Start-ups developing business relationships in the Swedish energy system

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Abstract
This paper focuses on the process of starting up in the Swedish energy system and in particular how existing resource structures both facilitate and hinder commercialization of new innovations that may contribute to renewable energy solutions. The Swedish energy system is an outcome of many years of investments being made in both public and private infrastructures that can be seen as a 'heavy resource structure'. However, the current 'heavy resource structure' containing for example plants generating electricity from fossil-based fuels is now subject to huge challenges and must open up for new actors and resources to meet the new demands. By using a case methodology this paper aims to explore how to capture the starting up process in the Swedish energy system and specifically the interplay between organizational and technical resources as a way to embed new technical solutions in already established resource structures. The theoretical starting point is the Industrial Network Approach and especially the concepts of resource interaction and resource interfaces.

Introduction
This study deals with starting up processes in business networks and in particular how start-ups interact with other actors in the process. As previous research has shown (see eg. Aaboen et al., 2017, Ciabuschi et al., 2012), starting up in business networks is a matter of resource interactions between the start-up and other actors with the aim of creating innovations. That is, innovation can be seen as creation of new solutions through combining of existing and new resources (Håkansson and Waluszewski, 2002). Bringing new resources into already existing resource structures can be difficult as the existing resources often are developed over long time in interaction with other resources. Thus, they can be featured as *heavy* resource structures (Håkansson and Waluszewski, 2002). Hence, these resource structures can be seen as the outcomes of years of investments, which makes existing resource combinations very hard to change. One reason for this could be, what Dubois and Araujo (2006) refer to as, the connectedness between resource interfaces and the fact that one change in one resource interface may impact other connected interfaces. Or in other words, a heavy embedded resource combination may hinder a new resource combination to take place.
The energy system in terms of several connected resources such as plants and sub-systems, represents a heavy resource structure resulting from years of investments in infrastructures. Development and adjustments of infrastructure components have been made both within well-established energy companies and across the boundaries of a broad range of public and private actors. Today the energy system faces a huge challenge to transform the energy production from fossil fuels to renewable energy sources. The European Union has set the goal to decrease its emissions of greenhouse gases with 20 % until 2020[1]. For Sweden, working towards a renewable energy system, it has been an important goal to gradually reduce the use of fossil fuels to zero, and hence to achieve 100 % renewable electricity production in 2040[2]. To be able to reach 100 % renewable electricity production, the Swedish government has appointed a special commission to investigate obstacles for energy efficiency and small-scale energy production[3]. One attempt to meet the new emission target is thus to create viable conditions for new actors, such as technology based start-ups, to enter the energy system with new technologies and mindsets. However, as Jacobsson and Bergek (2004) pointed out already 14 years ago, the problem is not the potential of renewable energy technologies but how these can be realized and adapted to what is already existing, to be able to contribute

[1] European Commission, 2020 climate & energy package, https://ec.europa.eu/clima/policies/strategies/2020_en
[2] SOU 2017:2, Energikommissisionens slutbetänkande, Kraftsamling för framtidens energi
[3] Kommitédirektiv Dir 2017:77. Utredning om energieffektivisering och småskalig elproduktion och lagring för mindre aktörer

to the transformation from fossil fuels to renewable energy. Moreover, as Sen and Ganguly (2017) stress, most national energy industries worldwide have a small number of large players constituted by distribution companies, regulators and grid operators, and most of the policies do not favour small supply technologies. This is also identified by Negro et al. (2012) who emphasize the problem of not letting the small innovative firms taking part in designing new policies as they often are neglected on behalf of the large actors in the network.

To be able to bring new technologies into the energy system it is therefore vital to understand how these can be integrated into established structures. One way to do this is by inquiring into how start-ups create business relationships with other actors in the energy system. Hence, this study takes its theoretical starting point in the Industrial Network Approach and the notion of business networks and interdependencies between firms, thus considering the functions and substances of the business relationships connected in business networks (see eg. Håkansson and Snehota, 1995). Consequently, new resources such as technologies, or in other words innovations, are seen as the outcomes of interactive processes where the start-ups' resources are embedded into existing resource collections of other firms to become useful (Ciabuschi et al., 2012). As mentioned before, the resource constellations building up the energy system could be referred to as heavy and have been, as Håkansson and Waluszewski (2002) explain, developed during years of adaptations between resources. Inevitably, this creates difficulties when trying to open up for new resources and actors. Still, a large part of the energy system needs to be replaced and/or modified to meet the target of becoming 100 % renewable.

