Circular economy among Swedish solar PV firms

Can service-based business models help enable the transition towards circularity?

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Abstract

While the development of solar power is an important step in replacing fossil fuels with renewable energy, the fast increase in PV system deployment is projected to create large amounts of electronic waste in the next decades. Circular economy has been suggested as a key concept for changing society towards more resource efficient systems where products and materials retain their value along their whole life cycle. Service-based business models are suggested to play a role in this transition as they are now emerging in the solar sector. This study explored how service-based firms in Sweden practice circularity. This was conducted through a case study approach where 10 firms participated in qualitative interviews. The aim of the interviews was to explore what circular practices are used today, which barriers exist towards further development and how they perceive customer and business value emerging from these practices.

The findings showed that the business models incentivise long-term strategies. Additionally, the economy of these firms is often linked directly to the performance of their PV system, creating incentives for high quality products, installation processes and maintenance routines. The market for circular strategies such as repair and reuse of solar panels is still underdeveloped, and while firms expressed an interest in these issues the barriers are too many. Barriers to further development spanned from regulatory obstacles generating insecurities towards exploring new markets and business models, to a lack of stakeholders for repair and remanufacturing.

Keywords: service-based business model, solar photovoltaics, circular economy, renewable energy, servitization, PPA, community solar.

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1 Introduction

The linear economic system that dominates our society is characterized by a saturated market, where fully functioning products are replaced with new ones and products end their service lifetime before their technological lifetime has ended. The overconsumption of goods and materials lead to constantly growing waste volumes and associated costs (Stahel, 2019, chapter 3). Resource outtake is projected to more than double over the next 30 years, and simultaneously, recycling is projected to obtain increasing importance in competition for virgin materials. The extraction of raw materials comes with a variety of environmental issues, such as pollution, greenhouse gas emissions and harmful consequences for both people and the environment (OECD, 2018). Across all sectors of the economy, urgent action needs to be taken in order to reduce waste generation and improve resource efficiency. Minimizing the over-extraction of resources and the degradation and depletion of raw materials is one of the big environmental challenges today (United Nations, 2019). Simultaneously, the growth of solar power and other renewables is bound to continue during the coming decades in order to support the decarbonisation of society that is needed to curb climate change (IEA, 2019; UNDP, 2020).

Solar photovoltaic (PV) deployment has been growing at a fast pace since the beginning of the 2000s (IRENA, 2016). With the expansion of the solar PV market, a rising amount of electronic waste from decommissioned panels will enter the waste stream. The average solar panel is expected to have a life time of about 30 years, and by the early 2030's, large annual amounts of consumed PV modules are anticipated, presenting a new environmental challenge as the issue of growing waste volumes from renewables must be attended (IRENA, 2016). Projections show that by 2050, PV waste volumes are estimated to reach 60-78 million tons annually (IRENA, 2016). The field of recycling, re-using and refurbishing broken or worn out PV panels is growing, yet only 10 % of PV panels are recycled today (Tsanakas et al., 2019b).

The challenge of exponentially growing volumes of PV waste could also be a possibility for new, innovative value creation. In order to obtain an environmentally and financially sustainable solar energy sector in the future, recycling of PV modules, recovery of raw materials, repair/refurbishment of worn or broken PV modules and second life creation is indispensable (Tsanakas et al., 2019a).

As regulators try to curb this development by pricing the negative externalities a new order of business, technology and industry can emerge (Ellen MacArthur Foundation [EMF], 2015b). The concept of circular economy (CE) has attracted more and more attention in recent years, as it can offer a beneficial and more sustainable alternative to the linear economic "take, make, dispose" mindset that dominates our society. The linear economic model is highly dependent on easily accessible natural resources and cheap energy, an approach that proves to be less and less viable on a finite planet (EMF, 2015a).

In the European Union, the transition towards a more circular economy is established as an essential part of the current work of moving towards a low-carbon, sustainable and competitive economy, within the planetary boundaries. The EU describes the circular economy as maintaining the value of products, materials and resources for the longest time possible, while minimizing waste and pollution of air, soil and water (European Union, 2015). This could be performed by extending product lifetimes, sharing and looping products, all with the aim of obtaining optimal yield and performance from natural and technological resources (EMF, 2015a).

The EU action plan towards a circular economy provides examples of how the transition will emerge, and mentions new technologies, services and business models as vital for the systemic change (European Union, 2020). A business model (BM) can be described as the way in which a firm does business and makes money (Antikainen & Valkokari, 2016), whereas a service-based business model is a term for describing business models that has moved beyond selling tangible products or offering ownership and instead delivering functionality to the customer (Bocken et al., 2014; Kindström, 2010). Servitization (Tukker, 2004) and product-service systems, PSS (Mont, 2002) are terms that are frequently used to describe the same concept.

According to Stahel (2019), the retained ownership that comes with most of the service-based business models entails both liability for risk and waste, giving incentives for better waste and risk prevention, creating a different perspective and way of action for the companies along the lifespan of the products, compared to the classic product system business model (Stahel, 2019). Up until just recently the solar sector has followed the classic product-focused, linear business model, with circular economy in the solar PV sector being a relatively novel subject. The literature in this area is somewhat limited and mostly focused on the recycling processes and technological innovations (Tsanakas et al., 2019b; IEA, 2019). The solar PV industry have however been identified as holding great potential for developing circular business models that can close and slow resource loops through strategies of repair, reuse, remanufacturing and recycling (Strupeit & Bocken, in press; Bocken et al., 2016). The businesses involved in the development from linear to more service-focused solar business models have been explored to some extent in the U.S, eastern Asia and the bigger European solar nations (Salim et al., 2019; Horváth & Szabó, 2018), while the situation in Sweden is yet to be explored.

Sweden has a solar production that constitutes less than 1 % of the total energy mix, however, the growth in the market is fast. Between 2005 and 2018, the installed effect went from 250 kW to 411 MW, and the Swedish government has decided to make solar distribution a priority and implemented a national strategy to promote solar power. The market is about to change from including only traditional business models to also include solar firms with service-based business models (IEA, 2019). Surveying the market for these business models could expose the opportunities for more circular PVs, as well as the role that innovative business models could play in the transition for a circular economy. Studies in the field have shown that the success of a business model is highly dependent on local prerequisites, making it difficult to transfer one business model to another context due to specific market premises and policy framework (Strupeit & Palm, 2016).

This study has explored barriers and customer value for service-based solar firms in Sweden, as these kinds of innovative business models are suggested to enable a more circular solar sector with a more sustainable resource consumption. The business is still young, but the issue of PV waste will get worse, hence the importance of exploring the opportunities and conditions for these business models. This study investigated what opportunities there is to move towards a more circular economy in the Swedish PV market through employment of service-based business models. With the background in this purpose, this study was designed as a case study, interviewing Swedish firms with service-based business models, exploring the circular practices that are used today and the opportunities these firms see in the future.

The target audience kept in mind when writing this thesis has been practitioners in the solar business, policy makers and people in general that could be interested in what circular actions might look like. This target audience is assumed to have some basic knowledge about solar PV systems and the market in general. This thesis focused on the role of the business model and the opportunities it gives in using circular practices.

1.1 Aim and research questions

The objective of this master's thesis is to investigate what opportunities there are to move towards a more circular economy in the Swedish solar market through employment of service-based business models. This objective was explored more specifically through the following research questions:

- How are service-based business models in Sweden enhancing circularity?
- What opportunities are there to further develop business models towards more circular approaches, and would there be any added value for customers from such business models?
- What are the barriers that could hinder such a development?

The scope of this study is solar PV firms with service-based business models operating in Sweden. The supply chains of the firms were included when it stretched outside of Sweden in order to include discussions on circular strategies involved in production and end-of-life management abroad. However, the focus lies in the installation and operations life stages, as those are most impacted by the firms. The study included solar firms working with all customer segments. The scope was limited to the environmental benefits in a resource efficiency perspective and did not look further into how service-based business models can impact the transition from fossil fuels to renewable energy sources.

In order to answer the aim of the study, the existing Swedish solar firms with service-based business models were first identified and mapped. Then interviews were performed with key stakeholders from 10 of the firms and the results were analysed with guidance from circular economy framework reSolve by Ellen MacArthur Foundation (2015c). The interviews provided findings to answer the three research questions.

2 Circularity and new business models in the solar sector

This chapter begins with an introduction to circular economy as a concept, followed by a literature review of the existing body of knowledge concerning circular practices in the solar sector. Thereafter follows an overview of the service-based business models figuring in this thesis. Lastly, the conceptual frameworks used in this thesis are presented in more detail. The aim of this chapter is to give a frame of knowledge to enable a full understanding of the results that follow.

2.1 Why circular economy?

Circular economy has become an important concept in catalysing the discussion on improved resource efficiency and waste reduction. Blomsma and Brennan (2017) summarize that while the individual strategies within the concept are not new, gathering them together as a concept draws attention to their possibility to slow resource loops. Circular economy can be described as a term framing a new concept of resource and waste management, offering strategies that present an alternative to the current "take, make, dispose" system (Blomsma & Brennan, 2017).

The concept of circular economy is built on a tradition of different paradigms within the waste and resource management field (Blomsma & Brennan, 2017). Between 1960-1985, attention was directed towards waste handling and the pollution problem that came with it. The focus was on improved incineration and other end-of-life processes, together with preventative measures to the generation of industrial waste. In these decades, waste was primarily seen as a cost and a cause for environmental and societal hazard. Simultaneously, recycling organisations emerged and were later replaced by commercial recycling companies.

In the years between 1985- 2013, the view of waste shifted to perceiving it more as a resource with intrinsic value, resulting in measures for extending product use phases and efforts to avoid putting resources to a finite end, as is the case in for example landfilling. Refurbishment and repair of products generated a growing interest together with product-service systems. However, the discussion on what would iterate efficient and meaningful waste management remained answer-less, leading to the emergence and re-emergence of concepts such as industrial ecology, green economy, sustainable consumption and zero waste (Blomsma & Brennan, 2017).

