in a longer average path length. As the average distance to other nodes grows, the closeness centrality decreases.

Table 3: *Centrality metrics for stakeholders with a betweenness > 0. The centrality measurements are based on an analysis of articles published between 2012-2014 on biodiesel in Sweden.*

Stakeholder	Betweenness	Degree	Closeness
Lantmännen Energi	62.5	24	1.04
Preem	24	18	1.28
Svebio	16	23	1.16
EON Gas	8.4	20	1.2
St1	8.4	20	1.2
SEKAB	8.4	20	1.2
Öresundskraft	5.1	11	1.6
Östersund kommun	5.1	11	1.6
Taxi 020	5.1	11	1.6
Svensk Kollektivtrafik	1.3	7	1
Svenska bussbranchens riksförbund	1.3	7	1
Svenska taxiförbundet	1.3	7	1

4.2.3 Conference participation

Mapping the participants of conferences and seminars on biodiesel shows which stakeholders are invited by others to conferences. This can indicate the existence of clusters and partitioning between different stakeholder and also shows which stakeholders gets invited more often. The hypothesis is that those who get invited often are considered important by others.

The network is seen in figure 33 where the size of the nodes is proportional to the betweenness of the nodes. It consists of 69 nodes and 486 edges which give

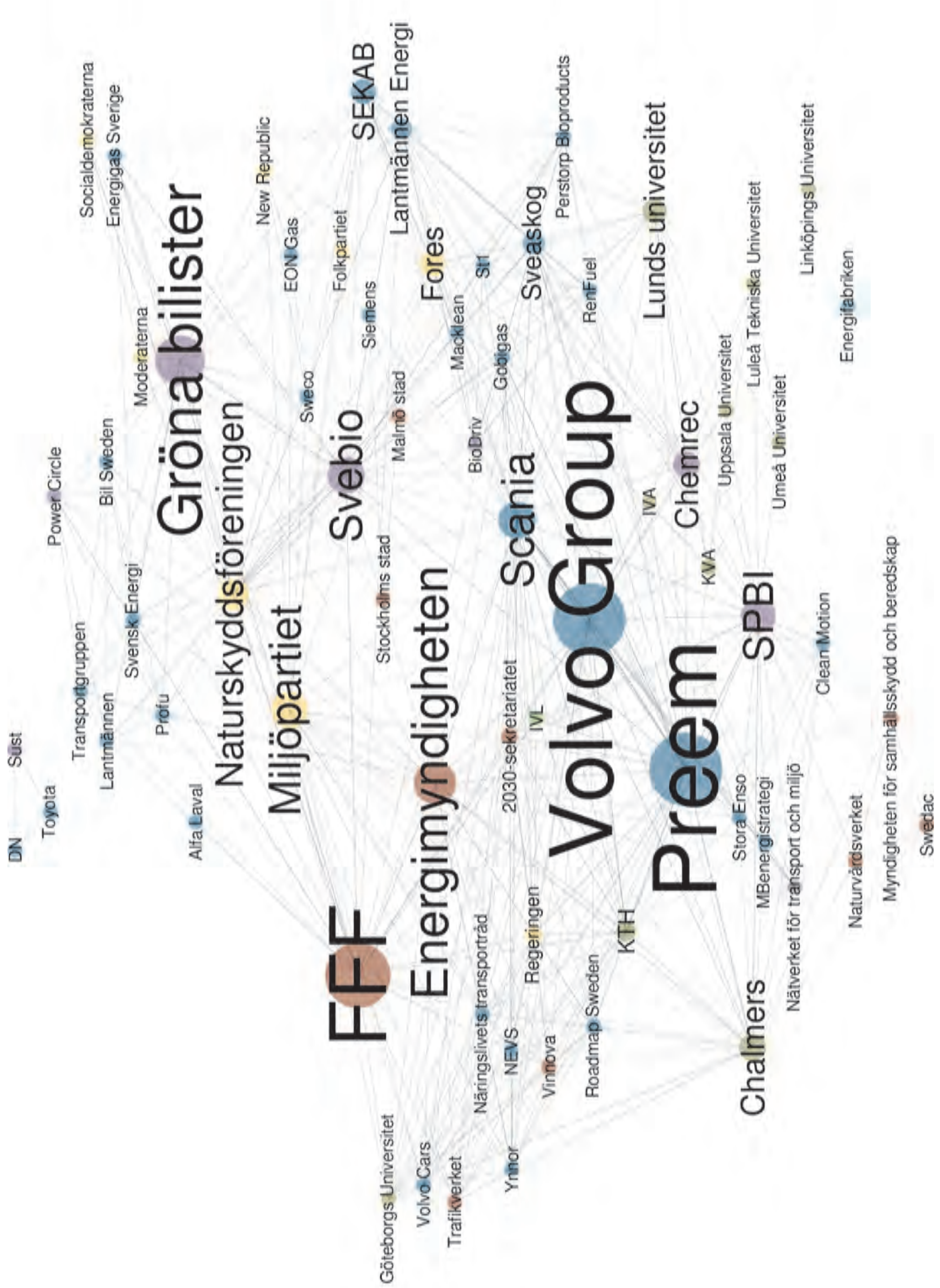


Figure 33: *Network of stakeholders who have published articles on biodiesel during 2012-2014. The size of the node indicates a stakeholder's betweenness centrality.*

a graph density of 0.204. This is denser than the interview based network but less dense than the article network. This is due to the fact that there are more stakeholders involved in conferences, hence more possible edges in the network.

Preem has the highest betweenness with Volvo Group having roughly the same. The FFF-node means that a member of the FFF-secretariat participated in a conference. Their high betweenness most likely is due to the fact that the FFF-investigation was presented at two of the seminars and was a burning issue during the investigated time period. Gröna bilister is a lobbying organisation for green cars and have participated rather eagerly in many conferences. They have both a higher degree and higher betweenness centrality in the conference network than the in the article network.

The betweenness, closeness and degree of stakeholders with a betweenness > 0 can be seen in table 4. The betweenness generally correlates well with the degree. Closeness is though less correlated. (As a reminder: closeness is a measurement of how close connected nodes are on average). KVA, the Royal Science Academy, has for example a high closeness since they are only present at their own conference together with other universities. This means that they have a close relationship to the nodes that they are connected to, but they are not connected to very many nodes.