Therefore, the aim of this paper is to discuss how to capture starting up processes in the Swedish energy system. By using a case study methodology to study the resources combined between a start-up and other actors in the energy system, the study reveals how present resource structures both may facilitate and hinder commercialization of new innovations in terms of renewable energy solutions. The overall research issue of the paper regards in specific analysing the resource interfaces (Dubois and Araujo, 2006, Baraldi et al., 2012, Landqvist, 2017) developed between the combined resources. Through this analysis it is possible to add new knowledge on how the process of realization and adaptation of new energy solutions takes place in the business network. Furthermore, and in line with Landqvist (2017), the understanding of how changes evolve in heavy resource structures as well as how it may impact on future connected interfaces can reveal new insights in resource development patterns in business networks. Thus, the study contributes theoretically to the Industrial Network Approach by inquiring into relationship building in established resource structures, and empirically to a better understanding of the transformation of the energy system.

The paper is structured as follows: first the theoretical frame of reference is presented. Thereafter the method is described followed by a case description. The paper ends with comments on further research.

Theoretical frame of reference

The theoretical starting point in this paper is the Industrial Network Approach (INA) to industrial markets (Håkansson et al., 2009, Håkansson and Snehota, 1995) and the concept of business networks. As previous studies have shown, no firm (or actor) works in isolation but is connected to other firms through business relationships. Previous research within the Industrial Marketing and Purchasing (IMP) tradition has mostly concerned already established firms and business relationships. However, start-ups, with a limited amount of resources, need to put emphasis on how to become part of the business network to get access to important resources (Ciabuschi et al., 2012). From a start-up's point of view it means efforts to develop relationships with established actors and having the courage to confront them as a way to start interacting around new and better solutions (Aaboen et al., 2016).

Starting up in business networks is a matter of creating the initial business relationships that will provide the start-up with access to necessary resources to be able to develop, produce and use its idea (Aaboen et al., 2017). During this interactive innovation process a number of different actors may be important. First of all, the potential customers and users often play an important role in the product development process. As Aaboen et al. (2011) stress the development of the start-ups' resources are very much dependent on the initial business relationships with customers. Furthermore, the business relationships with potential customers will also affect the direction of the start-up's product development in terms of application areas.

Secondly, the suppliers are also important actors in the process of starting up. According to Song and Di Benedetto (2008) they can provide not only new technologies but also financial support. As La Rocca et al. (2017) point out, creating initial business relationships with suppliers is a way to extend the resource base for the start-up and hence an important part of the start-up's business model. This is vital as it can reduce product development costs as well as time to market for the company. Thirdly, other actors such as for example universities, being a source of knowledge (Bercovitz and Feldman, 2006) as well as incubators, which provide resources in terms of office spaces and networking capabilities (Baraldi and Havenvid, 2016), can also play important roles in the start-up's process of becoming part of a business network.

As previously mentioned, starting up is about the process of commercializing an idea and hence to create an innovation that customers are willing to buy. According to Håkansson and Waluszewski (2007), innovation in business networks is the result of interactive processes where focus is put on embedding the firms' resources into a developing, producing and using context. More specifically, it is a matter of a mutual process where the start-ups' resources need to be used and developed together with other resources, i.e. combined with other actors' resource collections to become useful (Aaboen et al., 2016, Ciabuschi et al., 2012). Both the start-ups' and the counterparts' resources need to be adapted to create a more useful resource.

By taking an interactive view on business markets, an object is defined as a resource as long as it has *known use* in relation to other resources (Håkansson and Snehota, 1995, Holmen, 2001). Resources are seen as heterogeneous and the value of a resource is dependent on how it is use both within the firm and across firm boundaries (Håkansson and Snehota, 1995, Baraldi et al., 2012). Furthermore, resources can either be organizational or technical (Håkansson and Waluszewski, 2002), and as Gadde et al. (2010) stress; they can also be combined in different ways. When technical and organizational resources interact the value of the resources depend on how the resource interfaces between them develop (Baraldi et al., 2012). Three types of resource interfaces can be identified such as *technical* and *organizational,* visible when two technical or two organizational resources are combined (Dubois and Araujo, 2006), and *mixed*, which is an outcome of one organizational and one technical resource being combined (Jahre et al., 2006). In the interaction between two resources it becomes visible that features of the two resources not always are working well together. As Gadde and Håkansson (1993) explain, a resource can be seen as a piece of a puzzle where often the resource may not fit the common puzzle at first but has to be adapted to create a better fit. According to Dubois and Araujo (2006) these adaptations of resource features may not only affect a particular resource interface but also connected ones.

