ELECTRICITY SUPPLY CHAIN ADAPTION TO DISTRIBUTED SOLAR PV SOURCES: ELECTRICITY SUPPLIERS AND PROSUMERS

SWEDEN CASE STUDY BASED ON UK FRAMEWORK

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Abstract

Background

The Paris Agreement has forced the European Parliament to set a target of 35% renewable energies by 2030. In Sweden, the adaptation of the electricity supply chain to renewable energy production has created new opportunities for the electricity supply chain member. New business models between prosumers and electricity suppliers are currently being developed while the whole management of the grid is evolving.

Problem formulation

Distributed solar PV facilities installed around the territory are increasing in Sweden. Therefore, the kWh injected into the grid coming from several solar PV sources is affecting the management of the electricity supply chain. This bi-directional electricity flow is challenging the grid in terms of capacity, stability, and efficiency. A description of which is the current situation and what to expect in the future is the main goal of this research project. The relationship between prosumers and electricity suppliers, the last players in the chain value, have to evolve into new business models if small-scale generation and flexibility market is to play a productive role in the future electricity supply chain.

Purpose

The purpose of this thesis is to analyze and describe how Swedish electricity suppliers are managing the bi-directional electricity flow generated by the increasing installation of distributed solar PV systems. The research project also intends to study which are the possible future business models (incentives, barriers, etc.) of the electricity supply chain between electricity suppliers and prosumers, using the UK framework.

Method

The research project follows a descriptive – exploratory approach, for achieving a description of the current Swedish electricity supply chain and a further prediction of business models. Therefore, a theoretical framework has been developed using a single case study research - based on the company *E.On* – to gain a deep knowledge of the topic within the research area. The insights in which the research project is built have a qualitative behavior. Seven interviews have been conducted to achieve a deep understanding of the Swedish electricity market from several stakeholder's points of view.

Conclusions

The capacity challenge the Swedish grid is currently having is being faced by reinforcing the grid and making it smarter. A smarter grid will enable the use of flexible tariffs to do better use of the electricity grid, by consuming when there is a high electricity volume circulating and producing when there is a lack of generation. Consequently, the increasing number of solar PV prosumers and the new European legislation has forced the Swedish electricity market to promote business models as the basic prosumer scheme and, at the same time, developing and testing new ones – energy communities. However, incentives for the integration of solar PV facilities to the electricity market play, and will play in the future, the main role for triggering new prosumers to invest.

Contribution

Nowadays, there is a lack of scientific papers and reports regarding business models development and how it will affect the electricity supply chain in terms of collaboration.

Therefore, this research project is a first attempt to contribute this scholar's knowledge of the electricity market from a supply chain point of view.

Keywords: *Electricity Supply Chain*, *smart grid*, *solar PV*, *Supply Chain Management*, C*lose-Loop Supply Chain*, *prosumer*, *case study*, *electricity supplier, business model, collaboration, incentives.*

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Glossary

CERE	Centre for Environmental and Resource Economics
CLSC	Close-Loop Supply Chain
CPS	Collaborative Performance System
CPT	Critical Peak Tariff
CSCMP	Council of Supply Chain Management Professionals
DSO	Distribution System Operators
E.DSO	European Distribution System Operators
EDR	Emergency Demand Response
Ei	Energy Markets Inspectorate
EREF	European Renewable Energy Federation
ESCM	Electricity Supply Chain Management
EU	European Union
FiP	Feed-in Premium
FiT	Feed-in Tariff
GC	Green certificates
GO	Guarantees of Origin
ICAP	Interruptible Capacity Program
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
IVA	Royal Swedish Academy of Engineering Sciences
JIT	Just-In-Time
JRC	Joint Research Centre
LEC	Local Energy Company
MRP	Manufacturing Resource Planning
OFGEM	Office of Gas and Electricity Markets
P2P	Peer-to-Peer
PTR	Peak Time Rebates
PV	Solar photovoltaic
PwC	Price waterhouse Coopers
RQ	Research Question
RTT	Real-Time Tariff
SCADA	Supervisory Control and Data Acquisition
SCM	Supply Chain Management
SERO	Swedish Renewable Energy Organization
ToUT	Time of Use Tariff
TSO	Transmission System Operator
UK	United Kingdom
UoS	Use of System
VEC	Virtual Energy Company

1 Introduction

This first chapter describes the reasons why the topic is relevant and introduces the main concepts of the thesis. It also describes the purpose, the research questions along with the limitations of the study. Furthermore, a brief explanation of the target group is considered. Lastly, a report outline is written, aiming to shortly describe each following chapter.

1.1 Background

The International Energy Agency (IEA) states in its 2019 report that the electricity demand is set to increase further as a result of rising household incomes, such as the electrification of transport or the increasing demand for digitally connected devices. According to 2018 data, the worldwide electricity final consumption was 22.315.397 GWh, increasing by almost 4% over the situation in 2017 (IEA, n.d.). In the IEA annual report from 2020, the solar photovoltaic (PV) share in global electricity generation is almost 3% in 2019, achieving the third position in the largest renewable sources, after hydropower and onshore wind (IEA, 2020).

In 2018, Sweden had a total electricity production of 168.443 GWh, of which almost a 20,92% was exported. Nowadays, half of the electricity generation comes from renewable sources. Despite the small contribution of the solar PV in the Swedish electricity mix, 0,28% in 2019 (IEA, n.d.), the continuous growth of its technology is not questionable, as Figure 1 describes.

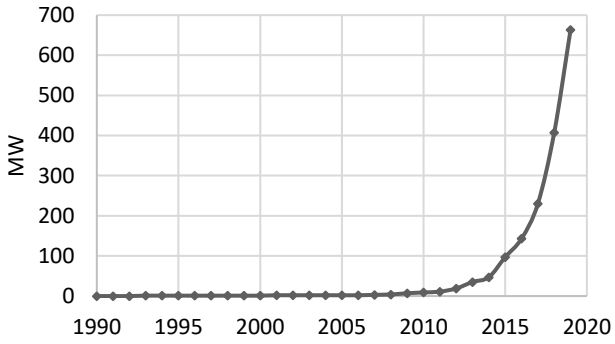


Figure 1: Solar PV electricity generation in Sweden (1990 - 2019) (IEA, n.d.).

IEA, in a recent report, explains that despite the good perspectives for this technology the Covid-19 crisis may lead to a slowdown in solar PV installations in the short-term, but long-term growth prospects remain strong (IEA, 2020). During the first half of 2020, the installation of solar PV has slowed due to the lockdowns in different countries and social distance restrictions, which have caused supply chain disruptions around the globe. As the IEA report remarks (IEA, 2020), the restrictions in mobility (closed borders) around the world caused an important reduction of energy demand and due to that a decreased consumption of renewable energies.

Nevertheless, the Paris Agreement, adopted during the climate conference in Paris 2015 (COP21), is the first universal and legally binding global climate change agreement. The aim is to define a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1,5°C (Europen Commission, n.d.). For being able to

comply with the agreement the European Parliament, in January 2018, vote for a target of 35% renewable energies by 2030 (Jäger-Xaldau, Huld, Bódis, & Szabo, 2018). In 2016, the majority of the Swedish parties voted that Sweden should have 100% renewable production by 2040 (Swedish Smartgrid). For being able to integrate renewable energy sources in the actual electricity grids, a higher level of supply chain collaboration between the different actors is needed.

As a result, a new concept of the electricity supply chain seems to earn more importance in the world today, especially in Europe, the United States, and Japan (IEA, 2020): distributed solar PV systems (GD2 and GD3 in Figure 2). The distributed generation may be a single structure in a private house, making the consumer evolve from a static position of receiving electricity from the grid, to be part of the electricity generation. This new role is known as prosumer, a concatenation of producer and consumer. As a result, the electricity supply chain is evolving from the traditional picture to the known as smart grids. Thus, the goal is to achieve an electricity supply chain more efficient in transport by reducing the losses during transportation and distribution, as well as improve its security. Thus, they are less sensitive to the uncertain availability of remote primary energy and transportation networks (Bouffard & S. Kirschen, 2008). One of the greatest challenges of distributed electricity generation is the bi-directional power flow: the consumers (C2* and C3* in Figure 2) might also inject electricity into the distribution or local grid (D in Figure 2). The traditional grid has a clear separation between producers (G1, G2, and G3 in Figure 2) on the one side and consumers (C1, C2, and C3 in Figure 2) on the other side, resulting in a uni-directional power flow. Thus, the supply chain management (SCM) earns importance to be able to adapt to this traditional electricity supply chain to the evolving electricity context (Halldórsson & Svanberg, 2013).

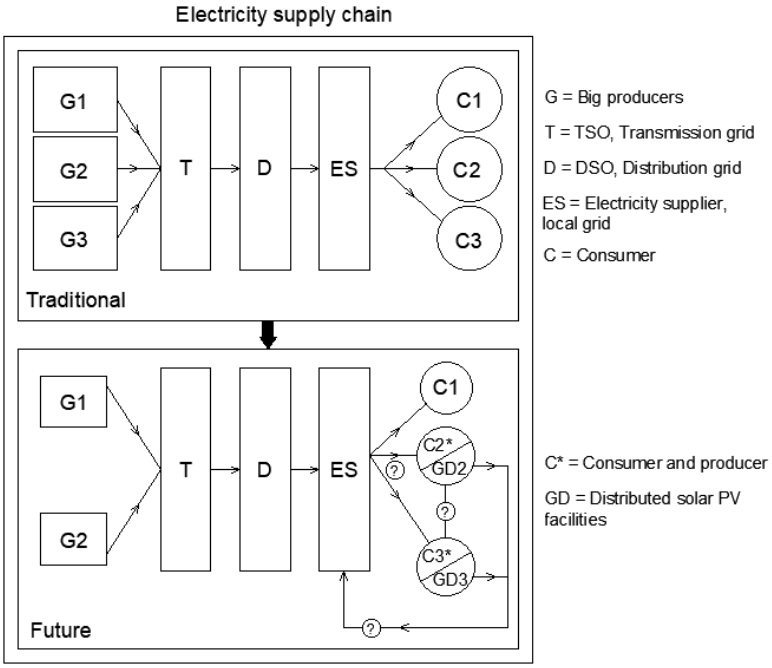


Figure 2: Scheme of traditional and future electricity supply chains.

This new type of electricity grids leads to the concept of a smart grid, which sets out different innovative solutions to monitor and control the network to be able to manage the bi-directional local supply and demand more efficiently (Gasparin, 2013). Smart grids trigger a new level of

customer engagement, as one of the most important driving forces (see chapter *2.3.1 Main drivers behind smart grids*). Hence, with the current increasing demand of distributed generation, business models are evolving in being more focused on the customers and more relaying in customer interactivity (PwC, 2016).

The European Distribution System Operators (E.DSO, 2020), the key interface between the leading electricity Distribution System Operators, DSO (D in Figure 2), and the European institutions and stakeholders, remarks that consumers (or prosumers) are not only valuable for being active in the supply side but also playing an important role into changing the energy system into a more flexible one, adjusting demand patterns to system needs. It is important to remark that there are some DSO who also plays the role of an electricity supplier (ES in Figure 2). These electricity supply, or retail, companies offer electricity contracts to end-consumers. However, despite the initial enthusiastic response to smart grid technology, the investment in this technology represents a small share of the investments in network infrastructure (IEA, 2020).

The adaptation of the electricity supply chain to renewable energy production has created new opportunities for electricity supplier companies all over the world. Therefore, the relationship between prosumers and electricity suppliers have to evolve into new business models if small-scale generation and demand response is to play a productive role in the new electricity supply chain. Due to its complexity, the countries are continuously looking to how their neighbor's countries integrate this new kind of electricity production with the aim of learning and adapting experiences to their needs (Karnouskos, 2011). The United Kingdom (UK) is one of the fastest countries to decarbonate the electricity supply, so this has triggered new business models to accomplish the new market requirements (Brown, Hall, & E. Davis, 2019). Hence, the Swedish Smart Grid Forum in January 2019 analyzed the UK electricity market to help the Swedish electricity supplier companies who want to invest in this market (Swedish SmartGrid, 2019). Therefore, the UK electricity supply chain can be an inspiration for Sweden.

Nowadays, self-consumption generation might be more attractive, from an economic point of view, than buying electricity from the grid. Hence, conventional energy demand is decreasing, so the electricity suppliers have to purchase less electricity from the network. This current scenario reduces the revenue the network operator receives to pay for a fixed cost. As a result, the bills the customer receives are increasing each year (IRENA, 2019). Therefore, the need for new business models, due to the smart grid innovation, aligned with different incentives and tariffs becomes a priority in the electricity sector.

1.2 Purpose

The purpose of this thesis is to analyze and describe how Swedish electricity suppliers are managing the bi-directional electricity flow generated by the increasing installation of distributed solar PV systems. The research project also intends to study which are the possible future business models (incentives, barriers, etc.) of the electricity supply chain between electricity suppliers and prosumers, using the UK framework[1].

[1] The UK framework is detailed in *2 Context of the electricity market*.

1.3 Research questions

Based on the purpose of the thesis, the following research questions are formulated:

> **RQ1**: How are Swedish electricity suppliers using smart grids for managing the bi-directional electricity flow coming from different prosumers and their solar PV plants?
>
> **RQ2**: How are the business models of the electricity supply chain between electricity suppliers and prosumers that Sweden can expect, and which are their incentives, barriers, etc.?

1.4 Focus and delimitations

This thesis aims to describe the current use of the smart grid when managing the bi-directional electricity flow in Sweden. So, any other country is out of the scope.

The thesis only focuses on one type of renewable source that is earning more importance year by year: solar PV power, specifically the distributed solar PV plants connected in the Swedish grid. So, it is out of scope to study other solar technologies (solar thermal power) as well as off-grid solar PV plants. Further, the research project will not examine whether the actual renewable plants can supply enough energy for being able to dismantle the traditional plants.

The electricity supply chain is very extensive, so the focus will be on the relation between electricity suppliers (who are also DSO) and prosumers, without analyzing the generation and transmission part of the chain.

When analyzing the different incentives and demand response methods in the current electricity market (*3.3.4.1 Incentives in the electricity market*), the thesis will only consider the price based approach, where the prosumer is free to change its consumption according to real-time data.

1.5 Target group

Three main groups have been identified as being interested in this thesis. The first group is the prosumers, aiming to describe which role they can play in the electricity supply chain in the short-term future. Nowadays, some consumers aiming to install solar PV plants do not know which future to expect and whether the investment is worth it or not. Thus, a description of the current and future incentives and tariffs in the electricity market is done, trying to clarify what prosumers expect.

The second group would be the Swedish electricity suppliers who can be interested in this thesis to know which future they might expect according to what neighboring countries have done. Hence, they can anticipate new incentives or tariffs for being able to benefit the business model they prefer the most.

At last, the third group is the supply chain scholars, since the research project is focusing on a new, and growing, relationship in the electricity supply chain, as well as the implementation of smart grids to help with electricity management.

1.6 Report outline

Chapter 1 Introduction

The introduction chapter gives the background, purpose, the two research questions, focus, and delimitations of this research project. The chapter also describes the target group interested in this thesis.

Chapter 2 Context of the electricity market

In this second chapter, a detailed overview of the Swedish electricity market is described. The chapter also presents a solar PV definition, followed by a description of the "smart grid" concept. Finally, there is the prosumer's description together with the support policies, incentives, and business models – based on the UK framework – they can have.

Chapter 3 Theory

This chapter gives an overview of the theoretical framework used in this thesis. Firstly, a literature study regarding Supply Chain Management and how is it considered in the electricity field. Secondly, the concept of the Close-Loop Supply Chain and its application for the bi-directional flow management. Lastly, a literature study of collaboration theory, focusing on incentive alignment.

Chapter 4 Methodology and method

The methodological framework is presented with a description of the research methodology and approach followed by its design, the data collection method, and its further analysis. Besides, an investigation model is designed as a baseline followed in the posterior chapters. Finally, there is a description of trustworthiness and which actions have been taken to ensure it along with the research project.

Chapter 5 Empirical study

This chapter states the information gathered during the data collection phase, following the investigation model structure.

Chapter 6 Analysis

This chapter presents the analysis of the project. The findings of chapter 5 and their connection to the theoretical framework are argued and developed, following the investigation model as a baseline.

Chapter 7 Conclusions

The conclusions of the research project are presented in this chapter. Firstly, there is a brief description of the steps followed to achieve the purpose of the thesis. Followed by the discussion of the research questions, a suggestion of future research projects, and the contributions the research project has done.

2 Context of the electricity market

This chapter provides an overview of the electricity market in Sweden: main players, shared market, and other relevant data used as a context in the thesis. A definition of solar photovoltaic (PV) technology, as well as a description of the current situation in this field, is also undertaken. An overview of the smart grid technology is presented as an innovation in the electricity supply chain. A description of the technology, the main drivers, and the smart grid framework in Sweden is given. Finally, there is the section Prosumers, presenting the subsidies currently existing in Sweden as well as the different business models, according to the information gathered from the UK electricity market.

2.1 Electricity Supply Chain in Sweden

The Swedish electricity network is made up of 564.000 km of power cables, which can be divided into three levels depending on the voltage (Swedish Smartgrid, n.d.). The national or transmission grid is a network of lines and stations with two different voltages, 220 kV and 400 kV, which connect the power plants to the regional grid. It is owned, administered, and operated by *Svenska Kraftnät*, a Swedish public utility company (Wangel, 2015). Thus, *Svenska Kraftnät* is the Swedish Transmission System Operator (TSO). The regional grid, usually 40 – 130 kV, connects the national grid to end-consumers, the majority-owned by *E.On Distribution*, *Vattenfall Distribution,* and *Ellevio* (Swedish Smartgrid, n.d.). These companies are known as Distribution System Operators (DSO).

Since November 2011 Sweden is divided into four bidding zones: SE1, SE2, SE3, and SE4 (see Figure 3). *Svenska Kraftnät* realized that the northern part of the country had a surplus of electricity generation, while the highest electricity demand was in the south. Hence, there were problems with the transmission capacity throughout the country. Thus, the bidding areas, established according to the location of the congestions in the national grid, were drawn to detect where the national grid has to be expanded and to know in which area there is the need to have more electricity generation to meet the consumption (Swedish Energy Agency, 2018). The four main players in the national grid can operate in more than one zone, as Figure 3 describes.

Figure 3: Swedish bidding areas (SE1, SE2, SE3, SE4) (Nord Pool, n.d.).

At the end of the electricity supply chain, there is the distribution or local grid, which connects to the regional grid and transforms the electricity to low voltage, 400/230 V. These are owned not only by the state, municipalities, and private companies but also by economic associations.

The electricity market in Sweden was deregulated in 1996, making customers free to decide from who they want to purchase the electricity, between one of the 120 different electricity suppliers (represented as triangles in Figure 4). The electrical suppliers play the role of traders by buying electricity from producers, via the electricity market (Nord Pool AS), or from other traders. Further a small portion of them buy directly from the electricity generators (Swedish Smartgrid, n.d.) (Svenska Kraftnät, 2017). In Figure 4 the electricity market is drawn as a discontinuous line. Some co-owned electricity trading companies have merged and formed a joint trading company, usually owned by municipal organisms (Swedish Smartgrid, n.d.). The Nord Pool AS is the wholesale electricity of the Nordic countries, owned by the TSOs, which each hour of the day establishes a common system price and area prices according to bids in the Day-Ahead market (THEMA Consulting Group, 2019). The Swedish retail market is dominated by three electricity supply companies (52% of all customers): *Vattenfall*, *Fortum*, and *E.On* (Swedish Energy Agency, 2018).

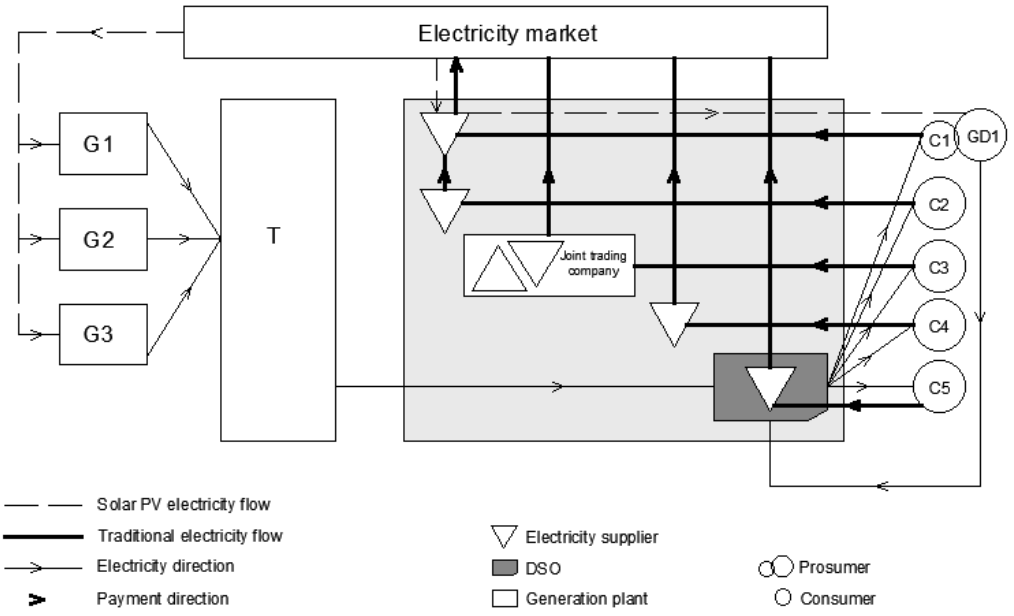


Figure 4: Swedish electricity market scheme.

The electricity suppliers have the responsibility to supply as much electricity as their consumers demand, hence they have to plan their sales based on a forecast of consumption. Thus, the electricity prices depend directly on consumption at a particular time. When there is a high demand the power plants have to produce otherwise the price rises (Svenska Kraftnät, 2017).

According to the Swedish Electricity Act, there must be a company responsible for the balance of the electricity system, which in Sweden is *Svenska Kraftnät*. If the electricity production does not match with the electricity consumption the responsible company has to ensure the balance within the minimum time. For being able to optimize the restore balancing time the TSO contracts different energy producers to provide backup (Swedish Smartgrid, n.d.). In Sweden, the weather has an important role in the amount of electricity produced, due to a high percentage of renewable sources (50%, quoted in *1.1 Background*), and consumed, especially during winter (Svenska Kraftnät, 2017).

The Swedish electrical market is connected with adjacent markets through the transmission network. The main connections are Norway (4000 MW), Finland (2700 MW), and Denmark (2000 MW). Nevertheless, there are more connections to neighboring countries, such as Germany (600 MW) through the Baltic Cable, Lithuania (700 MW), and Poland (600 MW) (THEMA Consulting Group, 2019).

2.2 Solar power

Solar energy can be transformed into electricity by two different technologies: solar thermal system or solar photovoltaic (PV) system.

2.2.1 Solar thermal technology

Solar thermal technology is used for heating water or other fluids to a high temperature to generate electricity with the steam produced. The collectors can be both flat or parabolic concentrating sunlight utilizing mirrors and lenses. According to IEA, Sweden does not have electricity generated by solar thermal technology. Thus, this technology is out of the scope due to the low impact on the Swedish electricity mix.

2.2.2 Solar photovoltaic technology

Solar photovoltaic (PV) technology is made of a PV cell, which is a nonmechanical device that converts sunlight directly into electricity. It can be connected in a package known as a panel, thus the more PV modules connected determine the total amount of electricity the array can generate. Therefore, the electricity generated can be injected into the grid, on-grid solution, or saved in a battery, off-grid solution.

The off-grid market in Sweden, according to the Swedish Agency of Energy, has been stable since 2006, having almost all of the installations in holiday cottages, marine applications, and caravans.

Since 2007 the on-grid installation systems have increased, according to the study made by the Swedish Agency of Energy in 2018, the total grid-connected distributed solar PV capacity incremented by more than 263% between 2015 to 2018 (see Figure 5). As Figure 6 describes, most of these on-grid installations (47%) are in commercial facilities, followed by the self-consumption solar PV plants on single-family houses (33%). At last, with 20% impact, there are the installations in multi-family houses, public and cultural buildings, and industrial facilities.

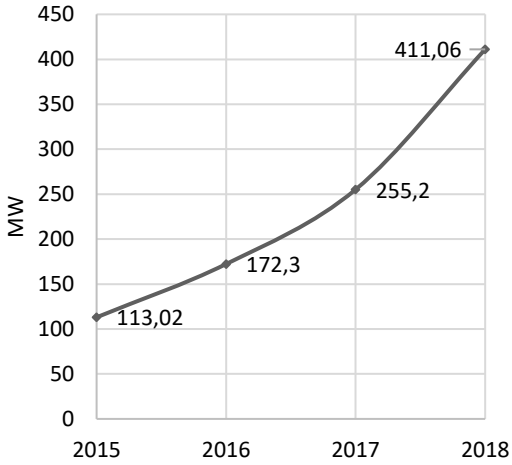


Figure 5: Grid-connected distributed PV (2015 - 2018) in Sweden (Swedish Energy Agency, 2018).

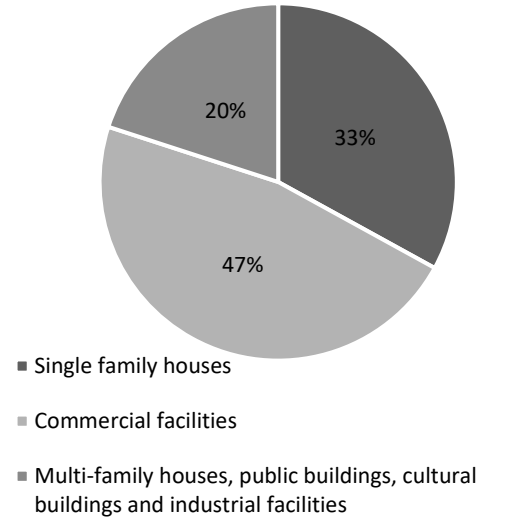


Figure 6: Type of grid-connected PV facilities in Sweden (Swedish Energy Agency, 2018).

This increasing number of solar PV installations connected to the local grid, apart from the other on-grid renewable power systems such as wind power, requires a capacity reinforcement of the network. According to Sweden's future electricity grid report (IVA, 2017), the main investments on the grid will be in the ones approaching the age of 50, in regions with strong population growth, or with an increasing electricity generation capacity. However, smart grids might play an important role in future electrical grid development, as is described in chapter *2.3 Smart grid*.

2.3 Smart grid

The traditional electricity grid is constituted by a centralized generation plant from where the power was pushed one-way through the power – national, regional, and local – grid to the end-consumers (Gelazanskas & Gamage, 2014). Currently, there are new market requirements such as distributed renewable generation or energy storage and charging of electric vehicles that are challenging the network capacity, stability, and efficiency.

The technological advancements in communications and sensing areas have enabled the development of smart grids. The European Technology Platform gives a definition: "*A smart grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both in order to efficiently deliver sustainable, economic and secure electricity supplies*" (Gelazanskas & Gamage, 2014, p. 22). Thus, as the European Commission remarks, the progressive development of this technology is shifting the energy supply industry, from being infrastructure-driven to being more service-driven (European Commission, 2020).

As a result, small distributed electricity generators can be integrated into the local grid through a metering system. If it is coupled, it is possible to have real-time consumption information, relevant for suppliers and consumers to automatically monitor energy flows and adjust to changes in energy supply and demand accordingly (Gasparin, 2013; European Commission, 2020). Hence, there is a new communications layer for information and control that increases electricity flexibility using the load in the closest local grid where the power load is high. Thus,

more electricity coming from the electricity market will be used when the price is low and less when the price established is high (IVA, 2017).

2.3.1 Main drivers behind smart grids

The key inputs that drive the development of smart grids are capacity, efficiency, reliability, sustainability, and customer engagement (Gelazanskas & Gamage, 2014).

In most developed countries the electrical network is being challenged due to the new demands of the electrical market, such as electrical vehicles. Nowadays, the concept that the grid has to have enough capacity to deal with the uncertainty in generation earns more importance with the increasing use of renewable sources. AFRYs consultancy remarks that in 2018 the Swedish grid capacity needed 16 GW of new connections. However, the information which smart grids can give can lead to better supply management and, as a consequence, less investment in upgrading the grid by focusing on improving the use of the existing one (Bagemihl, Boesner, & Riesinger, 2018; IVA, 2017).

Efficiency is directly related to losses in the system. As a result of smart grid implementation, consumers/suppliers will be able to have information about the current load of the grid and react to reach the balance and increase efficiency (Gelazanskas & Gamage, 2014).

Today's society is completely dependent on electricity, so the distribution system has to avoid system failures that might lead to outages. Thus, high delivery reliability occurs when the electrical grid delivers electricity when it is supposed to and with the minimum number of outages (IVA, 2017). Smart grids include a Supervisory Control and Data Acquisition (SCADA) which provides enough information to prevent accidents or to react to possible accidents faster, ensuring reliability, safety, and security of the network (IVA, 2017; Sayed & A. Gabbar, 2017).

The smart grid also aims to increase sustainability. This technology was developed due to the need to connect renewable generation into the grid. The main purpose is to know how this generation is managed to meet the demand (Gelazanskas & Gamage, 2014). The European Commission defines high sustainability at low cost as one of the goals of smart grids (Gasparin, 2013).

2.3.2 Smart grid in Sweden

In 2016 the Swedish government created a smart grid forum with 28 members representing both business and government players. This forum aimed to bring to the table the opportunities that the smart grid could deliver to the Swedish grid from 2016 to 2019. Since January 2020, the Swedish Energy Agency and the Swedish Energy Markets Inspectorate are continuing the work (Swedish Smartgrid, n.d.).

As it is cited in previous chapters, 1.1 Background, the Swedish electrical generation should be 100% from renewable sources by 2040. Therefore, the need for flexibility of the grid is also at the forefront in Sweden. However, last 2018 *Forumet* did a study in which remarks that it is impossible to know how much flexibility is needed, thus the players in the electricity supply chain will have an important role in the future development (Rydén, et al., 2018).

2.4 Prosumers

Brown, et al. (p. 2, 2019) define a prosumer as a "*household, commercial or industrial who produce, self-consume and modulate their consumption of renewable energy*". This actor in the supply chain has enabled the growth of the distributed solar PV installation system and the development of new business models. Prosumers are considered key actors when overcoming the challenges of renewable electricity systems as small-scale generation and demand response is to play a productive role in the value chain (Brown, Hall, & E. Davis, 2019). Hence, a prosumer marketplace leads to a more complex electricity market because it involves multi-agent systems that include several types of service, a wide variety of participant groups, and a different number of providers for each presumption service (Parag & Sovacool, 2016).

The following sections introduce the main support policies considered in the Swedish market, the concepts of demand response as well as business models between prosumers and electricity suppliers.

2.4.1 Support policies and incentives

The Swedish solar PV market has been increasing significantly since 2015, as Figure 5 illustrates. However, according to the national survey made by the Swedish Energy Agency in 2018, the prices of PV systems in Sweden have maintained almost constant for the last few years.

When analyzing the UK solar PV market, it has been seen that the high number of new solar PV prosumers in the UK is directly related to the Feed-in Tariff (FiT) the electricity suppliers pay. FiT is a fixed tariff for both generation and export from distributed installations, independently from the electricity market price (ECOFYS, 2014). The UK government introduced the FiT in April 2010 and 2018 decided to close this scheme to new applicants from April 2019[2] (OFGEM, 2020). This situation has enabled the necessity to change the prosumer's business models to keep distributed generation and demand response as a key element in the electricity supply chain (Brown, et al., 2019).

However, Sweden has never had a FiT. The solar PV distributed market has been promoted by capital subsidies in combination with different types of schemes that add value for the excess of electricity (Swedish Energy Agency, 2018), as it is explained in Table 1.

On-going measures in Sweden, 2018

Feed-in Premium (FiP)	The FiP gives 0,60 SEK/kWh for overproduction up to a maximum of 30,000 kWh/year (Swedish Tax Agency, n.d.). In this scheme, the electricity is sold on the electricity spot market (Nord Pool) and producers receive a premium on top of other compensations for the excess electricity, the main difference between FiP and FiT. There are two limitations: (1) The systems cannot export more electricity than what is purchased over the year. (2) The main fuse must be under 100 A (Swedish Energy Agency, 2018). A particular FiP for the excess electricity can be known as an income tax credit. There is an extra restriction: The DSO has to be notified that renewable energy is being produced at the connection point. As for the FiP, the prosumer cannot receive more incomes per kWh than the number of kWh bought within the same

[2] Due to COVID-19, there is a 12-month extension (OFGEM, 2020).

	year. The income tax credit is received on top of other compensations for the excess electricity. Unlike other European countries, the Swedish tax credits do not offer a constant income over some time, it can increase or decrease according to political decisions (Swedish Energy Agency, 2018).
Capital subsidies	Capital subsidies reduce the investment cost of a PV installation. The first capital subsidy for solar PV plants was introduced in 2006. After some modifications, since 2019, the maximum coverage of the installation costs is 20%, without distinguishing between the final customers. If the system costs exceed 1.2 million SEK, the capital subsidy only covers the part of the cost that is less than this amount of money (Swedish Energy Agency, 2018).
Green certificates (GC)	The electricity certificate system was introduced in 2003 to increase the use of renewable electricity by defining the minimum quantity of renewable electricity that has to be generated by a certain date. The government bill 2005/06:154 notes that producers who use renewable energy sources receive an electricity certificate for every MWh produced. If the producer sells this certificate to any electricity supplier it receives an income for it (Ministry of Sustainable Development, 2006). Thus, the sale of this certificate is an extra income apart from the revenues from electricity sales (Swedish Energy Agency, 2018). Green certificates are issued and traded in compliance markets due to governmental policies that require the electricity supplier to have a certain percentage of renewable production in their supply portfolio (KYOS, n.d.). The Swedish Energy Agency (2018) notes that green certificates do not provide significant support to increase smaller solar PV installations due to two main reasons: (1) The smart meter placed is usually installed at the interface between the building and the grid. This means that it only counts the excess production injected into the grid, not the electricity produced and consumed by the prosumer. If the prosumer wants to consider the self-consumed electricity has to install an internal smart meter. Hence, the additional cost that has to be considered might be higher than the revenue received from the green certificates. (2) For a residential prosumer, selling a low number of green certificates can be difficult. However, since 2011 more electricity suppliers buy green certificates from small solar PV installations.
Guarantees of Origin (GO)	In 2010, Sweden introduced the GO. It is an electronic document from the Government that guarantees the origin of electricity for each MWh of electricity production. As the GC, the GO enables the traceability of green energy from the generation point to the end-consumer. Therefore, the prosumer can sell GOs on an open market, usually bought by an electricity supplier who wants to sell energy from a renewable source. The main difference between GC and GO is that the second ones can be issued independently from governmental policies and they apply to any kind of electricity source, not only renewable sources. (Swedish Energy Agency, 2018; KYOS, n.d.)
Grid compensation	Prosumers who feed electricity into the grid are entitled to earn compensation for the offset of losses saved by the grid owner. According to the Swedish Energy Agency (2018), the compensation corresponds to the value of the energy losses reduction in the grid that the excess electricity entails. The compensation varies depending on the grid owner and the grid area.

Self-consumption	The prosumers have special taxation rules when it comes to taxation on self-consumed electricity. A prosumer with a total power of the PV installation less than 255 kW is exempt from any energy tax for the self-consumed electricity (Swedish Energy Agency, 2018). Hence, solar PV installations larger than 255 kW are not common in Sweden.

Table 1: Solar PV subsidies for residential installations.

The Swedish Energy Agency (2018) remarks that since 2011 the electricity suppliers who buy the excess electricity produced by the prosumers, the green certificates, and the GOs are increasing every year. However, each supplier has the freedom to compensate its clients most conveniently: to buy the electricity excess or maybe only the green certificate.

2.4.2 Prosumers business models in the UK

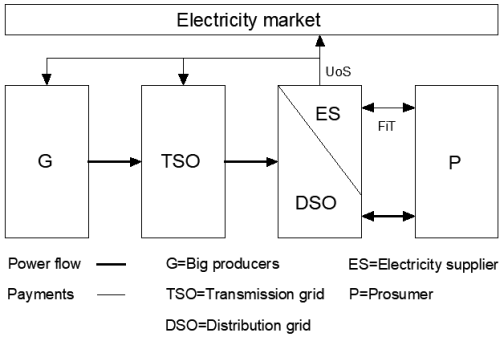
The UK is the world-leading in grid decarbonization and the perfect environment to trigger the development of new businesses that fulfill the requirements of the market, as is explained in chapter *1.1 Background* of this thesis. Like Sweden, the UK believes smart grids are the solution to be able to achieve an electricity supply chain with less carbon, more efficient, and more reliable (Swedish SmartGrid, 2019).

