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Drivers and hinders for a fossil-free energy system in the agriculture

a Swedish farmer perspective

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Abstract

This master thesis looked at the factors supporting and hindering Swedish farmers to produce renewable energy at farms. The main source of data used in this project was a survey answered by 1497 Swedish farmers who were member of the Federation of Swedish Farmers during the winter 2015-2016. To structure the results, Rogers' theory of *diffusion of innovation* was used. A literature review completed the survey and assessed its effectiveness.

The results showed that economic factors were the most important ones and that personal and business factors were the following most important factors. The results from the survey showed that political factors are only seen as hindering. This project highlighted that the perception of these factors differed depending on if the farms were producing energy for their own use or for selling purpose. For instance, farmers selling energy perceived that political factors, such as the lack of long-term regulations and the complexity of rules, were more hindering their development than what farmers using the energy at the farm perceived.

The drivers and hinders were broken down for three renewable energy sources (bioenergy, solar electricity, and wind power) and showed how each technology related to the different factors. Focussing on the economic factors, farmers generating renewable energy from photovoltaics panels or biomass are more satisfied about their investment than farmers who invested in wind power.

In order to overcome global warming, society should abandon fossil based practices and adopt fossil free ones. Agriculture has a role play by both reducing its own emission of greenhouse gases being a key actor for the supply of resources for fossil-free based products and services. A way to accelerate the conversion process is to apply measures that develop the existing drivers and reduce the perceived hinders. A sample of measures suggested in this project includes promotion of solutions for the supply of energy for the farm own use based on the current situation, the simplification of the regulations framing the sale of solar and wind power, and the spread of knowledge about both energy and its rules.

Summary

The coming decades are certainly the most crucial if humanity wants to overcome the challenges related to climate change and global warming. Every piece of the puzzle has to be reviewed, and agriculture is one part of the puzzle. This project looks in particular to the use and supply of renewable energy at the farm level. In order to eliminate the emissions due to fossil fuels in the agriculture, it was of interest to understand what factors push farmers to produce or buy renewable energies but also what factors prevent them from doing so. By using a survey answered by nearly 1500 Swedish farmers, the so called push-and-pull factors could be highlighted. It was not surprising to note that the economic factors are decisive: seen as a push-factor for farmers who decided to produce renewable energy, and as a pull-factor for farmers who are still reluctant to produce renewable energy. For those who are already producing renewable energy, they perceive the economic factor as a hinder to further develop their energy business. The farmers' personal factors, such as their interests for the environment, and their capacity to manage their business also plays a major role in the decision making related to the use of renewable energies in their enterprise.

The project also showed that the importance of the factors differed for the different type of renewable energies studied (bioenergy, solar, wind power), and different type of implementations (selling renewable energy, switching to renewable energy systems, making the farm more energy efficient, no implementation at all).

Sammanfattning

Endast framtiden kan avgöra om mänskligheten lyckades lösa de utmaningar som klimatförändringar och global uppvärmning genererat. För att närma sig en lösning, måste varje bidragande faktor granskas, och jordbruket är en utav flera. I denna studie har därför valt att undersöka utbud och användning av förnybar energi inom jordbruket. För att på sikt eliminera netto utsläpp från förbränning av fossila bränslen, behov utökad förståelse för vilka omständigheter som skulle leda till att jordbrukare producerar eller köper förnybar energi. Av samma anledning, var det även viktigt att förstå vad som förhindrade en eventuell investering i förnybara energikällor. Genom att låta omkring 1,500 svenska bönder svara på en omfattande enkät, var det möjligt att kasta ljus på de så kallade *push-and-pull* faktorer som låg till grund för den rådande situationen.

Oavsett om jordbrukaren hade för avsikt att investera i förnybar energi eller var ovillig att bruka förnybara energikällor, så var ekonomin den avgörande faktorn. Med andra ord så är ekonomin både en push- och en pullfaktor i detta fall. Den ekonomiska aspekten var även ett hinder för lantbrukare som redan investerat i förnybar energi men idag är i behov av att utveckla verksamheten. Jordbrukarens intresse för miljö och dennes företagsamhet är också avgörande i samband med beslutsfattande relaterat till användning av förnybara energikällor. Studien kunde även visa att olika faktorer spelade in beroende på vilken typ av förnybar energikälla som diskuterades.

För att påskynda övergången till förnybara energikällor bör de drivkrafter för ökad användning utvecklas samtidigt som eventuella hinder bör reduceras. Ett urval av åtgärder som föreslås i denna studie inkluderar främjandet att lokal energiproduktion, ett förenklande av det reglemente som omfattar sol- och vindkraft samt utvidgad utbildning i dessa frågor. Samtidigt som jordbruket spelar en viktig roll genom att minska sina utsläpp, kan jordbruket också vara en viktig aktör i tillhandahållandet av resurser för fossilfria produkter och tjänster.

Abbreviations

AAS: Agricultural Advisory Services, also known as agricultural extension services

AKIS: Agricultural Knowledge and Innovation System

AKS: Agricultural Knowledge System

CAP: Common Agricultural Policy

COP: Conference of Parties

EEff: Stands for Energy-Efficiency. Abbreviation created for this project and designating farmers who took measures to make their farm more energy efficient

ELoF: Stands for Energy-Low Focus. Abbreviation created for this project and designating farmers who have a lower focus for energy questions on their farm

ESell: Stands for Energy-Selling. Abbreviation created for this project and designating farmers who supply renewable energy which they sell

ESwitch: Stands for Energy-Switching. Abbreviation created for this project and designating farmers who switched to renewable energy systems

EU: European Union

FAME: Fatty Acid Methyl Esters, a type of vegetable oil based biodiesel

HVO: Hydrotreated Vegetable Oil, a type of vegetable oil based biodiesel

JTI: the Swedish institute for agricultural and environmental engineering

KAP: Knowledge Attitude Practice, often used to define the gap between what one knows and her or his action.

LRF: Lantbrukarnas Riksförbund in Swedish, and the Federation for Swedish Farmers in English

MWh: Mega-Watthour, unit expressing a quantity of energy. 1MWh=1,000,000 Watthour

OECD: The Organisation for Economic Co-operation and Development, a worldwide organisation aiming to promote policies that promote the economic and social well-being of people

RET: Renewable Energy Technology

RME: Rape Methyl Ester is a type of Fatty acid methyl esters based on rape seeds

RQ: Research Question

SBA: Swedish Board of Agriculture

TWh: Tera-Watthour, unit expressing a quantity of energy. 1TWh=1,000,000,000 Watthour

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Introduction

The increase of productivity of modern agriculture post world war two were eased by the development of some technologies like plant breeding, mineral fertilisers or pesticides (Egli, 2006). Moreover, the development of mechanisation powered by fossil fuels supported the development of these technologies. (Giampietro and Pimentel, 1994). The carbon dioxide release during the combustion of fossil fuels is the main contributor to climate change (IPCC, 2014). Globally, 2015 has been so far the warmest year on record and the ten warmest years were all between 2002 and 2015 (NASA, 2016). The same year (2015), probably one the most important agreement in the history of climate change was signed in Paris (C2ES, 2015). Agriculture has negative impact on the environment and contribute to about 11 % of the emission of greenhouse gases in Europe (Walls, 2006; EEA, 2016). At the same time the potential resources and services that agriculture can provide to a sustainable society are abundant. This project looks at the factors supporting and hindering the conversion of modern agriculture to a fossil free agriculture by focusing on the farmers' perspective. The project is limited to the supply of renewable energy at the farm level for own use and/or sale. To tackle climate change every single measure to decrease the emission of fossil greenhouse gases should be studied. By focusing on the energy use and supply of the Swedish agriculture energy system, this project brings its contribution to the global puzzle.

This project is part of a master degree in environmental science and has been performed in tight collaboration with and under the supervision of the Federation of Swedish Farmers (LRF).

The aim of this project was to research factors that would increase the spread of renewable energy technology (RET) innovations in the Swedish agriculture and focussing especially on a farmer perceptive. To reach this aim, three research questions (RQs) were developed to orientate and limit the project to a researchable subject given the timeframe and resources available. Each question is discussed below as well as the strategy used in order to answer them.

Research question 1 (RQ1): What are the factors that support and/or hinder Swedish farmers to adopt renewable energy technology innovations in the four different energy groups?

In order to answer the first RQ we will have to shortly introduce the energy systems in the Swedish agriculture (background), define what a renewable energy innovation is based on the theoretical framework, and then outline four different energy groups based on the findings from a survey (results).

The results from the survey are the main source of information to support the answer to RQ 1. The results of the survey shows the main factors influencing respondents to adopt or reject renewable energy innovations . Each energy group has different whys and wherefores that will be summarized. A brief literature review was performed in order to control that no factors were forgotten in the survey.

To structure the results from the survey and make the analysis clearer, a framework specially designed for this project and developed from the literature review has been used (Table 1).

Research Question 2 (RQ2): How the main renewable energy technologies relate to the factors found in research question 1?

In the survey, respondents who adopted a renewable energy innovation were asked about their experience and feedback regarding the production of renewable energy. The answers could be divided by type of renewable energy and their feedback could be assimilated to the factors highlighted in the answer of RQ1 using the same framework.

Research Question 3 (RQ3): How can renewable energy technology innovations spread within the Swedish agriculture at a higher pace?

By matching the results from RQ1 and RQ2 we will be able to give recommendations for actions that can increase the spread of renewable energy innovations within the current situation. Moreover, by looking at the results from the survey with the theory as framework we will be able to give further general recommendations concerning the knowledge part for instance. In addition, some comments will be made based on the material from the literature review and the theoretical framework. These comments are valuable information in regards to future research to be carried out.

In the first chapter relevant background information are given to readers not familiar with the energy systems in agriculture and the current practices used to spread knowledge and innovation within the Swedish agricultural system. Moreover, a brief political perceptive as well as a summary for earlier projects dealing with this project are presented.

The theoretical framework will be introduced in Chapter two there important terms and concept are discussed. Rogers' (2003) work on the diffusion of innovation is the foundation of this project and will be discussed in detail. Chapter two finishes by mentioning the main limit to Rogers' work.

The third chapter introduces the methodology used to answer the RQs introduced above. A global picture about the interaction between the different methods and data sources is sketched in this chapter. The survey used in this project is the main source of data and information and is therefore introduced in this chapter. The literature review and the framework used to analyse the results are presented at the end of Chapter three.

The results from the survey are presented in chapter four. First a comparison with existing statistics assess the reliability of the results. Then the respondents are divided in different groups based on several characteristics. Once these preliminary results are well understood, the deeper results are presented following Rogers' (2003) theory framework.

Finally Chapter five focuses on answering the three RQs based on the results introduced in Chapter four, and comments about the data gathered and future research are made.

1 Background

1.1 Energy systems within the Swedish agriculture

The Swedish agriculture has been supplying energy to the industry since the 17th century by selling charcoal to the iron industry (Larsson and Marklund, 2012). Beckman et al. (2013) argues that agriculture and energy went from a one way relationship where agriculture was using energy to a collaborative relationship where agriculture both uses and supplies energy. In the early 1990's through different initiatives, LRF and the Swedish Board of Agriculture (SBA) promoted the development of farm based bioenergy (Nitsch et al., 1991).

In Sweden, agriculture is responsible for about 1.8 % (in 2013) of the Swedish energy use (Swedish Energy Agency, 2015). On the other hand, direct energy related costs represent on average about 8.5 % of the total expenses of a Swedish farm between 2004 and 2013 and about 30 % of the operational costs (FADN database, 2016). This situation can be summarized by saying that the agriculture is not a fundamental factor for the national energy system while energy is a crucial factor for the Swedish agriculture.

The indirect energy use, for example the energy needed to produce fertilisers or make the plastic for ensilage bales, is making the energy related costs even higher. Some such as Baky et al. (2010) have looked at the indirect energy use in the agriculture, however the indirect use of energy will not be treated in this project.

The direct energy use in agriculture consists mostly of fuel for vehicles and heat. Lighting, ventilation, and other power tools driven from electricity are of secondary importance (Swedish Board of Agriculture, 2012). These energy systems will be briefly described for the Swedish agriculture.

The Europe 2020 is a strategical document setting targets for different areas to be reached by 2020. Sweden reached its target for renewable energy in 2013, which was 49 % of renewable energy in the gross final energy consumption (Europe 2020, 2016).

1.1.1 Vehicle fuel

Diesel is the predominant vehicle fuel in agriculture (95.4 %). Petrol is used for smaller machines and light vehicles (3.2 %), and rapeseed biodiesel is rarely used as substitute to conventional diesel (1.4 %) (Swedish Energy Agency and Statistics Sweden, 2013). Therefore, as most sectors, agriculture is highly dependent on fossil fuels for its vehicle fleet. However, 85 % of the diesel was blended with FAME (Fatty Acid Methyl Esters), which is a biodiesel, at a rate of 5-7 % in 2014. Assuming a blending rate of 5 % FAME in diesel, the Swedish agriculture vehicle fuel relies at 93.8 % on fossil fuels. Figure 1 shows the monthly average price of diesel in Sweden.

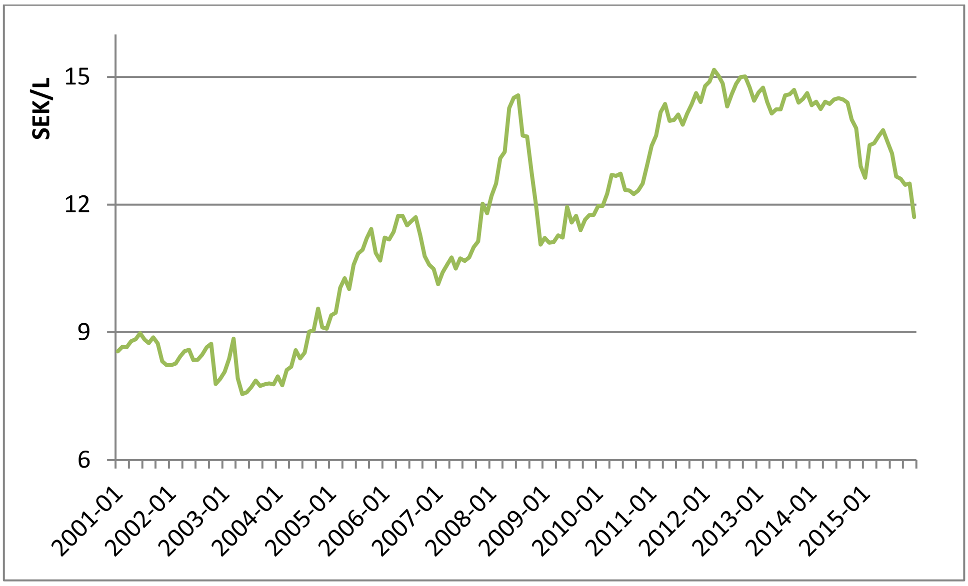

Figure 1: The price of diesel in Sweden between 2001 and 2014, monthly average (data source: Statistics Sweden and SPBI)

The price of diesel in Sweden was increasing until 2012 when it reached almost 15 SEK/L. Since then diesel price has been decreasing and was under 13 SEK/L in 2015.

The Swedish government has the ambition to have a fossil free transportation by 2030 (Ministry of Environment Sweden, 2014). This ambitious goal is seen as an opportunity for agriculture to supply with resources produced from domestic raw material needed to produce the needed biofuels (Altinget, 2016; Swedish Society for Nature Conservation, 2014).

1.1.2 Heating and drying

Heating is mostly used for animal production or in greenhouses for horticultural production. Based on the Swedish Energy Agency and Statistics Sweden (2013), the Swedish agriculture used about 3.3 TWh for heating, drying, and lighting in 2013. Sweden has access to renewable resources such as wood, pellets, wood chips or straw, which contributed to 41 % of the energy use for heating in 2013. The remaining energy needed for heating come from fossil resources (14 %, mostly oil, natural gas, and diesel) and electricity (43 %) (Swedish Energy Agency and Statistics Sweden, 2013). Assuming that different sources of electricity used for heating (hydropower, nuclear, wind, etc.) follows the national energy mix, 32 % of the energy for heating in the Swedish agriculture is fossil (Swedish Energy Agency, 2015). Börjesson (2016) shows that the Swedish agriculture has a great potential to increase its production of biomass that can be used mainly for heating and drying purposes but also electricity supply, and therefore could reach an independent fossil-free energy system when it comes to heating and drying with the opportunity to sell biomass to other sectors too. Figure 2 shows the yearly average price of different biomass resources, expressed in Swedish Kronor per MWh.

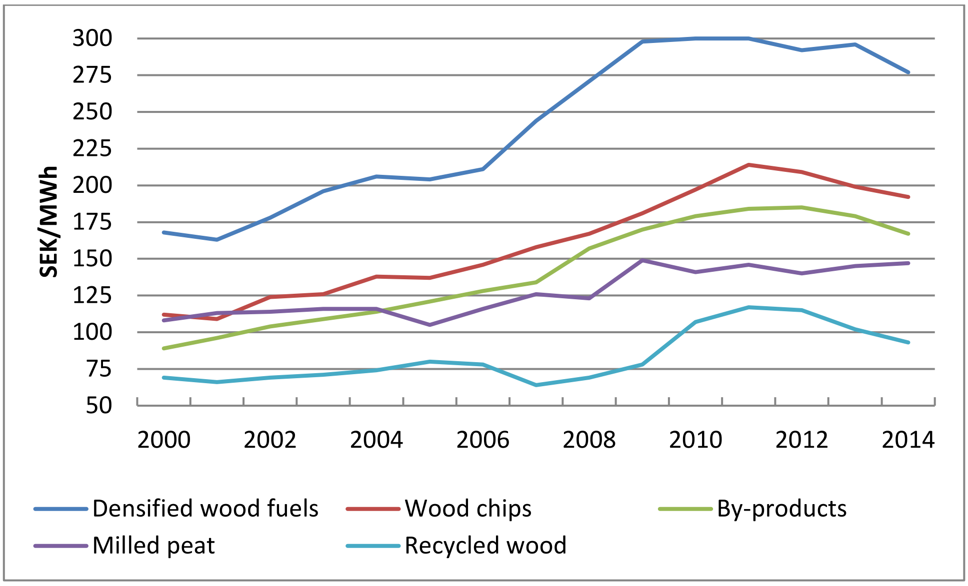

Figure 2: The price different biomass resources between 2000 and 2014, yearly average (data source: Swedish Energy Agency)

The price for biomass increased until 2011-2012 and then decreased except for milled peat which remained constant.

1.1.3 Electricity

It is assumed that the energy mix from the electricity used in the Swedish agriculture is similar to the average Swedish electricity available on the market. Figure 3 shows the energy mix for the Swedish electricity.

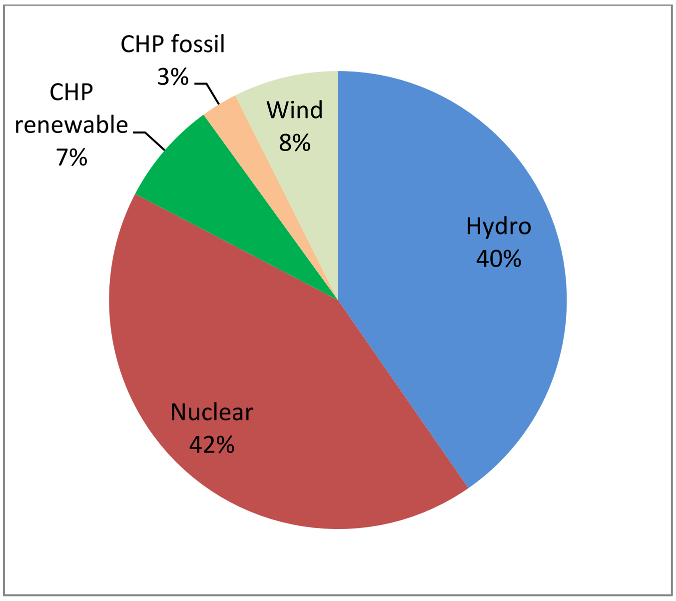

Figure 3: The Swedish electricity energy mix in 2013 (Swedish energy agency, 2015)

More than half (55 %) of the Swedish electricity is produced from renewable resources, assuming that nuclear energy is a fossil energy in the sense that there is a finite amount of nuclear fuel. On the other hand nuclear power is considered as a climate-smart technology as it does not emit carbon dioxides. Therefore, looking at the climate impact of electricity supply in Sweden, it only contributes to 3 % of the increase in concentration of greenhouse gases in the atmosphere. Figure 4 shows the monthly electricity price for the agricultural and forestry businesses.

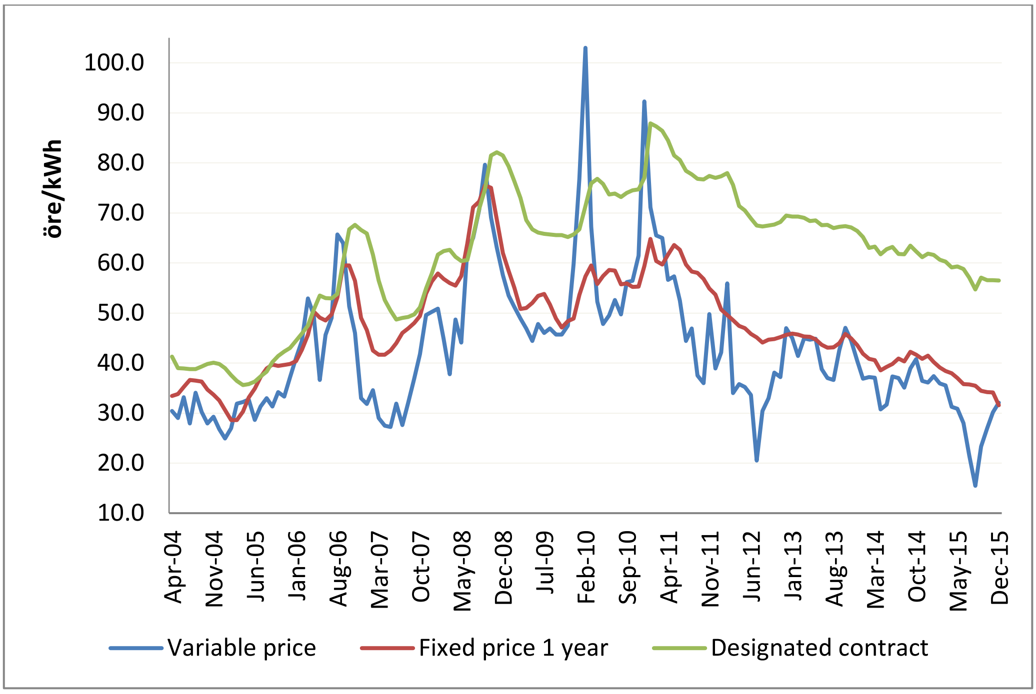

Figure 4: Electricity price for agricultural and forestry business in Sweden, monthly average (data source: Swedish Energy Agency and Statistics Sweden)

Between 2004 and 2011 the electricity price increased and has since then been decreasing with a particular rapid decrease in 2011 and 2012. This change in trend had major impact mainly on farmers selling energy.

1.1.4 Energy efficiency

The most renewable and sustainable energy is most probably the one never used. Therefore, reducing the energy use is also an important part of the solution. The Swedish Government set as a target to reduce the energy intensity by 2020 by 20 % in comparison to 2008 (Government Offices of Sweden, 2015). In 2014, LRF set as a target to reduce by 20% the use of energy and energy-rich products by 2020 in comparison to 2013 (LRF, 2014a). However, this target is based on the assumption that energy price would keep on rising and the price for an oil barrel price reach 150 USD in 2024. Recent predictions show that the price of the barrel will be far below the expected 150 USD (Figure 5).

