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Solar energy in Sweden

an implementation plan

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Summary

This project proposes an implementation plan that will contribute to increasing the implementation of solar energy in Sweden. The source of inspiration for this project has been the rapid expansion of the implementation of solar energy in Germany. The reason for this inspiration has been the fact that insolation in Germany is the same as in the most populated areas of Sweden: southern Sweden. Yet the Swedish implementation has been very slow in comparison to the implementation in Germany. The theoretical framework of this project is based on elements of transition theory: *the multi-level approach* is used as guidance for analyzing the findings of this project such as barriers and drivers for the implementation of solar energy. The *transition management cycle* is used as a base for the implementation plan that aims to contribute to increasing the implementation of solar energy in Sweden. Furthermore, the information gathered in this project is based on primary sources in the form of interviews; and secondary sources in the form document analysis. This project identifies the drivers and barriers for the implementation of renewable energy in general (with a focus on Sweden) and for the implementation of solar energy in Sweden. The result of this project has been a completion of its objective: creating an implementation plan, based on the identified barriers and drivers, which can contribute to increasing the implementation of solar energy in Sweden. This plan consists of getting necessary actors to work together; following common objectives through visions, paths, and executing different concrete experiments at various levels of aggregation in society in order to reach these objectives.

1. Introduction

Today's world has many people living in societies dominated by their energy systems. This is evident due to the fact that energy use in these societies is involved in almost every aspect of these people's lifestyles: transportation, production of goods, heating (if the conditions require it), etc. Dependency on energy use from societies around the world has become stronger and stronger throughout the latest decades, and with this, the dependency on energy systems. An example of this are the latest economic developments of China and India; which has caused, and is causing, energy use from these societies to increase (Ammenberg 2012; Gröndahl et al. 2011). Using energy or having a society dependent on an energy system is not necessarily negative per se. However, most energy systems in the world are fueled by fossil fuels. The wide use of fossil fuels for satisfying the energy demands of societies around the world has led to, and is still contributing to, many serious environmental problems. These are problems such as the greenhouse effect, pollution from the extraction and use of fossil fuels, and the very important fact that fossil fuels are finite resources. Since the need for energy and therefore the global use of fossil fuels is increasing; these environmental problems are getting more serious and more unsustainable with time. This creates the necessity for the (increased) implementation of renewable energy sources (Ammenberg 2012). Increasing the implementation of renewable energy sources in the world, and making sure that it benefits the environment and doesn't cause/increase social problems, is however not easy. There are many renewable energy sources for example that are seen as environmentally friendly; but have negative environmental or social impacts connected to them in different ways (Gröndahl et al. 2011).

The need for an increased implementation and use of renewable energy in the world; have led me, as a Swedish resident, to work with the implementation of the use of solar energy in Sweden. The reason that inspired me to choose solar energy in particular is that solar energy has an enormous potential for implementation in Sweden. Germany for example, which has the same level of insolation as the most densely populated area in Sweden, has seen a rapid and large expansion of solar energy in the latest years (Diekmann et al. 2012:3). This means that, even though the natural conditions required (insolation) are the same in Germany as in Sweden, Sweden has not yet seen this type of development. The implementation of solar energy in Sweden has in fact been so small that official statistics on the use of solar energy in Sweden are not taken by Statistics Sweden, the institution that takes official statistics in the country (SCB 2010). This inevitably leads to the questions: What has caused the implementation of solar energy in Sweden to look this way in comparison to Germany? Can this situation be changed? And what could be done to change it?

Using elements of transition theory; this project identifies the different barriers and drivers for the implementation (of the use) of renewable energy in general with a focus on the Swedish context; and later identifies the different particular barriers and drivers for the implementation (of the use) of solar energy in Sweden[1]. Afterwards, based on these barriers and drivers, this project formulates an implementation plan that aims for increasing the implementation of solar energy in Sweden, based also on elements of transition theory.

1.1 Objective and research questions

The objective of this essay is to make an implementation plan that can contribute with increasing the implementation of solar energy in Sweden. This leads us to the essays main research question:

How can the implementation of solar energy in Sweden be increased?

In order to find an answer to this question the following sub research questions have been formulated:

- *Which are the drivers and barriers for development of renewable energy in general?*

- *Which are the drivers and barriers for the development of solar energy in Sweden in comparison to other renewable energy sources?*

- *What could an implementation process towards solar energy look like?*

[1] This project excludes the technological development of solar energy in Sweden and only focuses on the implementation of the use of solar energy in Sweden.

1.2 Approach

The data collection methodology used to answer these questions is a mix of interviews and document analysis. This project also compares the recent expansion of solar energy implementation in Germany; in order to help identify the drivers and barriers for the implementation of solar energy in Sweden.

The theoretical framework used in this project is based on elements of transition theory: the multi-level approach is used to analyze the drivers and barriers for the implementation of renewable energy and the implementation of solar energy in Sweden. After this, the transition management cycle is used as a base for the implementation plan formulated in this thesis.

1.3 Delimitations

Energy consumption in the Swedish energy system is divided in three sectors: the residential and services sector, the industrial sector and the transport sector. In 2010 these sectors together consumed 395 TWh (Terawatt hours). 91 TWh out of these 395 TWh are consumed by the transport sector (Energimyndigheten 2013:58), which naturally makes it a substantial energy consumer. However implementing and using renewable energy sources on the transport sector poses extra difficulties (as will be explained more in detail later in the project). Considering the time-frame for this project; this project excludes the transport sector as part of the plan for the implementation of solar energy in Sweden.

When working with the implementation of solar energy in Sweden it is relevant to point out that there are two different types of solar energy production used in the country:

- *Low-temperature solar energy*: In which solar energy is transformed into heat through a *solar collector* (Turkenburg et al. 2012:843). Commonly known as solar collectors.

- *Photovoltaic solar energy:* In which solar energy is transformed into electricity through *solar cells.* Commonly known as solar cells.

This project will work with solar energy in general and will include both types of solar energy production in the study.

When working with the implementation of solar energy this project excludes the *technological* development of solar energy, and focuses on working with the implementation *of the use* of solar energy. This exclusion of the technological development also applies when studying the implementation of renewable energy in this project. Furthermore, this project focuses on the Swedish context when searching for the general barriers and drivers for the implementation of renewable energy.

Finally, as has been explained, this project uses the recent expansion of solar energy implementation in Germany as a comparative case.

1.4 Chapter overview

This project contains 7 chapters. Chapter 1 presents the introduction of this project. Chapter 2 presents the elements of transition theory used for the theoretical framework of this project. Chapter 3 presents the methodology used for gathering the data for this project. Chapter 4 presents the findings of this project; this includes a presentation of the German example (the inspiration of this project); the barriers and drivers for the implementation of renewable energy in general; and the barriers and drivers for the implementation of solar energy in Sweden. Chapter 5 presents the analysis of this project, which contains the implementation plan for increasing the implementation of solar energy in Sweden. Chapter 6 presents reflections on the theoretical framework used in this project. Finally, chapter 7 presents the conclusions of this project, giving an overview of the answers to the projects' different research questions.

2. Theoretical framework

2.1 Transition theory

Transition theory defines transitions as a number of processes of fundamental change to a sub-system or sub-systems of society; such as mobility, housing, energy supply, etc. (Frantzeskaki et al. 2012:23; Loorbach 2010:166). The way these subsystems have been managed in the latest decades has gradually led to the rise of complex problems which are rooted at different levels of society and lack simple and fast solutions. These problems are usually defined as *persistent societal problems* (Loorbach 2007a:1-2; Loorbach 2010:164). Transition theory is based on the assumption that these persistent societal problems are interconnected to other persistent problems in societies while at the same time being rooted in the different institutions and structures that dominate societies; which makes solving them in isolation an impossibility (Rotmans 2005:8). Rotmans (2005) describes these problems as system failures and symptoms of an unsustainable society (Rotmans 2005:8, 10). An example of a persistent societal problem can be found in the current energy systems of most countries in the world today: Many of these are dominated by fossil fuels; leading, and/or contributing, to many other known problems such as air pollution, which in turn affects climate change, health issues, environmental damage, etc. The fact that these fossil-fuel-dominated energy systems contribute to a variety of problems makes this "fossil-fuel-domination" a persistent societal problem. This persistent societal problem is hard to solve because of how it is embedded in the economy (lots of business interests involved, etc.), our infrastructure (cities built to accommodate the car, vehicles running on oil, etc.), our lifestyles (oil is at one point or another used to transport many/most of the goods we consume) and in summary most aspects of our lifestyles.

Naturally since persistent societal problems are considered system failures, transition theory suggests that solutions and changes to these system failures have to be executed at a systems level (Rotmans 2005:11-12). This means that transitions, in order to solve persistent societal problems, need to consist of *system innovations:* interconnected changes that reinforce each other and are executed in different domains of society at different levels of aggregation. These changes vary in nature and are therefore non-linear and have different speeds (Kemp et al. 2003:8; Loorbach 2007a:3).

Since system failures are considered symptoms of an unsustainable society, a principle of transition theory is focusing transitions on sustainability; and thus on creating sustainable societal sub-systems (Frantzeskaki et al. 2012:21, 24; Kemp et al 2005:23). Another important characteristic of transition theory is its focus on a long-term perspective, which is necessary in order to be able to break down existing structures and implement the required changes at different levels of aggregation and aspects of a system (Rotmans 2005:11-12).

2.1.1 Transition management

Transition management is a management strategy that uses a governance approach in order to execute transitions in practice. This management strategy takes into account the fact that transitions are unpredictable processes; which requires transition processes to be flexible and adaptive to unexpected outcomes, as opposed to focusing strictly on a certain plan or path. (Frantzeskaki et al. 2012:25; Kemp et al 2005:25; Loorbach 2007a:6). Transition management, being part of transition theory, has a central focus on sustainability and other collective benefits to society. The following rules of thumb are found in transition management: Short-term changes based on long-term thinking, working in many domains, the inclusion of multiple actors in the process, coordinating on different scale levels (of society), focusing on acquiring knowledge through the principle of learning-by-doing and doing-by-learning, and keeping a wide playing field with a large range of options. Transition management focuses particularly on the multi-actor and multi-level rule of thumb. (Rotmans et al. 2001:22; Rotmans 2005:43-44).

"The very idea behind transition management is to create a societal movement through new coalitions, partnerships and networks around arenas that allow for building up continuous pressure on the political and market arena to safeguard the long-term orientation and goals of the transition process." (Loorbach et al. 2010:239).

2.1.1.1 Transition management cycle

The transition management cycle is a model that helps create a strategy, or strategies, for the implementation of transition management. The model does this by, amongst other things, providing a description of the different steps involved in a transition management process (Frantzeskaki et al. 2012:26-27) and thus giving this process structure. The cycle is comprised by four steps: The first step is to form a *transition arena*. This is a forum in which the actors involved in a transition come together and form objectives, long-term visions and agendas for a certain transition. Here, different perspectives, expectations and perceptions of the problem to be solved are brought up to discussion; as well as possible ways to finding solutions to this problem. The important thing about this forum is that it prevents the interference of the political arena, creating more wiggle room for creativity and innovation for the actors involved. In the second step a *sustainability vision* is developed which in order to be fulfilled leads to the creation of *transition paths,* which are objectives and possible routes that help reach the sustainability vision. This finally leads to the creation of a common *transition agenda*. The transition agenda contains as Rotmans (2005:47) describes it: *"a number of joint objectives, action points, projects and instruments…"* derived from the *sustainability vision* and *transition paths* mentioned previously. The third step is to mobilize the actors involved in the transition arena and formulate and execute *transition experiments*. These experiments are very important in order to induce a learning process about the transition itself, which leads us to the final step. The fourth step of the transition management cycle is an evaluation and monitoring process; which consists of observing, reflecting upon, and learning from the transition experiments. Based on this, the learning effects from the transition experiments are incorporated into the transition process; and thus adjustments are made to the transition process itself in the form of changes in the transition agenda, visions, and other essentials (Rotmans 2005:43-47; Kemp et al. 2003:13-14,16; Loorbach 2007a:6; Loorbach et al. 2010:238; Loorbach 2010:173).

2.1.2 The multi-level approach

Because of the nature of transitions, the multi-level aspect will be one of the central aspects of transition theory that I will use as an approach to conduct my research. This aspect consists of categorizing the different societal levels to three scale-levels of aggregation for a transition: the *macro, meso* and *micro* levels.