Circular economy is now a broadly accepted concept, implemented in the policy work of the EU in the form of the European Circular Economy Action Plan, an important part of the European Green Deal (European Union, 2020). It has been adopted by the commission and contains measures for the transition towards a more circular economy in Europe. Measures are for example restrictions for planned obsolescence and sustainable product policies such as legislations demanding that products sold on the European market should be easy to repair, disassemble and last longer. Other included measures are the right to information for customers and access to reparation of products (European Union, 2020).

The European waste hierarchy describes a desirable way of mitigating waste generation (European Union, 2019). The waste hierarchy consists of (from highest to lowest priority) prevent, reuse, recycle materials, other recycling (such as energy recycling) and, as a last resort, disposal (The Swedish energy agency, 2016b). These goals are very similar to the ones of circular economy. According to this waste hierarchy, repairing or refurbishing broken or worn out panels, or even more preferably, prevent PV systems from failing, go beyond adequate recycling and recovery practices. Extending the lifetime of PV modules can eventually result in a lowered lifecycle environmental impact, as repair or re-use increases the energy yield extracted from each unit of material and energy in manufacturing (Tsanakas et al., 2019a).

2.2 Circular practices in the solar sector

The projections on emerging waste volumes explain the growing interest in both research and business development for solar (Tsanakas et al., 2019b). The potential for environmental and economic advantages in PV re-use is yet to be explored, and a gathered knowledge base of best practices aiming to prolong the life cycle of PV components is missing. Measures for prolonged life are suggested as repair/refurbishment and certifications or qualifications to specify the state of second life panels for their new owner. The research in the field is in fact still conducted in the perspective of linear business model logics, which excludes the value creation possibilities that lie within circular business models for solar PVs (Tsanakas et al., 2019).

The opportunities for circular practices within the PV sector are many, still a problem in the sector today is the lack of standardized or systemized measures that slow resource loops in the PV value chain. The systems for these actions are still informal and coherent strategies are lacking between private companies and the original manufacturers, leading to hardly any standards, testing, certification or systemisation on second life PV modules. These kinds of systems for labelling, validating performance ratio and security are vital foundations for the emergence of a market of second-hand PV components (Tsanakas et al., 2019b), one important step in circulating the sector.

Salim et al. (2019) concludes in a big literature review of the end-of-life management for photovoltaics that the current research is very much focused on the technological aspects of this issue, leaving a gap to fill for research on policy aspect and socio-economic incentives. Figure 1 below describes problems with the current system and shows an example of how linear and circular supply chains for solar PVs could look respectively (Salim et al., 2019).

Generally, defect modules are decommissioned and sent away into the waste stream, aiming for disposal or in the best case, recycling. All this despite the reparation of individual PV components is in fact in many cases possible (Tsanakas et al., 2019b). In order to enable a market for second life PV systems, there is an increasing interest for service providers specialised in repairing failed PV components. Together with the interest in a system for re-certification, recycling of worn out modules, the right stakeholders for repair and refurbishment of PV systems is necessary for the development of a more circular market. Repair/refurbishment is an alternative, especially in the case of defects in mounting structures and frames, bypass diodes and wires, PV back sheets and potential-induced performance degradation (Tsanakas et al., 2019b).

Repair and refurbishment services are still only available for some markets, as the stakeholders offering these services often are specialised companies, currently figuring mostly in pilot projects or under laboratory circumstances, with processes that are not systemised or standardized. There are practically no standards available for characterization and reliability testing that is needed for PV modules. It is concluded by Tsanakas et al. (2019a) that a reliable system for validation of performance and safety in second-life PV panels is vital for the emergence of a viable market for second life solar panels.

Salim et al (2019) considered the circular PV business model one of the required features for promoting the necessary industry development for a better, more circular end-of-life management of obsolete PV systems. In the case of end-of-life management, service-based or buy-back business models together with deposit-refund systems are suggested as enablers of a high return rate of obsolete panels when contracts are over (Salim et al., 2019).

Sustainability approaches to the solar PV market is mostly focused on the manufacturing stage and the end-of-life stage, everything in the life stages between is less discussed in both the academic literature and white papers. There are discussions on eco-design for PV panels, eco-labels and the environmental footprint of components in the business spanning regions over the world. The sustainability projects of IEA (2019) is focused on investigating end-of-life management techniques, opportunities for repair and recycle, performing LCA on solar PV and establish the health and safety implications that could impact stakeholder interest. Performance and reliability of PV systems are however described as a subject that gains more and more interest within the business, mostly with the prerequisite that it enables for the investment to continue to be beneficial as the years go by. In the more recent times, this topic show up more and more in conversations and contexts regarding sustainability and quality (IEA, 2019).

2.3 Service-based business models

Service-based business models is a term for describing business models that has moved beyond selling tangible products or offering ownership and instead delivering functionality to the customer (Bocken et al., 2014; Kindström, 2010).

Service-based business models have been proposed to increase sustainability and facilitate circular actions such as life- time extension increased control over re-collection and management at the panels' end-of-life stage (Strupeit & Bocken, in press). The main explanation lies in that the retained ownership that comes with most of the service-based business models entails liability for risk and waste for the provider, giving incentives for better waste and risk prevention. These measures create different perspectives and company actions along the life cycle of the products, compared to the classic product system business model (Stahel, 2019, chapter 3). The business logic within these business models is also more directed towards performance and long life, as the ownership and service responsibility often stay within the company instead of being passed over to the customer. In this way, these companies are financially incentivised to maintain high quality service for the longest possible time, with as little material and energy cost as possible, all while creating maximum benefits (Stahel, 2019, chapter 3).

Service-based business models that figure in this thesis are product-service system (PSS), third party ownership (TPO): power purchase agreement (PPA) and leasing, and shared ownership (here called community solar). Their description and how they relate to each other is depicted below.

Product service system, PSS

PSS can be divided into three subcategories, in which Tukker's (2004) definition below has been widely applied. The first subcategory is product-oriented services, where the business model is still oriented towards the selling of a tangible product, though also offering extra services. Within these business models, service agreements or maintenance contracts are common as additions to the sold product, and the service is the main feature that brings these away from traditional product-centred business models. Turnkey solutions with service agreements are examples of product-oriented PSS.

The second subcategory are use-oriented PSS, where focus lies in using a product rather than owning it. Product lease is an example of this, where ownership and usually maintenance and repair responsibility stay with the contractor. The customer pays a regular fee for use of the product and has unlimited access.

Thirdly, in a result-oriented PSS, the provider and the customer agree on a result and no tangible product is involved in the exchange. Result oriented PSS can be both pay per service unit or that the customer and provider agree on a delivered result. How this result is achieved is up to the owner, hence not dependent upon any specific technological system (Tukker, 2004).

Third party ownership: PPA or lease

The term TPO is commonly used in the literature, describing the financial ownership being taken care of by a third party, such as a bank or other investor (Ode & Wadin, 2019). The payment structure can vary a lot between different contracts and can roughly be divided into two subcategories: solar lease and power-purchase agreement, PPA (Davidsson, 2015).

For a PPA, the developer sells solar energy to the customer at a fixed rate, offsetting the customers energy bill with a price lower than the regular electricity price. The customer agrees on installing the solar PV on their property and buying the electricity from the developer at a low price (United States Environmental Protection Agency [EPA], 2018). A solar PPA is always performance based, the host pays only what the system produces. The solar service provider owns the system, maintains and takes care of service (EPA, 2019).

In a solar lease contract, the customer pays for using of the solar system, often installed on their own roof, over a specified period (EPA, 2018). When the panels are in place, the customer have the sole right to consume unlimited amounts of electricity generated by the panels (Liu, 2014). TPO is now dominating the market of residential solar in the United States, and the business model is spreading in Europe and Asia as well (Davidsson et al., 2015).

Shared ownership

Community solar is a group of utility end-users, together owning or leasing panels in a solar park. The panels are situated in a bigger solar park and not on the roofs of the residential or commercial buildings. The solar farms come in many sizes, but are often big, generating economies of scale which for the subscribers generate a low price even after administration fees are paid (EPA, 2016). The park is often owned by a cooperative, who sells the produced electricity to an electricity utility. The members then buy the electricity straight from the society at the cost price (The Swedish energy agency, 2019c).

2.4 Conceptual framework

For the analysis of this thesis, the reSolve framework (see Table 1 below), originally a tool for generating circular strategies for business makers and governments, was utilized (EMF, 2015b). The tool has previously proven useful (Strupeit & Bocken, in press; Horvath et al., 2019) for identifying and organising different circular business practices. Of several investigated theory frameworks, this one was therefore decided most suitable for answering the research questions above. Furthermore, the framework used in this study is inspired by Strupeit and Bocken (in press) and includes the four value chain stages of the solar panels, which show very different opportunities for circular business actions.

Table 1.
The reSolve framework describes six actions for businesses and regulatory authorities to help in the transition towards a circular economy. Adapted from Growth within: a circular economy vision for a competitive Europe (p.26) by Ellen MacArthur Foundation, 2015c, (https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf). In the public domain.

Circular action	Examples
Regenerate	Shift to renewable materials and energy. Restore and bring back health of ecosystems.
Share	Share resources, products and services. Use maintenance and durability design to extend life length of products and systems.
Optimise	Increase performance/efficiency of products and systems. Remove waste from all stages in the supply chain. Use big data and monitoring systems for system optimisation and analysis.
Loop	Remanufacture and refurbish products and components. Product and material recycling.
Virtualise	Deliver virtual utility.
Exchange	Replace old materials with advanced non-renewable materials. Apply new technologies.