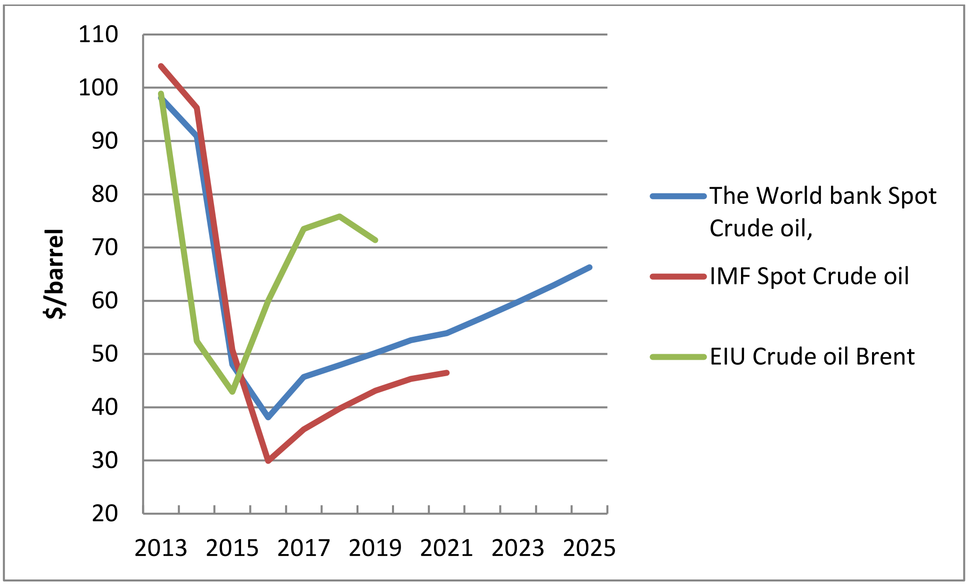

Figure 5: Prediction for spot price of crude oil (data source: The World Bank, IMF, and EIU)

In 2010 LRF published a handbook in collaboration with LRF Konsult that gave practical advice about energy saving at farms (LRF and LRF Konsult, 2010). Saving energy through energy efficiency measures leads to an economical saving, which is often a strong argument. However, the relative saving has been decreasing since the energy prices are unexpectedly decreasing as shown by Figure 1, Figure 2, Figure 4, and Figure 5.

Even though energy saving may be seen as the most sustainable energy it is not considered as a renewable energy technology innovation in this project due to the lack of data.

1.1.5 Climate and environment

When focusing on the issue of global warming, agriculture contributes to about 25% of the emissions globally in 2010 (Smith et al., 2014; IPCC, 2014). In the European Union (EU), this figure falls to 9.6 % (Eurostat, 2016), and 10.6 % in Sweden (Swedish Environmental Protection Agency, 2015). However, looking at the direct use of energy in the Swedish agriculture, between 7 % and 10 % of the agriculture greenhouse gas emission was caused by the use of fossil energy (LRF, 2009a; Statistics Sweden et al., 2012). Moreover, agriculture and forestry also act as carbon storage. In Europe, the agriculture and forest sectors store about 9% of the total greenhouse gas emission making the net emission of greenhouse gases less important (European Commission, 2016a).

The environmental impacts associated with the energy use in the Swedish agriculture are highly correlated with the use of fossil energy. Apart from its impact on the climate, emissions of particles and gases from fossil fuel pollute rivers and often cause severe damages on nearby areas (Vidic et al., 2013; Tiwary, 2000; O’Rourke and Connolly, 2003). Incidents and accidents occurring during the extraction of fossil energy have catastrophic impacts on the environment. For instance, the recent massive methane leak in California (Wilson, 2016) or the British Petroleum oil spill in the Gulf of Mexico in 2010 (Crone and Tolstoy, 2010; Deep Water, 2011; Lin and Mendelssohn, 2012). In the early 1990's LRF took decisions to improve its environmental work, for instance by aiming to achieve long-term sustainability in the Swedish agriculture (Persson and Christerson, 2000). Already in 1993 LRF included it in its strategical vision to phase out finite energy sources (Andersson, 1993). In 1996, LRF highlighted the need for Swedish agriculture to reduce its use of fossil fuels because of its environmental impacts and stressed the potential agriculture has to produce biofuels in order to decrease the society dependence on fossil fuels (LRF, 1997).

1.2 Politics

The Swedish agriculture and policies about energy are highly influenced by political decisions taken at the national and European level as well as on an international level. This section will provide an insight about the relevance of this project through a political perspective by briefly scanning the different current programs and policies applying at different geographical levels.

In December 2015 the Paris agreement was adopted by 195 countries during the United Nations conference on climate change, also known as COP 21 (conference of parties). The main outcome of the agreement was to hold "the increase in global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit temperature increase to 1.5 °C" (United Nations, 2015b p.2). Each party was to develop mitigation targets for each sector that will be performed in Sweden within the framework of Sweden "Environmental Goals" (Miljömålberedningen). Agriculture is perceived as one of the main sector to decrease its emission of greenhouse gases together with the transportation and industrial sectors and targets for each sector is going to be published during the summer 2016 (S.O.U., 2016). The global sustainable goals developed by the United Nation as part of the new sustainable development agenda are also clearly pointing towards sustainable food production and renewable energy systems (United Nations, 2015a).

The common agriculture policy (CAP) is the European policy in charge of the agriculture in the EU. About 40% of the EU budget is issued to the CAP (European Commission, 2014). The CAP sets the direction to follow and in 2013 the promotion of sustainable farming and innovation was a central key of its policy and acknowledged the challenges related to climate change (European Commission, 2014). The Rural Development Program is often considered as the second pillar of the CAP (the first being the direct payment to farmers under the CAP). There is also a strong focus towards sustainable agriculture like resource efficiency or greenhouse gas emission reduction (European Commission, 2016b). Another European program is the European Innovation Partnership, which has five different focus areas, one being agricultural sustainability and productivity. Lastly, Horizon 2020 is a financial instrument promoting initiatives to increase EU's competitiveness focusing on 18 areas, one being food security, sustainable agriculture and forestry (European Commission, 2015).

In 1999 15 environmental objectives were implemented in Sweden that were complemented by a 16th in 2003. One of these objectives is a "limited climate impact" with the goal of a greenhouse gas emission reduction of 40 % by 2020 in comparison to 1990 (Sweden Environmental Goals, 2016).

The SBA is the administration in charge to apply the political decisions related to agriculture in Sweden. During the period 2011-2016, an action program was deployed in relation to renewable energy technology, were Agricultural Advisory Services (AAS) and investment supports were developed in order to increase the investment within both the supply and use of renewable energy technology in the Swedish agriculture (Swedish Board of Agriculture, 2010).

LRF is since the 1990's driving environmental questions and later started with climate issues related to agriculture and forestry. LRF has as a goal to reach 75 % of renewable energy and 25 % biofuels in the Swedish agriculture by 2030 (LRF, 2016). In 2013 LRF started to work with a strategical energy agenda where goals concerning energy use and supply at farm level were developed: (i) investment for energy will have increased by 25 % by 2020, (ii) 80 % of the farmers that have energy as part of their business perceive the profitability as being good by 2020, and (iii) the direct and indirect use of energy will decrease by 20 % by 2020 (LRF, 2014a; 2015c).

1.3 The Agricultural Knowledge and Innovation System

The agricultural knowledge and innovation system (AKIS) was first known as AKS (Agricultural Knowledge System) which originated in the 1960's and seems to correspond to the development of the diffusion of innovation theory presented later (Leeuwis and Van den Ban, 2004). AKS were constituted of researchers, Agricultural Advisory Services (AAS), and educators. AKS aimed to produce formal knowledge which then was transferred by Agricultural Advisory Services (AAS) to farmers (Rudman, 2010).

The term AKIS was first introduced as Agricultural Knowledge and Information System by organizations such as The Organisation for Economic Co-operation and Development (OECD) and the Food and Agricultural Organisation (FAO), but drifted to the current term Agricultural Knowledge and Innovation System (Dockès et al., 2011). AKIS is defined as "a set of agricultural organizations and/or people, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in agriculture" (Röling and Engel, 1991). In comparison to the AKS, AKIS aims to embrace the complexity of knowledge and innovation embedded in the agricultural sector (Dockès et al., 2011). It is worth mentioning that the term/concept AKIS is not recognized all across the EU states (Knierim, A et al., 2014)

The reasons the agricultural sector moved from the more hierarchic AKS to a more holistic AKIS are: (i) the liberalization leading to the privatization of services, (ii) a new agenda focusing on the impacts of industrial agriculture on the environment, and rural development, (iii) adopting a participatory approach for innovation development, and (iv) reducing the knowledge gap between farmers and researchers (Dockès et al., 2011). Figure 6 introduces the Swedish AKIS.

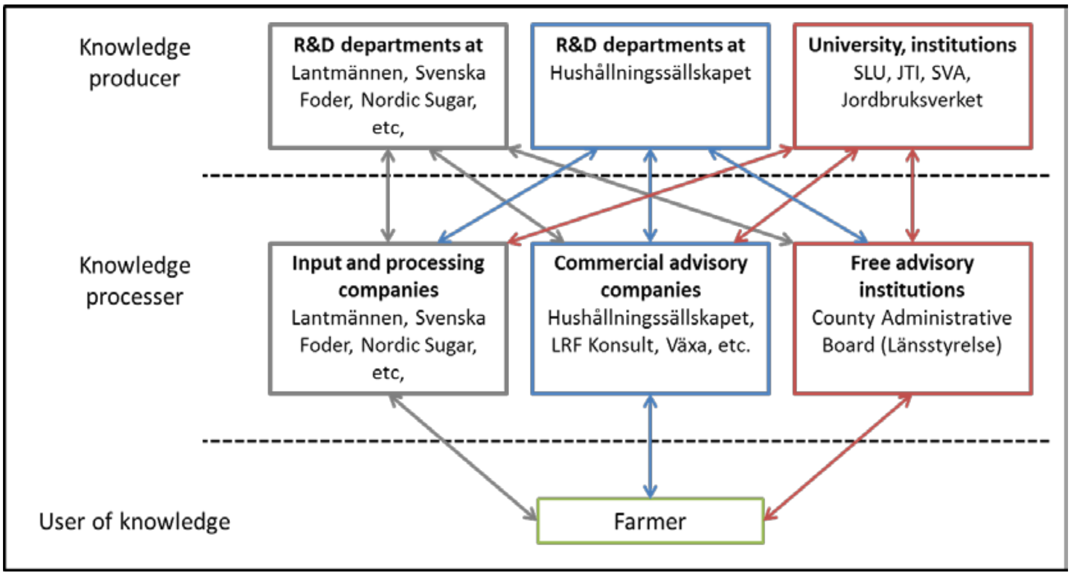

Figure 6: The Swedish AKIS (based on Dockès et al., 2011)

Throughout the time the focus and role of the Agricultural Advisory Services (laying at the "processer of knowledge" level in Figure 6) has changed. Before the 1970's the focus laid on production, then moved to the farm economy in the 1970's. From the 1980sthe adviser and farmer developed a long-term contract, sharing more on their mutual feedbacks, and making the Agricultural Advisory Services able to apply the right measures at the right time. In the 1990's more focus was laid on environmental issues. At the same time private Agricultural Advisory Services (like LRF-Konsult, Hushållningsskapet, or Växa in Sweden) developed due to the end of public Agricultural Advisory Services. Ljung (2015) argues that the Swedish agriculture moved from food safety and productivity perspective to a wider range of functions and activities including for instance energy supply, recreation activities, and culture.

1.4 Earlier projects

In order to give more perspective to the survey, results from earlier projects related to the subject dealt in this project are briefly presented. Most of the documents used in this part are documents produced by LRF or other collaborating organisations.

1.4.1 Perceived relative advantages

Previous studies have shown that farmers value the independence they experienced when producing their own renewable energy. Indeed, they could control their energy related cost and were not exposed to the global market (LRF, 2014a; 2014b; 2015a; 2015c). The positive environmental benefits were also valued as an advantage related to the supply of renewable energy (LRF, 2014a).

Different technologies have been highlighted in the recent years. Innovations related to heat and electricity have a great potential as they can be applied on a small scale (LRF, 2014b). For instance JTI (the Swedish institute for agricultural and environmental engineering) considers that there is an opportunity to substitute oil burner for biomass based heating system and to higher the biomass volume by developing new businesses and collaborating with other actors locally (JTI, 2015; LRF, 2015b). The potential and growing interest for solar electricity is covered in many publications (LRF, 2015a; 2015c; 2014a; 2014b). A survey answered by what could be assimilated to "renewable energy frontrunners" showed that there are a significant interest for renewable fuels and electrification (LRF, 2015a).

LRF has also examined the challenges that renewable energy technologies face at the farm level. In their energy strategy, LRF (2014a) points out the challenges related to the farm independency to fossil resources for heating, fuel supply, but also nitrate for fertilization. The main hinders preventing the Swedish agriculture to overcome the fossil free challenges are a lack of long-term vision in politics, high cost of fossil free alternatives, and low price of electricity (LRF, 2014b; 2015a; 2016; JTI, 2015), as well as the farmers' age, their current intense work load, and their unwillingness to develop their enterprise (LRF, 2011a). A workshop held by JTI and LRF during the fall 2015 focussed on frontrunners. It showed that the lack of knowledge, showcase events, and suitable business models hindered the Swedish agriculture to develop fossil free energy solutions (JTI and LRF, 2015). In their proposition for an innovation agenda within energy, LRF considered as a threat the low price of waste-for-fuel and oil, as well as the low acceptance for wind power and biogas plants (LRF, 2015b).

1.4.2 Innovativeness

When focusing at the profile that farmers supplying energy products or services have, former studies could grasp some target groups. These studies only looked at the farmers that sold renewable energy. It is important to remind the reader that the characteristics revealed in these projects represent trends and do not apply to every single farmers supplying renewable energy.

Younger farmers, with larger farming areas and conventional beef producers are target groups that showed more interest towards renewable energy innovations (LRF, 2014b; Landja, 2013). The farmers' age also influence the type of energy investment. For instance, older farmers would use mostly raw forestry material and are more passive and traditional about their energy enterprise. Younger farmers would try to combine energy supply for both their own use and selling or only selling and are more active by investing in wind turbines for instance (LRF 2011a).

LRF had a deeper focus on farmers that could be compared to frontrunners (innovators or early adopters in Rogers' theory of the diffusion of innovations). Some observed key characteristics helped us to define them as frontrunners. For instance some farmers are looking actively for information related to renewable energy technologies, tools to map their climate impact, scientific advancement, or are even lobbying towards politicians (LRF, 2015c). Others are able to see outside their closest social system and see the opportunity to deliver biofuels for the transportation sector (JTI, 2015). The capacity to go from the status "adopter" to being a promoter of the technology is another characteristics frontrunners have. The 26 farms that form the "Future Enterprise" network (framtidsföretag, LRF 2015a) are incited to play the promoter or change agent role during study visits for instance. More than only showing their experience, farmers appreciate the sharing process related to their change agent role: "it is fun to show what's going well and inspire" (LRF, 2015c).

1.4.3 Knowledge

LRF with other partners had different projects and communication campaigns concerning the spread of knowledge to promote the adoption of renewable energy innovations. Some of those will be briefly summarized in this part.

In 2009, LRF and SMHI (the Swedish Meteorological and Hydrological Institute) held a set of 30 lectures aiming to raise awareness about the climate issues related to agriculture. A brochure with facts and figures about the impact of agriculture including energy related measures was distributed during the lectures (LRF, 2009a). The same year a handbook titled "Climate smart business ideas" (klimatsmarta affärsidéer) was produced with tips from 12 Swedish farms (LRF, 2009b). This handbook included a chapter about energy.

In 2012, together with LRF Konsult, LRF produced another handbook focusing on tips to save energy at the farm. The goal was to inspire farmers and incite them to contact Agricultural Advisory Services specialized in energy (LRF and LRF Konsult, 2010).

Statistics Sweden, the Swedish Board of Agriculture (SBA), the Swedish Environmental Protection Agency, and LRF published in 2012 an extensive document about sustainability in the Swedish agriculture (Statistics Sweden et al., 2012). In this document a part is dedicated to the energy use in agriculture, and what kind of energy is used for which type of activity. To relate to the theoretical framework presented later in the project, this publication communicates facts belonging to the "principle-knowledge".

More recently, from 2013 until 2015, LRF implemented a project called "Good Business with Renewable Energy" (free translation). In this project knowledge about renewable energy systems were spread in different ways: lectures, study visits, Agricultural Advisory Services (AAS), and inspirational trips. Throughout its different activity, the project reached about 10100 farm entrepreneurs (LRF, 2015a).

2 Theoretical framework

Innovations, technologies, and systems diffuse within agriculture and other social system in a relatively structured way. Rogers' (2003) book is one the most recognised work in the field of diffusion of innovations and forms the backbone of the theoretical framework of this project. Everett Mitchell Rogers' book *diffusion of innovation* was first published in 1962. This thesis is based on the fifth and latest edition of the book published in 2003. It is interesting to underline that Rogers started his work on the diffusion of innovations by observing farmers in his home community in Iowa. Moreover, throughout the book, many examples come from the agricultural research. Therefore, the theory is applicable to the subject dealt with in this project. Other concrete examples underlined in the book are stressing both failures and best practices. Furthermore, empirical data from other studies dealing with agricultural innovations and/or energy innovations are presented in this part in order to illustrate Rogers' theory. The lessons learnt from these examples will be highlighted in this part giving practical advices for the discussion part.

The theory of diffusion of innovations aims to explain the different factors influencing the diffusion of ideas, systems, and technologies. By analysing the data through the scope of this theoretical framework, we will be able to give advices regarding future steps to take in order to reach LRF's goals in an efficient way. Moreover, the theory is helping the analysis of the data by defining terms in a scientific way.

2.1 Diffusion of innovation

Rare are self-diffused innovations. Rogers (2003) states that technology developers may believe that advantageous technologies will diffuse by themselves as the potential adopters will broadly understand the self-evident benefits and therefore adopt the innovation. However, historic data shows this to rarely be the case. For example, James Lancaster showed the obvious benefit of lemon juice against scurvy in 1601 during an expedition to India. In 1747, Dr James Lind's experiment showed again the benefit of citrus to cure scurvy. However, it took another 48 years (1795) to the British Navy to adopt a lemon based dietary supplement to eradicate scurvy during long sea voyages, and 70 years (1865) for the British Board of trade (Mosteller, 1981). More recently, in the 20th century, the QWERTY keyboard became standard while Professor August Dvorak had developed in the 1930's a keyboard that many considered more efficient. Nowadays, most keyboards follow the QWERTY model showing once again that obvious benefits are not always the key to the diffusion of innovation (Rogers, 2003). What factors influence to spread of innovation? The theory of diffusion of innovations will give some clues.

At first, we will briefly define the terms and concepts needed to fully understand the innovation-decision process that will be introduced later. Then we will have a closer look at the different communication channels used at different stage of the innovation-decision process. Finally, some critical comments concerning the theory will be presented.

2.2 Definitions

Key concepts and terms from Rogers's theory will be defined in this part in order to set solid and stable ground that will be used to communicate efficiently throughout this project.

2.2.1 Diffusion

Rogers (2003) describes diffusion as "the process by which an innovation is communicated thought certain channels over time among the members of a social system". However, he also clarifies that some authors differentiate between diffusion, which is a "spontaneous, unplanned spread of new ideas", and dissemination, which is defined as "directed and managed" diffusion (p.6). In this project the term diffusion will be used for both processes: planned and spontaneous.

2.2.2 Innovation

Some may argue that farmers often hold a conservative vision. EU SCAR (2012) would answered that: "This is wrong. Agriculture and innovation go hand in hand. Ever since agriculture was invented some 10 000 years ago, somewhere in the fertile crescent of the Middle East (and simultaneously in some other places in the world), farmers have innovated" p.11. In the Oslo manual, OECD and Eurostat (2005) define innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" p.46.

Innovation does not have to be necessarily a complicated, brand new high technology, or heavily expensive machinery. Rogers define it as "an idea, practice or object that is perceived as new by an individual or other unit of adoption". Therefore, the newness embedded in the innovation is subjective to the adopters. For example, in the 1950' s a research considered boiling drinking water as an innovation to sanitize drinking water in Peru (Wellin, 1955), even though the technology had existed for a very long time. Indeed, boiling water had been used only in certain cases but not in a systematic way, which was considered as the innovation. This example illustrates that innovation do not have to be objectively new neither have to be material. Therefore, a behavioural change is also considered as an innovation in this theoretical framework.

Most of the research on diffusion of innovation is based on technological innovations (Rogers, 2003). For the sake of clarity, the terms "innovation" and "technology" are seen as synonyms. A technology has both a hardware aspect and a software aspect (Rogers, 2003). Often the hardware aspect is the most obvious one but in some case, the software aspect can be the most significant. Rogers (2003) argues that software dominated innovations are harder to trace and observe in time in physical terms as the delimitation of the software component can be fuzzy and its consequences indirect.

Innovations have been spreading within the Swedish agriculture throughout the time. The spread of new technology like the use of tractor from the late 1940s till the late 1970s is also seen as an innovation and its diffusion is shown in Figure 7.

2.2.3 Potential adopter

Throughout the project, the term "potential adopter" is used to define individuals, groups of individuals or organisations that have not yet adopted or rejected an innovation. In the particular case studied in this project, potential adopters are Swedish farmers or groups of Swedish farmers that have the potential to improve their energy system in order to reduce the impact on the environment and climate change or want to develop their business by selling renewable energy. Rogers (2003) categorized the potential innovators by their degree of innovativeness. By innovativeness Rogers (2003) meant the relative quality a potential adopter has to adopt an innovation prior to other potential adopters. To clarify it, Rogers (2003) divided the potential adopters into five adopter categories: (i) *innovators*, (ii) *early adopters*, (iii) *early majority*, (iv) *late majority*, and (v) *laggards*. The general qualities shared by each adopter category will be briefly summarized. Innovators and early-adopters are also called frontrunners in this report.

Innovators have the highest degree of innovativeness, while the laggards have the lowest. Innovators have a genuine interest for innovations that lead them outside of the local social system to more diverse and varied relationships. The innovators are able to understand innovations that are more complex and can deal with innovation uncertainties. Innovators have contact with professional from Agricultural Advisory Services and may travel in order to seek for information (Jones, 1963). They play a key role in the diffusion of innovations in their local social system even though they might not be well integrated in it.

In comparison with the innovators, the *early adopters* are more integrated in their local social system. Their influence on the other members of their social system is high. By sharing their subjective evaluation of the innovation, early adopters are seen as an innovation catalyser or trigger. They are seen as opinion leaders and reflect the social norms within their social system. However, not every opinion leader is an early adopter. In fact, opinion leaders can support an innovation in which case they are seen as early adopters or even innovators, but they can also oppose to innovations. By adopting an innovation they act as an unofficial guaranty certification for the other members of their local social system. Based on Watts and Dodds (2007) work, Robinson (2009) argues that early adopters only influence "easy influenced" potential adopters. Early adopters actively seek for information but closer to their local system than innovators do (Jones, 1963).