- The *macro* level, also called the landscape level, is the highest level which comprises overarching aspects of societies such as the international solar power market, the natural environment, social values, the material infrastructure etc. This level is highly autonomous as it cannot directly be influenced by actors; and, while extraordinary circumstances (such as war) may cause rapid changes at this level to occur, changes at this level usually occur relatively slowly (Geels 2006:1004; Rotmans et al. 2001:19;). An example of a *macro* factor connected to solar energy, that will be discussed and explained later in this project, is a countries' energy infrastructure. If the energy infrastructure of a country for example cannot tolerate changes created by implementing solar energy; it becomes a problem at the *macro* level. There would then have to be changes made to the energy infrastructure for the implementation to be made. While changes in the energy infrastructure are not autonomous; changes here are still usually of relatively very large scale. Executing changes on an entire countries' energy system would obviously require working with different large scale aspects, such as costs, that slow changes down. An example of a *macro* factor that consists of autonomous changes and can change relatively fast on the other hand is insolation. This is a factor in the natural environment that cannot be controlled or changed. Not having enough insolation at a location where solar energy is to be implemented becomes a problem at the *macro* level.

- The *meso* level is commonly described as the regime level, which means in other words the factors that define the status quo of the system such as regulations, dominant practices, interests, shared assumptions etc. The factors composing the *meso* level interact and depend on each other giving stability to the regime. Also, the actors behind these factors are usually careful and resistant about changing the status quo. Obstacles like these make this level resistant to change and consequently slow down changes at this level (Geels 2006:1004; Rotmans 2005:25). A factor at the *meso* level that this project brings up for example is policy. Policy does not only manifest itself at the *meso* level. However there are aspects of policy related to solar energy that we can find at the *meso* level. Examples of this are laws that are related to the energy grid; such as the law for the implementation of net-metering that is currently under investigation, which will be explained more in detail later in this project. Many agree that the implementation of a net-metering system would be a key for the implementation of micro-generation of renewable energy in Sweden (see: Barriers and Drivers for the implementation of solar energy in Sweden). The process however requires the involvement of actors such as the Swedish government *and* the Swedish parliament: The Swedish government is currently investigating the implementation of net-metering. And for implementing net-metering; the Swedish government is needed in order to make a proposition to the Swedish parliament for a law for the implementation of net-metering. After this, the Swedish parliament is in charge of deciding whether or not this law is passed (Finansdepartamentet 2012; Sveriges Riksdag 2012). As we can see these actors interact and depend on each other, have significant control over national laws, and therefore significant control of the status quo. As we can also see, the processes behind changing this status quo can require time, can be complicated and can therefore slow changes down.

- The *micro* level, also called the niche level, represents individual actors, local practices, individual technologies, etc. At this level small developments take place quickly as many new technologies and ideas emerge, are tested and dismissed. It is therefore common that many changes at the micro-level can happen very quickly, but can also disappear very quickly (Loorbach 2007b:20; Rotmans 2005:25). A very relevant example of a factor at the *micro* level, which is brought up later in the project, is the prices for solar energy technology. These are obviously prices for an individual technology. And as we will see later, market prices for solar energy technology have changed rapidly during the latest years; and are by many expected to change even more in the coming years. Individual demand for solar energy could theoretically rise or fall relatively quickly due to the effect of different external factors such as market prices;

which is evidence of the rapid nature that changes at the *micro* level can have. Another example of a factor found at the *micro* level is policy. An example here explained later in the project is municipal policy such as building permits. Municipalities in Sweden can have control over the regulations included in their individual municipal building permits. Changes at municipal policy do not necessarily have to be quick; municipal policy is however nevertheless an aspect at the micro-level due to the individual nature of the policy in comparison to for example national policy which is overarching for the whole country.

2.2 Case studies and the theoretical framework

2.2.1 Implementation of solar energy in Germany

My research was inspired by the implementation of solar energy in Germany in the last couple of years (Diekmann et al. 2012:3). Looking at the implementation of solar energy in Germany and comparing it with the implementation of solar energy in Sweden helps me therefore identify the different drivers and barriers that have been the cause for the way the implementation of solar energy looks in Sweden in comparison to in Germany.

What makes this implementation interesting is the way the theoretical framework of this study can be connected to it. The legislative incentives for example were derived from the meso-level: a strong government which initiated a law that would foment a significant implementation of solar energy (Wüstenhagen et al. 2006:1685, 1687). Another thing worth noticing is how, as transition theory prescribes, the government has played a tremendous part in facilitating and initiating this process (Rotmans 2005:57). Transition theory can be connected even more when it comes to the economic aspect of the implementation: there has been a variation in actors and we can notice that factors at different levels of aggregation have been decisive. At the *micro* level the demand of individual actors such as residents has been a large driver for the development of "green power marketing"; as well as the demand from other individual actors, such as businesses, that are emerging as important contributing drivers. At the *meso*-level effects can be seen by the demand from authorities, the liberalization of the German energy market and the lack of a functioning standard eco-labeling scheme in the country (Wüstenhagen et al. 2006:1690-1691, 1695). While at the *macro*-level international aspects such as the international market for renewable energies, and its level of focus or non-focus on solar power, would obviously have an impact on how solar energy is implemented. This kind of effect from the international market has been seen in other cases such as in the Netherlands energy transition from coal to oil and natural gas: coal was made very cheap in the international market and therefore not very profitable for the Netherlands while at the same time the market and popularity for oil and gas arose, becoming one of the strongest drivers for the transition (Rotmans et.al 2001:20-21).

A very important factor of the economic aspect in the implementation of renewable energy in Germany can be connected to transition theory: that is the learning effects that "green power marketing" has and can have on consumers (which affects, as mentioned before, consumer demand at the micro-level) (Wüstenhagen et al. 2006:1692-1694). Even though these learning effects don't come from a transition experiment, the learning effects of green marketing could be seen as the result of an "unintended" transition experiment where the different ways of marketing solar energy could be seen as the transition experiments in the market area.

2.2.2 Implementation in Sweden

Transition theory has proven to work as a good guideline in helping implement change and therefore helping to lead towards successful transitions (Loorbach et al. 2010:240-241). It is even more motivating to use transition theory in the light of how aspects of transition theory, such as the effects of changes at different levels of aggregation, have affected the implementation of solar energy in Germany. This enforces this study's choice of transition theory as a useful framework. It is therefore that, even though this study (or any study for that matter) will not be able to give a full concrete recipe on how to reach an increased implementation of solar energy in Sweden, it will attempt to contribute in this matter by proposing ways in which an increased implementation of solar energy in Sweden could be achieved with the help of transition theory.

3. Methodology

3.1 Data collection

3.1.1 Using mixed methods

For the data collection process of this project I have used the qualitative methods of document analysis (secondary material) complemented by interviews (primary material). Throughout the project the data collected through both methods was meant to be combined in order to triangulate this data and find the answers to the research questions of this project. The triangulation approach was originally meant to be used as a tool to cross-check the data collected through the different methods of this project; in order to, as Grix (2010) prescribes, add validity to the data collected. Throughout this project however I encountered large difficulties in finding reliable and updated documents on solar energy in Sweden in particular; which complicated finding information to answer the second research question of the project. Since the process of searching for adequate documents started before the interviews for this project were conducted; I was able to notice these difficulties early on in the project process. This gave me the chance to find a solution to this problem of lack of documents through putting more of the focus of my interviews (however not all) on gathering data to answer the second research question; taking away some focus from the interviews on gathering data to answer the other two research questions.

Doing this naturally made it difficult to triangulate the data gathered through the different methods as was originally planned. This was in part due that the data gathered through the interviews focused mostly on answering the second research question (instead of all research questions equally); and because much of the data gathered in the interviews as was mentioned above could not be found in documents publicly available and therefore could not be cross-checked. This changed the original purpose of using triangulation of methods in this project to cross-check the data gathered. However triangulation of methods can still be seen as applied in a way since, as Cresswell (2009:191) suggests, the data collected through both enquiry methods was necessary and combined in order to reach the final conclusions and “build a coherent justification of themes” (Ibid) for this project.

3.1.1.1 Interviews

Interviewing can provide a number of advantages for research. The main advantage with interviews that motivated my use of this technique was that interviews are primary sources of information and provide the ability to gather information that is not printed or cannot be found elsewhere (Grix 2010). This was especially useful, as stated above, considering the difficulties that were presented to me in finding information about solar energy in Sweden in particular. Also, the information gathered from the interviews came directly from representatives of organizations working with sustainability issues related to energy supply. This is an advantage, as Denscombe (2009) states, since relevant information gathered from qualified informants can increase the level of detail and the quality of this information. I had to keep in mind however that the information gathered through interviews could be biased (Cresswell 2009). For example; all of my interviewees were very positive to the implementation of solar energy in Sweden. This might have caused that the information I got from them may have excluded some negative aspects or complications related to the implementation of solar energy in Sweden; which could have kept me from having certain information of the barriers related to this implementation. The lack of such information could naturally have affected the outcome of this project.

In my search for interviewees I looked for representatives of organizations that would have insight into sustainability and energy supply issues. This was done through browsing different organizations websites. The process of looking for interviewees was more timely and complicated than I had imagined. For example, I originally intended to include in the interviews energy companies which were solely positioned in the private sector (as opposed to public/private or only public) in order to get a larger variety of the type of actors interviewed. However these companies did not seem to have much interest in talking to me, since various attempts of calling and sending e-mails to these companies never resulted in an interview time. Another complicating factor was that some of the interviewees I originally planned on interviewing were unable to agree on an interview time since they had busy schedules. Many of the interviewees I was unable to interview were however very helpful in referring me to other relevant potential interviewees; and their attitudes towards me were very positive as most of them looked positively upon the implementation of solar energy in Sweden. After browsing the websites from different organizations related to energy and environmental issues and examining the referrals I had gotten, I got in contact with and interviewed the following people:

- Fredrik Andrén Sandberg. Business developer at the energy company Lunds Energi.
- Maria Elmwall. Project manager at the East Sweden Energy Agency in Linköping (in Swedish: Energikontoret Östra Götaland)
- Karin Lindholm. Energy and climate adviser at the municipality of Lund.
- Matz Hagberg. Environmental strategist at the municipality of Lund.
- Alvar Palm. PhD Candidate at Lund University's International Institute for Industrial Environmental Economics.

As it can be noticed, most of these interviews were conducted with interviewees representing organizations located in the municipality of Lund. This was due to that the time-consuming complications mentioned above combined with the limited timeframe of this project allowed me to be much more flexible in planning interviews adapting to the schedules of interviewees in nearby geographical locations (I am studying in the municipality of Lund); as opposed to interviewees further away. As Denscombe (2009) writes, this is often an issue when using interviews as a research method; since interviewing informants that are geographically scattered tends to cause high time and monetary costs that go beyond the limited resources available to the researcher. Also, the municipality of Lund is a center of knowledge and research due to its university (Lunds Kommun 2013); which led me to the assumption that organizations that I interviewed located in Lund would have high quality and updated information. However, in order to try to eliminate possible biases related to organizations' geographical locations I tried to get some interviews in other locations as well. For example I tried to conduct interviews in the municipality of Växjö, which promotes and works a lot with environmental action (Växjö Kommun 2013); however I was unsuccessful in booking an interview due to scheduling issues mentioned above. I was successful on the other hand in getting an interview in the city of Linköping. This city is one of the largest cities in Sweden (SCB 2013); which led me to the assumption that work on energy issues here could have relatively significant effects in Sweden.

All interviews were between 45 and 80 minutes long. Each interview was recorded and later transcribed and summarized. However in addition to recording the interviews, as Cresswell (2009) recommends, I took notes during the interviews in case possible failures from my recording equipment would arise. As Grix (2010) points out, recording interviews can make interviewees have a feeling of being more “on record”; and can therefore cause interviewees to be less open. However recording interviews gave me the chance to use the information gathered through the interviews more accurately; as I could listen to an interview repeatedly and transcribe it.