Opportunities and barriers to circularity were analysed separately using a simplified version of the barrier analysis tool presented by Ellen MacArthur foundation (2015a). The tool can be described as a method for combining a standard analysis of market and regulatory failures, combined with the social factors and economic matters that impact businesses. The barrier analysis tool consists of 15 different types of barriers divided into four categories: economics, market failures, regulatory failures and social factors (EMF, 2015a), and were deemed suitable for categorizing and organizing different barriers within the sector.

3 Method

The following chapter will explain how this study is performed and argue for some of the method choices made along the way. It begins with explaining the data collection method, followed by the selection of interview respondents. Then follows a brief description of the data analysis, followed by discussions on validity, reliability and ethics. Semi structured interviews, a generally recognized method for collecting data in case studies or similar qualitative research, were chosen for this study (Yin, 2003)

3.1 Data collection

The main method for data collection of this study was semi structured interviews with key stakeholders of 10 solar firms with service-based business models. Qualitative interviews were deemed the most suitable way to gain insight in both the business model, customer opinions and the potential for circular economy actions. Circular economy covers a broad spectrum of activities and this method was decided to best capture the different understandings of the subject, giving the best chances of covering the activities clearly. The possibility of asking follow-up questions is important and added to the decision in this case (Yin, 2015). A qualitative interview is also enabling the informant to ask questions and have things clarified, which is important when the subject might be new or difficult for people in general (Yin, 2015).

The empirical data collected in this study is a mapping of the existing solar firms with service-based business models in Sweden. This was performed through searches on Google, using the following search phrases in different combinations: "affärsmodell", "solel", "solenergi", "solceller", "innovativ affärsmodell", "cirkulär affärsmodell", "PPA", "solel som tjänst", "solabonnemang", "hyra solpaneler", "leasing"[1]. The identified firms' homepages were examined, focusing on their offered services. All firms that marketed a service beyond selling solar panels and installation were mapped into a table. After the collecting of relevant solar firms, the CEO at Svensk Solenergi, a trade organization for the Swedish solar market (personal communication, 13 February 2020) was consulted to ensure all relevant firms were identified.

1 Eng: "business model", "solar electricity", "solar energy", "solar PV", "innovative business model", "circular business model", "PPA", "solar power as a service", "solar subscription", "renting solar panels", "leasing".

In the identification of firms for this study, definitions were made in what business models would be included in the term. Clear cases of leasing and PPA were included, as well as turnkey solutions if the firm offered an additional service agreement to the PV system package. Firms offering consultancy services throughout the life span or monitoring during the first two years were not included. Firms offering online monitoring for the customer were not included either. In some cases, firms offer solar panels to several customer groups, but only offer turnkey solutions with services to some of them. In these cases, only the customer segment which was comprised of the turnkey solution was registered in the mapping. Firms that may have offered other service-based business models that are not communicated on the homepage was left out. In some cases where the business arrangements were unclear, the writer reached out to the firms per e-mail, asking them to clarify. Community solar parks were included in the cases where the share corresponds to a set-off on the electricity bill. Solar parks that are community owned as an investment or where the main purpose is to benefit the transition towards renewable energy in general, were excluded.

Interview respondents and selection

The mapping was used as the groundwork for choosing informants for the interview study. For the purpose of this thesis, a wide understanding of the different business models used in Sweden was desired. Therefore, maximum variability has been chosen as method of selection as proposed by Esaiasson et al. (2017). In this case, this meant that all firms in the categories PPA, leasing of panels and community owned solar parks were asked to participate in an interview. Due to limited time available, not all the turnkey solutions firms could be interviewed, so three firms were randomly selected. One of the firms marketed a performance-based service agreement, which qualified that firm to the list of informants. The list of respondents for the completed interviews are found in Table 2 below. Kalmar Energi preferred to have two persons answering the questions as they covered different areas of the interview questionnaire, which was welcomed. The interviews lasted between 25 and 75 minutes and were all performed in Mars 2020. It was decided that differences in customer segment and installed capacity would not have as large an impact on the circular practices as the business model, which are indeed the focus of this thesis, so these specifications did not have any influence on the choice of respondents.

Table 2.
List of respondents for interviews.

Name of firm	Business model	Position of respondent
Energiengagemang	Community solar farm	Sales manager
Ever energy	Leasing of PV modules	Sales and market manager
Bixia	PPA	Product manager
Eneo solutions	Leasing of PV modules	Technical manager
Gosol	Turnkey solution	Founder and project manager
Affärsverken	Community solar farm	Product owner energy
Svea solar	PPA and leasing of PV modules	CEO
Jämtkraft	Community solar farm	Project leader
Göteborg energi	Leasing of panels in solar farm	Projekt developer
Kalmar Energi	Community solar farm and PPA	Head of business support & controller

Through semi structured interviews, data was collected about their business strategy, what circular actions they applied in their daily routines and in their value chain. Further, enablers and barriers for more circular actions for these firms were investigated. Interview questionnaire were synthesized using themes in the framework reSolve (EMF, 2015b) and can be found in Appendix 1.

3.2 Data analysis

The ten interviews were transcribed in their entirety. Thereafter, the interviews were coded and analysed. Coding is an analysis method for characterizing, organizing and drawing conclusions from a set of raw data (Sanaña, 2009). The reSolve framework and barrier analysis tool described in chapter 2.4 built up the themes from which the coding was conceived. The frameworks guided the data collection and helped with structuring the findings (Sanaña, 2009).

3.3 Validity and reliability

When conducting research design and analysis, it is important to consider reliability and validity, two terms used to evaluate the quality of a study. Reliability of a study is dependent upon whether the method would generate the same results again, if reproduced under the same conditions (Yin, 2015). Issues of reliability are often negligence in data collection or analysis (Esaiasson et al., 2017). Validity could be described as the accuracy of a result, or to what extent the results really measure what is stated to be measured. A common validity problem is that the real-life indicator is not fully corresponding to the theoretical concept due to errors in the method (Yin, 2015; Esaiasson et al., 2017). This composed a risk in this thesis, namely in the gap between what the academy calls circular economy and the perception of the concept in the respondents. Circularity and circular economy are concepts that have vague definitions with a high level of abstraction. The measures taken to minimize the risk of validity issues were (1) to attempt to use established terms and (Esaiasson et al., 2017), and (2), give a thorough introduction (can be found in Appendix 2) to the informants on the subject, as this is allowed in qualitative interviewing (Yin, 2015). When dates were decided for the interviews, all informants were sent the introduction email which included the interview questions, a short summary of the terminology of circular economy, service-based business models and lastly, the aim of the study. The objective of this email was to avoid misunderstandings and make sure the author and the informants shared a common language and comprehension. It also fulfilled the purpose of making sure the booked person was really the most suitable one to talk to at that firm.

Three main reliability issues were identified in this study, the first being the nature of the qualitative interview, where follow-up questions are allowed (Yin, 2015), which can lead the conversations to new paths that cannot be reproduced in the next interview, which eventually could lead to inconsistent shortfalls in data collection. The fact that the interviews were performed and transcribed in Swedish, and then translated into a report written in English could have influenced the reliability of the study, as there was a risk of author's bias, mistakenly granting a translation in favour of the research aim. The author transcribed and analysed all ten interviews and is not a professional interpreter. However, the same person transcribed and analysed all interviews, enabling interpretations of tone and meaning to be consistent along the process. For reliability reasons, the choice of known CE frameworks for the analysis of the data was to prefer, as this could help comparisons with new and old similar studies. Validity and reliability are further discussed in chapter 6.2.

3.4 Ethical reflection

Ethical questions involved in this project were integrity for interviewees and their firms. This thesis was not expected to imply any ethical irregularities. The key thing was keeping the integrity of the informants in the interviews. The informants were informed about how the results would be published, their opportunity to be anonymised in the report and were also given the opportunity to read transcripts and drafts to change anything if needed. The transcripts are kept in the thesis' research data base (Yin, 2003), and have been completely anonymised on request from the respondents. If the results of this thesis were to be used, no foreseeable ethical conflicts are likely to occur.

4 Case: The Swedish solar market for service-based business models

This chapter provides an overview of the regulatory background for solar deployment in Sweden. The market-based support systems are differentiated upon the receiver and quite complex, for this reason this overview will only cover regulations and mechanisms that affect circularity aspects in the sector.

4.1 Development of solar in Sweden

Solar power constitutes a small share of the total energy production in Sweden, less than 1% (The Swedish energy agency, 2019e). However, estimates from the Swedish energy agency suggest that in 2040, 5-10% of the energy mix could derive from solar, so the recent growth in solar is likely to continue at increasing speed (IEA, 2019). The policy goal is to reach 100% renewable energy in Sweden by 2040 (The Swedish energy agency, 2019f). The Swedish solar market is still dominated by small scale producers, often people who own the PV systems mounted on their own roofs (IEA, 2019), while the development moves towards involvement of larger and more centralized systems. In the past years, new ownership models for solar has started to emerge, mostly small and medium sized third-party ownership arrangements. The regulations that govern production and consumption of electricity are originally designed based on the historical power system, where production plants were big and few, fuelling many small users. This has shaped today's electricity regulations, leading to barriers for the more varied small-scale production. Bureaucracy and other costs that are acceptable transaction costs for a big plant can become problematic for a small-scale producer. On the other hand, micro producers for solar power receive several governmental support schemes (Larson et al., 2017).

While solar power has for long been considered a renewable energy alternative with large potential, the relatively high implementation costs has composed a barrier for a real boom (The Swedish energy agency, 2016a). To lower the costs and increase the technological know-how, a variety of market-based support systems has been introduced in several countries, aiming to stimulate the market. Since the beginning of the 2000's, the market-based support systems in the world predominantly consist of feed-in tariffs and investment support. These support systems resulted in reduced costs and a growing solar power fleet in several countries (The Swedish energy agency, 2016a).