Therefore, Table 2 explores the state-of-the-art of some of the business models currently being developed in the UK (Brown, et al., 2019; Regen, 2018). The different business models differ from each other in two different aspects: the relationship between the prosumers and the electricity supplier and the relationship between the prosumers themselves.

According to Brown, et al. (2019), the prosumer phenomenon has to adapt to having fewer subsidies. So, "*the prosumer business model needs to evolve if small-scale generation and demand response is to play a productive role alongside heat and transport electrification*" (Brown, et al., 2019, p. 2). With demand response taking an important role in the electricity value chain, the variety of business models have to take into account possible tariffs (for the different tariffs definitions see section *3.3.4.1 Incentives in the electricity market*). (Brown, et al., 2019)

Thus, the tariffs associated with each business model are presented in Table 2, in agreement with Brown, et al. (2019) and Regen (2018).

Basic prosumer

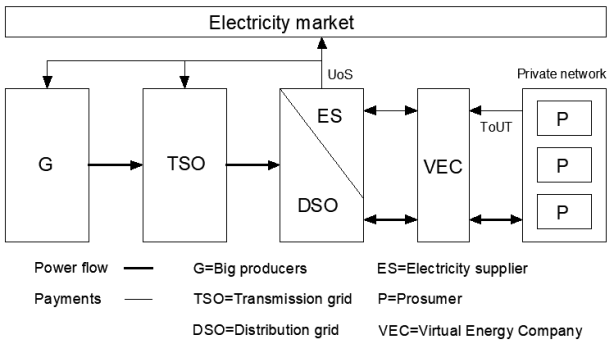


Description

The basic prosumers model involves distributed renewable generation, wind (not in the scope of this thesis), or solar PV. Thus, the prosumer can self-consume the electricity generated at the moment of the generation. The existing electricity surplus is injected into the grid. In the UK, from 2010 until May 2019, the distributed generators that injected the electricity surplus to the grid received an export tariff lower than the price of grid electricity, triggering the new prosumers to invest in this electricity generation. This business model does not allow the prosumer to interact with the up-stream players behind electricity suppliers. Therefore, the prosumer does not take part in the balancing between supply and demand, DSO functions.

Tariff: Feed-in Tariff (FiT)

Private wire or micro-grid

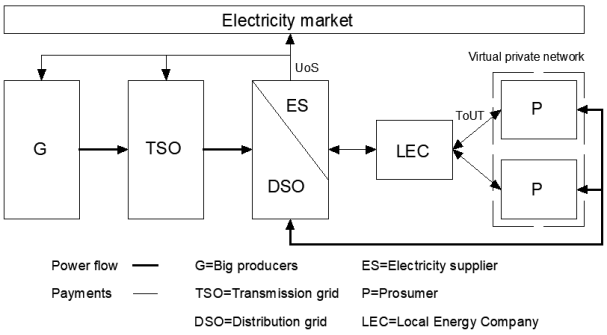


Description

The typical business model for isolated areas. There is a local private network operator, different than the DSO, who owns and is responsible for the low-voltage grid of the area. It can be that these private operators form a Virtual Energy Company (VEC) intending to bill the customers (who, at the same time are producers) for their electricity consumption within the private network. Even though this business archetype is commonly used in remote areas, sometimes it can also be seen inside connected areas to create viable business models for prosumers. However, the problems arise when the network between meter points is owned by the DSO. Moreover, the role of the DSO is to improve import and export tariffs.

Tariff: The VEC can incentivize optimal consumption by using the Time of Use Tariff (ToUT) during the high generation periods. The private operators can also reduce Use of System (UoS) costs because the grid might not be owned by the DSO.

Local Energy Company

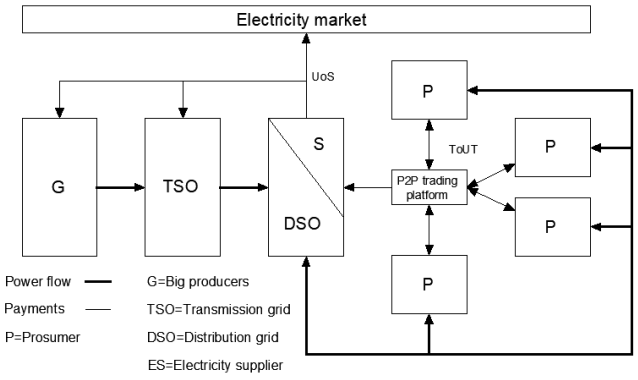


Description

A Local Energy Company (LEC) retains the energy produced within an area and shares it between all customers shaping a virtual private network. LECs can offer a local tariff to the prosumers that are part of the network. However, the balancing and settlement of the production/demand are done by the electricity suppliers. The electricity suppliers provide the customers with smart meters to be able to measure real-time consumption. Therefore, the distribution grid used to connect all the distributed generation points is owned by the DSO. Thus, LECs provide a virtual link between local generation and consumption and provide to the prosumers an improved price for the export-import of electricity.

Tariff: The local tariff can be static or dynamic ToUT. The dynamic ToUT responds to when both the generation and demand customers are active.

Peer-to-Peer (P2P)



Description

The Peer-to-Peer (P2P) business model uses a trading platform to trade electricity between the different prosumers involved in the network, replacing the role of the electricity suppliers. Therefore, P2P enables generators to set the price for their electricity and consumers to choose the generators that they want to buy from. The consumers still have to pay for the distribution grid management service, UoS. However, nowadays the UK market establishes that the local energy companies have to sign a contract with an electricity supplier to let them balance the system (supply and demand) with their local grid.

Tariff: ToUT pricing method is used to incentivize consumption when the electricity generation is local.

Table 2: Business archetypes definitions according to the UK experience (Brown, et al., 2019; Regen, 2018; Parag & Sovacool, 2016). Business models schemes adapted from Brown et al. (2019).

3 Theory

In this chapter, the theoretical framework of the literature review is presented in three divided parts, according to the research questions theory needs. The first section describes the Supply Chain Management (SCM) theory, focusing on the electricity field (ESCM). This ESCM theory leads to the concept of a Close-Loop Supply Chain (CLSC), also described in this chapter. At last, an overview of incentive alignments implementation is given as a key factor for successful implementation of SCM.

3.1 Supply Chain Management

In this chapter, there is an overview of the literature regarding supply chain management (SCM). Even though the term SCM is from 1982 (Salvi, 2020), there are still several definitions depending on the author, leading to some confusion about its meaning. For being able to clarify this ambiguity, Mentzer, et al. (2001) did exhaustive research looking for an accurate SCM definition. The statements, as well as the authors, are presented in the following Table 3.

	Statement	**Authors**
Management philosophy	*Systems approach to viewing the supply chain as a single entity.*	Ellram & Cooper, 1990; Houlihan, 1988; Tyndall, et al., 1998.
	The primary objective is to integrate and manage the sourcing, flow, and control of materials (or electricity) *using a total systems perspective across multiple functions and multiple tiers of suppliers.*	Monczka, et al., 1998.
	Concept of partnerships into a multi-firm effort to manage the total flow of goods from the supplier to the ultimate customer.	Ellram, 1990; Jones & Riley, 1985.
	SCM is a set of beliefs that each firm in the supply chain, directly and indirectly, affects the performance of all the other supply chain members, as well as ultimate, overall supply chain performance.	Cooper, et al., 1997.
	SCM is the integration of key business processes from end-user through original suppliers that provides products, services, and information that add value for customers and other stakeholders	Lambert, 2008.
	SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with (…) suppliers, intermediaries, third-party service providers, and customers. In essence, SCM integrates supply and demand management within and across companies	Council of Supply Chain Management Professionals, (CSCMP), 2018.

	The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and businesses within the supply chain, improve the long-term performance of the individual companies and the supply chain as a whole.	Mentzer, et al., 2001.

Table 3: SCM definitions according to management philosophy.

The SCM philosophy drives the supply chain players to view the supply chain as a whole to involve planning and management of material, electricity, etc. flow from the first supplier inventory to the end-consumer. The aim of SCM theory is to integrate all business processes for being able to add the maximum value for customers and stakeholders. Thus, there is the need to synchronize operation and strategic capabilities between intrafirm and interfirm players for being able to work as a single entity.

This thesis is focused on a particular area of SCM: Electricity Supply Chain Management (ESCM). The first research question aims to describe how electricity suppliers are managing the bi-directional electricity flow coming from solar PV prosumers. Figure 7 shows the common point between ESCM, the electricity suppliers as a part of the electricity supply chain, and solar PV as a form of distributed generation.

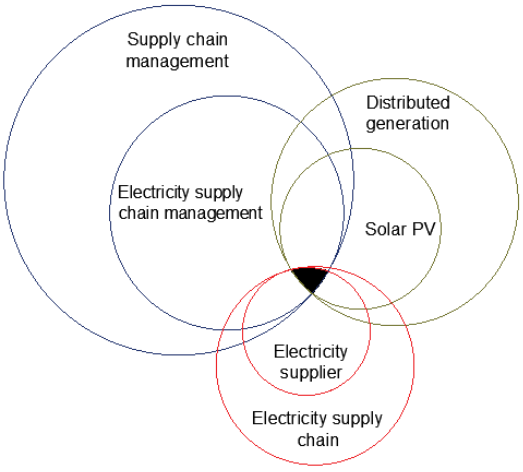


Figure 7: Scheme remarking the unit of analysis, painted in black.

Figure 7 also shows that ESCM has a common area with the whole electricity supply chain. In electricity supply chains, as Figure 8 describes, there are generators of raw materials and their suppliers, generators or also known as energy conversion, the transmitter (wholesaler), the distributor (retailer or utility), and at last the end-consumers (Salvi, 2020; Mentzer, et al., 2001).

3.1.1 Supply Chain Strategies

One of the most important goals of the SCM is to design a supply chain that serves customers effectively and efficiently. However, the supply chain strategy has to be chosen under the type of product (Fisher, 1997).

Fisher (1997) argues that products can be divided into two types, either functional or innovative. The following Table 4 gives the main characteristics of both product types.

	Functional products	**Innovative products**
Life cycle	Low	Short
Variety	Low	High
Volume	High	Low
Demand	Stable / Predictable	Volatile / Unpredictable
Production driver	Forecast	Demand / customer-order
Production control	JIT / Kanban [3]	MRP[4]
Average stock out rate	Lower	Higher

Table 4: Functional and innovative products. Salvi (2020) adaptation.

According to Salvi (2020), electricity is more of a functional product rather than an innovative product. Even though there is no stock after the electricity generation process, so it has no JIT and Kanban methods, the electricity supply chain has a regulation government entity looking for the whole chain equilibrium. The same author also announces three more reasons why this product can be considered functional: high-volume delivery, predictable demand, minimization of the blackouts (analogous to have a small average stock-out).

The supply chain can be classified into four different types: (1) Efficient, (2) Risk-hedging, (3) Responsive, and (5) Agile (see Table 5).

		Demand uncertainty	
		Low (*functional product*)	High (*innovative product*)
Supply uncertainty	Low (*stable process*)	(1) Efficient	(3) Responsive
	High (*evolving process*)	(2) Risk- hedging	(4) Agile

Table 5: Uncertainty and SC types (Birhanu, Lanka, & Rao, 2014).

When the supply uncertainty is low, the supply chain strategy can be efficient or responsive. An efficient strategy can be applied when the demand is predictable aiming to have the lowest possible cost by eliminating the non-value-added activities. Nevertheless, the goal of a responsive strategy is to reduce the lead time for delivery and to be flexible to the changing customer needs. However, when there is uncertainty in the supply, the strategy can be either risk-hedging or agile. The first one aims to share the risk of supply disruption by pooling and sharing the resources in the supply chain. It can also be defined as a resilient supply chain, as it can be prepared for unexpected risk events (Shi & Yu, 2014). The second one uses strategies to be responsive and flexible to customer needs while minimizing the risks of supply disruptions. (Fisher, 1997; Lee, 2002)

Therefore, the traditional electricity supply chain can be described as adopting an efficient strategy. Salvi (2020) argues that an important goal is to eliminate non-aggregated value and to avoid any possible waste. However, if renewable sources – as solar PV plants – are considered in the supply chain, the main goal evolves into having a more risk- hedging strategy. This type of

[3] JIT, Just-In-Time or Kanban is a methodology aimed to reduce times within the production system as well as response times from suppliers and to customers.
[4] MRP or Manufacturing Resource Planning is a method for the effective planning of all resources within a company.

electricity production relies mostly on the weather, where an important component for demand forecast is uncertain, as Salvi (2020) states.

3.1.2 Electricity Supply Chain Management

The theoretical baseline is structured first with a generic description of the role of ESCM in the whole electricity supply chain, followed by a more detailed explanation of the last step of the electricity supply chain. This is the electricity suppliers – solar PV prosumers, the focus of the thesis.

Halldórsson & Svanberg (2013) distinguish the electricity supply chain within three key operational processes or trajectories: input or up-stream supply, transformation or conversion, and output or down-stream provision. The three of them allow supplying the amount of energy needed to satisfy the demand. There is some misunderstanding between two authors, Halldórsson & Svanberg (2013) and Salvi (2020), whether it is convenient to consider heat and vehicle fuel as part of the electricity supply chain.

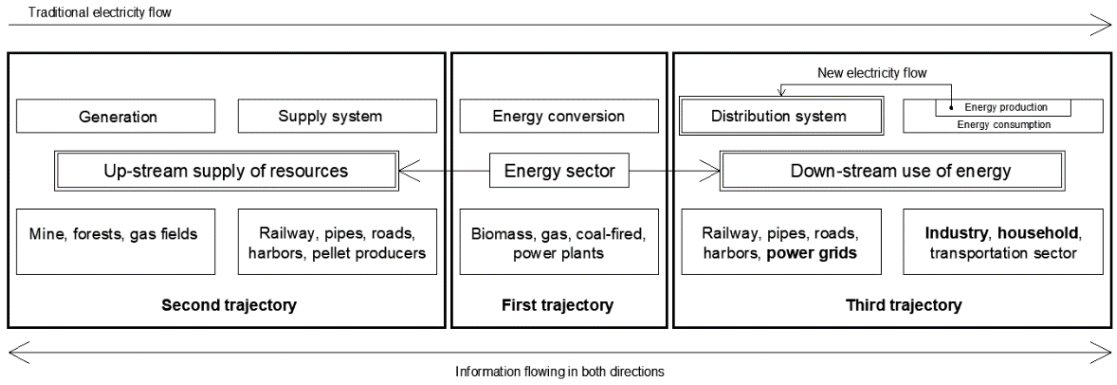


Figure 8: Scheme of the entire electricity supply chain. From the extraction of raw materials (on the left) until the consumption of the end-consumers. Halldórsson & Svanberg (2013) adaptation.

3.1.2.1 First trajectory

The first trajectory, the energy sector in Figure 8, is considered as an inter-connected number of companies that receive material from their suppliers (up-stream suppliers) to produce, distribute and trade energy resources and energy carriers vertically and horizontally in the supply chain (Halldórsson & Svanberg, 2013). As a result, the energy sector is the bridge between up-stream suppliers and the down-stream distribution system (see Figure 8). The three of them create time, place, and possession utilities to match the supply with the demand. Thus, the SCM gives the tools needed for being able to manage the energy flow between the origin of raw materials, through the electricity generation, transmission, and distribution and, at last, to the electricity end-consumers (Halldórsson & Svanberg, 2013).

The challenges in this particular step of the supply chain can be approached by two SCM principals. On one hand, up-stream suppliers are small and spread out geographically. So, SCM has to manage and coordinate small flows and different qualities. Furthermore, electricity consumption varies seasonally, and, from a long-term point of view, it can change according to the market needs. There are some authors, Halldórsson & Svanberg (2013) and Allen, et al. (1998), who suggests the combination of direct supply for the constant demand and the

fluctuating demand the use of storage in between the supply chain. However, this is not possible without good coordination between the different actors in a vertical (raw materials suppliers) and horizontal level (other generation companies) of the supply chain (Halldórsson & Svanberg, 2013). On the other hand, the operation performance plays an important role to deliver electricity with the minimum cost and time, taking into account the capacity utilization (Halldórsson & Svanberg, 2013).

3.1.2.2 Second trajectory

The up-stream supply resources in Figure 8 are the input to the energy supply chain. As they are the first step to the electricity supply chain, they are especially important for coordination, design, and strategy for the whole correct electricity supply chain (Salvi, 2020). The main objective of the generation and supply (see Figure 8) system is to be able to produce enough electricity to attend to the peaks of demand. Thus, SCM provides two categories as a framework and strategy to solve the supply challenges that energy producers (Halldórsson & Svanberg, 2013):

- Managing scarce supply. For the traditional fossil generation plants, the SCM is vital when securing the availability of raw material for electricity generation. The aim of the first's players in the electricity supply chain is to manage the fluctuation in the energy demand down-stream in the supply chain. Therefore, the need of having raw materials always ready to use is essential. As Halldórsson & Svanberg (2013) point, actors in the energy sector have three measures to have constant raw material provision: collaborative purchasing arrangements within several companies, insourcing of storage buildings to be able to be part of the company's operations and allowing an advance raw material purchase. However, renewable electricity production plants based on solar PV or wind power are challenged by the accessibility of the existing technology. The scalability of these renewable generation plants depends on this technology supply capacity to be able to go on a larger scale.
- Structure. Nowadays, the electricity supply chain is facing the challenges that the increasing decentralized production units generate. Hence, Halldórsson & Svanberg (2013) argue that SCM has to address the trade-off between operational efficiency of centralized production plants against logistics efficiency – due to its lower transportation cost – of decentralized production units. The supply management implication is that power is not the purchased unit anymore. Rather, the item bought is the mode of energy production itself (Halldórsson & Svanberg, 2013). The same authors discuss that a direct consequence is that more companies will have to deal with an increased risk, security, and dependency on a wider supply network of technology and the maintenance of the decentralized electricity network.

3.1.2.3 Third trajectory

The down-stream use of energy in Figure 8 sees the energy sector as a supplier and the electricity as a resource. Additionally, the energy sector has a strong influence on market trends according to providing economically efficient and environmentally sustainable solutions for their market (Halldórsson & Svanberg, 2013).

Thus, Halldórsson & Svanberg (2013) list two critical perspectives that can take place in this part of the electricity supply chain: supply risk and energy intensity. The supply risk can be understood as electricity dependency. Nowadays, not only electricity is a critical resource for industries and households, but also supply chains are highly dependent on accessibility, prices, and efficiency. Hence, the electricity supply chain design has to be able to quickly react to

possible disruptions due to availability or seasonality, quality of physical resources, changes in weather, etc. (Halldórsson & Svanberg, 2013). Distributed generation plants have shifted the electricity supply chain map by introducing smaller-scale and local sources, who are also electricity consumers from the grid, improving reliability and security of supply through using more energy sources (Bouffard & S. Kirschen, 2008). Thus, the electricity supply chain moving towards decentralization and multidirectional flows is characterized by greater volatility (Ritcher, et al., 2012). The second critical perspective is the energy intensity[5], an indicator used to study energy efficiency. According to IEA, the global target is to reduce this intensity, thus the future challenges the SCM theories to make energy manageable by measuring the footprints of products, processes, and even the whole supply chain (Halldórsson & Svanberg, 2013).

3.2 Close-Loop Supply Chain

The SCM during the last decades has been evolving to decentralization, multidirectional and volatile flows, which have led to the concept of the Close-Loop Supply Chain (CLSC) (Ritcher, et al., 2012). Ritcher, et al. (2012) define the main ingredients of CLSC as forward and reverse flows: "*The novelty of the concept is that both streams are considered at the same time and are organized with regard to one another in order to increase total benefits*".

Even though CLSC theories are usually addressed to manufacturing companies who have bi-directional flows of materials in their supply chains, the electricity sector has been experiencing an analogous development (Ritcher, et al., 2012). The increasing demand for distributed solar PV installation systems has increasingly fed electric power into the grid. As a result, Ritcher, et al. (2012) ensures that the electricity supply chain can learn from the knowledge earned during the last decades in the concept of CLSC and overcome the current and future challenges in the grid.

The traditional SCM is linear, the flow comes from several suppliers to the final point of consumption (black arrow in Figure 9), ensuring a unique direction of the elements in the supply chain. However, triggered by regulation and promotion schemes customers started to return all types of "things" to the initial manufacturer (return flow in bold line from the consumer to the company in Figure 9) (Ritcher, et al., 2012). Furthermore, in terms of manufacturer companies, there is an additional return flow within the company. According to Ritcher, et al. (2012), the main concept behind CLSC is that both streams, forward and reverse flow, are considered at the same time and organized in a way that the total benefit increases. An important characteristic of these return flows is that they are not easily predictable due to their several initiation points, so it is hard to predict the amount of reverse flow it is going to be in a certain time (Tibben-Lembke & Rogers, 2002).

[5] Energy intensity is measured by the quantity of energy required per unit output or activity, so that using less energy to produce a product reduces the intensity (U.S. Department of Energy. (n.d.). Energy Efficiency vs. Energy Intensity. Retrieved from https://www.energy.gov/).

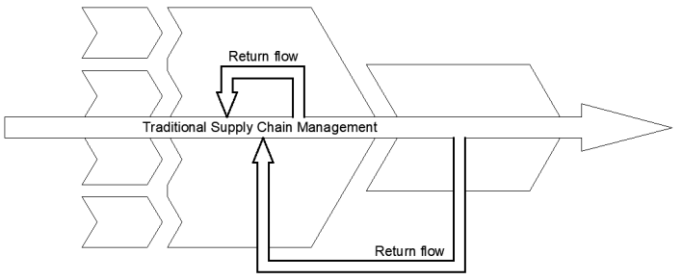


Figure 9: Scheme the traditional supply chain management, in black, throughout the value chain and the return flow, in bold line.

The return flow analogy to the electricity supply chain is the surplus electricity that prosumers from private houses or industries inject into the local grid. Due to its geographical distribution and its renewable nature, this return flow can be initiated at several different places and it can be discontinuous. Thus, the amount of electricity that the distributed generators will inject into the grid is hard to predict, as well as its stability over time.

3.3 Supply Chain Collaboration

Supply chain collaboration is known as "*two or more companies sharing the responsibility of exchanging common planning, management, execution, and performance measurement information*" (Min, et al., 2005, p. 237). Moreover, Scholten & Schilder (2015) note that supply chain collaboration gives the chain members the tools to respond to and recover from supply chain disruptions while reducing their impact. Certainly, collaboration is one of the driving forces that can lead to an effective SCM along the whole value chain (Min, et al., 2005). Additionally, collaboration compels the different actors in the supply chain to see the big picture (Simatupang & Sridharan, 2008) through interfirm collaborative arrangements which lead to sharing both, risks and rewards (Min, et al., 2005).

Scholten & Schilder (2015) highlight the importance of collaboration within a resilient supply chain. A resilient supply chain aims to reduce the impact of disruption by proactively identifying strategies that allow the supply chain to react while recovering to its original desirable state before the disruption. Therefore, a successful collaboration requires a change of business practice paradigm: realistic, informed, and detailed information sharing is necessary to ensure better decision-making and supply chain efficiency (Min, et al., 2005).

According to Simatupang & Sridharan (2008), supply chain collaboration can be achieved by implementing clear and effective strategies of five key elements of collaboration, closely linked one with the others, as it is illustrated in Figure 10: (1) Collaborative Performance System (CPS), (2) Information sharing, (3) Decision synchronization, (4) Incentive alignment and (5) Innovative supply chain processes. These five key elements aim to promote productive behavior in collaboration (Simatupang & Sridharan, 2008). Despite its linkages, Simatupang & Sridharan (2008) conclude that, after an extensive literature review, the tendency of recent research is that companies attempt to focus on two or three key elements of collaboration. Thus, a better knowledge of one of each key element is required.

> "(...) *developing and communicating the five elements of the architecture results in more committed and enthusiastic chain members because responsibilities are more interesting and stimulating and rewards are more clearly tied to overall supply chain performance*."

(Simatupang & Sridharan, 2008, p. 406)

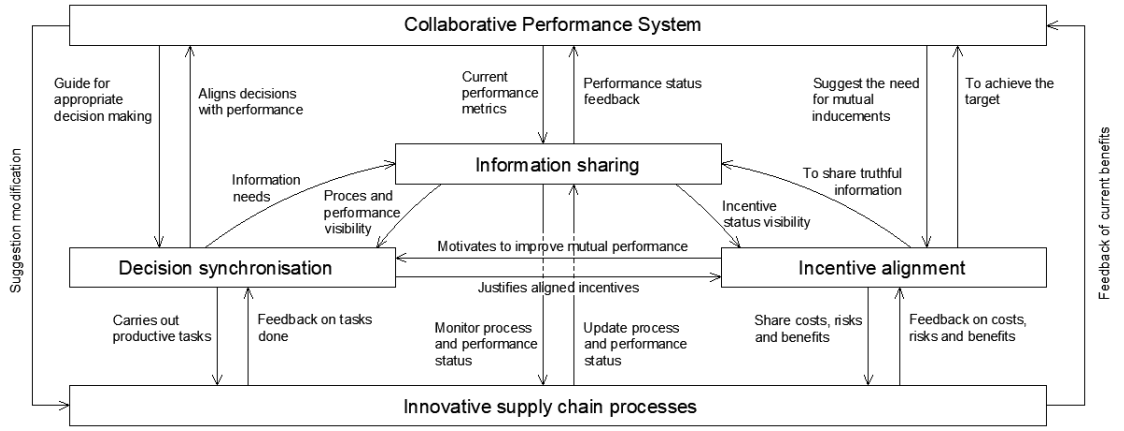


Figure 10: Architecture supply linkages between the five key elements of collaboration. Simatupang & Sridharan, 2008, p. 415, adaptation.

3.3.1 Collaborative performance system

Performance measurement quantifies the effectiveness and efficiency of a supply chain (Papakiriakopoulos & Pramatari, 2010) by implementing performance metrics and goals. The different supply chain players can follow to improve both, individual and overall performances (Simatupang & Sridharan, 2008) when applying the innovative supply chain processes, as it is shown in Figure 10. A Collaborative Performance System (CPS) uses the collected data during the information sharing (see section *3.3.2 Information sharing*) to evaluate and later modify the goals and performance metrics used in previous stages (Simatupang & Sridharan, 2008). Furthermore, decision synchronization (see section *3.3.3 Decisions synchronization*) and incentive alignment (see section *3.3.4 Incentive alignment*) is required to have more inputs to evaluate and modify the performance (Simatupang & Sridharan, 2005).

A good collaborative performance design has to have a clear objective, characterized by being measurable and quantifiable, clear, challenging yet attainable, written down and communicated to all the interested supply chain players (Simatupang & Sridharan, 2008). If this collaborative design is well implemented, the chain members become more committed to the final goal of the supply chain collaboration and how they have to play their roles to contribute to the final achievement.

3.3.2 Information sharing

For ensuring effective decision making and supply chain efficiency; realistic, informed, and detailed information sharing between chain members is needed (Min, et al., 2005; Simatupang & Sridharan, 2008). Therefore, the knowledge of several key performance metrics and process data enables the chain players to see a bigger picture, establishing the relationship between CPS and information sharing (see Figure 10). Hence, important factors can be considered in making effective decisions (Simatupang & Sridharan, 2008).

The information gathered with the five key elements of collaboration – the linkages between key elements are shown in Figure 10 – can follow several criteria, such as relevancy, accuracy,

timeliness, and reliability. According to Simatupang & Sridharan (2008), these characteristics define whether the information shared has enough quality. Min, et al. (2005) remark that the process, while exchange information is done, can occur in two different contexts: formally in periodic review sessions or informally between collaborative partners.

3.3.3 Decisions synchronization

Simatupang & Sridhara (2005 and 2008) define decision synchronization as the extent to which the supply chain players coordinate with one another to orchestrate critical decisions of planning and execution for optimizing the supply chain profitability. Thus, it is the process by which the decision right over actions is designed for each member of the supply chain. From this point forward each member is responsible to achieve the common target by developing its action (Simatupang & Sridharan, 2008). Moreover, it is argued that decision synchronization and incentive alignment (see section *3.3.4 Incentive alignment*) are the baselines for achieving an effective supply chain response (Scholten & Schilder, 2015).

As Figure 10 illustrates, the decision synchronization aligns decisions with a performance for being able to design a useful CPS.

3.3.4 Incentive alignment

When changing structures, processes, or capacity in supply chains, some investments have to be done to improve its performance. However, the person (or organization) taking the investment risk might not reap the benefits (Norrman, 2008). After an extensive literature review, Norrman (2008) notes that risk and gain sharing (or incentive alignment) are key factors for the successful implementation of SCM. Therefore, incentives must be aligned in the supply chain to achieve the full commitment of its different actors, in terms of supply chain coordination and collaboration. Furthermore, incentive alignment motivates the supply chain members to act in a manner consistent with the common strategic targets, both decision synchronization and sharing truthful and private information (see Figure 10) (Simatupang & Sridharan, 2008).

Simatupang & Sridharan (2008) establish three questions to have effective incentive alignments: (1) “What level of incentive is to be paid?”, (2) “How the incentive is to be linked to overall performance?” and (3) “How the incentive is to be paid?”. The goal of these three questions is to design the incentive alignment that attracts, motivates, and retains the members of the supply chain “*in achieving the overall performance by linking a portion of each chain member’s compensation to overall performance”* (Simatupang & Sridharan, 2008, p. 409). Thus, the players in the supply chain should reward good performances and, if it is needed, punish the unwanted behaviors. Thus, effectively designed and implemented gain sharing method gives value to the whole supply chain by motivating the different members, allowing effective decisions right allocation through sharing specific knowledge, and helping the members to overcome the barriers existing when there are challenging changes in the horizon (Simatupang & Sridharan, 2008).

Norrman (2008) lists three types of incentive designs:

- Contract-based by changing contracts to the supply chain actors who act for the supply chain’s best interest.

- Information based seeking to share information that was previously hidden between players.
- Trust-based. To use intermediaries or personal relationships to improve the trust within supply chain members.

3.3.4.1 Incentives in the electricity market

Demand response is a form of demand-side response that refers to the availability of the consumption modulation, aiming to decrease the energy demand at peak hours (Brown, et al., 2019; Rodríguez-Molina, et al., 2014; Nursimulu, 2015). Specifically, this term refers to "*the changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized*" (Eid, et al., 2016, p. 241).

Thus, according to the literature, there are two different ways to modulate consumption (Gelazanskas & Gamage, 2014; Rodríguez-Molina, et al., 2014). The first one is to reduce the load during critical peak-time and keeping a normal load pattern during off-peak time. The second one, to offset electricity use from peak to off-peak time, increasing the transmission and distribution efficiency. To achieve that target, end-consumers are encouraged with payment incentives (Gelazanskas & Gamage, 2014).

Eid, et al. (2016) discuss the two methods for demand response: price-based and controllable methods. However, this thesis will only consider the price-based approach, where the prosumer is free to decide in real-time.

Price-based demand response triggers the solar PV owner by the use of time-varying electricity rate (Eid, et al., 2016). Thus, the different tariffs can shift the demand in accordance with electricity generation, so when it is not abundant the consumption is decreased (IRENA, 2019). According to Eid, et al. (2016), in the price-based approach "*the customer is free to decide in real-time regarding the supply of flexibility*".

The following Table 6 describes the different price-based incentive types existing nowadays in the electricity market for solar PV installations[6].

[6] *Managing electric flexibility from Distributed Energy Resources: A review of incentives for market design* (Eid, et al., 2016) defines the appropriate incentives or control methods for each distributed energy management. This thesis only focuses on solar PV facilities.

	Pricing	Description
Incentives for baseline adjustments	*Those options require baseline consumption information penalizing or remunerating for specific load adjustments.*	
Interruptible Capacity Program (ICAP)	Dynamic	A rebate when electricity is reduced below a baseline value during system contingencies. If the customers do not reduce electricity consumption, they can be penalized by the electricity utility (Eid, et al., 2016; Aalami, et al., 2010).
Emergency Demand Response (EDR)	Dynamic	Allows the utility to establish a baseline load in return for monetary compensation. The baseline load can be directly controlled by the utility (through switching) or guaranteed by customers. Compensation could have a fixed component for participation and a variable component based on the amount shed in each event (Eid, et al., 2016; Tyagi & Black, 2010).
Peak Time Rebates (PTR)	Dynamic	A rebate when electricity is reduced compared to baseline consumption, within certain hours in a year (Eid, et al., 2016).
Basic pricing options	*To leave more freedom to the user, without requiring extra information on baseline consumption levels.*	
Real-Time Tariff (RTT)	Dynamic	The user receives a changing price per time step (for example 15 minutes) determined by real-time consumption. The customer can shift electricity consumption accordingly. Electricity prices are calculated based on an hourly rate depending on the day ahead real-time price (Eid, et al., 2016; IRENA, 2019).
Critical Peak Tariff (CPT)	Static and dynamic	At times the wholesale prices are the highest, a higher price is presented to the customer. Electricity customers receive notification of these moments in time for being able to plan their consumption (Eid, et al., 2016; IRENA, 2019).
Static Time of Use Tariff (TOuT)	Static	Fixed electricity prices for different time blocks of several hours within a period. Each time block is determined in advance and remains constant. Some examples are day and night pricing to reflect on-peak and off-peak hours, to split the day into smaller segments and/or seasonality (Eid, et al., 2016; IRENA, 2019).

Table 6: Possible dynamic pricing options for distributed solar installations management.

The electricity supplier offers this kind of tariff to encourage customers to use energy at off-peak times, to reduce the pressure on the distribution network.

According to Eid et al. (2016), direct control methods – also known as controllable, interruptible, or indirect methods for demand response – are contractual methods introducing the obligation for the flexibility supply. Direct control methods are more suitable when there is a frequent

variation of prices, achieving an increased level of reliability. However, the authors emphasize that the preferred option would be to combine tariffs, contracts, and direct control.

With the direct control methods, the TSO or the electricity supplier can make the end-consumer agree to automatically control the operation of the distributed energy resources appliances, such as air conditioners or electric hot water systems, for a limited period. This operational control is rewarded with some financial incentives. (Xu, et al., 2018).

3.3.5 Innovative supply chain processes

Innovative supply chain processes refer to the chain member's design and implementation of an adaptive supply chain process that aims to deliver the products to the end-consumers on time at lower costs (Simatupang & Sridharan, 2008).

Prosumers have, and will have, a more important role to play in the future electricity value chain. Therefore, the new SCM strategy has to evolve from having an efficient strategy to a more risk-hedging strategy – responsive and flexible to customer needs –, for integrating the solar PV utilities distributed around the region. This new form of generation leads to having a bi-directional electricity flow. Its management has some similarities to the concept of CLSC used with non-continuous reverse flows in industrial processes. So, knowledge in this field can be used to overcome the ongoing and future challenges of the grid by designing a faster supply chain to quickly react to disruptions due to availability or seasonality. (Simatupang & Sridharan, 2008)

For achieving an effective and efficient electricity supply, a good SCM has to be ensured. Consequently, a good collaboration between the chain members is required to minimize chain disruptions by having more tools to respond and recover from. In further chapters, information sharing, decision making, and incentive alignment are considered as the key elements which the electricity value chain is more likely to modify, to improve the relationship between prosumers and electricity suppliers. (Simatupang & Sridharan, 2008)

4 Methodology and method

The aim of any study can be achieved in several ways. Thus, the following chapter gives a definition of the different research strategies, methods, and approaches that will be undertaken in this thesis. Each definition will be followed by a description of the chosen methodology and an explanation of its motivation. An explanation of the investigation model and the case study selection can be found at the end of the chapter.

4.1 Research methodology

When doing a research project, a research methodology has to be followed to comply with its purpose. According to Runeson & Höst (2009), there are four different purposes for research methodologies, each one with its advantages and disadvantages:

- Exploratory. To look for new insights within an area where there is pre-existing knowledge and to come up with new ideas for future research.
- Descriptive. To portray a situation or phenomenon within an area where there exists knowledge.
- Explanatory. To seek for an explanation of a situation or a problem, mostly but not necessary in the form of a causal relationship.
- Improving. To find a solution to a studied phenomenon, as well as contributing to increasing the knowledge of the research.