The interview guides consisted of 8 to 10 questions depending on how broad the themes of the questions formulated were. As has been explained above; the questions formulated were mostly focused on finding information that would answer the second research question of this project. That is, information about drivers and barriers for the implementation of solar energy in Sweden in particular. However, while focusing mostly on the second research question, the interviews also included questions which were meant to collect information that would help answer the other research questions; such as information about the drivers and barriers for the implementation of renewable energy in general, and information about the actors required for the implementation of solar energy in Sweden. This was done in order to try to find missing information about these issues that could not be found by using my other research method of document analysis; while at the same time this information from the interviews helped me cross-check some facts found on the documents. Finally; some interview questions were adapted to the type of interviewee I was interviewing: The East Sweden Energy Agency for example works a lot with fomenting co-operation between different actors. Therefore in the interview conducted with Maria Elmwall I included questions related to this topic, apart from the standard questions formulated to all interviewees. Whereas some of the questions included in the interview conducted with Fredrik Andrén Sandberg for example, from the energy company Lunds Energi, were about possible technical issues related to the implementation of solar energy in Sweden.

3.1.1.2 Document analysis

Document analysis was mostly used to gather information to help answer my first and last research questions as well as other information needed in the project. This includes information such as barriers and drivers for the implementation of renewable energy sources; as well as the theoretical basis used for the implementation plan presented by this project. Document analysis was also the main technique for gathering information on the implementation of solar energy in Germany so far; which was the motivation of this project. Finally it is important to point out that while interviews were the main source of information for answering the second research question of this project; document analysis was used to complement this information.

As Cresswell (2009) points out, document analysis can provide the flexibility to the researcher of being able to access the information provided at any time. This aspect was useful to me, especially considering the time frame of this project, since I was able to gather and analyze information from various sources at the same time. This allowed me to look for information in an efficient way; since I could quickly filter away sources that seemed unreliable. However, as Cresswell (2009) also points out, analyzing documents poses the risk that the information found may be inaccurate. In order to gather information that was as reliable and credible as possible I therefore reflected carefully on the authors/organizations behind the documents used in this project:

For example amongst the most important documents used in this project for gathering information on renewable energy and the issues related to its implementation, as well as some information of the same type on solar energy, is the Global Energy Assessment. This is a project conducted by the International Institute for Applied Systems Analysis (abbreviated IIASA); which is a non-governmental organization funded by leading scientific institutions from various countries that researches global issues including climate change and energy security. This report "…was led by some of the world's leading energy experts…" (IIASA 2012) and contains a wide range and number of authors. These characteristics and the fact that the IIASA is a non-governmental organization led me to the assumption that this source of information was highly unbiased and credible. Also the information presented by this report seemed to be analyzed from different angles; as for example the barriers related to using and implementing renewable energy. All of these facts confirmed to me the reliability of this source of information. Another example of a central document for gathering information related to the implementation of renewable energy, in this case particularly in Sweden, was the report Energy in Sweden. This is an official report written by the Swedish Energy Agency which is a public authority in Sweden that works for a sustainable development of Sweden's energy system (Energimyndigheten 2013). The fact that this report presented much of its information side by side with official statistics; and that it was written by an official government institution; confirmed its reliability when it came to providing the type of information that I was looking for in this report in particular (information on the status quo of renewable energy in Sweden).

Relevant documents for this project also include for example the official documents used for getting information on certain surrounding facts; such as the ordinance on the solar cell support program by the Ministry of Enterprise, Energy and Communications (in Swedish: Näringsdepartamentet). This type of official documents provided objective and concrete information on the nature of for example subsidies and laws related to the implementation of solar energy; which was especially useful for being able to analyze certain barriers and drivers which were otherwise filtered through the eyes of other authors in many non-official articles. Finally, documents important for this project also include documents on background information, such as the theoretical framework of this project and the development of solar energy in Germany, such as the articles: "Societal Innovation: between dream and reality lies complexity" written by Jan Rotmans; and "Green energy market development in Germany: effective public policy and emerging customer demand" by Rolf Wüstenhagen and Michael Bilharz. The author of the first article mentioned (Jan Rotmans) and the corresponding author of the latter article (Rolf Wüstenhagen) are both currently professors at different universities and have published a variety of articles widely available to the public; which benefits the credibility of the work of these authors.

3.2 Data analysis

For the analysis of all the information gathered I mostly made use of the multi-level approach. First I categorized most of the information gathered from both the interviews and the document analysis into drivers and barriers for either the implementation of solar energy in Sweden or the implementation of renewable energy in general (see research questions). These drivers and barriers were further categorized into the three transition levels: macro, meso and micro; and analyzed after this categorization (for the use of the theoretical framework, see: the value of transition theory for this project). .

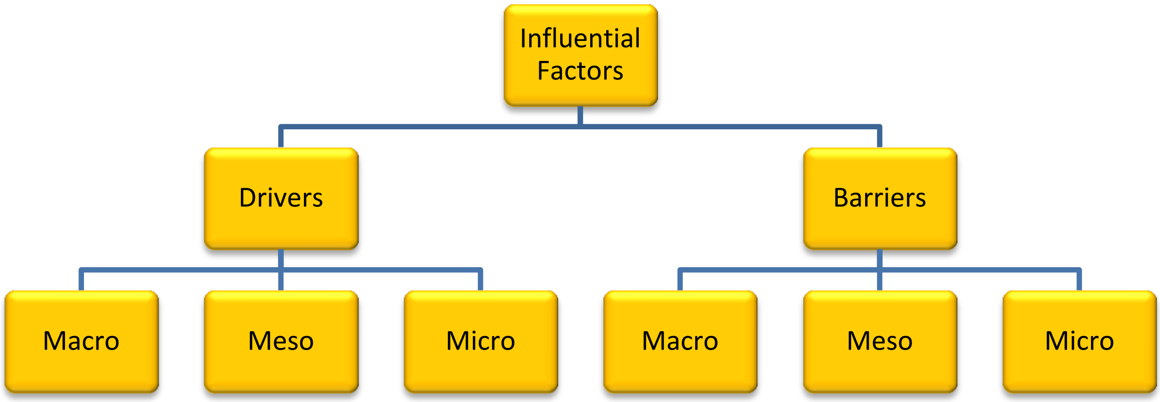

Figure 1: Multi-level approach as used in this project.

After the analysis of these barriers and drivers was completed I proposed the plan for contributing to increasing the implementation of solar energy in Sweden; based naturally on the analysis made on the drivers and barriers. My proposal adapted to the different barriers and drivers found in the analysis at the different transition levels in order to be able to be as realistic as possible. In the proposal I made use of the *three first steps* of the transition management cycle by using them as a model to base my proposal on. The reason why the fourth step of transition management is left out of my analysis is because it is out of the range of this project to predict the results of transition experiments and the learning processes that would be derived from them.

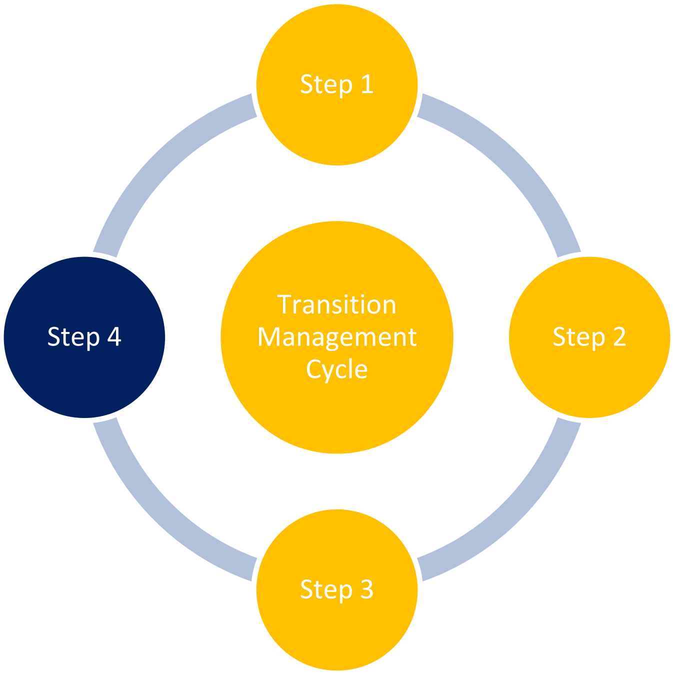

Figure 2: Transition Management Cycle as used in this project.

4. Findings

4.1 Renewable energy sources: the general picture

4.1.1 The German example

The German implementation of solar energy was the most important motivation for the objective of this research project: Germany has seen a very large expansion of solar energy in the latest years (Diekmann et al. 2012:3). In Sweden, the belief that there is not enough solar radiation in order to make it worthwhile to produce solar energy is common amongst many people. However, the amount of radiation southern Sweden gets (up to the latitude of Stockholm), which is the most densely populated area of Sweden, is almost the same as in Germany (Henning 2000:17; SCB 2011). This means that solar energy could potentially be implemented in the same way from the perspective of necessary natural conditions such as sunlight.

One of the most important drivers behind the latest rapid implementation of solar energy in Germany has been the economic aspects of this technology. One of these aspects found at the *meso* level is that electricity prices and the total production of energy in general are higher in Germany than in Sweden (Andrén Sandberg 2013: interview; Elmwall 2013: interview) which is an incentive to invest in new energy solutions. However the most important economic driver for the implementation of solar energy in Germany has been at the *micro* level: the decrease in price of solar equipment (Elmwall 2013: interview). Costs for solar power equipment in Germany decreased by around 60% in the decade of the 90's; however at around the year 2006, prices for solar energy technology in Germany, such as solar cells, were still at a *"substantial distance to cost competitiveness"* (Wüstenhagen et al. 2006:1989). But since 2006 another 60% decrease in prices for solar energy equipment such as solar cells has taken place. This combined with the support from the EEG-law (a policy for the development of renewable energy that will be explained soon), which is still in place, has resulted in that *"Support through the German Renewable Energy Sources Act (EEG) has led, in the past few years, to an unexpectedly wide expansion of systems for generating solar power because the system prices for photovoltaic (PV) systems have fallen at a faster* *rate than the solar power feed-in tariffs guaranteed by the law."* (Diekmann et al. 2012:3; Wüstenhagen et al. 2006: 1684, 1689). In Sweden, previously the solar energy market acted as a barrier for the implementation of solar energy due to the costs and difficulties involved in acquiring and using this technology. Recently however, different companies such as the energy company "Lunds Energi" have started offering solar cell packages which makes it considerably easier for customers (Andrén Sandberg 2013: interview) at the *micro* level, such as individual residential consumers, companies etc., to purchase and install solar energy production; which is transforming this barrier into a driver. Also, prices for solar cell equipment have lately decreased in Sweden (Lindholm 2013:interview; Hagberg 2013: interview), which decreases the cost barrier.

A very important driver that has also contributed largely to the implementation of solar energy in Germany is the policy incentives at the *meso*-level which have been created in Germany for the development of renewable energy. (Elmwall 2013: interview). These policy incentives take shape in the form of the renewable energy law, called the EEG-law, which has a feed-in tariff system that guarantees compensation for energy production to renewable energy producers feeding energy into the energy grid. The feed-in system in itself has worked as a very determining large incentive for the marketability and therefore implementation of solar energy in Germany. It is also important to point out that it was *support from the EEG-law* combined with a reduction in prices for solar cells that caused the *"unexpectedly wide expansion of systems for generating solar power"* mentioned before. (Wüstenhagen et al. 2006:1684-1685, 1688-1689; Diekmann et al. 2012:3). Therefore we can conclude that policy and economy have been very closely connected as drivers for the implementation of solar energy in Germany.

In comparison to Germany; the lack of adequate policy in Sweden (at the *meso level*) for making it worthwhile for individual actors producing electricity at a small scale (micro-generation) to sell excess energy to the energy grid creates a barrier. This is due to that the input and consumption of energy in Sweden is handled and taxed separately; which results in that the costs of buying electricity (at times of insufficient energy production) become much larger than the income produced by selling electricity to the electricity grid. This problem in Sweden is trying to be solved by a committee directive from the finance department in the Swedish government to research the introduction of net-metering (in Swedish: nettodebitering). Net-metering is a policy that eliminates the tax barrier by creating a system in which micro-producers (small scale individual producers such as solar energy producers) of electricity can feed in the excess electricity produced by their plants into the electricity grid. The producer is compensated for this excess electricity either by getting the same amount of electricity from the grid (as they have put into the grid) for free when they need it (when their own production is not covering their electricity demand); or by balancing out the total price of bought electricity (when their demand hasn't been covered by their own production) with the total price of the electricity sold to the electricity grid. (Naturskyddsföreningen 2012:3-4; Finansdepartamentet 2012).