4.2 Government investment support

The government investment support aims to increase the employment of solar PV systems, lower upfront costs and increase the number of stakeholders active in the sector (SFS 2009:689). The investment support has since it was introduced in 2009 fluctuated between 20-60% of the investment cost, since May 2019 future PV owners get 20% off their investment cost. The subsidy has been popular, and the demand for the fund has many times exceeded the amount of money in the fund. However, by the end of 2020, the support fund is said to be removed and instead be replaced by a green tax deduction (IEA, 2019).

4.3 Revenues from producing solar electricity

Revenues from the electricity produced from a solar power system play a part in creating incentives that affect the overall deployment of solar power (The Swedish energy agency, 2019a). Firstly, the electricity produced from the solar PV system replaces the electricity that otherwise would need to be purchased from a utility. The value derived from this could vary greatly between different kinds of producers but always consists of the electricity rate, energy tax, Renewable electricity certificates (REC) costs, distribution charges and sales tax (The Swedish energy agency, 2019a). Secondly, as an energy producer, the surplus electricity can be fed to the grid and generate revenue (The Swedish energy agency, 2019a).
Since 2015, Sweden has had a state system granting a tax deduction for excess solar electricity fed to the grid (Energiforsk, 2017). The system is similar to a feed in tariff-system and comprises a tax credit for each kWh fed to the grid, if the person is a net consumer (IEA, 2019). For private houses and some housing societies this system works well, but for larger apartment buildings, the tax deduction is seldom viable (Energiforsk, 2017), as it is limited to PV systems with a maximum effect of 255 kW,

even for the electricity used within the system (Larsson et al., 2017). The tax deduction is valid for both physical and legal persons as long as the input and output happen in the same connection, main fuse and meter, and the main fuse does not exceed 100 A (The Swedish energy agency, 2019a).

The monetary value of this excess energy is lower than the electricity production cost, hence the profitability of the PV system deteriorates if it is dimensioned to produce a lot of excess electricity (Larsson et al., 2017). Selling energy to the grid and then buying it back is unprofitable (Molin et al., 2010). Several energy companies offer their customers different solutions for net billing (Swedish Society for Nature Conservation, 2012). Through net debiting, the micro producer can set off either the number of kWh taken from the grid with the kWh fed to the grid, to only pay electricity rate and taxes for the net electricity, or the price for input electricity and output electricity respectively (Molin et al., 2010).

5 Results

This chapter presents the findings along the order of the research questions. As a first step of the research, the existing Swedish PV contractors with service-based business models were mapped out, resulting in an overall overview in Table 3. Then follows the results from the interviews, beginning with how the business models enhance circularity. This section is followed by the reSolve framework, which exhibits the occurrence and prevalence of different circular practices among the respondents. The reSolve framework is followed by explanatory text, elaborating on the details of the findings. After these sections, that all describe the situation today, follows an outlook on what opportunities there are for further circulating the sector in the future, describing the respondent's views on customer value, drivers and competitive advantage that could derive from implementing more circular practices. The third part of the chapter is answering the third research question, and in there are the identified barriers to circularity, explained in an organizing table and in text, ending with the identified facilitations needed to overcome these barriers.

5.1 Business models enhancing circularity

Research question 1: How are service-based business models in Sweden enhancing circularity?

Table 3.
List of Swedish solar firms currently with any kind of service-based business model for solar power.

Firm	Business model	Customer segment	Resource
ENEO solutions	PPA (some cases of leasing)	Property owners, companies and municipalities/regions	(ENEO solutions, 2018)
Bixia	PPA	Companies	(Bixia, n.d.)
Ever energy	PPA	Customer segment: private house owners and housing cooperatives	(Ever energy, n.d.).

Kraftpojkarna	PPA solar farm	Companies	(Mälarenergi, 2019, Kraftpojkarna. Personal communication February 20, 2020)
Svea solar	PPA solar farm Leasing of PV systems	Landowners and companies Companies	(Svea solar, n.d.a) (Svea solar, n.d.b)
Göteborg energi	Subscription of panels in solar farm	Private house owners	(Göteborg energi, n.d)
Umeå Energi	Leasing of PV systems	Private house owners and companies	(Umeå energi, n.d.)
Affärsverken	Community solar farm	Private house owners and companies	(Affärsverken, n.d.)
Energiengagemang	Community solar farm	Housing cooperatives	(Energiengagemang, 2019)
Jämtkraft	Community solar farm	Private house owners and companies	(Jämtkraft, n.d.)
Kalmar Energi	Community solar farm PPA/leasing	Private house owners and companies Skanska, a swedish construction and development company	(Kalmar Energi, n.d.) (Kalmar Energi, n.d.;delvis personlig information från Kalmar Energi 24 februari)
Leva i Lysekil	Community solar farm	Private house owners and companies	(Leva i Lysekil, n.d.)
Tranås energi	Community solar farm	Private house owners and companies	(Tranås energi, n.d.)
Aktea energy	Turnkey solution with service agreement available	Property owners and companies	(Aktea energy, 2020)
Gosol energy	Turnkey solution with service agreement available	Property owners and farmers	(Gosol energy, 2020)
Gothia solenergi	Turnkey solution with service agreement available	Private house owners, companies, farmers, housing cooperatives	(Gothia solenergi, n.d)
Holje el	Turnkey solution with service agreement available	Private house owners and companies	(Holje el, 2016)

Paneltaket	Turnkey solution with service agreement available	Private house owners, companies and housing cooperatives	(Paneltaket, n, d.)
OTM Eko energi AB	Turnkey solution with service agreement available	Private house owners and companies	(OTM Eko energi AB, n.d.)
PPAM solkraft	Turnkey solution with service agreement available	Private house owners, companies, farmers, housing cooperatives	(PPAM solkraft, n.d.)
Save by solar	Turnkey solution with service agreement available	Companies	(Save by solar. n.d.)
Soldags	Turnkey solution with service agreement available	Private house owners and companies	(Soldags, n.d.)
Solect power	Turnkey solution with service agreement available	Property owners and companies	(Solect power, n.d.)
Vallacom	Turnkey solution with service agreement available	Private house owners and companies	(Vallacom, n.d.)
Sun solutions	Turnkey solution with service agreement available	Companies	(Sun solutions, n.d.)
Solkompaniet	Turnkey solution with service agreement available	Companies	(Solkompaniet, n.d.)
Soltech energy	Turnkey solution with service agreement available	Private house owners, companies, public sector	(Soltech energy, n.d.)

Five different categories of service-based business models were identified in the study. They all enhance circularity in their focus on maintenance and service, allowing for efficiency measures and minimizing system downtimes. For the cases where the ownership and financial risk stays with the firm, many of them stated that this was a strong incentive for them to invest in high quality PV system from the start and take care of it optimally.

The identified business models above differ in many things, such as ownership arrangement, contract length and where the panels are situated, but they have one thing in common: service. They all have in common that the end-user of the energy is not the one being responsible for maintenance and operations.

- In leasing or PPA, energy output guarantees are often part of the contract, creating financial incentive to optimise all the time and minimize downtimes.

- Another feature of the PPA that enhances circularity is that the long contract times ensures the customers guaranteed an optimised, maintained and fully working PV system for a time of often 25 years. This compared to the regular ownership model where the customer usually has a 25-year guarantee for the panels, 10 for the inverters and 5 for the installation process and are themselves responsible for maintenance and repair.
- For firms offering performance-based service agreement to their customers, the incentive is the same. To sell the plant they must make an offer of a profitable, competitive calculation, and to keep the customer and avoid financial losses they must live up to their promise, creating incentives for a highly productive PV plant.
- As basically all firms have contracts with a set time frame with their customers, long-term thinking is included in the business model, incentivizing them to make long-term decisions throughout the value chain. This aims for high quality panels and high-quality installation, operation and maintenance.

Turnkey solution

The most common one is the product-oriented service model, the turnkey solution with service agreement. This business model is also the one that most resembles the conventional business model of selling a product to the end-user. The feature that includes this business model in the scope of this thesis is the service agreements that these firms offer. The power in these service agreements differ, in length, the amount of service and monitoring that is included in the deal and of course, cost. One company offered a performance-based service agreement, where any occasions of under production lead to monetary losses in the firm.

PPA & leasing

For PPA, circularity was enhanced in the matter that the PV system had a maintenance and operations warranty for all of the contracts length, which usually lasted for 20-25 years. PPA appeared both in cases where the panels were mounted on the customers roof, and on others situated elsewhere. One PPA firm pressed that a PV plant that lasts a long time is serving both the firm and the customer.

> "The two most important things are that we own the plant ourselves, unlike if you are just a company that wants to sell and install your materials and then move on, it is our own investment that will come back over the lifetime." (PPA firm)

Community solar

Second most common is community solar, a business concept that has emerged recently in Sweden, with solar parks appearing in more and more places. Many of the identified solar parks did only just start up or had been in operation for less than two years. The ownership model here is often an economic association making the decisions for the park, sometimes together with larger companies or a municipal owned energy utility.

> "We take overall responsibility not only for the construction of the park but also for operation and maintenance throughout the life cycle, so we make sure that we maintain them optimally so that they can be in operation and produce as efficiently and maximally as possible throughout the life span." (Community Solar)

Subscription

Subscription of panels in a community solar park (where a customer subscribed to panels and their production for a time span of 5 years at a time) as well as subscription of a whole PV system mounted on the customer's own roof occurred in a few cases.

Circular practices and their prevalence

The circular practices are explained in more detail in the body of text below, presented by their circular economy action: Regenerate, Share, Optimise, Loop, Virtualise and Exchange. In table 5 the rows indicate life stage of the PV system and the columns represents the different business actions in the reSolve framework. Each dot represents a firm using this practice. The darkest squares indicate that five firms or more use this practice.

Table 5.
Circular practices and their prevalence in the data set.