The *early majority* is also well integrated in the local social system, but probably less active than the early adopters. They need more time to forge an opinion and are seen as followers.

The *late majority* is more sceptical toward innovations. Because of their relatively limited resources, they need to learn from the majority in order to decrease the uncertainties linked to the outcome of the innovation.

Laggards are often isolated or outside social systems. They base their opinion on the past and have relatively traditional values. Their suspiciousness to adopting innovation can be explained by their unstable economic situation. Rogers (2003) underlines that the term laggards should not in any case be seen as pejorative.

The five-adopter categories are adopting the innovation in a rather sequential way, from the innovators to the laggards. Therefore, depending on which category is adopting the innovation at a given time, different strategies can be implemented focusing on the different adopter categories.

2.2.4 Change agent

Rogers (2003) defines a change agent as "an individual who influences client's innovation-decisions in a direction deemed desirable by a change agency" (p.366). To remove ambiguity, the term "client" used by Rogers is replaced by the term "potential adopter" presented above and used throughout this project. Earlier in this project, change agents were referred as persons promoting the diffusion of innovations. The change agent often works for the adoption of a given innovation, but may also prevent the diffusion of other innovations judged as harmful by the change agency. In the case studied in this project, LRF is seen as a change agency, whereas project managers working at LRF and other change agencies within the agricultural sector or Agricultural Advisory Services are seen as change agents. As we will see later in the communication channels part, the change agent plays a major communication role throughout the innovation-decision process. Indeed, a major role for the change agent is to bridge the knowledge-gap between the potential adopter and the innovation. It is not a one way communication flow where the change agent teach and dictate an innovation, but rather dialogue where the change agents report feedbacks from potential adopters to the change agency in order to better fit the diffusion program to the actual needs of the potential adopters. In the innovation-decision process section, the role of change agents for each stage of the innovation-decision process will be described.

In general change agents have a higher education level than the potential adopters they work with. This gap in education level, which is often associated to differences in socioeconomic status and norms gaps, often hinders the communication between both parties (Rogers, 2003).

2.2.5 Social system

The members of the social system "may be individuals, informal groups, organizations, and/or subsystems" (Rogers, 2003). To be part of a social system, members are expected to "cooperate at least to the extent of seeking to solve a common problem in order to reach a mutual goal" (Rogers, 2003). To relate it to the case studied in this project, the problem may be seen as the unsustainable use of energy in the Swedish agriculture while the common goal is to provide safe food while supporting the farms economy. Furthermore, the social system can be a group of farmers coming from the same geographical region and acknowledging the above problem goal. The "future enterprise" network (framtidsföretag), launched by LRF is a network of agricultural entrepreneurs that are implementing renewable energy related innovations. This network, facilitated partly by LRF, counted 26 enterprises in 2015 and can also be considered as a social system (LRF, 2015).

Rogers (2003) identifies two main structures within the social systems; *social structure* that can be related to the hierarchical structure and the *communication structure* that describes the way members interact within the system. Both structures influence the adoption rate of the innovation by facilitating or hindering the diffusion of the innovation.

Rogers (2003) identifies three major types of innovation-decisions that are highly related to the structure of its social system: (i) *optional*, (ii) *collective*, and (iii) *authoritarian*. The type of innovation-decision can influence the speed of adoption. An optional innovation-decision leaves the initiative and responsibility to the individual choose whether to adopt an innovation or not. However, its choice is highly influenced by its social system. Innovation-decisions taken as a consensus by the social system are collective, while innovation-decisions taken by few members of the social system (often high up in the hierarchy) are authoritarian. Rogers (2003) underlines that agricultural innovation are in most of the cases optional.

2.2.6 Rate of adoption

The rate of adoption is defined as being the share of potential adopters within a social system to have adopted a given innovation under a given period of time. For most innovations, the cumulative number of adopters over time forms an S-shaped curve as shown in Figure 7. The slope as well as the shaprness of the curve depend on the innovation. Rapidly diffused innovation have a steeper S-curve than slowly diffusing innovations. The curve is used to show the advancment of the diffusion. Petrini (1966) argues that the rate of adoption for innovations in the farm management or an expension of the business are slower than technical innovations aiming to improve the productivity.

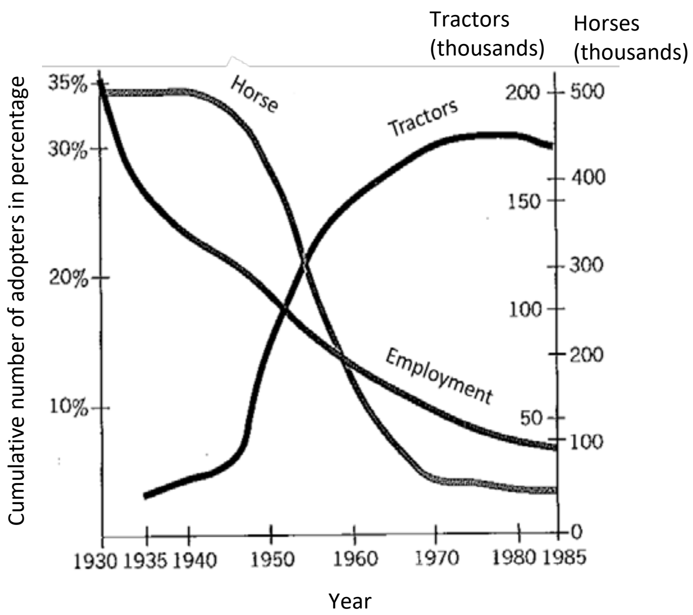

Figure 7: The diffusion of tractors in the Swedish agriculture- rate of adoption over time (data source: Andersson, 1993, authorisation to use the figure has been obtained from the Natural Step)

The curves labelled "tractors" in Figure 7 is the curve showing the rate of adoption for tractors in Sweden. The S-shaped curve is relatively clear. Figure 7 also support the background chapter by showing that the Swedish agriculture moved from a man and animal powered agriculture in the early 1940's to a fossil fuel based agriculture by the end of the 1970's.

2.3 The innovation-decision process

Potential adopters do not decide impulsively about the adoption or rejection of an innovation. The *innovation-decision process* developed by Rogers (2003) aims to explain the decision-making process that potential adopters encounter before and after the adoption/rejection of an innovation. The time-sequenced process includes: (i) *knowledge*, (ii) *persuasion*, (iii) *decision*, (iv) *implementation*, and (v) *confirmation*. The process is seen as an information-seeking and information-analysing process. During this process the potential adopters aim to decrease uncertainties related to the outcome of the innovation.

Similarly, Ryan and Gross (1943) showed in their research focusing on the use of hybrid corn that farmers first learn about the existence of this new alternative (*knowledge*), then seek for deeper information (*persuasion*) before adopting (*decision*) and trying the new seeds (*implementation*). After few years of experimentation the farmers confirmed the presence of subjective benefits which reduce or remove the uncertainties related to the consequences of the innovation (*confirmation*). Finally they could decide to adopt completely the innovation or reject it.

At the *knowledge* stage, the potential adopters seek information to understand the operation of the innovation. Once the general functions of the innovation are mastered, the potential adopters seek to assess the benefits and hindrances of the innovation for his or her particular case. This process takes place during the *persuasion* stage during which, potential adopters form a positive or hostile attitude toward the innovation. Based on this attitude, the potential adopters will adopt or reject the innovation during the *decision* stage. If the innovation is adopted, the adopter implements the innovation (*implementation* stage). During the final stage the adopters seek information and results that support their decision. Rogers (2003) underlines the possibility of discontinuance during the confirmation stage. In other words, a positive decision can be reversed in the future due to, for example, new available innovations, conjectural changes, or unanticipated undesired consequences.

2.3.1 The knowledge stage

As mentioned above, at the knowledge stage, the potential adopter seeks for general information regarding the innovation that answers the questions: “What is the innovation?”, “How does it work?” and “Why does it work?”. Rogers (2003) arranged this information into three categories: (i) the *awareness-knowledge*, (ii) the *how-to-knowledge*, and (iii) the *principles-knowledge*. The awareness-knowledge indicates that the potential adopters knows that the innovation exist and can trigger her/him to seek for the two other type of information. The how-to-knowledge regroups the information dealing with the operation of the innovation. To relate it to the example studied by Wellin (1955), the awareness-knowledge is the fact to know it is possible to boil water. The how-to-knowledge is the knowledge needed in order to be able to boil water. Lastly, the principle-knowledge tends to explain why the innovation is working. In Wellin’s (1955) example it is the theory that germs would die if heated up to a certain temperature.

Different factors influence potential adopters to enter the knowledge stage. First we must acknowledge that potential adopters are biased by their own belief/norm system. They see and analyse the information through their subjective filter and therefore only allow information fitting their belief/norm system to be seen. Second, another factor facilitating the potential adopter to enter the knowledge stage is the perception of needs or problems. For example, it is more likely that a farmer would process information about an innovation if this innovation will help the farmer to solve a recognized problem. Rogers (2003) argues also that some innovations may create a need. Change agents are often the one to induce needs while introducing an innovation. Change agents may benefit from interpersonal communication at this early stage as it will help them to assess the potential adopters' needs which will help to better tailor both the innovation and the argumentation.

Rogers (2003) generalized that individuals learn about the existence of an innovation earlier if they have: (i) higher education, (ii)higher social status, (iii) higher exposure to mass media channels, (iv) higher exposure to interpersonal channels, (v) more contact with change agents, (vi) more social participation (more active in their social network), or (vii) are relatively more cosmopolite. These characteristics highly correlate with the ones of an *innovator* or *early adopter* (see above).

2.3.2 The persuasion stage

In Rogers theory, by persuasion is meant the construction and development of an attitude toward the innovation from the potential adopter. In the theory, persuasion is not used in the sense that one party is trying to induce the potential adopter to hold a desired attitude towards the innovation, even though the change agent fulfils this role and has an influence on the potential adopter.

At this stage, the potential adopters value the potential subjective benefits and drawbacks of the innovation for his or her specific case in order to develop a positive or negative attitude towards the innovation. Rogers (2003) warns that a positive attitude does not always mean that the innovation with be adopted. This non-linear relationship between the attitude and the action is called the "KAP gap" (Knowledge-Attitude-Practice). KAP-gaps are often experienced with preventive innovations. A preventive innovation is an innovation that aims to avoid future potential undesirable consequences, such as drug prevention and contraception programs or climate change mitigation measures (Rogers, 2002). However, the KAP-gap can be closed by a cue-to-action which is "an event occurring at a time that crystalizes a favourable attitude into overt behavioural change" (Rogers, 2003, p.176). This event may occur naturally like the sudden change of energy price or be created by a change agency, for instance a tax reduction program.

Rogers (2003) recognizes five perceived attributes of innovations. As for the subjective newness aspect of the innovation, Rogers underlines the importance of the individual subjectivity in regards to the innovation. In other words, the intrinsic attributes of the innovation are not of importance. Indeed, it is how the potential adopter personally sees the innovation attributes. The example about the scurvy issue in the British Navy introduced earlier illustrates well this phenomenon (Mosteller, 1981). In our case, we should focus on the farmer's perception and not the objective attributes. This five attributes are (i) *relative advantage*, (ii) *compatibility*, (iii) *complexity*, (iv) *trialability*, and (v) *observability*. Each attribute will be briefly introduced and their influence on the rate of adoption discussed.

The *relative advantage* is defined as the extent to which the potential adopter perceives the innovation as better than the idea/system the innovation aims to replace. The potential adopter can also value the benefits and drawbacks of the development of a new business or side activity. However, even in this case the development of a new business competes with other options. The objective advantages, which may be obvious to some but not be perceived as advantageous by the potential adopter, are not necessarily accelerating the diffusion of innovation. As it may appears obvious, "the greater the perceived relative advantage, the more rapid its rate of adoption will be" (Rogers, 2003).

The *compatibility* is defined as the extent to which the innovation fits the existing context. The existing context englobes social aspects like norms and values, past experiences as well as future needs. Innovations incompatible with the social context have generally a slower rate of adoption, as they might need a prior adoption of new norms and values, which are deeper changes and therefore known to be a slower process. One example is the drinking water sanitization program analysed by Wellin (1995). The failure of the program (about 5% of the families adopted the innovation) can be partially explained by its incompatibility with social norms in the village. Indeed, the innovation objective advantage could not be explained through the village belief system. This example also underlines the relationship between the compatibility and the relative advantage attributes. The objective advantage could not be perceived as the social norms did not fit the argumentation. The more the innovation is compatible to the existing norms and values, the more rapid its rate of adoption will be.

The *complexity* is defined as the extent to which an innovation is perceived as complex to understand and use. The adopter of a complex innovation might need to require new skills and knowledge. A less complex innovation will be adopted more rapidly.

The *trialability* is defined as the extent to which the innovation can be implemented in a partial way. Innovations that can be implemented partially have a more rapid rate of adoption than an innovation that is either totally implemented or rejected. For instance within the field of sustainable energy use in agriculture, eco-driving has a high trialability as the farmer can decide how much the innovation is implemented (all the time, only during longer trips, etc.). On the other hand, some innovations do not offer the scale flexibility. For instance if a farmer decides to install a biogas power plant, the opportunity to try the innovation on a smaller scale does not exist. Moreover, an innovation with a high degree of trialability allows the adopter to learn by doing. The trialability attribute is related to the hardware and software aspects of the innovation. An innovation with a high degree of software aspects has a greater trialability. The more triable the innovation, the more rapid its rate of adoption will be. Nitsch (1984) showed that: "farmers give more importance to their own experience than to external information" (p43), proving the relevance of trialability for farmers.

The *observability* is defined as the extent to which the innovation results are observable by individuals other than the innovation adopter. Rogers (2003) brings the example of solar water heaters, which seems to develop in a clustered way. He explains this phenomenon by the observability attribute. In this sense, innovations with a great software aspect, such as eco-driving, have a low observability. The greater the observability, the more rapid its rate of adoption will be. Demonstration activities can increase an innovation's observability. Innovations that can demonstrate their efficiency in term of yield are more rapidly accepted (Petrini, 1966).

Perlaviciute and Steg (2014) also raised the fairness factor as fundamental for the implementation of alternative energy innovation. An innovation that will induce cost for a particular group but benefits to another has a low degree of fairness. They also argued that financial compensation can increase the fairness, for example for wind turbine projects.

2.3.3 The decision stage

The decision stage corresponds to the time when the potential adopter "engages in activities that lead to a choice to adopt or reject the innovation". At this stage, the potential adopter is still seeking information to reduce the uncertainties regarding the consequences of the innovation. Trying the innovation is a way to reduce these uncertainties. Therefore, the *trialability* also plays its role at this stage. Change agents can convince potential adopters to partially adopt the innovation by offering free samples of the innovation, such as offering a time-limited trial for machineries. Feedback from peers can also be considered as indirect trials that have a lower persuasion level than self-trial.

One could see this stage as a bridle on the innovation-decision process where potential adopters decide to adopt or reject the innovation. However, forgetting the existence of an innovation at the knowledge stage is also seen as rejecting the innovation.

2.3.4 The implementation stage

Once a positive attitude triggered the adoption of an innovation, the physical and concrete part of the process takes place. However, at this stage the adopter is still seeking information as well as getting feedback from the implementation of the innovation in order the reduce the uncertainties. The implementation stage can be a relatively long period and eventually ends when the new idea has become a routine for the adopter. Based the use of the innovation, the adopter still seeks information in order to fully understand the innovation outcomes.

During this stage the adopter may adopt certain changes to the initial innovation. This process is called *re-invention* by Rogers (2003). The degree of re-invention can be seen as the extent to which an innovation can be modified by the adopter. A higher degree of re-invention increases the adoption rate and makes the innovation more sustainable. The sustainability of an innovation is defined as the "the degree to which an innovation continues to be used after a diffusion program ends" (Rogers, 2003 p.183).

Re-invention occurs for different reasons. Complex innovations may be simplified with relatively low negative or perhaps even positive impacts on the desired consequences of the innovation. However, the lack of principle-knowledge and ignorance may results in re-invention with more negative consequences. When a set of innovations are "packaged" into a central innovation, re-invention is more likely to occur if the interdependence of each innovations is low. Innovations aiming to solve a wide range of issues are also often re-invented in order to solve the adopter's specific problem. Some adopters may perform minor changes in order to feel more ownership over the innovation which may be seen as "pseudo-re-invention". In general, innovations are re-invented in order to fit the adopter's own situation.

Re-invention is seen as a misuse of the innovation by researchers and development agencies as the "pure" innovation have not been adopted as such. Moreover, it makes it more difficult to measure over time the actual impact and performance of an innovation. However, as we have seen above, the degree of re-invention can affect both the adoption rate and the innovation sustainability. It seems that re-invention occurs more often in the late course of the diffusion process as later adopters learn from the earlier adopters' experience.

Rogers (2003) also recognized that some primary rejecters are taking part of the implementation stage. However they may only experience it on an indirect way, especially from peers' experience.

2.3.5 The confirmation stage

At the confirmation stage the individual seeks to reinforce their decision concerning the adoption or rejection of an innovation. The information acquired during the entire innovation-decision process will facilitate the decision-making. At this stage an innovation adopted at first may be confirmed or rejected and innovations rejected at first may be rejected for good or adopted in the second hand.

The decision to reject a previously adopted innovation is called *discontinuance*. Discontinuance often occurs when the potential adopter is not convinced about the benefits cascading from the implementation of an innovation in his or her particular situation, or the implementation of new legislation may forbid or hinder the use of an innovation. This kind of discontinuance is called *disenchantment discontinuance*. On the other hand, *replacement discontinuance* occurs when other innovations with better perceived attributes replace the existing innovation. For the sake of innovation this kind of discontinuance is less dramatic as it is renewed by other and perhaps more effective innovations.

Rogers (2003) argues that late adopters, due to their social status explained above, are more likely to discontinue innovations in comparison with earlier adopters. Factors that could reduce the discontinuance rate in the short run are a better understanding of the innovation principles-knowledge as well as more interaction with change agents. In the long term, higher formal education and socioeconomic status could also decrease the discontinuance rate.

2.4 Communication channels

New technologies and research are needed for the creation of innovation. However, if these innovations are not communicated, it is most likely that they will not be adopted: "It is not enough that knowledge should grow; it should also be diffused, and applied in practice" (Lewis, 1955, p.157). As we can see in Figure 9, communication channels are used during the entire innovation-decision process. In this part we will recommend different communication channels to use depending on the stage in the innovation-decision process, the perceived attributes of the innovation, and the potential adopters' characteristics. Rogers (2003) defines a communication channel as "the means by which messages get from one individual to another" (Figure 8).

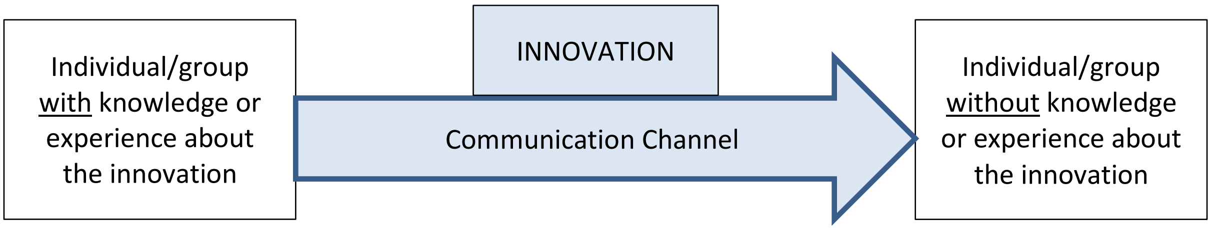

Figure 8: Communication process during the diffusion of innovation

Rogers identify two main communication channels for the communication of innovation: (i) *mass media*, and (ii) *interpersonal communication*.

Mass media channels include media that allow an individual or group to communicate to a larger audience. Examples include radio, television, journals, and newspapers. As a rule of thumb, mass media have more influence on innovators and early adopter than on laggards. According to Rogers (2003) *interpersonal communication* requires a face-to-face exchange between at least two individuals. It includes any kind of communication from a simple dialogue to a week-long seminar. Laggards are highly relying on interpersonal communication in order to develop their own opinion.

With the development of the Internet, new means of communication have appeared. Some means can be associated with mass media channels, for example online newspaper, while others may be related to interpersonal channels such as forums or online learning where interaction is possible. Rogers (2003) grouped these means of communication as interactive communication. However, in this project, the online means of communication are classified as either mass-media or interpersonal depending on their characteristic. Moreover, the face-to-face characteristics qualifying interpersonal communication in Rogers' theory are substituted by the interactivity quality of the communication means. For instance, exchanges on specialised forum are regarded as an interpersonal media channel in this project. The development of the internet accelerates the exchange of information and improves access to information, but cannot replace face-to-face communication in every case. Dockès et al. (2012) argues that social media and other new communication technology are not well used at the moment by Agricultural Advisory Services in Sweden.

Rogers (2003) also separates the communication channels between *cosmopolite* and *localite* channels. Information sent from outside the local social system are shared through *cosmopolite* channels while the *localite* channels are those linking the potential adopter with sources within the social system. Both channels can be either mass media or interpersonal media. As mass media channels, cosmopolite channels are more important during the knowledge stage of the innovation-decision process. Respectively, as interpersonal channels, localite channels are more important during the persuasion stage.

What is often considered as the first empirical innovation-diffusion study was the study of the diffusion of hybrid corn in Iowa, USA. Even though most farmers first heard about hybrid corn from a salesman, the farmer-to-farmer exchanges was a key factor in the diffusion (Ryan and Gross, 1943) Moreover, in the 1960's, Petrini (1966) focused on the relationship between the perceived complexity of innovations and the communication channels used. His study focused on the Swedish farmers' case. Petrini concluded that the diffusion of complex innovations among Swedish farmers would be slow if communicated through mass media channels like specialized magazines. The examples above illustrate well the diffusion process, but should be handled cautiously due to the time-lapse between the findings and the case studied in this project.

Different communication channels are often used during the diffusion of the same innovation. For instance, general information concerning the software aspects of an innovation are efficiently shared through mass media channels. Once the potential adopters have general knowledge about the innovation, more specific information related to the potential adopters' specific situation is mostly communicated through interpersonal channels. Jones (1963) argues that communication channels must be accepted by farmers in order to be effective.

2.4.1 The knowledge stage

As we have seen earlier, during the knowledge stage of the diffusion of innovation, the potential adopter discovers the existence of an innovation at first. An efficient way to diffuse *awareness-knowledge* is mass media. Both traditional and online media can be considered at this stage. The burst of the Internet, which facilitate the access to information, accelerates the diffusion of *how-to-knowledge* and *principle-knowledge,* which would answer the questions "How does the innovation work?" and "Why does it work". If enough interest has been created at the awareness-knowledge stage and if the information is easily accessible on the Internet, the Internet may suffice at this stage. In the 1960's Petrini (1966) showed the correlation between the presence of an innovation in specialised media and the related rate of adoption. The more the innovation was treated in farm journals, the more is was accepted.

As mentioned earlier, the role of the change agent is crucial in the communication of innovation. At this stage the change agents aim to create a durable communication with potential adopters and can introduce them to the innovation. By targeting the "perfect" potential adopter and matching its needs to the appropriate innovation, the change agent will be more efficient. Change agents may benefit interpersonal communication at this early stage as it will help them to assess the potential adopters needs which will help to better tailor both the innovation and the argumentation.

