Ida Amalie Smith Johannessen

Accelerating the Energy Transition

A comparative case study of Denmark and Sweden

Bachelor's project in European Studies
Supervisor: Viktoriya Fedorchak
May 2020

Bachelor's project

NTNU
Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical Studies

NTNU
Norwegian University of
Science and Technology

Ida Amalie Smith Johannessen

Accelerating the Energy Transition

A comparative case study of Denmark and Sweden

Bachelor's project in European Studies
Supervisor: Viktoriya Fedorchak
May 2020

Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical Studies

NTNU
Norwegian University of
Science and Technology

Acknowledgements

This thesis marks the end of three years at NTNU Trondheim and is written as a part of my final work in my bachelor's degree in European Studies with political sciences. Writing this thesis has been an educational and interesting process, but also, at times, presented challenges and frustration. However, this process has given me valuable lessons and academic tools, which I will bring with me further on to master's level.

First of all, I would like to thank my supervisor Viktoriya Fedorchak for good advice and input during this process.

Secondly, I would like to thank Emilie Dvergsnes and Elisabeth Nakling for reading through my paper and providing grammatical support, even though I know this is not your main field of interests.

Lastly, I would like direct my gratitude to my friends during these three years at NTNU. A special thanks to my fellow students Aurora H. Røed Hagen, Stine M. Gaustadnes Hansen and last but not least Mira Grimsdatter Gullichsen for your support, motivation, our discussions and laughs along the way.

Ida Amalie Smith Johannessen

Trondheim May 9, 2020

Abstract

Expanding innovation for accelerating the energy transition to meet the Paris Agreement's Sustainable Development Goals (SDGs) raise a complex challenge for policymakers. It must ensure sustainable economic growth as well as reduce the environmental footprint. This thesis look into how the countries are managing the energy transition in lights of circular economy (CE) principles. Acceleration demands recognition and capitalization on the interlinkages between SDG 7 (Affordable and clean energy) and CE. A comparative case study of Denmark and Sweden, with high share of renewables in their energy generation, will be carried out by CE theory. Sweden and Denmark have set ambitions for further leadership in the European Energy Transition, still, they have somewhat different perquisites to lead the way forward. This paper seeks to pursue the differences between their leading positions, opportunities and conditions. While Denmark invests heavily in offshore wind projects and international energy hubs, Sweden aims to develop hydro-storage and hydro-transfers across borders further. With that being said, both countries are highly emphasizing interconnectivity and research and development (R&D), which the UN-secretary desired when calling for "The Decade of Action". However, further technological breakthroughs are needed to meet this demand. The concept of CE is presented as a crucial tool for accelerating the energy transition in order to reach SDG 7.

Sammendrag

Videre akselerering av energiovergangen gjennom innovasjon for å nå FNs bærekraftige utviklingsmål (SDGs), byr på en kompleks utfordring for beslutningstakere. Beslutningstakere må sikre bærekraftig økonomisk vekst, samt redusere miljøavtrykket. Denne oppgaven tar for seg hvordan Danmark og Sverige håndterer energiomstillingen i lys av sirkulærøkonomiske (CE) prinsipper. Akselerasjon krever anerkjennelse og kapitalisering av koblingen mellom SDG 7 (tilgjengelig og fornybar energi) og CE. Oppgaven er en komparativ case-studie av Danmark og Sverige, som har en betydelig andel fornybar energi i sin energiproduksjon. Den komparative case-studien vil analyseres ut ifra CE-teori. Sverige og Danmark har satt ambisjoner om å fortsette sin lederposisjon i den europeiske energiomstillingen, men har ulike forutsetninger for å oppnå dette. Denne oppgaven søker å belyse likhetene og forskjellene i deres ledende posisjoner, muligheter og forhold. Der Danmark investerer stort i havvindprosjekter og internasjonale «energihubs», tar Sverige sikte på å utvikle vannlagring og vannoverføring over landegrensene. Når det er sagt, vektlegger begge land videre samarbeid, forskning og utvikling, noe som FN-sekretæren savnet når han erklærte "The Decade of Action". Imidlertid er det behov for ytterligere teknologiske gjennombrudd for å imøtekomme denne etterspørselen. CE-prinsipper presenteres som et viktig verktøy for å akselerere energiovergangen, slik at SDG 7 oppnås i tide.