A common misconception is that the research studies should be seen as a hierarchical point of view, where it is thought that case studies only can be worked as an exploratory point of view or that for the description phase-only surveys and histories are valid. However, as Yin (2018) notes, this assumption is wrong because there can be, for example, exploratory or descriptive case studies.

This thesis has two main goals. The first research question aims to describe how the Swedish electricity suppliers manage the electricity supply due to the increased amount of bi-directional electricity injected into the grid. So, a descriptive approach is needed to describe the current situation of a certain phenomenon. The second research question tries to predict possible business models within the last step of the electricity supply chain. As a result, an exploratory approach will be used.

4.2 Research design

According to Yin (2018), a researcher can choose between five different research strategies: experiment, survey, archival analysis, histories, and case study.

An experiment aims to measure one or more variables, which can be manipulated in a controlled environment (Runeson & Höst, 2009). Survey research is used to quantitatively describe specific aspects of a selected portion of the population, which can later be generalized as the whole population (Glasow, 2005). The archival analysis involves consulting in an archive that can contain a wide variety of primary sources (Allen, 2017). A case study is empirical research used

when the researcher investigates a particular real-life phenomenon within specific contexts and with previous pre-defined boundaries (Allen, 2017).

The selection of which method can be related to three conditions defined by Yin (2018):

- The type of research questions posed.
- The extent of control and investigator over actual behavioral events.
- The degree of focus on contemporary as opposed to historical events.

Thus, the method strategy directly depends on the first condition is whether the research questions focus on “who”, “what”, “where”, “how” and “why”, as Table 7 describes.

Strategy	**Form of the research question**	**Require control over behavioral events?**	**Focuses on contemporary events?**
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how many/much	No	Yes
Archival analysis	Who, what, where, how many/much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

Table 7: Relevant situations for different research strategies (Yin, 2018).

In this particular thesis research questions are mainly focused on trying to answer “how” questions, so according to Table 7, it could be any of the five strategies. However, the topic of the thesis does not require control over the behavioral events, the aim is to try to capture information about which is the current situation in the electricity supply chain and the relation between electricity suppliers and prosumers. Besides, the changes in the electricity supply chain are at the forefront due to the increasing installation of new renewable plants connected to the grid, both distributed solar PV solutions and big solar plants. Hence, there are two options left, a survey and a case study research. Due to the descriptive – exploratory nature of the thesis, the most appropriate research method is a case study research.

According to Yin (2018), there are four basic types of designs for case studies, depending on the design situation (single or multi-case study) or the number of unit analysis (holistic or embedded).

	Single case design	Multi case design
Holistic A single unit of analysis	*Type 1*	*Type 3*
Embedded Multiple units of analysis	*Type 2*	*Type 4*

Table 8: Basic types for case studies (Yin, 2018).

Following Yin’s procedure, the first step is to determine whether the case study has to be a single or multi-case study design. There are two rationales for single case studies, the first one is when

it represents a critical case in testing a well-formulated theory, the second one is when the case represents an extreme or unique case (Yin, 2018). The study can also be either holistic when the case is studied as a whole, or embedded where multiple units of analysis are studied within a case (Runeson & Höst, 2009).

The research design used in this thesis is a holistic case study, Type 1 in Table 8. Figure 11 draws the rationale followed for establishing that there is a unique unit of analysis. First, the Swedish market was selected for being one of the most advanced countries related to distributed electricity generation. The newest innovation in the electricity supply chain, the smart grid, is then followed in line to study the supplier – prosumer relationship between the last two players in the supply chain. The whole research study will take the UK electricity supply chain as a baseline. Thus, the unit of analysis can be defined as the description of the current and future electricity supply chain in Sweden, focusing on the relationship between electricity suppliers and solar PV prosumers.

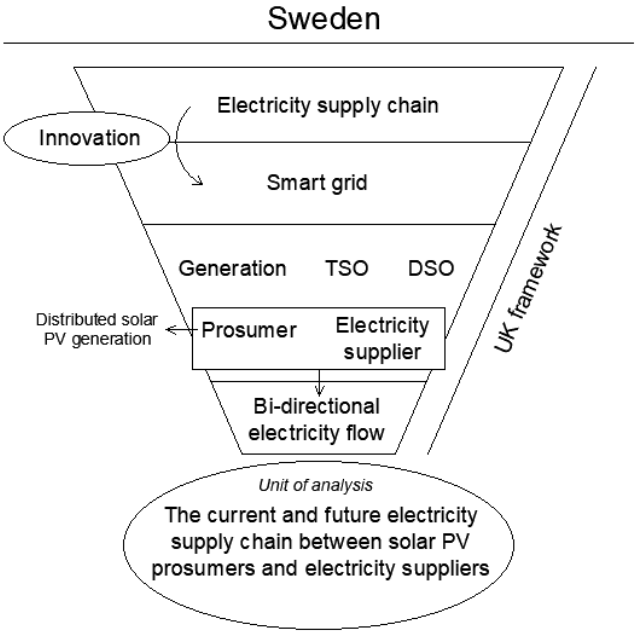


Figure 11: Scheme description of the unit of analysis.

Hence, the author believed that this unit of analysis can be studied with *E.On* as a critical case. This company is one of the most important electricity suppliers in Sweden (see chapter *2.1 Electricity Supply Chain in* Sweden*)* and it has also an important presence in the UK market (see chapter *4.2.1 Case study*).

The investigation model followed along with the thesis is represented in Figure 12. The thesis will try to describe which relationships exist nowadays between electricity suppliers and prosumers (discontinuous line in Figure 12 drawing *(a)*), as well as the role that smart grids and incentives can have in the development of the future business models in the Swedish electricity market (continuous line in Figure 12 drawing *(b)*). In section *4.4.2 Interviews,* is it detailed how the data collection is done for achieving the description of each current and future relationship.

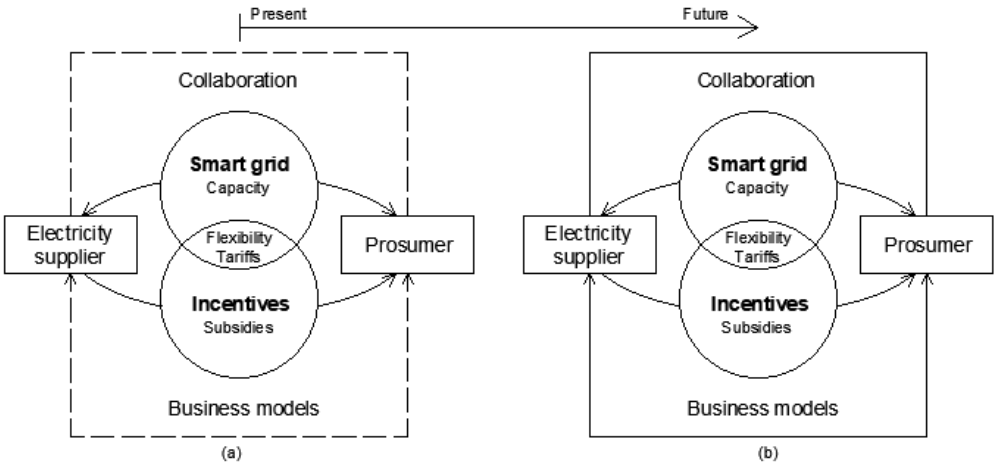


Figure 12: Investigation model. (a) Scheme representing, in discontinuous line, the current relationship between electricity suppliers and prosumers. (b) Scheme representing, in continuous line, the future relationship between both chain members.

4.2.1 Case study

A case study is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context (Crowr, et al., 2011). Thus, the present case study aims to be able to describe the current situation and the future of the Swedish electricity supply chain. For studying this topic, two research questions are formulated at the beginning of the report. The already introduced first research question in chapter 1 is "RQ1: *How are Swedish electricity suppliers using smart grids for managing the bi-directional electricity flow coming from different prosumers and their solar PV plants?"* which will give insights into the current situation of the electricity supply chain in the country. The knowledge gained with the RQ1 will enable to explore the second one "RQ2: *How are the business models of the electricity supply chain between electricity suppliers and prosumers that Sweden can expect, and which are their incentives, barriers, etc.?*". The goal is to be able to have enough knowledge to define which future can electricity suppliers expect and by extension the prosumers, when talking about the electricity supply chain and their relationship with both players.

4.2.2 Case study selection

As it is said before, this thesis will be focused on the Swedish electricity supply chain. Specifically, on *E.On*, an electricity supplier who also is one of the most important DSO companies in Sweden (black triangle painted in Figure 7), so it has enough power to influence the electricity market. In this case design, the goal is to describe and explore the relation between *E.On* and the distributed solar PV prosumers (circles painted in black color in Figure 7) connected to the local grid.

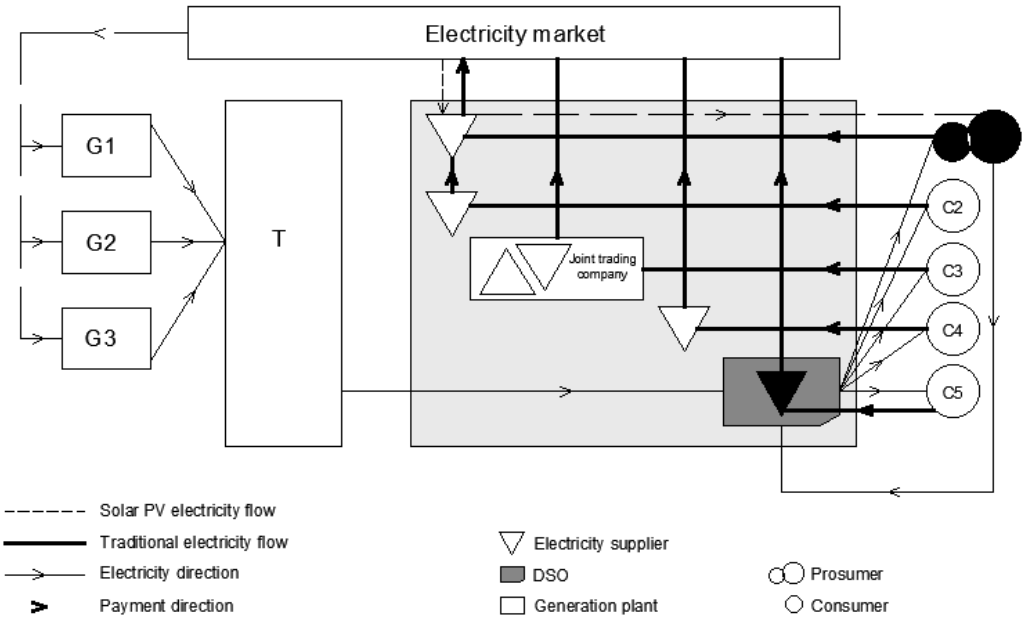


Figure 13: Electricity supply chain remarking the case study with a black triangle.

4.3 Research approach

As empirical research, a case study can have two different types of data collection: quantitative or qualitative. Quantitative data involves numbers, so it can be analyzed using statistics to identify a pattern that could either confirm or contradict the hypothesis formulated at the beginning. Qualitative data has to be analyzed with categorization and sorting because it involves words, descriptions, pictures, diagrams, etc. (Runeson & Höst, 2009). Usually, qualitative methods are less structured than the quantitative methods, starting with wider aspects and then narrowing the study due to the knowledge earned during the data collection. Runeson & Höst (2009) remark that the most common data for a case study is qualitative due to the aim of providing a deep description of the research topic.

There are three different options during the acquisition of new knowledge. Inductive research is defined as a process that seeks to build a theory based on the investigated phenomenon by using observations of specific instances (Spens & Kovács, 2006). In other words, to be able to understand the results an inductive approach needs an empirical study and a further development of the theory. Deductive research is a method that seeks to check whether the initial theory applies to specific instances or not. So, it uses theory to a form preliminary hypothesis and in further stages of the study, they are tested in an empirical context (Spens & Kovács, 2006). At last, according to Spens & Kovács (2006), abductive research is generally understood as reasoning from effect to causes or explanations and can be said to furnish the reasoner with the problematic theory which induction could verify. Thus, it can be seen as a combination of the two previous approaches, inductive and deductive, because it works constantly between ideas and observations.

The aim of this thesis is to go deep into a very concrete part of the electricity supply chain through the collection of qualitative data. The limited resources for executing this thesis are an additional reason why qualitative data is used rather than quantitative. The discussion of how this data will look like is described in the following chapter *4.4 Research data collection*. The purpose of this research project is to do a description and further analysis to be able to predict

a future scenario for business models of the electricity supply chain between electricity suppliers and prosumers in Sweden.

4.4 Research data collection

During the designing time of the case study, the methods for data collection have to be defined. There are four different methods for collecting the data: interviews, observations, archival data, and questionnaires. In this thesis, two of the four methods will be used. First, an extensive literature review of different sources relevant to the goal of the thesis. This is followed by interviews with the main stakeholders to gain knowledge and insights from different points of view and, based on that, to be able to build a more detailed actual and future picture of part of the electricity supply chain.

4.4.1 Literature

Yin (2018) distinguishes between documentation, as a qualitative data collection, and archival data, as a quantitative data collection. However, in this thesis, the term literature does not differentiate between both terms and it includes scientific journals, documents from different development phases, organizational charts, etc. (Runeson & Höst, 2009). Thus, two different types of literature have been used: scientific journals and reports.

On one hand, the literature review regarding the electricity supply chain and its management, collaboration within the different players in the supply chain, and the business models in the electricity market is used as a base of the project. The literature was found using the database Google scholar for the academic papers as well as looking the references in the reports the author considered necessary. Thus, some keywords were needed: *Electricity Supply Chain*, *smart grid*, *solar PV*, *Supply Chain Management*, C*lose-Loop Supply Chain*, *prosumer*, *case study*, *electricity supplier, business model, collaboration, incentives*.

The most relevant scientific journals used in this thesis can be seen in Table 9:

Literature within bi-directional electricity flow
Ritcher, A., van der Laan, E., Ketter, W., & Valogianni, K. (2012). Transitioning from the traditional to the smart grid: Lessons learned from closed-loop supply chains. *2012 International Conference on Smart Grid Technology, Economics and Policies (SG-TEP)*, 1-7. doi:10.1109/SG-TEP.2012.6642382
Literature within Electricity Supply Chain Management (ESCM)
Zomkowski Salvi, V. (2020). Electricity Supply Chain Management – A Literature Review. *Archives of Business Research*, 8(1), 182-191. doi:10.14738/abr.81.7691
Halldórsson, Á., & Svanberg, M. (2013). Energy resources: trajectories for supply chain management. *Supply Chain Management: An International Journal*, 18(1), 66-73. doi: 10.1108/13598541311293186
Literature within supply chain collaboration and incentives in the electricity market
Min, S., Roath, A., Daugherty, P., Genchev, S., Chen, H., & Arndt, A. (2005). Supply chain collaboration: what's happening? *The International Journal of Logistics Management*, 16(2), 237-25. doi:10.1108/09574090510634539

Simatupang, T. M., & Sridharan, R. (2008). Design for supply chain collaboration. *Business Process Management Journal*, 14(3), 401-418. doi:10.1108/14637150810876698
Norrman, A. (2008). Supply chain risk-sharing contracts from a buyers' perspective: content and experiences. *International Journal of Procurement Management*, 1(4), 371-393. Retrieved from http://www.inderscience.com/storage/f107114651912382.pdf
Brown, D., Hall, S., & E. Davis, M. (2019, December). Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK. *Energy Policy*, 135. doi:10.1016/j.enpol.2019.110984
Eid, C., Perez, Y., Reneses, J., & Hakvoort, R. (2016). Managing electric flexibility from Distributed Energy Resources: A review of incentives for market design. *Renewable and Sustainable Energy Reviews*, 64, 237 - 247. doi:10.1016/j.rser.2016.06.008

Table 9: Key scientific journals used as a baseline for the thesis.

On the other hand, reports related to the current Swedish electricity supply chain situation. This literature is considered for being able to provide a descriptive picture of the current electricity supply chain, which has already initiated the use of smart grids, compared to the traditional supply chain. Furthermore, some reports consider the current electricity tariffs that the prosumers can use to change their consumption behavior depending on their necessities.

The most important reports used are shown in Table 10:

Key reports
IRENA. (2019). Innovation landscape brief: Time-of-use tariffs. Abu Dhabi: International Renewable Energy Agency.
Swedish Energy Agency. (2018). National Survey Report of PV Power Applications in Sweden. Retrieved from https://iea-pvps.org/

Table 10: Key reports used as a baseline for the thesis.

4.4.2 Interviews

An interview is a first-degree data collection technique, meaning that the researcher is in direct contact with the interviewee (Runeson & Höst, 2009). According to Runeson & Höst (2009), there are three different types of interviews depending on the type of interaction between the interviewer and the subject:

- Unstructured interview. The conversation will develop according to the interests and concerns of the author and the interviewee.
- Fully-structured interview. All questions are planned in advance and all of them are asked in the same order as in the plan.
- Semi-structured interview. This type of interview is a combination of the previous ones. The questions are planned beforehand but they are not necessarily asked in the same order as they listed.

In this case study, semi-structured interviews will be undertaken to have a baseline during the interview for being able to allow some improvisation during its conduction. Consequently, an interview guide will have to be prepared to have the questions. Due to the COVID-19 pandemic situation, the interviews will be conducted through *Google Meet, Zoom,* or *Microsoft Teams*, even though it is not the best method. A standard template will be used, however, depending

on the subject background, some questions will be changed to have the correct insights from each one of them. Furthermore, a few days before the interview, the respondents will receive an email with an overview of the interview guide[7]. It will be detailed the purpose of the thesis as well as the topics that will be considered during the interview.

The plan designed is to interview different stakeholders within the electricity supply chain for being able to collect different insights from a wide variety of points of view. Several emails were sent to different people, assuming that not all of them would answer. The following Table 11 lists the stakeholders aimed to interview and why their point of view is interesting for the thesis.

Contact	**Expected insights**
Elinorr https://www.elinorr.se/projekt/forsta/	*Elinorr*'s project aims to achieve effective local grids for the customers' future needs. This contact might have more knowledge related to technical topics but, his expertise in the field can give the author more knowledge related to how smart grids are being used nowadays in Sweden.
E.On DSO *E.On Retail* https://www.eon.se/	*E.On* is one of the most important supply companies as well as a DSO, they have an important influence on the challenges the Swedish electricity market is facing.
AFRY https://afry.com/en/competence/distribution?sub_sector=1612	Consultancy company working with the current challenges in the distribution network in Sweden. Their generalist point of view of the electricity supply chain viewed as a whole can give insights related to each player in the value chain.
SERO http://wp.sero.se/ http://www.goranbryntse.se	On April 22, 2020, Renewable Energy Organization's (*SERO*) chairman wrote an article talking about the small-scale initiatives as a part of the solution to the conversation of the energy system in Sweden[8]. Thus, the author as the chairman of the *SERO* and board member of the European Renewable Energy Federation (*EREF*) can give insights into how Swedish authorities are facing the future.
Svensk Solenergi https://www.svensksolenergi.se/	As the CEO of *Svensk Solenergi*, an association that represents the Swedish solar energy industry as well other players operating in the solar energy area. During an interview in November 2019[9], the *Svensk Solenergi*'s CEO provides interesting insights from a holistic point of view.
Telge Energi http://www.solelkommissionen.se/kontakt/ https://telgeenergi.se/	*Telge Energi* owns and operates the local electricity network in Södertälje and Nykvarn municipalities. It is also an electricity supplier that only sells electricity generated by renewable sources. This company also buys the surplus generation of its prosumers. As a Project Manager in the company, can give insights from an electricity supplier point of view who also interacts with the prosumers when they are installing the solar PV cells.

[7] The overview of the interview guide can be found in Annex.

[8] Article: http://wp.sero.se/svenska-energikooperativ-behover-battre-villkor/

[9] Interview: https://www.solcellskollen.se/blogg/anna-werner-om-forsta-tiden-som-svensk-solenergis-allra-forsta-vd

Alight https://www.alight-energy.com/	As a member of the International Energy Agency's PVPS workgroup[10] on solar business models. He is also the founder and CEO of Alight. He can give insights into the business models in the future.
Sustainable Innovation https://sustainableinnovation.se	Sustainable Innovation was founded in 2008 to contribute to a sustainable transition bringing solutions from research in collaboration with leading companies and entrepreneurs. There is a project (*Nya affärsmodeller i elnätet*, 2017-04-01 to 2020-03-31) studying innovative business models that allow the integration of distributed renewable energy resources in the distribution network.
STUNS Energi https://stunsenergi.se/	*STUNS Energi* supports innovations and entrepreneurship to contribute to new ways in which supply and demand for sustainable energy and environmental solutions can meet. As a Project Manager can give insights into the current and future business models in the Swedish electricity market.
Solar Commission https://solkompaniet.se/tjanster/politik-och-regelverk/	As president of the *Solar Commission* aims to ensure that legislation is not a barrier to solar PV self-production[11]. The *Solar Commission* is a network of companies consisting of *HSB*, *IKEA*, *Telge Energi*, *Solkompaniet,* and *Vasakronan*. He can provide insights related to incentives and how these can trigger different business models.
Fortum www.fortum.com	Fortum, as *E.On*, is one of the most important electricity suppliers operating in Sweden. Its point of view can give insights similar to the ones from *E.On* but from another strategy and/or point of view.
Vattenfall https://www.vattenfall.se/	Vattenfall, as *E.On*, is one of the most important electricity suppliers operating in Sweden. Its point of view can give insights similar to the ones from *E.On* but from another strategy and/or point of view.
CERE http://www.cere.se/en/research/research-projects.html#article-id-1056	The Centre for Environmental and Resource Economics (*CERE*) studies environmental and energy economics, currently focusing on real-time pricing of electricity in Sweden. As a Project Manager he can help to describe how the tariffs are affecting or might affect the future development of new business models.
Ei https://www.ei.se/en/	Energy Markets Inspectorate (*Ei*) is the authority responsible for the regulation of the electricity network operations in Sweden. They also inform customers about how they can be active as electricity consumers.
Electricity retail department https://www.kraftringen.se/privat/	*Kraftringen* is the electricity network owner in Lund, Lomma, Eslöv, and Hörby municipalities. As part of the electricity retail department, she can give insights concerning the

[10] Technology Collaboration Program by IEA https://iea-pvps.org/

[11] Article: *Solelkommissionen – bättre förutsättningar för egen solel* posted in https://solkompaniet.se/tjanster/politik-och-regelverk/

	commercial relationship between retailer and prosumer from a network company owned by different municipalities.

Table 11: Planned interviews with different stakeholders in the Swedish electricity supply chain.

In Figure 14 are plotted the stakeholders aimed to interview according to the kind of insights they can give and their location within the investigation model drawing presented in previous sections before.

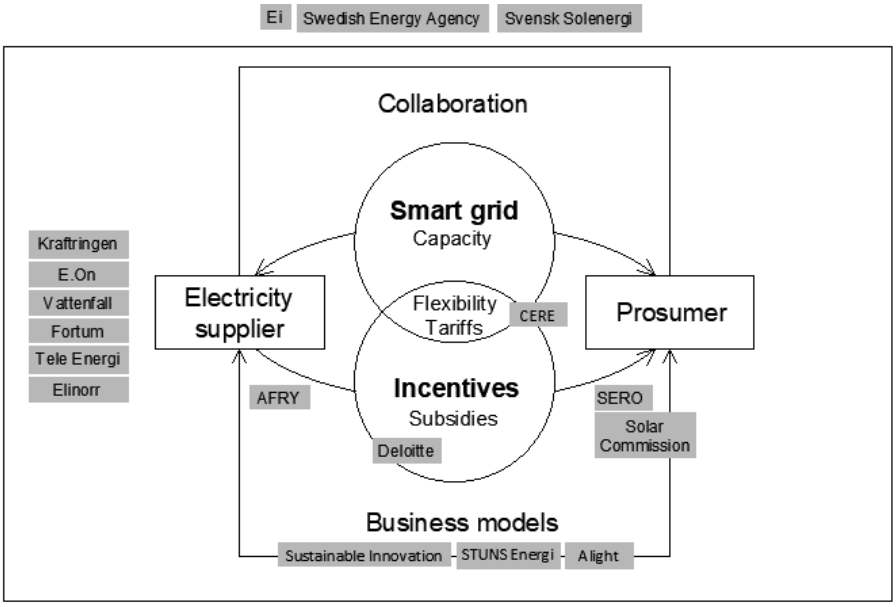


Figure 14: Stakeholders aimed to be interviewed plotted in the investigation model scheme.

An email, or a maximum of three emails, were sent to the contacts listed in Table 11. Some of them never replied and some of them said they did not have any valuable insights into the topic on which the thesis is based.

Finally, seven interviews have been conducted[12], listed in Table 12.

Contact	**Position**	**Company / Project**	**Date**
Jan-Erik Olsson	Senior Advisor	*E.On Distribution (Energy Networks)*	03/12/2020
	As part of *E.On* Distribution, Jan-Erik is currently occupying the Senior Advisor position. He is mainly focused on two aspects. The first one is related to how the company can be involved in creating a more sustainable way of working. The second one, he is the manager of the project "DSO project". This project is aligned with the energy package coming from the European Union.		
Göran Bryntse	Chairman	*SERO*	04/12/2020
	Göran Bryntse[13] is the chairman of the Swedish Renewable Energy Organization, *SERO*. He has been involved in the Swedish energy and environmental debate for 40		

[12] The complete interview with its transcription can be found in the Annex.
[13] The information has been found in http://www.goranbryntse.se/ .

	years. He is also a Board member of EREF, European Renewable Energy Federation, and assistant professor in Energy Efficient Technology at Strömstad Academy. Between 1998 and 2003 he was a Board member of the Swedish National Energy Authority.		
Anna Werner	CEO	*Svensk Solenergi*	05/12/2020
	Anna is the CEO of the *Svensk Solenergi* association with 260 members, including installers, producers, research institutes, schools, consultancy firms, electricity suppliers, and grid companies.		
Håkan Feuk	Head of CEO Office & Political Affairs	*E.On Retail (Customer Solutions)*	16/12/2020
	Håkan is working in *E.On Retail* as Head of CEO Office & Political Affairs, a wide position but with a deep knowledge of different types of market arrangements. In the past, he was chairman of the market design team in the *Eurelectric European Association*[14], federation for the European electricity industry, representing more than 3,500 companies in power generation, distribution, and supply.		
Martin Nilsson[15]	Analyst	*Energy Market Inspectorate*	22/12/2020
	The *Energy Market Inspectorate*, *Ei*, is the Swedish national regulator authority. Martin is currently working at the Technical Analysis Department as an analyst.		
Daniel Persson	Strategy & Regulation	*E.On Distribution (Energy Networks)*	05/01/2021
	As part of *E.On Distribution*, Daniel is currently working with the role of Strategy & Regulation. He has a 15-year background within *E.On.* First, he was working in the customer solution company working with energy trading and portfolio management, responsible for buying and selling for external customers (i.e., *IKEA*).		
Marie Liljewall	Electricity retail department	*Kraftringen*	05/01/2021
	Business development responsible for electricity sales, gas sales for households, and vehicles. She has been working in the electricity field for several years; starting in *E.On* as a Portfolio Manager and Dispatch Operator for 11 years, followed by a similar role in *Öresundskraft Marknad AB*, a regional energy company in the south part of Sweden.		

Table 12: Interviews conducted during the stage of data collection.

In the following Figure 15, the interviews conducted are plotted on the investigation model scheme, showing the stakeholders that take part in the thesis.

[14] https://www.eurelectric.org/

[15] The respondant replied that it was impossible to find a meeting date and suggested to answer the questions in a mail. A second round of questions was impossible to do since Nilsson is in a parental leave until August 2021.

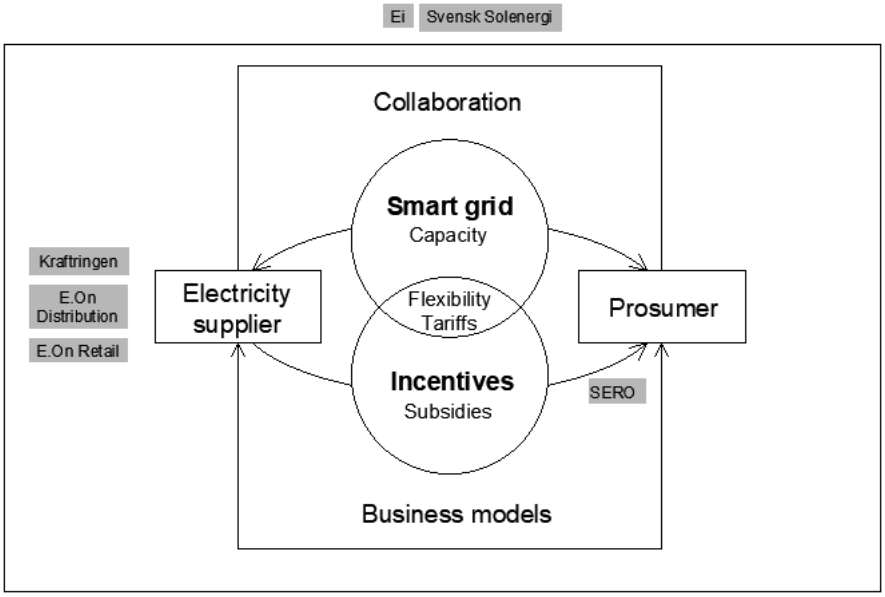


Figure 15: Stakeholders interviewed plotted in the investigation model scheme.

The conducted interviews represent three of the four different stakeholder groups considered in the investigation model (see Figure 15). Regarding the knowledge of new business models in Sweden, after more than 20 emails exchanged, it has been impossible to find an interview date with the project manager in *Sustainable Innovation* to give information within the field of business model's future development.

E.On, as the case study company, represents one of the big DSO and electricity suppliers in Sweden. The opinion of the other two main players, *Ellevio* and *Vattenfall*, are not included in the thesis due to the lack of response on their part. However, the lack of these opinions does not change the value of the thesis because the interviews are considered interesting enough for answering the research questions raised.

4.5 Research data analysis

Qualitative data analysis is a flexible method, as well as the case study research method. This type of analysis must be carried out in parallel to the data collection, for being able to include the insights gained with the data analysis into the interviews (Runeson & Höst, 2009). Hence, the analysis of the semi-structured interviews conducted along this project will consist of the following stages (Gale, et al., 2013):

- The ideal procedure is to transcript the recording of the whole interview, word by word. Due to the limited resources, the data analysis of this thesis will only be transcript the parts which the researcher finds more important.
- Familiarization with the interview. This stage is made for being able to become familiar with the interview using the recording and transcription made in the previous stage.
- In the coding stage, the researcher will review the whole interview noting which passages are the important ones for the analysis and describing the interpretations made.
- Charting data into the framework matrix. By nature, qualitative data are voluminous, so charting involves summarizing the data by category from each transcript. As Gale, et al. (2013) remarks, summarizing has to balance retaining the original meaning and "feel" of the interviewees' words on the other. The matrix shown below has been designed following the

investigation model design beforehand. The aim is to have in the same row the opinions of several stakeholders for further analysis.

	1	2	3
	Interview 1	Interview 2	Interview 3
Grid management			
Interest in smart grids. Electricity suppliers/DSO			
Capacity. Investment type			
Switch			
More supply uncertainty			
Less demand uncertainty			
Subsidies			
Tax deduction 2021			
Relation to business models			
Capital subsidy			
Guarantee of origins			
Grid compensation			
Green certificate			
Ethical incentive			
Self-consumption			
Payback time			
Tariffs			
To earn trust			
Capacity of the grid / Flexibility / Incentives & business models			
Preferred tariffs			
Incentives for capacity			
Business models			
Barriers			
Advantages for prosumers			
Disadvantages for prosumers			
Advantages for electricity suppliers			
Disadvantages for electricity suppliers			
Increase prosumer electricity injection			
Basic prosumer			
Aggregator			
Hydropower <--> Solar power			
Off-grid solution			
Share production			
Virtual arrangements			
Decentralized power market incentive			
P2P			
Local / energy communities and energy cooperatives			
Prosumers			
Decision making			
Earning trust			
Information sharing			

Table 13: Data collection matrix.

- Interpreting the data.

The aim of the data analysis of the case study is to provide a baseline to a further information crossing between the data gathered and the literature review. This analysis is made in chapter *6 Analysis*.

4.6 Trustworthiness

The last step in the methodology is to ensure that the conclusions written in the thesis are answering the studied phenomenon. The trustworthiness of a research project consists of the evaluation of potential sources of error during the application of the methodology (Shenton, 2004). According to Shenton (2004), Guba (1981) proposes four criteria to ensure trustworthiness: (1) Credibility, (2) Transferability, (3) Dependability, and (4) Confirmability.

One of the most important key criteria to ensure trustworthiness is credibility or internal validity. The literature describes this criterion as the "*truth value*" (Miles & Huberman, 1994). The aim is to confirm that the study measures what is intended (Shenton, 2004), and that the findings of the study make sense (Miles & Huberman, 1994). The following Table 14 lists the measures considered in this thesis.

Quality criteria	**Actions taken in this research study**
Credibility	Asked the respondents if the purpose of the thesis is their field of expertise. Some of them refused to interview due to the lack of knowledge of the topic. Conducted constant feedback with the supervisor of the research project to have different perspectives and perceptions, aiming to avoid wrong assumptions.

Table 14: Actions taken to increase credibility.

Even though, it was not possible to conduct interviews with two of the main players in the electricity supply chain – *Ellevio* and *Vattenfall*, developing the role as DSO and retailers –, the lack of their insights does not change the value of the thesis. The insights provided for all the other respondents, not only *E.On* as one of the most important DSO and supply organization in Sweden, are considered interesting enough for achieving a satisfactory argumentation of the research questions. However, as is mentioned in section *7.3 Future research study suggestions*, future research projects might include these chain members in the study to probe whether they play similar roles, or not.

Transferability or external validity "*is concerned with the extent to which the findings of one study can be applied to other situations*" (Shenton, 2004, p.69). This criterion is not considered in the project since, as Shenton (2004) discusses, the findings of a qualitative project are only focused on a particular environment, thus it is impossible to demonstrate the findings can apply to other situations.

Dependability or reliability, aiming to check "whether the process of the study is consistent, reasonably stable over time and across researchers and methods" (Miles & Huberman, 1994, p. 278). For being able to increase the reliability of the study some literature, Björklund & Paulsson (2014) and Runeson & Höst (2009), propose the use of control questions during the interview for examining the same thing twice and to ask the same question in different ways. In Table 15 are listed the actions taken along the project to increase reliability.

Quality criteria	Actions taken in this research study
Reliability	Conducted control questions during the interviews to make sure the answer obtained is the correct one. Conducted similar questions to different stakeholders for having a variety of points of view within the same topic. Send emails to confirm some ambiguous concepts found, during the data analysis, in the interviews. Developed and used an interview guide (see Annex) for the data collection phase. Developed a database with a background of the companies or associations the interviews are working on, as well as a description of their background (see Table 11).

Table 15: Actions taken to increase reliability.

Confirmability or objectivity of the research project. To achieve a high level of objectivity the researcher should clarify and motivate the different choices made along with the study, allowing the reader to take his/her own opinion according to the results. Furthermore, the author should avoid using emotionally charged words which can lead to subjectivity in the sentence. (Björklund & Paulsson, 2014)

5 Empirical study

This chapter is divided into three different sections where the findings from each interview are presented, organized depending on the topic discussed, following the concepts drawn in the investigation model. Firstly, a description of E.On's role within the Swedish electricity market. Secondly, the interviewees' insights related to smart grids and ESCM in Sweden. Finally, the last two sections are a description of how the different stakeholders perceive the current and future relationship between electricity suppliers and prosumers and which is the role that incentives and tariffs have in the development of the future.

5.1 Introduction to the empirical study

The empirical study, as is explained in section *4.4 Research data collection*, has consisted of conducting interviews representing different stakeholders within the Swedish electricity supply chain. The chapter is organized according to the investigation model developed in previous sections (Figure 16).