Table 4: *Centrality metrics for the network based on conference participation at conferences during 2012-2014.*

Name	Betweenness	Degree	Closeness
Preem	248.91	42	1.33
Volvo Group	244.77	36	1.43
FFF	215.30	34	1.46
Gröna bilister	149.72	25	1.65
Energimyndigheten	116.50	32	1.49
Scania	96.31	35	1.44
Svebio	93.43	28	1.56
Miljöpartiet	93.29	24	1.62
SPBI	83.35	25	1.67
Naturskyddsföreningen	71.68	26	1.59
Chalmers	52.39	26	1.59
Chemrec	50.32	21	1.68
Fores	43.32	20	1.70
SEKAB	43.32	20	1.70
Lunds universitet	39.68	20	1.70
Sveaskog	31.75	23	1.65
Lantmännen Energi	24.36	19	1.70
KTH	19.95	25	1.60
Regeringen	5.58	20	1.68
2030-sekretariatet	5.58	20	1.68
KVA	2.10	9	2.08
Svensk Energi	1.39	11	1.95
IVL	0.69	9	1.92
Gobigas	0.69	9	1.92
Energigas Sverige	0.60	8	2.06

4

Discussion and recommendations

This chapter discusses both phase I and the Challenge Lab method and phase II with the biodiesel research project. Recommendations from our discussion are given in centered and bold text.

1 The Challenge Lab

Being the pilot students of the Challenge Lab has been an exiting experience and makes room for many reflections. It is difficult to discuss on behalf of all the Challenge Lab students therefore we will use “students” to make neutral comments of all the student members of the Challenge Lab, and “we” to make discussions on behalf of us (Cecilia Hult and Daniella Mendoza), two students out of twelve.

1.1 The Challenge Lab aims

In this section we discuss if the aims and objectives of the Challenge Lab were fulfilled and which activities facilitated or obstructed them. The aims of the Challenge Lab are wider than those stated in phase I. Here we take the opportunity to discuss the aims for phase I as well as some of the aims stated by John Holmberg (2014a):

The aims of the Challenge Lab, as stated in phase I, are i) to combine diverse competencies and to bring them together to find innovative solutions to complex problems associated with sustainability and ii) to be a "neutral arena" that brings stakeholders together in dialogue on sustainability topics.

The aims of the Challenge Lab, as stated by Holmberg (2014a) are i) "strengthen the educational dimension in the knowledge triangle within the Areas of Advance", ii) "become an important hub for the triple helix actors within the five regional knowledge clusters where all actors can gather around the students, as they all are interested in and care for the students", iii) "build trust within the clusters through students. As they often carry the capacity of simultaneously being unthreatening and challenging, they can take the role of being the highly needed change agents to society", and iv) "give the students the opportunity to develop unique skills in working across disciplines and from a challenge driven perspective".

We consider that the following aims were fulfilled:

- To be a "neutral arena" that brings stakeholders together in dialogue on sustainability topics.
- To "become an important hub for the triple helix actors within the five regional knowledge clusters where all actors can gather around the students, as they all are interested in and care for the students"
- To "build trust within the clusters through students"

The actions and activities that greatly contributed in achieving these goals were mainly i) having twelve students from seven different countries and five different master programmes which have been previously working on building trust, communication and openness and ii) bringing stakeholders from academia, public and private sectors to the Challenge Lab to speak about "sustainability topics". The interactions between students and the stakeholders can be classified into three types.

The first type of interaction was mainly in the form of lectures and Q&A-sessions with invited stakeholders. Stakeholders had different purposes within the Challenge Lab, and these purposes were previously defined between the stakeholder and the team behind the Challenge Lab. The students of the Challenge Lab were encouraged by the team to challenge the stakeholders. When doing so, we sometimes felt that we challenged only for the sake of challenging rather as a result from an inner conviction. Therefore it would be interesting for us to have a deeper knowledge of the factors that influence students (and people in general) to challenge their current situation and induce change towards a more sustainable development.

The second type of interaction was between students and the stakeholders relevant for each thesis project, mainly held at the stakeholders' locations and not in the Challenge Lab office. Interviews with individual stakeholders were the only source of interaction and our main purpose was to obtain information from them, therefore the conversations were neither creative nor challenging on our part.

The third type of interaction involved stakeholders contacted by the students who were interested in knowing more about the Challenge Lab concept. Conversations between the stakeholder and one or more students (there was an open invitation for joining) were usually about the Challenge Lab or about creative ideas on sustainability topics. This type of interaction was characterised by high creativity, freedom of speech, no defined purpose and challenging existing systems. Nevertheless we identified two areas or opportunities in need of deeper knowledge: i) find out the interest and value that stakeholders see in the Challenge Lab project and ii) discover how creative ideas can become viable projects.

We overall perceived that stakeholders were honest and open with the Challenge Lab students mainly in the first and third types of interaction. Therefore we conclude that students are considered nonthreatening mainly when students had no defined purpose behind the conversation. We also consider that there is an area of opportunity of making the Challenge Lab location a bigger "neutral arena", by making it well-known to more stakeholders and increasing its accessibility.

> **Overall, the Challenge Lab has been an interesting journey and we recommend other universities to try the Challenge Lab methodology or a modified version of it in their own innovation and sustainability work.**

We consider that the following aims were not fully reached, because we think that challenge and innovation and still weak areas (or too inexplicit to be understood) within the Challenge Lab:

- To combine diverse competencies and to bring them together to find innovative solutions to complex problems associated with sustainability.
- To "give the students the opportunity to develop unique skills in working across disciplines and from a challenge driven perspective"
- To "strengthen the educational dimension in the knowledge triangle within the Areas of Advance"

In regard to the knowledge triangle, although we consider that innovation is still a weak point, we would also consider that education is a strong point. As students, we are able to compare the education received in the Challenge Lab to previous educations (in Sweden and in other countries). We consider this education to be more “humane” and “holistic” than our previous educations. We learnt and acquired skills by working across disciplines, in the sense that we experienced many things for the first time. For example, some topics were completely outside our field of study and we got to understand the “culture” and “ways of thinking” of other disciplines. We also consider that many of the results and “take-aways” of the students cannot be readily identified or measured. We consider that we learnt a lot in the Challenge Lab and that the Challenge Lab is a good environment for professional and personal development. Sir Ken Robinson (2010) a British educator, writer and lecturer, considered to be an expert on issues related to creativity , quality of education, innovation and human resources said that “the industrial model of education is based on linearity, standardisation and conformity [...]. Human flourishing is not a mechanical process, it is an organic process and you cannot predict the outcome of human development. All you can do is create the conditions under which they will begin to flourish”. The Challenge Lab follows this “new” way of thinking about education.

We consider that although the concept of “challenge driven innovation” was at the heart of the Challenge Lab project it was not completely understood by some of the students, the role it had within the Challenge Lab (phase I) or within the projects (phase II). What was understood by us was that i) the challenge was to have a sustainable transport system in Gothenburg and that ii) diverse competencies were gathered up within the Challenge Lab to exchange information and ideas on this topic. It is also understood that phase I provides with a wide systems perspective, from which phase II emerges as a way to go deeper in addressing a “hot spot” or a “leverage point”. Nevertheless, it remains unclear what the “challenge” is in phase II. It is implicit that the challenge is too big to be undertaken by the students or groups of students within their thesis projects (phase II) therefore we consider that there is a need to reduce the challenge into “manageable” terms and then to find innovative solutions to “smaller” challenges. Therefore many questions still remain in this topic: Was our research question supposed to address a “smaller challenge”? What was the purpose to have an innovative challenge or an innovative solution to this challenge? We think that by making the ”smaller” challenge explicit it would be easier to find innovative solutions. Hence, we feel that more clarity on this subject from the Challenge Lab supervisors towards the students would be appreciated, specially when defining the relation between challenge driven innovation and the projects (phase I and phase II).