Table of contents

1. Introduction

1.1. Presenting the subject

Less than a decade is left until the Paris Agreement's target of reducing global warming below 2°C should be achieved, in order to reach zero emissions by 2050. This framework sets out 17 global goals (SDGs) to facilitate sustainable growth. Yet, the progress towards delivering these goals is far off track (WEF, 2021). In 2019, the UN Secretary called for mobilizing "The Decade of Action" desiring developments of smarter solutions, stronger frameworks, investments and partnership. With the statement "Ending the depression through planned obsolence" in 1932, Bernard London started the modern linear economy which has dominated ever since (O'Reilly, 2018). This "throwaway society" constantly push the end of the material reservoirs in front of us, yet the world continues in the same pattern (European Commission, 2020a). However, the new reality has finally kicked in; the earth is not inexhaustible and has an urgent need for fundamental transition.

A recently highlighted model provides a great pristine opportunity to utilize new technologies to speed up the progress towards sustainable development (SD), including deepening and broadening current action (Nilsen, 2019). It manages to ensure growth and value creation without consumption. This kinder egg of wishes is called "circular economy" (CE), which aims to decouple economic growth from consumption. From Brussel to Davos, this term has gained prominence by top executives and ministers (WEF, 2021).

Unfortunately, because of limited forces, little can be done at EU-level to boost the transition. In order to deliver the SDGs in time, frontrunners are needed to drive the energy transition. Sweden has good prospects of addressing this transition, being one of the world's most innovative countries (Ministry of the environment, 2020). Among the most sustainable countries, Danish companies have optimized their industrial processes, equipment and facilities (OECD, 2019a). This thesis sets out to discover what are the innovation interventions Denmark and Sweden are developing in the energy sector, and how do they correspond to the Sustainable Development Goals?

The thesis objective is to explore the following research question:

> What are the innovation interventions Denmark and Sweden are developing in the energy sector, and how do they correspond to the Sustainable Development Goals?

In order to answer the main issue, the thesis will also uncover the following questions:

- What are the governments' overall objective in their strategies towards achieving sustainable development?
- Can they turn the urgency and willingness into accelerated interventions and deliver the transition in time?
- How can Denmark and Sweden become at the forefront in accelerating the energy transition?

1.2. Methodology

In order to answer the research questions, this thesis will combine qualitative comparative case study and document analysis. This will enable a descriptive analysis considering Sweden and Denmark's incentives, as well as grasp their differences and similarities, and contextualize them.

1.2.1. Comparative Case Study Method

Comparative case studies (CCS) explore how actions at diverse scales mutually affect one another and are especially convenient for research on a policy or practice. Compared to traditional case-study, CCS are effective due to its ability to incorporate information over time. Two or more units are explored in-depth and systematically compared in a way that raises more generalizable information (Barlett & Vavrus, 2017, pp. 1, 14). The result is valuable in conforming interventions to support achievement of intended outcomes. CCS also involves examination and synthesis of the differences, similarities and the patterns across cases that share a common goal (Goodrick, 2014).

CSS considers how social actors with varied intentions, motives, and levels of influence, work with, or in response to, social forces. This "policy as practice" mindset, where practices are never isolated, fits perfectly with the holistic CE approach. Social actors adopt and develop practices in relation to other political, social, and economic environments. Studying policies are important for understanding how current social lives are governed (Barlett & Vavrus, 2017, p. 1). Practical limitations of this method can be substantial time lag between empirical data collection and the results' publication (Krehl & Weck, 2020). Consequently, this thesis will compare "similar" countries that are well-integrated in the energy transition.

1.2.2. Document Analysis

To gain a good understanding of the cases data will be carried out using document analysis. Since the data is already collected; "data selection" will be more accurate rather than "data collection". "Data selection" effectively gathers content from multiple documents related to the evaluation motives (Bowen, 2009, p. 31). Findings will primarily consist of public documents such as official documents, which includes detailed data, governmental statements and reports from the EU and IEA.

Document analysis proves much information and enables to understand governmental targets and strategies to obtain the SDGs. Limitations can occur when using documents that lack accuracy or are non-authentic (Creswell, 2009, pp. 179-180). In organizational context, published data are likely to be aligned with procedures, policies and agendas of the organization's principles. The documents used, however, are published by highly reliable sources, such as Ellen MacArthur Foundation and International Energy Agency (IEA).