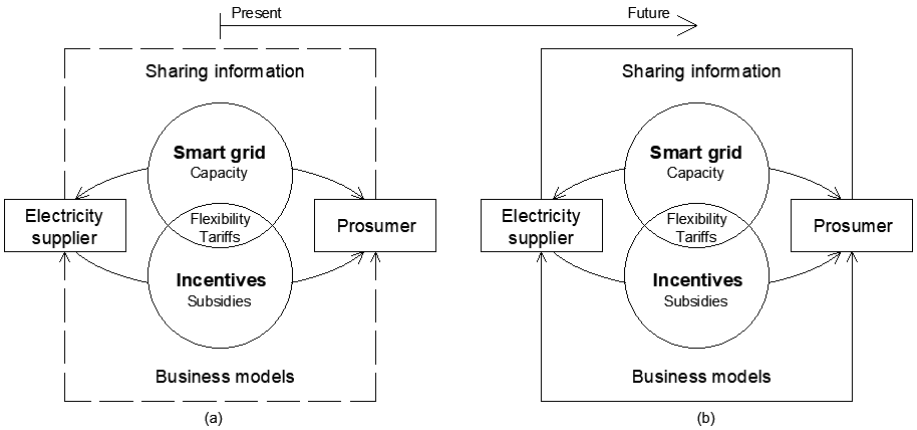


Figure 16: Investigation model.

5.2 Electricity supplier (*E.On*) perspective

E.On is an investor-owned energy company with approximately 79,000 employees, the previous 2019. The company headquarters are based in Essen, Germany. However, its operating units are present in several countries, such as Sweden, the United Kingdom, Czech Republic, Hungary, or Romania. *E.On* is focused on four business areas: Energy Networks, Customer Solutions, Innogy[16], and Renewables (E.ON SE, 2020). During the data collection phase, employees from Energy Networks and Customer Solutions segments were interviewed.

The Energy Networks segment, the distribution part of *E.On* (DSO), are operating the regional electricity networks safely and reliably, carrying out the maintenance and all type of needed repairs and/or expansions due to new customer connections (E.ON SE, 2020). The Swedish regional grid is a monopoly, mainly owned by three big companies, as it is described in section

[16] In September 2019, *E.On* took over Innogy Group. Since then, the organization is responsible of the network, the sales business, the corporate functions, and internal services. This business unit does not operate in Sweden. However, the integration of Innogy has resulted in *E.On* operating regulated distribution networks in eight with European countries, resulting one of the biggest DSO in the Europe (E.ON SE, 2020).

2.1 Electricity Supply Chain in Sweden. Independent on how or where the electricity system has to be changed to be functional for the future demand, the regional grid is in the middle of the transformation. The grid companies have to ensure that all kinds of customers and producers can be part of the system (J. Olsson, 03-12-2020). Several interviewees agree that *E.On*, as being one of the most important DSOs, has a significant role regarding the regulation of the future Swedish electricity market. They are contributing to the design by cooperating with the regulator, *Ei*, other companies, and customers. Feuk is an employee in *E.On* and member of the board of the association *SwedEnergy*, a non-profit industry with an interest in companies that supply, distribute, sell, and store energy (SwedEnergy , 2019). The aim of being part of this association is to influence as much as possibly can for achieving something fit for purpose (H. Feuk, 16-12-2020).

> *"We are trying to influence a lot. We are working and cooperating both with the authorities, Ei, the government for the supervision function in Sweden. We have a lot of contact with the authorities, of course, trying to cooperate on how the rules and conditions should be when it comes to the grid. (…) We are quite pleased, and it works quite well, as well. This Ei function well into this change of the market and they have a lot of on-going projects."*
>
> (D. Persson, personal communication, 05-01-2021)

The goal of being part of the regulation process is to ensure that the conditions for the DSOs will be profitable for the future. According to *E.On*, not only the future must have a profit level for the organization due to the investments the grid needs, but also the rules have to be good for the society and customers (D. Persson, 05-01-2021; J. Olsson, 03-12-2020).

> *"We are trying to make the society and the regulator understand that it must be a very long term, very competitive and correct profit level."*
>
> (D. Persson, personal communication, 05-01-2021)

The urgent need to change the electricity market is a common problem for the whole society, therefore is being discussed at the regulation level in Sweden. Persson states that all the players in the electricity market are positive and trying to solve all the questions that the future presents. Furthermore, the three big companies within the electricity market – *E.On*, *Vattenfall,* and *Elevio* – are positive about this kind of change. They are taking the responsibility needed for what needs to be done (M. Liljewall, 05-01-2021). However, there is not an answer, yet (D. Persson, 05-01-2021).

To achieve a competitive, reliable, and well-structured market design, Persson states that *E.On* has to look at other electricity markets where the company has projects going on inside Europe, such as Germany, Romania, or Hungary, to learn how the regulation has been built. As Feuk discusses, the business direction that *E.On* group wants to follow is according to what the headquarters in Germany decide, even though he agrees with the transfer of knowledge between different business units.

Even though the unit of Energy Networks in the UK was sold three years ago, *E.On* still keeps the Customer Solutions part in this country (J. Olsson, 03-12-2020). The UK was frontline at the beginning of the change of the energy market. Nowadays, the British regulator, OFGEM, is still

being proactive when it comes to finding new ways to evolve within the electricity market (J. Olsson, 03-12-2020). Therefore, according to Olsson, it is interesting for *E.On* to understand the British regulations for further discussion in Sweden's electricity market design. However, there is another point of view inside the company questioning that the UK market might not be a role model for the Nordic countries, as Sweden.

> *"The UK market has changed tremendously. I do not know if they are in advance compared to Sweden or not. They have some differences compared to Sweden. I do not know if they are going that way or to another. The UK is a little bit special compared to the Nordic market."*
>
> (D. Persson, personal communication, 05-01-2021)

As for the Customer Solutions, or retail division, its function is to supply customers with electricity, among other products and services that guarantee their energy efficiency and autonomy (E.ON SE, 2020). The electricity supplier location within the investigation model is plotted in Figure 17.

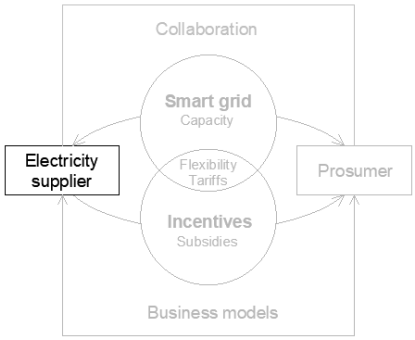


Figure 17: Investigation model with "electricity supplier" concept highlighted in black.

Only one out of the three interviewees, Feuk, is currently working in the retail division of *E.On*. Since some years ago, *E.On* Retail is interested in selling solar PV panels to the customers to help them to have their electricity facilities in their private households. The organization is taking advantage of solar PV interest within the market, which follows the sustainability mentality of *E.On*. The new solar PV facilities have to be connected to the local grid. Thus, the Energy Network segment must ensure that each household can be connected.

> *"We are selling PV plants as well. It is because there is an interest in the market, it is something we believe as well. We would like to push sustainability further in the market as well. But basically, a lot of customers, it has been accelerating a lot the last years."*
>
> (H. Feuk, personal communication, 16-12-2020)

Thus, *E.On* is taking part in the development of the future Swedish electricity market by being part of the discussions with the authorities.

Conclusively, *E.On* is trying to influence the authorities during the regulation phase of how the future electricity market must look like. The purpose is to ensure profitable incomes for the organization in the future, as well as advantageous conditions for clients, and with a sustainable mindset for society development. The Swedish unit of *E.On* is taking advantage of the lessons

learned at other markets, such as the UK, to have a baseline in which to get inspired for the new market rules. The future in electricity will involve distributed utilities installed in private households – i.e., solar PV plants –; the reason why *E.On* is currently using this increasing demand for selling PV plants around Sweden.

5.3 Smart grids

In this section is considered insights regarding smart grids and how their implementation can lead to solving the capacity issues the grid is facing, nowadays and in the future. In Figure 18 these concepts are highlighted in the investigation model.

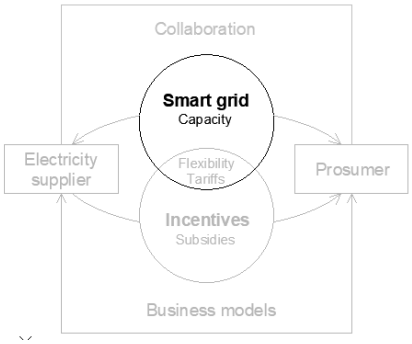


Figure 18: Investigation model with "smart grid and capacity" concepts highlighted in black.

5.3.1 Grid capacity

According to some reports (see section *2.2.2 Solar photovoltaic technology*) the capacity of the Swedish electricity grid is being challenged. Most of the interviewees agree that southern Sweden is the most challenging part of the country due to new urbanization (H. Feuk, 16-12-2020), heavy industry, and the transport sector (M. Liljewall, 05-01-2021). And the grid pressure will increase in the future (M. Liljewall, 05-01-2021). Regarding how solar PV facilities affect the grid, there are opposite opinions. Feuk states that solar PV facilities owned by prosumers are not a problem for the grid. But Persson argues that in the future, if Sweden experiences a growing number of this generation in private households, the pressure in the grid will also increase, leading to possible capacity complications. However, he also believes that the current situation, even though it is challenging, it is still manageable for the grid company.

> *"At the moment I think we can cope with it, with the levels we have now. But when we see growing numbers of solar panels this could be an increasing problem for us. In that case, we could do investments into the grid that could cope with this situation. But, right now, I think we can cope with it in the majority of states. It could be a future thing and it can also be a local thing."*
>
> (D. Persson, personal communication, 05-01-2021)

For solving this problem, the capacity of the grid has to increase. To achieve this goal, there are two different options: investing in the current grid with new cables or investing in smart grids. Even though the lack of clarity of the concept of the smart grid among the interviewees, its innovation aims to offer the customer flexibility to cope with capacity issues. All the interviewees state that both options have to be taken into account for achieving efficient electricity

management. However, Werner argues that, due to the oligopoly behavior of the electricity market, the big companies are more interested in investing in new cables rather than smart grids.

> *"You know it is a natural oligopoly[17], so maybe the 'grooms' are in favor of buying new cables (…). Right now, I think they get more money if they strength the net with more cables rather than if they implement smart technologies."*
>
> (A. Werner, personal communication, 05-12-2020)

Despite all opinions, the regulator authority, *Ei*, confirms that due to the challenging situation the Swedish grid is living in, there are currently some investments going on in the grid as well as several testing capacity markets and design of the frequency restoration reserves (M. Nilsson, 22-12-2020).

In Sweden, the electricity prices have been always low and with low volatility, partially removing the need for flexibility. The electricity generation in the country is mainly due to hydropower resources. During nights, the demand consumption decreases, and the water is staying in the utility. Thus, during the day, when the consumption is at its highest value, more hydropower can be used. Therefore, the prices are more stable (H. Feuk, 16-12-2020). Recently, Sweden has closed two nuclear plants in the south, and wind power plants are being built to replace the gap in generation (H. Feuk, 16-12-2020; M. Liljewall, 05-01-2021). Since then, the distribution companies started to prepare and reinforce the grid, from the north part of Sweden where the wind facilities are located, for achieving the required capacity level (M. Liljewall, 05-01-2021). However, as Feuk states, wind and solar electricity generation are not stable. Thus, the incentives for capacity will ensure the supply of electricity when there is a lack of wind or sun.

Therefore, the predictable capacity problem has increased the flexibility need. From *E.On* site, they argue that the company is already working with designing and building a smarter grid for offering flexibility to the customers. Nevertheless, Olsson states that Sweden has had a smarter grid for some years since the first smart meter installation which enabled hourly metering (H. Feuk, 16-12-2020). Feuk affirms that the DSOs have been always working with flexibility by, for example, regulating the frequency. The big change in the future is the management of the bottle necks – or capacity problems – within the grid.

> *"You are able to get hourly supply contracts. Already today you can shift and say, I am using the washing machine during the night instead because the electricity is cheaper. This is something you have been able to do in Sweden for quite some years now."*
>
> (H. Feuk, personal communication, 16-12-2020)

However, the flexible market is still not available in Sweden (H. Feuk, 16-12-2020). Currently, there is a project going on, known as SWITCH[18]. The works take place in collaboration with the EU-funded project CoordiNEt, which also includes *Vattenfall*, *Svenska kraftnät* (E.On

[17] A. Werner uses the word monopoly. According to the Cambridge Dictionary, a "*monopoly is an organization or group that has complete control of something, especially an area of business, so that others have no share*". The electricity market is not a strict monopoly, but an oligopoly. Therefore, the word has been changed. An oligopoly is a "*situation in which a small number of organizations or companies has control of an area of business, so that others have no share*". (source: https://dictionary.cambridge.org/dictionary)

[18] More information about SWITCH project: https://www.eon.se/foeretag/elnaet/switch

Energidistribution, 2020), and *Kraftringen (*M. Liljewall, 05-01-2021). The project aims to find out how flexibility works in the electricity market. How the customers can be part of this change to help the electricity supply chain in capacity issues (J. Olsson, 03-12-2020).

> *"We have a lot of projects going on, testing different techniques, measuring the energy flow in different parts of the grid, and getting into calculations in how to optimize the use of the grid, going from a more static dimension to a more dynamic one. (…) The main message is that there are a lot of projects going on, but it is still not commercial."*
>
> (J. Olsson, personal communication, 03-12-2020)

Nonetheless, *E.On* employees also remark that the distribution company needs clear incentives to make the grid smarter, which will enable flexibility on the customer side (J. Olsson, 03-12-2020; D. Persson, 05-01-2021). There is no profitability in doing the grid smarter since there are no incentives for the distribution company (D. Persson, 05-01-2021). However, the Swedish regulator authority, *Ei*, is aware of the lack of incentives, even though there is no solution, yet (D. Persson, 05-01-2021).

Due to the uncertainty of the investment in smart grids, *E.On* is also investing in the grid by laying more cables and overhead lines to increase the capacity (D. Persson, 05-01-2021). Nowadays, the main income of a DSO is by doing investments (H. Feuk, 16-12-2020). However, Olsson argues that if you invest a lot in new grids, maybe in the future with flexibility methods being a reality, the grid will have too much capacity. The plan, design, and execution of building or reinforcing the grid is a slow procedure. Feuk argues that it might take at least 10 years, a claim that also Liljewall agrees on.

The investment for a smart grid is also being carried out at the transmission level, which has a lot of bottle necks (H. Feuk, 16-12-2020). According to Nilsson, an employee in *Ei*, large projects are going on and more of them are planned within the transmission grid to face the increasing and intermittent demand and generation.

Currently, if a customer is installing a solar PV facility at their household and the grid does not have enough capacity to absorb the electricity injected, the DSOs have the responsibility to increase that local grid capacity (G. Bryntse, 04-12-2020). The Swedish regulation declares that, if the facility is for a small household, the cost of the grid investment has to be spread out within the customers (D. Persson, 05-01-2021).

Fundamentally, the lack of capacity of the Swedish grid is faced by both, investing in the reinforcement of the grid and the implementation of smart grids. However, the unanimous claim of the different stakeholders is that more incentives for triggering smart grid investments are needed.

5.3.2 Grid management

In section *3.1.1 Supply Chain Strategies*, it is discussed how the electricity supply chain is evolving due to renewable sources, according to the recent literature. The increasing electricity generation coming from renewable sources challenge the electricity distributors and suppliers to deal with the uncertainty and intermittency of this generation (M. Nilsson, 22-12-2020). However, Werner states that renewables sources, such as solar PV utilities, do not have a high

impact on demand uncertainty because the impact they have on the whole electricity supply chain is low.

> *"Imagine when you have a problem with a nuclear plant. Then you do not have the energy for half a year when they have to fix it. It is just a different uncertainty. Because you know, after the rain there is always sun."*
>
> (A. Werner, personal communication, 05-12-2020)

The customer expects to receive the same electricity availability and quality (J. Olsson, 03-12-2020) since more generation will be needed to satisfy the future electricity demand (J. Olsson, 03-12-2020; A. Werner, 05-12-2020). According to Nilsson, the demand uncertainty is increasing due to its intermittency. However, from *E.On* site, the demand is a parameter easy to forecast (H. Feuk, 16-12-2020), leading to a low grade of demand uncertainty.

> *"I think we will see an increasing number of renewable generation but not a decrease in availability and quality. So, that is a big challenge for us."*
>
> (J. Olsson, personal communication, 03-12-2020)

Therefore, the different stakeholders forecast an increasing value of electricity demand in the future. The opinions regarding its demand uncertainty are not unanimous, depends on the role of the player. However, the uncertainty of renewable sources generation is a statement which all interviewees agreed on, even though one of them remarks that its uncertainty has a low impact on the whole electricity supply.

5.4 The electricity market in Sweden: incentives and tariffs

The current Swedish electricity market is changing due to different market needs and new regulations that have to be followed. Therefore, tariffs and subsidies are also evolving in parallel. The following points describe which is the relationship between tariffs and flexibility, which are the current subsidies that a prosumer can expect. Finally, how both, tariffs and subsidies, can influence the development of new business models.

5.4.1 Tariffs

5.4.1.1 Flexibility and tariffs

In the previous section, *5.3.1 Grid capacity*, the interviewees agreed with the fact that the flexible market is not available in Sweden, yet. From *E.On* point of view, nowadays the impact that prosumers have in their organization is low. This has led the company to a poor time-investment in creating new tariffs that incentivize flexibility.

> *"E.On as a supplier, it is a huge difference if we have 1000 customers that are prosumers or 100000, because it has much more impact and then you need much more precise."*
>
> (H. Feuk, personal communication, 16-12-2020)

The current tariff that consumers can contract has either fixed or variable prices (H. Feuk, 16-12-2020). According to Feuk, some of the customers have variable prices, where you pay a

monthly average of the spot price[19]. This type of contract enables the client to use flexibility by consuming more when the price is lower and less when the electricity has its higher cost (Figure 19). But, *E.On* also give the opportunity to pay for hourly prices, even though it has not a high demand (H. Feuk, 16-12-2020).

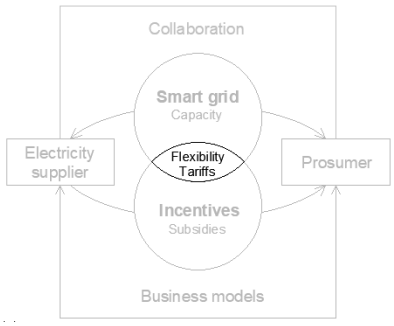


Figure 19: Investigation model with "flexibility and tariffs" concepts highlighted in black.

As is detailed in the previous section, the electricity price in Sweden is low. Therefore, the customers are used to have the same electricity price all the time, without distinguishing any period (A. Werner, 05-12-2020). *Svensk Solenergi*'s opinion is that the customers want to continue with the same price method, therefore the electricity suppliers are afraid to change (A. Werner, 05-12-2020), lowering the evolution of the electricity market.

> *"They do not want to get a bad reputation. There are companies who did that and they got a lot of upset consumers."*
>
> (A. Werner, personal communication, 05-12-2020)

Even though the theory discusses the relationship between tariffs and business models (see section *2.4.2 Prosumers business models in the* UK), it has not been possible to find out any relation along with the interviews.

In a conclusion, the flexible market is coming and with it, the tariffs that electricity suppliers can offer to the consumers. Therefore, the network tariffs can affect the design and type of investments in the future of the grid (M. Nilsson, 22-12-2020).

5.4.1.2 Tariffs and business models

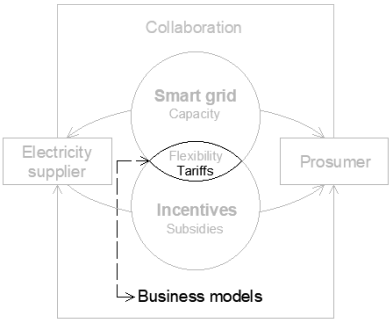


Figure 20: Investigation model with "tariffs and business models" concepts highlighted in black.

[19] The spot price is the current price in the marketplace at which a given asset can be bought or sold for immediate delivery (Source: https://www.investopedia.com/terms/s/spotprice.asp).

The relation between tariffs and the development of new business models (concepts highlighted in Figure 20) is, according to Feuk, determined by the installation of batteries in private households. In the short future, when the batteries have more presence, the consumers will be more alike to be flexible and contract variable prices.

> *"So, then, of course, you could benefit from more hourly price where you actually can use your battery (…). I think then you benefit more from the variable price. If you have a fixed price over the year, you do not really have any incentive to be flexible."*
>
> (H. Feuk, personal communication, 16-12-2020)

Nowadays, a low percentage of the Swedish population has batteries installed, even though Feuk ensures that you can get grants for its installation. Today the prosumers that sell the surplus electricity to the grid, receive a tax deduction. However, the lack of incentives for batteries is, again, a bottle neck. (H. Feuk, 16-12-2020)

Therefore, it is not clear how the tariffs can change the behavior of the electricity market or how they can influence the development of new relationships between electricity suppliers and prosumers.

5.4.2 Incentives and subsidies

In section *2.4.1 Support policies* are discussed the different economic initiatives Sweden has had since 2018. Along this section, the interviewees argue which kind of incentives trigger the prosumers the most for investing in solar PV utilities (Figure 21).

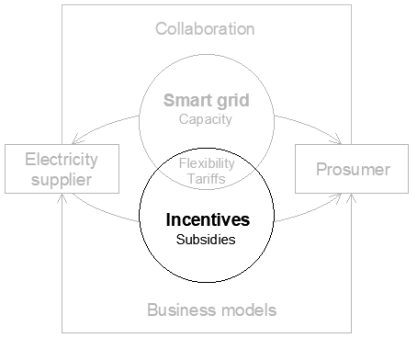


Figure 21: Investigation model with "incentives and subsidies" concepts highlighted in black.

Even though during the theoretical framework of the thesis only economic incentives are considered, some interviewees stated that there are two types: the economic incentive, also known as a subsidy, and the ethical incentive (H. Feuk, 16-12-2020; M. Liljewall, 05-01-2021).

5.4.2.1 Economic incentives

In the theoretical framework, six different economic incentives are presented (listed in Table 1 in section *2.4.1 Support policies and incentives*): (1) FiP, (2) Capital subsidy, (3) Green Certificate or GC, (4) Guarantee of Origin or GO, (5) Grid compensation, and (6) Self-consumption.

All the interviewees agree that the situation in 2021 is good for self-consumption solar PV utilities. Since the 1st of January exists a tax deduction[20] for facilities with a production of a maximum value of 500 kW (G. Bryntse, 04-12-2020). Thus, the prosumers will perceive less income tax at the end of the year due to the solar PV system installed at their rooftop (A. Werner, 05-12-2020). The authorities have increased the amount of electricity generation, from 255 kW to 500 kW, a prosumer can self-consume and avoid paying taxes for it. Therefore, the big solar utilities (or any other renewable sources) still have to pay taxes (A. Werner, 05-12-2020). For Feuk, the tax deduction is the basic financial incentive existing nowadays in Sweden.

The capital subsidy is an incentive for private producers where they receive government support for a one-time contribution to the installation of all types of network-connected solar cell systems (Deloitte, 2020). According to Nilsson and Liljewall, it is the best kind of subsidy for triggering customers to invest in solar PV facilities. With this subsidy, the payback time of the investment has a value between 10 and 15 years, acceptable for some private investors (H. Feuk, 16-12-2020, M. Liljewall, 05-01-2021). However, the steps that have to be followed to receive the money are numerous and not easy (H. Feuk, 16-12-2020). Liljewall claims that the system should be easier, faster, and unanimous in the whole country.

> *"Sweden, I think, it is the world championship in messy administration and authorities they do everything by the book. I think it could be easier to apply for these subsidies and it should be the same in the whole country. As it is now, I think it depends on the resources its region has (…).*
>
> (M. Liljewall, personal communication, 05-01-2021)

Nowadays, first, you have to build the facility and then, maybe a couple of years later, you can get a percentage of the money back. Until now, all the people who have asked for this subsidy has received it because the government has put a lot of money into the system (H. Feuk, 16-12-2020).

Last December 2020, the Swedish government decided to cut the line of the private individuals that had already applied for the capital subsidy (M. Liljewall, 05-01-2021). According to the Swedish Energy Agency, there are about 9,000 applications from private individuals that have been banished from the subsidy[21]. The expected budget for these banished applications was around 900 SEK[22]. The government will allocate 260 million SEK to grant previous applications from municipalities, companies, and associations. However, they will only receive the 10% of the installation value instead of the 20% as it was promised when they applied for the subsidy[20]. Instead of the capital subsidy, a green tax reduction is set up for private individuals (A. Werner, 05-12-2020; Regeringskansliets, 2020). This new incentive has a deduction of 15% of the labor and material costs for PV systems and a 50% of the labor and material costs for installing

[20] In Table 1 from section *2.4.1 Support policies and incentives,* this economic incentive is known as "self-consumption".

[21] Information gathered from the article "*Regeringens besked om solcellsstödet: fortsatt stopp för företag att ansöka och privatpersoner stryks ur kön* (22-12-2020)", provided by M. Liljewall after the interview conducted the 05-01-2021. (Source: https://solcellskollen.se/blogg/regeringens-besked-om-solcellsstodet-fortsatt-stopp-for-foretag-att-ansoka-och-privatpersoner-stryks-ur-kon)

[22] Information gathered from the article "*Stopp för stöd till solceller: Pengarna räcker ej till dem som står i kö* (18-12-2020)", provided by M. Liljewall after the interview conducted the 05-01-2021. (Source: https://www.hsb.se/nyheter/nyheter-2020/stopp-for-stod-till-solceller-pengarna-racker-ej-till-dem-som-star-i-ko/)

batteries. The maximum value of this deduction is up to 50,000 SEK/person_year and is only applicable for houses built in the last 5 years (Wallnér, 2020).

The GC, according to Liljewall, is not an important subsidy for prosumers, as also agree on the Swedish Energy Agency in the report written in 2018 (see Table 1 in section *2.4.1 Support policies*). The money a prosumer can receive for selling them is almost zero (H. Feuk, 16-12-2020). Feuk states that this financial incentive will disappear next year.

A similar incentive is the GO, bought by the supply company (D. Persson, 05-01-2021). Some interviewees disagree with considering the GO as an incentive or a market arrangement due to its small value compared to the electricity ordinary price.

> *"I would not call GO a subsidy. (…) is something you get for all types of generation."*
>
> (H. Feuk, personal communication, 16-12-2020)

The value of this electronic document is around 0.2 €/MWh, thus according to Feuk, it has not a real impact on the electricity market. However, for some interviewees even though the low market value, it can make a difference for some prosumers (M. Liljewall, 05-01-2021, D. Persson, 05-01-2021).

The consumers who are injecting electricity into the grid are benefiting the grid, hence the DSOs compensate them with a value of 0.05 SEK/kWh. The injections the prosumers do, help the DSO in two aspects. Firstly, they reduce grid losses due to electricity transportation. Secondly, their injection into the regional grid makes the DSO more independent of the TSO, owner of the national grid (D. Persson, 05-01-2021). However, according to Persson, the current problem within the Swedish electricity market is how DSO compensates the capacity contribution of the prosumers. It should be better compensated for triggering the prosumers to use the grid more smartly.

> *"The thing that needs to be complemented is how you contribute with the grid benefits and capacity benefits. That needs to be better valued. That is the problem of the market of today."*
>
> (D. Persson, personal communication, 05-01-2021)

The new EU legislation package[23], currently being interpreted by the *Ei* and coming in a short-term future, will establish how the electricity market has to face flexibility. The national authorities of each country have to adapt the European legislations to their electricity market. Thus, it might force the Swedish authorities to regulate how to compensate flexibility (D. Persson, 05-01-2021).

Finally, the prosumers get money for the electricity they inject into the grid by selling it to any electricity supplier. For example, *E.On* buys the surplus of electricity from the clients with a price of, approximately, 0.58 SEK/kWh (D. Persson, 05-01-2021). Due to the increasing solar PV facilities in private households, Persson argues that the future of this subsidy is not guaranteed. Furthermore, he believes there is an incentive problem. With the current system, you sell the

[23] For more information about the EU legislation package: https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

electricity at the same price the whole day. Hence, the production during the most challenging times in the day is not incentivized.

> *"Today it is all the same during all hours of the day. That could be quite of an incentive problem. You are not incentivizing to limit or increase production."*
>
> (D. Persson, personal communication, 05-01-2021)

Therefore, Persson states that the authorities have to work with regulations that let them adjust the price they buy the electricity from the prosumers during the day.

> *"(…) may be higher during the day and lower during the night. Something that incentives us to lower our consumption more during the day and increase during nighttime."*
>
> (D. Persson, personal communication, 05-01-2021)

5.4.2.2 Ethical incentives

The ethical incentives remain to be one of the most important for triggering the prosumers to invest in solar PV plants. The main reason is that people want to support sustainability (H. Feuk, 16-12-2020), they want to be part of the change of the whole electricity supply chain value by producing their energy (M. Liljewall, 05-01-2021). Liljewall states that this motivator will keep being a particularly important incentive for customers of all ages in the future.

> *"When I first started with this business, I thought it would only be really young and the people with big dreams for the future and so on. But you can see that a lot of older customers make the step. And you think, are you really going to stay in this house for so long that you will actually benefit from the payback. But they think further ahead, generations ahead. I think that's a really remarkable thing."*
>
> (M. Liljewall, personal communication 05-01-2021)

5.4.2.3 Subsidies and business models

The relation that subsidies have with the development of new relationships between electricity suppliers and prosumers is not clear within the interviewees. Feuk states that subsidies are a mechanism that will disappear in the future. Therefore, their role in the future electricity market development might be uncertain.

5.5 Prosumers in Sweden

This section describes the opinion of each interviewee regarding the prosumer's role in Sweden (see prosumer's concept plotted in Figure 22); from barriers that prosumers find in the current electricity market to different business model architectures that will build the future electricity supply chain.

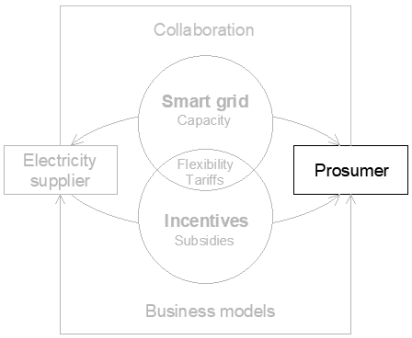


Figure 22: Investigation model with "prosumer" concept highlighted in black.

During the interviews, it was discussed the advantages and disadvantages of being a prosumer nowadays in the Swedish electricity supply chain.

Firstly, the compensation the prosumers receive for injecting electricity into the grid is favorable for them (G. Bryntse, 04-12-2020; M. Liljewall, 05-01-2021). Besides, Liljewall remarks that the electricity suppliers, as *Kraftringen*, want to please the customers, so the prices they buy the electricity to the prosumers are good.

Second, the new green tax deduction combined with the continuous lowering prices of the solar PV cells is good for the prosumers and it will be in the future too (A. Werner, 05-12-2020).

> *"We have something called the green deduction, that will go on for a long time, but we will not get more than that. And prices have gone down so, I think we are happy with that. It is a stable system. It will be a good system."*
>
> (A. Werner, personal communication, 05-12-2020)

Third, from the DSO point of view, the current situation in which the small producers do not have to pay for the whole connection cost (H. Feuk, 16-12-2020), is also an advantage for prosumers. Nowadays the cost has to be collectivized (D. Persson, 05-01-2021). However, Bryntse claims that there should not be any costs for connecting your sun utilities to the grid[24]. He argues that sometimes is more profitable for the prosumer not to have facilities because the connection cost is higher than the value the prosumer receives for the electricity injected into the grid.

Continuing with the distribution companies, all types of consumers have to pay a fixed charge for the maintenance of the grid – UoS –, independently on how much they consume (G. Bryntse, 04-12-2020). The chairman of SERO, states that there should not be any fixed charge, it should be charged only depending on the consumption.

> *"The fixed charge is really high, and it is unfair for people who have an apartment for instance who consume 2000 kWh per year because most of the cost for this is the fix connection price that the companies ask for."*

[24] There are some wind private facilities of 2 MW instate of 1.5 MW. Hence, the prosumer might pay 100 times more for the connection to the grid. Therefore, some prosumers prefer to disconnect some wind turbines in order to produce less electricity and wait until the income they receive from selling the surplus is advantageous (G. Bryntse, 04-12-2020).

(G. Bryntse, personal communication, 04-12-2020)

Fourth, some of the interviewees agree on the fact that the lack of subsidies in the Swedish market goes against the prosumer's growth, considering it a barrier for the private solar PV market development (A. Werner, 05-12-2020; M. Liljewall, 05-01-2021). Also, the bureaucratic process a prosumer has to follow for achieving these subsidies is long and not easy, even though companies as *Kraftringen* offers help with all the steps (M. Liljewall, 05-01-2021). However, Werner points out that this year, 2021, will be a better market for solar PV prosumers – due to the new green tax deduction. Nonetheless, *E.On* retail's opinion is the opposite, arguing that the lack of subsidies is not a barrier because the number of new installations is growing (H. Feuk, 16-12-2020).

> *"I do not really see any barriers. I think it is growing. Still, we are quite at a very low level in Sweden when it comes to PV, especially if you compare it to Spain or Germany. Because we have never had these huge subsidies and feed-in tariffs that you have had in some other countries."*

(H. Feuk, personal communication, 16-12-2020)

Fifth, as it has been pointed in previous sections, the Swedish electricity price is low, leading to a longer payback time for solar PV investments (M. Liljewall, 05-01-2021), a clear barrier for new solar PV private facilities. Furthermore, the current pandemic situation might have both effects; increase the solar PV demand or decrease it. According to Liljewall, since people have to stay at home more often, they are investing in their homes. Hence, it might be that in the short-term future more people decide to invest in solar PV facilities.

Finally, the Swedish electricity market is an oligopoly mainly dominated by 3 big companies. Hence, the prosumers have to fight for their interest against these companies (G. Bryntse, 04-12-2020), which can influence the market due to its collaboration with the national authorities (see section *5.2 Electricity supplier (E.On) perspective*).

However, the electricity suppliers' employees interviewed, also claim to have disadvantages with prosumers consuming their self-generated electricity. On one hand, the solar PV prosumer is buying less electricity during summer and buying more during winter. Since the electricity price is usually cheaper in summer than in winter, Feuk states the following:

> *"The average price should be a little bit higher from the supplier to the prosumer, as they buy less when prices are low and buy more when prices are high."*

(H. Feuk, personal communication, 16-12-2020)

For now, since the variation on prices is low and also the prosumers volume, the impact they have to *E.On* income is not extremely important. Thus, it has not been in focus for the organization (H. Feuk, 16-12-2020). On the other hand, *Kraftringen* remarks that buying the surplus electricity from the prosumers is currently a loss for the company. The main reason behind this is that the company cannot sell the electricity to the market at the same price (M. Liljewall, 05-01-2021). Liljewall states that even though *Kraftringen* losses money with the electricity purchase from prosumers, they do it because is the way the company has to help the development of a more sustainable energy system in Sweden.

5.6 Collaboration between prosumers and electricity suppliers

The following sections describe the stakeholder's opinions regarding three different elements of collaboration (see Figure 23): (1) Information sharing, (2) Decision making, and (3) Earning trust.

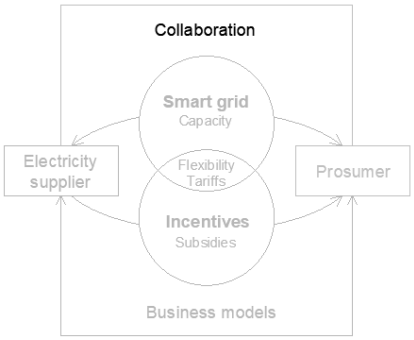


Figure 23: Investigation model with "collaboration" concept highlighted in black.

5.6.1 Information sharing

In the short-term future, due to the smart grid implementation, the prosumer – and consumer – will get more information regarding prices. Consequently, the prosumers will be able to increase or decrease the production according to their interest (A. Werner, 05-12-2020). According to Feuk, the quality and quantity of the information shared will earn more importance with the future flexibility market.

> *"(…) you need much more real-time data to be able to provide flexibility and sell flexibility."*
>
> (H. Feuk, personal communication, 16-12-2020)

5.6.2 Decision making

Regarding the decision making the prosumers have in the electricity supply chain, there are two different opinions.