Another driver for the German implementation of solar energy has been the status of the German energy system. The total energy production in Germany is much larger than in Sweden (Elmwall 2013: interview) at the same time that the German energy system is supplied by a much larger proportion of fossil fuels than Sweden. (Andrén Sandberg 2013: interview; The World Bank 2013). This is naturally something that affects the demand for renewable energy sources, and increases the urgency for incentives such as the EEG-law.

4.1.2 Renewable energy and the Swedish status quo

The Swedish energy system has undergone many changes in its composition in the last few decades towards cleaner and more sustainable energy solutions. Just in the last twenty years for example the proportion of the final energy use provided by renewable energy sources has risen from a third (33%) to almost half (48%) of the country's final energy use (Energimyndigheten 2013:6). This chapter will give an overview on how different drivers and barriers affect the implementation of renewable energy; while at the same time focusing on the Swedish context. This is due to the importance of having knowledge of the current situation for the implementation or increase of renewable energy production; before embarking in the implementation of a particular renewable energy source.

4.1.2.1 Barriers for the implementation of renewable energy sources

The variety of renewable energy sources available is significant. However with this variation in opportunities comes a variation in difficulties; since most renewable energy technologies carry with them different barriers depending on the type of renewable energy source that is to be implemented (Elmwall 2013:interview; Andrén Sandberg 2013:interview). Next, I will discuss some of these barriers:

Infrastructure of the energy system

One of the main barriers related to the implementation of renewable energy sources is found at the *macro* level. That is that many of these renewable technologies often have an intermittent energy production since they are not able to operate full time. The reason for this is that these technologies require specific conditions in the natural environment in order to function. Solar energy for example requires a certain amount of solar radiation; wind power requires wind at the specific location of the wind turbine, etc. This creates the need for infrastructural changes in the energy system. One of the most necessary changes related to this is the necessity of a strong and flexible energy system. This consists both in setting up backup systems to satisfy the energy demand at times of low energy production; at the same time as having a system that can handle the excess production at times of high energy production. This is usually costly. The excess production problem has manifested itself for example in Denmark. Here the countries' wind power production supplies approximately 20% of the country's electricity demand. This has led to problems when there have been strong winds; due to the excess production of electricity from the wind turbines. (Turkenburg et al. 2012:775; Patwardhan et al. 2012:1181; Lund 2007:912, 914, 918; Energimyndigheten 2013:45, 49).

However excess energy production from intermittent renewable energy sources does not *currently* hinder the implementation of renewable energy in Sweden. This is due to that the current Swedish implementation of renewable energy from intermittent renewable energy sources; is not large enough in order to make it necessary to implement the changes related to sudden excess production from intermittent energy sources: *"If our biggest problem is that we have too much renewable energy, then we are very fortunate."* (Andrén Sandberg 2013:interview). Another reason this does not currently hinder the implementation of renewable energy is that energy companies are required to be able to receive input from renewable energy by law in Sweden. This means that if changes were required due to the expansion of intermittent renewable energy sources; these changes would have to be made. Also, Sweden is well suited for the intermittent nature of certain renewable energy sources due to its good supply of renewable regulating power such as hydropower: which makes it possible to compensate for underproduction from intermittent sources (Andrén Sandberg 2013:interview). Nevertheless according to Hagberg (2013: interview) many energy companies are already working together for research and development of "smart grids" that can take the challenges posed by an increase in intermittent renewable energy sources (Hagberg 2013: interview).

The current work on "smart grids" means that the infrastructural barrier presented here would be, if the work is successful, eliminated. This would be a large advantage in the event of a substantial implementation of intermittent renewable energy sources; considering that changes at the *macro* level are difficult and take time to make. It is however hard to predict exactly when this development will happen; which could lead to some complications: If these changes are not completed in time; the infrastructural barrier might halt and possibly prevent a substantial implementation of intermittent renewable energy sources. This would be a large disadvantage since, while not all renewable energy sources are intermittent, not being able to implement intermittent renewable energy sources could considerably limit the possibilities and options for a substantial implementation of renewable energy in general. However, even if not completed in time, this anticipation in working on smart grids gives a head-start in preparing for such an event.

The thin line between environmental friendliness and hostility

At the *micro* level we can find that the use of certain types of renewable energy sources, while fulfilling the goal of producing greenhouse-gas-free and renewable energy, has at times caused negative environmental and social consequences. An example of this when it comes to environmental consequences can be found in hydropower. Hydropower is a beneficial and reliable renewable energy source in many ways. However one must be careful when choosing location and building the infrastructure required for hydropower; since the dams required for hydropower have at occasions been known to cause environmental damage in rivers in which they have been built (Turkenburg et al. 2012:794, 796-797). Furthermore an example of the negative social consequences that can be caused can be found in the cultivation of crops for the production of biofuel. Apart from the environmental damages that arise from the cultivation; using space to grow biomass which would otherwise have been used for food production can cause food shortages for various populations at the same time as it can cause increased food prices (Gröndahl et al. 2011:242). Hence this would therefore create social problems.

As was explained in the theory chapter, transition theory has a large focus on sustainability. Therefore, before embarking in a transition process to increase the implementation of a certain renewable energy source; it is important to investigate the positive and negative consequences that the use of the renewable energy source in question might have. Not doing so might bring negative environmental and social consequences like the ones exemplified above. This would counteract the sustainability benefits gained by using a certain renewable energy source (such as not using up finite resources and not expelling greenhouse gases); by creating unsustainability in other areas (such as other environmental damage and social problems).

Technology prices and the position of fossil fuels

Even though prices for renewable energy technologies vary depending on the renewable energy source in question; the prices for renewable energy technologies (and therefore for the use of renewable energy sources) have generally decreased both in Sweden (*micro level)* and globally (*macro level*). This has led to an increase in the availability and affordability of the use of renewable energy sources and therefore an increase in their use. In spite of that, this economical barrier (prices) is still present. Installation costs for renewable technologies are still high; especially if this is to happen at a large scale. Another aspect of the economical barrier is high operational costs for some types of renewable energy technologies (Turkenburg et al. 2012:768-769, 775; förnybart.nu 2010:3). If fossil fuels are to be replaced by renewable energy sources; then the use of renewable energy sources (including of course all the costs related to their implementation) have to be made cheaper for investment. Economic advantages are usually necessary in order for comprehensive changes like this to be made; and many still consider fossil fuels to be the cheapest solution (Elmwall 2013: interview). An aspect worth noting is also that fossil fuels are, as we know, already widely used; which means that most of the infrastructure needed for their use is already installed and established. This naturally makes it harder for the use of renewable energy sources to decrease prices and compete with fossil fuels; due to the high installation costs that come with a large scale implementation of renewable energy.

A barrier at the *meso* level is that the general perception of fossil fuels is not only that they are the cheapest solution; but even the *easiest* solution: For many in this context it is *"often simplest to do as one always has done."* (Elmwall 2013: interview). Fossil fuels are also considered more energy intensive than most renewable solutions which adds to the level of "easiness" for using fossil fuels. (Turkenburg et al. 2012: 768-769). It does however not really help to create "easy" solutions that create the illusion of contribution in the use of renewable energy; but really don't have much effect. This is reflected in the option that consumers in Sweden have to choose electricity source. In this case, consumers can choose to buy "green electricity" (electricity from renewable energy sources) through their electricity providers. Buying "green electricity" however only means that certain electricity production is allocated to a certain consumer. This only means that other consumers get "dirtier" electricity allocated to them since the total electricity in the grid is still the same. *"So if we say that you get hydropower it actually only means that somebody else will get a little less hydropower and a little more nuclear power, and vice-versa, so that it doesn't really make a real difference for the energy system."* (Andrén Sandberg 2013: interview). Many expect a flawless and obvious solution to come when it comes to using renewable energy (Elmwall 2013: interview). Finally, the perception of reliability of fossil fuels as reliable energy sources (excluding of course its finite nature) makes it hard to be replaced. This can be seen in the way every EU country is required to have a certain amount of oil reserves available in cases of emergency (Energimyndigheten 2013:40).

4.1.2.2 Drivers for the implementation of renewable energy sources

The original drivers

There are many drivers for the implementation of renewable energy. Fossil fuels are known to be leading to environmental catastrophes in different aspects. The most commonly known issue related to this is climate change; in which fossil fuels contribute through their emissions of greenhouse gases into the atmosphere and creation of pollutants in general. However another equally important sustainability issue that comes with fossil fuels is the fact that these fuels are finite resources. This combined with a growing world population means that the world's energy security is threatened. The renewable nature of renewable energy sources would counter this effect. (Turkenburg et al. 2012:767-768).

These factors at the *macro* level, namely the environmental damage and finite nature of fossil fuels, are in short the ones that dominate the discourse on *why* renewable energy should be implemented. They are the result of the way many societies and lifestyles have developed. This means that these factors are constant drivers for the implementation of renewable energy sources. They are not only drivers but they are part of the persistent societal problems created by the widespread use of fossil fuels. If we want to keep the consequences that result from this use from increasing; the obvious answer is that these factors that also act as drivers need to be solved. While these drivers are constant, due to the fact that they are also the consequence of fossil fuel use, many other drivers are volatile. That means their nature in strength as drivers can change depending on the way they are perceived, handled and enhanced (or not enhanced). Therefore their presence, their status quo and their effect are not as obvious as the constant drivers. Furthermore, these other drivers are also volatile due to their tendency to have different characteristics and levels of strength from country to country. Below I will present two decisive categories of volatile drivers for the implementation of renewable energy sources. Note that even though surely other determining drivers exist, this project deems these drivers as the most relevant; focusing on a Swedish context.

Economic factors

Economic factors as we can see can work as barriers for the implementation of renewable energy sources. However economic factors are at the same time crucial drivers for this implementation.

Even though many consider fossil fuels as the cheapest energy solution; there has been an almost constant increase of oil and general fossil fuel prices in the world. Despite from there being general global prices for fossil fuels like oil (*macro* level); prices vary from country to country (*micro* level). Certain countries, like Sweden, have implemented green taxation; which means that there has been increased taxation on fossil fuels. In the Swedish industrial sector for example, industries get taxed depending on which type of fossil fuel they use and for the greenhouse gases and other polluting emissions that these fossil fuels cause in their use. The result of the increasing global fossil fuel prices (and therefore of their use) combined with green taxation in countries like Sweden; has resulted in a gradual increase in prices of fossil fuels and the costs related to their use in these countries (Energimyndigheten 2013:17, 23). Since high prices for the use of renewable energy sources act as a barrier for their implementation; it is safe to assume that high prices for the use of fossil fuels can in the same way act as a barrier for the use of these fuels. That means that the currently increasing prices of fossil fuels, especially in countries that have applied green taxation, has become an increasing driver for the use of renewable energy sources.

Furthermore, looking at the German example and considering the strong effect economic drivers and barriers can have; the increasing prices of fossil fuels will most likely eventually affect the previously mentioned barrier related to the perception of fossil fuels as being the easiest energy sources to use. This is due to that if the increase in prices of fossil fuels continues; it will most likely reach a point where costs for using fossil fuels will be high enough to gradually overcome the barrier mentioned above. In other words, the high prices of fossil fuels will most likely, in spite of the "easiness" in their use, make their use become unattractive; leading on the other hand to, combined with decreasing prices for the use of renewable energy sources, an increase in interest for the use of renewable energy sources.

Direct prices are however not the only economic driver for the implementation of renewable energy. The use of renewable energy sources is in general perceived as positive. This means that companies and other economic actors have the opportunity of marketing themselves through the use of renewable energy sources (Elmwall 2013: interview). That would create an economic opportunity and therefore an incentive for these actors. This is a driver at the *micro* level.