1.3. Structure of Dissertation

The previous sections promote the relevance of the research question through presentation of key terms and methodology. Furthermore, theory and literature review will be presented, followed by Denmark and Sweden's energy systems, bestowing national objects and strategies. This study aims to pursue the countries' strengths and weaknesses, and how they can complement each other. Lastly, recommendations will be proposed on how the countries can speed up their efforts, followed by a conclusion.

2. Theoretical framework

2.1. Circular economy

Sustainability does not necessarily mean ending economic growth. The SDGs, however, cannot be reached without reducing energy demand and increasing energy efficiency. CE is a systematic approach to economic development designed to benefit the environment, businesses and society. In contrast to the "take-make-waste" linear model, the CE gradually decouples from the consumption of scarce resources (Geissdorfer, 2017, p. 759). The Ellen MacArthur Foundation defines CE as "restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles" (Ellen MacArthur Foundation, 2012, p. 7). The biological nutrients are designed to safely re-enter the biosphere and create natural capital. The technical cycle, however, is designed to circulate at high quality externally from the biosphere (Ellen MacArthur Foundation, 2012, p. 22). This holistic approach aims to optimize the system rather than its components, involving attentive management of material flows. Mastering CE will secure access to materials, increased value creation, new jobs, and greenhouse gas (GHG) emissions will diminish.

CE offers solutions to handle "hard-to-abate" emissions with activities that are easier to decarbonize like renewable- or low-carbon energy, eliminating emissions already from the outset (Ellen MacArthur Foundation, 2019a, p. 26). The core is utilizing the resources the best way possible to ensure long-term SD and value creation. These fundamental measures are not done overnight (Geissdoerfer, 2017, p. 759). An economic system that mimics nature, breaks with most regulatory regimes and most industry structures. It will simply be a brutally big challenge.

Recently, CE has gained increasing prominence as a catalysator providing solutions to some of the most pressing crosscutting SD threats today. By addressing root causes, CE, where pollution and waste do not exist by design, materials live in cycles, and natural systems are regenerated, bring forth promises for accelerating the process (Ellen MacArthur Foundation, 2012, p. 20). CE practices can potentially contribute to the achievement of several SDGs targets. The most substantial relationship exist between CE and the energy transition is SDG 7 (Affordable and Clean Energy). This target addresses sub-goals where CE concerns similar aims like renewable energy, energy efficiency, and investment of new technology and infrastructure (Schroeder et al., 2018).

In order to limit the environmental footprint throughout the value chain, true CE requires collaborations across and within sectors, and the developments of new partnerships and innovative solutions (State of Green, 2016). These new ways of thinking promote sound resource use aimed at implementing a sustainable economy characterized by new business models and the call for innovations. With potential to tackle radically new patterns while supporting society and increase energy of low- or zero-pollution sources and material costs, this theory is very applicable when analyzing innovative SD-interventions (Ghisselini et al., 2016). That said, CE offers a positive way forward by addressing the current systems' shortcomings, while creating new opportunities. This thesis will use CE to understand how the national objectives and initiatives lead to greener energy systems and discuss if their implementations correspond to SDG 7.

3. Literature review

Conducting an exhaustive literature review, this section identifies themes, debates and gaps in the existing literature related to the research question. After critically reading a broad range of research articles on the energy transition, CE and renewable energy, gaps have been addressed.

Increased attention has been put towards CE as a key to achieve the SDGs. Recognizing this, Ashby, Callegaro, Adeyeye and Granados contest CE contributions to SD (Ashby et al., 2019). CE strongly contributes to SD as portrayed in Nilsen´s article (2010). This article offers a reflexive approach which highlights the CE's opportunity to include all stakeholders within nature and economy (Nilsen, 2010). This thesis will oppositely go more in-depth of the governments through a contemporary approach.

Limitations of CE have been carried out in a few studies. Hobson and Lynch (2016) demonstrate that CE policies are quickly becoming key to regional and international visions for sustainable futures. As CE has recently been adopted by the European Commission and global business leaders alike, it is framed as economically profitable and technologically driven growth in a resource-scarce world. Nonetheless, little of the literature mentions political and social implications (Winans et al., 2017). An important obstacle in the development of CE is this absence of basic institutional and social conditions throughout the analysis (Ghisellini et al., 2016) (Moreau et al., 2017) (Hobson & Lynch, 2016).