On one hand, there are grid companies owned by municipalities, for example, *Kraftringen*. The parties are represented on the board of these companies pointing out which direction should be taken (M. Liljewall, 05-01-2021). Thus, when there are elections at the municipality level, the citizens can vote for a party that defends their interests in the board (A. Werner, 05-12-2020). However, a direct influence is not possible (M. Liljewall, 05-01-2021).

On the other hand, from *E.On* point of view, a prosumer representing himself does not have much power in the decision making, maybe can influence a little bit (H. Feuk, 16-12-2020). However, according to Feuk, if there is an association of prosumers, their voice might be more important to consider.

> *"(…) one house it really doesn't matter but if it's a lot of them it makes much more difference."*

(H. Feuk, personal communication, 16-12-2020)

5.6.3 Earning trust

According to Werner, the level of trust the prosumers have in electricity suppliers is low. She points out that the DSO also has a bad reputation due to its monopoly behavior. However, its popularity and trust of the clients are earned when the company is trustworthy when it comes to the power supply (H. Feuk, 16-12-2020).

Therefore, measures to increase the prosumer's trust could be having good customer service with employees willing to help the clients or offering good tariffs with flexible prices (A. Werner, 05-12-2020). Feuk states that, apart from fair pricing, the electricity suppliers should also be able to offer a useful user interface for the customers to use, as well as the traditional customer service by telephone.

5.7 Business models types

The relationship between prosumers and electricity suppliers determines the different business models. This section describes the business models the interviewees commented on during the data collection phase.

5.7.1 Basic prosumer

Nowadays, the most common business model is the basic prosumer (A. Werner, 05-12-2020; H. Feuk, 16-12-2020; M. Nilsson, 22-12-2020; D. Persson, 05-01-2021). The concept behind this architecture is simple; a private solar PV utility has to have a supply contract with an electricity supplier. If the prosumer has a surplus, when there is more generation than consumption, the electricity supplier purchases the electricity excess. So, when the prosumer needs more electricity than he can generate himself, he has to buy it from the retail company (H. Feuk, 16-12-2020).

Usually, the electricity suppliers have deals where they offer to buy the surplus of electricity, but in exchange, the prosumer has to have them as the retail company (A. Werner, 05-12-2020; M. Liljewall, 05-01-2021). Sometimes these deals offer to the client a good spot purchasing price but the price that the prosumer pays for the electricity coming from the grid is not so good (A. Werner, 05-12-2020).

> *"It is a package deal. It is difficult to see what you really pay. We call it 'bundling'; when you put together many different things in a deal. They are bundling the buying and selling.*
>
> (A. Werner, personal communication, 05-12-2020)

According to Persson, the most common deal between the two interesting parts can be, the spot price with some adding on or a deduction on the spot price. The option of having fixed price arrangements is mostly used by bigger producers (D. Persson, 05-01-2021).

Currently, all prosumers must be connected to the grid, otherwise, they cannot apply for any subsidies (A. Werner, 05-12-2020). Thus, the electrical installation requires two meters, one for consumption and the other one for production (H. Feuk, 16-12-2020). It is forbidden to have net

metering[25]. Thus, the prosumer will always be able to compare the grid consumption, in which he has to pay electricity taxes (H. Feuk, 16-12-2020), versus the generation (D. Persson, 05-01-2021).

However, during the interviews, some deficiencies have been noted with this business model design. First, there is the need to find a solution for the period of the year when the sunlight is low and, consequently, the solar PV generation. Bryntse proposes the exchange between hydropower and solar power, further described in section *5.7.3 Hydropower for solar power*. Second, there is the possibility that consumers, aiming to be prosumers, own apartments that are part of a larger building not suitable for the installation of solar PV panels (M. Liljewall, 05-01-2021). It can be difficult for them to have a solar PV facility on the building's rooftop (H. Feuk, 16-12-2020). Feuk states that has to be developed other types of arrangements rather than the one that a private prosumer owns a solar PV facility.

> *"It is difficult for people living in flats because you do not have the same opportunity to have a PV on your roof. To find similar solutions maybe you have a share in a larger PV plant. This is not possible today, but there are some discussions if you should make this possible."*
>
> (H. Feuk, personal communication, 16-12-2020)

Liljewall proposes to install more solar PV facilities to the buildings suitable for them and share their costs and generation between different customers. However, she also remarks that the current electricity tax is difficult to arrange.

5.7.2 Aggregator

According to Feuk, in Uppsala[26], there is a different entity in the electricity market known as an aggregator, currently being tested. An aggregator is an electricity supplier who is aggregating several consumers or prosumers for being able to trade in the electricity market (H. Feuk, 16-12-2020).

Uppsala has had a lack of capacity in its transmission and distribution grid due to the increasing number of citizens living there. Therefore, an aggregator can gather flexible resources to sell them collectively to the power market. The aim is to effect flexibility to the market with municipal companies and administrations, test how an aggregator can affect flexibility, and engage other local players to participate in the electricity market (Uppsala kommun, 2020).

This business model in Uppsala municipality is being developed within the CoordiNet project until 2022.

[25] Net metering: when consumption and production are measured as two separate values (D. Persson, 05-01-2021).

[26] For more information about the Uppsala project go to Uppsala kommun webpage: https://www.uppsala.se/kommun-och-politik/sa-arbetar-vi-med-olika-amnen/sa-arbetar-vi-med-miljo-och-klimat/eu-projektet-coordinet/

5.7.3 Hydropower for solar power, and vice versa

This business model type, according to Bryntse, has been implemented for a company located in the middle of Sweden, *Jämtkraft*[27]. The functioning is based on the hydropower reservoirs Sweden has available. The company offers to the prosumers the exchange of their amount of electricity generated by solar PV sources (kWh) during the summer, for electricity from hydropower facilities (also kWh) during winter. Therefore, there is no money transfer from the electricity supplier to the prosumer, but an exchange of kWh. (G. Bryntse, 04-12-2020)

Bryntse states that this method is advantageous for the prosumer because the electricity has higher prices during winter. Therefore, the big companies are not interested (G. Bryntse, 04-12-2020). From *E.On* Retail point of view, this is not a business model but an administrative set up (D. Persson, 05-01-2021).

> *"That is just a trading agreement (…). In reality, of course, it is not like that. It is just a supply company guaranteeing you a fixed price for something during the winter. It is just a marketing thing to do."*
>
> (D. Persson, personal communication, 05-01-2021)

However, Liljewall, also representing an electricity supplier organization, remarks that is an interesting development, even though she believes that this business model must be in the very front line of testing.

5.7.4 Virtual arrangements

An alternative of a basic prosumer architecture but with a different perspective is, according to Feuk, the virtual arrangement. The main difference is that, if a prosumer has a surplus of electricity, he can sell it "directly" to the neighbor, in a virtual form. However, due to market limitations, the surplus has to be injected into the grid. Hence, the person who is buying the electricity still has to pay taxes for the use of the distribution grid (H. Feuk, 16-12-2020) because the connection between two houses will still be owned by the grid company (D. Persson, 05-01-2021).

> *"It is basically that I am selling to the market and my neighbor is buying from the market. Then, virtually you could say that he is buying from me. Because the electricity still has to go to the grid and you still have taxes (…). You cannot avoid that.*
>
> (H. Feuk, personal communication, 16-12-2020)

Therefore, the main difference is that the private electricity purchaser – or consumer – knows where the electricity comes from (H. Feuk, 16-12-2020).

5.7.5 Decentralized power market

According to Liljewall, some years ago, the Swedish electricity market tried to develop the decentralized power market incentive. So, an electricity retailer central market would centralize all the purchases from the consumers. Thus, the consumers would only have contact with the

[27] Company webpage: https://www.jamtkraft.se/privat/

electricity supplier, and not with both, retail company and DSO. However, due to several delays in the regulation, this business model has never been applied.

> *"The changes in the Swedish laws to make this happened have been delayed for many years now. It has taken so long that now people are saying that it is too late anyway, so let us move on to something else."*
>
> (M. Liljewall, personal communication 05-01-2021)

Besides, Liljewall also argues that a possible reason why this new regulation never arrived at the market might be, due to the different opinions within the Swedish electricity market, or the influence the big companies have inside the regulation authorities. But, contrary to the statement mentioned before, she strongly believes that the three bigger ones in the market are on board with a change.

5.7.6 Energy communities

During the conducted interviews, a concept came up: local or energy communities (D. Persson, 05-01-2021; A. Werner, 05-12-2020; G. Bryntse, 04-12-2020).

From *E.On* side, Persson states that the organization is waiting for a further definition of the concept of energy community from the regulator side (A. Werner, 05-12-2020). At present, *Ei* is working to interpret the new EU legislation package. The European directives include the energy communities as a new business model scheme that each country will be able to implement (A. Werner, 05-12-2020) in 2 or 3 years (D. Persson, 05-01-2021). However, there is a unanimous claim regarding the ambiguity of the definition the European directive does. *Svenska Solenergi*, after the interview, provided a document where the association discusses the *Ei*'s report with proposals for the implementation of EU legislation. This document is further analyzed in section *6.4 Business models development*.

5.7.7 Off-grid solutions

Even though off-grid solutions are not in the scope of this thesis, during the interview with Bryntse representing the prosumer side of the electricity supply chain, he states that Sweden has a good distribution grid, reason enough to take advantage of it by using it.

6 Analysis

This chapter presents the analysis of the thesis. The findings of the previous chapter, 5 Empirical study, and their connection to the theoretical framework.

6.1 Introduction to the analysis

At the beginning of the thesis, two research questions are formulated, and an investigation model is designed (see Figure 16).

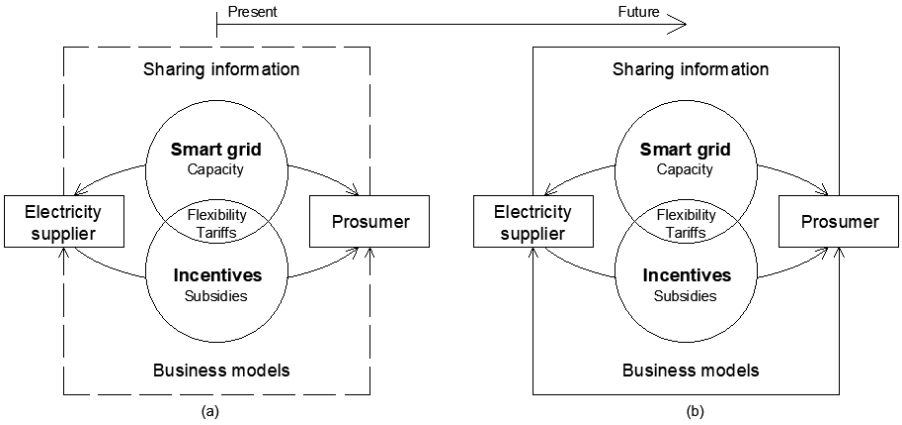


Figure 16: Investigation model.

Thus, the purpose of the thesis is to analyze and describe how is the current situation in Sweden regarding the management of the bi-directional flow of electricity due to solar PV prosumers and how does it challenge the capacity of the grid. Consequently, the current and future business models between prosumers and electricity suppliers are also being analyzed. The aim is to find out what to expect in terms of different schemes, incentives, and collaboration between the chain members.

6.2 Electricity suppliers Supply Chain Management

The local grid, as the connection network between the regional grid and the end-consumer, is the first step in the electricity supply chain that has to deal with the bi-directional flow of electricity (see Figure 24). In section *3.1 Supply Chain Management,* an extensive definition of SCM is undertaken. Thus, it is noted that one of the most important goals of SCM is to achieve an efficient and effective supply chain, integrating all business processes for adding the maximum value for customers and stakeholders.

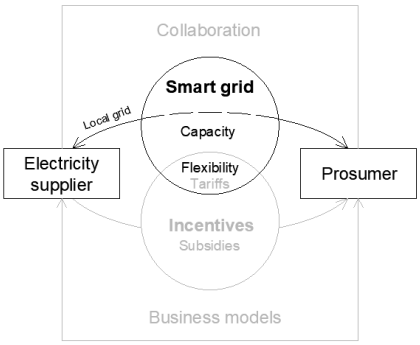


Figure 24: Investigation model highlighting the relation between electricity suppliers and prosumers, connected by the local grid

In Sweden, as is pointed out by several stakeholders, the grid is currently challenged in terms of capacity. In the future, there is the prevision that it will be even more challenged and, as some interviewees pointed, the increase in distributed solar PV facilities might be one of the reasons. Especially if these facilities are installed in areas where the grid has not been reinforced – i.e., rural areas. This situation might lead to possible outbreaks and, consequently, an inefficient and/or ineffective supply.

However, both Swedish authorities and DSOs are taking measures to reverse the situation by investing in reinforcing the grid and/or making it smarter. The direction of the investment is not clear, therefore *E.On* Distribution claims that more incentives are needed to trigger the implementation of smart grids in the country (see section *5.3.1 Grid capacity*). The goal of having a smarter grid is to be able to use flexibility as a means to avoid or delay large investments in increased grid capacity (IVA, 2017). In addition, a flexible market will help the electricity distributors – owners of regional and some local grids – to cope with the grid overloading at some periods of the day. But the flexible market is still not a reality. In the short-term future, the electricity suppliers will be able to offer flexible tariffs to prosumers.

Sweden's Future Electrical Grid report (2017) stated that user flexibility will not have a high impact to reduce the amount of capacity needed. However, the use of batteries as a method of local energy storage will have a greater impact on the grid dimension. The same report argues that the battery prices are currently falling, and the use of this storage system will enable the management of local power peaks. (IVA, 2017)

The current situation of several producers distributed around the territory has triggered the electricity supply chain to evolve. In section *3.1.1 Supply Chain Strategies* is stated that the literature considers the new electricity supply chain with a more risk-hedging strategy, characterized by having high supply uncertainty and low demand uncertainty (Salvi, 2020). However, the reality seems to be another one. Even though there is a clear statement that the electricity demand will increase in the future – 1 TWh or 40 TWh between the years 2013 and 2030 (IVA, 2017) due to electric vehicles, electric roads, etc. –, the demand behavior is not that clear. It can be easy to forecast – an opposite statement to the one Salvi (2020) makes in his article – but, at the same time, more intermittent in time. The final demand behavior will be seen when all the variables currently changing are stabilized.

As for the supply, from a solar PV owner, the electricity quantity injected into the grid is not constant, depends on the weather and the consumption the prosumer does of its generation. Regardless of this uncertainty, solar PV facilities are considered to still have a low impact on the

whole electricity supply chain. Therefore, its uncertainty does not contribute enough to create a higher level of supply uncertainty of the whole supply value chain.

The Close-Loop Supply Chain (CLSC) theory determines that the return flows are not predictable, leading to an uncertain supply to the value chain receiving these reverse flows (Ritcher, et al., 2012). But, as it is mentioned before, this supply uncertainty does not affect the quality of the electricity supply to the end-consumers. In the future, when the number of distributed solar PV facilities increase, which according to some *E.On* employees it will, the whole electricity supply chain might be affected. However, in the current situation, this uncertainty is not one of the biggest concerns between the stakeholders.

The distributed generation plants have increased the reliability and security of the supply by reducing grid losses, as the literature points. It might be due to its low time-travel from the generation point to the consumption point, as well as a higher number of generation points. Thus, if there is a malfunctioning of any part of the local grid, the supply chain still has several other sources located in different places for supplying to the end-consumers.

The following Table 16 summarizes the ideas commented above by considering the challenges, barriers, and advantages that electricity suppliers, DSOs, and prosumers are currently facing in Sweden.

	Electricity suppliers	**DSO**	**Prosumers**
Challenges	The grid is currently challenged in terms of capacity. The future is to have a higher demand and a growth of distributed solar PV facilities, leading to an even more challenging grid. Easy demand forecast but more intermittent in time. To supply with the same availability and quality. To cope with the reverse electricity flow coming from the prosumers (to learn from CLSC applied in industrial processes).	Decide whether the investment has to be on reinforcing the grid or in the implementation of smart grids.	More demand due to electric vehicles, electric roads, etc. The flexible market and the future role of the batteries. Intermittent production.
Barriers	They cannot offer flexible tariffs to the clients.	Lack of incentives that enable these companies to invest in smart grids, and consequently, developing the flexible market.	Weather dependence.

Advantages		Decrease of energy losses in transportation due to the local electricity generation.	Less dependency on the electricity market prices.

Table 16: Challenges, barriers, and advantages regarding the SCM of electricity suppliers, DSOs, and prosumers.

6.3 Collaboration between prosumers and electricity suppliers

An effective SCM needs a good supply chain collaboration among the players (Min, et al., 2005). In this case, the collaboration strategies (in section *3.3 Supply Chain Collaboration* the five collaboration strategies are described) of information sharing, decision making, and earning trust between electricity suppliers and prosumers are evaluated (see Figure 25).

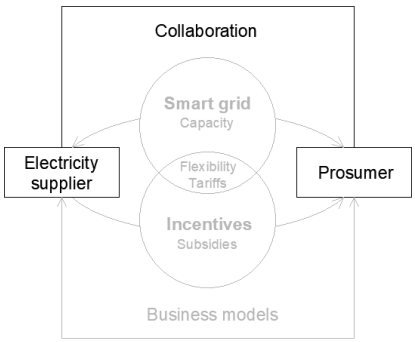


Figure 25: Investigation model highlighting the collaboration required between electricity suppliers and prosumers.

Due to the different player sizes within the electricity supply chain – i.e., prosumers versus grid owners –, it is difficult to achieve good information sharing between them. But, with the coming flexible market, the level of information shared between both chain members has to increase (see Table 17).

The decision making is not spread equally along the value chain. Even though the amount of decision making of the small players might not experience a significant change, the information shared between players might evolve positively. If flexibility has to be part of the forthcoming electricity market, the information shared between prosumers and electricity suppliers has to grow. Also, with the upcoming flexibility within the market and the increasing number of distributed solar PV facilities, prosumers will be more active in the supply chain. Therefore, prosumers will have to find a solution, for example, bigger prosumer associations, to have a louder voice within the value chain (see Table 17). Nowadays, the prosumers – and consumers – can influence the chain value decision making by voting political parties that will be board members of some grid companies owned by municipalities.

	Now	Future
Information sharing	The prosumer reads the consumption and production of his household.	More importance with the flexible market.
Decision making	Grid companies owned by municipalities have on the board members of political parties. A prosumer itself does not have a strong voice.	To continue to have a low level of decision making by prosumers. More prosumer associations.

Table 17: Comparison of information shared and decision-making situation now and in a future.

The trust between chain members is a basic characteristic necessary for the achievement of an effective supply chain. However, it has been seen that the prosumers – and end-consumers in general – do not trust the electricity suppliers. Even though the retail companies try to increase the trust level with good customer services, fair pricing, etc. (see Table 18), the oligopoly behavior of the Swedish electricity market might create a continuous mistrust from the small chain member to the big one.

	Level	Actions
Earning trust	Low level of trust, from prosumers to electricity suppliers.	Good customer service, good interface consumer – supplier, fair pricing.

Table 18: Current level of trust between chain members and actions considered to improve.

Therefore, in terms of collaboration, the role that prosumers have is still not very important due to the low impact the distributed solar PV facilities have on the value chain. In the future, if the number of distributed facilities increase and the electricity suppliers and DSOs rely on prosumer for balancing the grid and increase the reliability of the supply, the prosumers might have more decision making in the value chain. But the evolution of the electricity supply chain has the added complexity of the oligopoly behavior of the market with a lot of influence in the regulatory authorities.

6.4 Business models development

The thesis business models theory framework is based on the UK electricity market. According to different reports, the UK is the leader in grid decarbonization (ECOFYS, 2014). But *E.On*'s representatives do not have a common idea whether the UK is a role model for Sweden, or not. Even though it is accepted that OFGEM[28] – it has always been proactive to take the lead for the change – there is an opinion appealing that the UK market might not be a role model for Sweden, due to its many market differences.

[28] The Office of Gas and Electricity Markets (OFGEM) regulates the monopoly companies which run the gas and electricity networks (source: https://www.gov.uk/government/organisations/ofgem).

Currently, the Swedish regulator – *Ei* – is translating and interpreting the EU legislation package. This package is written by the European Commission, but it is on each country's behalf how they want to implement the new directives. Therefore, the future of the Swedish electricity supply chain, and how the relationship between the two last players of the value chain will be, is intricately linked to what the *Ei* establishes. However, *E.On* is trying to influence the regulatory process by giving insights learned in other markets where they have business units, for example, the UK, among others.

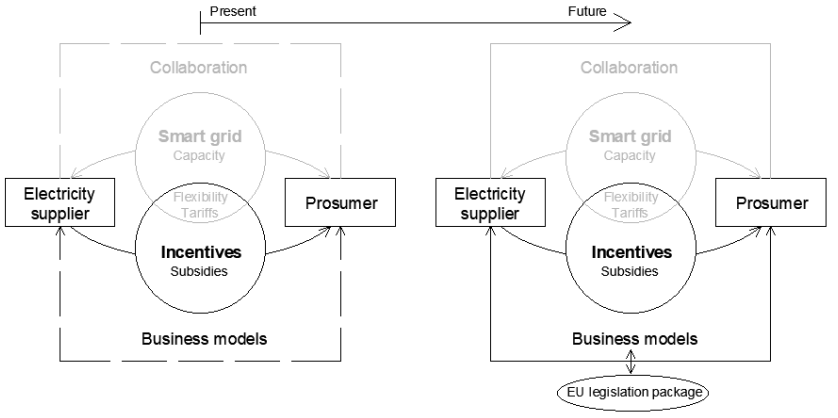


Figure 26: Investigation model highlighting the relation between electricity suppliers and prosumers in terms of business models and the respective incentives.

The different business models have two direct actors, electricity suppliers and prosumers (see Figure 26). Thus, prosumers, the new chain members, are going to have an important role in the evolution of the electricity supply chain for overcoming the challenges the grid is undergoing. Especially, the future role they will have inside the different business models.

	Prosumers
Advantages	Green tax deduction. Low prices of solar PV cells. Collectivized connection cost for small producers. COVID-19 can increase the interest in private solar PV facilities.
Disadvantages	Long payback time due to the low electricity price. Investment complications if the utilities have to be installed in a flat part of a larger building. Oligopoly market.
Barriers	Cost of connection higher than the money received for the surplus. Lack of subsidies. Bureaucratic process. COVID-19 can decrease the prosumer's investment capacity.

Table 19: Advantages, disadvantages, and barriers of prosumers, regarding the development of new business models.

Nowadays, consumers are investing in solar PV facilities due to their many advantages, such as the green tax deduction and the low price of solar PV cells (see Table 19). Besides, small power

plants do not have to pay for the complete connection cost, triggering more private households to invest in solar PV technology. However, from SERO's point of view – a Swedish prosumers association – the connection cost should be free for small producers. But, the oligopoly market behavior does not allow this.

The current pandemic situation can lead to two different scenarios, one is an advantage and the other a barrier in Table 19. On one hand, the people have to stay home more often. This aspect can trigger many prosumers to invest in solar PV utilities because they want to increase the value of their households. On the other hand, it can be a barrier due to a loss of economic capacity of the families because of the job loss of a family member, or the fear to invest in something with a long payback time.

The current situation has many disadvantages and barriers for enabling prosumers to invest. As Table 19 lists, the long payback time of the investment or the lack of subsidies can stop prosumers to make the decision.

6.4.1 Current existing business models

According to the literature, there are four different business model schemes (see Table 2 in section *2.4.2 Prosumers business models in the UK*) in the UK electricity market, the framework of this thesis: basic prosumer, private wire or micro-grid, Local Energy Company (LEC), and Peer-to-Peer (P2P). However, the current Swedish electricity market has mainly two business models schemes: basic prosumer and virtual arrangements.

Most of the connections made in the Swedish local grid use the basic prosumer scheme (drawing (a) in Figure 27), where the private households inject the surplus of electricity they do not consume. In return, the electricity suppliers purchase this electricity, subject to how many kWh the prosumers inject. Due to the large amount of water in Sweden, a second business model (scheme (b) in Figure 27) means the possibility to store the kWh generated during the summer with the solar PV facilities, in hydropower utilities. Thus, in winter when the electricity is more expensive, these prosumers receive the equivalent amount of kWh they produced over the summer.

However, the business model exchanging kWh is just a contract agreement. Nowadays in Sweden is stipulated that the DSOs, electricity suppliers, and TSOs cannot store energy, aiming to avoid the influence in the market price. The regulation states that the energy storage is strictly limited to cope with grid losses or temporarily replacing a loss of electricity in the event of an outage (IVA, 2017).

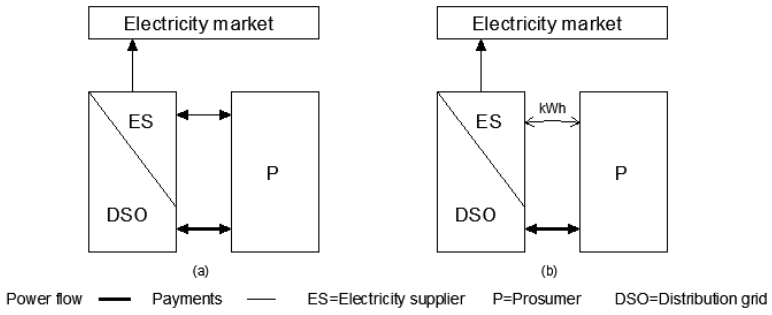


Figure 27: (a) Basic prosumer, and (b) Basic prosumer but exchanging kWh between summer and winter.

Both versions of basic prosumer business models, schemes (a) and (b) in Figure 27, are beneficial for all the interesting parts. Firstly, as a basic prosumer, the solar PV owner receives money for the generation surplus, making the investment in the facility more profitable. However, the exchange of kWh benefits the prosumers, because during the winter they do not have to pay for part of the electricity they consume from the grid, coinciding with the most expensive period of the year. Secondly, there is a decrease in the grid losses due to the new generation locations closer to the end-consumers, benefiting the whole supply chain. The electricity has to travel less, therefore the supply chain becomes more resilient and the risks of supply disruptions are minimized – the goal of an effective and efficient SCM. Finally, the DSOs are more independent of the up-stream supplier, the TSO, due to the reverse flow of electricity coming from the distributed solar PV facilities (for understanding the Swedish electricity market go to Figure 4). However, if the number of basic prosumers increases, as some experts point out, the grid can experience capacity problems, as it is commented in the previous section.

A virtual plant arrangement could be considered the same as the P2P scheme in the UK framework (see drawing in p. 15 included in Table 2). Today, it is mandatory to be connected to the local grid for the distribution of the electricity surplus. Therefore, the prosumer has to pay taxes on it. So, it can be considered the same as a basic prosumer, until the prosumers can connect their houses within themselves without the need to use the local grid. However, being disconnected from the local grid might force the households to use batteries. As is commented in the previous chapter (see section *5.4.1.2 Tariffs and business models*), the use of batteries will come in a short-term future, not only for the development of new business concepts but also benefit the flexible market, as is stated in section *6.2 Electricity suppliers Supply Chain Management*.

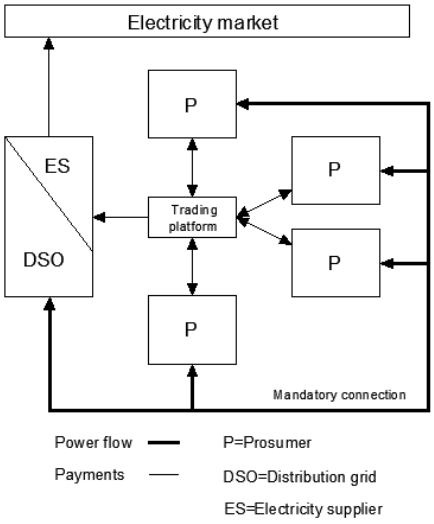


Figure 28: Virtual plant arrangement.

6.4.2 Future business models

An interesting development is the energy communities, recently defined within the new energy rulebook – Table 18–, as a tool to achieve the commitments signed in the Paris Agreement. This new form of organization might come when the *Ei* finishes the detailed description of which are the rules that must be followed for its development. When conducting the interviews, all the

respondents agreed on the clear path the electricity market will follow, the development of energy communities.

The EU regulation describes energy communities as new types of non-commercial entities that, although they engage in economic activity, their primary purpose is to provide environmental, economic, or social community benefits rather than prioritize profit-making (Caramizaru & Uihlein, 2020). Therefore, these communities can have more than one potential schemes. The report "*Energy communities: an overview of energy and social innovation*" by the European Commission (Caramizaru & Uihlein, 2020), argues that there 24 schemes, even though not all of them are defined in the Clean Energy package.[29]

Svensk Solenergi argues the implementation of energy communities as a new relationship between prosumers and the grid that will enable collective self-use of electricity (Svensk Solenergi, 2020), involving the actors in the decision-making and benefits sharing (Caramizaru & Uihlein, 2020). A collective self-consumer is a group with at least two cooperating prosumers who are in the same building or multi-apartment block (Frieden, et al., 2019). The current situation in Sweden is that collective self-consumption is not allowed if the households have to use the local grid to be inter-connected (Caramizaru & Uihlein, 2020).

These business arrangements can help the bottlenecks in the electricity grid, helping the whole electricity supply chain to face capacity issues. Thus, in parallel to the regulation-making, some incentives should be designed. *Svensk Solenergi* proposes that energy communities should avoid paying energy tax on self-consume electricity (Svensk Solenergi, 2020).

During the interviews, a pilot project was described as a different business type currently being tested in Uppsala: the aggregator business model scheme (see Figure 29) (see section *5.7.2 Aggregator*). This city has had a lack of capacity in its transmission and distribution grid due to the increasing population.

Therefore, an aggregator is an independent actor who combines and sells flexible services on behalf of multiple consumers (Regen, 2018). In other words, aggregators combine the electricity demand of two or more customers into a single purchasing unit to negotiate with the electricity supplier (Nursimulu, 2015). The aim is to bring flexibility to the market through municipal companies and administrations, to test how an aggregator can affect flexibility, and to engage other local players to participate in the electricity market (Uppsala kommun, 2020).

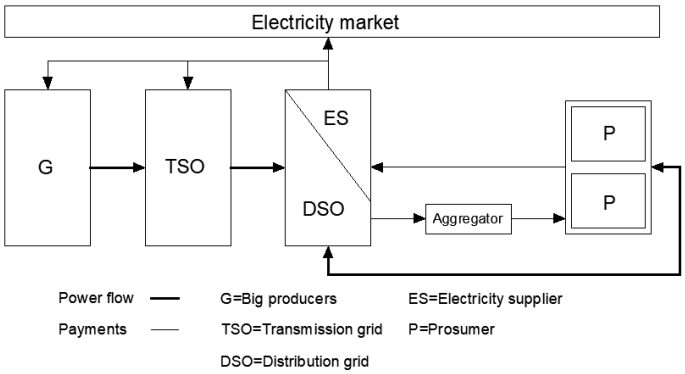


Figure 29: Aggregator scheme. Adaption from Regen (2018).

[29] In *7.3 Future research study suggestions* is stated the need of a further study within the field of energy communities.

6.4.3 Development of new business models: incentives and tariffs

The development of new business models depends on the evolution of the flexibility market, as Figure 30 describes. The flexible market, at the same time, depends on the incentives the DSO can receive, as well as the subsidies the prosumers can get for their private solar PV facilities.

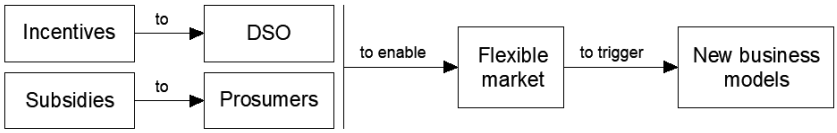


Figure 30: Development of new business model closely related with the use of the flexible market among both chain members, DSO and prosumers.

Regarding the increased number of distributed solar PV utilities, two main reasons might justify its growth. On one hand, the option of being flexible on how to manage the consumption can trigger some prosumers to invest in solar PV facilities, to reduce the electricity bill. On the other hand, the current Swedish electricity market has some economic incentives. Most of the interviewed stakeholders agreed on the improvement of the market since this 1st of January 2021. Currently, the installed capacity (kW) of the solar PV facilities in which you can get a tax deduction has increased up to 500 kW (see Table 20). Consequently, prosumers can have more solar PV plants maintaining a good profit and a more reasonable payback time.

Subsidies in the Swedish electricity market

Capital subsidies	Abolished in December 2020.
Green tax reduction	Deduction of 15% of the labor and material costs for PV systems and 50% of the labor and material costs for installing batteries. The maximum value of this deduction is up to 50,000 SEK/person_year and is only applicable for houses built in the last 5 years.
Green certificates (GC)	Low market price.
Guarantees of Origin (GO)	Electronic document bought by the supply company. Low market price.
Grid compensation	DSOs compensate the prosumers (0.05 SEK/kWh) for reducing the losses of the grid and making them independent of the TSO.
Self-consumption	Electricity suppliers buy the surplus of electricity generated by the prosumers (0.58 SEK/kWh).
Tax deduction	Since the 1st of January exists a tax deduction for facilities with a production of a maximum value of 500 kW (before the limit was up to 255 kW).

Table 20: On-going subsidies for solar PV facilities in private households.

Even though the economic incentives in which you receive a certain amount of money – GO and GC (see Table 20) – do not have a strong influence and might decrease or even disappear – the capital subsidy has been already abolished and it has been replaced by the green tax reduction (see Table 20) –, the prices of solar PV installations are going down. Also, the current prices paid

for the surplus of electricity are advantageous for prosumers (self-consumption incentive in Table 20).

Therefore, the Swedish electricity market, as most of the stakeholders interviewed, seems to have positive growth, regarding the use of distributed solar PV installations. All the interested players are on board with having a more sustainable system, despite some critical opinions from the prosumer site.

Despite the subsidies, the tariffs enabled by the flexible market will play an important role in shaping the Swedish electricity supply chain future. Thus, a pilot project is being tested in the Malmö region. The SWITCH project (introduced in section *5.3.1 Grid capacity*), led by *E.On* among others, is developing a digital marketplace where prosumers reduce their electricity consumption or increase their electricity production for short periods (E.On Energidistribution, 2020). The way flexibility is being managed can trigger private households to invest in solar PV facilities, for both economic reasons as well as ethical beliefs. However, as it is commented, there is still the need for incentives flexibility among prosumers for being able to drive this kind of initiative.

6.4.4 Business models comparison

The following Table 21 summarizes the strengths and weaknesses of the existing business models commented in section *6.4.1 Current existing business models*.

	Strengths	**Weaknesses**
	Existing business models	
Basic prosumer	- Economic compensation for electricity surplus. - Shorter payback time. - Contribute to the decrease in the grid losses.	- Depending on how many kWh are injected into the grid. Related to the weather. - Need to pay taxes for the mandatory connection to the grid. - Waiting for the implementation of the future flexible market. - If a want-to-be-prosumer lives in a flat part of a larger building, the investment becomes difficult.
Basic prosumer exchanging kWh	- Use of kWh stored in summer, during the winter when the electricity is more expensive. - The benefit of hydropower facilities, an abundant resource in Sweden. - Contribute to the decrease in the grid losses.	- Administrative agreement because electricity suppliers or DSO cannot store energy to avoid market manipulation. - Need to pay taxes for the mandatory connection to the grid. - Waiting for the implementation of the future flexible market. - If a want-to-be-prosumer lives in a flat part of a larger building, the investment becomes difficult.
Virtual plant arrangement	- Without batteries, it can be considered the same as a basic prosumer.	- It is mandatory to be connected to the local grid for the distribution of the electricity surplus

Table 21: Summarize of strengths and weaknesses of the existing business models in Sweden.

Finally, Table 12 is an overview of the strengths and weaknesses of potential business models, energy communities, and aggregators, analyzed in section *6.4.2 Future business models*.

	Strengths	**Weaknesses**
Potential business models		
Energy communities	- To provide environmental, economic, or social community benefits. - The collective self-use of electricity will trigger more decision-making and benefit-sharing. - To cope with the bottlenecks.	- Its development depends on the interpretation *Ei* does of the European legislation. *Ei* is working on its new regulation. - Nowadays Sweden's legislation does not allow collective self-consumption if the households have to use the local grid to be inter-connected. - Specific incentives.
Aggregator	- The aggregators can be electricity suppliers or municipalities.	- It is still being tested.

Table 22: Summarize of strengths and weaknesses of potential business models in Sweden.