Innovation throughout the project should be reflected in the Challenge Lab (phase I), in the project (phase II) or in both. We consider that phase I was innovative as the methodology followed in the Challenge Lab was a combination of tools and frameworks never tested before. Nevertheless, we do not consider that phase II was more innovative than a "conventional" master thesis. All master theses present some degree of innovation as there are not two identical master theses. The innovation in this master thesis came from the combination of methodologies (FIS and SNA) to analyse the biodiesel system in Sweden, which lead to innovative results that filled a knowledge gap. The combination of the two methodologies has been done before, and the use of FIS to analyse biofuels (including biodiesel alone) have also been done before in other countries.

We therefore consider that even though we present innovative results associated with sustainability, that this project is not more innovative than any other master thesis. Although there was initially an intention from our part and support from the Challenge Lab team to do an innovative thesis, either consisting of a "new" problem or a "new" method/methodology, during the decision processes we fell back into what was already well tested i.e. defined solution and defined methodologies.

> **We recommend that the areas of "challenge driven" and "innovation" should be address with particular care for the next run of the Challenge Lab, since they were the main areas where the aims were not fulfilled.**

We have identified three main problems that lead to a lack of innovation. The first problem was the lack of creativity. Although there were many creative "moments" throughout the process of defining the research question, there were no major creativity breakthroughs when defining "sustainability problems" or "sustainability solutions".

The second problem was the lack of time. We consider this a problem because we prioritised the assurance of qualitative results over having innovative results. We ensured qualitative results by taking on "previously" explored research paths, therefore the "risky" and innovative ideas had a low priority and were left out once we realised we did not have enough time for them. One example of an innovative idea was to have a multi-stakeholder dialogue within a neutral arena in order for key stakeholders (identified by us) to discuss the identified barriers for the wide spread use of biodiesel and who could overcome them. This idea was cancelled due to a lack of time.

The third problem was that we focused on a "sustainability solution" rather than a "sustainability problem" i.e. biodiesel as a solution to problems associated with fossil fuel replacement for vehicles. There are more degrees of freedom for creativity when the focus is earlier on in the causal chain, starting with peoples' desires and needs. Therefore there is more room for innovation and creativity when focusing on “sustainability problems” rather than “sustainability solutions”.

> **Hence we recommend for the Challenge Lab faciliators to have more in-depth knowledge of the barriers that students can encounter when trying to develop innovative solutions to complex or wicked problems associated with sustainability; and to find ways to lower these barriers.**

The approach to complexity was presented in the project when studying the biodiesel system. Many components of the biodiesel system i.e. actors, networks, institutions and technologies were explored with the aim of understanding the complexity of the system. When evaluating if the degree of complexity that we undertook in the project was enough to satisfy the aim of the Challenge Lab i.e. complex problems associated with sustainability, we consider that this aim was reached. There are many degrees of complexity that a master thesis can undertake. Complexity can always increase when taking more factors in consideration i.e. widening the system boundaries, but this requires more resources to be used, in terms of time, tools, etc. Therefore we consider that the degree of complexity was enough to deliver concrete results to a current problem considering the limit of resources.

1.2 The Challenge Lab method

This sections contain some reflections of the method itself and how it was executed in the pilot run.

There are pros and cons with ending up in a project (phase II) at the end. The pro is that the projects might be more likely to be based on the knowledge gained in phase I. It could possibly be hard for students to kill their darlings if they have grown fond of an idea at an early stage. However, in practice most of the project did not come entirely from the insights gained during phase I.

Also, discussing with the thesis partner and prototyping a project idea was useful. For us, the choice of biodiesel as a renewable fuel was made after the phase I. We started out studying biogas (our initial project idea), but then found some indications that this might not be a promising option although it was mentioned to a greater extent by visiting stakeholders than biodiesel. So we iterated the process of choosing a topic, and started over with biodiesel but did not go through the steps of e.g. design thinking a second time. This iterative prototyping process is time consuming and could maybe be improved by letting the project formation proceed during a longer period of time.

There are also different ways to view the method and its steps. We have described them as consecutive steps but the inside-out step can be viewed as a continuous process that last throughout the Challenge Lab. It is difficult to say which perspective that is the best one, since personal development is not only achieved by actively working with self-leadership but also by taking on challenges and this is done during the entire Challenge Lab.

> **For the Challenge Lab team, we recommend them to develop the method even more for next year. The inside-out step, the interaction with stakeholders and the outside-in step should definitely be kept. Interaction with stakeholder could be extended even further and the intersection between the Challenge Lab and stakeholders could be deeper so that we all work together towards sustainability.**

1.3 The tools and frameworks

Most of the tools and frameworks were completed and delivered results, like the dialogue tools and the MLP. However, the main take-away is the sum of being introduced to a lot of new tools and hence it is hard to point at a specific tool that was extra useful. The variety of tools is one of the reasons we consider the Challenge Lab to be a great place for personal and professional development.

There were also some less positive aspects of the tools and frameworks. We consider that some results were be unsatisfactory because of three reasons i) they were based on opinions rather than facts, ii) decision making processes was not legitimate i.e. consensus or democratic processes and iii) the results were not seen as a "collective accumulated knowledge" but rather a collage of individual work and opinions that were sometimes inconsistent and not used to build upon.

We will now give some examples to illuminate there reasons. Some of the exercises, such as the compass, CLD, exercises related to design thinking, were done purely on brainstorming exercises from the Challenge Lab students. Brainstorming was useful to explore the topics in a creative and open manner but it was difficult to agree and take decisions. For example, during the CLD taking small decisions took a lot of time and there was high uncertainty on the purpose, the process and the usefulness of the exercises. Also, the brainstorming sessions could benefit from verifying theories with facts found in literature or from stakeholders.

When it came to taking decisions during the exercises, more often than not did these decisions not include all the members nmeaning that the results were not given full legitimacy. The work done within the backcasting exercises, which included the funnel, was divided within the students (some of which didn't complete their tasks) after which the results weren't revised or discussed by the rest of the group. The vision, for example, which was a step in the backcasting, was crafted by only two members of the Challenge Lab.

Hence, we ask ourselves if not evaluating these "weak points" would help achieving better overall results for the phase I, i.e. defining "better" research questions that really target the leverage points in the system.