2.4.2 The persuasion and decision stage

The communication channels used during both the persuasion and decision stages are similar. At these stages the potential adopter seeks for deeper information, especially for more complex innovations, in order to value the expected consequences of an innovation. Mass media often fail to communicate such information. Therefore interpersonal is more than recommended at this stage. As we have seen in the example highlighted by Petrini (1966) above, an efficient interpersonal communication for Swedish farmers in the 1960's was peer-to-peer communication. Change agents can also play an important role at this stage by facilitating peer-to-peer communication during workshops or demonstrations where peers can easier relate to the innovation. Helmersson (2011) showed in his study that out of the six studied farms who adopted a given innovation, all of them did a study visit. A study visit does not necessarily lead to the adoption of the innovation but seems to be a prerequisite for adoption.

Another "trick" change agents may use at this stage is to offer a free trial of the innovation, reducing the need for the potential adopter to engage too many resources. A determinant aspect to bear in mind at this stage is that subjective opinions from near peers are often more persuasive and better understood than hard-science facts presented by the change agent itself.

At this stage, the Internet has also a role to play. The development of specialized forums or distant learning system should also be considered even though they were not included in Rogers' book.

2.4.3 The implementation stage

At this stage, the adopters mostly seek for technical information applied to their particular case. Rogers (2003) underlines the importance of the change agents at this stage to deliver the appropriate information and thus ensuring the good use of the innovation and prevent discontinuance. However, the change agent's task becomes harder if durable communication has not been developed earlier in the process.

2.4.4 The confirmation stage

From the point of view of a change agency, a really efficient way to have a self-sustaining rate of adoption is to turn the final adopters into change agents. Therefore, the role of the change agent at this point is to make sure the adopter get the necessary communication tools. Moreover, to keep the relationship between the adopter and the change agent alive would also help the change agency to get feedback concerning the use of the innovation on the field.

2.5 Summary

Figure 9 summarises all the above information about Rogers' theory into a diagram.

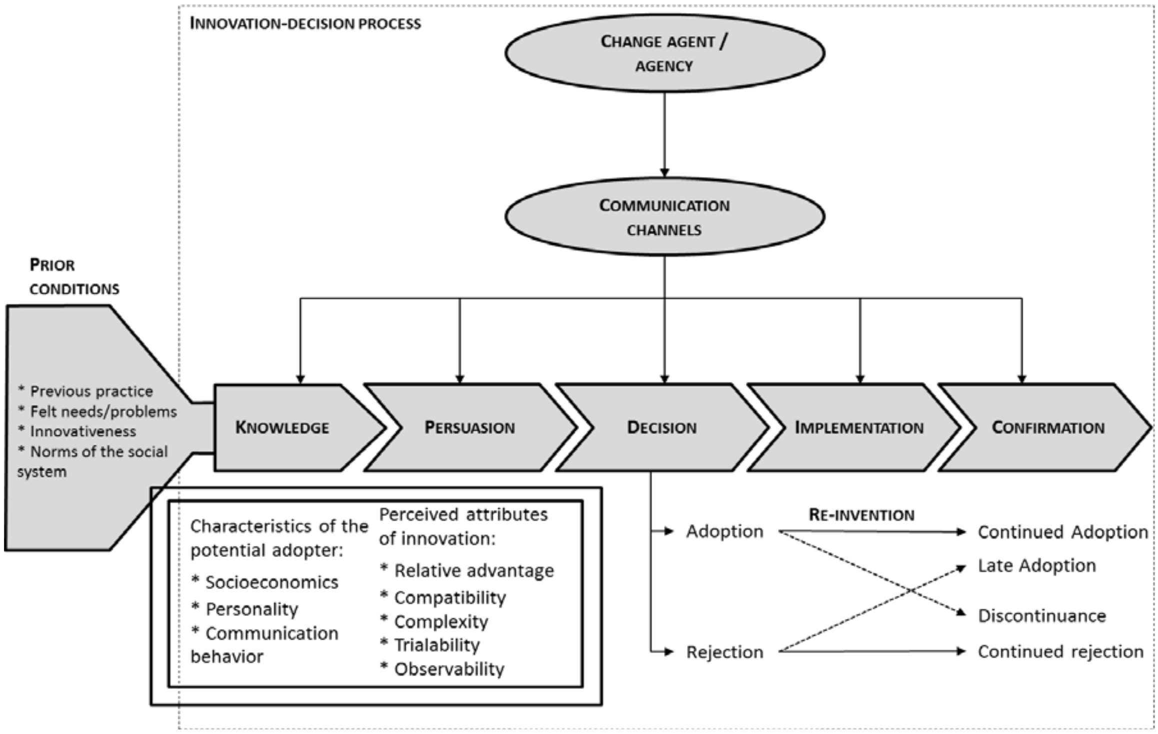

Figure 9: The innovation-decision process (based on Rogers, 2003)

Perlaviciute and Steg (2014) looked at the factors influencing the acceptability of energy alternatives (Figure 10).

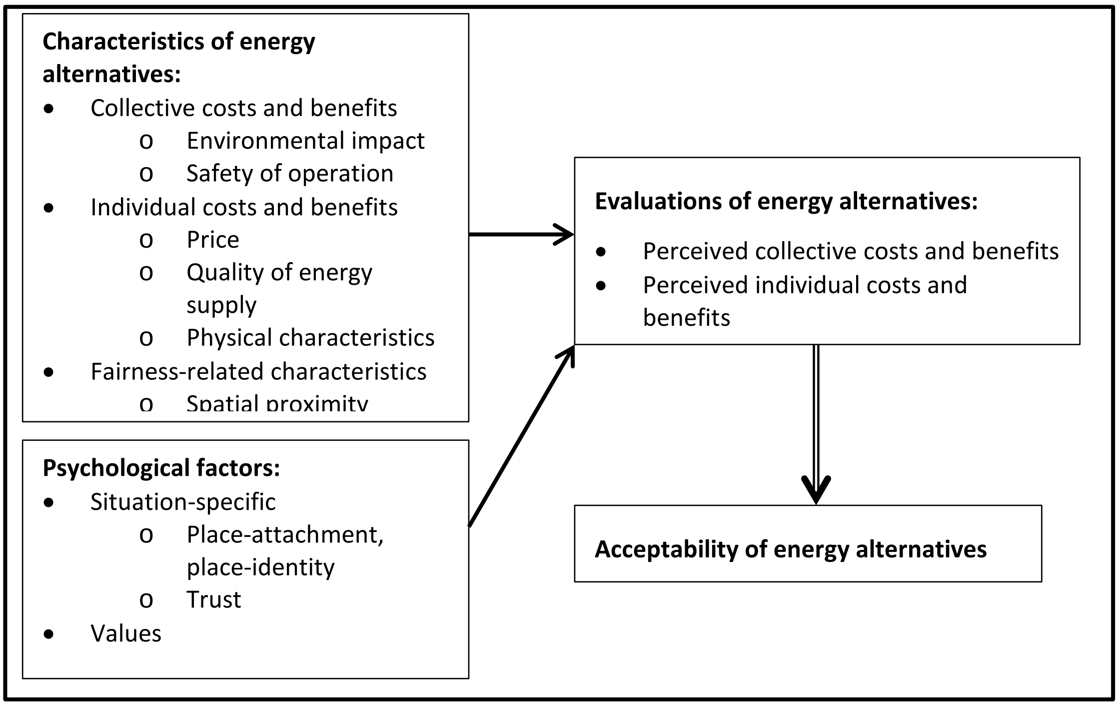

Figure 10: Conceptual framework showing the factors influencing the evaluations and acceptability of energy alternatives (Based on Perlaviciute and Steg, 2014)

The framework developed by Perlaviciute and Steg (2014) divides on one side the characteristics related to an energy alternative (innovation, the upper box), and the psychological factors on the other side (the lower box). In a similar way, Rogers' theory distinguishes between innovation related and personal related factors (Figure 9). When both factors are combined the perceived attributes of energy alternatives are found. In turn the perceived attributes influence one's acceptability for a given energy alternative. Perlaviciute and Steg's (2014) framework supports Rogers' theory in the sense that it is developed specifically for energy innovations and therefore is not as general as Rogers' theory. Figure 10 can support Rogers' theory by complementing or substituting the content from the double rectangle in lower right corner of Figure 9. Therefore once a potential adopter has come to an opinion about the innovation, he or she can take a decision about the adoption of the innovation.

2.6 Criticisms about the diffusion of innovation theory

In this part criticism about the theory of diffusion of innovation found in the literature is briefly introduced. Thereby, the reader will be able to nuance the theoretical framework based on the following criticism. One of the biggest weaknesses of the diffusion of innovation theory was, until the 1970s, the lack of critical research on the subject (Rogers, 2003). Rogers (2003) identified three limitations to his theory that are applicable to our case: (i) the pro-innovation bias, (ii) the individual-blame bias, and (iii) the recall problem. To these three limitations, we will also discuss (iv) the sequential problem embedded in the theory of diffusion of innovation.

The *pro-innovation bias* holds the view that innovations must be adopted by the entire social system as fast as possible (Rogers, 2003). This bias avoids the study of innovation rejection or ignorance as well as overlooks the re-invention process, which has been given more importance recently. Moreover, generally the study of diffusion of innovation focuses on successful examples giving valuable knowledge about how great diffusion looks like, but not necessarily learning why some innovations did not diffuse. For example, one of the first empirical results funding the theory diffusion is provided by Ryan and Gross (1943) where the studied innovation spread "with phenomenal rapidity" (p.15). One reason for this bias mentioned by Rogers (2003) is that change agencies often are the ones initiating research on diffusion of innovation and often hold a pro-innovation attitude.

The *individual-blame bias* or *close system issue* is stressed by Rogers (2003) by saying that in the diffusion of innovation studies, the individual is often considered as the cause of failure (or success). As a consequence studies often underestimate the role of the system and society.

The time dimension is one of the main elements in the diffusion of innovation theory. For example it affects the classification of potential adopters (early adopters, late majority, etc.) and is used to measure the rate of adoption. Moreover, the data are often based on questionnaires or interviews asking respondents to recall information. The time-lapse between data collection and actual events as well as the respondents' own critical thinking may cause information to be incorrect to a certain extent. This issue is seen as the *recall problem*.

As we can see in Figure 9, the innovation decision process, which aims to explain how and why individuals adopt or reject a given innovation, is a model based on a sequence of different stages. Furthermore, in his book Rogers (2003) failed to fully integrate the generation of innovation and the diffusion of innovation. In other words, the innovation is first generated and then diffused. This limitation of the theory is called the *sequential problem* in this project. The concept of AKIS and the initiative EIP (see background) may help scholars and the agricultural innovation process to be perceived in a more holistic way.

3 Methodology

Great ingredients put together do not necessarily make for an appetising meal, but a wise integration and combination of them often result in a tasty experience. The methodology should be like a great recipe, where the ingredients support and collaborate with each other in order to reach a common goal. Figure 11 shows how the different elements (ingredients) of the methodology (recipe) are used in order to reach the set aim (delicious meal).

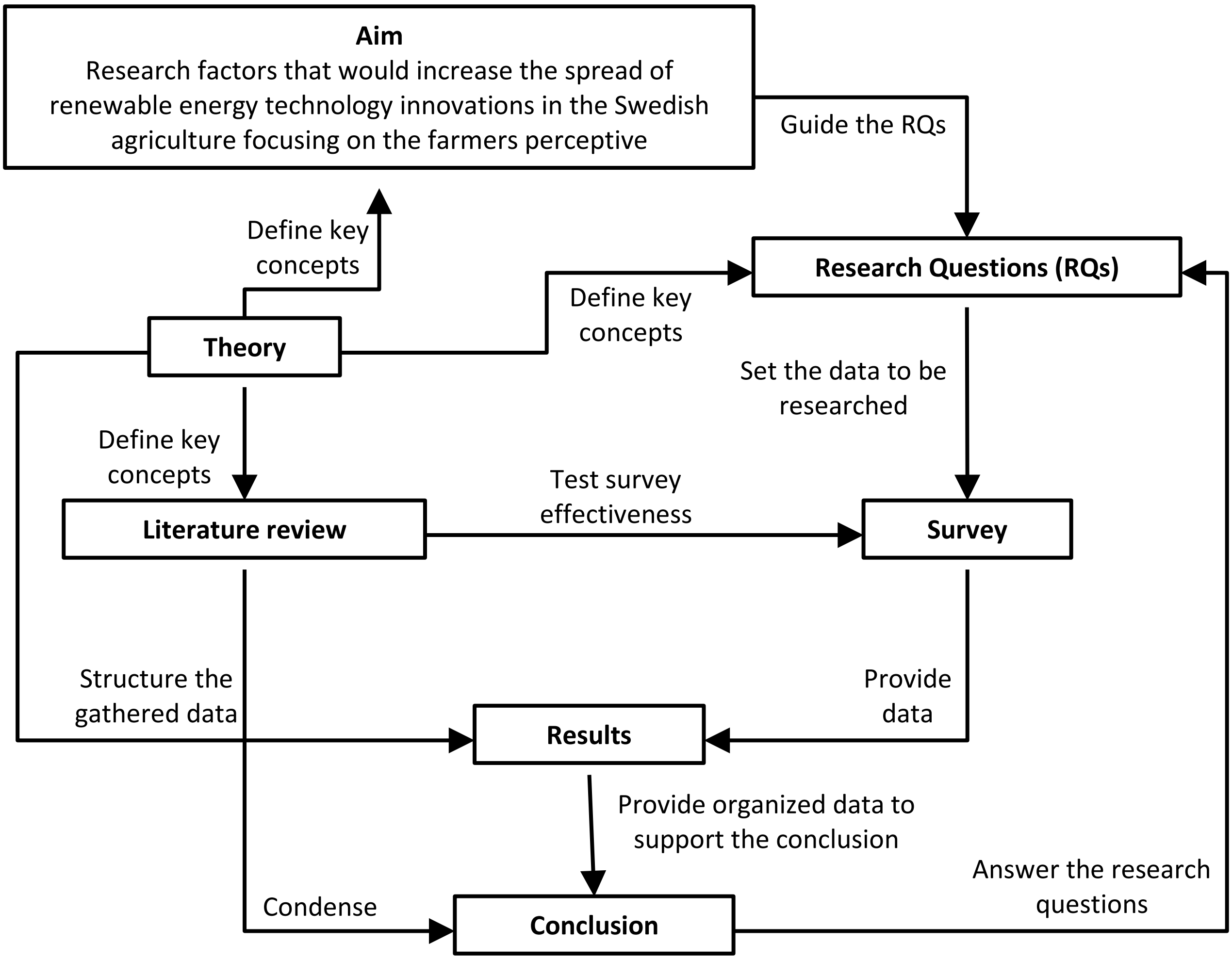

Figure 11: The key elements of the methodology and their interactions

3.1 Survey

The main source of data for this project was a survey. Therefore, information about how the survey was carried out, its aim, and how data were analysed are introduced in this part.

One of the main concept developed in the theory is the *perceived relative advantages* which deals with the individual's own experience and perception. Therefore, a survey is suitable to value those as it asks the respondents about their own awareness about the innovation and not about the true characteristics of the innovation in terms of efficiency, economy, or environmental impact. The background data needed to understand and interpreted the results, as well as value the quality of the survey are presented in this part.

The survey was designed before the start of this project by LRF in collaboration with Nova Affärsutveckling (Business Development) during the autumn of 2015, which also helped for the spread and the analysis of the survey at the beginning. The survey aimed to gather data in order to better understand the situation of renewable energy technologies within Swedish Agriculture and measure the progress towards the goals set by LRF within their strategical energy agenda (see Background). The survey was not specially designed for this particular project, but its content appeared to be an underexploited gold mine that fitted the need of this project.

The survey has been sent via the internet to 5,897 LRF members with a turnover over 50,000 SEK selected from LRF's member register. The survey was sent on December 15th 2015 and closed on January 31st 2016. Three reminders were sent under this time. In total 1,497 responses were collected, giving a response rate of about 25 %, which is within the norm for similar surveys (Nulty, 2008).

Respondent were first asked background questions in order to know their gender, age, regional location, and type of farm (type of business and certification). Moreover, respondents were asked to describe their work related to energy at the farm level. Depending on this answer, different questions were asked. More about the different groups is covered in the result chapter. The survey questions used in this project are presented in the appendix.

The data collected by the survey are mostly quantitative as for each question the response rate for a given group was given. However, respondents could comment in an additional field for each question in case they had further information to contribute with which is considered as qualitative data.

Many group meeting were organized in order to analyse the survey, both internally at LRF and with Nova Affärsutveckling. Many of the group analyses were not specifically organised for the sake of this project, but were still very beneficial for this project. Nova Affärsutveckling provided at first a set of reports that helped to understand how the survey was designed. Later the raw data compiled in a pivot table in Excel were made available for the project. It was then possible to use the data in order to extract relevant results giving material to answer the research questions. The data presented in the different figures and tables in this project were produced by the author.

3.2 Analysis framework

In order to organize the factors influencing the diffusion of renewable energy innovations in the Swedish agriculture found from the survey, an adapted framework had to be developed. To develop this framework, a brief literature review about the drivers and hinders of the development of renewable energy technology in the Swedish agriculture has been carried out. The literature focused on factors influencing farmers in general, factors influencing the adoption of renewable energy technologies in general, and factors influencing Swedish farmers to adopt a given renewable energy technology.

The drivers and hinders found from the literature review supported the development of six main categories within which the found drivers and hinders could be classified under global non-overlapping factors: (i) economic, (ii) political, (iii) personal/individual, (iv) farm and busines, (v) self-sufficiency/energy-independency, and (vi) technology. Ljung's (2012) conclusions have been used in order to find the six categories. The drivers and hinders found in the literature review are summarized in Table 1.

Table 1: Drivers and hinders to the adoption of renewable energy innovations in the Swedish agriculture, data from literature review

Drivers	Factors	Hinders
Economic and financial aspects (Petrini, 1961; 1966; Zdravkovic, 2013; Tsoutsos and Stamboulis, 2005; Silk et al., 2014; Ljung, 2012; Ostwald et al, 2013) **Perceived economic importance** (Petrini, 1966; 1966) **Decrease energy cost perceive** (Dóci and Vasileiadou, 2015) **Anticipating future rise of energy prices** (Mattes et al., 2014)	**Economic**	**Petrol price** (Mamone, 2014) **Uncertain energy price in the future** (Petrini, 1961) **Uncertain profitability and economic** (Lewis et al., 2011) **Price volatility** (Zdravkovic, 2013)
Introduction of carbon tax (McCormick and Kåberger, 2014) **Subsidies** (Mamone, 2014)	**Politic**	**Bureaucracy** (Zdravkovic, 2013; Ostwald et al, 2013) **Long-term regulations** (Ljung, 2012)
Perceived collective benefits, such as climate change mitigation and environmental aspects (Dóci and Vasileiadou, 2015; Lewis et al., 2011, Zdravkovic, 2013; Silk et al., 2014) **Hedonic motivation, meaning-making** (Dóci and Vasileiadou, 2015; Petrini, 1961) **Obtain higher social or political status** (Petrini, 1961) **Personal health and well-being** (Lewis et al., 2011) **Personal engagement** (Mamone, 2014; Hilm, 2012) **Innovativeness** (Rogers, 2003**)**	**Personal/ Individual**	**Age** (Petrini, 1961; Laitila, 2007) **Lack of knowledge** (Petrini, 1961; 1966; Nitsch, 1982; Ljung, 2012: Ostwald et al, 2013) **Social acceptance** (Zdravkovic, 2013; Tsoutsos and Stamboulis, 2005) **Emotional resistance** (Petrini, 1961; 1966)
Business development and self-employment (Zdravkovic, 2013; Silk et al., 2014) **Spreading risks** (Zdravkovic, 2013) **Efficient use of farm resources** (Hilm, 2012) **Modernize farm** (Petrini, 1961)	**Business/Farm related**	**Bigger farms were less interested** (for crop energy) (Laitila, 2007) **Not adapted/applicable to the farm** (Petrini, 1966) **Smaller farms often not contacted by AAS** (Yngwe, 2014) **Habits** (Ostwald et al, 2013)
Self-reliance on green energy (Zdravkovic, 2013; Silk et al., 2014; Ljung, 2012)	**Self-sufficiency / energy independency**	
	Technological	**Lack of adapted technology** (Hilm, 2012) **Poor communication of the innovation technicities** (Petrini, 1961; 1966)

The perceived economic advantages and disadvantages are the main factors influencing farmers to adopt or reject renewable energy innovations (Petrini, 1961; 1966; Zdravkovic, 2013; Tsoutsos and Stamboulis, 2005; Silk et al., 2014; Ljung, 2012; Dóci and Vasileiadou, 2015). The economic, politic, individual and farm/business related factors are both seen as drivers and hinders. However, the factors related to the energy independency connected to renewable energy technologies are only seen as drivers while technological factors are seen as hinders. The literature review may have a low quantity of articles, but the aim was to develop a framework to analyse the results from the survey, and not necessarily to extract factual knowledge from it. The heading of each factors as well as their content will be briefly discussed in this part.

Economic: the economic factors are the most critical and perceived as both drivers and hinders. It includes for instance the perceived profitability related to the renewable energy technology, the potential reduction of current energy cost, and the secured cost of energy in the future.

Politic: the political factors can through incentive and tax reduction support the development of renewable energy technology at the farm level. However, uncertainty about regulations in the long-term or the complexity and bureaucracy related to the implementation of renewable energy technologies are perceived as hinders.

Personal: By personal factors is meant factors that are related to the farmer and not necessarily related to the farm business or the renewable energy technology. Interest for environmental issues is one of the main personal factor. However, less rational and deeper factors are also supporting the development of renewable energy projects like seeking new challenges or contributing to the development of your local community. The farmer's age is seen as a hinder in the sense that the payback time for investment is longer than their remaining active work life. The lack of knowledge is also seen as a personal factor hindering the adoption of renewable energy technologies. The farmer innovativeness described by Rogers (2003) belong to the personal factors, even if it has consequences on the farm operation and the next category of factors: business.

Business: The business or farm related factors are in opposition to the personal factors, factors that are proper to the farm operation and not necessarily related to the farmer as person. Factors such as business development like resource efficiency or business diversification in order to spread risks are the main business factors supporting the adoption of renewable energy technology. Hindering factors are more related to the farm characteristics. For instance the geographical location, the size, or the type of farm might make some innovations non applicable and therefore perceived as hinders. In this project, the driving factor "resource efficiency" is treated apart from the business factors because of its importance in the results.

Self-sufficiency: To be energy independent is an important driving factor. One could argue that it is related to both the economic factors of securing the future cost of energy and to the business related factors. The self-sufficiency factors are not seen as hindering from the literature review performed in this project.

Technology: The lack of adapted technology for agriculture which often requires small-scale technologies is perceived as a hindering factor. The poor communication about the technology is also perceived as a hinder. However, the literature review could not highlight technological factors supporting the development of renewable energy technology in the Swedish agriculture.

The answers for the three RQs will use the factors discussed above in order to organize and present the results in a structured way.

4 Results

The results from the survey are presented in this chapter. First, the results are compared to existing statistics to assess the reliability of the results. Then, some general results about the respondents are introduced as it will support the analysis of the last part that relates to the theoretical framework and provides data to answer the RQs.

4.1 Reliability

This part will focus on the reliability of the survey in comparison to existing statistics about the group targeted by the survey: Swedish farmers being LRF members.