7 Conclusions

This chapter presents the conclusions of this thesis, by giving a brief overview of how the purpose has been achieved followed by the discussion of the research questions. Also, it is suggested some future research projects as well as the theoretical contribution of this project.

7.1 Road to achieve the purpose

The purpose of this project (Figure 31) has been to analyze and describe how Swedish electricity suppliers are managing the bi-directional electricity flow generated by the increasing installation of distributed solar PV systems. The research project also intends to study which are the possible future business models (incentives, barriers, etc.) of the electricity supply chain between electricity suppliers and prosumers, using the UK framework.

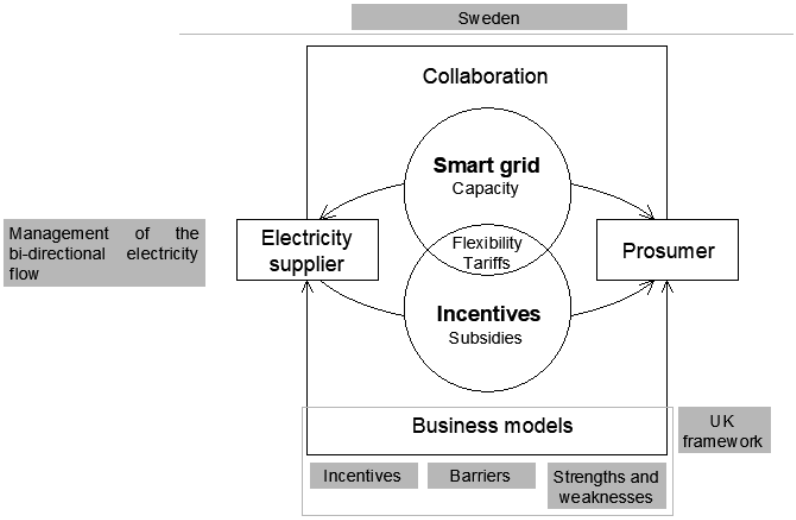


Figure 31: Purpose of the thesis plotted on the investigation model.

Aligned with the purpose, there are the research questions aimed to answer. First is "RQ1: *How are Swedish electricity suppliers using smart grids for managing the bi-directional electricity flow coming from different prosumers and their solar PV plants?"*. The insights gained with the RQ1 have enabled the author to explore the second one "RQ2: *How are the business models of the electricity supply chain between electricity suppliers and prosumers that Sweden can expect, and which are their incentives, barriers, etc.?*"

To fulfill the purpose and answering the research questions, a qualitative case methodology has been chosen, accordingly with the resources available. The following step has been the literature study, made of two different parts. First (chapter *2 Context of the electricity market*), the electricity market context is described, covering the Swedish current electricity supply chain situation, as well as the most innovative solutions in the electricity market today: smart grids, incentives, and business models. Secondly, (chapter *3 Theory*)Theory, covers the theoretical framework where topics as SCM, CLSC, and collaboration are discussed.

The literature study work has been followed by data collection consisting of seven interviews with Swedish electricity stakeholders. The results of this extensive data collection can be found in chapter *5 Empirical study*.

In the last part of the project, after the knowledge gained with the literature review and the data collection, the analysis of the results has been done. The aim has been to analyze and describe the current situation in Sweden and how the future will be, as it is stated in the purpose and the research questions. Therefore, in chapter 6 there is an exhaustive analysis, done by crossing the information gathered during the literature review with the insights gained with the interviews. Summary tables with the main ideas of the analysis regarding SCM, collaboration, and business models development, have also been done (from Table 16 to Table 22) in the same chapter.

7.2 Research questions discussion

The research questions proposed at the beginning of the thesis can now be answered.

RQ1: *How are Swedish electricity suppliers using smart grids for managing the bi-directional electricity flow coming from different prosumers and their solar PV plants*?

Nowadays, the Swedish grid is challenged in terms of capacity, mostly because of the increasing electricity demand in some parts of the country. However, the injections of electricity the solar PV prosumers do to the grid, are challenging its capacity and management. But, this new reverse flow of electricity also has some advantages to the local grid. It helps the grid with reducing the energy losses – the generation points are distributed around the area – and makes the electricity suppliers, and in extension DSO, more independent from the TSO, the up-stream part of the electricity supply chain.

For solving the capacity issues the grid is presenting and achieving an efficient and reliable electricity supply, a combination of two investments is being adopted. Investing in reinforcing the grid and making it smarter. The smart grid aims to offer the prosumer the option of being flexible using different tariffs incentivizing the generation and consumption in specific periods. However, nowadays the flexible market is being developed and tested – i.e., the SWITCH project in the Malmö region (full description in section *6.4.3 Development of new business models: incentives and tariffs*).

In the future, with the flexible market being a reality, prosumers will have a more relevant role within the electricity supply chain.

RQ2: *How are the business models of the electricity supply chain between electricity suppliers and prosumers that Sweden can expect, and which are their incentives, barriers, etc*.?

Even though there are some business models in development –i.e., aggregator, energy communities, etc. –, the Swedish electricity market is evolving to, mainly, two of them.

On one hand, the basic prosumer (Figure 32) where the households sell the surplus of electricity to the electricity suppliers. When the weather does not allow the solar PV cells to generate, the prosumers have to consume electricity from the grid. Hence, the bi-directional flow of electricity is established.

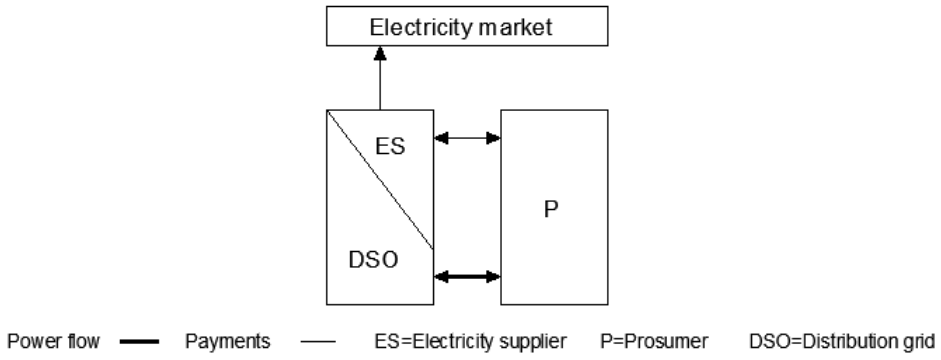


Figure 32: Basic prosumer configuration. The power flow has a bi-directional flow between prosumers and DSO, same behavior of the payments.

This form of organization, currently the most common in Sweden, helps the grid owners to manage the capacity issues challenging the grid today. But is also advantageous for the prosumer itself, due to the income of assets from the sale of the electricity surplus.

On the other hand, there are the energy communities. These business models can have more than one possible scheme, yet to be regulated and developed. The common idea of all of them is the promotion of collective self-use of electricity, by enabling a group of prosumers to consume the electricity they generate in a collective form. Energy communities are discussed in the package of new regulations from the European Commission.

Despite the current uncertainty of its definition, the regulations *Ei* – regulatory authority in Sweden – will submit eventually, will lead the value chain to evolve in this direction. However, the authorities have to create incentives to encourage both, companies and customers, to invest in this new business type.

The number of distributed solar PV facilities will increase in the future due to the good conditions of the Swedish market. Nowadays, the tax deduction income, the surplus electricity purchasing, and the grid compensation trigger the prosumers to invest in private facilities. But, in the future when the flexible market becomes a reality, the tariffs the electricity suppliers offer the prosumers will be one more incentive to consider.

Finally, the electricity market has always been an oligopoly. This behavior, the multiple political interests among the big players, and the lack of incentives can slow down the evolution of the whole supply chain. Is yet to be seen whether the COVID-19 pandemic will be a barrier or an element that triggers the solar PV facility's investments.

However, the baseline that the European Commission is drawing with the *Clean Energy for All Europeans Package*[30] completed in 2019. This legislation package aims to upgrade the EU energy policy framework to the transition away from fossil fuels towards cleaner energy and to deliver on the EU's Paris Agreement commitments (European Commission, 2020). At the end of the day, all European countries will have to adapt to the European regulations, thus the electricity market will certainly evolve to a more sustainable value chain adapted to renewable sources.

[30] To find more information regarding these measures: https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

7.3 Future research study suggestions

During the development of this research project, many potential research areas have been found interesting to study. However, due to the limited sources and time, they are not included in this thesis. Therefore, they are pointed out as future research studies suggestions.

First, this research project includes the point of view of one important DSO and electricity supplier, *E.On*. But, in the Swedish electricity supply chain, there are other big players – *Vattenfall* and/or *Ellevio* – which are not included in the thesis because of the limited resources. Hence, capturing insights from these organizations could provide a clear mapping of the situation in the Swedish electricity market.

Second, a further research study focused on energy communities and which implications can have to the energy supply chain. The future European electricity market seems to clearly follow this path as it is included in the European Commission's *Clean Energy for All Europeans Package*. The study could include what is necessary to integrate these communities into the value chain in a collaborative environment for achieving a great interaction between the chain members. A baseline of the research could be the report "*Energy communities: an overview of energy and social innovation*", published by the Joint Research Centre (JRC), the European Commission's science and knowledge service[31].

Finally, the same analysis and further prediction of how the future electricity market will be, can be done in other countries. A comparison between different European countries can give a picture of how different countries are following the European legislation.

7.4 Contribution

When working with the literature review, the author realized that scientific papers and reports regarding business models development and how it will affect the electricity supply chain in terms of collaboration is missing. Therefore, this research project is a first attempt to contribute this scholar's knowledge of the electricity market from a supply chain point of view.

Particularly, the paper "*Energy resources: trajectories for supply chain management*" written by Halldórsson and Svanberg in the Supply Chain Management: An International Journal (2013) describes the electricity supply chain from the national grid to the local grid. So, the down-stream use of energy (Figure 8) and the impact of distributed production plants is poorly developed. Therefore, this research project aims to open a "new" field of research within the electricity supply chain and the collaboration between the chain members.

[31] Link to the report:
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf

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Annex

Interview overview

Introduction

The purpose of this thesis is to analyze and describe how Swedish electricity suppliers are managing the bi-directional electricity flow generated by the increasing demand for distributed solar PV sources. The research project also intends to study which are the possible future business models (incentives, barriers, etc.) of the electricity supply chain between electricity suppliers and prosumers, using the UK framework.

The following table summarizes the main concepts discussed in the thesis:

Business models	**Subsidies**	**Tariffs**
Basic prosumer	Feed-in Tariff (FiT)	Interruptible Capacity Program (ICAP)
Microgrid	Feed-in Premium (FiP)	Emergency Demand Response (EDR)
Local energy company	Capital subsidy	Peak Time Rebates (PTR)
Peer-to-peer (P2P)	Green certificate	Real-Time Tariff (RTT)
	Guarantee of Origin	Critical Peak Tariff (CPT)
	Grid compensation	Static Time of Use Tariff (TOuT)
	Self-consumption	

Interview topics[32]

1. Smart grids and electricity supply chain management in Sweden.
    a. Some insights related to the relation between Smart grids and local grid capacity.
    b. How smart grids can benefit the whole electricity supply chain.
2. The current situation in the Swedish electricity market. Focusing on the electricity supply chain management and its collaboration between players as well as how are the current business models.
    a. Advantages, disadvantages, barriers (subsidies, disinformation, …), etc. of the current business models.
    b. Opinion regarding the current Swedish subsidies for solar PV systems.
    c. How can the different tariffs affect the development of the different business models in Sweden?
    d. Which role do the prosumers have in the current electricity market?
3. Prosumer's future in Sweden. Again, focusing on the relationship they have with the electricity suppliers.
    a. Possible future business models: possible barriers as well as future subsidies and tariffs for their development.
    b. Prosumer's role within the electricity supply chain.

[32] The interview guide was adapted for each interviewee.
- Jan-Erik Olsson: (1) General questions related to *E.On* (i.e. How many solar PV system installations have *E.On* made the past 10 years?, etc.).

Interviews

Interviewee:	Jan-Erik Olsson	Date:	03/12/2020	
Company:	E.On Distribution			1
Position:	Senior Advisor			

Contact information

1. Can you tell me about your role at E.On?

   I work in the networks company, to start with because you probably know that there is a clear unbundling between E.On networks and customer solutions & retail. So, I'm on the network side and there my title right now is senior advisor and working with one big, well 2 main focuses the one is sustainability and how the company could be involved and create a more sustainable way of working and also try to support the society around us. The other part, which I think it's more relevant for this interview. I'm the manager of a project we call the "DSO project". It comes out from the ten-energy package from the European Union who sent it at the end of last year the beginning of this year. (…)

   We are waiting for the regulation to be changed by the parliament of Sweden. Because I think you are familiar with the European Union and the rules they send, directly to different nations. The different nations have to implement the changes in the national law. And that has not taken place in Sweden but it'll be in no long time, I think.

   Is this for achieving the COP agreement?

   Yes, it's linked to the climate, but the declinate packages are specific about the energy market and market rules and how to "cop" more renewables in the system.

2. For how long have you been working in the electricity market?

   30 years.

E.On

3. Why is E.On interested in distributed solar PV plants?

   [RETAIL COMPANY – CUSTOMER SERVICE]

   What we do in the grid company is that we have to connect, of course, all solar panels, independent of if they are installed by E.On or any other company. We have to deal with the consequences of the energy networks and the balancing of the system, locally and regionally.

4. How many solar PV system installations have you made in the past 10 years in Sweden? Does the customer have to have you as the electricity supplier?

   [RETAIL COMPANY – CUSTOMER SERVICE] I think we have 3000MW installed

5. How E.On, as an electricity supplier and also one of the most important DSOs in Sweden, can influence in shaping the future of the Swedish electricity supply chain? Which are the driving forces when deciding how the future in terms of distributed solar PV plants must look like?

   We say that the grid company makes it possible to change the energy system. Independent on how or where we have to change the system the grid is in the middle of that transformation. We make the grid available to all kinds of customers and producers. Make it as easy as possible to change from one way to produce to the other.

   But, do you have any influence related to new policies? Not only influence over the people who want to invest but also the government or the people responsible for the new regulations.

   As we [E.On Distribution] are only in the networks, we are a monopoly company so in our areas we are the only ones who are allowed to build power grid. In that sense, we are of course supervised by the authority, so that the customer pays the right bills to us and not too much. In that regulation of our revenues, of course, we have a lot of influence and we try to make the rules as good as possible for ourselves and also for the society and our customers. For example, we have highlighted that we are now increasing the amount of renewable generation. We have to also have clear incentives to work and to introduce flexibility on the customer site to make a fair balance between generation and consumption. Otherwise, we have to build a net power grid that is too big and has a too big capacity.

   Yes, to invest in the capacity of the grid.

   Yes, exactly. We think that is very important to get the right incentives to start the flexibility market in Sweden. That is the way that, from the grid company, can influence routes and laws.

6. Why E.On is interested in the UK market? Are you going to apply some “lessons learned” from the UK to Sweden?

   I can not give you a 100% answer because this is a question for our head offices in Germany, from the group perspective. One thing, from a historical perspective we had a big company including customer solution, a retail company, in the UK. It was 2-3 years ago the grid company was sold from E.On, but the retail company is still within E.On. I think at the beginning of the change of the energy market, the UK was quite the frontline. Therefore, is interesting into being in that market and see and learn how it works and how do we influence other countries by the experience from the UK. For our part at the grid company, we have the UK regulator called OFGEM, it’s quite proactive in finding new ways. We think that is interesting to understand and also to have a discussion when we discuss with the Swedish regulator how they do things in the UK.

   Then we even have the experience of good and bad solutions from the UK.

7. Do you want to add any more comments related to the role of E.On in the Swedish electricity market future?

I will connect you with one of the colleagues of the retail division of the company.

Smart grids and electricity supply chain management in Sweden

8. Is it the Swedish electricity grid challenged in terms of capacity? If yes, which kind of resource is used: investment in the grid or the implementation of smart grids? Why?

   Yes, it is. Some parts of Sweden are really challenged right now. We are moving forward in both directions. We are using flexibility to involve the customers to increase or decrease their power units in some hours during the year and they get paid for that flexibility. So, we have established a platform we call Switch, supported by an EU funded project called Coordinet. We work together with the Vattenfall and also the TSO in Sweden. We have implemented a pilot for that in southern Sweden and also Vattenfall and Ellevio are establishing pilots in the Stockholm area to find out how this market place for flexibility work and how can we have customers on board to help us out in the capacity issues. We think it's really important that we got incentives in the regulation for that because we have not now so we think it's just a development project. If this would be in our business models, we have to get incentives for this kind of solution for being able to involve the consumers in the flexibility market.

   We are also investing in the traditional grid, with the most modern technology possible.

   When you talk about the flexibility of the grid, is it necessary to have smart grids or smart meters in every home to be able to do that?

   In Sweden, we have had smart meters for some years now and now we are changing the smart meters to the next generation so we get the more smart technique to all the meters. But they are not there now. The flexibility market it's just in the beginning. Then we deal with a few big customers to see if the flexible market it's an option. But in the long round I think yes, we can use the smart meters to balance the system quite good.

9. Which level of smart grid implementation (low, medium, or high) Sweden has? Why?

   That's a very hard question, I think. The smart grid definition it's not common or well defines. So, we have a lot of projects going on, testing different techniques, measuring the energy flow in different parts of the grid, and getting into calculations in how to optimize the use of the grid, going from a more static dimension to a more dynamic one. We have finalized a project in a small village in the south of Sweden where we tested a local system that could go off-grid. That was consisting of wind power, PV panels, backup generator, battery as a backup, and balancing the system. That was quite interesting because it worked. The quality of delivery was even higher in that grid when we were offline of the system. That is part of how we develop smart grids. The main message is that there are a lot of projects going on but it's still not commercial.

10. One of the driving forces of the smart grid is customer engagement. The supply chain management philosophy drives the supply chain players to view the supply chain as a whole. How do you think the smart grid implementation will change the electricity supply chain management?

The solution I said before is an option, but we don't want customers to go off-grid. Just in small areas. Test the system how to balance between renewable generation and consumer needs. We think that could be scaled to a regional level in some way.

We really believe that the grid must and should be smarter because we have a lot of problems now and the solution is doing the grid even smarter.

11. Do you agree with this statement: "*if renewable sources – as solar PV plants – are considered in the supply chain, the main goal evolves into having a more risk- hedging* (high supply uncertainty and low demand uncertainty) *strategy*"? Why?

    We will get more and more renewables. The expectation of the customer is to receive the same availability and quality in our delivery of power. So, I think we will see an increasing number of renewable generation but not a decrease in availability and quality. So, that's the big challenge for us.

Current situation in the Swedish electricity market

12. Which are the most common business models between prosumers (basic prosumer, microgrid, etc.) and E.On?

    [RETAIL COMPANY – CUSTOMER SERVICE]

    Is it mandatory for the customer to be connected to the grid?

    Yes. We have to connect everybody. If it is not enough capacity today, we have to build capacity for the customer.

    Who pays that, the owner or E.On Distribution?

    The connection fee is paid by the customer and they paid to us. It is related to the investment we have to do.

    So, if I leave in a rural area and I don't have enough capacity, I'll have to pay for the investment.

    If you make it black and white, yes. In the investment capacity from our site let other customers also connect. Then you have to pay your share of that extra investment. The rest is on our behalf or divided to other customers.

    a. Which are the advantages and disadvantages of the current prosumers business types in Sweden?

       I think these questions are more related to the retail company, how do they treat prosumers and how they divide generation and consumption.

    b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid?
    c. What should be changed to have more prosumers connected to the grid?

d. Does E.On distribution always receive money for UoS (Use of System) or is there any possibility that the prosumer is exempt from this payment?

We stick to laws and rules. In that case, there are some rules that give us how to deal with the connection fees when there is a solar panel that the customer wants to connect. Then we're limited to, by law, to take connection fees in some direction. But we don't have any influence on that. It's not exactly a business model, it's something we have to do, the law says. From the other retail side, there are no strict rules and there you can create different market solutions.

13. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?

Also, for the other part of the company.

14. Nowadays the electricity grid is under a lot of pressure due to the increasing electricity demand. For ensuring effective decision making and supply chain efficiency; realistic, informed and detailed information sharing between chain members is needed.

e. Assuming that tariffs are tools (1) to achieve a detailed information sharing between prosumers and electricity suppliers like E.On and (2) to optimize the electricity grid pressure. Which are the tariffs preferred by the prosumers? And by E.On? Why?

With the connection to the grid, they cannot choose tariffs, they have one option. But when they sell the generation, they can make a deal with different companies. This is where these questions have relevance. The connection to the grid is highly regulated.

So, the consumer buys the electricity, he cannot choose which can of tariffs he can have, because there's only one. But when it comes to the selling then they can choose between the different tariffs I said to you.

Yes, between the different retail companies.

Does E.On offer, all kind of tariffs or it depend on the retail company whether they want to sell or to buy the electricity on one way to the other.

Is the retail company that says which is the price and have the negotiation with the producers. How they will pay and for how long they will have the contract. This is purely a retail business.

f. How do you think the different tariffs can affect the development of the different business models?

I don't know how to answer it. I just have heart a speech about this, this morning. Because the regulator is now thinking and investigating how to create future green tariffs. The main message is that there will be fix prices for the grid connection and not related to the energy flow because the grid stands they are independent on which energy flows on the grid. It's a lot of capital cost and so on. Our part of the economy is actually is not as flexible is quite fix. There is no big incentive in the grid

tariffs. It's more if we have capacity enough today or we have to wait some years. The retail companies are more flexible.

g. If prosumers are considered players in the electricity supply chain:
    i. Do they have any possibility to take part in the decision-making of the local grid?

    I think that's an irrelevant question and again, it's a retail question. Because there you also have a new role called aggregator. If the producer is quite small or even the consumer is small, but they want to be involved in the electricity market they have to be aggregated so the amount of power they can hand out in the flexibility market should be not too small. in the legislation, there will be the introduction of a new role called aggregator. For example, deal with 100 private households and summarize it to one interface to the retail company. Then the retail company can take it or leave that amount of energy. That is also all relate to the energy market on the retail side.

    Actually, this is what I wanted to study. Which kind of new players can we find in a short-term period of time? For example, the aggregator you commented on before, is it a new player that we will have in the market?

    Yes, and also you talked about the P2P form. We think that they'll come because the customer wants to do this. how to deal with that is also a question for the retail company. Our part is to measure the energy flow from the producer and then do the same measurement on the consumer side and how is the balance. The balancing responsibility, in that case, is up to the retail company which is responsible for buying and selling that energy.

    You are more focused on how the grid is challenged due to this new demand.

    It's not actually business models and so on. That's kind of stable and fix by regulation.

    ii. According to collaboration theory, a trust-based relationship within supply chain members leads to effective supply chain management. Do prosumers trust E.On, which is the level of trust: low, medium, or high? Why?
    iii. Which tools (tariffs, customer service, etc.) E.On have to earn the trust of the clients?

<u>Prosumers future in Sweden</u>

15. Which business models is Sweden planning to implement in the short-term future?
16. Which business type benefits the prosumer the most? And E.On?
17. Which are the barriers to the implementation of new business models?
18. Which subsidies can a prosumer expect in the future?

19. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?
20. Related to the collaboration between electricity suppliers and prosumers. If prosumers are considered players in the electricity supply chain:
    h. Is it expected them to have more power with the decision making of the local grid?
    i. Is the information shared between prosumers and electricity suppliers, like E.On, going to improve and with that the level of trust between them?
    j. In general, are prosumers going to have more advantages in the future?

Other

21. Is there anything you want to add?

At last, if you have some suggestions of other people to interview, please send me their contacts.

Interviewee:	Göran Bryntse	Date:	04/12/2020	
Company:	SERO			2
Position:	Chairman			

Contact information

1. Can you tell me about yourself and your field of study?
2. For how long have you been working in the Swedish electricity market?

   50 years.

Smart grids and electricity supply chain management in Sweden

3. Is it the Swedish electricity grid challenged in terms of capacity? If yes, which kind of resource is used: investment in the grid or the implementation of smart grids? Why?

   Historically Sweden has been dominated by 3 big companies and they want to keep their oligopoly situation. So, to make some changes in order to get prosumers to get some influence you have to fight against them. Unfortunately. But we do our best. One example of this is that there was an investigation from the European University in Frankfurt, Germany, going through the 28 countries in the European Union about energy cooperatives or energy communities. It showed that Sweden was one of the worst when comes to the support of these communities. The reason for that would probably be that the 3 big companies have had a very big influence on the energy politics in Sweden. I've been involved almost 50 years now in the Swedish energy world, so I know them too well. They are smart. I can also say that during this period I've seen that the biggest companies in Swedish, Vattenfall, have very close relationships with the governments. So, I've noticed that the people at the administration in Stockholm, if they wanted to get a higher salary they would move to Vattenfall main office in Stockholm. On the other hand, if the people of Vattenfall wanted to have something new, they could apply in positions in the government's administrations. I've seen so many cases of that, so I know that they are quite good friends. And Vattenfall is an estate company, of course, they are number one in that case. The other 2 big ones, Fortum and E.On. E.On from Germany and Fortum from Finland. They don't have that nice position that Swedish Vattenfall has. So, anyway, there was a woman in this European university, Claire Gotier, who presented a report for the board of ERIF showing that Sweden was among the 4 worst countries when coming to support energy cooperatives in the European union.

   When you speak about energy cooperations, do you talk about prosumers or the union of prosumers? I mean…

   No, it's a local production, I must say, but together for instance a village could be self-sufficient of power. That's a kind of XXX sent. I've friends who are involved. There is a village here in Skane. I think you stay in Lund. So, in Röstånga which is a village 40-50 km from Lund. They are now starting an energy cooperative and I know these guys who are working there. Actually, Christian, he has made a Ph.D. at Lund University in energy. So, that's one guy who should maybe meet. I will send you the name of the guy after the interview.

I've been studying the different types of relationships existing in the UK between electricity suppliers and prosumers, but I was more focused may be in private investments, not community investments.

Oh yes. Within my organization, SERO who own their own wind power or maybe a couple of them. And, of course, also sun power. On my roof, there is a sun facility, so I have some private experience on how to connect my sun power facility to the local grid.

I am more focused on sun power. Basically, because in Spain it's so much more common to have sun power on your rooftop.

(…)

4. Which level of smart grid implementation (low, medium, or high) Sweden has? Why? How developed is the smart grid in Sweden? Because for me when we talk about distributed generation plants we also have to talk of smart grids.

   Historically the big 3 companies are not interested in smart grids because they want to maintain the oligopoly. But it's improving all the time so you'll see changes now and then for better conditions for instance. For me as a sun power owner. From the 1st of January, there will be an exclusion of taxes from 255kW to 500kW, so you don't need to pay taxes if you produce less than 500kW. Of course, for private people, it's good enough. So, most of the people who have rooftop installations of sun power they can from 1st of January be realized from taxes. That's important. Then you have the big companies or utilities that they still have to pay taxes.

5. One of the driving forces of the smart grid is customer engagement. The supply chain management philosophy drives the supply chain players to view the supply chain as a whole. How do you think the smart grid implementation will change the electricity supply chain management?
6. Do you agree with this statement that due to the distributed renewable generation plants the electricity supply chain will evolve into having more supply uncertainty and less demand uncertainty? Why?

<u>Current situation in the Swedish electricity market</u>

7. Which are the most common business models between prosumers (basic prosumer, microgrid, etc.) and electricity suppliers? Because I've been looking for different business models, like P2P, self-consumption, which I guess it's the case at your home.

   Yes, we are connected to the local distributor and producer, its name is Skanska Energi[33] which is partially owned by Kraftringen in Lund. Skanska Energi is an interesting company, almost 100 years old it was founded by some farmers who came together to get some power to their equipment. So, it's a quite small company but it's very local, so I enjoy that. They pay me when I have a surplus of sun power basically during summer of course and my personal opinion is that I'm not going to be released from the grid. Actually, we have a board member who has disconnected from the grid outside Gothenburg. He is self-sufficient in power. He doesn't need a grid. I would say that we have a good grid in Sweden

[33] https://skanska-energi.se/

so, why don't we use it? You can sell your power to your grid, in my case Skanska Energi. Because dark Swedish winters mean that you don't manage sun power during winters, you have to find another solution. There is an interesting case actually, there is a company in the middle of Sweden: Jämtkraft[34]. They have a lot of hydropower so it's very easy for them to store power from summer to winter in their hydro magazines. They offer that if you produce and sell to them sun power during the summer, they will give the exact same amount (kWh) during winter.

So, they don't pay you with money but with energy during the winter.

They replace the delivery of sun power during the summer with hydropower during the winter. That's beneficial for the private part because it's quite expensive to buy power this time of the year, December for instance. You don't get that much money selling sun power during summer so you don't really increase the value of your sun power facility.

So, this is like a unique electricity supplier who offers this kind of …

Yes, it's the only one. But I hope it'll be more of them and I really wish that it will be possible in the future to increase the amount of energy storage facilities in Sweden. So, in long term, I hope that if I produce an excess of sun power during summer, I can store it with the help of my power company in the winter. That will be an exchange of KWh.

But, I guess that the big 3 companies are not interested in this method.

No, they aren't. must be some lawmakers for that. So yes, Jämtkraft has done that because they have a lot of hydropower back in the mountains.

a. Which are the advantages and disadvantages of the current prosumers business types in Sweden? We have talked about the self-consumption case (your case), the one which exchanges the surplus of sun power generated during the summer for hydropower in the winter. I guess this is an advantage for the prosumer as well and maybe it's also an advantage for the electricity supplier because they can have more prosumers injecting electricity to the grid.

   Yes. And there are the benefits of local production because then you have small losses in the grid and you get compensated because you produce locally power instead of sending it all over Sweden. So, you'll have an extra bonus for producing local power in Sweden.

b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid? Which are the problems that the prosumers are facing?

   First of all, if you connect your power facility to the grid, and that is maybe more important for wind power owners. We have a number of wind power owners and they have to pay a lot to the power company to sell their power.

[34] https://www.jamtkraft.se/om-jamtkraft/hallbarhet/investeringar-och-projekt/

Do they have to pay in order to sell?

Yes. They call it a connection cost. So, for instance, if you have a wind power station of 2MW instate of 1.5MW you pay 10 times more maybe 100 times more to connect to the grid. So there is a very huge connection cost if you want to be connected to the grid with units >1.5MW.

To who do you pay? Do you pay the electricity supplier or the DSO?

The DSO. I've got a friend XXX, he owns a couple of wind stations. But, because of this unfair connection cost he has for selling his green power to the grids, he doesn't produce what is possible. His wind power units are 2MW but he has to pay too much for connecting this 2MW, so he only runs the 1.5MW.

And this is because of the DSO?

Actually, most of the DSO are connected to the 3 big companies in Sweden like Vattenfall. Then, Fortum has sold their district net to Ellevio but they behave the same. So, they want a lot of money if you want to connect to the grid. We want to change that and we are working on that actually. Now there is an investigation from the government about raising this level from 1.5MW to 2.3MW, because a lot of wind power units are 2MW, so if you low this connection cost you will cover a lot of wind power units that way. SEROS's opinion would be that there shouldn't be any taxes on sun power. Now, next year [2021] *any utility >500kW will have to pay taxes. The taxes are quite big: 35€/kWh.*

So, you pay taxes for the electricity you generate?

Yes. You have to pay the state.

Do you receive more money than the taxes you pay?

I hope so. The taxes are per kWh, so you always get some money for kWh. But basically, last summer the power price that you sold to the local distributor was less than the tax you have to pay. So, in some way you're right that you pay more taxes than what you get from kWh.

Yes, and for me, this is a barrier as well, because it's not worth it for the prosumer to invest in this.

That's an obvious barrier. But now for people like me who have only 5kW power on my roof, I don't pay tax for that. But for utilities who have more than 255kW this year and more than 500kW next year, the tax can mean that they don't run some power units, because they will lose money.

I think it doesn't make any sense.

No, no. We are working on getting rid of all kinds of taxes for sun power actually.

But, if you have these big companies fighting against you.

Yes, they want to keep their oligopoly, of course. I think that's all over Europe. I'm a little familiar with the European situation as I worked for the European Renewable Regulation. Last year we have had two applications in the EU about founding's for energy cooperatives and they have disliked them even though they were nice applications I would say. There is an EU organization for this, RESCoop[35], the chair XXX. Then the power companies have a couple of thousand lobbies in Brussels, so when they see that this kind of replication is on the table, they contact administrators they shouldn't support this because they want to keep their oligopoly. I don't have very good experience with the EU because they are too much influenced by the power companies.

c. What should be changed in order to have more prosumers connected to the grid? I guess it would be to get rid of the barriers we have now, as you have suggested before: not having taxes for the sun power, for example.

I can give you some good advice. There is a very good person XXX who is the best when comes to explain how the sun power market works in Sweden and he also has some sun power facilities on his roof. He is a very good guy; I'll give you his name and his connection. For your information, I can say that I also had some cooperation with XXX National Laboratory outside San Francisco. I have friends there, XXX, and he is working with Nanogrids. There is a concept called nanogrids which is local nets for 10 houses that can go together and the constructed net that bits these 10 houses can be self-sufficient.

So then, you are off-grid.

Yes, that's the idea of this solution. Nanogrids focus on cooperation with 10 houses or so. You can google nanogrid word within Berckley university and you might find information.

Yes, because I'm interested in which kind of business models you can have in Sweden in the short-term future. What prosumers can expect. Because I've talked to some people and I also know people from Spain who are afraid of investing in this kind of thing because they don't know how electricity suppliers will pay them. So, I think it's good to know how it'll be in order to have more prosumers investing in this kind of things.

I can also say that one important change that we want to do in Sweden is if you buy from the local distributor, they have fix charges independent of how much you consume and it's high in Sweden. And we think that it should be no fixed charges, it should be a charge for kWh. So, the only thing you should pay for connection is per kWh. The fixed charge is really high and it's unfair for people who have an apartment for instance who consume 2000kWh per year because most of the cost for this is the fixed connection price that the companies ask for. That should be no relevance for this fixed price because if you buy a flight ticket or a train ticket you don't divide it into two pieces, one for the fixed price and one for the ticket.

[35] https://www.rescoop.eu/

Is this price you are talking about the UoS? I've read a lot about the UoS tax, so you have to pay in order to use the distribution network. Is this cost fix you are talking about?

[thinking]

Because I've seen a type of business model, which now I don't remember the name, in which you can use the distribution network of the 3 big companies and then you have to pay this UoS cost fix because you are using their distribution network.

Oh yes.

But if you have your own [distribution network] then you get rid of this type of cost fix. But I also have read that in the UK, the framework I'm taking, it's mandatory to use the distribution network. So, you cannot get rid of this fixed cost. I don't know here in Sweden how it works.

Not sure if I understand your question but I can say that most of the revenue that the power companies make today are from the fixed connection costs. So, the Swedish system works that if you want to buy a kWh, you can buy it from anybody but there are local monopolies, so the local distributor can charge you a lot actually. We have complained about the level of this fixed cost. To my calculation, I can say that you could save at least 4 billion € if you have a decent price of connection costs. I mean, the nets are already there so why should you pay for that each year. You should pay once they have made this net, but not every year because it's a very low cost of maintenance.

Because now, how does it work here in Sweden? Because, if you don't have enough capacity, for example, you live in a rural area and you want to invest in a solar PV system and the grid doesn't have enough capacity in order to connect, who pay for the investment on the grid? Because I guess an investment is needed since you have to increase the capacity. Is it the prosumer who has to pay for it or is it the DSO? Because then it's also a barrier.

Well, the DSO will charge you for increasing the net of course. It's their responsibility, if you want more power, they should give you that. But they will charge you for it, a lot of course. Still, it's their responsibility to deliver power to people who need it. There is a very strange situation in Sweden that we are divided into 4 countries. We think that's a bad idea. For example, in Skåne, in Lund, we pay a lot much more for the power than in the north of Sweden. You can see it today if you look at the Nord Pool prices. There is a huge difference in how much do you pay in Skåne and the middle of Sweden. The extra price you pay here in Skåne is not correlated to the transmission costs because they are maybe 2€/kW. But you might pay 1SEK extra if you live in Skåne compared to if you live in the north of Sweden. There is no justification for that. I wrote an article in XXX the day before yesterday, where I said that you should only have one power zone in Sweden. Because Sweden is 1 country, not 4. To my knowledge was the Danish who wanted

to have it to be able to sell wind power to Skåne in a profitable way. But I think it's not a good argument.

d. Do DSO always receive money for UoS (Use of System) or is there any possibility that the prosumer is exempt from this payment?

8. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?

There's the tax reduction, of course, important, especially for sun power. Otherwise, I think sun to power it's cheap enough. From the 1st of January, you will receive a tax reduction in your income declaration. I think that's a good situation, it minimizes the bureaucracy. Today you have to apply to the regional authority to get some support. But this will be different now since the 1st of January, it will be written down in your income declaration: I want a tax reduction because I have a solar PV facility. I think it's a good idea. So, as I told you in the beginning, it's getting better but there is still a lot to do. Especially when it comes to the grid costs. They are far too high. The big companies are making money because of the grid costs, rather than the production of the kWh. I can tell you also that the power consumption in Sweden has been decreasing all the century. So, in 2001 I was sitting on the board of the Swedish National energy Authority, then the consumption of power in Sweden was 150TWh. Now, the last year we are down to 132TWh. We have really decreased the consumption of power. It's not a big problem for the net because you distribute less power, you don't need to expand. There is a discussion in Sweden, sponsored by the big companies. I don't know if you are familiar with professor XXX from Chalmars University, he is a national expert. I ask him: who is sponsoring this campaign for nuclear power? He said, the Finish company, Fortum. He was sitting on the board of Vattenfall so he had some inside information. There are some big power companies who are expanding a lot of money telling some politicians that don't know very much, you should say this. So, there is propaganda in Sweden. As I am against nuclear power, I've been XXX. [….] we don't have really freedom of speech in Sweden because the media are sponsored by power companies.

Yes, they have a lot of power.

Yes, that's worldwide I would say.

I have looked for subsidies in Sweden and I have seen that you have, not only the reduction of the tax but you also have things the green certificates, the capital subsidies, or the guarantee of origins. This king of subsidies, do you think they will change in order to have more prosumers?

Some European countries, like Austria for example, pay less rent for some investments which are sustainable. That should be developed. Green investments should have lower rent than business investments.

9. Nowadays the electricity grid is under a lot of pressure due to the increasing electricity demand. For ensuring effective decision making and supply chain efficiency; realistic, informed and detailed information sharing between chain members is needed.

e. Which are the tariffs preferred by the prosumers? And by electricity suppliers? Why?

f. How do you think the different tariffs can affect the development of the new business models?
g. If prosumers are considered players in the electricity supply chain:
    iv. Do they have any possibility to take part in the decision-making of the local grid?
    v. Do prosumers trust electricity suppliers, which is the level of trust: low, medium, or high? Why?
    vi. Which tools (tariffs, customer service, etc.) electricity suppliers have in order to earn the trust of the clients?

Prosumers future in Sweden

10. Which business models is Sweden planning to implement in the short-term future?
11. Which business type benefits the prosumer the most? And electricity suppliers?
12. Which are the barriers to the implementation of new business models?
13. Which subsidies can a prosumer expect in the future?
14. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?
15. Related to the collaboration between electricity suppliers and prosumers. If prosumers are considered players in the electricity supply chain:
    k. Is it expected them to have more power with the decision making of the local grid?
    l. Is the information shared between prosumers and electricity suppliers going to improve and with that the level of trust between them?
    m. In general, are prosumers going to have more advantages in the future?

Other

16. Is there anything you want to add?

At last, if you have some suggestions of other people to interview, please send me their contacts

Interviewee:	Anna Werner	Date:	05/12/2020	
Company:	Svensk Solenergi			3
Position:	CEO			

Contact information

1. Can you tell me about the role of *Svensk Solenergi* in the Swedish market?

   Svensk Solenergi is an association. I am the CEO of the Swedish Solar Energi association with 260 company members. They are listed on my home page. Many of them are installers, some are producers (few), research institutes, schools, consultancy firms, and suppliers. Even electricity companies selling and buying electricity are members. I even have the grid companies as members.

   When do you say grid companies you are saying for example E.On?

   Yes.

2. What are you working with? You have inputs from all of your members and …? Which goals do you have?

   I am the voice of the members of the whole sector/business. So, when you need somebody who says what the sector thinks, I'll try to answer.

Smart grids and electricity supply chain management in Sweden

3. Is it the Swedish electricity grid challenged in terms of capacity? If yes, which kind of resource is used: investment in the grid or the implementation of smart grids? Why?

   I think both are needed. I am sure they are working on both right now. But maybe they don't tell everything to us. But, I'm sure most grid companies are investing in smart technology right now. Of course, also building more grid, strengthening the grid in many ways as possible. Because we have a shortage in some of the high-density areas where there is a lot of people. The population in Sweden has been growing and we have foreign companies coming here because of the cheap electricity. So, of course, that challenges the grid.

4. Do you think that the electricity suppliers are interested in smart grid implementation? Why?

   You know it's a natural monopoly, so maybe the "grooms" are in favor of buying new cables, they don't operate in a free market where supply and demand meet. It's a monopoly market. It's all about what you write in the instructions. Right now, I think they get more money if they strength the net with more cables rather than if they implement smart technologies.

   Because do the smart grid technology will reduce electricity consumption?

No, I don't know. Or maybe to put it into another time of the day.

5. Do you agree with this statement that due to the distributed renewable generation plants the electricity supply chain will evolve into having more supply uncertainty and less demand uncertainty? Why?

   No. I just think we will get more electricity. We still have a lot of hydropower in Sweden. Then we will add renewable generation on top of that.

   So, you'll have more electricity generation.

   More than today.

   But this question was aligned with the fact that the renewable sources you cannot rely on them all the time because for example the solar PV power it's only during the day and mostly here in Sweden during the summers.

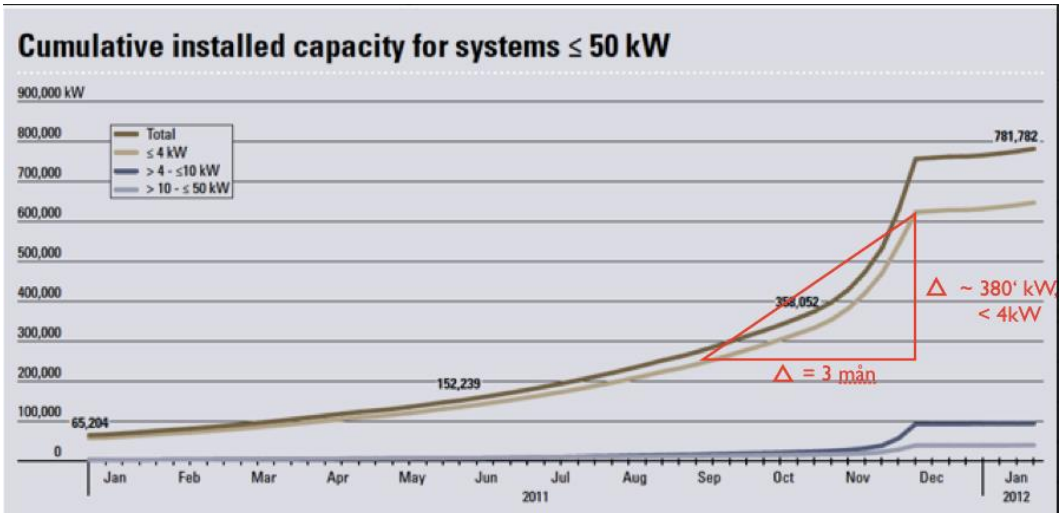
   But it's small variations. Imagine when you have a problem with a nuclear plant. Then you don't have the energy for half a year when they have to fix it. It's just a different uncertainty. Because you know, after the rain there is always sun.

Current situation in the Swedish electricity market: incentives and business models

6. Which are the most common business models between prosumers (basic prosumer, microgrid, etc.) and electricity suppliers?

   [About basic prosumers] Yes they connect to the grid, otherwise, they don't get the subsidies. They are all connected to the grid.

   But I've also found that in the UK, my framework of the study because they have a lot of things going on. They have 3 more business models: the microgrid (…). Which kind of relationships exists in Sweden between prosumers and electricity suppliers? It is only the basic prosumer?



The normal business, the traditional, is that (…) I have an interesting graph of the English market. The normal business model is that they sell the electricity trader, the XXX in

Swedish. And some electricity traders, are specialized, they buy a lot of electricity for solar plants (Bixia, Telge Energi, Vattenfall, etc.). All of them have different ways of buying it. You sell your electricity to them and many of them have deals where they say: I can pay you a lot for the electricity but we also want you to buy electricity from us. What they think is that maybe the deal when they are buying your solar electricity you get a got price but maybe the price you pay for the electricity is not so good. It's a package deal. It's difficult to see what you really pay.

This is why in the UK they are trying to develop new business models in order to have more information shared between electricity suppliers and traders and the prosumers itself.

We call it bundling when you put together many different things in a deal. They are bundling the buying and selling. This is how it works today, I don't know about microgrids. I don't think we have many. We have a company called Ferroamp, which has made DC microgrid. We don't have energy communities yet.

But do you think it will be?

Of course, it has to be. It's a directive from the European Union. We will have them, but not yet.

Do you know why don't you have it yet?

They are working on it. The ones who are implementing it is Ei, an authority.

So, this institution is the one leading the future of the electricity market?

Yes, and also implementing energy communities.

a. Which are the advantages and disadvantages of the current prosumers business types in Sweden?

   There is a company called Umea Energi, they have some kind of leasing agreement with the small house owner. That works differently.

b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid?

   After the new year, you'll get the subsidies. So right now, you don't invest because there are no subsidies. But they will be soon. So, maybe we will see an increase.

c. What should be changed in order to have more prosumers connected to the grid? Give more subsidies maybe?

   No. we should take away the… like if you want small consumers you might continue the way you do today. But if you want bigger plants the policy has to be changed. But in Sweden, we have politics that they have been wanting to have small plants on the single house roofs. That's why we have that.

What do you mean?

We have a good situation for small solar installations. Not today, but after the new year we will have subsidies again. So that part of the market will be growing.

Do you know which kind of subsidies will you have?

Yes, you'll have the tax deduction. So, when you work you usually pay a lot of income tax but if you have installed solar PV systems you will pay less income tax. (…) if you have a small plant you don't pay tax on the electricity that you're consuming yourself. But for bigger plants you do.

d. Does the DSO always receive money for UoS (Use of System) or is there any possibility that the prosumer is exempt from this payment?

7. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?

For small PV plants, I don't think you need to do much. I mean, they have a good market. Next year will be a good market for them.

8. Which are the tariffs preferred by the prosumers? And by the electricity suppliers? Why?

I think the electricity suppliers are very afraid of changing the tariffs of the consumer side because they are afraid that the consumers will be angry. Because a lot of consumers are used to have the same electricity price all the time and they are lazy so they don't want to think: shall I use now or tonight? They want to continue the same life with more or less the same price of electricity all the time. Therefore, the grid companies a little bit afraid to say that it'll be expensive to transport electricity during the day for instance. So, that's why we see such a slow change in the tariffs on the consumer side. They don't want to get a bad reputation. There are companies who did that and they got a lot of upset consumers.

9. How do you think the different tariffs can affect the development of the different business models?

It affects everything. Because you optimize how much you pay for everything. Of course, it is important. For instance, the grid tariff is very high for large plants. That explains why we don't have large plants in Sweden. It can be 30% of all the costs. But for small houses, they are exempted from a lot of those costs. They have a goof market next year.

10. If prosumers are considered players in the electricity supply chain:
    b. Do they have any possibility to take part in the decision-making of the local grid?

    We have 160 grid owners in Sweden and some of them are owned by the municipality. So you can vote for a party. You can affect by voting. We have elections on the municipality level also. The parties are on the board of that companies when they are voted by the people.

    c. Do prosumers trust electricity suppliers, which is the level of trust: low, medium, or high? Why?

The trust is low, there is like a blacklist [guy of the chat]. There are a few companies who are cheating on the consumers. He has a list of these companies. The grid companies have a worse reputation because it's a monopoly.

d. Which tools (tariffs, customer service, etc.) electricity suppliers have in order to earn the trust of the clients?

They can have nice salespeople which they don't lie and are honest. Because they do a lot of calls. They should have good tariffs with the flexibility of prices, low – high (…). For earning trust, you can always do marketing and I'm sure they have some certification, like a nice electricity brand. Like fare trades. I'm sure they have a lot of things they can do, because some of them have a very good reputation, and obviously some of them not.

Prosumers future in Sweden

11. Which business models is Sweden planning to implement in the short-term future?

I think maybe it'll depend on how the European directives are implemented. You can have different kinds of energy communities.

(…) the European directive is very vague on how these communities have to look like. It's up for every country. (…) Maybe we can get some small energy communities with your neighbors and then maybe you can get some …. You don't use the grid so much, you don't pass the next station so then you just take a lot of electricity from yourself and your neighbors. So you pay less for the grid, so then maybe you can call that, I don't know, self-consumption tax or maybe you can get rid of that too.

12. Which business type benefits the prosumer the most? And electricity suppliers?
13. Which are the barriers to the implementation of new business models?

Main barrier: the producers of all kind of electricity they don't want this new source of electricity. And we are very small. The association is very small. The other kind of powers they have 20 people working for them, with good salaries. It's difficult for us to be heart, all the rules are made for all types of electricity. for all the other kind of electricity you cannot use your own electricity, so then for them, it's good that you pay tax for the electricity you produce and consume yourself. (…) those players are making really hard. The district companies burn garbage [for heating]. They don't want solar electricity in the summer. What they do is burn garbage for electricity in the summer. They have the combined power plants where during the summer they burn garbage for electricity generation because nobody wants to buy heat in the summer. They don't want solar electricity in the summer because that will compete with their electricity. Those players are the main barriers. They want the world as it has always been. They don't want this new kind of power source to take the market.

And then when you are alone as a private investor it's really difficult to fight with them. You cannot fight with big players.

Exactly. They have to organize the prosumers. Maybe if energy communities are incrementing in a smart way maybe that will make the prosumers strong together. Then the solar electricity will take more market shares. Maybe. It all depends, who lives will see.

14. Which subsidies can a prosumer expect in the future?

No [no more subsidies apart from the tax deduction]. We have something called the green deduction, that will go on for a long time but we won't get more than that. And prices have gone down so, I think we are happy with that. It's stable system. It'll be a good system.

15. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?

I don't know. It's all about politics. I don't know how it'll be changed.

16. If prosumers are considered players in the electricity supply chain:
    e. Is it expected them to have more power with the decision making of the local grid?

Any difference.

    f. Is the information shared between prosumers and electricity suppliers going to improve and with that the level of trust between them?

It will get much more information, like the prices right now, for instance. So you can increase or decrease your production. The level of trust, I don't know. Trust it's something you earn, so if they do a good job the trust will increase.

    g. In general, are prosumers going to have more advantages in the future?

<u>Other</u>

17. Is there anything you want to add?

At last, if you have some suggestions of other people to interview, please send me their contacts

Interviewee:	Håkan Feuk	Date:	16/12/2020	
Company:	E.On Retail			4
Position:	Head of CEO Office & Political Affairs			

Contact information

1. Can you tell me about your role at E.On?

   I am head of CEO office and political affairs. So, it's quite a general topic but I've been working a lot with some heading political affairs department. We are working a lot with different types of market arrangements and things like that. In the past, I've actually been chairman of the market design team in the Eurelectric[36] European Association. So, I still quite know how it works in Spain and other countries as well.

E.On

2. Why is E.On interested in distributed solar PV plants? Because my thesis is focused on business models between prosumers who have solar PV facilities.

   I think it's because there is a huge interest by consumers to start their own production and PV is a thing you can do as a private person. There are also companies, more and more companies, that would like to enter into this. By rooftop PV, there is more and more field mounted plants coming in Sweden. So, I think we have two different rows in E.On. First of all, we are the largest distribution company in Sweden so of course, we are connecting a lot of PV plants in our distribution business. Then we have the energy solution business, where we are selling PV plants as well. It's because there is an interest in the market, it's something we believe as well. We would like to push sustainability further in the market as well. But basically a lot of customers, it has been accelerating a lot the last years.

3. How many solar PV system installations have you made in the past 10 years in Sweden?

   Do you mean as E.On?

   Yes.

   We haven't communicated this number. It's something we are not communicating.

4. Does the customer have to have you as the electricity supplier?

   No, basically not. I think it's the most common that you are a customer when it comes to the supply of electricity. But basically, we can sell the installation only as well.

5. You said before that E.On is the largest distribution company in Sweden. So, how E.On can influence in shaping the future of the Swedish electricity supply chain?

[36] https://www.eurelectric.org/

Of course, there is a dialog, like in other countries as well. As a company, we have a lot of political contacts and regulators as well. Also, through the association: SwedEnergy[37] where we are a member and I'm actually a member of the board in SwedEnergy. So, there is a dialog to make sure that we have something that it's fit for purpose.

6. Why E.On is interested in the UK market? Are you going to apply some "lessons learned" from the UK to Sweden?

   I am not the right person to comment on this. I think basically, E.On is a German company with the head office in Germany. I think when it comes to PV, we have done much more on PV in Germany than in Sweden. In Sweden, it's still a new development. If you look at Germany, they have a lot of PVs for many years. So, I think of course there is a transfer of knowledge and so between the different units, but it's basically more coordinated by the mother company in Germany.

Smart grids and electricity supply chain management in Sweden

7. Is it the Swedish electricity grid challenged in terms of capacity? If yes, which kind of resource is used: investment in the grid or the implementation of smart grids? Why?

   It's certainly challenged in terms of capacity. First of all, you can say that if you look at the transmission network operated by the Swedish TSO, Svenska Kraftnat, there you have a lot of grid bottle necks. As you might know, Sweden is split up into 4 price areas, and you see that we live here in the South. On average, we have much higher prices than in northern Sweden. There are huge bottle necks within Sweden and of course with the neighboring countries as well. So, I think this is one thing. There is the basic method you use is to build more power lines which take at least 10 years to build a new power line, especially when it comes to licenses and process, and staff. And then you also have counter trading other measures that you have to take during operation to make it work. When it comes to the regional grid, there are challenges as well. When it comes to renewable, you have some kind of connection that stops in some parts of Sweden, in XXX, (…). They have actually made it mandatory on connections. I think PV plants more than 1 MW and also wind plants you cannot connect from the time being because there is no capacity in the grid. We have had some issues as well with capacity in southern Sweden. I think it's happing a lot of things lately, but certainly, PV is not a problem for prosumers. It's mainly a lot of new urbanization where you have a lot of growth in the large cities, you have a lot of new consumption coming in (…). It has not been possible to build new lines in time. So, you have to have both solutions. Of course, you need to invest in more grid but we also have one initiative, which's called Switch[38]. We have a system, I think we have 110MW of capacity for this winter here in the south of Sweden. It's basically a bidding system where you qualify and then depending on the situation in the grid we actually have some kind of XXX system where the one that is prepared to get less remuneration is then reducing its capacity needs. So, it's something we are using here. It's actually a project called CoordiNET, the EU project. In the Swedish part, it's E.On, Vattenfall and Svenska Kraftnat are involved in this. This platform is used in the Stockholm area as well. (…)

[37] https://www.energiforetagen.se/in-english/
[38] https://www.eon.se/foeretag/elnaet/switch

So, the summary would be that you are using both ways depending on the situation?

Yes. And you can say that when it comes to the smart grid like using flexibility this is still not really fully functioning. Today the basic way that the DSO can make money is by investments. You get a return of investments on your asset base and if you do other things it's basically just a pass-through. But there is a discussion, I think it's also part of the European regulation, that you should be able also to get remunerated. If it's better for the consumer that instead of just investing that you use flexibility then you should be able to do that and also get paid for that in a proper way. But I think this is coming. It's still in an early phase.

8. Which level of smart grid implementation (low, medium, or high) do you think Sweden has? Why?

It depends of course on what you mean by the smart grid. I think you can say that the transmission has always been smart. We have always been measuring in real-time and we have always done a lot of optimization. I'd say that the regional grid is similar. We actually have a lot of monitoring. If we come down to low voltage, so far you have basically in some parts are blind as a DSO. You don't really know what is happening to each customer. We have some smart meters already today. In Sweden, we have had for many years. Everyone has automatic metering. You don't have people doing manual metering. But, this generation that we have in operation right now is more just measuring down to XXX values. The next generation, starting to be installed and they have to be installed the latest at 2025 for all consumers, you'll have much more information. For instance, today we don't see if there is a power cut for single customers, we just see it for an area.

Maybe this question was more understanding smart grids as the flexibility that customers can have when they have to choose between consumption periods.

You can say this is something you can have already today. Because we have hourly metering. You are able to get hourly supply contracts. Already today you can shift and say, I'm using the washing machine during the night instead because the electricity is cheaper. This is something you have been able to do in Sweden for quite some years now.

So, which kind of flexibility is the one you cannot do in Sweden right now?

I think you can do a lot but you haven't had any market for it. Sweden traditionally you can say the price is not that volatile as for instance Spain or many other countries. (…). But in most markets, you have a lot of variation with much lower power prices during the weekends and nights. Due to the hydropower that we have in XXX, in the night when you have lower demand, you use less hydropower. So, the water is staying in the reservoir and during the daytime, you are pushing more hydropower. That means that prices are averaging out much more, you haven't had any incentives. The incentives are now coming mainly on the grid with the switch where we can bid in capacity. So far in southern Sweden, it's mainly a little bit larger customers and energy companies. I know that in Stockholm and Uppsala area you also have some aggregators that are aggregating small customers. So, I think you have been able to do it for many years but you haven't had any incentives because there hasn't been any market need. This is coming now. Especially if we get very cold weather, we might get very high prices and then you could, of course, benefit from it.

So, the flexibility of the grid will come because is a need of the market?

Yes. When I was working a lot with Brussels [markets are very different in different countries] they wanted to push these solutions. Basically, there have been some people believing that large companies are not really interested in it, but I think it's more, so far, we haven't had the need for it. But we see that it's actually coming quite fast. We have a lot of electrification going on, where we need to use flexibility much more than we have done so far.

9. How do you think the smart grid implementation will change the electricity supply chain management?

I think that you need to be able to offer this type of solution to the customers to be able to be competitive. With the new technologies, as a customer, you don't really have to anything on your own. You'll have intelligence systems that will manage [for you]. (…) so, I think that to be able to be competitive you need to offer this. You'll have interaction with the grid operators as well. So far, as an electricity supplier basically, you are buying electricity at the power exchange, and then you have to make sure that you balance it so that what your customers need is what you have bought, matching your supply. Which always has been a little bit tricky. This will be much more flexible in the future when you need to work with flexible customers. It will put a lot of new challenges, new opportunities as well. If you want to be competitive in the future you need to be able to manage this.

Competitive as an electricity supplier, I guess.

Yes, because if someone is able to have solutions where you can actually benefit from flexibility, then you'll be more competitive compare to other suppliers that don't have this opportunity. Then there are, of course, differences in different segments. If you are living in a small apartment in Lund as a student maybe you don't use so much electricity, the need for flexibility is less than for other customers.

10. Do you agree with this statement that due to the distributed renewable generation plants the electricity supply chain will evolve into having more supply uncertainty and less demand uncertainty? Why?

I think in practice it's mainly PV, I don't see, for the time being at least, that you have other technologies. It might come in the future, fuel cells and things like that. But I don't see that because it's quite easy to forecast. You'll learn from this; I think you'll learn.

<u>Current situation in the Swedish electricity market</u>

11. Which are the most common business models between prosumers (basic prosumer, microgrid, etc.) and E.On?

I think it's very simple. I have PV at home and I basically have a supply contract. When I have a surplus, when I generate more than I consume, then I sell it to E.On. And the opposite, when I need more than I produce, I buy it from E.On. So, this is quite simple.

Do you think there are more types of relationships?

I believe this is the only one. Of course, you can develop in different ways, but that's basically how it needs to be done. You need to have 2 meters, you have one meter for the consumption and the other one for the production. You need to measure this and you need to pay electricity taxes for what you are buying.

Before you said something about Uppsala and aggregator form, where prosumers are unified in order to sell electricity together or maybe consume the electricity they generate together?

It's actually a supplier who is aggregating. This is less to do with prosumers, is more to consumers. But in any way, it could also be prosumers, it really doesn't matter. But I think it's quite straight forward. I don't think it's that complicated.

a. Which are the advantages and disadvantages of the current prosumers business types in Sweden?

   I think it's a difficult question. Of course, you can have other types of arrangements where you don't own your PV yourself and you have a renting arrangement. You have discussions of different types of more virtual arrangements, but at the end of the day, it goes back to the same model.

   This virtual arrangement, what is it?

   If I have a surplus, maybe my neighbor would be interested in buying it. But this is something you can do virtually, but I think due to the market arrangements it's basically that I'm selling to the market and my neighbor is buying from the market. Then, virtually you could say that he is buying from me.

   But, is this more advantageous for the prosumers?

   No. There is no such advantage. There are discussions that, today it's for self-consumption you don't need to pay the electricity tax for self-consumption. It's difficult for people living in flats because you don't have the same opportunity to have a PV on your roof. To find similar solutions maybe you have a share in a larger PV plant. This is not possible today, but there are some discussions if you should make this possible.

   So, back into this virtual plant, it's not cheaper for the customer to buy electricity from the neighbor. It would be exactly the same but the thing is that you know where the electricity comes from.

   Yes, I'd say it like that. Because the electricity still has to go to the grid and you still have taxes and things like that. You cannot avoid that.

b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid?

   I don't really see any barriers. I think it's growing. Still, we are quite at a very low level in Sweden when it comes to PV, especially if you compare it to Spain or

Germany. Because we have never had these huge subsidies and feed-in tariffs that you have had in some other countries.

Maybe these would be barriers?

I wouldn't call it a barrier. It will never come either in Sweden. Now there is a situation that you actually will facing out… you have the green certificate system in Sweden right now that will be facing out next year. The basic financial incentive you have today is that you have the opportunity to get the grant, then you also avoid tax on self-consumption, and then you get a tax release for the volume that you are selling to the grid. So, there are certainly benefits today.

c. What should be changed in order to have more prosumers connected to the grid?

To make it financially more attractive, of course. Because in practice it's not a problem to do the arrangements. If you look at private consumers, you could say that you could do it possible for people that do not have their roof, to have similar arrangements. A large house with apartments where could put it on the roof and then you could have the share of it, or some other solutions. So, this is something you could make possible. Today you also have a certain limit for larger consumers. It's basically commercial storage, so you have a lot of roof area. Then you actually have a limit of how big these PV plants can be but you still have this tax exemption. This is something you can do. Then I think it's quite a positive step what it's taken now for private consumers where you actually get a deduction at construction. Today we have had a very complicated system where you build the plant and then you make an application to the authorities and then you can get back some money. Sometimes it could get 2 years before you get it, and you don't really know in advance. So far everyone has got it because the government has put more money into the system. But basically, when you made an investment you really didn't know if you get the money or not. Now will be more upfront, which makes it much easier straight forward. Has been a little bit complicated but that has been simplified as well. When I built this, I had to register for tax, as a company to be able to sell electricity to the grid. This has been changed as well. There have been some of these steps taken to simplify things. So, it has to be simple for customers to be a prosumer. I'd say that to make it possible for people without their roof to be a prosumer, simplify processes, which I think has been done quite… for private consumers there have been certain very good steps taken. Then I think, this pressure [33:33] that you have for larger consumers, basically companies that are interested in building large rooftop plants as well.

d. Does E.On always receive money for UoS (Use of System) or is there any possibility that the prosumer is exempt from this payment?

You always have to pay for the grid and then there are certain rules when it comes to connection costs. Smaller prosumers they don't have to pay connection cost on their own, it's socialized. But larger prosumers have to pay for the connection as well. What you get as a prosumer is payment for the grid, that you actually supporting the grid. So, when I'm exporting electricity, I'm supporting the grid. Normally the flowing is getting to the other direction, from the transmission to

regional to the local grid. So, I get the payment per kWh for what I'm selling from the grid company.

12. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?

First of all, I think that subsidies it's probably something that will disappear. I think, today you can actually get this tax release when you build it. It's a simple system. So, I think this is good. I don't think that you need more subsidies. I would say that for a private customer, it depends on how you calculate, but maybe you get your money back in 10 or 15 years. (…) Many people do it because they want to support sustainability. (…)

13. Which are the tariffs preferred by the prosumers? And by E.On? Why?

I don't think there is a clear preference. The basic opportunity you have is that either you have a fixed price. I think so far it has not been considered that much, the volume it's quite low.

What do you mean the volume is low?

E.On as a supplier, it's a huge difference if we have 1000 customers that are prosumers or 100000, because it has much more impact and then you need much more precise. So, I think, normally you can say that a customer is buying less electricity in the summer and buying more in the winter, compared to a customer that doesn't have any PV plant. The electricity's normally cheaper in the summer than in the winter, which means that basically, the average price should be a little bit higher from the supplier to the prosumer, as they buy less when prices are low and buy more when prices are high. And this is something I think's not being so much in focus so far because they are so few and we don't have these huge variations anyway in the Swedish market. I think the basic question for a consumer is if you want to have a variable price or a fixed price. Actually, most customers have a variable price, but then you pay the monthly average of the spot price. But then you can also pay the hourly price, to have a different price for each hour. That is actually when you can use flexibility the most. But I think there are so far quite a few customers that have it. It's something that everyone can have. And you can have fixed prices like 1 year, 2 years, 3 years. It's like if you have a mortgage by the bank, it should have a variable interest rate, or should I have a fixed interest rate.

14. How do you think the different tariffs can affect the development of the different business models?

I think to really make a difference you need to have a battery as well. Because given the framework in Sweden that there are very few people that they have storages. For instance, you can get grants for building and installing a battery. The price is about the same. If I use electricity myself or if I sell it to the grid, it's more or less the same value because you get some kind of tax deduction if you selling to the grid. So, right now you don't have any incentives, but I think over time you'll probably have an advantage if you are able to be more flexible and if you have a battery. So, then, of course, you could benefit from a more hourly price where you actually can use your battery and of course your consumption if you have a heat pump or something like that. I think then you benefit more from the variable

price. If you have a fixed price over the year, you don't really have any incentive to be flexible.

15. If prosumers are considered players in the electricity supply chain:
    e. Do they have any possibility to take part in the decision-making of the local grid?

    The same as for all consumers and producers. We make grid plans and this will be a more structured process and public process in the future where we'll do it together with the DSO and the local grid. There you have to look at different, it's like XXX with customers that want to establish themselves or if they want to extend operations and things like that. The same for producers. So, of course, as a grid operator, you need to look at first of all what will happen with consumers and producers and prosumers. And then I also think that when it comes to flexibility, if you know that a lot of customers are flexible, maybe you don't have to build a new power line since you can use flexibility instead. But I don't see that you have a lot of decision making, but of course, you can influence decision making.

    As a prosumer?

    Yes, and I think everyone. Then it depends if it is very small. It's like, one house it really doesn't matter but if it's a lot of them it makes much more difference.

    f. Do prosumers trust E.On, which is the level of trust: low, medium, or high? Why?

    I know that we have made some because we are measuring basically customer satisfaction and things like that. You can say that the ones that have bought PV from us are much more pleased with us. But it's quite difficult because if you wouldn't be pleased with us you would probably not do it. I think you have a preference from the start if you believe that E.On is a good company, then you are much more likely to do this type of business with us. It's still quite a high investment for many customers. So, if you don't trust us, you won't do this type of business with us. First of all, prosumers are much more interested in energy than other people. They do it because they have an interest. If you don't care you wouldn't do it anyway. I would probably say that in average is higher. Because they trust and they are much more active than others.

    g. Which tools (tariffs, customer service, etc.) E.On have in order to earn the trust of the clients?

    You have to have fair pricing, customer service. More and more customers are making interactions digitally today and you need good and simple digital tools. You have to be able to do everything you need to do in our apps and so. In a large company you also have very different customer groups. Some people want to call us. We have to be able to say that we care about people. To be a trustworthy company that you have to ensure that the grids are working. I think we do it.

    But I think the big change in the future is when it comes to flexibility and I think also related to the grid. You've always been able to work with flexibility to the

energy market, frequency regulation, and things like this. But, working with grid bottle necks is something that is coming more and more.

Prosumers future in Sweden

16. Which business models is Sweden planning to implement in the short-term future?
17. Which business type benefits the prosumer the most? And E.On?
18. Which are the barriers to the implementation of new business models?
19. Which subsidies can a prosumer expect in the future?

But, as I said, you actually can expect fewer subsidies. In Sweden we have much more generation on average than consumption, we are exporting a lot. But at the same time, we have problems with capacity, sometimes. Actually, we have closed down some nuclear plants, we are building more wind power. Then everything is fine when the wind is blowing, but it is not blowing all the time. The basic thing that is happening now is that you need to have incentives for the capacity to make sure you can supply also when the wind is now blowing and the sun is not shining.

(…)

I wouldn't call a guarantee of origins a subsidy. Today you have the green certificate and the market prices more or less zero today because we have no supply [49:38]. Then you have GO which is something you get for all types of generation. You have a certain market value this, which is currently very low.

So, you wouldn't say that this is a subsidy?

No. I wouldn't say it's a subsidy. I'd say is a market arrangement. The green certificate it's a subsidy. A GO not because you can get GO from nuclear power as well. Then you can sell this to consumers. So, it's more a market arrangement. Maybe some people call it a subsidy.

I was considering it a subsidy because it's a thing that the prosumers can earn money from by selling them.

I think now no one cares. I think now it's something like 0.2€/MWh, so it's very low today.

20. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?
21. Related to the collaboration between electricity suppliers and prosumers. If prosumers are considered players in the electricity supply chain:
    e. Is it expected them to have more power with the decision making of the local grid?
    f. Is the information shared between prosumers and electricity suppliers, like E.On, going to improve and with that the level of trust between them?

    Today it's basically the measurement of the values for invoicing. I think if you use the flexibility it will be much more important. Then you need much more real-time data to be able to provide flexibility and sell flexibility. This will increase in the future because you need real-time data in order to be flexible.

g. In general, are prosumers going to have more advantages in the future?

Other

22. Is there anything you want to add?

At last, if you have some suggestions of other people to interview, please send me their contacts

You can contact Power Cercle.

Interviewee:	Martin Nilsson	Date:	22/12/2020	
Company:	Swedish Energy Markets Inspectorate			5
Position:	Analytiker			

(*) This interview was answered via e-mail due to difficulties in finding a date.

The following table summarizes the main concepts discussed in the thesis:

Business models	**Subsidies**	**Tariffs**
Basic prosumer	Feed-in Tariff (FiT)	Interruptible Capacity Program (ICAP)
Microgrid	Feed-in Premium (FiP)	Emergency Demand Response (EDR)
Local energy company	Capital subside	Peak Time Rebates (PTR)
Peer-to-peer (P2P)	Green certificate	Real-Time Tariff (RTT)
	Guarantee of Origin	Critical Peak Tariff (CPT)
	Grid compensation	Static Time of Use Tariff (TOuT)
	Self-consumption	

Contact information

1. Which role does Ei play in the Swedish electricity market?

   Ei is the Swedish national regulator authority.

2. Which is your role inside Ei?

   I am working in the technical analysis department as an analyst.

Smart grids and electricity supply chain management in Sweden

3. Is it the Swedish electricity grid challenged in terms of capacity?

   Yes, on all voltage levels I would say. Large projects are ongoing and planned for on transmission systems.

   If yes, which kind of resource is used: investment in the grid or the implementation of smart grids?

   Both, we are also investing and testing local capacity markets as well as a bit of new design of the frequency restoration reserves.

   Why?

   It is coming from an increase in intermittent demand and generation.

4. Which level of smart grid implementation (low, medium, or high) do you think Sweden has? Why?

   I am not 100 % sure what your idea of what a smart grid is. I cannot rate it right now.

5. Do you agree with this statement that due to the distributed renewable generation plants the electricity supply chain will evolve into having more supply uncertainty and less demand uncertainty? Why?

   I would not agree. I would say that the demand uncertainty is increasing as some of the new demand is of a very intermittent character and uncertain. However, you are right that the uncertainty and intermittency in the generation are increasing.

Current situation in the Swedish electricity market

6. Which are the most common business models between prosumers (basic prosumer, microgrid, virtual plants, etc.) and the electricity suppliers?

   I am not 100% sure I know these definitions, however, I would say that it is the "basic prosumer".

   a. Which are the advantages and disadvantages of the current prosumers business types in Sweden?