Policy

As the German example showed us, policy measures can be significant drivers for renewable energy implementation. The European Union has set out different legal documents fomenting the implementation of renewable energy; that are to be followed by all member states. While EU legislation is supposed to be followed by every member state; some of it gives much wiggle room for action towards a certain goal. Like for example directives: The EU sets minimum goals in a directive and each member country can decide which legislation to use in order to comply. Sweden has incorporated into Swedish law many directives that relate to the energy sector and act as drivers for the implementation of renewable energy; such as *the renewables directive*. This directive chooses goals for the implementation of renewable energy for each member country individually. Sweden's goal according to the directive is to have at least 49% of the country's final energy use supplied by renewable energy. Sweden has raised this goal slightly to 50% (European Union 2013; Energimyndigheten 2013:6). Raising this goal shows the positive attitude that there is in Swedish policy for the implementation of renewable energy. This is a driver in the country at the *meso* level.

Policy is in general a strong driver (at the *meso* level) for the implementation of renewable energy sources in Sweden and has been applied to all energy consuming sectors. These are the industry sector, residential and services sector, and the transport sector.

The most energy using sector is the *residential and services sector,* where policy has been applied mainly with the goal of increasing energy use efficiency. Policy tries to achieve this by setting building regulations which contain a number of points that have to be followed in the construction of new buildings and even conversion of old ones. These points specify different requirements to be followed such as regulations on building insulation, efficient electricity use, systems related to ventilation and the regulation of temperature, etcetera (Energimyndigheten 2013:14-15, 58). This policy's aim is not explicitly intended for the increased use of renewable energy. However, the policy's energy efficiency aims still function as a driver for the use of renewable energy. Buildings producing their own renewable energy for example would cause a good impression in the context of these types of regulations; which could be an incentive for building owners to pursue renewable energy production. Also, more efficient energy use would slightly reduce the challenge of increasing the implementation of renewable energy sources; since a higher energy demand obviously requires larger investments in renewable energy which are costly.

The “middle” sector when it comes to energy use is the *industry sector*. The strongest impact on greenhouse gases from Sweden comes from industrial plants, accounting for 80% of Sweden’s emissions of greenhouse gases (Energimyndigheten 2013:21-22). Policy in this sector is therefore extra important when it comes to reducing environmental damages from fossil fuels. Fortunately, policy measures are in place for both energy reduction and the use of renewable energy, such as The Environment Framework Code. This policy tries to change the way industrial production consumes its energy. Industries are to exercise efficient energy use by conserving energy and using the best technology possible in order to help achieve this. The Environment Framework Code also requires industry to use renewable energy sources where possible (Energimyndigheten 2013:24). The point on the use of renewable energy sources where possible makes this policy within industry a strong driver for the implementation of renewable energy. Another reason this policy is a strong driver is that large actors, such as actors in the industry, have a large effect on the implementation of renewable energy sources because of the effect they can have on the market (Elmwall 2013: interview); and therefore on the market for renewable energy sources.

Finally the smallest sector, making for 91 out of 395 TWh (Terawatt hours) of the total final energy use per year (as recorded in the year 2010), is the *transport sector* (Energimyndigheten 2013:58). However, as was explained before, the transport sector is excluded from the implementation plan formulated in this project.

Level	Drivers	Barriers
Macro	**The original drivers** (climate change and resource problems caused by fossil fuels) **Increasing global market prices of fossil fuels** (which can work as an incentive leading to increased use of renewable energy sources)	**Infrastructure of the energy system** (National grids have to be able to cope with the intermittent nature of some renewable energy technologies, such as solar energy) **Technology prices (**High prices for use of renewable sources globally despite price reductions)
Meso	**Positive attitude towards the use of renewable energy sources in Swedish policy** (reflected in the incorporation of EU directives fomenting the implementation of renewable energy and the fact that Sweden has raised minimum goals) **Policy measures for industrial sector, and residential and service sector** (such as energy reduction policy) **Policy measures for industrial sector** (Policy such as the Environment Framework code which dictates energy reduction and the increased use of renewable energy sources)	**The position of fossil fuels** (fossil fuels are viewed as the easiest, most reliable and most convenient energy source)
Micro	**Increasing local prices for fossil fuels** (Added taxation to already rising global prices makes the local prices even higher; possibly accentuating the incentive for the use of renewable energy technology) **Marketing opportunities** (for companies through use of renewable energy sources)	**The thin line between environmental friendliness and hostility** (Certain renewable energy sources can have negative social and environmental consequences) **Technology prices** (High local prices for the use of renewable energy sources despite price reduction.)

Table 1: Drivers and Barriers for the implementation of renewable energy sources

Table 1 summarizes the drivers and barriers for the implementation of renewable energy sources at the different levels of aggregation. As was described previously, some of these drivers and barriers, such as technology prices and the increasing prices of fossil fuels, belong due to their nature both to the *macro* and the *micro* level. We can also notice that the overall picture for implementing renewable energy sources is positive: This is evident in drivers such as policy measures and the increasing prices of fossil fuels. Also as we could notice in this chapter; many of the barriers presented here, such as the infrastructure of the energy system and technology prices, are gradually being reduced or solutions are being investigated in order to reduce them.

4.2 Solar energy in Sweden

Interest at the *micro* level in the implementation of a micro-producing renewable energy technology, such as solar energy, is decisive. The fact is obvious: for micro-production in for example roofs of individual houses, an interest from the individuals owning these houses is needed. A company installing solar cells on their roof for example must first be interested in this. The conclusion: it is decisive to have the interest of all kinds of individual actors, such as property owners, in order to micro-produce solar energy on these surfaces. Luckily public interest for solar energy in Sweden is rising.

In the municipality of Lund for example, interest in solar energy has been rising. Amongst the groups interested in solar energy are large property owners (such as apartment building owners) and home-owners (Lindholm 2013: interview; Hagberg 2013: interview.) which is a driver for micro-production of solar energy. And in the county of Östergötland, energy and climate advisors in every municipality have noticed a substantial increase in questions asked to them about solar energy (Elmwall 2013: interview). Even more evidence of an increased interest in solar energy is the way different initiatives for promoting solar energy have been successful: The "solar safari" arranged by the East Sweden Energy Agency in the county of Östergötland for example, where there was an open house for showing eighteen solar energy plants, had as many as two hundred visitors. And the "solar seminar" also arranged by the East Sweden Energy Agency, a seminar about different types of (mostly large) solar energy plants in the county of Östergötland, got quickly filled with visitors (Elmwall 2013: interview). Yet another example of signs of increased interest in solar energy is the "solar cell competition" made by the energy company Lunds Energi(in the municipality of Lund). This is a competition in which people have a chance to win a solar cell package (solar cell packages will be explained later) for their home by completing a quiz about solar cells. This competition already has at least six hundred interested people.

There are many drivers and barriers that have affected and still affect the overall interest in, and therefore implementation of, solar energy in Sweden. These are discussed and categorized below into what this project has found to be the most determining categories: *economic factors, policy, knowledge* and *technique*.

4.2.1 Barriers and Drivers for the implementation of solar energy in Sweden

Economic factors

A category of barriers and drivers of much relevance which we can see in both the German implementation of solar energy and the implementation of renewable energy in general has been the economic category. Even though renewable energy technologies follow the same general downwards trend in prices; as we know, prices vary depending on renewable energy source. For solar energy; many had until now not seen the use of solar energy as economically worthwhile due to high installation costs and high equipment prices. This is a barrier that had resulted at both the *macro* level (the global market) and the *micro* level (the Swedish market). Globally for example, prices for solar cells had been so high that until now the global market for solar cells has been dependent on support schemes from different countries' markets to keep up. However both global (Turkenburg et al. 2012:823) and domestic prices for solar power technology have decreased significantly, which turns this barrier into a driver. Prices for solar cells have sunk globally (and therefore domestically) to such an extent that the number of Swedish solar cell producers has decreased to one; due to their inability to sell solar cells at such low prices in Sweden (Lindholm 2013:interview; Hagberg 2013:interview).

The decrease in prices has attracted interest from individual actors, such as companies and individuals, to acquire solar energy. This is due to that investment in solar energy can now be recuperated in a shorter time, as opposed to previously. This is why prices until now had played such a strong role as barriers. As a result there has been an increase in the demand and number of solar energy products sold in the Sweden (Elmwall 2013:interview). This demand has naturally resulted in an increased usage of solar energy systems in Sweden. This has been reflected in the installation subsidies for grid-connected solar energy systems from the Swedish government, the solar –cell support program (in Swedish: solcellsstödet). These subsidies are set depending on the *need* for subsidies; and have decreased from a maximum of 75% to a maximum of 35% of installation costs (Lindholm 2013:interview; Näringsdepartamentet 2012). This reflects that prices for solar energy have become more suitable and have therefore led to more willingness (and capability) from actors to pay larger shares of the costs.

Another driver, at the *micro* level, related to prices is the one-time investment nature of solar energy. Like with other micro-producing renewable energy technologies, micro-producers of solar energy such as solar cell producers, can make themselves independent from market prices of electricity while producing their own electricity (Andrén Sandberg 2013: interview; Patwardhan et al. 2012:1188). The one-time investment factor is also beneficial due to the fact that solar energy technologies require almost no maintenance (Andrén Sandberg 2013: interview). This gives solar energy technologies an economic advantage: Solar energy technologies don't have the economic obstacle of operational costs. That reduces cost related economic barriers; making solar energy technologies more attractive for use; and more suitable for competition in the market.

When it comes to the marketing benefits companies can acquire through the use of renewable energy; solar energy possesses a particular advantage. That is that solar energy technology such as solar cells are very visible. That is a driver at the *micro* level for companies since companies trying to promote themselves as "green" can, in contrast to "just" buying green energy, show an active initiative to contributing to renewable energy production by producing renewable energy themselves. *"Solar cells draw with them a certain value."* (Andrén Sandberg 2013: interview). However while there is interest from certain companies to install solar cells; for big companies with a lot of energy consumption, such as manufacturing companies, it is currently still cheaper to buy electricity than to produce it with solar cells. Companies like these then usually lack interest since there is no real incentive to invest in solar energy for them. Their incentive could still be the marketing effects by showing good will, but that is usually not enough (Lindholm 2013: interview; Hagberg 2013: interview).

Policy

Policy can play a crucial role in the implementation of solar energy. We have seen evidence of this in the rapid German implementation of solar energy where the EEG-law's feed-in tariffs played a crucial role. However, a strong barrier at the *meso* level for the implementation of solar energy in Sweden is the previously mentioned barrier related to the lack of appropriate policy for making it worthwhile to sell excess energy production to the energy grid; such as net-metering (Elmwall 2013: interview). New users of solar cells have, according to Swedish law, the right to a free of charge installation of an electricity meter which makes it possible for them to sell excess electricity produced into the electricity grid (Palm 2013: interview). However, considering solar energy production is intermittent; this does not take away the problem that calls for the introduction of net-metering in the first place: namely the costs caused by the separate taxation and administration for buying and selling electricity. That is naturally because micro-producers of solar energy usually also have to buy electricity from the electricity grid at times of insufficient or no solar energy production, unless of course they produce it themselves in another way. (See "The German example")

There is currently a market based electricity certificate system in Sweden. Actors producing renewable energy, such as a company with solar cells on its roof, get electricity certificates for every megawatt hour they produce. Electricity companies are then obliged to purchase a certain amount of these electricity certificates per year from the producers of renewable energy. Prices for electricity certificates are determined in a supply and demand principle. If the production for renewable energy is little, then there will be few certificates and their prices will therefore rise: creating an incentive to produce more renewable energy. The extra income producers make creates in this way an extra incentive to produce renewable energy (Vattenfall 2013; Ekonomifakta 2013). But the electricity certificate system mostly benefits large producers of renewable energy; therefore it does not benefit micro-producers such as solar energy producers (Hagberg 2013: interview).

An existing policy driver (at the *meso* level) for the implementation of solar energy in Sweden however is the solar cell support program. This is a program that grants subsidies to actors such as *"individuals, municipalities and companies as a one-time subsidy for the installation of all types of grid-connected solar cell systems."* (Näringsdepartamentet 2012). However this program is not properly suited for the level of demand it is receiving; as the program has waiting queues that can go up to two years. This makes the program not very effective since it creates uncertainty for potential investors in solar energy (Hagberg 2013: interview; Palm 2013: interview). The subsidies granted by this program are also too small in order to be able to foment a relatively fast growth of solar power. The good side is however that, as we mentioned above, prices for solar cells have sunk to a point where it is becoming conceivable for the public to invest in solar cells even without subsidies (Elmwall 2013: interview).