> **We recommend the Challenge Lab team to make the most of the fact that the Challenge Lab is a place for personal development and broadening the horizon. This can be used in the marketing of Challenge Lab as well as something to keep in mind when developing the Lab further. The large set of tools and frameworks, meeting people and learning new perspectives are the main take-ways.**

Apart from the overall method, there are a few tools and frameworks that we would like to mention on their own.

Backcasting

Backcasting is a very reasonable approach to sustainable planning and could be used to an even greater extent. Instead of using existing goals we could craft our own with the sustainability principle as a benchmark. Then we could have compared the current strategies with our desired future, our vision and our decided sustainability framework.

Dialogue

Overall the dialogue tools taught were good, but they were not used much in reality. One possibility would be to have structured discussions after a dialogue session and try the tools out i.e. crafting our own dialogue sessions. This could help constructive dialogue in teh group as well as being an opportunity to practise dialogue. Learing dialogue by doing could be one way to increase the likelyhood that it would then be used in meetings with stakeholders.

Design thinking

Design thinking is an interesting framework that could potentially be very helpful. However, the current implementation might still be too closely related to product development. The prototyping of the results in the design thinking methodology could probably be very useful for getting the students to think about what they want to achieve and should be tried in future Challenge Labs.

Multi-level perspective

The multi-level perspective theory as a framework for understanding transitions of socio-technical system was interesting but only touched upon. It could even be complemented with more theories on system transition in order to understand systems from many different perspectives. Depending on the students interests, theory can be a great tool in crafting a project for phase II.

Causal Loop Diagrams

This is potentially a very useful tool to identify hot-spots and it would have been valuable to have carried the tool out completely. CLD was abandoned in the middle of the process due to time restriction, meaning that the results were inconclusive. The way we used it, the results (in the form of the groups of critical factors) were sadly ignored. Apart from time limitations, the tool is normally used to test a hypothesis and in the conventional way of using CLD the objective has to be clearly stated on beforehand. The objective in the Challenge Lab was to identify critical factors but it was not achieved.

It might be better to use it according to theory and test different hypotheses formulated by the students. Like this, the students would also practice their ability to make prototypes, testing and working iteratively. This could include verifying if your assumed connections are correct by comparing with literature. For us, it could have meant brainstorming criteria that are needed the success of a biofuel, inserting biogas in the model and then seeing if e.g. it was economically viable or energy efficient. Since we hadn't formed a hypothesis about biogas in the CLD-exercise, we had no opportunity to find the weaknesses of biogas in this analysis.

External collaboration

For the biodiesel project, the external stakeholders were the major source of inspiration. Overall, the students seems to have appreciated the stakeholder interaction. It would be exciting to collaborate even more: to train the students in innovation and sustainability and to let them truly work together with stakeholders and let their knowledge about sustainability drizzle down in the stakeholder organisations. Many of the stakeholder meetings in phase I had more the style of a lecture from the stakeholder and them providing us with their opinions. It could be due to the fact that they had much more experience in the area, but it did not feel like we worked *together* towards sustainability.

This feeling of working together towards sustainability might be achieved by connecting the Challenge Lab to some projects in an early stage of the Challenge Lab. On one hand, it would decrease the degree of freedom for the students to chose a project that exactly fits with their interest. On the other hand, working within existing frames also challenges the creativity of the students who would have to find innovative solutions that would fit into the projects.

> **Hence we offer four recommendations to next Challenge Lab projects: i) Let students understand what the "key areas" in need for innovative ideas are i.e. the "sustainability problems", ii) provide students with the right environment to develop creative ideas in these "key areas", iii) provide tools for the students to evaluate the creative ideas and turn "creative thoughts" into "rational thoughts" and iv) provide more time to complete the project (phase II).**

2 Biodiesel and stakeholders

The major finding are the drivers and barriers, being: high biodiesel production costs, limited state aid that lacks future-oriented vision, low visibility of biodiesel, weak of market for high-blends, petition on regulatory change for HVO, environmental concerns, feedstock limitations and lack of strong advocacy coalitions. Legislation being one of the identified barriers are further highlighted by the fact that the government was often identified as a key stakeholder. Driving change is in the interest of private actors that already are in the biodiesel business, like Preem.

A few points of interests about biodiesel and stakeholders are discussed in this section. There are also recommendations and comments given for researchers and research institutions, policy makers, entrepreneurs, and actors within the biodiesels value chain in Sweden.

2.1 Results

The results should best be seen as preliminary results or a pre-study of the field. The results point out to the most important drivers and barrier and the present key stakeholders, available for whomever wishes to proceed with them. However, the low availability of previous studies addressing biodiesel and stakeholders in Sweden makes it difficult to judge if our findings correlate well with current knowledge. Therefore, this thesis could also be considered as a suggestion of stakeholders, barriers and drivers to include in further studies and to be more closely examined in future research.

> **We encourage further research on the topic of biodiesel in Sweden in order for stakeholders to take strategic actions**

and informed decisions. Further research on the same research path taken in this thesis can result in strengthening some of the findings as well as challenging others. We also recommend having strong economic and legal knowledge bases in further investigations. We specifically encourage more research on barrier and drivers for biodiesel as well as prioritising the actions to be taken. From a stakeholder perspective, we recommend a more wide and thorough stakeholder analysis by including, for example, those stakeholders that were left out in this research.

The legislation and policy issues related to biodiesel need to be addressed urgently as we consider it to be one of the main barriers for the growth of biodiesel. In order to reduce the uncertainty for entrepreneurs it is best if policy aid is unconstrained and reliable.

Therefore, we consider that re-designing policy for it to be long-term and without disturbance of the government budget could allow biodiesel to grow even further. This could mean the un-blocking a strong barrier for the growth of drop-in biodiesels (now HVO), to which there are proposals for it to be taxed as a conventional diesel. There might also be room for improvement on the bureaucratic processes related to biodiesel tax exemptions and emission standard certification for vehicles.

We also encourage more research and development on second and third generation biofuels. Research should address current feedstock limitations, such as finding alternative feedstock sources for HVO production as well as research on how to transform existing plants of first generation biodiesel into second and third generation biodiesel.

Networks are important within a technological system as they allow for the transfer of tacit and explicit knowledge, creation legitimacy, influencing the political agenda by those who share a set of beliefs and ideas, etc. (Bergek, Hekkert, and Jacobsson, 2008). Only a few of the interviewees said that they saw a need for network of biodiesel actors where they could discuss these questions. One of the interviewed stakeholders claimed that there is no real need for a network because the biodiesel community is so small that the stakeholders already know what the others are doing (Lind, 2014). The lack of desire or need for a network for biodiesel could mean that there is no such need and that current structures are enough since the interviewees are in general knowledgeable about biodiesel. It could also mean that interviewed stakeholders have not realised that networks are important. Many of them did however claim that biodiesel was not getting the attention it deserved. Therefore we consider that a network for biodiesel could still be helpful in claiming for attention and support for biodiesels in Sweden, as well as for, knowledge transfer and learning. It is also interesting that academia is by no parties seen as a key to development. This could indicate that academia is separated from the private sector and does not work closely together. However, this can also mean that academia is seen as "neutral" and could act as a facilitator.