	Explanation	R&D and manufacturing (indirect impact)	Distribution and installation	Use-phase	End-of-life (indirect impact)
Regenerate	Shift to renewable materials and energy	*			
	Restore and bring back health of ecosystems		**		
Share	Share resources, products and services				
	Use maintenance and durability design to extend life length of products and systems		*****	****	
Optimise	Increase performance/efficiency of products and systems		*****	*****	
	Remove waste from all stages in the supply chain	*			
	Use big data and monitoring systems for system optimisation and analyse		**	**	
Loop	Remanufacture and refurbish products and components		**	*	

	Product repair, refurbishment or remanufacture			***	
	Product and material recycling	*			***
Virtualise	Deliver virtual utility			*****	
Exchange	Replace old materials with advanced non-renewable materials				
	Apply new technologies				

Regenerate

The business actions in Regenerate are mostly focused on practices that are outside of the scope of this thesis. One firm put indirect pressure on their manufacturer of solar panels by having claims of renewable energy in their procurement data, supplemented with aims to increase the percentage by time. Two community solar firms had chosen waste land/old landfills as site for their solar park, making use of land areas that are unfit for most other uses.

Share

Direct circular practices in the R&D and manufacturing life stage is beyond the scope of this thesis. Here firms can impact the market in making demands on panel properties to their manufacturers, something that was occurring among the larger firms. This led them to the conclusion that they could also make requests on design for repairability and durability for their panels. This will however be dependent on whether they had the knowledge to what requirements to make, knowledge that is missing today.

> "Our ambition, which is the same as for the customer, is that the photovoltaic plant should last as many years as possible in order to increase the return on the investment, and we do this mainly today by trying to sell products that we believe have good quality and good operational reliability." (Turnkey firm)

There were split opinions on the most common evaluation document for solar panels, the Solar score card resource for wholesalers to get insight in how manufacturers score in terms of environmental and social responsibility. A top rating in the solar score card is the one sole biggest requirement for firms choosing their panels. The informants differed in their perception of the usefulness of Solar score card, as participation is charged with a fee for manufacturers, and some good scoring companies have chosen to drop out. On the other hand, many customers know about it and demands good scoring manufacturers from the contractor firms. Many circular practices are included in the Solar score card (Silicon Valley Toxics Coalition, 2019), hence it could work as a platform to further drive these questions of design for disassembly, waste management in the production process et cetera. For firms that did not rely on Solar score card for their product selection, cooperation with the European recycling project PV cycle was often requested.

Optimise

Optimisation and maintenance of solar PV systems is discussed more and more as very important for their sustainability and performance (IEA, 2019). However, the view of the importance of these measures differ greatly between firms: some firms do characterize these measures as increasing circularity and being important sustainability measures, while others read circular economy to be exclusively about recycle and repair.

Being careful with maintenance and high-quality installation from the start, is key to a good business case and gives competitive advantages on the market according to one PPA firm.

> "The better the facility we have, the better prices we can offer. Because here is the idea that when we get to the end of the PPA, then the idea is that we will have a fully functioning plant and that we should be able to extend the contract at very beneficial prices, because both the customer and us benefit from the plant last for a very long time. " (PPA firm)

The service business model includes circularity by default, for example a system that won't produce as contracted entails noticeable losses in revenues, and this motivates them to work with optimisation and high-quality products and processes from the start. This was true also for the one firm that claimed that they do not work with circular strategies at all. For leasing/PPA, a system that underperforms means that a PPA firm need to purchase additional energy from a utility to cover up for the shortfall. The PPA business model gives a strong financial incentive to constantly work with maintaining and optimising the PV plant throughout its life span. This is further reinforced in that energy output guarantees are often part of the contract in PPA and leasing. This motivates swift actions when panels or inverters go down or when they are not producing on top of their ability.

A full-time monitoring routine for the up and running solar fleet is an important step in optimising the performance of the plant and to detect errors early for minimized downtimes. In the case of service-based business models mentioned in this study, the retained ownership over the PV systems mean that they are responsible for monitoring the customer's systems. Many of the firms' own several bigger and smaller PV systems, a fact that gives beneficial economies of scale in terms of quality of monitoring systems and access to comparative data. Firms that monitor systems in the same area can compare production with both insolation and production in equivalent systems in the vicinity, giving a heads up when strings do not produce as expected.

Economies of scale are also obtained in community solar parks, which are often very large and therefore operated as industrial facilities. This demands harder quality controlling in both installation and operations processes, something that minimizes damage and maximises performance of the PV system. The monitoring function of bigger plants is very strong, and a problem could result in a big shortfall. Within one respondent's firms, errors are fixed quickly in many cases, or at least if the error is big enough to cause noticeable financial losses. For companies running both small and large plants, they tend to have a more reactive maintenance in the smaller plants and a more preventive maintenance policy in the larger ones as the financial losses there are more distinguishable.

The optimal operations and maintenance of a PV system requires expert knowledge. In service-based business models, solar experts are keeping the service and maintenance responsibility along the life span of the product. This is believed to establish higher maintenance quality with more optimized PV plants, exhibiting less downtimes and a longer life cycle.

Within the business, there seems to be no consensus regarding how much maintenance a PV system needs. In the interview findings, different sentences prevail some firms arguing that one of the great benefits with solar is that the PV plant once it is installed and adjusted, practically needs no maintenance. Others mean that they still need a small portion of maintenance and one firm stated that they need a lot of maintenance not to break prematurely.

Loop

Only one of the consulted firms claimed to have a routine of repairing broken PV components, and one said that in the case of the electrician on site deems it possible and financially viable, it is done. The company first mentioned above is a certified service partner to most of their inverter manufacturers. For them, repairing is cheaper than replacing with new ones, in addition to being more environmentally sustainable. While being service partner, they can stock up on spare parts and inverters, enabling swift measures whenever things break, minimizing system downtimes and unnecessary transports.

While inverters break much more often than panels, repair of broken solar panels is very rare in these interviewed firms. The warranty times are often about 20 years for panels, in which defect panels are sent back to the manufacturer, so repair of solar panels is not very common. More common is it that panels might get damaged during the installation, thereby sent to a recycling station. In the few cases where panels are only mildly damaged, for example aesthetical flaws, one firm made a habit of mounting them on their office building or selling them cheap to less picky or technically interested customers, giving them a second life.

> “There is a reason why we have been trained to be certified repairmen and it is precisely to avoid waste, avoid going there [to the site], picking something up, shipping and get something back, when you can do something else." (Community solar)

Drivers for repairing damaged components or not differ between companies. Many say repair is not an option because there are no repair partners available, others that it would be too expensive, while other companies do it a lot because it saves them money and/or transportation. This practice is of course dependent on the business model, and is more widely used in solar parks, where it is possible to stock spare parts and have proficient technicians close to the PV system.

In a situation where nobody really knows what will happen in 30 years when today’s panels probably reach their end-of-life, firms take on different approaches to the disposal-problem. Four companies only purchased from manufacturers who took part in PV cycle, hence investing in recycling solutions for the future, while one firm stated that they do not know what will happen with the panels and they do not see how that is their responsibility. One firm said that even though there is no recycling system in Sweden today, they are keeping the question in mind when they chose manufacturer and panels, avoiding metals that are hazardous to handle/recycle, aiming for components that are easy to disassembly or beneficial to recycle when possible. Some more firms do not have a plan but have made it a promise to their customers to demount and recycle the panels when they are obsolete according to the recycling scheme that is available when that day comes.

As long as the knowledge base is so small for second life panels and their performance, firms will stay hesitant to venture into a second-hand market. Many firms deem it unlikely that a market for second life solar panels will emerge, mainly due to the fast progress in which new panels are more efficient than panels produced a couple of years ago. Looking into efficiency and energy payback times, using second life panels could be a hard business deal as the panels would not produce as much as new ones would. Other firms see no problems at all in offering used panels to the customers at a lower price, since the panels doesn’t degenerate with time. These firms would be happy to use second life panels if there was a market selling them. The lack of a market and particularly the need for a labelling and specification system of second life panels is a barrier mentioned by many. A second life market would need to provide product specifications and a system for quality warranty to render security for the buyer. Even some PPA firms that do not believe second life panels to be an alternative for their business today, believe that in a few years, the solar sector might follow the second-hand trend in society and develop in that same direction. As the market grows, there is according to them a great potential for a rise of both a second life market and specialized service providers, working exclusively with repair and refurbishment of PV components. A couple of the interviewed firms are also in the hydro power business. Hydro power is a branch that has developed for longer and these firms can see that market initiatives and discussions about obsolete components are rising, and they are expecting solar to probably follow the same route when the market is more mature.

Several informants bring up that the loss in efficiency in older panels often can be offset by using modern, more efficient inverters, as has been made in older solar parks in Sweden.

> “I think very well that [in 30 years] there is a second hand market, everything is depending on the fact that at the time when such a decision is to be made, we will actually have all the facts. And we have the specifications on each string's panels, what they produce. And if the guarantee has expired by then- sad, but so be it. It will happen in other products as well. And if they are fully functional then […] I imagine that a secondary market is obvious in that situation. Then it might be cocky to say, it's 30 years away and maybe the technology will be prehistoric at that point, but from where I consider it now, I make that assessment.” (Community solar)

Being a large solar firm, the idea of offering second-hand panels as a special business offer was often more in question for the interviewed firms. Given that many larger solar parks are recently built, buying panels that already aged 10 years is understandingly not a very good idea, and some say that it could be possible only when the park is older. For solar parks that may be demounted before the panels reach their end-of-life, many panels will be in good shape and be ready for a second life. Several firms expressed interest in acting as distributor to the second life market and could see a lot of sustainability value in doing so. Both in PPA and solar parks, there are possibilities that fully functioning solar fleets need to be demounted prematurely due to contracts or leaseholds finishing before the fleet is obsolete.