A study requested from The Club of Rome discusses how CE, based on resource efficiency and renewable energy, can make environmental benefits. By including case studies on France, Finland, Sweden, Spain and the Netherlands it shows that CE creates decreased carbon emission (Wijkman & Skåneberg, 2016). However, this study focuses more on social benefits, such as creating jobs, rather than SD.

Increased sustainable resource management is announced as a strategic target in CE and the Green Deal (Smol et al., 2020). There is a grand mass of various implementation strategies, which makes it challenging for decision makers to identify which initiative would benefit their stakeholders (Kravchenko et al., 2019). Despite numerous frameworks navigating organizations towards CE, very few help the practitioners to understand what systemic selection for suitable leading performance. This paper on procedures to make systematic selection of indicators for sustainability performance, however, uses a hypothetical-deductive approach to explain how the business industry can overcome these challenges of creating a sustainability-orientated decision-making process (Kravchenko et al., 2020).

Current research offers a system of possible indicators for evaluating the transition towards CE in EU countries (McDowall, et al., 2017). A few studies propose frameworks for the CE process based on various instruments and incentives (Scheinberg et al., 2018) (Botezat et al., 2018). Nevertheless, there exists a lack of a system of indicators monitoring and evaluating the CE progress on regional level. Thus, the main purpose of the current research was proposing a possible system of regional level CE evaluation indicators. The limited attention paid to the processes for local- and regional-level policies creates a gap between policymaking and practical implementation. Therefore, it is important to analyze CE indexes for different regions (Avdiushchenko & Zajac, 2019).

Bridging the SDGs and the sustainable supply chain management, Alexander and Delabre discuss potential practical implementations and management of sustainability implications. Recognizing the need for strong forerunners to lead the process reaching the goals, they study the relationship between particular companies and countries that may adjust in inquiry of specific SD challenges. They also highlight the benefit of looking towards specific countries to advance SD (Alexander & Delabre, 2019). Schroeder, Anggraeni and Weber identifies the relevance of CE in achieving several of the SDGs – especially the ones affecting the energy sector. CE is acknowledged as supportive to achieve energy targets related to renewable energy. Already, implemented CE practices can be applied as a "toolbox" towards the SDGs (Schroeder et al., 2018). These articles focus on the importance of studying developing countries, but this paper studies wealthy countries.

Most studies on CE so far, concentrate primarily on the business view on resource efficacy. By exploring policy experimentation in driving a clean energy transition on country level, an article on the political economy of the transition describes broad-scale and locally relevant policies in clean energy transitions and its political economy. It presents innovative efforts in clean-tech industries and a case study of the Nordic countries (Arent et al., 2017). However, this case study analyzes two countries separately and will compare them against each other.

Byrne and Lund set out the constraints of infrastructure transformation as the main issue for the transition and calls for new innovations from urban cities (Byrne & Lund, 2017). "Nordic countries have the ability to find and establish synergies between different parties. For instance, from waste you generate electricity and district heating" (Nordregio, 2017, p. 47). This article proposes a framework where the Nordic Sustainable Cities are taken into consideration. Moreover, they reveal the possibilities for Nordic countries, and how their values and tools can be used to create local sustainability. However, they do not identify the need for acceleration.

Despite increased interest towards CE, it is surprising that so little empirical research on national level has actually been conducted. The existing literature recognize the link between CE and the SDGs. However, CE and its practice have almost exclusively been led by practitioners, not governments. While many articles explore how to implement CE, limited case studies have been studied, thus, it lacks comparable data. Little attention is raised how Denmark and Sweden can lead the energy transition. That said, the work on CE appears to be scarce and in its infancy. This chapter seeks to cover the gaps and illustrate where the proposed paper fits in. This thesis will not consider how new CE solutions can benefit the energy transition; but delve into how the existing CE-strategies works in practice.