> **We encourage the creation of a network exclusively for biodiesel in Sweden. The network can address biodiesel related issues, and serve as a platform for interaction between the "biodiesel community" as well as for working together with other biofuel actors. The Svebio *BioDriv* initiative could be expanded and arranged to fulfil this role. The network should include as many actors as possible in the biodiesel value chain, but in particular bring different existing clusters together and encourage companies to work together for biodiesel development. We specifically encourage Preem and Neste Oil to work together in the development and diffusion of HVO. The network could be developed and maintained with the help of a facilitating organisation which is perceived knowledgeable and neutral by other stakeholders, f3, for example.**

In regard to low-blend biodiesels, some of the interview stakeholders considered that there are almost no barriers for these, and the market is soon to be saturated. On the other hand, an outcome of the analysis for high-blend biofuels is that there are many barriers to their growth with eventually result in a weak market: need for complementary assets, need for supporting regulation, need to solve technical challenges. Therefore, many stakeholders turn into drop-in biodisels (HVO) as a solution to increase the use of biodiesels while mostly relying on existing infrastructure.

> **We therefore encourage support from all relevant stakeholders to drop-in biodiesel as a manner to increase the growth. We encourage, whenever possible, for entrepreneurs**

> **not to wait for the public sector to take the first step and for the public sector to use their power of public procurement to boost green fuels. These actions could increase the visibility of biodiesel, increase the use of biodiesels and increase the articulation of demand by users. Furthermore, we encourage activities that focus on high-blends for the long term future.**
>
> **We consider that there is the need to solve and address the already articulated environmental concerns, in particular the food vs. fuel debate. This task although difficult and broad, requires attention for the sake of certainty and legitimacy within the system.**

One of the limitations of this study is the imbalance of interviewed stakeholders. The public sector should probably have been included to a much larger extent. This might be a reason for why private actors are represented to a much higher degree in the networks than public and political actors. Though the article and conference network also show that private actors are the most active ones, and the balance of the interviews did not affect those networks.

2.2 Method

Using interviews to collect information of the system is overall an adequate method. It gives a lot of information that is not available in written reports, since they are in general more focused on facts and figures. After all, stakeholders are the focus of this thesis so it feels only natural to use stakeholders as the main source of information. We have throughout the interviews felt that the stakeholders were very direct when talking to us.

The interviews themselves have been of varied quality as it has sometimes been hard to communicate our objectives. Some interviewees did not see any barriers at all and we believe that it is because we did not succeed in conveying what we mean by barriers. Others did not add as much as we had hoped considering that they were knowledgeable in the field. The main conclusion we can draw is that it is definitely better to do face-to-face interviews than phone interviews for clarity and understanding.

The selection of interviewees could be improved. Snowball sampling is always involves the risk of skewed results. The distribution of what level and in what sector the interviewees were acting could also be more balanced.

Time is a major limit to what a thesis can contain and there is a long list of stakeholders that would have been interesting to talk to but that were left out in this research. These stakeholders include: Klimatneutrala godstransporter (KNEG), Svebio and their biofuel for vehicles project Biodriv, Trafikverket, Neste Oil, St1, Gröna bilister, Fores, SPBI, Chemrec and politicians both on a national and a regional level.

Comparable SNA analyses have used 27, 45 and 70 sources respectively, both by semi-structured interviews and questionnaires. Compared to the 13 we have performed, this further suggests that this is an inconclusive SNA study.

Both FIS and SNA are methodologies that has not been used in the field to a great extent. This have both pros and cons. One of the problems is that it is harder to benchmark the results to similar ones. Neither biodiesel nor Swedish actors has really been the target of an SNA is this way before (at least to our knowledge).

5

Conclusion

This chapter contain conclusions from working with the Challenge Lab method as well as conclusions regarding the biodiesel research.

1 The Challenge Lab

The Challenge Lab is a methodology both for education and innovation and is intertwined with the challenge of sustainable transitions. The method has certainly helped the students broaden their perspectives by using a novel approach in their engineering educations. Most students have gained deeper understanding of themselves as well as of sustainability.

This report describes the pilot of the Challenge Lab and the authors' experience of the implementation. We also discuss the outcome of different tools and methods tested. In the end, all students in the Challenge Lab did define a research question aiming at contributing to a more sustainable transport system. So far, stakeholders have yet to come together to discuss sustainability topics but students have come together with different master's educations to work on sustainable transport solutions. The element of innovation in the method could be further accentuated and integrated into the students' work, but the complexity is thoroughly dealt with.

Our experiences during the Challenge Lab have partly helped us identify the research questions for the second part of this thesis. However, we also brought our own interest areas into the Lab which very much formed the questions.

2 Biodiesel

This thesis is an effort to fill the gap of biodiesel-specific research. By doing so, we hope that biodiesel will gain more attention and not only be considered together with ethanol or biogas. The research has resulted in identifying two drivers and eight barriers for increased biodiesel usage.

In the past, the main driver that formed the biodiesel market in Sweden was the allowed increase in the low blend in percentage. In 2006, the allowed percentage of low blend was increased from 2 vol.% to 5 vol.%, and in 2010 to 7 vol.%. Today, there are other relevant *drivers*:

- The commercialisation of HVO, much through the effort of Preem, has also helped expanding the market of biodiesel.
- EU regulation on emission standards (Directive 2009/28/EC) puts restrictions on energy efficiency which indirectly increase the demand of diesel vehicles, and consequently, increases the use of biodiesel.

The *barriers* are:

- Biodiesel relies on policy instruments for the development of a market since biofuels are in general more expensive than fossil fuels.
- State aid (one of the main policy instruments) is costly for the government and historically there has been limited state aid that lacks future oriented vision causing disturbance in the market.
- Biodiesel is mainly used in its low-blend form (up to 7 vol.% for FAME and 20 vol.% for HVO) therefore the development of biodiesel has barely been visible for the users and the public.
- The market for low-blend biodiesel is close to be saturated, but there are many obstacles for the market development for high-blend biodiesel.
- Drop-in biodiesels (such as HVO) which can be added in high percentages to conventional diesel without requiring modification of the engine or the fuel system, have different barriers than other high blend biodiesels. A strong obstacle for HVO is the (SFS2013:859, 2014) proposal which intention is to classify HVO as a conventional diesel therefore charge it with full energy tax.
- There is much environmental concern associated with biofuels, with special focus on greenhouse gas emissions and resource use, which creates a snowballing effect of lack of legitimacy, debates, political uncertainty and on hold entrepreneurial activities, etc.
- In turn, there is much attention to second and third generation biofuels, although there are some barriers associated with these, the main one being feedstock limitation.