Virtualise

Remote monitoring is giving firms an opportunity to quickly detect errors in panels or production. Remote monitoring more or less 24/7 was one of the most common circular strategies in the findings.

Exchange

No circular practices were found that could be categorised under Exchange.

5.2 Opportunities for further development

Research question 2: What opportunities are there to further develop business models towards more circular approaches, and would there be any added value for customers from such business models?

Implementing more circular strategies could add new values for the customers. Many of the respondents saw opportunities for new customer values in circular strategies, only one of the firms stated that they saw no such opportunities. Better economics and lower prices, security if anything happened with the PV system and better environmental reputation (for commercial customers) were the most common. When the company can anticipate a high yield and a long lifecycle for the utility, the customer value gets higher. Many respondents agree on that the importance of high quality products and installations, and that maintenance and operations can positively impact the production. The more they work with these things, the better the value.

Being a firm that openly works with circular economy strategies could make the firm more attractive to customers. Commercial customers that buy shares in solar parks often use the park as a part of their sustainability reporting. Also being able to prove working with circular strategies would further strengthen their sustainability case. One community solar firm described it as having a possibility to be prepared and do the homework so that their customers already have the answers when journalists ask them about recycling rates, circular economy and energy pay back times. Another firm explains this as one of the reasons to how PPA and leasing is working in the market despite high prices: their customer is willing to pay a high price because the benefits for their company are so many. The better the value the solar solutions brings to the buying company, the better the ability to pay, the more value is created everywhere in the value chain.

Drivers

There are many alternate drivers to why firms implement service-based business models. One firm was both energy utility and PV contractor and for them the BM meant that they had a contract with the customer for 10-20 years, during which time the customer would likely not change energy company. By offering additional services such as wall-boxes for electric cars or PV systems, they reduce the risk that their customers will turn to other firms for these products and services.

Another driver was expressed to be that firms looked for new ways to make business, avoiding energy tax and network monitoring fees that is applied when energy is produced in one spot and consumed in another. Community solar is argued to be a way of avoiding this and create a win-win for everyone. For the firms that were partly owned by their municipality, one driver for the emergence of these business models were to find ways to make solar available for broader customer segment, for example people without the possibility of paying a high upfront cost for a PV system, or people in apartments or with villas unfit for solar panels. In general, business models seemed to have emerged rather organically, as a way of constantly adapting to the customer needs and the changing regulatory conditions.

Competitive advantage

Implementing more circular practices could create competitive advantage in terms of value, brand and marketing, but could deter customers if prices became elevated or performance of the PV system were affected. Many, but not all respondents believed that there could be competitive advantages from developing their work with circularity.

The possibility for implementing more circular strategies in the interviewed firms was considered by many to be unlikely, would it result in increasing costs. Solar power in general is quite expensive and the electricity price in Sweden is very low, so higher costs for expensive repairs or more extensive monitoring could break the business case. These two factors make it difficult for the company to keep the customer inflow if prices would increase. One way of handling this would be to offer two different price packages, where one is environmentally better in terms of resource efficiency. The problem with this solution could eventually be that the customer experiences the other alternative as environmentally bad, as one respondent stated.

The use of more circular strategies could positively impact the relationship with the customers and strengthen the brand and how the firm is perceived. The same municipality community solar firm as above saw money saving possibilities in more extensive use of circular practices. Consequently, with lower costs, the firm could offer the end-user a lower price.

> "If we do good things for the environment and for our economy, it will spill over both at it can strengthen our brand and strengthen how we are perceived. And financially even back to, if we do good business, we can keep low prices." (Leasing in solar park)

Implementing more circular strategies were simultaneously believed to be a great opportunity for cost reductions if done right. The greatest costs of a PV system are labour costs and components. To be able to sustain some of the value of a module when it is obsolete, repairing defect components and using spare parts to a larger extent, could create financial benefits. If component costs can decrease through increased use of repair and refurbishment, initial costs as well as maintenance & operations costs can go down, creating a better value proposition for the customer.

If the company could communicate their transition to a more circular business, they could build trust for the company and for the line of business in general, as it shows that they are not part of the wear and tear culture. By being early in adopting these strategies, companies could win competitive advantages from this.

> "I think it is a way to build trust among customers and to, both to us as a company and to the industry in general, that we also take on our responsibilities and not being part of this wear-and-tear culture. In this way, I think you can gain competitive advantages by being early" (Community solar)

In summary, the investigated firms are enhancing circularity predominately by writing contracts that give long term relationships with the customers, having performance in the financial parts, incentivising high quality and maintenance product and service. In the findings of this study, turnkey firms with different levels of service agreements and community solar were the most common business models.

5.3 Barriers for further development

Research question 3: What are the barriers that could hinder such a development?

The main barriers to implementing more circular strategies within these business models are explained in the matrix (Table 4), and further explained in text below.

> "I think the main thing is that you should be able to get a system where you can produce where it is appropriate and then consume where you have the need, and not be penalized for it." (Community solar)

Table 4.

Below is an overview over the highlights of barriers to circularity according to the respondents. The columns in white explain the different possible barriers, and the green column to the right are the barriers mentioned by the respondents.

	Barriers according to Ellen MacArthur Foundation(2015a)	Barriers identified in the findings of this study
Economics	Not profitable	Old panels are too inefficient compared to new ones. No economic value is expected from using second life panels.
	Capital intensive	
	Technology	Quality uncertainties in second life panels- need for test routine to ensure the same technical specifications and coherent aesthetics. Panels are put together as one unity, not possible today to replace or repair.
Market failures	Externalities	Raw materials are too cheap to motivate second life market.
	Insufficient public goods/infrastructure	Repair service partner missing or is too expensive. Solar power is so new, there is a lack of infrastructure for re-use. The range of controlled second-hand panels is practically non-existent.
	Insufficient competition/ markets	
	Imperfect information	The lack of information on how collection and dispose-systems for panels will be, is holding back the possibility in businesses to make claims on their manufacturers for better disassembly and more environmentally friendly materials.
	Split incentives (agency problem)	The guarantee takes away the incentive to repair a broken panel, as the manufacturer just sends a new one if anything is broken. As soon as something is done to the panel in order to repair it, the guarantee (which is often 25 years) expires.
	Transaction costs	Lack of useful tool to find the best, most environmentally friendly manufacturer.
Regulatory failures	Inadequately defined legal frameworks	Unclear regulations on net debiting for community solar.

	Poorly defined targets and objectives	
	Implementation and enforcement failures	
	Unintended consequences	The administration of guarantees of origin and electricity certificates is manual and heavy to administrate for PPA companies. This affects the electricity price in the end for the customer and it hinders them from offering the PPA solution to smaller, individual customers as the price gets too high.
Social factors	Capabilities and skills	
	Custom and habit	No demand among customer for second life panels. Difficult to offer a competitive price when having high quality. Customers doesn't always understand why they should pay more for a service or product that will last for longer. Challenging to implement new and innovative business models in traditional energy firms.

Old panels are too inefficient compared to new ones.

Panels that enter the second life market are believed to have an effect inferior to virgin panels, so contractors of a solar park would need a bigger area to achieve the same energy production as with virgin panels.

Repair service partner missing

In the few cases where panels break, it has been due to vandalism where objects are thrown upon the panels causing the glass to break. Repairing the broken glass would be interesting, states one PPA firm, but no service partners are available to do it. This doesn't only go for broken glass, but it is generally hard to see economic incentives in repair services if panels breaking is so rare. The cost of having somebody repairing panels is still much too high, compared to buying new ones.

Barrier for use of second life panels

A problem that creates hesitancy towards the use of second life panels is the difficulty to visually determine whether a panel is damaged or not. There is a risk of small cracks in the glass deriving after mounting and demounting the panels several times. When a panel is intact, there is still an issue of determining the quality of a second life panel. The informants have different takes on this issue, while some say that since they monitor the panels and performance, they often have a good hinge on their quality given that data together with visual inspection. Others say that it is complicated to estimate the quality and status of a demounted panel, and that the true potential in a second life market lies in the components, more specifically the inverters. Inverters have a much shorter life span than panels and do break more easily compared to panels.

Knowledge gap in how collection and dispose-systems for panels will develop

Because no one knows what the Swedish recycling systems for solar will look like in 30 years, firms cannot make informed demands to their manufacturers about end-of-life qualities of the panels, such as design for disassembly and other circular strategies. Several firms inquire for research and information on this, as they want to prepare for correct end-of-life management.

Challenging to implement new and innovative business models in traditional energy company

For a conventional utility company, the energy line of business is traditional, and they have been operating in a centralised energy landscape for a long time, purchasing and selling electricity as a product to large and small customers. To keep up with the customers and continue to be relevant in a changing market, these companies need to explore new business models. Creating new business models and developing digitalisation solutions is costly and time consuming, and there is sometimes a fear against investing that money, especially in a traditional energy company. People, investors and boards are used to a certain business model and certain kinds of investments, which makes them hesitant to invest in digitalisation, according to one firm. Additionally, new business models require different sections of the company to work together in new ways, which could be challenging. The new business model urged for making everyone feel ownership over the project in the new organisational structure.

Support systems penalize community solar parks

Share owned solar parks hold multiple benefits, such as economies of scale, the possibility to build where the prerequisites are the most beneficial, and experts are available to optimise and maintain the park's condition. For micro producers today with PV systems on their own roof, a number of market support systems are applied, such as no energy tax for the electricity consumed on site and tax reduction for the excess electricity that is sent out on the grid. These financial support systems are lacking for community solar. Potential new regulation regarding net debiting has been under discussion for some time in the sector, and the lack of answers are creating uncertain conditions for firms operating in this field. To allow net debiting was the most common request from community solar firms.