Finally, when it comes to policy in Sweden it is important to keep in mind that municipalities in Sweden are quite autonomous (SKL 2013). This can be both a driver and a barrier at the *micro* level. As a driver, this aspect makes it possible for municipalities to promote and support solar energy by for example fomenting the use of solar energy in their policy documents. Municipalities can also form cooperation with other municipalities for the implementation of renewable energy, such as "klimatkommunerna" and "Solar Region Skåne", and offer information about technologies such as solar energy through for example the municipality's energy advisors (Hagberg 2013: interview; Palm 2013: interview). Another aspect municipalities can help in is by making it more economically suitable to invest in solar energy by taking away "unnecessary" fees for its installation; as is the case with the municipality of Lund (Lindholm 2013: interview). Municipalities also have a positive attitude towards solar energy which makes it easy to get building permits for solar energy from them (Lindholm 2013: interview). However a barrier that the autonomous nature of municipalities in Sweden creates is that municipalities can put their own requirements on these building permits. This creates complications for construction companies installing solar cells; due to that these companies have to then research and find solutions for installing solar cells according to the different rules of different municipalities (Palm 2013: interview). Naturally this hinders the implementation of solar energy since the process becomes more complicated.

We can see that policy and economic factors, as was the case in Germany, are closely related when it comes to barriers and drivers for the implementation of solar energy. The lack of adequate policy for making it worthwhile to sell excess energy into the energy grid barrier, and the solar cell support program driver; are both examples of policy that, as we could see, directly affect economic factors related to the use of solar energy. The same can be said about a part of the policy driver relating to the autonomy of Sweden's municipalities; in which municipalities have the ability to take away fees related to the installation of solar cells, affecting once again an economic factor. The relationship between these categories can also be found in the drivers and barriers for implementation of renewable energy in general. Here, the driver related to the high prices of fossil fuels for example is partly caused by green taxation, which is a policy measure. It is worth noticing however that, in this context, there seems to be a one-way relationship between these categories: aspects of policy seem to mostly affect economic factors; whereas this effect is not as evident the other way round.

Knowledge

Knowledge has been a category with many aspects that have acted as barriers (at the *meso* level) for the implementation of solar energy until now. Myths about a lack of necessary insolation in Sweden, discussions about seasonal top production and under production not coinciding with seasonal energy demand; and a lack of good quality information about solar energy on media like the internet have been some of the barriers in this area (Elmwall 2013:interview). There is also a split in the information about solar energy: nationally for example information about solar heating is good, but there is a lack of updated information on solar cells available (Lindholm 2013: interview). Even though solar cells are the ones currently attracting most interest from the public and expanding the most when it comes to solar energy implementation in Sweden (Elmwall 2013: interview). The lack of information on solar cells becomes therefore a barrier.

Knowledge barriers have an extra strong effect on the implementation of a micro-producing renewable energy source such as solar energy; due to what was explained in the beginning of this chapter: the need for interest from individual actors. The drivers and barriers presented in other categories naturally also affect this interest. Having all the right drivers in place in other categories however; is not as effective for the implementation if individual actors lack the right knowledge about solar energy that can wake their interest in the first place. Or even worst, if individual actors have incorrect information that may work as a deterrent and therefore decrease their interest; such as the information brought about by myths. This makes initiatives in the knowledge category extra important.

Luckily, some initiatives to reduce these knowledge barriers are already in place. One of the important initiatives in some municipalities is the creation of a "solar map"; a map that shows the potential for producing solar energy on each roof of a determined geographical area (Göteborg Energi 2013; Stockholms Stad 2013; Lunds Energi 2013). This is a good way to not only spread knowledge about solar energy but also initiative, due to the ability for people to actively see the potential of solar energy on their own roofs (Andrén Sandberg 2013: interview). Some of these maps, like the one made for the municipality of Lund, even show how to proceed in order to acquire solar energy (Lunds Energi 2013) which makes it simple for the individuals to investigate about these possibilities. Solar maps like these can also act as tools for energy and climate advisors (Lindholm 2013: interview) to inform about solar energy. Other important initiatives that are helping reduce these knowledge barriers are information campaigns. Information campaigns are generally very important to counter the lack of good quality information that is available (or unavailable) to the public. The big masses, before investing in a technology such as solar energy, usually want to know if they are in for a good deal before investing: they want to see that the technology is established, viable, advantages, disadvantages, if there are any complications, etcetera. Information campaigns such as the solar safari done in the county of Östergötland give this opportunity; while at the same time giving potential solar energy producers the opportunity to ask questions to existing solar energy producers (Elmwall 2013: interview).

Technique

Solar energy production, like energy production from many renewable energy technologies, is intermittent. This naturally means that solar energy shares the previously mentioned infrastructural barrier related to this characteristic with other intermittent renewable energy sources. However the nature of the intermittency of solar energy production also provides a particular barrier (at the *micro* level): It does not provide energy all year round; and reaches its peak production in summer, when energy demand in Sweden is at its lowest. (Andrén Sandberg 2013:intervju). On the other hand however solar energy having its top production in the season with the lowest energy demand can also be a driver: the excess energy produced during the summer could be exported to other countries around Sweden; contributing either way to a decrease in the use of fossil fuels. This excess energy could even technically be stored by using it to produce hydrogen or biogas (Andrén Sandberg 2013: interview).

Solar energy technology also possesses other technical advantages (*micro* level). Solar cells are easy to install. They have no moving parts, which makes them able to be installed on most surfaces with the condition of receiving sunlight (Turkenburg et al. 2012: 822). Installation of solar cells is also very easy to acquire nowadays. Previously installing solar cells in Sweden was a complicated process; whereas now many energy companies have started to offer solar cell packages. (Hagberg 2013: interview). These are complete packages that include equipment and installment of solar cells making it very easy for customers to acquire this type of solar energy (Vattenfall 2013). Solar cells are also very space-efficient since the space used by solar cells is usually space that is not designated for other use, such as rooftops. Also the production of solar cells can be flexible in resources used: solar cells can be made out of a large variety of products such as common elements like silicon, which as Levier et al. (1995) confirms, is the second most abundant element on earth after oxygen. Finally, solar cells do not make any noise (Palm 2013: interview), which is an advantage that prevents social conflicts that can be caused by sound disturbances.

The environmental advantages provided by the different drivers presented here are, from a sustainability point of view, a strong driver for the implementation of solar energy. Especially when taking into consideration the “thin line between environmental friendliness and hostility” barrier mentioned earlier (see “barriers for the implementation of renewable energy sources).

Interest from individual actors at the *micro* level. Interest is rising, which is a driver in general (This is a main requirement due to the micro-production nature of solar energy production. The drivers and barriers presented affect individual actors' general interest in various ways)

Level	Drivers	Barriers
Macro	**Global market prices for solar energy have decreased** (Enough to cause an increase in the interest for solar energy use)	
Meso	**Solar cell support program** (Subsidy)	**Lack of adequate policy** (for making it worthwhile for micro-producers of solar energy to sell excess energy to the energy grid) **Myths** (such as about lack of necessary insolation in Sweden) **Lack of good quality information in the media** (About solar energy) **Lack of information about benefits despite seasonal production** **Split in information about solar energy** (Lack of information on solar cells, especially solar cells)
Micro	**Local market prices for solar energy have decreased** (enough to cause an increase in the interest for solar energy use) **One-time investment** (Solar energy producers can make themselves independent from market prices of energy; and solar energy technologies require almost no maintenance) **Municipalities' level of autonomy in Sweden** (can adapt municipal policy and documents to benefit solar energy implementation; can co-operate with other municipalities for the implementation of solar energy; can offer information and advice about solar energy implementation) **Easy installation** (Solar cells can be installed on most surfaces) **Easy to acquire** (Full "solar cell packages" are available in Sweden) **Space efficiency** (Solar cells are usually installed on spaces not designated for other use such as roofs **Resource flexibility** (very common materials can be used to produce solar cells) **No noise pollution**	**Municipalities' level of autonomy in Sweden** (Municipalities have their own building permits which can differ from each other) **The nature of the intermittency of solar energy** (Solar energy does not provide energy all year round ; and production peaks in the time of lowest demand)

		Solar cells are very visible (Accentuates marketing benefits for companies using renewable energy) **Excess energy produced in summer can be exported** (Solar energy production reaches its peak in summer (when Swedish energy demand is at its lowest) and can thus help reduce the use of fossil fuels in nearby more fossil fuel intensive countries)	

Table 2: Drivers and barriers for the implementation of solar energy in Sweden[2]

Table 2 summarizes the drivers and barriers for the implementation of solar energy in Sweden. As was explained previously, the barriers and drivers in this category all affect the interest that is required for the implementation of solar energy. Naturally the barriers presented here, such as the ones related to the lack of correct information and the nature of the intermittency of solar energy are quite strong. However as was explained throughout this chapter, we can also see that many of the drivers presented here form a good base to counter these barriers. The technical, environmental and social advantages presented for example, such as space efficiency, resource flexibility and the lack of noise pollution; can be used as facts when providing correct information about solar energy. Another example is the possibility to contribute to the reduction in use of fossil fuels by exporting excess energy, this helps counter the nature of the intermittency of solar energy. The drivers presented do not only form a good base to counter these barriers; some of these drivers are very strong in themselves: such as the drivers of decreasing prices for solar energy and the one-time investment of solar energy.

[2] The necessary actors for the implementation of solar energy were not included; this is because them and their functions are mentioned and explained later on in the implementation plan.

5. Analysis

5.1 Increasing the implementation of solar energy in Sweden

In this last section I will propose an implementation plan for contributing to increasing the implementation of solar energy in Sweden. For this I will use the theoretical framework based on the three first steps of the transition management cycle which I have presented and discussed in the theory and methods chapters.

5.1.1 Transition arena

Building a transition arena is the first step towards starting the implementation process. Here it is important to bring a limited amount of actors that have different backgrounds together to form a transition arena (Rotmans 2005:45). There are a variety of actors needed for working towards an increase in the implementation of solar energy in Sweden which I have categorized as follows:

- *Government:* Here both the national government and municipalities are included. The national government can contribute at the *meso* level with the leverage they have at the *meso* level. For example in working with overarching policies such as subsidies like the solar cell support program. Municipalities' contribution here on the other hand can be at the *micro* level. The level of autonomy that municipalities in Sweden have can be very beneficial in the implementation of solar energy if the right co-ordination between municipalities is achieved towards steering in the same direction. This co-ordination can help reach universal agreements on points mentioned earlier such as building permits, fomentation of the use of solar energy on policy documents, fees, etc. This would eliminate barriers that complicate the implementation of solar energy; such as the previously mentioned barrier that can rise due to municipalities having their own particular building permit requirements. As Hagberg (2013:interview) confirms, many municipalities already have co-operation forums, such as "klimatkommunerna" (the climate municipalities), on climate issues. This indicates that municipalities' attitude towards co-operation on sustainability issues is positive (Hagberg 2013: interview); and that municipalities would most likely co-operate for the implementation of solar energy. Furthermore, municipalities in co-operation forums such as "klimatkommunerna" should be encouraged to join the transition arena and set an example of co-operation; while at the same time making an effort to get as many of Sweden´s municipalities on-board with the project as possible.

According to Rotmans (2005:45), there should not be too many actors involved in the transition arena. Considering Sweden has 290 municipalities (SKL 2013) and assuming of course that all municipalities would want to participate; having all municipalities give input simultaneously would be a timely and complicated process. Therefore municipalities in the transition arena should divide in *dialog groups* depending on their region of origin. Each group would then choose a representative. The representatives of each dialog group would summarize and present the results of the dialogs and agreements between the municipalities in their groups and bring them up in the general transition arena.

- *Companies:* Necessary actors for the implementation of solar energy are: companies that offer solar cell products (Elmwall 2013: interview); energy companies, and construction contractors (Hagberg 2013:interview; Lindholm 2013:interview; Andrén Sandberg 2013: interview). These are important from an infrastructural point of view at the *macro* level. Energy companies, solar cell product companies and construction contractors can co-operate with each other in order to facilitate and find solutions for the use and implementation of solar energy products in the Swedish energy system. Competition between companies of the same type (such as competition between energy companies) could become a barrier for this kind of co-operation. However as Hagberg (2013: interview) confirms there are already existing forums such as "Vinnova" in which companies, which normally in other contexts compete with each other, manage to co-operate with each other for a common goal in this specific context. Finally, another important actor that should be included in this category is banks; in order to facilitate financing (Hagberg 2013: interview) for the projects and experiments formulated in the transition arena.