4. Comparative Analysis: moving deeper into the energy transition

4.1. The Energy systems

Responding to the "Decade of Action", the European Green Deal (2019) makes up the ground-pillar for Danish and Swedish initiatives (Ministry of Environment and Food, 2018, p. 13). Green Deal presents an action plan towards CE that seeks to cut pollution and restore biodiversity, hence portrayed as a vital support for implementing the Paris Agreement (European Commission, 2020b). Similarly, Sweden and Denmark responded by upgrading their energy and climate policies. This chapter will explore *what are the governments' overall objectives in their strategies towards achieving sustainable development?*

4.1.1. National energy and climate policy

In addition to EU's targets, national targets have been set; short- and long-term goals. In 2019, Denmark stepped up its game; the government promoted a more sustainable policy under which the Danes resumed leadership of the green transition and ensured its compliance with the SDGs (Danish Ministry of Climate, Energy and Utilities, 2019, p. 5). Long-term strategies became adopted in the climate policy framework as a step to reach the SDGs. The main objective of the Danish Climate Act bridges existing policies along with future climate action towards the 2030 Agenda. Reaching net-zero emissions by 2050 and limit the global temperature rise to 1.5°C, The Danish national target for this process requires 70% reduction of GHG-emissions by 2030 (relative to the 1990 baseline). Characterized as one of the most ambitious climate targets in the world, this represents Denmark´s first legally binding climate target. Furthermore, their aim to make gross final consumption consist of minimum 55% renewable energy in 2030. The Swedish 2016 Energy Agreement, on the other hand, has set the overall long-term target of reaching net zero GHG-emissions already by 2045, and reach 100% renewable power of the electricity generated by 2040 Another governmental target is that energy consumption must be 50% more efficient. The Integrated National Energy and Climate Plan builds upon these targets and seeks to increase their already high carbon and energy tax levels (The Ministry of Infrastructure, 2020, p. 4-19).

Taking short-term targets into account, The Danish Climate Act mandates sets new national climate targets every five years, with a 10-year perspective (Danish Ministry of Climate, Energy and Utilities, 2020, p. 29). These new plans include, among other things, the following initiatives regarding renewable energy; 1) construct a common strategy for electronification, 2) explore Danish potential to prepare a common strategy together with the North Sea countries to expand and utilize the potential of offshore wind, and 3) examine Danish potential to build the first energy island by 2030. The Energy Agreement outlines a plan for the energy transition in the period 2020-2024, which defines the first step reaching the SDGs (Danish Ministry of Climate, Energy and Utilities, 2019, pp. 6, 85). While Denmark has set sub-goals to its overall target, Sweden has no national short-term targets for the share of renewable energy in 2030. They are content with the EU Renewable

Energy Directive recommendations that renewable energy should account for 65% of gross energy consumption by 2030, 7% below the Danish target (The Ministry of Infrastructure, 2020, p. 19). Despite Sweden having less short-term targets than Denmark, the Swedish Climate Policy Framework (2019) still provides stable energy policy as it conducts to the EU.

The Danish Energy Agreement (2018) agreed to strengthen Denmark's international position focus on energy efficiency, renewable energy, energy regulation, and research and development (Danish Ministry of Climate, Energy and Utilities, 2019, p. 5). In line with this vision, the Swedish Energy Act (2015) stresses efforts to promote effective energy markets and strength its competitiveness to ensure energy supply at internationally competitive prices. Hence, intertwin security of supply, competitiveness and sustainability. Therefore, both countries must ensure sustainable energy use and efficiency without reducing the economic growth (The Ministry of Infrastructure, 2020, pp. 7, 14). Due to their long-term ambitions of being placed among the first fossil-free welfare nations, both countries have made significant progress. Turning high ambitions into actions, the Danes and Swedes promotes the transition and development of green technological solutions.

4.1.2. Strategy of Circular Economy

Together with the energy transition, CE completes the pictures of Sweden and Denmark's strategies to address climate change (Ellen MacArthur Foundation, 2019b, p. 49). Along with long-term policies, Sweden and Denmark aim to perform a CE strategy to complement their future prospects as innovative forces on technologies for renewable energy to sustain an energy system fit for the future. CE desires definite plans for infrastructure on, energy sources, power generation and power grids in the process to alternative sources. Fundamental industrial and market changes are much needed for the opportunity for consumers to benefit from climate efforts and get access to various renewable energy sources (Ellen MacArthur Foundation, 2019a, pp. 30-32). Moving into the future, these countries strive to use sustainable production methods and alternative raw materials to advance CE. A successful shift to renewables requires technological process, definite political action, and increased societal acceptance of climate-friendly measures.