> “The intention with the tax reduction is to benefit the micro-producers that clearly have made large investments. But there are also many share owners who have made large investments to contribute to the transition towards a renewable society. So, hence another argument that share owners also should receive some kind of tax reduction. (Leasing in solar park)

Doubtful and complicated rules and support systems

One barrier that goes for the whole PV market in Sweden is that the market-based support systems are many, complicated and inconsistent. The support system is made up of several different VATs, taxes and investment supports. Some are applicable for all, some only for small plants and some only if you consume in the same socket as you produce and so on. There is an ongoing discussion on whether the investment support will stay around for much longer and how high the support will be. According to one PPA firm, this is something that makes the potential customers uneasy, leading to decisions being postponed to the future, where they hope to have more clear information on what financial basis their investment will rely on. On the other hand, for customers that already decided on installing a PV system, the confusion in support systems could absolutely be a factor that benefits the service-based businesses, as they offer the service of taking care of everything from legal to financial aspects of deploying and operating a PV system. When the systems are complicated, the business model that can offer an untroubled experience for the customer, do have a competitive advantage.

Inconsistent rules and legislations are apprehended to slow the market down, where firms wait for information or hesitate to implement innovative business models due to the uncertain legal conditions.

Despite not being positive about subsidiaries in general, one informant believed that share owners of solar power should have access to the same subsidiaries as the people who have the possibility to install a PV plant on their own facility. They both contribute to the decentralisation of the electricity grid and helping alike and should have equal access to the subsidies. They both take a big investment and a great cost, and they both contribute to the transition towards a renewable energy system. The informant wishes that share owners of solar parks could be exempt from paying electricity tax on the electricity they are using from their own production.

> “What governs how PV plants are sized today and what one expects for their repayment time and life time, is greatly influenced by the regulations regarding taxes and VAT rates and so on, and this has probably almost the greatest significance and is probably the single biggest factor that can change anything.” (Turnkey firm)

Customers not willing to pay for higher environmental value

The use of second-hand products or to work more with repair is perceived in one PPA firm as something that will increase company costs and not render any financial benefits. Their customers are assumed not being willing to pay a higher price for these services. The customer needs a good price to buy PPA, and second-hand products and repair is not a part of that today according to this informant.

6 Discussion

6.1 Main findings

The main feature that makes these firms enhance circularity is that they all have performance demand comprised in their very business model. This gives them a very strong incentive to choose both high quality products and labour and maintain high maintenance and operations along the lifespan. In the light of this, service-based business models can be considered to play a part in the transition towards a more circular PV sector. The findings of this study suggest that there are two major ways in which the investigated solar firms enhance circularity:

- Firstly, they are almost always financially connected to the performance of the PV plant or park, meaning that they will increase revenue if production is high, and lose revenue if performance is lower than expected for some reason.
- Secondly, as the firms in PPA, community solar and service turnkey contracts are bound to their customer by contract often exceeding 20 years, they have warranties for the installation process that last much longer than for the conventional BM. Accordingly, they have to live up to their promise of a highly productive, low maintenance PV plant for many years, incentivising high quality PV products and processes with ambitious maintenance and operations.

Moreover, the study found that there are two main sets of barriers to the use of more circular practices in the solar sector. Partly, the market for repair, refurbishment and end-of-life management for PV systems is undeveloped, or non- existent. The lack of service partners and lack of information about what the PV recycling systems will look like in the future hinders companies from buying the easily decommissioned or less hazardous panels today, that will be obsolete in 30 years. Additionally, uncertainty among the firms whether circular practices will pay off or not are common. The perception of financial consequences from the use of more circular practices was to some extent deciding whether companies saw advantages from applying them or not. Some firms read circularity to be about saving resources, optimising the system that was already in place, and repairing when possible due to both financial and environmental purposes. For other respondents, circularity seemed to imply adding costs of repair services, more work and the need to buy more expensive panels. Given these two very different opinions, no doubt the conclusion and view of circular practices would be different.

The Swedish market-based support systems were found to be both a barrier and a driver for the emergence of service-based business models. A barrier because it could make renewable energy more expensive dependent on the business model, penalizing small scale production that are not the traditional private house owner with panels on their roof. A driver because it made firms come up with ways to come around these barriers, creating value and a solid business proposition despite the barriers, hence making solar power available for more customer groups. This study implicates that the support systems are favouring some producers while not others. This might need some further investigation in order to facilitate the development of solar in Sweden.

Previous research has taken either a very detailed take on either one circular practice (IRENA, 2016; Salim et al., 2019; Tsanakas et al., 2019b) or a review of circular practices in the global market (Strupeit & Bocken, in press), or service-based business models in the sector (Horváth & Szasbó, 2018; Lam, 2018). This study describes the conditions in the Swedish market, which could hopefully prove useful in the development of circular policy. As Strupeit and Palm (2016) discussed, the emergence of business models is always context specific, so in this case, the generalizability of the results is not very high.

Associations and regulators need understanding of the barriers that firms face in becoming more circular in order to pursue the right questions and legislate the most pressing things. Studies like this one can illustrate the main barriers for companies in the Swedish context, which could pose helpful guidance to policy makers. Given the right prerequisites service-based business models can pose an important factor in making the solar sector more circular. Results from this study indicates that the intrinsic features of the BM stipulate possibilities for circular practices. There is an interest in exploring repair, reuse and refurbishment because of the potentials for competitive advantages these practices inherit, but the market is not there yet.

This thesis has mapped out current circular practices in the growing solar market of Sweden, providing knowledge to a field that is quite new. Hopefully, the practices described here, and how business models can integrate with circular economy objectives can be dispersed to other stakeholders, exhibiting what possibilities there are. The literature is still focused on repair and recycle in terms of circular practices. However, this study proved that the circular business actions that are currently in questions for the firms in Sweden are panel choices, installation for durability and maintenance and service for optimal performance and long life.

One could argue that the development in solar CE practices is following the same pattern as the sustainability debate; first, focus lies in end-of-pipe solutions, taking care of emerging waste, secondly comes prevention of waste and pollution. Last, the CE paradigm (Blomsma & Brennan, 2017) focus shifts to circulation and optimization of resources instead. Results from the interviews show a similar trend: spontaneously, the respondents talked about recycling when asked about circular practices, whether they did know a lot about it or not, and measures of operations and maintenance came only when asked directly. Many seem reluctant to move the gaze away from recycling as the one and only circular approach.

In the review from Tsanakas et al., (2019), they conclude that in order to enable/ catalyse the entry of refurbishment and repair, there needs to be a consensus within the industry with systematics for standardisation along the supply chain. This was brought up by several of the informants as incremental to overcome some of the main barriers against refurbishing and repair of old panels.

Many of the firms stated that their BM incentivized them towards high quality operations, something that match earlier studies where result-oriented PPS (such as PPA) implied operational performance superior to conventionally owned PV systems (Guajardo, 2018). More empirical proof for this statement has been requested by Strupeit and Bocken (2019). As this is not a comparative nor quantitative study, no proof emerged here saying that the service-based business models have superior performance, but the PPA firms stated to be very aware of operations due to the configurations of the business model. Conflicting results have been obtained in studies in the US, where a solar service company performed operational performance under the market average, presumably due to a too fast expansion, disabling the possibilities for high quality installation and efficiency (Wang, 2017).

Rogers (1999) points out that the opportunities to gather large volumes of data of operations and maintenance are one big advantage for service-based business models. The numerous measure points give large advantages in gathering information and enabling further optimisation on operations and system design. This feature was pointed out as a circular advantage by several of the informants in this study.

Sweden might not be one of the biggest solar nations, but there is still a will to expand the amount of solar PV (IEA, 2019), and studies exhibiting the drivers and barriers of circular practices in different contexts are needed to facilitate the transition.

Bocken and Strupeit (2019) recently concluded a list of barriers to practices such as repair, reuse and remanufacture. They stated that barriers for development were both practical and economic. Just like the informants in this study, they stated that few panels are available for a second life market due to the sector still being immature. Because the number of modules that need this kind of service is still scarce, there is no economy in offering repair and remanufacturing services. Secondly, just as the informants in this study stated, insecurities prevail about the market value of used panels. Prices for newly produced panels are falling, while performance capacity is constantly increasing. However, these issues aren't problems yet, but they will be when the market matures, and panels start to break. These issues need to be addressed so that the market is prepared when it happens.

6.2 Limitations of the study and method discussion

The reason why the reSolve framework is presented in its entirety despite the row Exchange being empty, is to improve the comparability of the study. As explained above, due to limitations in the method, there might be gaps in the frameworks where circular practices are practiced but not displayed in the framework. The application of the practices within Exchange are usually presented in other stages of the value chain than was presented here, so this one being empty comes as no surprise.

There was a certain worry from the beginning that the results would be influenced by firms wanting to appear environmentally aware, thereby exaggerating practices. As this was not a quantitative study, this possibility could not be fully eliminated. The risk was kept in mind of the author in both analysis and interview, where follow up questions were posed, asking for specific standards or routines to back up the statements.

Despite attempts to explain the idea of circular economy through an introduction for the respondents, there is still a risk that not all applied circular practices in the firms were declared in the interviews, simply because the informants might not have seen these practices as circular. As was discussed in the methods chapter, there is a risk for skewed concept validity, in that the method, instead of measuring circular practices in the contractors' sector, might have measured the informant's perceptions on circularity. For many of the interviews, time was limited and it was not possible to cover the questionnaire fully. Due to timely reasons, there was not a set of questions that could fully cover for all circular practices possible among the contractors. There was therefore a risk of missing out of practices that were not fully understood or good enough explained. Correspondingly, practices that might have not been labelled circular practices could have been interpreted as circular practices due to author's bias. Another risk is that the informants showed a variety of professions, so maybe they had different amounts of insight into certain areas of their business. However, professional titles differentiated between companies and in the first stages of the method, efforts were made to make sure the person with the most insight was booked for an interview.