Regarding the respondents' gender, 14 % were women and 86 % men. Statistics from LRFs members from 2014 showed that 17 % of LRF's members were women and 83 % men (IPSOS, 2014). Therefore, women are slightly under represented in this survey in comparison to the member statistics.

The respondents' age was distributed as shown in Table 2, where it is compared to the statistics for LRF's members from 2014 (IPSOS, 2014).

Table 2: Age distribution comparison

Energy survey 2015-2016		IPSOS survey 2014	
Under 35	2%	Under 35	3%
36-49	18%	35-44	10%
50-64	49%	45-54	25%
		55-64	30%
Over 65	30%	65-74	28%
		Over 75	5%

Even though the age intervals used in the survey were different to those from the available statistics (see Table 2), the age distribution of the survey matches the age distribution of LRF members well.

The repartition of the regions are compared to the LRF's member register from the last of December 2015, which correspond to the time the survey was answered (Figure 12).

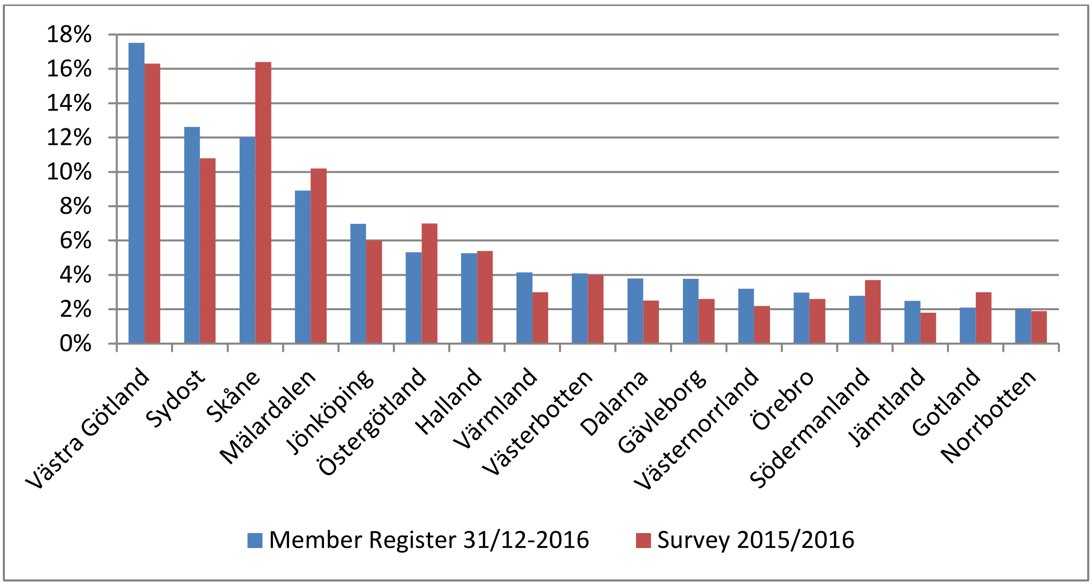

Figure 12: Regional representativeness comparison

Figure 12 shows that except for the region “Skåne” (Southern Sweden), which is over-represented, the geographical repartition of the respondents follow the figures from the member register. The analysis did not show any obvious differences between the regions related to the focus of this project.

The answers for the type business have been compared to LRF latest member register (last of December 2015) and the results are showed in Figure 13.

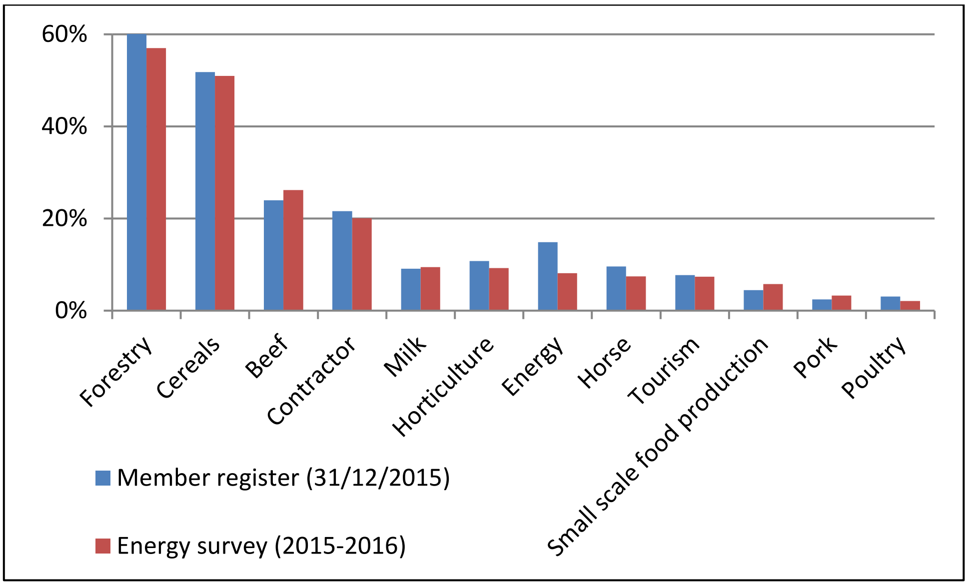

Figure 13: Business representativeness comparison

The survey follows the available statistics for the type of businesses. However, we can observe an under representation of farms with energy businesses (8 % for the survey against 15 % in the member register).

4.2 Respondent profiles

In this part the respondents are divided according to three variables: energy groups, farm business, and type of renewable energy innovation adopted.

4.2.1 Energy groups

Regarding the energy work at the farm level, this project considers four main groups: (i) those who have no special interest for energy related questions and do not necessarily work with energy questions, (ii) those who are working with energy efficiency, (iii) those who have switched to renewable energies, and (iv) those who are selling renewable energy products or services. In order to simplify the reading of the results, the meaning of all four different groups are discussed below and an abbreviation is attributed to each group. The term “energy groups” is used throughout this project to refer the following groups.

ESell (Energy – Selling): This energy group contains farmers who sell renewable energy products or services. It includes for instance farmers that sell firewood to private persons, forestry raw material for energy use, solar electricity to energy suppliers, or heat to communities like schools or municipalities.

ESwitch (Energy – Switch): This energy group contains farmers who switched from fossil dependent energy system(s) to renewable energy system(s). It includes for instance farmers who changed their oil based heating system to a biomass based one, and farmers who buy certified green electricity for the farm operation.

EEff (Energy – Efficiency): This energy group contains farmers that are actively working to reduce their energy consumption. It includes for instance farmers that have taken an eco-driving education (LRF, 2011b), farmers that changed to LED lighting, and farmers that have insulated their buildings in order to decrease their heating demand.

ELoF (Energy – Low Focus): This energy group contains farmers that have a lower degree of focus on energy questions and do not lay any special weight towards energy matters at the moment and could be considered non-adopters according to Rogers (2003). It includes farmers who actively decided to do not work with energy questions and those who are passive. Galjart (1971) separates non-adopters in three groups depending on the reason of refusal: (i) ignorant, (ii) unwilling, and (iii) unable. Nitsch

(1972) argues that additional knowledge will not change the decision of unwilling farmers as the refusal is based on values. Farmers laying in the “unable” group are hindered from adopting due to their finance, age, location, farm size, etc. However, farmers laying in the “ignorant” subgroup may later adopt a given innovation if the right knowledge is diffused.

In the survey, respondents could choose between these four different energy groups or combination of those. Therefore, respondent within the ESell group may also work with efficiency or/and switching to renewable energy systems, and respondent within the ESwitch group may have made their farm more efficient too. Table 3 presents the different combinations each groups embrace and Figure 14 the weight of the four different energy groups in the survey.

Table 3: Combination for the four different energy groups

Energy Group	Alternatives
ESell	ESell ESell + EEff ESell + EEff + ESwitch
ESwitch	ESwitch ESwitch + EEff
EEff	EEff
ELoF	ELoF

The different subgroups in the right hand side of Table 4 are grouped within the four energy groups in order to have a bigger basis for the analysis (Figure 14).

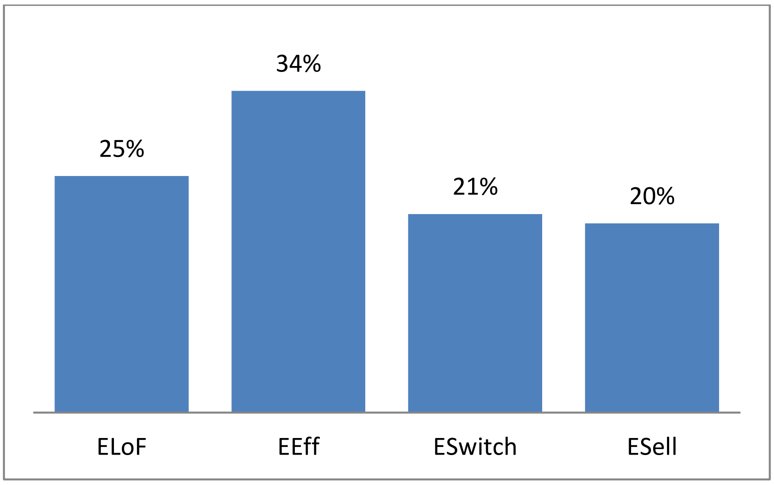

Figure 14: Distribution of the four energy groups

For the analysis, the ESwitch group had to be broken down into two groups. Indeed, some of ESwitch are buying in renewable energy and not producing. Therefore, for the questions dealing with the investment related to the switch to renewable energy technology the ESwitch buying in renewable energy are removed. Moreover the driving forces or experienced hinders differed between these two sub-groups. Overall half of the respondent in the ESwitch category are buying renewable energy, while the other half is producing it. Figure 15 shows how these two subgroups of ESwitch (buying in and producing) are represented for the main renewable energy technologies.

4.2.2 Farm businesses

Farms often comprise and combine different type of businesses. Table 4 gives an insight into what kind of combinations often exists. In this project, when results are discussed in term of farm businesses, the answers are split as a function of the farm main business. Only the results for the six main farm businesses are discussed as other businesses had few answers making the quality of the analysis poor. The farms having energy as main business are also included as energy is the focus in this project. Moreover, when relevant, some less represented businesses like pork production are added to the analysis.

Most of the farms combine different type of businesses. The frequencies of combinations are presented in Table 4.

Table 4: Combination of farm businesses

		Main business X											
		Grains			**Forestry**			**Beef**			**Milk**		
All Businesses Y		**346**			**336**			**189**			**130**		
Grains	**733**	**346**	100%	47%	63	19%	9%	97	51%	13%	84	65%	11%
Forestry	**796**	125	36%	16%	**336**	100%	42%	127	67%	16%	72	55%	9%
Beef	**381**	36	10%	9%	49	15%	13%	**189**	100%	50%	54	42%	14%
Milk	**142**	2	1%	1%	1	0%	1%				**130**	100%	**92%**
Contractor	**286**	61	18%	21%	30	9%	10%	45	24%	16%	26	20%	9%
Horticulture	**130**	16	5%	12%	5	1%	4%	3	2%	2%	5	4%	4%
Energy	**119**	38	11%	**32%**	18	5%	**15%**	5	3%	4%	6	5%	5%
Other	**314**	59	17%	19%	46	14%	15%	32	17%	10%	15	12%	5%
Business/farm		1,80			1,49			2,47			**2,90**		

		Contractor			**Horticulture**			**Energy**			**Other**		
All Businesses Y		**96**			**91**			**28**			**118**		
Grains	**733**	51	53%	7%	23	25%	3%	10	36%	1%	59	50%	8%
Forestry	**796**	60	63%	8%	18	20%	2%	15	54%	2%	43	36%	6%
Beef	**381**	29	30%	8%	3	3%	1%	5	18%	1%	16	14%	2%
Milk	**142**	2	2%	1%							7	6%	1%
Contractor	**286**	**96**	100%	34%	7	8%	2%	4	14%	1%	17	14%	2%
Horticulture	**130**	5	5%	4%	**91**	100%	70%	1	4%	1%	4	3%	1%
Energy	**119**	9	9%	8%	5	5%	4%	**28**	100%	**24%**	10	8%	1%
Other	**314**	22	23%	7%	19	21%	6%	3	11%	1%	118	100%	16%
Business/farm		2,63			1,62			**2,25**			2,32		

Some explanations are needed in order to facilitate the reading of Table 4. The headings of the columns correspond to the farm's main business in terms of turnover, while the headings of the rows correspond to all businesses carried out at the responding farm. The numbers in the table on blank background are the number of farms. Two different percentage calculations facilitate the understanding of the figures.

The percentage in green represents how big share of the farms with a given main business X have the business Y. Therefore, if businesses X and Y are the same the figure reach 100 % as 100 % of the farms having X as their main business carry out Y business. This figure shows what combinations are the most common within each business and is related to the figures from last row showing the average number of business per farm.

The red percentages show how each business is spread among the farm's main businesses. For example, looking at the horticulture row, we see that 70 % of the horticulture businesses take place in a farm having horticulture as its main business. The results are analysed horizontally, and the sum of them are 100 %.

Farms having milk as their main business are on average the farms combining the most businesses (2.9), while enterprises having forestry as their main business have on average 1.49 businesses. 92 % of the respondents having milk production have it as their main business. On the other hand, only 24 % of the farms having an energy business have it as their main business. This proves that energy businesses are often implemented on the side of the main business. 11 % of the grains farmers have also an energy business, representing about a third of all energy businesses.

4.2.3 Renewable Energy Technology

In this study, the respondents who switched to renewable energy systems (ESwitch) or who are selling energy products and/or services (ESell) have been asked what kind of renewable energy technology they are working with. They could choose between eight alternatives: (i) processed bioenergy, (ii) raw bioenergy, (iii) hydropower, (iv) solar energy for electricity supply, (v) wind power, (vi) biogas, (vii) biofuel, and (viii) other. Each category will be briefly explained.

Bioenergy: The survey separated this group into two: "processed bioenergy" and "raw bioenergy". The processed bioenergy group includes all type of bioenergy products and services that have been processed at some point. It covers for instance firewood, pellets, heat from straw, or delivery of heat. The raw bioenergy group includes mostly raw material sold as such to companies that then will process the biomass. The results from both groups were similar. Therefore, in the following analysis, both groups belong to the group "bioenergy".

Hydropower: Most of the respondents producing electricity from hydro power operate small scale systems. Within this category, most ESwitch buy certified electricity based on hydropower from their energy supplier (Figure 15).

Solar energy for electricity supply: The Swedish term "solel" which means solar-electricity has been used in the survey as the term is widely used and understood. Respondents having this renewable energy technology are using photovoltaic panels in order to generate direct current that is then converted to alternative current with the help of an inverter. The electricity is then either used on the farm (ESwitch) or sold and fed into the grid (ESell). This group is designated as "solar" in the coming analysis. Some ESwitch respondents are buying solar electricity from their electricity supplier and therefore not producing solar electricity at the farm (Figure 15).

Sweden does not a have net-metering system, meaning that if the supply is higher than the electricity usage, the over-production is fed into the grid. The electricity fed into the grid can be sold to energy suppliers.

Wind power: As for the hydro power and the solar energy, wind power generates electricity. Respondents within this category may have invested in wind turbines that are installed on their property, they may be part-owner of a wind park or have a special agreement with an energy supplier which can use or rent the respondent's property to install wind turbines. Some ESwitch respondents are also buying solar electricity to their electricity supplier (Figure 15).

Biofuel: Only 11 respondents are working with biofuels and only one respondent is selling biofuel. Therefore, most of the respondents working with biofuels are buying in biofuels. The technics and products exist in order to run a farm on fossil free biofuel. For instance, the three farms who started "the energy factory" (Energifabriken) have replaced their fossil fuel with biofuel (GAFE, 2015).

Statistics about the use of biofuel in the Swedish agriculture are gross and not detailed. Moreover, diesel is the main fuel used in agriculture. Therefore, as farmers buy diesel that is available on the Swedish market, statistics about the Swedish use of biofuel substituting fossil diesel will be shortly introduced.

Two fossil free alternatives to fossil diesel are available on the Swedish market: FAME and Hydrotreated Vegetable Oil (HVO). RME (Rape Methyl Ester) is the most common FAME available in Sweden and is produced from rapeseeds (Batchelor et al., 1995). HVO can be produced from different vegetable oils (such as rape seed, sunflower, soya, and palm oil) and is a fuel chemically similar to diesel (Swedish Energy Agency, 2014; Aatola et al., 2008). In 2014, 4.8 % of Sweden's fuel used for transportation was HVO, and 1.2 % FAME (SPBI, 2016). Moreover, in 2014 85 % of the diesel sold was blended with up to seven percent (volume) FAME, , although the FAME fraction is only tax-free up to five percent of the mixture. (Swedish Energy Agency, 2014). HVO can also be blended with diesel but without limitation and is tax-free. The FAME blended in diesel corresponds to 2.7 % of the fuel use for transportation in Sweden (Swedish Energy Agency, 2014). Together, HVO and FAME represented about 9 % of the total energy use for transportation fuel in Sweden in 2014.

Due to the low number of respondents, the biofuel group will not be further analysed in this project.

Biogas: Biogas is produced during the anaerobic (in absence of oxygen) digestion of organic matter. Agricultural waste, such as manure, can be used alone or in combination with other input such as ley, household and industrial organic waste. The biogas produced can be directly burned in a combined heat and power unit that provides both electricity and heat. Biogas can also be upgraded to biofuel standard by lowering the carbon dioxide content in order to have a methane-content of around 97%. The upgraded biogas can be used as fuel in appropriate vehicles, such as city buses or some adapted tractors (The Swedish Gas Association, 2011).

Agriculture plays a minor role at the moment, as only 3% of the Swedish production of biogas in 2013 came from farm based production (The Swedish Gas Association, 2016). However, biogas production from agriculture based waste has by far the biggest potential (Linné et al., 2008). Due to the low number of respondents, biogas will not be further analysed in this project.

Other: Most of the answers from the category "other" include geothermal heat (14 respondents out of 33). There are also some respondent using district heating and solar heating. With the data and tools available for this project, it was not possible to create a "geothermal" group to analyse the results. Therefore, this group is not going to be analysed in this project.

Table 5 presents the relation between the different renewable energy technologies and main business. The left hand side of the table shows how renewable energy technologies are divided within each main business, meaning that the sum of each row on the left hand side of the table is 100 %. The right hand side of the table shows how each renewable energy technology are represented within the farm main businesses, meaning that the sum of each column on the right hand side of the table is 100 %.

Table 5: Repartition of the different types of renewable energy in the main farm businesses

	Total	Bioenergy	Solar	Wind	Water	Other	Biogas	Biofuel	Total	Bioenergy	Solar	Wind	Water	Other	Biogas	Biofuel
Total	**420**	**61%**	**15%**	**13%**	**4%**	**5%**	**2%**	**1%**	**420**	**255**	**65**	**53**	**16**	**21**	**7**	**3**
Forestry	**131**	70%	12%	8%	4%	5%	0%	1%	**31%**	36%	25%	21%	31%	29%	0%	33%
Grains	**100**	51%	15%	22%	4%	5%	2%	1%	**24%**	20%	23%	42%	25%	24%	29%	33%
Beef	**38**	82%	13%	0%	3%	0%	3%	0%	**9%**	12%	8%	0%	6%	0%	14%	0%
Milk	**31**	68%	13%	13%	0%	0%	6%	0%	**7%**	8%	6%	8%	0%	0%	29%	0%
Contractor	**31**	71%	16%	3%	0%	10%	0%	0%	**7%**	9%	8%	2%	0%	14%	0%	0%
Energy	**28**	25%	7%	43%	11%	11%	4%	0%	**7%**	3%	3%	23%	19%	14%	14%	0%
Horticulture	**17**	65%	24%	6%	0%	6%	0%	0%	**4%**	4%	6%	2%	0%	5%	0%	0%
Other	**44**	45%	32%	5%	7%	7%	2%	2%	**10%**	8%	22%	4%	19%	14%	14%	33%

From Table 5 we can see that renewable energy technologies and business are not distributed randomly. The figures for waterpower, biofuel, biogas, and other renewable energy technologies are presented but not further analysed due to the low quantity of responses, and the diversity embedded within the renewable energy group "other".

Bioenergy represents 61 % of all adoption of renewable energy innovations and represents more than half of the renewable energy technologies used at the farm level except for farms having energy or “other” (pork, poultry, tourism, etc.) as their main business.

43 % of the respondents that have energy as their main business are working with wind power, while on average only 13 % do. Concerning wind power, we also see that only few respondents having beef production, horticulture production, or being a contractor are working with wind power. Farmers having forestry or grains as their main business represent together 63 % of the respondents who implemented wind power.

Solar energy innovations are most popular within farms belonging to the “other” category and farms that have horticulture as their main business.

Table 5 is important to keep in mind for the following analyses. Indeed, in order to avoid double counting, it is worth acknowledging that a given renewable energy technology may be correlated with a given farm business. For instance, as discussed above, farms that have energy as their main business are much more likely to have wind power than farms with other main businesses.

As discussed in the energy groups part, farmers adopting a given renewable energy innovation do it in different ways. They can invest in infrastructure in order to sell energy (ESell, dark blue in Figure 15). They can also at the same time use the energy produced for the farm operation and sell the over production (ESell which ESwitch, light blue in Figure 15). Farmers who switched to renewable energy are either producing the energy (ESwitch Produce, dark green in Figure 15) or buying the energy (ESwitch Buy in, light green in Figure 15).

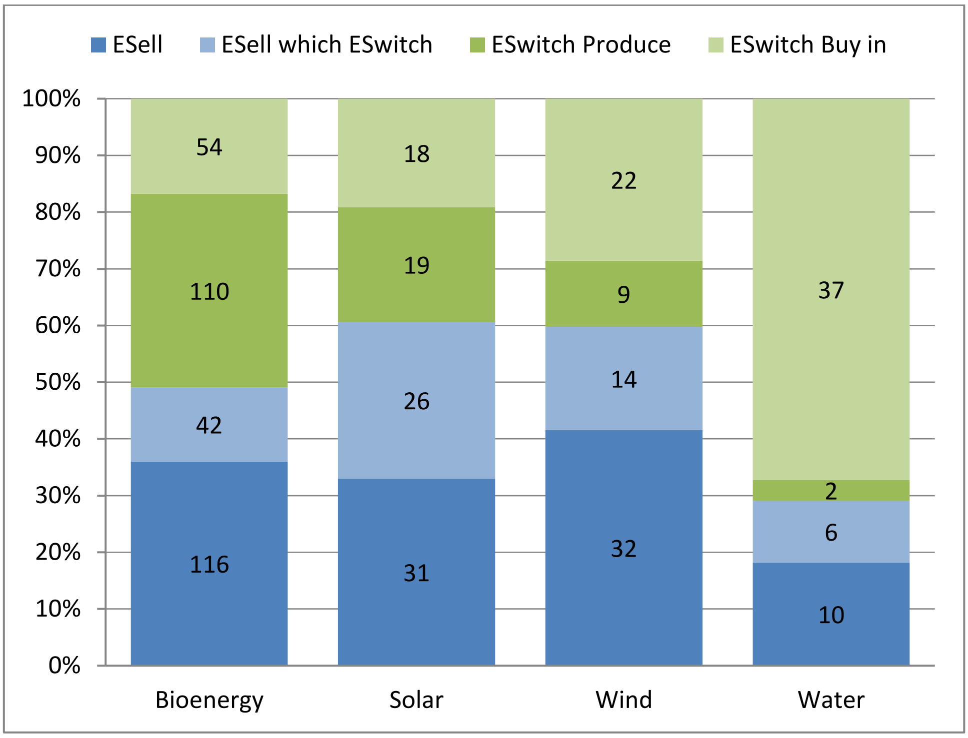

Figure 15: The different degree of adoption for the main type of renewable energy

In the coming analysing, the "ESwitch Buy in" group has been left aside as the group was not considered relevant for this study, especially for questions regarding the investment, driving forces and hinders. Another reason is that "ESwitch Buy in" refers to a diverse group. For instance, respondents buying in bioenergy may have had to invest into a biomass heater or may be buying heat produced from biomass. Moreover, the respondents buying in solar, wind, or hydro power had most likely not invested into infrastructure, but are buying certified electricity to their energy supplier. Therefore, it was difficult to assess which respondent within this group actually made an investment.