Furthermore, existing resource combinations may not only be featured by current resource interfaces but may also carry imprints of old resource interfaces and thus will affect the new resource structure it will become part of. Relating to the energy system and the resource collections belonging to the large energy firms (Sen and Ganguly, 2017), they are all a result of resource combinations and adaptations being made over long time. The resource interfaces developed are thus hard to change as many of them are affecting other connected resource interfaces located both inside and across the firms' boundaries. Hence, to be able to bring new resources into the system it is therefore necessary to consider how existing resource interfaces hinder or facilitate new resource interfaces. Therefore, to be able to analyse the starting up process in the energy system it is of importance to identify and analyse resource interfaces in interaction (RI1). Furthermore, to bring new resources (and new ideas) into an already existing system is not only about technical resources but also about the embedding of organizational resources (Håkansson and Waluszewski, 2002).Consequently, the second research issue deals with how to capture the interplay between technical and organizational resources (RI2).

Method

This study takes its starting point in a project called "*Technology based start-ups as engines for renewable energy*" funded by the Swedish Energy Agency. The project aims to shed light on how existing and new resources both facilitate and hinder commercialization of renewable energy solutions in the Swedish energy system, an energy system that should be 100 % renewable in 2040. The study relies on a case methodology and abductive research process where the continuous interaction between the theory and the empirical world is important to achieve matching of the case and theoretical framework (Dubois and Gadde, 2002). A process that is not described fully in this paper due to limited space. To analyse the process of starting up in the Swedish energy system, a start-up from Chalmers School of Entrepreneurship was chosen. This start-up; Swedish Algae Factory (SAF), is part of a larger study conducted by Landqvist (2017) and was chosen because of its very distinct collaborative innovation process with different types of actors, operating both within and outside the energy system. Six interviews have been done with the founder of SAF so far and the plan is to interview other actors connected to SAF's innovation process. Furthermore, to build an understanding of the Swedish energy system and its transformation, initial orientation interviews with researchers within the field of Innovation and Sustainability at Chalmers were carried out in the end of 2017 and a visit was paid to the Sustainable Energy conference at Chalmers in the same period. Additionally, secondary data from homepages and other written materials as well as social media and radio shows have been used to create a description of the case of starting up in the Swedish energy system.

Starting up in the Swedish energy system

The Swedish energy system under transformation

An energy system encompasses everything from energy sources to production, distribution and use of energy. It is very much characterized by a country's geographical and economical prerequisites. Looking at Sweden and its energy system, its development has been a result of both the good access to natural resources such as wind, water and forestland and also political interests related to oil prices and nuclear power debates (Nilsson et al., 2004). Today's main sources of energy are hydropower (11%), nuclear power (35%), oil (24%), and renewables including for example biomass and wind (25%). The rest is constituted by coal and natural gas. Even though the Swedish energy system is performing well currently compared to other countries when it comes to providing renewable energy, there is still a lot to be done to meet both environmental and societal demands. As stated by the World Energy Council, the transport system needs to be less dependent on oil and the politicians are also recommended to find a substitute to the nuclear power as the plan is to gradually phase it out. Hence, Sweden is approaching a paradigm shift where the ambition is to have a 100 % renewable electricity production in 2040[4]. This transformation will not only put demand on creating new technological solutions but will also affect the existing actors in the system[5]. When it comes to the actors involved in the energy system they can be found in all stages of the transformation; from generating the energy from different energy sources to transforming the energy into useful products, such as electricity and heating, as well as distributing it and using it in the end[6].

In Sweden, the energy system has historically been regulated and includes few large actors. Still in 2009, three large energy companies produced 90 % of all electricity consumed in Sweden's. It is a system known for being inert and as the Swedish government's stressed in a proposition in 2005 "*a transformation of the Swedish energy system is a long-term commitment* […] *its inert is not only a result of the time it takes to develop new technology but also of the existing infrastructure and investments been made in current technology, which needs to be written off before investing in new technology*".[7] Moreover, the proposition highlighted the situation of an energy system encompassing profit-driven large energy companies facing global competition. Thus, investing in renewable energy solutions only for the Swedish market was not a main priority for these companies in 2005. At this point, the Swedish government's main concern was to convince these actors that a decrease in energy production and embedding of new technology were necessities to be able to meet the social and environmental concerns of tomorrow. In 2016, five of the largest political parties in Sweden agreed upon the three foundation pillars of the Swedish energy policy[8] and from then on, the continuous development of the Swedish energy system should be characterized by a more

[4] Energiöverenskommelsen 2016 http://www.regeringen.se/498070/globalassets/regeringen/dokument/miljo--och-energidepartementet/energioverenskommelse-20160610.pdf
[5] RISE Research Institutes of Sweden, Energisystem http://www.sp.se/sv/index/research/energisystem/sidor/default.aspx
[6] Energimyndigheten, Energisystemet http://www.energimyndigheten.se/om-oss/press/energisystemet/
[7] Forskning och ny teknik för framtidens energisystem Prop. 2005/06:127
[8] Energiöverenskommelsen 2016 http://www.regeringen.se/498070/globalassets/regeringen/dokument/miljo--och-energidepartementet/energioverenskommelse-20160610.pdf

diverse production structure including both large scale and small scale renewable production units; adapted to both local and industrial needs.