      It seems to be a good business as many are investing however, when they start to become a producer and inject power into the system we hear that they have issues in the lower voltage grids.

   b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid?

      As I have heard the prosumers i.e. houses with solar panels, invest as they get enough economic incentives at the moment.

   c. What should be changed in order to have more prosumers connected to the grid?

      -

7. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?

   I think the best is subsidies on the investment.

   The reason is that it is simple and lowers the need for speculations. Tariff subsidies are not good for the system.

8. How do you think the different tariffs can affect the development of the different business models?

   You mean network tariffs. I think that they can affect the design and type of investment yes.

9. If prosumers are considered players in the electricity supply chain:
   h. Do they have any possibility to take part in the decision-making of the local grid?

I guess they should have a dialog. I mean the local grid is a monopoly and if the prosumer disagrees with decisions they can talk to the authority.

i. Which tools (tariffs, customer service, etc.) the electricity suppliers have in order to earn the trust of the clients?

don't know

Prosumers future in Sweden

10. Which business models is Sweden planning to implement in the short-term future?

-

11. Which business type benefits the prosumer the most? And the electricity suppliers?

-

12. Which are the barriers to the implementation of new business models?

-

13. Which subsidies can a prosumer expect in the future?

-

14. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?

-

15. Related to the collaboration between electricity suppliers and prosumers. If prosumers are considered players in the electricity supply chain:
    d. Is it expected them to have more power with the decision making of the local grid?

    -

    e. Is the information shared between prosumers and electricity suppliers going to improve and with that the level of trust between them?

    -

Other

16. Is there anything you want to add?

-

Interviewee:	Daniel Persson	Date:	05/01/2021	
Company:	E.On			6
Position:	Strategy & Regulation			

Contact information

1. Which is your role inside E.On?

   I am part of the E.On Distribution. We are part of E.On, of course, but it's a separate and parallel company. We are having approximately 1.1 million customers in Sweden so we are covering perhaps about 20% of the grid market in Sweden. I think we are the biggest grid company in Sweden. Then we have other actors like Vattenfall and Elevio, which have a similar size. We have both the regional grid and the local grid. (…) We have the whole picture. We have connections from the households and then all the way up when we connect ourselves to Svenska Kraftnat, the Swedish TSO. We're a customer to the TSO for our regional grid and then we distribute further for our regional grid to different local grids. We represent large parts of Sweden. We have a high density in southern Sweden but also some areas in the Stockholm area and also a bit in northern Sweden. It's a distribution over Sweden. The history is quite old, so it's more than 100 years of history. (…) So, I'm in the strategy and regulation team. Myself I have a 15-year background within E.On, in different positions. Before this position, I worked in the customer solution company with energy trading and also portfolio management, where you buy and sell for external customers like IKEA. Before that, I also was a student in LTH, which I guess you are as well. So, I also had lectures with Andreas, for example (…).

2. E.On is the largest distribution company in Sweden. So, how E.On can influence in shaping the future of the Swedish electricity supply chain?

   We are trying to influence a lot, of course. We are working and cooperating both with the authorities, Ei, the government for the supervision function in Sweden. We have a lot of contact with the authorities, of course, trying to cooperate on how the rules and conditions should be when it comes to the grid. Also, when it comes to trading and the market side. So, we're having a steady contact and cooperating with them. We're quite pleased and it works quite well, as well. This Ei function well into this change of the market and they have a lot of on-going projects. For example, regarding micro-productions and tariff incentives, and so on. There're a lot of projects going on and a lot to read on the Ei home page. We are also contributing to the cooperation with other grid companies and other electricity companies and also with customers. We have a lot to do and what we do we come with competence and we engage and we expend our time ensuring that the conditions will be fine for the future. We have to look at the total picture, of course, it must be still investable for us, we need to invest in the future and it must have a correct profit level as well. We have to ensure that for our sake when it comes to investment on our grid. But we also have to see what is logical and profitable also for the customers. It must be a competitive environment, so our industry and our households could be competitive from a European perspective. What E.On can do, of course, is… we have sister companies out in Europe, for example in Germany but it could be Romania, Hungary and so on. So we could also compare

how does it look for the sister companies, how are the regulators, the ones who stare at the market – the Ei in Sweden – how are they doing in the other countries and we could learn from each other within Europe. We are also engaged in the European contribution and cooperation. We are playing in all the fields as E.On. (…)

3. Why E.On is interested in the UK market? Are you going to apply some "lessons learned" from the UK to Sweden?

   It's quite a hard question. E.On has a history in the UK since before. I can't really say much more about it because I'm not that into it. I have to pass on that question. (…)

   The UK market has changed tremendously. I don't know if they're in advance compared to Sweden or not. They have some differences compared to Sweden. I don't know if they are going that way or to another. The UK is a little bit special compared to the Nordic market.

Smart grids and electricity supply chain management in Sweden

4. Is it the Swedish electricity grid challenged in terms of capacity? If yes, which kind of resource is used: investment in the grid or the implementation of smart grids? Why?

   It's a challenging situation right now but at the moment it's still manageable for us. But if we look a little bit into the future, we say that investment conditions must be correct. So, either we do, as you say, we make a grid investment like laying cables or building overhead lines, for example, that's a physical investment. We have to have proper profitability to make that investment. At the moment, I don't how much you know about that but, it's a challenging situation between the regulator or the society who wants to pay as little as possible but as a company, we have to have at least a competitive profit. As an international investor like we, we have other alternatives. We can invest in, for example, Romania instead. So, if the conditions in Sweden are poor, then we have to decrease our investment value. But we're trying to make the society and the regulator understand that it must be a very long term, very competitive, and correct profit level. But we're, of course, always favoring smart grids. But what is a smart grid? That's a hard definition. Of course, it's a combination of both physical and technical and computer science. It could also be: we should use the correct grid in a better way, we're also working on that. Then there's the flexibility. I'd say that we are favoring smart grids, of course, it's better than a damn grid. At the moment the absolute majority of investments are on the physical investment side. (…) But we're trying to get incentives for making the grid smarter because in the regulation of today there are not many incentives. There are not many alternatives for doing these old-school investments. All money and profitability lie on doing real investments, like cables and overhead lines. There's not much money in try to get things smarter. In the best case, you just cost compensate. So, if it costs you 1000SEK you get 1000SEK back, but you don't have any interest on top of that when it comes to flexibility or doing the grid smarter. That is something to push to the regulator. The regulator, Ei, is also aware of this. Ei knows that there's a lack of incentives for smart grids or flexibility. That must be better. Also, the political side in Sweden has now seen this problem and they are aware of it. But, there's no solution yet. I'd also say that in a European perspective it is also a question; how would you make investments in smart things or flexibility more profitable.

   So, there is a lack of incentives for you, the DSO, not only incentives for micro-producers?

I'd say that on both sides is quite naked. There's not much to grasp when it comes to flexibility. Of course, there're other incentives for the producer; you get paid for the electricity as you have said or written. You also get the GO, you can get some less self-consumption. So, for producers, there are some incentives, but when it comes to the grid company there is not much to do, but just building the grid and renewing the grid. (…) But there is not much for doing it smarter or doing it flexibly. There still a lack of incentives.

5. Maybe the lack of incentives can influence the level of smart grid implementation (low, medium, or high) that Sweden has? Maybe the lack of incentives causes a low level of smart grid investment?

   Yes, exactly. For a major part, we have to use tender components which many of which are probably created 5-10 years ago. It's a standard transformer. Of course, it's also depending on how do you define the smart grid. I mean, a new cable that you lay today perhaps it can be considered to be smart as well. And that could also be the best for the consumer. It's not always the best case to try to do something else. It might be the best solution just to lay the cable because you know that it'll be there for 50-60 years and nothing will happen. Instead of perhaps having the risk of optimizing a cable that is running at a 100% of utilization. That could be a risky situation as well. One of our highest priorities is to keep the power interruption at a very low rate. You can't risk that thing as a consequence of being flexible. It's hard to say what is the best solution for the customer. But we are interested, of course, in using the current grid and all the investment that has already been done. Using it in the best way we can. So, optimize the grid. That could be a smart grid. Then, of course, we are also engaged in future projects, how could we make things with computers even better (…). We're interested in how to use technology in a better way. But, that's more in a trial phase.

6. How do you think the smart grid implementation will change the electricity supply chain management?

<u>Current situation in the Swedish electricity market</u>

7. Which are the most common business models between prosumers (basic prosumer, microgrid, virtual arrangement, etc.) and E.On?

   I think that's [basic prosumer] the standard one. I think that's the largest one. I don't see other forms today. Of course, in some way you do a connection on the roof and the grid company connects you to the grid. Then you have to decide who should buy my overshooting electricity on an hourly basis. That's the trading with the supply company. You can decide for free who should be that actor. So, if you are in our grid you can choose our supply company or you can choose someone else. That's as freely as the electricity contract itself when you have consumption. It's probably quite logical that you have the same consumption company and production caretaker company. I think you can even have them switched, there I'm a little bit uncertain. (…) From the consumption side, that is one time series of hourly basis which are measured. Then you have the production time series, which is measured. Sometimes then you have nothing outgoing production, you have zero because you consume everything yourself within your building. But then, sometimes, especially summertime during the mid of the day you can get some overshooting production. Then you have something in that time series. You'll have some values in that

route. Then you'll get compensation for the electricity price. There you have a deal with your supplier: what will be the price? What price will we give you? Most of the time it'll be the spot price with some adding on or deduction on the spot price. Of course, I think you can also get some kind of fixed-price arrangements if you're interested in that. But that's more tailer made. That would be done for very much larger facilities. (…) That's the primary function of the supply company.

What is also happening, as you know, you get the lower self-consumption. There's not much more happening there. We could not net your consumption against your production. You have to measure this as two series. You are not allowed to have net metering. So, you'll see that the consumption compared to before it'll be lower and thereby you pay lower for the consumption and then at the same time you get a little bit of reward for the electricity production. I think, one parameter that is quite important is the energy tax. The energy tax is 0.36 SEK/kWh at the moment. Then you pay tax on top of that, so you end up with 0.45 SEK/kWh. If you lower your self-consumption you get rid of this energy tax as well, so 0.45 SEK/kWh. That's quite much. So, that's good, of course, on the consumption side. Then, on the consumption side at the moment there's the subsidy, you get to compensate. I think it still applies. You get compensated, I think it's 0.58 SEK/kWh, that you overproduce. So, that's a subsidy. I don't know for how long that it will hold for.

Who is responsible for paying this subsidy? The DSO?

I think it's the grid company that fits that further on to you. I am not 100% sure because I haven't been into this for some years now. It could be that you do it in your tax declaration the year after. The metering values are coming from the grid company. How much production, how many kWh did you have. Then you compensate it with 0.58 SEK/kWh. I think it's settled in the tax declaration. As I said, I don't know for how long this subsidy will last, perhaps that will only be for some more years in the future because as it grows right now I don't think they can have that forever. So, yes, that's the trading side of it. On the trading side as well, of course, when it comes to the compensation of the spot price and some additional deduction the trading or the supply company could also compensate you if you give up your GOs. You can apply for having GOs for production or not. It depends on if you have that administrative process or not. But, if you have it, of course, the supply company could buy them as well. But, that's quite small money compared to the ordinary price.

But it could be like a subsidy for the micro-producers because it's a thing that they can earn money from.

Yes, a little bit. It's a very little price, it could be 0.001 or 0.002 SEK/kWh. It's just fractions of the electricity price. But still, it could help you a little bit. Then there's another thing. If you connect to our grid, we also compensate these producers with some grid benefit, because they are doing some benefit to the grid. That corresponds to the fact that they reduce a little bit the grid losses. Since they help us with grid losses and they reduce our need for the above grid, they get a little bit of compensation from the grid company. That applies of course to all companies in Sweden and it's about 0.05 SEK/kWh.

Is it a problem for the DSO the bi-directional flow of electricity? Do you have to invest in the grid for being able to face this?

I'm not a technical expert. At the moment I think we can cope with it, with the levels we have now. But when we see growing numbers of solar panels this could be an increasing problem for us. In that case, we could do investments into the grid that could cope with this situation. But, right now, I think we can cope with it in the majority of states. It could be a future thing and it can also be a local thing. (…) In some cases, it could be quite expensive for us to connect a facility if it's not proper for that location. But the small households we have to connect them no matter what. We are not allowed to take a fee for that specific customer. That fee is spread out for all the customers.

So, if I'm living in a rural area and I don't have enough capacity, does it mean that I don't have to pay for the investment of the grid?

I'm not sure, but there are some levels that it should not cost anything for the micro-producer. But if you're a very large producer, you have to pay for it. There's a subsidy from the state of a rule saying that that cost should be collectivized. (…) It's something that we need to keep our eyes on for the future much more now when it grows a lot. We haven't seen it all yet. But we are aware of the things happening, we tried to manage them.

This is why the first question was how E.On can influence the market, because since you are a big company and you have a lot of clients and a lot of injections to the grid, maybe you have more voice than other companies.

Of course. We try to have a voice on economical or technical questions. We are there to cover it, one way or another. It's often through good cooperation between the regulator and the Ei and also the other companies in Sweden. There's a cooperation group and so on. And also together with customers and industry, of course. There're a lot of discussions going on, it's a common problem for all of us. Everyone is very positive and trying to solve the questions but no one has the final answer. As a big actor, we try to strike for a solution.

a. Which are the advantages and disadvantages of the current prosumers business types in Sweden?
b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid?

   For connection of producers, the most things are probably at the other business side. If the electricity price is correct, if you do a reduction in your self-consumption or not. I think that's the main thing for these producers. I also believe that some of the producers would like to see better incentives if they can come up with flexibility. As a solar installation producer, it could be hard to be flexible. You produce when the sun is shining. But if you have combined heated power or another technology, these kinds of producers probably would like to see better incentives for being flexible. But, as I said, if you are a wind or solar producer, I don't see that there is much flexibility. Perhaps you could limit your wind power and be able to increase it a little bit more if you get paid for it. I know there are some cases like this going. Maybe you are running only 90% of your wind power. You could run 100% but you are waiting for the last 10% to get paid correctly. (…) Then, of course, everyone is interested in getting better paid, especially for flexibility. But it's also something that all of Sweden and Europe are looking for incentives in flexibility. It's a very hot topic at the moment. We should also be aware that is coming legislation and laws

from the European energy act. They are setting the rules and standards and they're now interpreted by Ei. So, they will come up with new rules and regulations on how to act in this environment for the coming years. Because of this European energy act, this energy package, the EU is stating that flexibility it should be paid for. But then it's up to each country and the regulator to set up a regulatory framework. There's a lot of push now from the EU side. (…) Now the nations have to interpret and come up with the rules and regulations. There're a lot of things going on at the moment, to improve. Not every nation is sure of how does it should look like in the final end. Flexibility should be better in the future and should be better paid.

c. What should be changed in order to have more prosumers connected to the grid?

8. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?
9. How do you think the different tariffs can affect the development of the different business models?
10. If prosumers are considered players in the electricity supply chain:
    j. Do they have any possibility to take part in the decision-making of the local grid?
    k. Which tools (tariffs, customer service, etc.) the electricity suppliers have in order to earn the trust of the clients?

<u>Prosumers future in Sweden</u>

11. Which business models is Sweden planning to implement in the short-term future? [description of the business model consisting of the exchange of sun power for hydro power]

I will call that an administrative setup. It's not the reality. But you can make a deal with someone, a supply company: the energy I produce in summer I'm allowed to take it in winter. That's just a trading agreement, an administrative agreement. In reality, of course, it's not like that. It's just a supply company guaranteeing you a fixed price for something during the winter. It's just a marketing thing to do. That's my view on it. They take it out in wintertime instead. But that is much more costly. The spot price is most likely higher during the winter. As it is right now, it might not cost more in the grid. That could change in the future. That could be a more different tariff, from the grid side. But it's mostly a supplier agreement if you can do that or not. It seems very convenient and it looks good for a trading company: you can store that in a hydropower facility and you can use it in the winter instead. But in reality, of course, it goes out to the grid and then is completely something else that you use in the winter. You never store it for that long. But, as a paper product, it looks like that. I could also assume that the trading company that does this take a payment. Somewhere they take out a monthly fee or something that is compensating them for putting in cheap electricity in the summer and taking out more expensive in the winter. (…) you'll have to pay for it, in one way or another.

So, in your opinion, this is not a new business model it's more an administrative setup.

It's a paper product for the end-consumer. (…) You can't be a magician. They will compensate themselves some way or another. Most likely they compensate themselves with a monthly fee. It looks like a good solution for the customer but you don't notice that

you pay a monthly fee. There's nothing more profitable for you anyway. (…) So, it's the same business model but with a different way to administrate the invoice.

Which business models do you think Sweden is going to have? Or maybe it will only increase the number of basic prosumers (?)

It will change. It'd be brave to say something else. The fundamental thing it will stick for a long time. I think we're having a quite correct business model as a fundamental business model. You get the compensation for what it's worth. The thing that needs to be complemented is how you contribute with the grid benefits and capacity benefits. That needs to be better valued. That's the problem of the market of today. The electricity trading side is quite good and fundamentally correct. But, how to compensate the flexibility, your capacity contribution. That needs to be looked at in more detail and it'll probably count large pieces both from the regulator due to this EU legislation packages that are coming. I'm quite confident that the pure electricity trading model, Nord Pool, and the spot price trading, I think we're quite correct in that matter. But, on the grid side, capacity and its compensation it has to improve. It could also be that you have to look more into the local conditions of some areas.

I was thinking that, I'm not sure if I told you but I'm taking the UK framework. There I found some business models that the UK is using and I found the P2P model. This model consists of different prosumers that sell and buy electricity within themselves. If they need more, they buy it from the electricity supplier.

That's also something that comes out now with the EU legislation. You can create your local energy society. That it's very likely. I can't say that this won't happen. That's possible.

Is it interesting for E.On?

We're interested and we're observing and, we try, of course, to look into that as well. But I don't think at the moment we see the incentives for doing that if I'm being realistic. I don't see how that could improve. In what step are they bypassing by doing that. If you have a competitive trading place and you get competitive compensations for electricity. I don't see the advantage, how you should be able to optimize it more. If you have an internal grid, then you should optimize it, within your building you can optimize things. But it's also a question of a… if you are out in the street, the lines that connect households that are the grid company lines. You're not allowed to consider that one area. There have to be certain conditions that have to be fulfilled to be able to define yourself as a certain community. I don't see the business case at the moment, but it could be possible. If they see some competitive edge by doing that. But I can't really see it at the moment.

Maybe the electricity will be cheaper for the prosumers because they wouldn't have to pay for the benefit that the electricity supplier gets. That could be an incentive as well.

Yes. The trading company maybe earns 10-15%, they can save that money. That's correct. That could be in the future. But at the moment the compensation to the solar producers is very advantageous. They give them a huge compensation, even better than the market price because there's a marketing interest in this as well. If you involve in supplying solar producers, it looks good for your brand. At the moment they get really good paid. So, it's

hard to compete with it at the moment. They cannot do it better themselves at the moment. In the future, if you see that solar panels everywhere, it'd be very standard. Then it could be useful to create our pole instead. You can be your trader between each other. But probably we are some years into the future. In the coming years, I don't see any profitability. But you can also have other reasons that you want to be independent. Then you have to be an internal grid. Perhaps you can create an artificial trading place. But, the grid is still the same. And the grid is owned by the grid company between two houses. That you have to handle as today. But, with the trading side, you can create your setup. I don't see it now, but in 10 years is impossible to say.

Since the EU says something about this in the new regulation, it might be a reality.

They talk about, what they call local communities. They are one part of the new legislation. They are incentivizing and setting up rules for these kinds of things and also define what requirements do you have. That's part of what we called "energy package" from the EU.

What are the local communities that you are talking about?

We have some difficulties defining ourselves. I don't really know. It's coming in 2-3 years, now we even have a hard time defining what it is. But, you never know. Things can go quite rapidly. But it's also when this sets of regulations come up and it's more clear, perhaps then it will happen: oh! There's the definition, we can create that. The new do it. But now it's very unclear. But it could be possible.

12. Which business type benefits the prosumer the most? And the E.On?
13. Which are the barriers to the implementation of new business models?
14. Which subsidies can a prosumer expect in the future?

The energy tax. Today it's all the same during all hours of the day. That could be quite of an incentive problem. You are not incentivizing to limit or increase production. It's so big. It's almost half a crown. Is as much as the electricity price itself. But it's completely flat during the day, is as much during night as during the day. The authorities and the politicians must have to do something to make that adjustment during the day, maybe higher during the day and lower during the night. Something that incentives us to lower our consumption more during the day and increase during night time. For example, another big thing here is loading the electric vehicles. That's a big thing when we look at the future. At the moment is quite ideal perhaps to load the Tesla during night time, not during daytime when everyone else is using it. But then the energy tax could be profile to correspond to that. The solar panels side, that's quite hard to connect also to the trend of electric vehicles. How do you should load electricity vehicles. They come to hand and hand and in a strong way. The market is strong on both sides. Another hard thing is battery technology and so on. What will happen on that side. (…)

15. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?
16. Related to the collaboration between electricity suppliers and prosumers. If prosumers are considered players in the electricity supply chain:
    d. Is it expected them to have more power with the decision making of the local grid?

e. Is the information shared between prosumers and E.On going to improve?

Other

17. Is there anything you want to add?

Interviewee:	Marie Liljewall	Date:	05/01/2021	
Company:	Kraftringen			7
Position:	Electricity retail department			

Contact information

1. Which is your role inside Kraftringen?

   I'm in the retail department, so it's a kind of business development responsible for electricity sales, gas sales and gas sales to vehicles. I've been with Kraftringen for almost 2 years. Before that I had a similar role in Öresundskraft Marknad AB, maybe you know it. It's another regional energy company in the south part of Sweden. Before that, I was 11 years in E.On as a portfolio manager and dispatch operator.

2. Which are the differences between a company like yours and, for example, E.On?

   It's a big difference. E.On is a super large company with, I don't know how many employees, 30K or 40K people. Kraftringen is a couple of hundred with a very regional focus and center of attention. It's a quite slim organization, each employee has quite a broad perspective. You have to be a generalist. Since E.On is very large and has an international perspective you have a lot of more specialists and deeper pockets concerning all kinds of developments.

Smart grids and electricity supply chain management in Sweden

3. Is it the Swedish electricity grid challenged in terms of capacity? If yes, which kind of resource is used: investment in the grid or the implementation of smart grids? Why?

   [She suggests talking to her colleague: Håkan Skarrie because she's only in the sales point of view]

   From a more general point of view, yes, the Swedish electricity grid is very challenged in terms of capacity. It is now and it'll increase, I think. Since a lot of heavy industry and transport sector is using more and more electricity in the years to come. It has been a lot of investments trying to decarbonize the steel industry in the northern part of Sweden and as you know they have been building really big suburb centrals for the big tech companies in the northern part. They have also been building quite a lot of new wind power plants up in the northern part. So, you have a really big problem with the transport of products from the north to the south of Sweden. It has been a problem for many years and it increased about 20 years ago when we closed the 2 nuclear power plants here in the south of Sweden. At that time, they started to prepare and reinforce the grid and to increase the capacity to transport the electricity from the north to the south. Several of these projects are very delate. There is a project called XXX to increase the capacity from the north to the south here on the west coast and it has been delated for, I don't know how many times, I think 5-6 years. The problems are increasing because there is a political incentive to use more and more electricity in the transport sector with the busses, electric trucks, and electric cars. One of the aspects is that this is very time-consuming to go through the projects like these and this XXX project it's a good or bad example of this. It has taken many years to just start

building. It's easy to close down a nuclear power plant, you can do it quite rapidly (…), but to replace that capacity in the south part of Sweden that could take 10 or 15 years. It's a mismatch in time. Svenska Kraftnat is saying "We've got a lot of projects". Yes, you have, but they won't make any difference until 2030 or longer than that.

So, it's a problem that you're facing now but you'll see the results in some years.

Yes. For the upcoming 10 years, I think this will still be a problem in the south of Sweden.

The flexibility of the grid is it a thing that you are working on...?

Yes [She mentions Håkan again]. Kraftringen is part of many projects to use electricity in a smarter way to make sure that you can maybe flatter the curve when it comes to consumption. (…) you have big consumers that maybe is possible for them to move their consumption in time. If they have some incentive or if they get some kind of business set up. I know Kraftringen has been involved in some regional projects concerning this along with E.On: the switch project.

The question was more focused on the fact that maybe with flexible methods you can flatter the curve and you don't have the problem anymore.

Yes. I think you cannot aim for one solution you have to try a lot of things to attack this problem, both from the added capacity and from the increased demand side. Because Sweden has a very robust system. We have very few outages. We have very low electricity prices compared to other European countries. But, in order to keep our base industry and our innovation going, we need to be able to handle that. (…)

4. Which level of smart grid implementation (low, medium, or high) do you think Sweden has? Why?

   I don't think we are very far along. Maybe that is because we have been spoiled in a way. We've been a net exporter of energy for a long time and the problem hasn't been "real" until the last 2 years. Maybe we are a little bit slow compared to other countries.

5. How do you think the smart grid implementation will change the electricity supply chain management?

   [She mentions Håkan again]

<u>Current situation in the Swedish electricity market</u>

6. Which are the most common business models between prosumers (basic prosumer, microgrid, virtual arrangement, etc.) and electricity suppliers?

   Not within Kraftringen, not at the moment at least. You have one relationship as a grid company and one relationship with the customer as an electricity retailer. If I just speak as a retailer, we buy the surplus from the customer. But we have the demand that they also have to buy whatever they need from the grid from us. Because, as it is right now it's quite favorable to the customer to sell it to the grid. You get a better price than you would if you

had a largest scale power plant. You want to play nice with the small customers, so they can get quite a good price for their surplus production.

Is this only the case of your company or is it in general?

I think it's in general and within Kraftringen. Right now, it's a small loss for us to actually buy the power back because we cannot sell it to the market at the same price as we buy it from the small producers.

So, do you actually lose money?

Yes, a little bit.

Why do you do it if you lose money with this transaction?

If it would be zero, we'd still do it. This is our way to help the development of a more sustainable energy system in Sweden. It's hard to be a big company in the energy business and it's really really hard to understand to be just a consumer. There are so many guidelines and rules and fees and tariffs and so on. We just want to make it simple. You get the price and the customer can maybe find to Nord Pool power exchange. Then we don't mess around with those little fees that go to XXX, Svenska Kraftnat, or Nord Pool power exchange. It's small. But there is one of the reasons why we want to be their suppliers as well for the power they actually have to buy from the grid. So, all and all, it should be profitable for you. Maybe a little bit less than it would be. But we want customers to have the opportunity to be part of the sustainable power market.

a. Which are the advantages and disadvantages of the current prosumers business types in Sweden?
b. Which are the current barriers (lack of subsidies, prosumers disinformation, political decisions, …) for the integration of new prosumers into the grid?

   I saw some news just the other day. They have cut the line of the people applying for these subsidies [capital subsidy]. There was a long line, ~9000, of people waiting for subsidies. Their applications were too old so they had to re-apply. Sweden, I think, it's the world championship in messy administration and authorities they do everything by the book. I think it could be easier to apply for these subsidies and it should be the same in the whole country. As it is now, I think it depends on the resources its region has and I think that is hard. Also, right now the price of electricity is quite low. So, the payback time is right now getting quite long. Most customers that actually take the step in this direction do it mainly, or partially I would say, for the financial prospect of it. But I think one of the big motivators is that you want to be part of this kind of development and you want to produce your own energy.

   It's more an ethical thing.

   Yes. I think that will keep on as a very important incentive for the people who do this. When I first started with this business, I thought it would only be really young and the people with big dreams for the future and so on. But you can see that a lot of older customers make the step. And you think, are you really going to stay in this

house for so long that you will actually benefit from the payback. But they think further ahead, generations ahead. I think that's a really remarkable thing.

So, do you agree that maybe the most important incentive is the ethical one?

As important as that you can have a payback time of 10 to something.

c. What should be changed in order to have more prosumers connected to the grid?

I think right now it hasn't helped with the pandemic. [thinking]

But, on the other hand, people are staying a lot in their houses and they are realizing that you have to stay at home a lot more and they are improving the place they live. I'm not sure, it could go either way. What am I going to do with the money? I'm not going anywhere, I'm not traveling, I'm not buying any new clothes.

Have you seen any change during this pandemic?

I'd have to talk to the sales department for answering that. We've had a long list of interested consumers. But I also know that we have had delayed on the supplies, they are stuck somewhere between China and Lund. I think the value chain has been hit quite hard by the pandemic. That might be something that puts you off, because now when you want something you want it now. You don't want to wait; you want to see something happening on your roof.

7. Which kind of subsidies, in your opinion, trigger prosumers to invest in solar PV systems? Why?

I think the FiT is quite small in Sweden. I think maybe the capital subsidy would be the most important one. The GC and the GO that is small potatoes in this, I think.

Also, I have done several interviews and some people have told me about the new tax deduction coming this year, so the 1st of January.

If you're a micro producer I think, I'm not really good with the legal framework, you don't have to pay electricity tax for the electricity that you produce yourself.

I think there is a limit from where you don't have to pay for it.

And that's a big deal. Because the energy tax is around 1/3 of the total of your electricity bill. That is a big deal.

That for me would also be a subsidy.

Yes. And I think is one at the very top 3.

So, we'd say that the capital subsidy, which reduces the installation cost. Is this subsidy the one you have told me that they have cut the queue?

Yes.

So, now, people who wanted to install facilities on their rooftops are not in the queue anymore or how does it work?

I will send the article.

8. How do you think the different tariffs can affect the development of the different business models?

   Most customers that have this kind of installation today you've it as a demand that they are measured every hour so they get the hourly price of the production and also of the consumption for their installation. So, you cannot get a fixed price for your production. It varies every hour.

   Is this a thing that Kraftringen offer?

   Just flexible price, no fixed price.

9. If prosumers are considered players in the electricity supply chain and since Kraftringen is a company owned by municipalities:
   a. Do they have any possibility to take part in the decision-making of the local grid?

      You can say that but it is a long road so to speak. Kraftringen is owned by 4 municipalities, 4 cities in the southern part of Sweden. In that way, we have politicians on our board and they are in a way pointing out the direction for Kraftringen. So, if we would have politicians in our board that demand that Kraftringen has to do this or that, you can have a say. In that way, you can influence Kraftringen's operates. But as a customer it's maybe hard to have a direct influence, so to speak. Of course, you can always come up with suggestions, but this part that I represent it's not regulated, like the grid part of Kraftringen. So, as a consumer, you are free to approach any electricity retailer of the Swedish market, which would be over 100 different companies. I think it'd be quite easy for you to do a survey of the market to see if there is a business model that maybe is better suited for you. I know there are some newcomers in the market, smaller companies (startups), that are very very narrow in their business. Maybe they can set you up with a different type of business model. Since Kraftringen is working from a wide perspective we cannot maintain too many different kinds of setups.

   b. Which tools (tariffs, customer service, etc.) the electricity suppliers have in order to earn the trust of the clients?

      I think Kraftringen has a quite good reputation. We've been around for more than 100 years. Even that maybe they don't like us, they trust us. Since we have the regulated part of the electricity business around here you have to be a customer of Kraftringen for the grid part and Kraftringen has quite high grid fees. There are some customers that they say: ok, I have to buy from you on the grid side because I have no other choice, it's a natural monopoly. But I'll not buy anything else from you. There are pros and cons to having electricity sails and grid operations within the same company group. Kraftringen is a quite open company, everything is available, all kinds of information. If you are own by the local municipality, I think,

that makes people trust you a little bit more because they know the money we earn, goes to the local community. It doesn't end up in some big shareholder wallet. It goes back to the local society. So, as I said before, even if you don't like us, you trust us because we've been around for a long time and we've got a sustainable business for a long time. I think we're seen as a trustworthy, technical but no very funny company. We had a customer survey not that long ago and the customers defined Kraftringen as a Volvo: dependable, highly functional but not very sexy. We have to work on our image. If you can provide the customer with the correct and updated and complete information and really guide them through this process, I think you can earn their trust. I think Kraftringen has been working a lot with the process of helping the customers from the decision making and through all the steps of applying for different subsidies. Because it's hard, there are a lot of steps.

If I want to have solar PV facilities at my home, all I have to do is contact you and then you help me?

Yes, we help you.

So, are you the ones requesting all the subsidies?

We, at least, can help you and point you in the right direction. Some of the steps we can do for you. I think that is a way to be successful in this customer relationship. Because it's quite tricky and you have to have a lot of contacts with the grid company and with the supplier.

Then, "these bureaucratic difficulties" would be a barrier. Do you agree?

Yes, but we have all kinds of customers. Some of them want a key solution, they just want to pay money and to have everything done. Some other customers want to do it by themselves.

Do you take care of all of this spectrum of customers?

We try. At least be there for the ones who just want to have a simple solution. Maybe we are not the cheapest ones, I know we are not the cheapest ones. But we will make your customer experience quite reliable, I think. (…)

Prosumers future in Sweden

10. Which business models is Sweden planning to implement in the short-term future? I know there is an electricity retail company that exchanges sun power that the prosumers inject into the grid for hydropower during the winter. They say that they store your sun power in their hydropower facilities.

    I think it's an interesting development. The laws concerning electricity are very strict, so maybe that it's in the very front line of testing. If you are allowed to have that kind of set up where you store the electricity for the customer. But I agree that could be an interesting development. Also, I think that we'll see the development that people can share production in another way. Because maybe you have 4 or 5 buildings. Not all of them are suitable for

solar panels, but some of them are. Maybe then you can build more in one and you can share it between different customers. This is hard today because of the electricity tax and so on. Maybe, if you live in an apartment and you want to be part of this transformation, you can have your own solar panels but you can buy and share a bigger part, I think there will be more setups like these, both for companies and for customers, to buy directly from a park. (…)

There is a real demand, a lot of companies really want to be part of this, but they have to get something in return. Something that they can use.

So, incentives at the end of the day.

Yes. So, maybe Sweden has to be a little less rigid. I can understand from a regulator's point of view because they have to get the energy tax from somewhere. You still have to maintain the grid that would be really expensive if you only use it 1000 h instead of 8000h, for example.

But, do you agree that it will change?

I think it will change. I think it'll change quite rapidly. But I think it might be a bit hard along the way because the wheel of law-making is turning quite slow in Sweden. Do you know about the decentralized power market incentive?

No.

You'd have an electricity retailer central market, so the customers would only be in contact with the retailer for all kinds of questions and the grid operator would not even send a bill to the customers. Everything would be through the retailer. The changes in the Swedish laws to make this happened it has been delayed for many years now. It has taken so long that now people now are saying that it's too late anyway so let's move on to something else. (…) I think it'll be chances coming but it will not be smooth.

Do you think it's because of the low speed or it's maybe because of the influence that big companies have when it comes to change regulations? Are the big companies interested in changing the layout of the current electricity supply chain in Sweden?

I think they're. I think that from a political point of view it's hard to advance. Of course, there are people having a different opinion and in Sweden the electricity market is funny. You have 3 large companies and then you have nothing and then you have 50 regional companies that are very much smaller and then you have a lot of very few companies. So, the 3 bigger ones have a lot to say when it comes to this. But I think they're on board. I don't find them negative on this kind of change. I think they have a responsible point of view and they are responsible for what needs to be done.

11. Which business type benefits the prosumer the most? And the electricity suppliers?
12. Which are the barriers to the implementation of new business models?
13. Which subsidies can a prosumer expect in the future?
14. Are subsidies going to change in order to profit one business model or another according to the preferences of municipalities, electricity suppliers, and other important players of the electricity supply chain?

(…) I think it could be that you have different setups in different regions in Sweden. I'd prefer if this kind of administration and all that kind of system is treated the same way in the whole country. (…)

15. Related to the collaboration between electricity suppliers and prosumers. If prosumers are considered players in the electricity supply chain:
    a. Is it expected them to have more power with the decision making of the local grid?

       The grid is a monopoly. I think it could be quite hard to influence the local grid directly. There're also the 3 different levels of the grid, I think that maybe you can influence the local grid a bit more. If you want to build something a little bit larger than an ordinary rooftop you have to be in cooperation with the local grid companies. So, in that way yes, you can influence.

       Maybe for the micro-producers, are they going to have some kind of association in order to have some power.

       I don't if there's something already, but it'd be definitely a good thing.

    b. Is the information shared between prosumers and electricity suppliers going to improve?

<u>Other</u>

16. Is there anything you want to add?