About 20 % of the respondents who had adopted bioenergy or solar energy are buying in the energy, the other are producing it at the farm. Almost 70 % of the respondents who switched to electricity from hydropower are buying it. Therefore, only few answers could be used in order to understand the hinders and the drivers to investment in hydro power and this group is not included in the analysis in this project.

Figure 16 shows how the three renewable energy technologies are distributed within the two energy groups who adopted a renewable energy innovation.

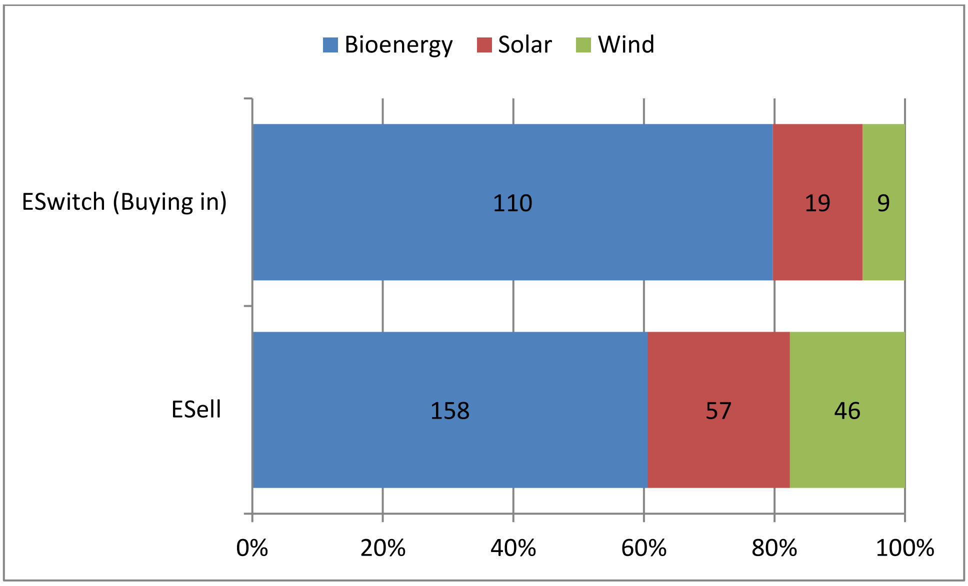

Figure 16: Repartition of the renewable energy technologies in the two energy groups (ESell, and ESwitch)

In both groups bioenergy innovations represents between 60 % and 80 % of the renewable energy technologies.

4.3 Knowledge and persuasion stages

The survey contained three questions that focused on the knowledge aspect. The first question asked if respondents perceived a need for more energy related knowledge (Figure 17), if so what kind of knowledge was needed (Figure 18), and finally how the knowledge should be spread (Figure 20).

Rogers' theory claims that the innovation-adoption process is an information seeking process. The results for this part correspond to Rogers' knowledge and persuasion stages.

4.3.1 Knowledge

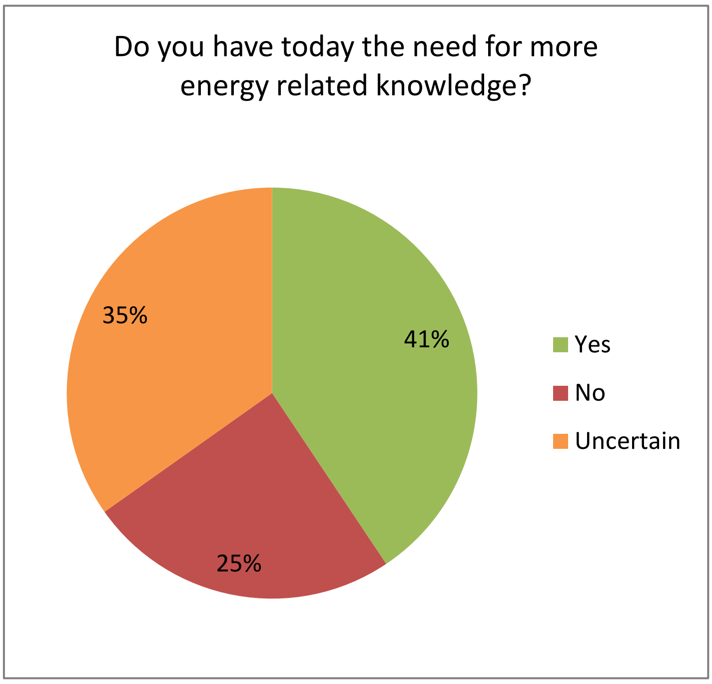

Figure 17: Perceived need for energy related knowledge

Figure 17 shows that 41 % of the respondents perceived a need for more knowledge related to energy. This could mean that they might have entered an innovation-decision process, but lay at the knowledge or persuasion stage. Out of the remaining 59 %, 58 % are uncertain and maybe just about to enter the innovation-decision process. Therefore, further knowledge will potentially be beneficial for about 75 % of the respondents and could possibly accelerate their innovation-decision process.

The remaining 25 % that see no need for knowledge might either be far away from entering the innovation decision process or might have gone through it already. The results show that only 24 % of ELoF perceived a need for more energy related knowledge. This would correspond to farmers who have not entered an innovation-decision process and are most likely far from entering it. On the other hand, ESell in general, a group which has already gone through an innovation-decision process related to energy at the farm level, also see less need for further energy related knowledge than the average (31 %), (Table 6).

Table 6 divides the results from Figure 17 by main businesses and energy groups.

Table 6: Perceived need for energy related knowledge divided by energy group and main business

	ELoF	EEff	ESwitch	ESell	Grains	Forestry	Beef	Milk	Contractor	Horticulture	Energy	Other
	380	510	315	292	346	336	189	130	96	91	28	118
Yes	24%	47%	54%	35%	39%	31%	43%	53%	42%	48%	43%	44%
No	31%	16%	21%	35%	26%	30%	17%	22%	24%	19%	29%	17%
Uncertain	44%	37%	25%	30%	35%	38%	40%	25%	34%	33%	29%	39%

ESwitch (54 %) and EEff (47 %) are the two groups that experienced the most need for further knowledge about energy. Only 35 % of ESell and 24 % of ELoF experienced a need to develop their knowledge related to energy.

Looking at the main farm businesses, milk producers, beef producers, contractors, and horticultural farmers are the groups that most want more knowledge. Only 31 % of the respondents having forestry as their main business perceived a need for more knowledge.

Another observed trend was that younger respondents saw a greater benefit of more energy related knowledge as 68 % of the respondents under the age of 35 perceived a need for more knowledge.

By comparing both sides of Table 6 (separated by the vertical double line) we can see that concerning the need of further knowledge, the four different energy groups (ESell, ESwitch, EEff, and ELoF) differ more from each other than the different main farm businesses do (Table 6).

4.3.2 Knowledge content

Respondents that perceived a need for further knowledge were asked two follow-up questions concerning the knowledge content and the communication channels (Figure 18, Figure 19, Figure 20)

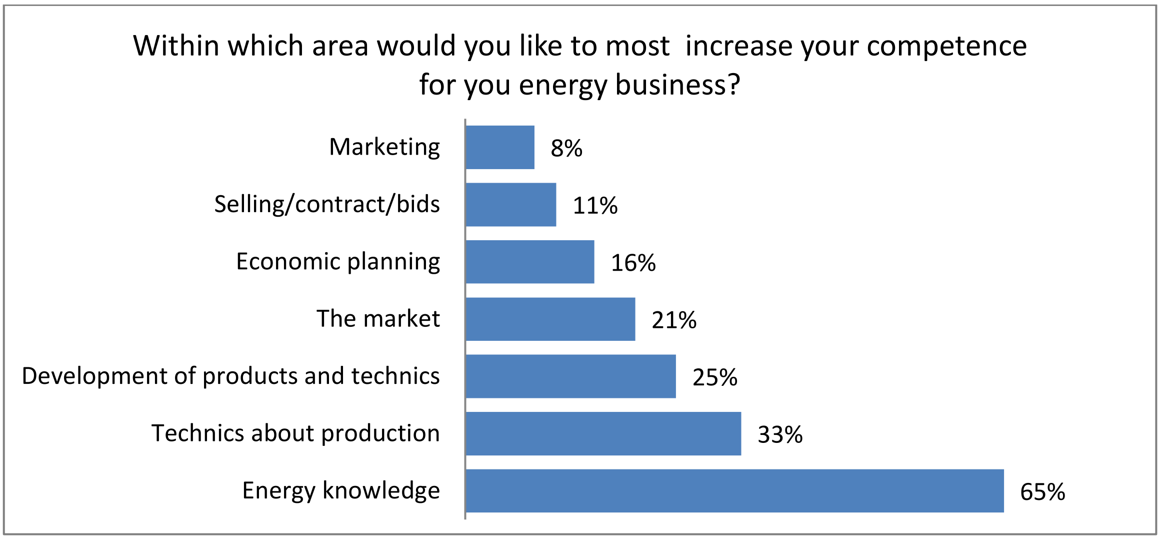

Figure 18: Desired content for energy related knowledge

To analyse the results from Figure 18, it is good to bear in mind the results from Figure 17 as only respondents recognizing a need for more knowledge answered this question.

Those who perceived a need for more knowledge were most interested in information related to the knowledge stage (basic energy knowledge). However, the remaining type of desired knowledge belonged to both the knowledge and the persuasion stages as the farmers sought for background information as well as information applied to their particular case. Moreover, answers other than the "energy knowledge" alternative could be clustered into two main groups: business related or technical related. When looking at the number of answers for each of the three groups (energy knowledge, business, and technical), they represent each about a third of the total number of answers (Figure 19).

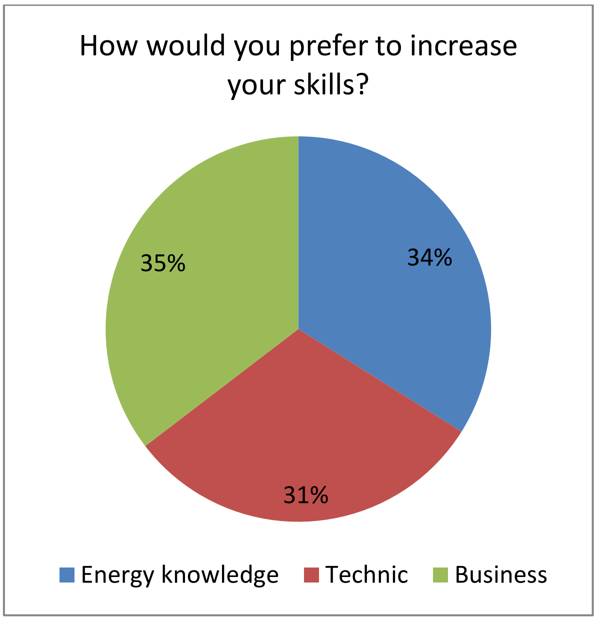

Figure 19: Distribution of the desired content for energy related knowledge into three groups

The answers for the different energy groups also differ regarding the knowledge content. ESell lays much more importance, in comparison with the other groups, on knowledge related to business development and technology, and much less on general knowledge about energy (42 % against 65 % in average). The other three energy groups (ESwitch, EEff and ELoF) follow the average trend with slightly more interest about general knowledge. Milk and grains farmers are more interested in technology related knowledge, horticultural farmers in the marketing aspect and beef producer in general energy knowledge.

4.3.3 Communication channels

The third question of the knowledge block focuses on the preferred way knowledge should be spread. Reflecting on Rogers' theory, this question corresponds to the communication channels used. Petrini (1966), Jones (1963) and Ryan and Gross (1943) mentioned that farmers appreciate and value more interactive and peer-to-peer communication. The results from Figure 20 follow this theory.

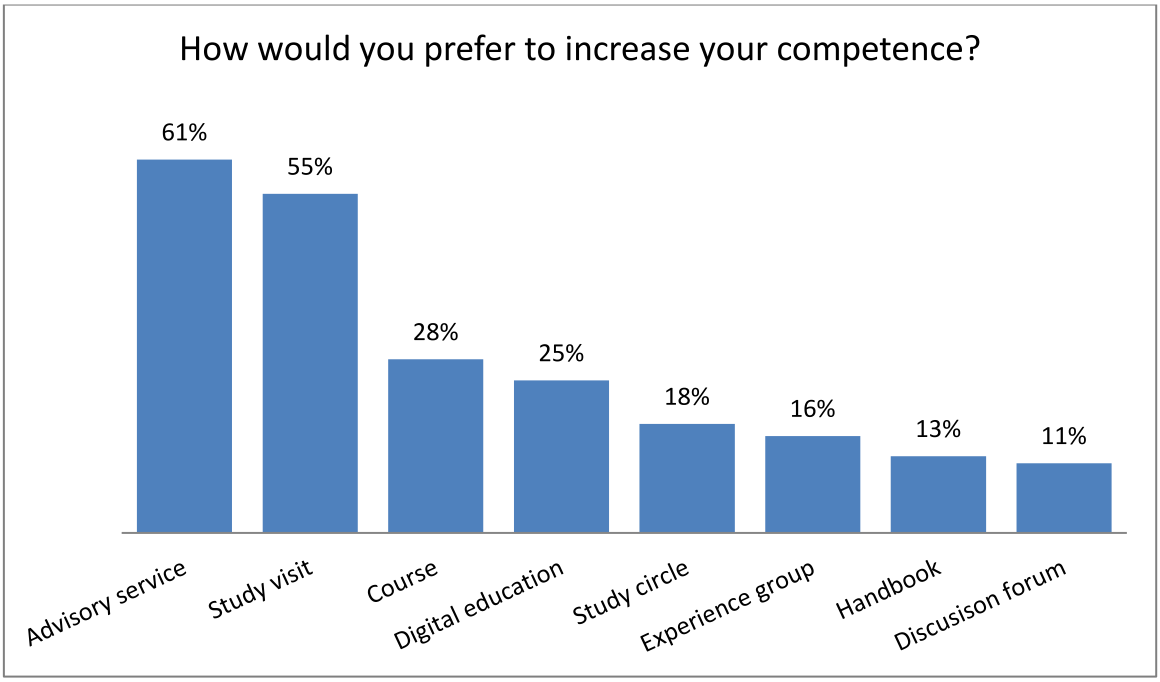

Figure 20: Desired channels for energy related knowledge

Figure 20 shows the importance farmers lay on personal and interactive communication channels (adviser, study visits, course, digital education, and study group). Focussing on relatively new communication channels, a target group is more interested and positive about digital/online education than the average. This groups is farmers under 35 years old (43 %), but other groups are slightly over the average: contractors (28 %), forestry (30 %), ESwitch (31 %), women (32 %), as well as ELoF (26 %).

Jones (1963) argues that in order to be effective, a communication channel must be accepted by the farmer. Therefore, the result from this survey gives us an insight into what communication channels are asked for and accepted.

Getting advisory support or implementing an energy survey may be seen as adopting an energy related innovation. Based on the results shown in Figure 20, Agricultural Advisory Services is the respondents' favourite communication channel to increase their energy skills. Figure 21 shows us how many respondents had adopted these innovations.

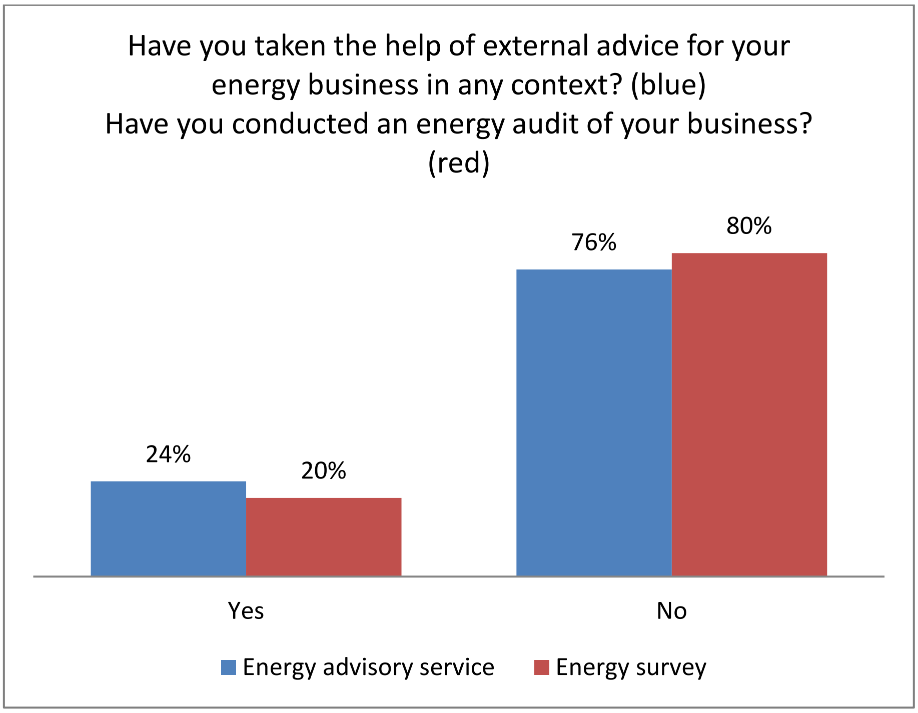

Figure 21: Adoption innovations linked to energy related knowledge

On average, 24 % of the respondents used an external energy adviser for their farm. ESell and ESwitch are the ones that got the most help, 38 % and 36 % respectively, which make sense as they are the ones who work most actively with energy questions at the farm. 21 % of EEff and only 6 % of ELoF took help from an external energy adviser. On average only 20 % of the respondents adopted the energy survey innovation. The trend for the four different groups is similar for the implementation of an energy survey (27 % of ESwitch, 25 % of EEff, 18 % of ESell and 8 % of ELoF.

The target for the two innovations differed slightly. An external energy adviser is mostly appreciated by ESell and ESwitch as they seek expertise about the best investment to do in order to sell energy products and services, or save energy at the farm. Energy surveys would beneficiate more ESwitch and EEff more, as they aim to reduce their energy cost and/or use. By knowing their energy use, EEff will be able to take more efficient action to reduce their energy use.

4.3.4 Perceived relative advantages

In this section, the result from the questions dealing with the reasons for the adoption or rejection of renewable energy innovations at farm levels will be presented. First general results are discussed and then relevant results specific to particular groups are presented. This part relates to the perceived relative advantages developed by Rogers and is referred to as drivers and hinders in this project.

4.3.4.1 ESell

Figure 22 presents the main motives and reasons why farmers started to sell energy products and services.

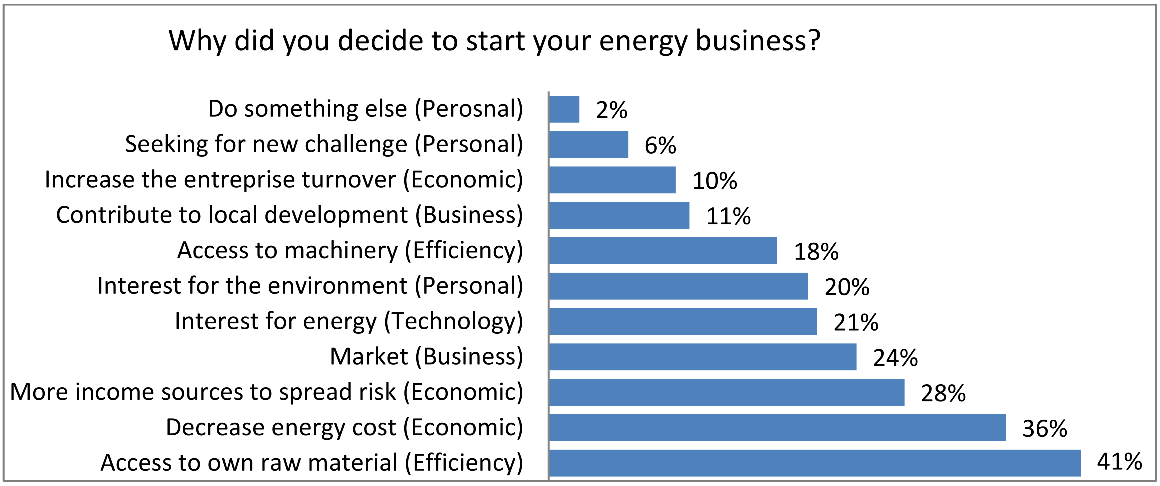

Figure 22: Main reasons to start a farm-based energy business

From Figure 22, three factors could be seen as being particularly important: economic, business, and efficiency factors. Table 7 presents the results for the five main groups of reasons corresponding to the factors discussed in the methodology. The political factor is not included in this result but further discussion about this are found in the Conclusion. The results are divided by renewable energy technologies and farm main businesses.

Table 7: Main reasons to start a farm-based energy business by TYPE OF RENEWABLE ENERGYand main farm business

	Total	Bioenergy	Solar	Wind	Forestry	Grains	Energy	Beef	Contractor	Milk
	277	158	57	46	97	64	25	23	22	21
Economic	65%	54%	79%	70%	52%	67%	56%	61%	68%	52%
Efficiency	52%	76%	16%	4%	66%	38%	28%	57%	36%	62%
Business	36%	36%	16%	57%	33%	34%	52%	30%	27%	38%
Personal	29%	16%	37%	48%	23%	28%	52%	30%	23%	29%
Technology	22%	12%	42%	30%	19%	17%	36%	17%	27%	10%

The figures in Table 7 show the percentage of respondents choosing at least one alternative related to the factors defined in the method. From Table 7 we can note that the driving forces for starting an energy business differ between the type of innovation adopted and the main farm business.

Overall, entrepreneurs started their energy business for economic reasons (65 % on average). Respondents working with bioenergy started an energy business because they had access to the raw material and saw it as a way to make their enterprise more effective. On the other hand, they did not start it because of their interest for energy (technology) or the environment (personal). Respondents selling electricity from solar energy started their energy business mainly for economic reasons. The personal and business related factors are of importance for respondents who invested in wind power technology.

Moreover, according to the survey, women perceived their interest for the environment to be a bigger reason for starting their energy business than men (32 %).

In addition, ESell have been asked how important for their energy business were the economic, environmental, independency, and tradition factors (Figure 23).