- *Other necessary target groups:* One of the advantages of solar energy technology that we mentioned earlier was the possibility to install solar cells on unoccupied surfaces such as roofs. With this in mind it is important to include all kinds of property owners (*micro* level) such as house owners, apartment building owners and other property owners as actors in the transition arena. As we have noticed throughout this project, solar energy is mostly acquired through decentralized micro-production on various surfaces (Patwardhan et al. 2012:1188). We have also mentioned how, due to this, it is essential that these surface owners are interested in solar energy in the first place. Having perspectives from property owners could therefore help plan for promoting the implementation of solar energy; based on property owners' own perspective on what attracts their own interest. Another important group of actors for the implementation of solar energy are enthusiasts of solar energy, which according to Lindholm (2013: interview) and Hagberg (2013: interview) have shown to be very important for displaying solar energy technology and for creating inspiration for the use of it. Having the knowledge from enthusiasts could therefore also help plan for promoting the implementation of solar energy.

As we can observe, a number of the groups of actors named above already have been or are involved in some kind of co-operation with each other. And as we have seen from the marketing possibilities that actors get from the use of renewable energy; work with renewable energy has a good connotation. Based on this we could also say that even a co-operation in the form of a transition arena could potentially have marketing/promoting functions for the actors involved. However, these may not be strong enough incentives to some actors for joining the transition arena. First of all, marketing might not at all be of importance for certain actors, such as individual property owners which represent themselves only as individual property owners; and the good connotation that working with renewables brings might not be motivation enough for certain actors to join. Secondly as it is commonly known, there are other particular interests different actors have which may differ and even conflict with each other. Since co-operation between the different actors in the transition arena is the core of a process based on the transition management cycle; this risk jeopardizes the whole process. However, even though this risk always exists, a large focus should be put on the sustainability advantages and therefore the contributions to the future that the transition arena aims to achieve. A constant reminder of this may possibly diminish the effects of conflicting interests.

To form a transition arena, an actor or group of actors that works as initiators is required. This is obvious and we can see it in examples of transitions presented by Loorbach et al. (2012:239, 241) such as the "Parkstad Limburg" and the healthcare transition in the Netherlands; where there is always an initiating actor. Therefore a transition arena such as the one suggested in this project, that would have so many actors at different scale levels involved; would need an initiator that has the range to contact all of these actors and get them together in the first place. Organizations that could work as transition arenas have started to emerge in Sweden. An example of one of these organizations is the East Sweden Energy Agency in Östergötland. This organization works as a neutral actor that tries to create space for the right actors (for a certain project) to have the opportunity to meet each other at the same level; and work together in projects in an unprejudiced environment. However the East Sweden Energy Agency is a non-profit organization; which means that projects led by them need external financing and external demand (Elmwall 2013: interview).

A solution to this can lie in municipalities and their autonomous nature. As we know, many municipalities have already been known to form forums such as "klimatkommunerna" in order to work together with sustainability issues. At the same time municipalities, as we have discussed before, have a high grade of autonomy and govern at the local level (*micro* level). That means that municipalities have a closer relationship to their local citizens than the government does (SKL 2013). This leads to the assumption that municipalities coming together in order to form a transition arena; can have a higher chance than other actors of reaching out to diverse actors spread around the country needed for the transition arena. If this is the case municipalities would be suitable actors to start the process of forming a transition arena; since they could reach these actors (in the actors' municipalities) and try to get them to join the transition arena. This could be done with the help of organizations such as the East Sweden Energy Agency; at the same time that organizations like these could be used as transition arenas themselves. The question that rises now is: how do we get so many municipalities to get together and create a transition arena? It is here that the role of the government as an initiator at the *meso* level comes in. The Swedish government could use its contact with the different municipalities to propose the idea of the formation of a transition arena; while encouraging municipalities to come together to form such an arena. Many would argue that for this to happen there would have to be sufficient interest from the different municipalities. We have however confirmed that there is a rising interest in solar energy in Sweden from both the population and government at different levels (reflected in initiatives such as solar cell support program). That makes this possibility realistic.

5.1.2 Transition agenda

5.1.2.1 Sustainability vision

The next step after the transition arena has been formed is to create a *transition agenda*. The first step for this is defining a sustainability vision from which transition paths can be derived in order to achieve this sustainability vision (Rotmans 2005:47).

The sustainability vision of this project is naturally the same as the objective presented in the introduction: to increase the implementation of solar energy in Sweden. As we discussed previously, the finite nature and the environmental damage caused by the use of fossil fuels creates sustainability problems and calls for the implementation of renewable energy sources. We have also found through the different drivers for the implementation of renewable energy that favorable conditions for this implementation are increasing.

The choice of solar energy in particular as the renewable energy source to be implemented in this sustainability vision is motivated by the previously mentioned rapid expansion of solar energy implementation in Germany in comparison to the current Swedish implementation. This choice is also motivated by the combination of environmental and social advantages solar energy possesses identified in this thesis.

5.1.2.2 Transition paths

The next step is making transition paths. These transition paths describe more generally the different paths that are to be taken in order to achieve the sustainability vision. Before presenting the transition paths it is important to keep in mind however that we are working with a hypothetical transition arena. This means that the creation of the transition paths presented shortly is done under the assumption that the necessary actors mentioned previously have agreed to join and are already part of the transition arena.

As we have discussed, one of the basic principles of transition theory in general is that for transitions to happen changes have to happen at different levels of aggregation. Therefore it is natural, based on the theoretical framework of this project, to form transition paths based on the barriers and drivers for implementation of solar energy found at different levels of aggregation discussed earlier:

- Taking the German implementation of solar energy as an inspiration source; the first transition path is the *meso policy path*. The meso policy path works with policy at the *meso* level and turns its attention on improving the solar cell support program and making it more effective. The opportunity seen here is the fact that this subsidy already exists and is in place. Unfortunately, as was discussed earlier, this programs effectiveness is compromised by considerable waiting queues. Having the government on board the transition arena is here a great advantage; as it can create regulations (in Swedish: förordning) that directly affect the status of the solar cell support program to the detail. Ideally the meso policy path would also work on the implementation of net-metering. However the Swedish government can only affect the introduction of new laws to a certain degree. Passing a law for net-metering requires parliamentary processes that are not in the control of any of the actors in the transition arena. Therefore the *meso policy path* is unfortunately not deemed capable of working with the implementation of net-metering.

- We have confirmed that policy factors at the *micro* level also affect the implementation of solar energy. Therefore, the next transition path is a *micro policy path.* The transition path consists of municipalities in the transition arena coming together as part of the transition arena to try to agree upon a set of common actions in their policies. The objective would be to reduce barriers and create drivers in policy at the *micro* level. This transition path takes advantage of a driver encountered before: the level of autonomy municipalities in Sweden possess.

- As we could see in the knowledge category earlier; making the right information available to the public and spreading this information is important for promoting solar energy. Therefore a transition path in this transition arena at the *micro* level is the *information path.* The main objectives in this transition path are to have an information campaign in order to reduce knowledge barriers found for solar energy. Here the property owners and the enthusiasts of solar energy in the transition arena have a special function; in order to help shape this information campaign. Property owners would do this by giving perspectives based on what they as property owners would react to and would become attracted to when it comes to solar energy. Enthusiasts would help in selecting the best and most essential information about solar energy.

- Last but not least, the *technical path*. This is a transition path at the *macro* level. Here the actors named in the previously mentioned *companies* actor group (except for banks) come together to work with infrastructural questions. An opportunity found here is that many energy companies are already on their way in the research and development of making the national energy grid capable of handling the new challenges posed by intermittent renewable energy sources. This is a driver. The main objective for the actors in this transition path is to research and come with solutions in this area; and therefore contribute to current research in order to make future changes potentially needed on the energy grid easier to handle.

A specific transition path related to the category of economic barriers and drivers, such as prices of equipment in the market, was not formulated. This is due to the fact mentioned previously: that the economic changes on the solar energy market globally and domestically are the result of interactions between markets at the *micro* level and markets at the *macro* level. Domestic market incentives can be put in place in order to steer the market into the right direction. However the effects of the market at the *macro* level (which is very overarching) are still very strong; which leads to the conclusion that it is not within the range of this project to affect the market in significant ways. It is however important to keep in mind that, as explained before, many aspects of the transition paths, such as the policy aspects, directly affect economic drivers and barriers; as for example installation costs of solar energy technologies. Therefore economic drivers and barriers can still be considered taken into account in the transition paths.

5.1.3 Transition experiments

For reasons explained in the methods chapter (see: data analysis), creating transition experiments will be the last step of this implementation plan. The transition experiments here are made directly based on the transition paths presented above; and are experiments that are made to achieve the transition paths. Transition experiments are usually costly; and there are high levels of risk for failure connected to them (Rotmans 2005:50). However, as was explained in the theory chapter, transition experiments are very important, apart from for achieving the transition paths, for inducing a learning process; it is after all, according to the transition management cycle, learning from transition experiments that cause re-adjustments to be made to the transition process. The costly nature of transition experiments obviously creates a necessity for financing. It is here that co-operation from banks in the transition arena is needed; in order to provide loans and possibly sponsoring for transition experiments. The different transition experiments are presented below.

- *The solar cell support program experiment:* This transition experiment will consist in making policy at the *meso* level as friendly and encouraging for solar energy implementation as possible. The work of the experiment would be on the solar cell support program. Here the actors in the transition arena would work together in order to estimate what would be required to make the solar cell support program more effective. This would consist of estimating which size the subsidy should have in order to be effective; as well as reviewing the way the program is designed and coming up with optimizations for it. In the next stage of the transition experiment the role of the government as an actor in the transition arena would come in: the government's task for the transition arena would be to use its leverage, in the form of creating regulations, in order to implement these changes in the solar cell support program. Net-metering remains a determining policy obstacle at the *meso* level; however a more effective solar cell program could help reduce significant economic barriers related to the prices of solar energy equipment.

- *The municipal agreement experiment:* This experiment would consist of the municipalities in the transition arena coming together in order to make an agreement on necessary changes in their policy to foment solar energy. The first step would consist of formulating a common building permit policy. The reason for this comes from the barrier encountered before: namely the complications that can arise from municipalities having different building permit policies when installing solar energy technology. The next step would consist of municipalities working together and coming to an agreement on removing any non-necessary fees related to solar energy. This would be done in order to reduce costs for the implementation of solar energy; which would (as with the previous transition experiment) contribute in the reduction of the economic barriers related to this. The final step would be for municipalities to agree upon including solar energy in their policy documents as standard procedure; in order to increase local awareness about the technology.

- *The grid experiment:* In this transition experiment all actors in the *companies* actor group, except for banks, of the transition arena come together and form a research group. The objective of this research group is to contribute in finding solutions for the energy grid; in order for it to be able to tolerate a large expansion of intermittent renewable energy sources. In this way contributing to the previously mentioned research that is currently being done on "smart grids". As we have mentioned before, a large expansion of renewable energy from intermittent renewable energy sources such as solar energy poses some challenges. While these challenges may not present themselves currently; having a solution ready in case of such an expansion would be benefiting.

- *The information campaign experiment:* The last transition experiment is related to the knowledge barriers. This is extra important in order to increase, much needed, interest in solar energy from individual actors (*micro* level). Here the actors of the transition arena would come together in order to create a widespread information campaign with the goal of promoting solar energy. Property owners would have a special function in this experiment. Their function would be to help shape the campaign based on their perspectives, perceptions and wishes as property owners potentially installing solar energy. Enthusiasts would help select the right information used for promoting solar energy in the information campaign. Promoting solar energy would be done through trying to provide correct information and reduce incorrect myths about solar energy technology. The campaign would also advertise the advantages and know-hows of solar energy to the public; steering attention towards these instead of the negative aspects. The information campaign would follow the following action points:

    - Spreading information putting emphasis on the economic advantages of producing solar energy such as: independence gained from market electricity prices; and the one-time investment nature of solar energy.

    - Advertising the concrete contributions to the environment that producing solar energy brings; in comparison to "just buying green energy". This point would make an extra effort in attracting companies' attentions by pointing out the marketing advantages involved in visible concrete contributions to the environment such as solar energy production. Another aspect brought up in this point would be the possibilities of exporting excess energy to other countries; contributing to a reduced use of fossil fuels. Also, the resource flexibility in the manufacturing of solar energy products would be presented here.