- The actors in the biodiesel system are fragmented and the union needed for cooperation, therefore the is a lack of strong advocacy coalitions.

There are a few stakeholders with high connectivity and high credibility that should definitely be involved in future networks or efforts to promote biodiesel.

- *Preem* is the key representative from the oil companies, but also other oil companies such as St1, OKQ8, Shell or Statoil could be beneficial to include.
- *Volvo Group* is the most important vehicle manufacturer working with biodiesel, but there is also Scania. Volvo Cars have a marginal role.
- Government or ministry involvement is crucial for the development of policy instruments.
- Public sector on a local or regional level could also be included in future work and could, via public procurement, create market opportunities for biodiesel. This includes organisations such as Svensk Kollektivtrafik and Sveriges kommuner och landsting.
- There are also a few partitioned clusters. Finnish HVO-producer Neste Oil and Preem seem to not work together even though they both deal with HVO.

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A

Contact list

Date of contact	Organisation	Person	Result
2014-02-28	Perstorp Bioproducts AB	Lars Lind	Interviewed
2014-03-13	Chalmers	Staffan Jacobsson	Interviewed
2014-03-14	Chalmers	Tomas Kåberger	Interviewed
2014-03-24	Gröna bilister	Jakob Lagercrantz	No reply
2014-03-24	Energifabriken	David Varverud	Interviewed
2014-03-25	SP	Hans Hellsmark	No reply
2014-03-25	SP	Johanna Ulmanen	Interviewed
2014-03-27	BRG	Maria Strömberg	Interviewed
2014-03-27	Västra Götalandsregionen	Hans Fogelberg	Interviewed
2014-03-14	F3	Ingrid Nyström	Interviewed
2014-04-07	OKQ8	Erik Stenströmer Moglia	Interviewed
2014-04-07	Preem	Eva Lind-Grennfelt	No interview
2014-04-07	Volvo Cars	Lisa Jacobsson	Interviewed
2014-04-07	Chalmers	Maria Grahn	No reply
2014-04-08	Sunpine	Valeri Naydenov	Interviewed
2014-04-21	VTI	Lina Jonsson	Interviewed
2014-04-22	Energimyndigheten	Kristina Holmgren	Interviewed
2014-04-14	Volvo GTT	Anders Röj	Interviewed
2014-04-21	GU	Thomas Sterner	No interview
2014-02-28	Chalmers	Vilhelm Verendel	Interviewed
2014-04-22	Svebol Logistics	Martin Svedin	No reply

B

Standardised questionnaire

Questions for stakeholders

Name of interviewee:
Organisation:
Date:

Circle stakeholder properties						
Sector:	Private	Public	Academia	Politics	NGO	Mixed
Role:	Producer	User	Facilitator	Distributor		
Resources:	Capital	Knowledge	Official power	Human capital	Biodiesel	
Level:	Local	Regional	National			

Questions on Functions of innovation systems

Entrepreneurial activities

- Do you know how many companies are being formed per year related to biomass based diesel?
- Do you know the number of experiments run per year related to biomass based diesel?
- Is your (name of company/organisation) is running any experiments on biodiesels? Are these experiments considered a success or failure?
- Do you consider the test trial successful?
- Which are the actors/companies involved in these trials?

Knowledge development and diffusion

- How many workshops and conferences have been organised on the topic of biomass based diesels?
- Are there any networks organised specifically on biomass based diesels? If so, please specify the size and intensity of the networks and their purpose.
- Are you a member of any network or organisation working with biodiesel products?

Influence on the direction of search

- What is your opinion of RME in comparison to HVO or DME?
- Which biofuels you think receives more attention, resources and acceptance within the political arena?

Market formation

- Do you see any strong competitors?
- Have you perceived any change in the market size though time?
- Have you encountered difficulties with the market formation?
- What is (name of company/organisation) market share of the bio-diesel (RME) in Sweden?

Legitimation

- Can you name a project/company/technology that you consider successful in increasing the legitimacy of biodiesel?
- Do you perceive that biodiesels are widely accepted in Sweden?
- Do you know what are the attitudes towards biodiesels among the different stakeholders?
- Do you see bio-diesel as a legitimate bio-fuel?

Resource mobilisation

- Do you know how much capital and venture capital is being invested in the value chain of biomass based diesels?
- Has there been resource mobilisation, in terms of human capital, financial capital, etc. allocated to the bio-diesel systems?
- Does your (name of company/organisation) receive any type of external aid (i.e. financial support, government funding, an organisation with training programs on bio-diesel)?
- What is the volume of feedstock (e.g. of crude tall oil) used by your company/organisation?

Development of positive externalities

- Do you remember any event that radically affected the biodiesel system (i.e. change in regulation, adoption of a technology, etc.)?

Barriers and drivers

- What are the barriers and drivers you perceive in biodiesels?

Others

- Which other companies or actors are part of the bio-diesel value chain? How is your relationship with other actors within the bio-diesel system (producers, consumers, vehicle manufacturers)?
- How is your perception on how the actors in the biodiesel systems relate to each other? You think there is more competition, cooperation or collaboration?
- Do you consider that there needs to be coordination between fuel producers, fuel distributors and car manufacturers? How is this coordination being handled?
- Which is (name of company/organisation) production share and who are the other RME producers?

Questions on stakeholders and networks

1. Name the organisations (companies, institutions, NGOs) that you believe have the power to overcome the identified barriers.
2. Are you member of any biodiesel network or have participated in any conferences? If yes, which?
3. Can you name a project/company/technology that you consider successful in increasing the ligitimacy of biodiesel?

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List of published articles and authors

Name	Organisation	Date	Link
Lena Bruce	Svebio	25/3 2014	www.atl.nu/synpunkten/regeringen-har-satt-grimma-p-biodrivmedlen
Stefan Sedin	Svensk Kollektivtrafik	30/1 2014	www.svenskkollektivtrafik.se/Documents/ÖverklaganbeskattningavHVO-oljorEU.pdf
Charlotte Wäreborn Schultz	Svensk Kollektivtrafik	13/9 2013	www.svenskkollektivtrafik.se/Global/Nyheter2013/HVO.pdf
Gunilla Glasare	SKL	13/9 2013	www.svenskkollektivtrafik.se/Global/Nyheter2013/HVO.pdf
Göran Forssen	Svenska Bussbranchen	13/9 2013	www.svenskkollektivtrafik.se/Global/Nyheter2013/HVO.pdf
Per Juth	Svenska Taxiförbundet	13/9 2013	www.svenskkollektivtrafik.se/Global/Nyheter2013/HVO.pdf
Charlotte Wäreborn Schultz	Svensk Kollektivtrafik	25/4 2013	www.svenskkollektivtrafik.se/Global/Omoss/remisser/2013/remiss_kvotplikt_biodrivmedel.pdf
Petter Holland	Preem	14/2 2014	www.gp.se/nyheter/debatt/1.2278724-fossilfri-trafik-kan-ordnas-vid-pumpen
Carl von Schantz	Lantmännen energi	14/2 2014	www.gp.se/nyheter/debatt/1.2278724-fossilfri-trafik-kan-ordnas-vid-pumpen
Lena Bruce	Svebio	25/3 2014	/www.dn.se/debatt/nya-reglerna-for-biodrivmedel-ar-orattvisa
Johanna Jusslia Hammes	VTI	24/2 2014	www.dn.se/debatt/nya-regler-for-biodrivmedel-gynnar-mest-producenter