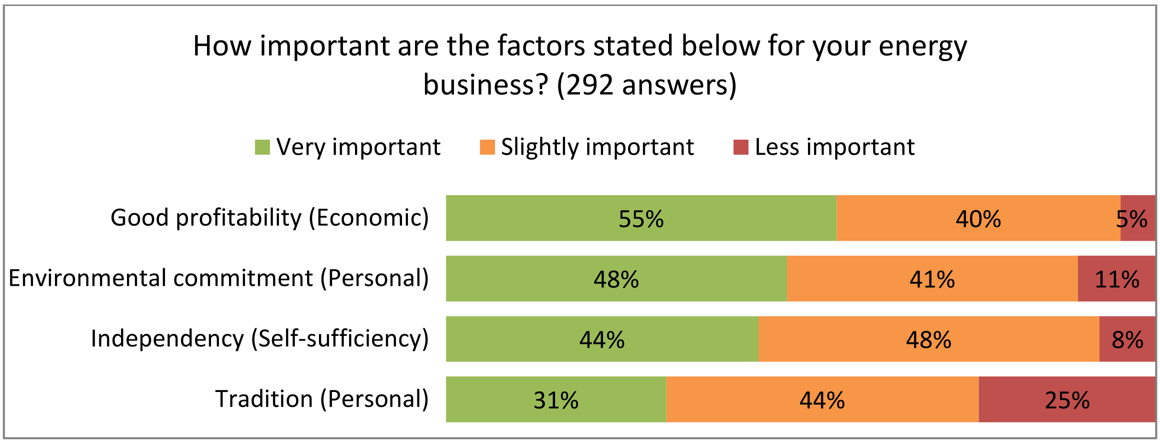

Figure 23: Factors of importance for an energy business

Figure 23 compared the importance of various factors for their energy business according to the ESell group. The economic factor is the most important, followed by commitment to the environment and interest to be independent have relatively the same importance. The tradition factor is the least important in this study. These results strengthen the results from Table 7 and complement it by highlighting the importance of self-sufficiency.

4.3.4.2 ESwitch

In Figure 24 are presented the main reasons why respondents (ESwitch) decided to switch to renewable energy systems.

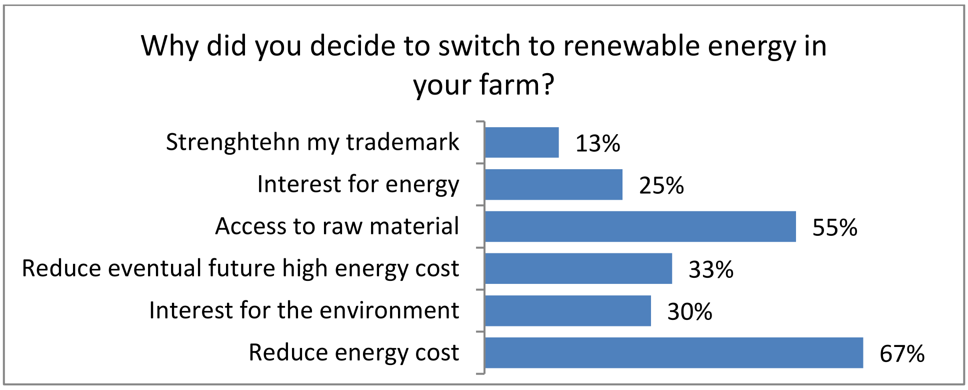

Figure 24: Main reasons for switching to renewable energies

The answers can be clustered into similar groups to ESell's reasons for starting their energy business (Table 7) according the methodology. The results are presented in Table 8 and divided by renewable energy technologies and farm main businesses.

Table 8: Main reasons for switching to renewable energies by TYPE OF RENEWABLE ENERGYand main farm business

		Bioenergy	Solar	Wind	Grains	Forestry	Horticulture	Beef	Milk	Contractor	Pork
	159	**110**	**19**	**9**	**36**	**34**	**11**	**15**	**10**	**9**	**10**
Economic	**77%**	77%	95%	44%	86%	74%	73%	73%	70%	89%	90%
Efficiency	**55%**	73%	0%	22%	69%	56%	55%	40%	50%	78%	50%
Business	**13%**	9%	21%	0%	17%	6%	36%	7%	10%	11%	0%
Personal	**30%**	25%	58%	44%	28%	24%	55%	47%	30%	22%	30%
Technology	**25%**	21%	37%	33%	17%	32%	0%	27%	40%	11%	30%

The results from Table 8 show that reasons or driving forces to switch to renewable energy systems differ with the type of renewable energy technology and main business. For instance, respondents who switched to solar energy, wind power or hydropower did not do it because they had access to raw material (efficiency). On the other hand, most of the respondents who adopted a solar energy innovation considered the economic and personal factors as the most important (95 % respectively 58 %). Respondents adopting a bioenergy innovation are the group that perceived the most efficiency factors as a driver (73 %). Moreover, because they are the most represented renewable energy technology, it explains why the efficiency factor is high in Figure 24.

In addition, the survey showed that women value their interest for the environment as a reason to switch to renewable energy (51 %) higher than men, but their interest for energy lower (10 %).

4.3.4.3 EEff and ELoF

Both groups who had not switched to renewable energy as part of their operation or product and services (EEff and ELoF) were asked the main reasons for not adopting a renewable energy innovation. Both groups showed similar results. Figure 25 introduces the main reasons why farmers had not switched to fossil free or renewable energy systems.

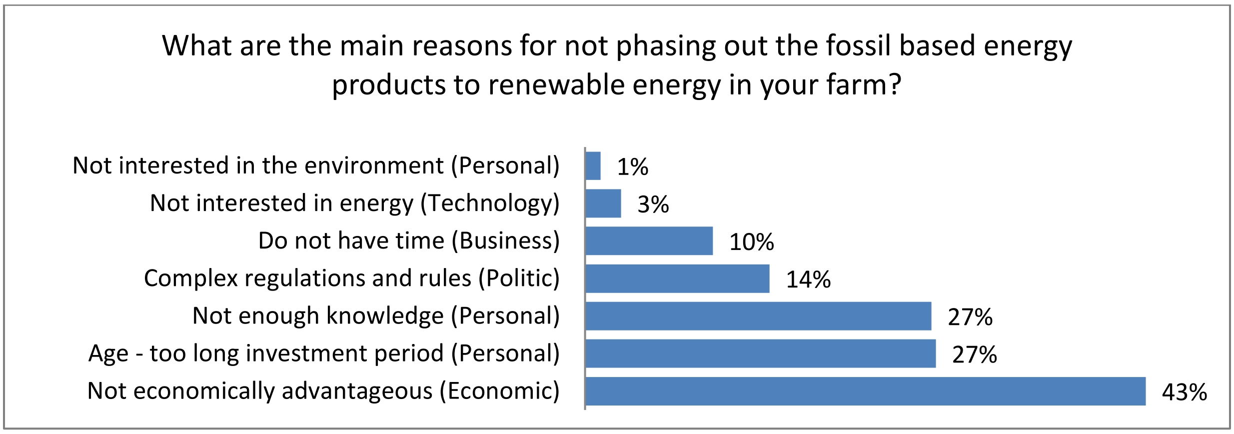

Figure 25: Main reasons for not switching to renewable energies

The most important reasons for not changing to fossil free energy systems were economic and personal factors (age, knowledge, and interest for the environment). Based on the categories defined in the method, 51 % of the respondents answered that at least one reason was related to personal factors. In comparison with Figure 22 and Figure 24 where interest for the environment was a major driver, the lack of interest for the environment is barely perceived as a hinder in Figure 25.

4.4 Implementation and confirmation stage

In this section we will look in particular to farmers who have adopted and maybe confirmed an energy related innovation. Therefore, only results for ESell and ESwitch are presented in this part. EEff have not been asked similar questions and are therefore excluded from this part.

The focus will lie on the perceived hinders and advantages encountered with the adoption of the innovation. The results correspond to Rogers' implementation and confirmation stages.

4.4.1 ESell

Figure 26 presents the nine main hinders to further development ESell encountered during their innovation-decision process.

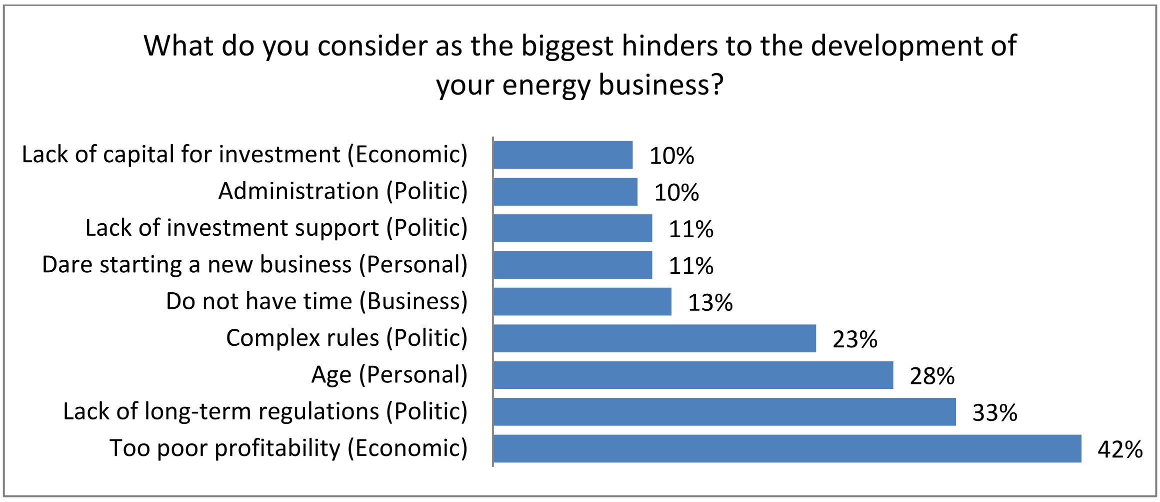

Figure 26: Main hinders to the development of energy businesses

The main reason hindering ESell from developing their energy business further and "re-inventing" the innovation or adopting others is a perceived poor profitability. However, when answers concerning politics and regulations are clustered within the same group (lack of long-term rules, complex rules, and lack of support for investment), 46 % of ESell considered at least one of the three alternatives to be a hinder (Table 9). In other words, farmers selling energy at the moment experience that politics and a poor profitability hinder their development. Their age is also an important obstacle to bear in mind.

In general women considered the lack of support for investment and the lack of knowledge as greater hinders than men. On the other hand men considered their age as a hinder, mainly due to the fact that male respondents are older than female respondents.

Table 9 presents factors hindering ESell to develop their energy business as well as the share of respondent who do not see any hinders for the three most represented renewable energy technologies and five main businesses.

Table 9: Main hinders to the development of energy business by TYPE OF RENEWABLE ENERGYand main farm business

	Total	**Bioenergy**	**Solar**	**Wind**	**Forestry**	**Grains**	**Beef**	**Contractor**	**Milk**
	292	158	**57**	**46**	**97**	**64**	**23**	**22**	**21**
Economic	**46%**	41%	39%	70%	34%	56%	39%	45%	57%
Politic	**46%**	27%	67%	67%	29%	59%	35%	50%	24%
Personal	**38%**	41%	42%	26%	49%	38%	39%	18%	29%
Business	**13%**	21%	5%	0%	12%	13%	9%	14%	29%
No hinder	**7%**	5%	7%	9%	8%	3%	26%	5%	5%

Table 9 shows that reasons for hinders can significantly differ from one business to the other but also between renewable energy technologies. For instance, 26 % of farmers having beef production do not see any hinder and a lower share than the average see economic and political factors as hindering their development.

When focusing on the different renewable energy technologies, 70 % of the respondents with wind power see the poor profitability as a hinder. Political factors are seen as a hinder by respondents with solar energy (67 %), and wind power (67 %), while only 27 % of respondent with bioenergy see it as a hinder. It also worth pointing out that only 39 % of the respondents with solar energy and 41 % of the respondents with bioenergy considered economic factors as a hinder.

ESell have been asked to which extent they could influence the profitability around their energy business (Figure 27).

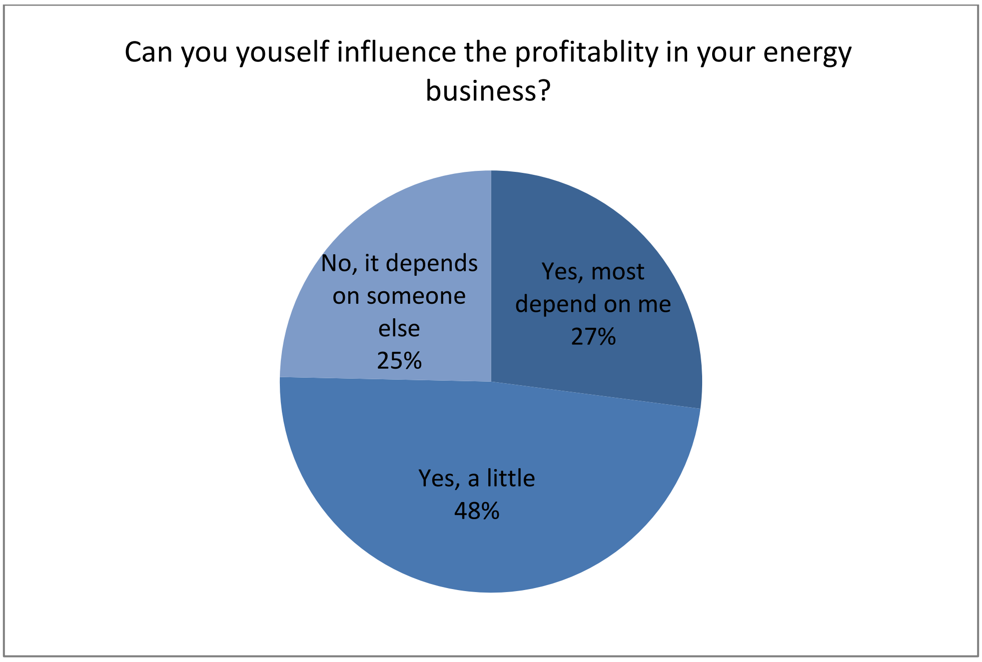

Figure 27: Perception of influence over the profitability of the energy business

Figure 27 shows that three quarters of the respondents experienced that they could influence their profitability to some extent. More respondents with solar energy (84 %), or bioenergy (82 %) perceived that they could influence the profitability of their energy business than respondents with wind (43 %). Moreover, 37 % of the respondents with bioenergy considered that they were the ones mostly influencing the profitability.

Concerning the profitability experienced by ESell, they were asked to assess the current profitability for renewable energy (Figure 28).

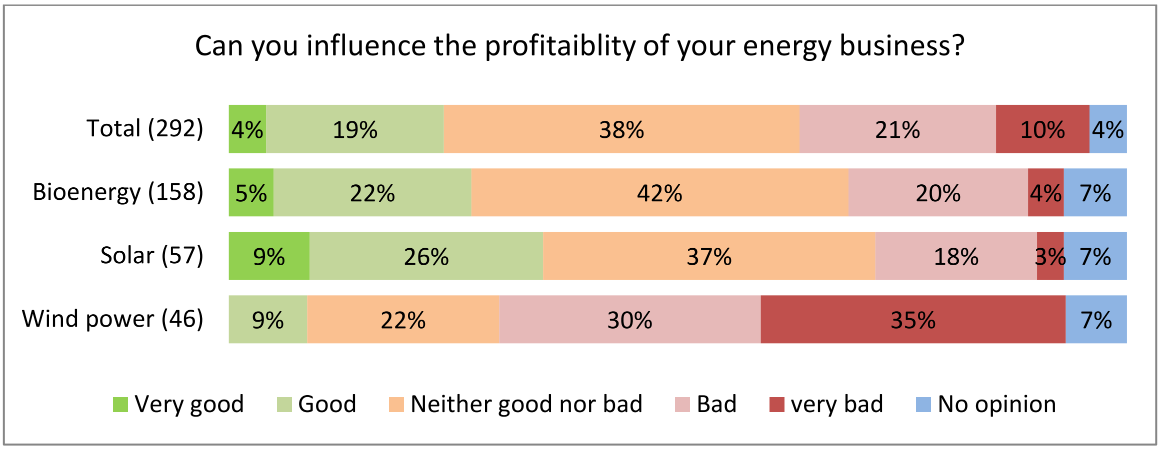

Figure 28: Perception of the profitability of the energy business by type of renewable energy

About 22 % of ESell considered that the renewable energy technologies had a relatively good profitability (both very good and good). The results for the three main renewable energy technologies from the survey differ especially for the perceived current profitability for farmers producing electricity from wind power.

4.4.2 ESwitch

Figure 29 presents the difficulties ESwitch encountered during the transition process from fossil fuel based energy systems to renewable energy systems.

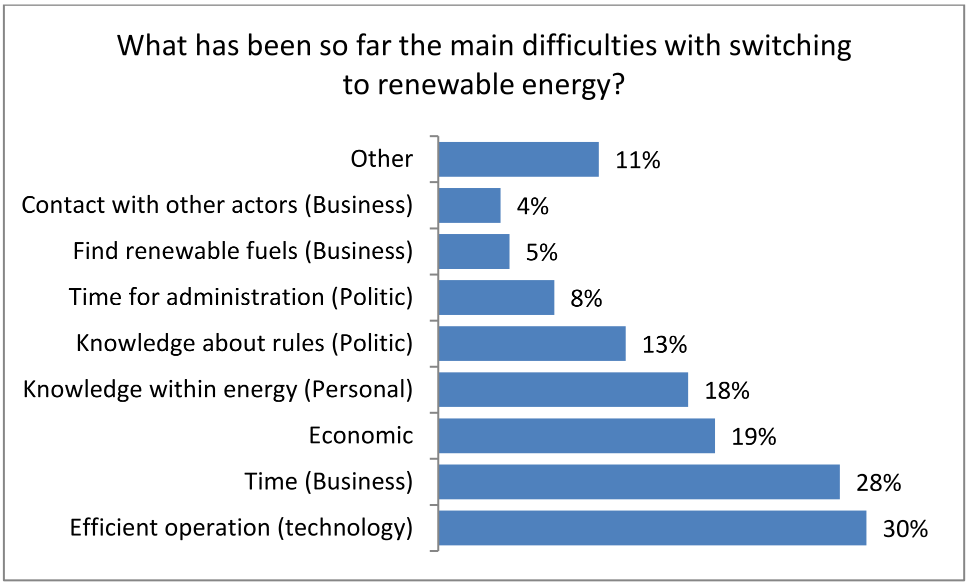

Figure 29: Main hinders encountered by ESwitch

ESwitch acknowledges that the main difficulties encountered during the switch to renewable energy were to get the system working efficiently and practically, the time load needed to run the new system, the profitability and the lack of knowledge. About two thirds of the answers from the alternative "other" stated that no hinders were experienced (about 7 %)

Table 10 shows the result for the difficulties encountered by ESwitch classified by renewable energy technologies and main businesses.

Table 10: Main hinders encountered by ESwitch. Presented by TYPE OF RENEWABLE ENERGYand farm main business

	Total	Bioenergy	Solar	Wind	Cereals	Forestry	Horticulture	Beef	Milk	Contractor	Pork
	159	110	19	9	36	34	11	15	10	9	10
Economic	19%	16%	26%	44%	19%	15%	18%	13%	30%	33%	30%
Politic	19%	10%	53%	44%	8%	26%	18%	7%	20%	11%	30%
Personal	18%	16%	16%	33%	17%	18%	36%	20%	0%	11%	20%
Business	37%	43%	26%	11%	39%	47%	55%	40%	40%	44%	10%
Technic	30%	34%	16%	11%	33%	29%	45%	33%	20%	22%	40%

Political factors are the main factors that hindered respondents who adopted solar or wind power innovations during the implementation stage. Respondents who implemented wind power experienced that the economic, political and personal factors hindered the innovation. The main difficulties encountered by respondent implementing bioenergy innovations were related to technical and business factors. Respondents having horticulture as their main business were the group experiencing the most technical, personal and business related hinders.

Figure 30 shows the benefits ESwitch experienced during the adoption of a renewable energy system

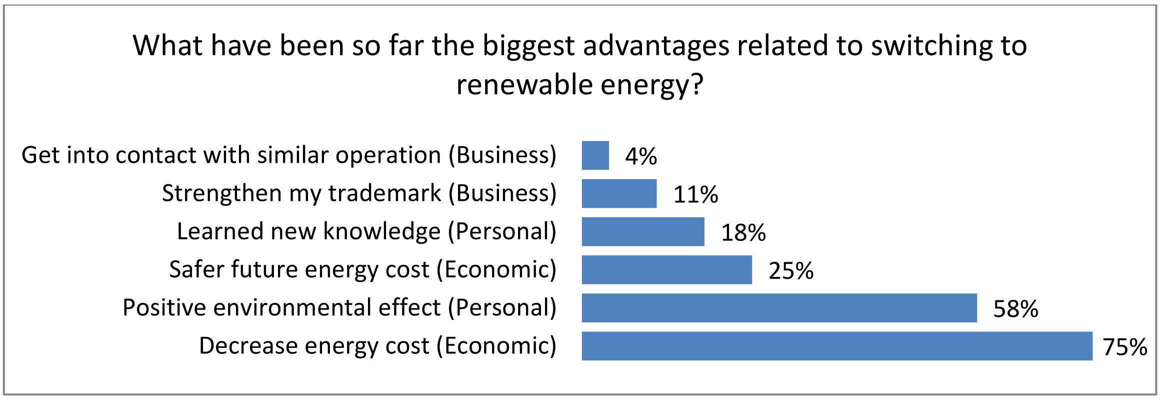

Figure 30: Main advantages experienced by ESwitch in relation to the adoption of a renewable energy

A great share of the respondents experienced both an economic advantage (75 %) and a positive environmental impact (58 %) when switching to renewable energy systems. A secured future energy cost, an increased knowledge, and a strengthening of their branding was also perceived as beneficial by ESwitch. Table 11 shows how the three main renewable energy technologies and seven farm main businesses differentiate from each other when looking at the factors defined in the methodology.

Table 11: Main advantages experienced by ESwitch. Presented by TYPE OF RENEWABLE ENERGYand farm main business

	Total	Bioenergy	Solar	Wind	Grains	Forestry	Horticulture	Beef	Milk	Contractor	Pork
	159	**110**	**19**	**9**	**36**	**34**	**11**	**15**	**10**	**9**	**10**
Economic	86%	89%	84%	56%	86%	91%	82%	80%	60%	89%	100%
Personal	73%	72%	89%	78%	56%	76%	82%	80%	90%	67%	90%
Business	16%	10%	32%	33%	6%	15%	36%	13%	30%	0%	10%

Most of the adopters implementing bioenergy innovations (89 %) and the adopters having pork (100 %) or forestry (91 %) as their main farm business or being contractor (89 %) experienced the economic factors as beneficial. Over three quarters of the adopters implementing solar energy or having beef production, milk production, or horticulture as their main business experienced a positive environmental effect as a benefit. 27 % of the respondents having horticulture as their main business experienced that switching to renewable energy systems had strengthened their trademark. Moreover, when looking only at the ESwitch having horticulture and buying in the renewable energy instead of producing it, then 41 % of them experienced that switching to renewable energy had strengthened their trademark.

4.4.3 ESell and ESwitch

Finally, ESell and ESwitch were asked if they were satisfied about the outcome of their investment (Table 12).

Table 12: Investment satisfaction

	Yes	No	Uncertain	Don't know	Total
ESwitch	83%	2%	9%	6%	145
ESell	62%	9%	18%	11%	292

Table 12 shows that in general both groups were satisfied with the outcome of their investment even if the trend was clearer for ESwitch. To a similar question asking only ESwitch if they would invest again if they had the chance, 90 % answered that they would, only 3 % would not, and 7 % were uncertain or did not know.