- Pin-pointing the technical advantages of using solar energy. These would include the ability of being able to install solar energy equipment on unused surfaces such as roofs; the evasion of social problems due to noise; and promoting the easiness in acquiring and installing solar equipment due to for example energy companies' solar cell packages.

- Tackling myths by providing correct and updated information. Here, correct information would be spread about insolation in Sweden; making a comparison with the levels of insolation in Germany and the German implementation of solar energy. An emphasis would be made on the advantages of solar energy despite the lack of insolation on certain months of the year. This point would take advantage of, and advertise, the existing solar maps; in order for people to become more aware of the potential for solar energy of their roofs. Also solar safaris, like the one the East Sweden Energy Agency organized, would be organized as a tool in spreading information.

6. The value of transition theory for this project

Transition theory was considered adequate to use in this project largely because of its focus on sustainability and the way it defines problems of the types addressed in this project, such as fossil fuel dependency, as persistent societal problems. Transition theory's definition of "persistent societal problems" motivates the choice of a theoretical framework of a relatively large-scale and non-linear character (See: Theory). Such a motivation is important considering that aspects of transition theory such as the long-term, multi-domain, multi-level and multi-actor aspects, rightly make the use of transition theory give the impression of requiring large amounts of resources and co-ordination; at the same time as they can make transition theory seem unrealistic at times. This may act as a deterrent for actors looking for "simpler" solutions. Analyzing an issue from the lens of the concept of persistent societal problems gives therefore a clear motivation as to *why* transition theory, or elements of transition theory, should be chosen over many other "simpler" conventional solutions when dealing with issues that can be considered persistent societal problems.

6.1 Multi-level approach

The multi-level approach contributed to answering the research questions of this project by helping me identify opportunities and difficulties for change at the different levels of aggregation; which is an important aspect of transition theory.

The characteristics and examples provided by the approaches' different levels of aggregation contributed to my understanding of to which level the barriers and drivers I found belonged to. For example, there were barriers and drivers related to the Swedish energy grid infrastructure. The Swedish energy grid is part of the countries' material infrastructure, which is a characteristic of the *macro* level. Therefore barriers and drivers caused by the energy grid infrastructure were categorized as being at the *macro* level. This categorization also helped me understand the nature and behavior of the barriers and drivers encountered, based on their level of aggregation; which later contributed in determining how the transition paths and experiments were formulated in the implementation plan of the project. For example the *information campaign experiment*, a transition experiment needed due to the knowledge barriers discussed in the project, aiming at the *micro* level, was created taking into consideration that new ideas and innovations can occur quickly at the *micro* level; however these can disappear quickly as well. Therefore the experiment was designed to spread information at a wide range through many different action points. The way this was done was in order to spread and plant the idea of using solar energy technologies as deeply as possible; attempting by this to prevent the idea from quickly disappearing; and attempting therefore to prevent these knowledge barriers from being created again.

The multi-level approach clearly brought advantages to this project; however the approach also has some conceptual pitfalls. One of them identified in this project was while making the categorization of the barriers and drivers. At times; it was hard to determine which category a barrier or driver belonged to. For example the market prices for solar cells, as is the case in this project, can according to the multi-level approach be considered to be both an aspect at the *macro* level and *micro* level; depending on whether the prices refer to global or local market prices. However solar cell technology is an individual technology; and according to the multi-level approach, individual technologies belong to the *micro* level. This creates a conceptual conflict since that means that market prices for solar cells could also be considered an aspect belonging solely at the *micro* level; regardless of whether or not the prices are local or global. The dilemma in this situation then becomes: do global and local market prices for solar cells both belong to the *micro* level since they both are characteristics belonging to the same individual technology? Or do they belong to different levels since, while related in some ways, each of them possesses their own characteristics such as magnitude, economic level of aggregation, geographical boundaries, can be affected by different factors, etc.? While my conclusions led me to the second option; this unclearness as to which type of characteristics of a certain aspect should be prioritized during a categorization and thus which level a certain aspect belongs to, can be and was problematic while categorizing the drivers and barriers.

Another conceptual pitfall of the multi-level approach identified in this project was how it describes the way factors belonging to each level of aggregation are supposed to behave. At the *macro* level for example change is supposed to be highly autonomous. However the material national infrastructure of a country (such as the energy grid), while it according to the multi-level approach belongs to the *macro* level, is obviously directly affected and can be changed by actors leading and administrating the country. The change is then obviously not highly autonomous; contradicting one of the main characteristics of the *macro level.* Even though in this particular example it remains clear that change is not highly autonomous; the concepts presented by the multi-level approach could occasionally be misleading in other examples when using the approach to determine the behavior of factors categorized in different levels of aggregation.

6.2 Transition management cycle

As it is mentioned in the beginning of this project; the transition management cycle helped answer the research questions of this project by working as a model for the implementation plan that this project formulates (see: data analysis). The steps of the transition management cycle were useful for knowing where to start when formulating the implementation plan; and in which way to structure this plan. Furthermore the concepts presented by the transition management cycle on the different steps, such as for example the *transition agenda* and *experiments,* worked as tools for getting suggestions and the knowledge basis on how to formulate each step using the results of my findings. The concept of for example *transition experiments* helped me formulate the transition experiments of this project by for example suggesting the attempted use of existing experiments; and giving tips about the pitfalls and other aspects of transition experiments that should be kept on mind. Also; the transition management cycle worked as a good base in order for me to look for the right information required for the implementation plan from the beginning. For example in the interviews conducted; I always included questions which intended to find out which were the relevant actors required for an increase in the implementation of solar energy in Sweden. This was directly connected to the presence of the concept *transition arena* in the transition management cycle. I also included questions that intended to find out about existing co-operations and projects related to the implementation of solar energy. This was done based off the recommendation mentioned above taken from the concept of *transition experiments.*

As with the multi-level approach, the transition management cycle also has some pitfalls. While the transition management cycle through its concepts helps formulate its different steps; the model lacks the description of some important aspects. This pitfall found in this project was mainly found in relation to the transition arena. Much of the literature on transition management provides good descriptions on the goals and processes that should occur in a transition arena; and the concept of *transition arena* describes how to build a transition arena; together with some recommendations on what to avoid, etc. However, the transition management cycle assumes that the end result of creating the transition arena, after some initial disagreements, will be a group of actors with different backgrounds that reach a consensus. The concept lacks enough mechanisms to cope with the problem that would arise in case there would be major disagreements between the actors of the transition arena; which is realistic to assume since actors with different backgrounds will most likely have diverging interests. Furthermore, as Frantzeskaki et al. (2012:28) confirms the transition arena contains selection criteria for the actors that are to be involved in the transition arena; however it was noticeable when using it in this project that the concept does not provide more recommendations on which type of actors would be most suited to *start* the process. This led me to the questions: Do certain types of actors tend to be more biased than others in these processes? Should the transition arena process then be started by any kind of actor? Or should the actor(s) that wish to start the transition arena consult and recur to an "objective" and more transition-arena-experienced actor to start it? The transition management cycle, as was mentioned before, provides overall adequate descriptions of its concepts and the course of action to be taken while applying this model. Transition management is after all not supposed to provide a concrete blueprint for managing transitions. However investigating aspects like these about the initiating phase of a transition management plan, the transition arena; would facilitate the successful kick-start of a transition management process.

7. Conclusions

The objective of this project is to propose an implementation plan for contributing to increasing the implementation of solar energy in Sweden; based on elements of transition theory. The project is inspired by the rapid implementation of solar energy that has taken place in Germany in comparison to the much slower implementation in Sweden; due to the fact that Germany is a country with the same insolation conditions as southern Sweden. For creating the implementation plan to be proposed; three research questions have been formulated in order to find out the necessary drivers and barriers that need to be taken into account when working with the implementation of solar energy in Sweden. Furthermore to help guide the process of finding these drivers and barriers; the project has compared the current implementation of solar energy in Sweden with the current implementation of solar energy in Germany.

The answers to the research questions formulated in this project are as follows:

- *Which are the drivers and barriers for the implementation of renewable energy in general?*

  This question focuses on finding drivers and barriers for the implementation of renewable energy in general with a focus on the Swedish context.

  As was to be expected, the ongoing discourses in the world about the unsustainable negative effects created by the use of fossil fuels remain the main drivers for implementation of renewable energy. These are effects such as the greenhouse effect and the finite nature of fossil fuels; which are very established drivers and are therefore called *constant drivers* in this project. There are however other drivers related to the implementation of renewable energy which have been categorized into *economic* and *policy* drivers. In the *economic* category we can find drivers such as the increasing prices for fossil fuels (both domestic and international). Another example of a driver in this category is also the marketing effects the use of renewable energy can bring to companies. In the *policy* category we can find various policy incentives, such as regulations, that foment the use and/or production of renewable energy sources in all sectors of energy consumption in Sweden.

When it comes to barriers for the implementation of renewable energy there are four most relevant barriers for this project. Amongst infrastructural issues we can find the infrastructure of the energy system; which poses a barrier because of the current inability of the energy system to tolerate certain changes created by the large-scale implementation of certain renewable energy sources. When it comes to sustainability; a barrier found for the implementation of renewable energy are the environmental and social negative effects that can result from the use of certain renewable energy sources. Finally we have the barrier created by the position of renewable energy sources contra fossil fuels: the prices for renewable energy technologies and their use are currently still high; while at the same time fossil fuels have a position in the majority of energy systems today as the cheapest and easiest solution.

- *Which are the particular drivers and barriers for the implementation of solar energy in Sweden?*

The interest from individual actors is crucial in implementing solar energy; due to the fact that solar energy production is done mostly through micro-production. This interest is affected by different barriers and drivers categorized as following: *economic factors, policy, knowledge* and *technique*.

The implementation of solar energy in Sweden has many barriers and drivers that can also be found in the general implementation of renewable energy sources. This is natural since solar energy is a renewable energy source. An example of these common barriers and drivers is the important barrier found in the *economic factors* category: high technology prices; which solar energy has shared until recently. Also, in this category solar energy shares the driver of falling technology prices, even though the magnitude of this varies depending on renewable energy source. Another example of a shared barrier, in the technical aspects, is the one related to the infrastructure of the energy grid; which needs to be adapted for intermittent renewable energy sources such as solar energy. However, there are also barriers and drivers that are more particular for solar energy implementation in Sweden such as the solar cell support subsidy; and the independence of municipalities which are drivers in the *policy* category. An example of a barrier in this category is also the lack of adequate policy in order to make it worthwhile to sell excess energy into the energy grid. In the *economic* category; we can find drivers such as the advantages of solar energy due to its one-time-investment nature. Also; solar energy can bring particular marketing advantages to companies due to the fact that solar energy production is very visible. In the *knowledge* category we can find barriers such as the lack of correct and updated information on solar energy; and myths around this technology. Finally, in the *technique* category we can find drivers such as the environmental and social advantages that solar energy use possesses. In this category we can also find the barrier of solar energy production in Sweden not producing energy all year round; and having its peak production when the demand is at its lowest.

It is important to point out that the majority of the drivers and barriers for the implementation of solar energy found in this project; have been drivers and barriers for the implementation of solar cells in particular. The project could not find many obvious barriers and drivers for the implementation of solar collectors. This leads to the conclusion that in order to currently reach a successful increase in the implementation of solar energy in Sweden; focus should lie on the implementation of solar cells.

- *What could an implementation process towards solar energy look like?*

The answer to this research question lies in the implementation plan contributing to increasing the implementation of solar energy in Sweden. The implementation process is based on certain elements of transition theory. In this case, the transition management cycle: First a transition arena with all the necessary actors for the implementation of solar energy is formed. After this a transition agenda is made that describes how to reach an increased implementation of solar energy in Sweden. This agenda consists of a sustainability vision and transition paths in order to do so. Finally, transition experiments are made. These are concrete experiments made in order to achieve the transition paths in the transition agenda.

Finally, this implementation process based on elements of transition theory also takes into account the multi-level approach of transition theory: namely that these kinds of processes have to include changes at different levels of aggregation. As a result, the different transition paths and transition experiments in the implementation plan consist of making changes at different aggregation levels.

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