Taking this policy shift into account, the number of new actors in the energy system is increasing and the power balance is changing. The policies, that previously were developed together with the large actors in the network (Negro et al., 2012), are now starting to be discussed on the local level including new types of stakeholders. Hence, it is now recognised that the transformation of the energy system into renewables requires involvement of a wide range of actors such as public organizations and private actors like municipalities, energy companies, vehicle manufacturers, real estate companies and grid operators, to name a few. Moreover, private non-profit actors such as households and associations are also taking part in the transformation[9]. One heterogeneous group of actors is the entrepreneurs who try to bring new technology and mind-sets related to renewable energy sources such as solar, water and wind. To illustrate the complexity of becoming part of the Swedish energy system (under transformation) one start-ups' journey is described below.

Swedish Algae Factory

Swedish Algae Factory (SAF) is a start-up in the cleantech industry that focuses on creating environmentally friendly waste water treatment combined with the production of organic biomass and nanoporous silica material. The start-up was founded in 2014 as a result of a project carried out by students at Chalmers School of Entrepreneurship. In 2012 two researchers from the University of Gothenburg (GU) found a special type of algae growing on polar ice, which has characteristics suitable for the Nordic climate with low temperatures and low light conditions. The researches brought the algae to the students at Chalmers School of Entrepreneurship, which together with the researchers started to explore different application areas that could be developed with regards to different parts of the algae. The vision at that time was, and still is today, to create a business model that includes a circular economic mindset and in which carbon dioxide, nitrogen and phosphorus are turned into valuable products and at the same also clean water in a sustainable way. In May 2017, SAF received the World Wildlife Fund's global award "Climate Solver 2017", emphasizing the huge climate benefit of introducing these kinds of products on a global market. The process of bringing new technology into the energy system has required SAF to work actively with different companies and research groups to develop the different application areas.

Embedding the algae into different energy related contexts

Since 2012 SAF has put effort and time to network and develop relationships with external partners to gain knowledge and support when exploring different application areas connected to the algae. When it comes to the application connected to the waste water treatment system SAF is working closely with GU and has already from the start used the university's facility to test and develop the application. Namely, in the botanical garden in Gothenburg there is a greenhouse where researchers measure how much nitrogen and phosphorus the algae can absorb from water. In 2016 the water used in the tests at GU was coming from a waste management company called Renova group, which saw an opportunity to develop an alternative way to clean its water. By teaming up in a project sponsored by Vinnova (Sweden's innovation Agency) SAF was able to use the water for free to test the absorption of the algae while at the same time evaluate if this could be a suitable way to clean water from the municipality. However, during the tests it became visible that the water from Renova contained a too unstable level of nutrition for the algae to be able to grow in a suitable rate. As a result, SAF turned to the fishing industry and the waste water coming from fish farms. During the new tests it became clear that this water has a constant flow of nutrition, compare to the water coming from the inhabitants in Gothenburg. This result was an important step towards the change from cultivating the algae in sweet water to using salt water instead. Furthermore, it was also the starting point for building a demonstration plant run today at a symbiosis center in Sotenäs.

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[9] Energimyndigheten, Vägval och utmaningar för energisystemet (2016) p. 75
https://www.energimyndigheten.se/globalassets/klimat--miljo/fyra-framtider/38764_vagval-och-utmaningar-for-energisystemet_webb.pdf

The second application area is connected to the biomass, encapsulated in the algae. Back in 2014, SAF joined a project together with Imperial College London and Preem, Sweden's largest fuel company with sales of petrol, diesel, fuel oil and lubricating oil. The aim of the project was to evaluate if the bio crude oil developed from the biomass could be used in Preem's facilities to produce diesel and plastics in a sustainable way. The results of the tests carried out at Imperial College showed a composition of the bio crude oil, which according to Preem needed to be modified to become useful in Preem's existing refining process. Consequently, SAF changed its production process at GU by adding an extra step that extracted the proteins in the bio-crude oil, thus lowering the nitrogen level. However, in the end Preem had no intention of continuing the R&D collaboration with SAF even though the results from the project were promising. The CEO of SAF expressed the following thought regarding the ended R&D collaboration: *"When I entered this project I was probably a bit naive and thought that of course everyone wants to invest in a renewable future, with SAF providing the renewable part and the oil companies seeing it as important. But I could see that they didn't want to take the risk."*