Table 13 splits the result for the three main renewable energy technologies implemented at the farm level and seven main farm businesses. The results for both ESell and ESwitch are mixed.

Table 13: Investment satisfaction by TYPE OF RENEWABLE ENERGYand farm main business

	Bioenergy	Solar	Wind power	Forestry	Grains	Beef	Horticulture	Milk	Contractor	Energy
Are you pleased with your investment?										
Total	**268**	**76**	**55**	**131**	**100**	**38**	**17**	**32**	**30**	**28**
Yes	72%	74%	51%	66%	64%	76%	94%	69%	77%	61%
No	3%	0%	27%	5%	9%	0%	0%	16%	0%	14%
Uncertain or do not know	25%	26%	22%	29%	27%	24%	6%	16%	23%	25%
Would you invest again? (Only ESwitch)										
Total	**110**	**19**	**9**	**34**	**36**	**15**	**11**	**10**	**9**	**3**
Yes	90%	95%	67%	85%	92%	93%	91%	90%	89%	100%
No	1%	0%	22%	6%	0%	0%	0%	10%	0%	0%
Uncertain or do not know	9%	5%	11%	9%	8%	7%	9%	0%	11%	0%

Table 13 shows clearly that respondents who adopted wind power innovations were the least satisfied about their investment. On the other hand, respondents who implemented a bioenergy or solar energy innovation were mostly satisfied.

As many respondents having energy as their main business had implemented wind power (see Table 5). It explains that only 61 % of them were pleased with their investment. On the other hand, it seems that respondents having bioenergy or solar energy were the most satisfied about their investment. The high satisfaction expressed by respondents working mainly with horticulture could be explained by the kind of renewable energy technology implemented. Indeed, 75 % of the respondents having horticulture as their main business implemented a bioenergy or solar innovation and only 4 % implemented wind power (Table 5).

5 Conclusion

In this part, each research questions will be answered separately.

The results from the survey are synthetized and organized according to the framework developed in the methodology and divided by energy group in Table 14. By analysing the survey through this framework the first RQ is answered:

What are the factors that support and/or hinder Swedish farmers to adopt renewable energy technology innovations in the four different energy groups?

Table 14: Review of the driver and hinders to the adoption of renewable energy innovations in the Swedish agriculture based on the framework developed for this project

Drivers			Factors	Hinders		
EEff and ELoF	ESell	ESwitch		EEff and ELoF	ESell	ESwitch
✕	Decrease energy cost Spread risk	Decrease energy cost Decrease future energy costs	**Economic**	Not financially interesting	Get the economy during operation	Profitability
✕	✕	✕	**Politic**	Rules	Lack of long-term regulations Complex rules	Complex rules Time for administration
✕	Interest for environment	Interest for environment	**Personal**	Age Knowledge	Age	Knowledge
✕	Efficiency Market driven	Efficiency Branding	**Business**	No time	No time	No time Find renewable fuels
✕	Independency	✕	**Self-sufficiency**	✕	✕	✕
✕	Interest for energy	Interest for energy	**Technology**	✕	✕	Systems not working efficiently

The cells marked with a "✕" highlight the factors that the survey did not try to grasp. As the energy groups ELoF and EEff did not yet adopt a renewable energy innovation on their farm they were not asked what would be potential drivers to the adoption of renewable energy technology. Moreover, the literature review (Table 1) shows that political factors can also have driving effects. ESwitch were not offered the alternative to express the self-sufficiency factors as drivers. The survey seized the technological factors as drivers for ESell and ESwitch which was not highlighted in the literature review. However the question asked in the survey was also relating to personal factors as it asked if the respondent's interest for energy was a driving factor. Finally, ESwitch were the only energy group able to express technological factors as hinder to the adoption of renewable energy technology.

Table 14 shows that the four energy groups perceived different drivers and hinders to the adoption of renewable energy innovations. In the coming paragraphs the results for each energy groups are discussed.

ESell are highly driven by economic factors. They see the development of an energy business as a way to increase their income. They have in general well-developed entrepreneurship qualities and perceive the energy part of their business as a way to diversify their incomes and to take advantages of the resources they already have. Their interest for the environment and energy is also a driving force. They strive to be energy independent, but are hindered by the lack of long-term regulations and complex rules. Their age and the poor profitability of the energy branch of their enterprise also hamper their development.

ESwitch are slightly more driven by economic factors than ESell, and their interest for environment and personal factors have more influence on their decision making than it does for ESell. They see the transition to renewable energy as a way to strengthen the branding of their production. The drivers related to efficiency are similar to ESell. They experienced technical issues with the implementation of their innovation, especially farmers having horticulture as their main business. They perceive that the improvement of the energy related knowledge could have facilitated the implementation process. ESwitch seems to be less hindered by political factors than ESell.

As we see in Table 14, the drivers for EEff and ELoF were not researchable from the survey in this project. Both groups expressed similar hinders. The main factor hindering them is the economy which they perceive as not advantageous. Their age is also mentioned as an important hindering factor, making investment uninteresting due to their short remaining time in the active working life. They also experience that their lack of knowledge and the complexity of regulations hinder them from adopting renewable energy innovations.

In general both ESell and ESwitch are satisfied about the outcome of their investment. However, ESwitch reach a higher satisfaction (Table 12) which could be explained by the decreasing energy prices in the last past years as shown by Figure 1, Figure 2, Figure 4, and Figure 5. Indeed, ESell's profit depends directly on the current energy price. On the other hand, ESwitch investment has secured their energy costs against the volatility of the market.

As shown in the result part, the answers to the survey could be divided by type of renewable energy technology. By using the same methodology applied to answer RQ1, the second research question could be answered (Table 15):

How the main renewable energy technologies relate to the factors found in research question 1?

Table 15: Drivers and hinders to the adoption of RENEWABLE ENERGYinnovations in the Swedish agriculture divided by the of renewable energy, data from the survey

	Drivers		Factors		Hinders	
Bioenergy	**Solar**	**Wind**		**Bioenergy**	**Solar**	**Wind**
Decrease energy cost	Decrease energy cost	More income sources	**Economic**	Profitability	Profitability	Poor profitability
			Politic		Lack of long –term regulations Lack of investment support	Lack of long –term regulations
Environmental interest is less important	Environmental interest is important	Environmental interest is important	**Personal**	Age	Knowledge about rules To dare starting new business	Knowledge about rules Knowledge about energy To dare starting a new business
Horticulture Beef Contractor Safer future energy costs Efficiency	Other businesses Strengthen trademark	Energy "Saw a market"	**Business**	Lack of time	Lack of capital for investment	Lack of capital for investment
Lower interest for energy	High interest for energy	High interest for energy	**Technology**	Efficient operation		

The results from the survey presented in this project highlight the importance of economic factors for the adoption of renewable energy innovations in the Swedish agriculture. Looking at the different renewable energy technologies, wind power is the energy having the lowest economic benefits and the biggest economic hinders. Since 2009, the profitability of wind power has drastically decreased in comparison with the other renewable energies as in 2009 wind power was perceived as being more profitable than the average of the renewable energy (LRF, 2009c).

Political hinders are perceived to be higher for solar and wind power adopters but rather low for bioenergy adopters.

Bioenergy adopters are the group having the least interest for environmental issues, whereas adopters of solar or wind power innovations perceive it as a significant driver. Age is mostly hindering bioenergy adopters to further develop, while knowledge about rules and regulations would benefit solar and wind power adopters. More knowledge about energy in general would also help wind power adopters to develop their energy business.

Certain farm businesses adopt more renewable energy technology than others. For instance horticultural, beef, and contractor farms are mostly interested about bioenergy technologies.

Farmers adopting a bioenergy technology seek safer future energy costs and to make the resource use at the farm level more efficient. Bioenergy adopters are the only group perceiving hinders at the business level, mainly due to the lack of time. Solar electricity is adopted at higher proportion by farms having another farm business than the seven most represented in this survey. Farmers adopting solar innovation perceive the potential to strengthen their trademark. Almost half of the farmers having energy as their main business adopted a wind power innovation. 57% of the respondents who adopted a wind power innovation acknowledged that they did because they saw a potential market.

As for the interest for environment, bioenergy adopters are the group with the least interest for energy issues. At the same time, adopters of bioenergy technologies are the one having the most problem to get the innovation to work efficiently at the farm level. However, technological factors seem to have been of significant importance for the respondents adopting solar and wind power innovations.

The self-sufficiency factors was omitted from Table 15 as the three renewable energy technologies innovations had similar results (Table 14 and Figure 23).

Finally, the combination of the results for the two above research questions will provide content to answer the last research question:

How can renewable energy innovations spread within the Swedish agriculture at a higher pace?

The answer will be structured in a similar way as for the previous RQs, using the framework developed in the methodology.

Table 16 present different measures to be taken.

Table 16: Potential measures to be taken in order to increase the pace of RENEWABLE ENERGY adoption within the Swedish agriculture

Actions based on the drivers	Factors	Actions based on the hinders
• Highlight even more the economic factors of renewable energies. • Foster ESwitch innovations based on the perceived profitability (due to the current energy prices)	**Economic**	• Lay less focus on wind power innovations as its economy is perceived as unsatisfying • Foster solar and bioenergy innovations as they have the least perceived economic hinders
• Communicate more about the incentives or tax reductions for renewable energies at farm level which could hamper the perception of economic hinders	**Politic**	• Simplify the regulation concerning solar and wind power especially for ESell

• Lift the environmental benefits related to bioenergy innovations • Use more the environmental benefits related to solar and wind power innovations in the communication	**Personal**	• Spread knowledge about the rules which could dimmer the perceived political hinders • Spread knowledge about energy and renewable energy technologies • Focus on younger farmers
• Focus on certain businesses for a given type of renewable energy technology • Use the adoption of renewable energy as part of the farm business plan	**Business**	• Make renewable energy technologies available and adapted to farm businesses (through research and innovation) • Develop new business models to overcome the economic hinders (especially for wind power innovations)
• Research the importance of self-sufficiency factors for ESwitch (seem it could be even more significant than ESell)	**Self-sufficiency**	•
• Use the technological factors to trigger potential adopters to enter the innovation-decision process (How-knowledge)	**Technology**	• Lay more focus on the development of bioenergy innovations (especially applied to the horticultural sector)

The measures introduced in the left hand column of Table 16 are measures based on observed drivers whereas measures in the right hand column of Table 16 are based on observed hinders.

Looking at the spread of knowledge, the survey used in this project can help future projects or Agricultural Advisory Services by showing what kind of knowledge is desired by Swedish farmers, as see in Figure 18 and Figure 19. Moreover, the result part offers a deeper analysis for the type of knowledge different target groups desired.

Discussion

In this part the potential biases and limitations of the project as well as the suggestions for future study and some results outside the project boundaries are presented.

It is important to acknowledge the potential biases present in this project. First looking at the survey, there is probably higher chance that farmers who received the survey and have some interest for energy questions answered the survey than farmers having less or no interest for the matter. Moreover, full-time farmers may consider the time needed to fulfil the survey as too long. However, Figure 13 shows that farms having energy businesses were under-represented in the survey.

Data on the size of the farm in term of revenue, work load, or area was not part of the survey. It may happen that some factors were highly related to the farm size, but as said this could not be studied in this project.

Overall, most of the factors highlighted in the literature review (Table 1) were covered in the survey. The areas that the survey did not succeed to cover are discussed below.

The main factors not covered in the survey were the potential supporting political factors to the adoption of renewable energy innovations. LRF, which ordered the survey in the first hand, is working with political lobbying as a part of their operative activity. This situation may have created a bias in their vision of politics where political factors are mostly seen as hindering the Swedish agriculture in general. However, it seems that LRF has the ambition to work with a proactive approach in the future which may dampen this bias.

Comparing the survey to Rogers' theory, other aspects were lacking in the survey. For instance, the survey did consider mass media. Indeed, only interpersonal media were dealt in the survey (Figure 20). The supporting and hindering factors highlighted by the survey only cover two of five perceived attributes developed by Rogers: relative advantages and compatibility.

The results from the survey revealed that the personal fulfilment highlighted in the literature review were only marginal. Softer values like the desire to reach higher social or political status are harder to cover in surveys. However, some comments left by respondents can be related to these factors, but could not be quantify. Deep interviews or focus groups could highlight better these softer values as drivers to the adoption of renewable energy innovations.

The energy group EEff got the same question as ELoF even if according to Rogers theory EEff did adopt an energy innovation. The survey revealed that EEff perceive different drivers and hinders than the other energy groups and more knowledge about this group is needed.

As seen in the limits to Rogers' theory, non-adopters are often excluded of researches. The survey used in this project succeeded to reach them. However, more knowledge would be needed in order to understand the deeper reasons for rejection, and to look at their personality and values. Interviews could help fill this gap. It has been discussed during this project about the way rejecters should be approached. Indeed ringing a farmer and inviting him or her to participate to a study because he or she has no intention to adopt a renewable energy innovation may be perceived as negative and the invitation kindly refused.

The comparison between different energy groups was difficult as they got similar questions, but had different alternatives to choose from.

The energy group ESwitch was separated into two subgroup for this project, focussing only on the farmers who were producing renewable energy. The results between the farmers buying the renewable energy and those producing it were not presented in this project but the difference in drivers and hinders were important.

The difficulty for the respondents to understand the questions and interpret them the right way was a problem that occurred for several questions. For instance 292 respondents stated that they were selling energy as part of their farm business (ESell). However, only 119 answered that energy was part of their business (Table 4). The lack in general knowledge about the energy system in general could also have impact the quality of the survey. For example ESwitch were asked to which degree they switched to renewable energy in regard to vehicle fuel, heating, and electricity use. The result showed a relative important difference between the answers and the actual energy system in Swedish agriculture, where the energy systems based on the answers was less renewable than the actual energy systems. The survey dealt with the terms "renewable energy" and "fossil free energy" which can be seen as synonymous for some, but might have confused others.

Only results for bioenergy, solar energy and wind power were possible to obtained using the survey. More specific studies would beneficiate the understanding of the drivers and hinders for other renewable energies.

This project used a literature review to triangulate the results and verify the efficiency of the survey. As discussed above, interviews could have been used in order to explore the importance and diversification of personal and business related factors.

The project looked partly at the perceived personal factors. However, a study focusing on the personality of the different energy groups would complement the current findings by getting a deeper understanding of the decision making process.

To summarise, if the survey is to be re-conduct, it is recommended to include a background question concerning the farm size, integrate political factors as drivers, develop a set of questions for the EEff group, follow the framework developed in the methodology in order to formulate alternatives that can be compared between the different energy groups, and define key terms consistently. The use of the framework developed in the methodology as well as the summary of Rogers theory could help the implementation of future studies. A qualitative study could deepen the role and impact of different factors.

Literature showed the importance farmers lay on peer-to-peer communication. LRF had used early adopters as change agents for instance during the GAFE project (Goda Affärer på Förnybar Energi, ”Good business on renewable energy”, a two-year long project lead by LRF). This strategy should be kept and developed to other projects. An empirical study about this subject could be of interest.

There are room for improvement for the Swedish agriculture to be more sustainable when it comes to the use and supply of renewable energy. As said in the introduction, to move agriculture to a fossil free energy system is only a piece of the global problem of climate change and environmental issues.

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Appendix

Question	Closed Answer Alternatives
Vilken typ av verksamhet bedriver du i ditt företag?	1) Mjölkproduktion 2) Fjäderfäproduktion 3) Grisproduktion 4) Nötproduktion 5) Hästproduktion 6) Produktion trädgård 7) Förädling livsmedel 8) Skogsbruk 9) Växtodling 10) Entreprenadverksamhet 11) Energi 12) Turism 13) Annat, nämligen
Vilket område är störst omsättningsmässigt i din verksamhet?	1) Mjölkproduktion 2) Fjäderfäproduktion 3) Grisproduktion 4) Nötproduktion 5) Hästproduktion 6) Produktion trädgård 7) Förädling livsmedel 8) Skogsbruk 9) Växtodling 10) Entreprenadverksamhet 11) Energi 12) Turism 13) Annat,
Kommentar	
Är du som svarar	1) Kvinna 2) Man
Har ditt företag någon märkning eller certifiering?	1) Krav 2) IP grundcertifiering (gris, mjölk, livsmedel 3) IP Sigill(frukt & grönt, prydnadsväxter och plantskola) 4) IP Sigill Klimatcertifiering 5) IP Sigill Naturbeteskött 6) PEFC 7) FSC 8) Annat, nämligen 9) Nej ingen märkning eller certifiering
Nuläget inom energiområdet för er verksamhet	1) Har inte lagt någon särskild vikt vid energifrågorna i mitt företag 2) Har i någon omfattning effektiviserat användningen av energi (t ex. drivmedel, belysning, uppvärmning) i mitt företag 3) Har ökat användningen av förnybar energi i mitt företag 4) Har i någon omfattning effektiviserat användningen av energi i mitt företag och ökat användningen av förnybar energi

	5) Säljer förnybar energi (t ex. flis, el, ved, biogas, halm) 6) Har i någon omfattning effektiviserat användning av energi i företaget och säljer förnybar energi 7) Har i någon omfattning effektiviserat användningen av energi i företaget, ökat användningen av förnybar energi och säljer förnybar energi
Vilken produktionsinriktning inom energiområdet är det i huvudsak som du satsar på?	1) El från sol 2) El från vind 3) Biogas 4) El från vattenkraft 5) Förädlat biobränsle (ved, flis, pellets) 6) Bioenergi 7) Biodrivmedel 8) Annan, nämligen
Varför väljer du att ställa om till förnybar energi i din verksamhet?	1) Jag har ett stort energiintresse 2) Jag vill minska risken vid framtida eventuellt höga energikostnader 3) Jag har ett stort miljöintresse 4) Jag vill förstärka miljöaspekten i mitt varumärke 5) Jag har tillgång till egen råvara 6) Jag vill sänka mina energikostnader 7) Annat skäl
Producerar du den förnybara energin själv?	1) Ja 2) Nej, köper in
Varför har du valt att starta energiverksamhet?	1) Jag såg en marknad 2) Jag hade ett stort energiintresse 3) Jag sökte en utmaning 4) Jag ville göra något annat 5) Jag hade ett stort miljöintresse 6) Jag ville bidra till lokal utveckling 7) Jag hade tillgång till maskiner/anläggningar 8) Jag ville öka omsättningen i företaget 9) Jag ville ha fler inkomstkällor för att sprida risken i verksamheten 10) Jag hade tillgång till egen råvara 11) Jag ville sänka mina energikostnader 12) Annat skäl, nämligen
Är du nöjd hittills med utfallet av din investering?	1) Ja 2) Nej 3) Tveksam 4) Vet inte
Skulle du ta samma beslut idag att byta till förnybar energi, om du fick chansen att välja igen?	1) Ja 2) Nej 3) Tveksamt 4) Vet inte
Vilka har hittills de största förtjänsterna med byte till förnybar energi varit?	1) Sänkta energikostnader 2) Positiva miljöeffekter 3) Lärt mig ny kunskap 4) Förstärkt mitt varumärke 5) Ökad trygghet, vet vad mina energikostnader är

	6) Fått kontakt med andra företagare som genomfört liknande omställning 7) Annat, nämligen
Vilka har hittills varit de största svårigheter med omställning till förnybar energi?	1) Få anläggningen att fungera effektivt rent praktiskt 2) Få ekonomi i driften 3) Få kunskap inom energiområdet som krävs 4) Komma i kontakt med företagare som genomfört liknande investering för att dela kunskap och erfarenheter 5) Avsätta tid som krävs för att utveckla anläggningen på ett bra vis 6) Få kunskap om regler och lagar som är kopplade till energianläggningen 7) Hitta förnybart bränsle 8) Avsätta tid för att hantera tillstånd och administration som krävs för anläggningen 9) Annat, nämligen
Hur viktiga är nedanstående faktorer för din energiverksamhet?	1) Mycket viktigt 2) Måttligt viktigt 3) Mindre viktigt
God lönsamhet	1) Mycket viktigt 2) Måttligt viktigt 3) Mindre viktigt
Oberoende (trivsel, utveckling, spelregler)	1) Mycket viktigt 2) Måttligt viktigt 3) Mindre viktigt
Tradition (förvalta, bevara)	1) Mycket viktigt 2) Måttligt viktigt 3) Mindre viktigt
Miljöengagemang	1) Mycket viktigt 2) Måttligt viktigt 3) Mindre viktigt
Kan du själv påverka lönsamheten i din energiverksamhet?	1) Ja, till största delen beror det på mig 2) Ja, lite 3) Nej, det beror på annat
Hur ser du på lönsamheten inom förnybar energi idag?	1) Mycket god 2) God 3) Varken god eller dålig 4) Dålig 5) Mycket dålig 6) Ingen åsikt
Hur bedömer du att lönsamheten kommer att utvecklas inom förnybar energi under de närmaste åren?	1) Öka kraftigt 2) Öka 3) Oförändrad 4) Minska 5) Minska kraftigt 6) Ingen åsikt
Vad ser du som de största hindren för att utveckla din energiverksamhet?	1) Administration 2) Att veta hur man ska sälja eller nå marknad 3) Att våga satsa på ny verksamhet

	4) Avtalsfrågor 5) Brist på kompetent rådgivning 6) För dålig lönsamhet 7) Att få förtroende hos kund som leverantör 8) Offentlig upphandling 9) Brist på kapital till investeringar 10) Brist på långsiktiga spelregler avseende skatter, stöd m.m. 11) Brist på investeringsstöd 12) Krångliga lagar, regler etc 13) Bristande logistik 14) Konkurrens 15) Brist på idéer 16) Brist på samverkan med andra aktörer 17) Svårt hitta personal 18) Vill inte ha (fler) anställda 19) Har inte tid 20) Åldersskäl 21) Brist på kunskap 22) Annat skäl, nämligen 23) Jag ser inga hinder
Har du tagit hjälp av extern rådgivning för din energiverksamhet i något sammanhang?	1) Nej 2) Ja
I vilket sammanhang har du haft extern rådgivning?	1) Projekt GAFE (Goda affärer på förnybar energi, en subventionerad rådgivning) 2) Regionalt energiprojekt i LRF:s regi 3) Projekt Biogasaffärer på gården 4) Utbildning i sparsam körning 5) Annat sammanhang, ange vad
Har du idag behov av ytterligare kunskap inom energiområdet?	1) Ja 2) Nej 3) Tveksamt
Inom vilket/vilka område är det främst du vill öka din kompetens när det gäller din energiverksamhet?	1) Energikunskaper 2) Företagsledning 3) Produktionsteknik (maskiner och metoder) 4) Logistik (materialflöden och lager) 5) Försäljning/offerter/avtal/kontrakt/LOU 6) Internationell handel 7) Utveckling av produkter och tekniker 8) Datakunskap, grundläggande 9) IT (hemsida, söka på internet, mejla) 10) Ekonomisk planering/styrning/kontroll 11) Kunskap om marknaden 12) Marknadsföring 13) Annat, nämligen
Hur skulle du föredra att öka din kompetens?	1) Studiebesök 2) Erfagrupper 3) Studiecirklar 4) Digital utbildning 5) Kurser

	6) Rådgivning 7) Handböcker 8) Diskussionsforum 9) Annat sätt, nämligen
Har du genomfört någon energikartläggning av din verksamhet?	1) Ja, Greppa näringens energikoll 2) Ja, Energimyndighetens kartläggning 3) Ja, ange vad 4) Nej

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