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Fredrik Törnqvist	Neste Oil AB	7/2 2014	www.dn.se/debatt/mest-klimatsmarta-branslet-missgynnas
Anna-Karin Hatt	Regeringen	18/3 2013	www.svd.se/opinion/brannpunkt/sa-ska-drivmedlen-blir-mer-fornybara_8005828.svd
Alarik Sandrup	Lantmännen Energi	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Anders Östlund	Öresundskraft	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Ann-Sofie Andersson	Östersunds kommun	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Fredrik Scholander	Taxi 020	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Gustav Melin	Svebio	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Tina Helin	EON gas	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Jonas Siden	ST1	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Martin Prieteu	Gröna bilister	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Mattias Goldmann	Fores	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Olle Johansson	Power Circle	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Ulf Jakobsson	Move about bilpooler	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Ylwa Alwarsdotter	Sekab	16/12 2013	www.aftonbladet.se/debatt/article18018512.ab
Andreas Eklund	EcoPar	2/8 2012	31.216.32.137/forum/ordet-ar-fritt/nya-miljozonsregler-dyrt-och-daligt-for-branschen
Lena Bruce	Svebio	25/3 2014	www.atl.nu/synpunkten/regeringen-har-satt-grimma-p-biodrivmedlen

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Mattias Goldmann	Gröna Bilister	27/9 2013	www.atl.nu/synpunkten/l-t-bli-att-beg-ra-l-ngsiktiga-spelregler
	Värmlandsmetanol	8/10 2012	www.atl.nu/synpunkten/skatter-viktigare-n-klimat-f-r-regeringen
	Gröna bilister	16/1 2012	www.atl.nu/synpunkten/regeringen-slarvar-bort-m-jlighet-f-r-gr-na-n-ringarna
	Svebio	25/10 2012	www.atl.nu/synpunkten/marken-r-cker-till-mycket-biodrivmedel
Fredrik Törnqvist	Neste Oil AB	14/1 2014	www.dagenssamhalle.se/debatt/regeringen-straffbeskattar-miljoevaenliga-braenslen-7350
Per Juth	Svenska Taxiförbundet	14/1 2014	www.dagenssamhalle.se/debatt/regeringen-straffbeskattar-miljoevaenliga-braenslen-7350
Toni Schönfelder	Sveriges Bussresearrangörer	14/1 2014	www.dagenssamhalle.se/debatt/regeringen-straffbeskattar-miljoevaenliga-braenslen-7350
Martin Svedin	Svebol Logistics	14/1 2014	www.dagenssamhalle.se/debatt/regeringen-straffbeskattar-miljoevaenliga-braenslen-7350
Johannes Nilsson	EcoPar	14/1 2014	www.dagenssamhalle.se/debatt/regeringen-straffbeskattar-miljoevaenliga-braenslen-7350
Mattias Goldmann	Gröna bilister	10/2 2012	www.dagenssamhalle.se/debatt/ny-miljoebilsdefinition-drabbar-kommunerna-1912
Petter Holland	Preem	30/9 2013	www.nyteknik.se/asikter/debatt/article3773374.ece
Per-Olof Nyman	Lantmännen	30/9 2013	www.nyteknik.se/asikter/debatt/article3773374.ece
Carl von Schantz	Lantmännen energi	23/1 2014	www.nyteknik.se/asikter/debatt/article3799660.ece
Petter Holland	Preem	23/1 2014	www.nyteknik.se/asikter/debatt/article3799660.ece

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Alarik Sandrup	Lantmännen energi	27/10 2013	www.nyteknik.se/asikter/debatt/article3782216.ece
Gustav Melin	Svebio	27/10 2013	www.nyteknik.se/asikter/debatt/article3782216.ece
Mattias Goldmann	Gröna bilister	27/10 2013	www.nyteknik.se/asikter/debatt/article3782216.ece
Anders Fredriksson	SEKAB	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Anders Mathiasson	Energigas Sverige	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Bo Ramberg	Fordonsgas Sverige	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Carl von Schantz	Lantmännen energi	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Claes Ramel	Ecobränsle	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Gustav Melin	Svebio	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Helena Jonsson	LRF	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Jand Lindstedt	BAFF	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Jonas Sidenå	St1	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Lars Fritz	NBE Sweden	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Lars Lind	Perstorp Bioproducts	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Lasse Holm	Q3	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Max Jönsson	Chemrec	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Mikael Runesson	Nordisk Etanol och Biogas	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Petter Holland	Preem	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece

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Stellan Jakobssen	Svensk Biogas	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Tina Helin	EON gas	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Åke Westberg	SCA Energy	10/5 2012	www.nyteknik.se/asikter/debatt/article3472239.ece
Helena Jonsson	LRF	28/5 2012	www.svd.se/opinion/brannpunkt/m-och-s-maste-enas-om-energin_7233817.svd
Anna-Karin Hatt	Regeringen	31/10 2012	www.gp.se/nyheter/debatt/1.1114093-biobranslena-ska-ha-goda-forutsattningar
	Värmlands-metanol	4/10 2012	www.gp.se/nyheter/debatt/1.1084168-satsning-pa-biobransle-en-droppe-i-havet
	Värmlands-metanol	4/10 2012	www.gp.se/nyheter/debatt/1.1084168-satsning-pa-biobransle-en-droppe-i-havet
	Gröna bilister	7/9 2012	www.gp.se/nyheter/debatt/1.1057317-fossilfri-omstallning-kraver-subventioner
Mattias Goldmann	Gröna bilister	3/6 2013	hd.se/ledare/2013/06/03/konsumentmakt-vid-pumpen
Mattias Goldmann	Gröna bilister	18/6 2013	www.dt.se/opinion/1.5995304-jag-vill-veta-vad-jag-tankar-
Fredrik Törnqvist	Neste Oil AB	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel
Göran Forssen	Svenska Bussbranchen	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel
Stefan Sedin	Svensk Kollektivtrafik	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel

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Per Juth	Svenska Taxiförbundet	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel
Toni Schönfelder	Sveriges Bussresearrangörer	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel
Martin Svedin	Svebol Logistics	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel
Johannes Nilsson	Ecopar	27/12 2013	www.di.se/artiklar/2013/12/27/debatt-regeringen-straffbeskattar-vara-biodrivmedel
Bengt Westerberg	SPBI	7/3 2013	www.di.se/artiklar/2013/3/7/debatt-reglera-biodrivmedlen
Ulf Svahn	SPBI	7/3 2013	www.di.se/artiklar/2013/3/7/debatt-reglera-biodrivmedlen

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List of conferences and participants

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		Anna-Karin Hatt	Regeringen
		Per Alvfors/Göran Finnveden	KTH
		Julia Hansson	IVL
		Sören Eriksson	Preem
		Åsa Burman	Gobigas
		Jakob Lagercrantz	2030-sekretariatet
		Rolf Willkrans	Volvo Group
		Ebba Tamm	SPBI
		Tomas B. Johansson	FFF
Sverige på väg mot en fossilfri fordonsflotta	14/2 2014	Joachim Glassell	Näringslivet transportråd
		Rolf Willkrans	Volvo Group
		Jonas Strömberg	Scania
		Sören Eriksson	Preem
		Mikael Östlund	NEVS
		Jakob Lagercrantz	2030-sekretariatet
		Axel Edh	Volvo Cars
		Ulf Gustavsson	Volvo Group
		Ronny Svensson	Ynnor
		Thomas Sterner	GU
		Lars Nilsson	Trafikverket
		Karin Svensson-Smith	Miljöpartiet
		Johan Konnberg	Roadmap Sweden
		Anna-Karin Hatt	Regeringen

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		Thomas B. Johansson	FFF
		Eva Schelin	Vinnova
		Agneta Vargsjö	Trafikverket
		Magnus Henke	Energimyndigheten
			KTH
			Chalmers
Bioenergidagarna 2013	5/11 2013	Petter Holland	Preem
		Julia Hansson	IVL
		Åsa Burman	Gobigas
		Gustav Melin	Svebio
Bioenergidagarna 2012	5/11 2012	Tomas B. Johansson	FFF
		Karin Öhgren Gredegård	Alfa Laval
GIN2012		Helen Lidestam	Linköpings universitet
Energiutblick 2012	14/3 2012	Bengt Nippe Hylander	KTH
		Magnus Brandel	MBenergistrategi
		Jens Otterstedt	Sveaskog
		Mikael Hannus	Stora Enso
		Patrik Klintblom	Volvo Group
		Anders Lewald	Energimyndigheten
		Ebba Tamm	SPBI
		Paul Westin	Energimyndigheten
		Sören Eriksson	Preem
		Per Salomosson	Volvo Group
		Magnus Swahn	Nätverket för Transport och Miljö
		Maria Grahn	Chalmers
		Lars Stenqvist	Scania
		Anders Kärrberg	Volvo group
		Göran Folkesson	Clean Motion

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		Staffan Lundgren	Volvo Group
BioDrivmedelsvalet	28/11 2013	Gustav Melin	Svebio
		Jan Lindstedt	Biodriv
		Petter Holland	Preem
		Pål Börjesson	Lunds Universitet
		Martin Eriksson	Macklean
		Svante Axelsson	Naturskyddsföreningen
			Preem
			RenFuel
			Chemrec
			St1
			Perstorp Bioproducts AB
		Mattias Goldmann	Fores
		Urban Wästljung	Scania
		Jan Wintzell	Sveaskog
		Lars Lind	Perstorp Bioproducts
		Alarik Sandrup	Lantmännen Energi
		Jan Lindstetd	SEKAB
Ratta rätt mot framtiden - biodrivmedel och politik	4/7 2013	Tomas B. Johansson	FFF
		Svante Axelsson	Naturskyddsföreningen
		Mattias Goldmann	Gröna Bilister
		Anders Mathiasson	Energigas Sverige
		Gustav Melin	Svebio
		Alarik Sandrup	Lantmännen Energi
		Monica Green	Socialdemokraterna
		Lars Hjälmered	Moderaterna
Dags att sätta nya tuffare mål för förnybart i transportsektorn - 25% till 2020!	5/7 2012	Gustav Melin	Svebio
		Jakob Lagercrantz	Gröna Bilister
		Anders Mathisson	Energigas Sverige

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		Henrik Wingfors	Svensk Energi
Almedalen 2014		Karin Varverud	Energifabriken
Så når vi en fossilfri fordonsflotta - speed dating om bilen, bränslet och beteendet	3/7 2014	Mattias Goldmann	Fores
		Tina Helin	EON Gas
		Andreas Gyllenhamar	Sweco
		Martin Prieto Beaulieu	Gröna Bilister
		Stina Bergström	Miljöpartiet
		Anita Broden	Folkpartiet
		Lena Nordgren	SEKAB
		Olle Schubert	New Republic
Hur åstadkommer vi en fossilfri fordonsflotta och minskad klimatpåverkan från våra städer?	2/7 2012	Karolina Borg	Malmö stad
		Ulla Hamilton	Stockholmsstad
		Mattias Goldmann	Gröna Bilister
		Niklas Gustavssin	Volvo group
		Tina Karlberg	Siemens AB
Biodrivmedel - nu och i framtiden	7/6 2012	Sven Kullander	KVA
		Lars Tegner	Uppsala Universitet
		Anders Nordin	Umeå Universitet
		Rikard Gebart	Luleå Tekniska Universitet
		Linda Tufvesson	Lunds Universitet
		Ingvar Landälv	Chemrec
		Anders Röj	Volvo Group
		Ulf Svahn	SPBI
		Per Salomosson	Volvo Group
Hållbarhetsdagarna 2013	5/2 2013	Lasse Swärd	DN
		Bengt Dahlstrm	Toyota

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Biodrivmedel - hållbart framtidsalternativ	12/2 2013	Owe Fredhold	IVA
		Sven Kullander	KVA
		Ingvar Landälv	Chemrec
		Jan-Olov Eriksson	Preem
		Per Salomosson	Volvo Group
Cisterndagarna 2014	5/2 2014	Thomas Kåberger	Chalmers
		Sören Eriksson	Preem
		Ulf Svahn	SPBI
			MSB
		Henrik Sandström	Naturvårdsverket
		Kaarlo Book	Swedac
Vägen mot en fossiloberoende fordonsflotta Utmaningar och möjligheter	7/2 2012	Olle Hådell	FFF
			Profu AB
		Henrik Wingfors	Svensk Energi
		Anders Lewald	Energimyndigheten
		Frida Källström	Lantmännen
		Jessica Alenius	Bil Sweden
		Jonas Ericson	Svebio
		Mattias Goldmann	Gröna Bilister
		Olle Johansson	Power Circle
		Stefan Back	Transportgruppen
		Sven Hunhammar	Naturskyddsföreningen