Given the outcome and how the thesis turned out, it is obvious that the informant selection is showing irregularities concerning different business models. In Sweden, the most common service-based business models are community solar and turnkey solutions with service agreements. In hindsight, the selection could have been more diverse in order to better represent an overview of the market, such as more turnkey firms and more straight out leasing firms. However, there were some cancellations and some candidate firms that were not available for interviews.

Some firms in the interview materials are contracting other firms, to plan, install and care for the PV systems, firms that were sometimes present in the material. This information emerged during the interviews. However, it was decided that this fact would not exclude these firms from the study, as they are still the decision maker in choice in panel quality and service in the services they purchase.

6.3 Future research

The next step, taking over from where this study ends, would be to look further into a quantitative estimation over what possible emission reductions, reduced material consumption and other ratios on how to measure sustainability and circularity. From such a study, measures could be prioritized and policy suggestions could be proposed that create better prerequisites for these service business models in Sweden, actions that would be aligned with the EU Action plan for a circular economy (European Union, 2020).

The interviews revealed a lack of consensus on several things. The amount of maintenance a PV system needs to function well was one thing, whether implementing more circular practices would generate additional costs or savings another. While these issues could of course differ between different firms with different prerequisites, this incertitude might be a sign of a knowledge gap within the sector; the firms do not have enough information to make informed decisions and demands concerning circular practices. A basis for making demands to upstream manufacturers about end-of-life quality of panels is to know what demands they need to make.

Another lack of consensus is the notion that panels do not degenerate and are therefore excellent candidates for second life, versus they are easily outrun by new panels and are therefore bad candidates. The knowledge gap on how disposal and eventual recycling processes of old panels will look like in the future needs to be filled in order for the firms to be able to make just demands from their manufacturers. Possibilities for disassembly or recycling must be comprised already in the design phase of the panels.

As has been mentioned in the data, firms exhibit doubt to whether some circular practices in the reSolve framework would pay off. These insecurities concern both finance and environmental impact. From a life cycle perspective, sometimes replacing an old, ineffective panel with a new and more effective could be a more sustainable alternative than to repair it. This issue has been previously mentioned by Strupeit and Bocken (in press) and remains an important question mark that needs to be answered in further research.

Ideally, as a next step in this research, it would be interesting to do a comparative study of this field, with a quantitative approach instead of qualitative. A comparative study could enlighten if, and how much a service-based business model could contribute to increased circular practices. With a quantitative approach, some of the weaknesses of this study, like inexact value words like “high quality” or “ambitious maintenance and service”, could be quantified and thereby more accurate. For this first step in exhibiting the used circular practices, this was not deemed possible within the time period.

7 Conclusion

The global increase in solar power is needed to replace fossil fuels, but as the number of installed PV systems grow, so does the projected waste volumes from obsolete modules. This study focused on circular economy as a possible road towards minimizing this waste, while exploring the Swedish market of solar firms with a case study approach. The scope of the thesis covered how service-based business models could enable the transition towards a more circular solar sector. The findings showed that because service-based business models are often themselves financially dependent upon the performance of the PV systems they are motivated to work with high quality products and installations as well as ambitious service and maintenance plans. These measures are important steps in pursuing circularity, as they prolong lifespans and optimise yields from manufactured products.

This study shows that opportunities for more circular practices in the Swedish solar sector are many and there is both interest and awareness within the contractor business. Applying more circular practices in the future is considered an opportunity for gaining competitive advantages, as it could fortify customer trust. Most of the circular practices from the reSolve framework are welcomed under the right conditions, meaning that there are some barriers that need to be addressed in order to further facilitate the transition towards circularity. Barriers identified in this thesis range from market-based barriers such as the absence of key stakeholders for creating a market of repair and reuse to regulatory failures, such as a complicated support system that benefits different customer groups unfavourably. These regulations would optimally be more flexible towards the new business models presented in this thesis, as they have great potential to catalyse the transition towards a more sustainable and resource efficient society.

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Appendix 1

Interview guide

Är det okej att jag spelar in intervjun? Kommer att tas bort när uppsatsen är inlämnad.

Du kommer att få tillgång till transkriptet och kunna rätta om du tycker att något blivit fel.

Önskar du att ditt namn eller din firmas namn förblir anonymiserat i den färdiga rapporten? (av forskningsetiska skäl kommer det gå att koppla ihop dem, men då behöver folk söka upp mig).

För de som erbjuder fler affärsmodeller, poängtera att det är den tjänstebaserade jag är intresserad av.

Berätta lite om din roll på ---? Vad är dina huvudsakliga ansvarsområden och uppgifter? Hur länge har du arbetat där?

På vilket sätt skulle du själv säga att er affärsmodell ökar cirkulariteten hos ett solpanelsystem längs livslängden i ert företag? (Circularity prolong the life of the pv system?)

Hur länge har ni varit igång med den här affärsmodellen?

Vad för reaktioner har ni mött från era kunder, varför väljer de just er?

På vilket sätt genererar er affärsmodell mer värde för era kunder?

Utveckling och produktion

Vilka kriterier går ni på vid val av solpaneler att sälja?

Vad för påverkan har ni på solpanelens leverantörskedja uppströms? / Har ni dialog om produktionens miljömässiga fotavtryck eller CSR-arbete?

Vad kan ni berätta om under vilka omständigheter solpanelerna tillverkas?

Hur ser ni på möjligheten att använda andrahandspaneler? Antingen i helt nya projekt eller som reservdelar vid reparationer?

Distribution och installation

Hur tror ni att installationsprocessen på ert företag ser ut jämfört med ett företag som bara säljer/ installerar paneler?/

Användningsfasen

På vilka sätt kan ni som företag påverka livslängden på solpanelsystemet ni arbetar med?

Hur ofta reparerar ni eller helt byter ut en panel som ni äger/servar? Eller görs det alls?

Turnkey: Hur mycket skulle ni säga att ert serviceavtal förbättrar produktiviteten hos era kunders solpaneler? På vilket sätt vet ni det, har ni jämförelser med liknande system i närheten, hur kontrolleras det?

Vad för typ av reparationer gäller det vanligtvis? Är det fel som sänker effekten eller fel som gör systemet obrukbart?

Beskriv era serviceavtal/ rutiner

Uttjänta paneler

Vad händer med era solpaneler när de är uttjänta?

Hur ser ni på möjligheten att reparera en panel som är uttjänt? Har ni kontakt med sådana företag som är specialiserade på den typen av reparation?

(till Turnkey) Hur kommunicerar ni till kunden vad de ska göra av panelerna när de är uttjänta?

Möjliggörare och hinder

Vad tror du gör att tjänstebaserade affärsmodeller börjar vinna mark i Sverige? - *Bonus question*

Finns det specifika tekniska hinder som försvårar för ditt företag att öka cirkulariteten hos era solpanelsystem? Vad skulle kunna göra det lättare för er? Lagstiftning, skatter, industripraktik, mer kunskap inom sektorn…

Vad skulle ni vilja se mer av?

De vanligaste cirkulära strategierna inom solel är optimering vid användning, förlängd livslängd, reparation, end-of-life management och uppgradering, vad för typ av värde skulle användningen av dessa strategier kunna bidra till hos era kunder?

I kortsiktigt perspektiv?

I ett långsiktigt perspektiv?

Får ni frågor om miljö och hållbarhet från era kunder, och isåfall av vilken typ?

CSR? Energin som krävs vid tillverkning jämfört med den energi som produceras?

Om ja, ser ni möjligheter att få fler konkurrensfördelar av att ytterligare implementera dessa cirkulära strategier?

Finns det någonting du vill tillägga som jag missat? Stort tack för att du ställde upp!

Appendix 2

Introduction to respondents

Bra att veta inför intervjun:

Här är en introduktion till min uppsats och även frågorna jag kommer att ställa i stora drag. Introduktionen är till för att vi i så stor utsträckning som möjligt ska prata samma språk när vi börjar intervjun. Hör gärna av dig om det är något du undrar över!

Syftet med den här intervjun är att samla in primärdata till min masteruppsats i strategiskt miljöarbete. Arbetstiteln är just nu "How can service-based business models increase circular material flows in the Swedish photovoltaic sector?" Uppsatsen kommer att publiceras inom universitetet och finnas tillgänglig för nedladdning. Min handledare Lars Strupeit på IIIEE (International Institute of Industrial Environmental conomics) och hans kollegor arbetar med CIRCUSOL, ett EU-finansierat projekt som undersöker potentialen i tjänstebaserade affärsmodeller inom solel. Den här uppsatsen kommer att bidra med kunskap till dem om den svenska marknaden.

Den stora ökningen av installerade solpaneler kommer inom några år innebära betydande volymer av uttjänta solpaneler som behöver tas om hand inom avfallssystemen. Material- och avfallsaspekten av solenergi behöver vara hållbar för att undvika att vi skapar nya miljöproblem medan vi löser de gamla.

Ett resurseffektiv mål med solenergisystemen är att få ut maximalt antal kWh från varje producerad enhet. Inom den cirkulära ekonomin finns exempel på cirkulära strategier som alla leder till en mer hållbar resursanvändning. Exempel på sådana strategier är optimering av existerande system, reparation, upcycling, återanvändning och olika sätt att förlänga livslängden på ett solelsystem.

Tjänstebaserade affärsmodeller (PPA, leasing av paneler och nyckelfärdiga lösningar med serviceavtal är vanliga exempel) har visat sig kunna leverera vinster både för miljön, kunden och företaget, och kan leda vägen mot större resurseffektivitet inom branschen, därför är ditt företag av intresse för min uppsats.

Mer finns att läsa på: https://www.circusol.eu/en och IRENA: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf

Tack igen för att du ställer upp!

Vi hörs i nästa vecka, ha en fin helg

Hanna