When it comes to the third application area it is connected to the silica shell surrounding the algae. Since the silica contains layers of nanopores with a very high strength-to-weight ratio, and which is both insulating and anti-reflecting, it opens up for different areas of use. In 2015, a company in France started to test the use of the silica in batteries. Unfortunately, the tests showed that the silica contained too much oxide, which had to be removed to make the silica useful in the batteries. Unfortunately, neither SAF nor the company could remove the oxide and there were no resources to find a third actor that could accomplish the removal. Instead focus was turned towards the solar cell industry and the fact that research has showed that the use of the silica shell on solar cells could increase the efficiency of energy production with 30 %. Today tests are conducted with a large chemical company to evaluate if the silica can be used in existing coating solutions to be sold to the solar panel producers. Instead of trying to add the silica as an extra step in the existing process at the solar panel producers, which may take several years, SAF saw the opportunity to integrate the silica already in the supplier's production process. Consequently, by teaming up with the chemical company SAF created a win-win situation. On one hand, the large chemical company was new to the solar panel industry and felt a need to prove its ability towards the solar panel producers by offering a coating solution with unique features. On the other hand, SAF could integrate its silica in an existing product and therefore avoid adding an extra process step in the solar panel production.

Developing relationships in a local cluster

The testing and development of the algae's different applications made SAF understand that to be able to sell products to companies, the production of the algae needs to be stable and scaled up into large quantities. Therefore, numerous discussions were held with a supplier of production equipment with the aim to develop an automated harvesting technique for a potential cultivation plant. However, the discussions terminated due to the contact persons' withdrawal. Instead, SAF turned its interest towards the upcoming industrial symbiosis cluster in Sotenäs. The idea of the symbiosis was to take the starting point in the resources connected to the ocean and the marine food industry and create a circular production of feed and biogas. Specifically, a number of smaller companies could use each other's waste in their own production facilities to create valuable products. In 2016, SAF built a small demonstration plant next to the company Rena Hav AB's fish farm. The plant, including the algae cultivation, consists of a number of shelves stacked on top of each other and was connected through a pump to the fish farm's water. This was a good opportunity for SAF to get water to measure the productivity of the algae and at the same time develop the harvesting technique together with a local actor called AH Automation.

By taking help from a master thesis student at Chalmers a project was initiated to scale up the production over time and hence evaluate the possibility to use 3000 m^2 on top of the fish farm for the algae cultivation. During the project it became clear that the cultivation needed to be connected to the fish water through a new pump. The algae will then clean the waste water from the farm while, at the same time, an evaluation can be made of the attractiveness of SAF as a water cleaning actor. Moreover, the strategy is to use the test plant as SAF's first commercial plant for silica production. The project resulted in a proposition that is planned to be operationalized in 2018. Today, 500 grams of silica per week can be harvested and sent to laboratories to evaluate for example the use of silica shell on solar cells. Furthermore, SAF's plan is to use the biomass of the algae in fish food to feed the fish at the fish farm and the bio crude oil to produce plastic. Hence, the results from the test with Preem will be of great use.

Comments on further research

To be able to capture the starting up process in the Swedish energy system, a first step would be to analyse the energy system as an industrial network with particular focus on the key resources and resource interfaces of relevance. By using a case study methodology and in detail analyse the resource interfaces between the algae and other relevant technical and organizational resources of concern for SAF to develop its products and relationships, it is possible to capture the process of becoming part of the energy system in a micro perspective. The case description reveals some part of the difficulties involved in embedding the algae into existing (and heavy) resource structures such as the ones controlled by Preem, Renova and the solar panel producers. These challenges open up for a need to find other ways to develop the different application areas for the algae. One way is to embed the algae into a more flexible resource constellation in the local context. By analysing the resource interfaces in detail, how they are developed in interaction between actors both within and outside the energy system and how they are connected, it is possible to start discussing the starting up process from a more general perspective in a macro perspective. Potentially start-ups will be added to the study to analyse the resource interfaces from various perspectives. Are there some resource interfaces that are more important than others for the start-ups to support the transformation from fossil fuels to renewable sources? Related, what business relationships are critical to become embedded in the energy system? The study thus aims to use the micro understanding of connected resource interfaces in order to increase the understanding of the energy system on a macro level. To conclude, if we assume that the formation of the future energy system will result from interaction among a great number of actors and connected resource interfaces, both new and established, longitudinal case studies will contribute insights along the process.

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