Denmark has outlined six areas of effort to support a further CE transition. In brief, it emphasizes enterprises, digitalization, design, improved consumption patterns, functioning market and more value from resources (Ministry of Environment and Food, 2018, p. 12). Sweden, on the other hand, has set four focus areas for CE. This includes for instance production and design, consuming and using materials, circular lifecycle and the business sector. However, all these focus points are closely linked. Regarding the energy sector, CE strategies require increased use of renewables and energy efficiency, together with development of measures concerning this transition. To further develop; energy efficiency, cost-efficiency and energy security are central components of CE. Moreover, to improve energy efficiency both countries concern innovation and technology in their CE strategies. The countries' strength in receptive to new technology and innovation, are important factors for their success in developing CE (Ministry of the Environment, 2020, pp. 3, 13).

SDG 7 aims to ensure access to renewable and reliable energy for all. Its targets include access to affordable energy services, increased energy efficiency and the use of renewable energy, and support energy technology transfer (UN, 2015). With the same vision, CE also encourage the transition to renewable energy. By decoupling the use of fossil-fuels from society, CE endorses a wide use of renewables to cut emission, waste generation and raw materials use (Dantas et al., 2021, p. 220). The overall aim of this interlink is integrating energy climate change measures in governmental strategies and improving the energy systems' utility (Schroeder, 2018, s. 86). The CE strategies provide two main objects delivering the SDG 7; firstly, they aim to reduce fossil-fuels by increasing the share of renewables. Secondly, by developing new and more efficient practices and technologies.

4.2. The Energy landscapes

Clearly, the era of fossil-fuels is coming to an end. The energy transition is here to stay and presents the perfect opportunity to reset energy production towards a greener path. In Sweden, hydropower and bioenergy make up the highest share of renewables, where hydropower is mainly used in electricity and biomass for heating. The energy system is an important element in Swedish energy development since the electricity generation has largely been decarbonized though investments in renewables (IEA, 2019, p. 4). In contrast to Sweden, wind is well-established in Danish energy and produces almost twice as much wind-power per capita as the runner-up among industrialized countries in the OECD. Wind power is nevertheless not the strongest energy contributor. Bioenergy takes first place, followed by wind-power, solar and geothermal energy (Ministry of Foreign Affairs of Denmark, 2019). This makes Denmark and Sweden among the IEA countries with the highest share of renewable energy in their electricity generation (IEA, 2020). With access to substantial clean energy resources, especially hydropower and wind, sustainable utilization of their main resources can contribute to deliver the SDGs. First of all, export of clean power can displace more emission-intensive generation. This is set to escalate deployment of wind energy in the Nordics and a number of transmission cables under construction. Secondly, mobile hydropower can provide balancing services to help integrate variable renewable sources (Nordic Energy System, 2018, p. 6). The question is *whether we can turn the urgency and willingness into accelerated interventions and deliver the transition in time?* Now, long-horizon net zero roadmaps must be turned into actions. Concrete policy implementations, robust delivery plans and interim target-setting is required, otherwise, even in the most optimistic scenarios, the SDGs will be missed (GWEC, 2021a, p. 6).

4.2.1. Tracking SDG 7

Energy effectivity

Energy efficiency is the prerequisite to complete decarbonization, along with smarter alignment of supply and demand. Energy intensity has decreased significantly the last decades, in part due to specific efforts to get more from less energy. Given some of the best wind conditions along with the highest electricity share of wind globally, it is pretty straightforward to understand how Denmark became a global hub for wind power technology. Danish wind power enterprises are merged in an impressive cluster with members such as Vattenfall, Ørsted and Vestas, which all are ranked among the top ten of the world's wind turbine manufacturers (GWEC, 2021b). Denmark's reputation as a wind power pioneer relies on focused research and development, technology innovation, efficient production and market testing. Offshore and onshore developers, turbine manufacturers and suppliers, research institutions, engineering companies and test centers are all the stakeholders involved in this innovative value chain. Together, they develop more cost-efficient and dependable wind energy (Ministry of Foreign Affairs of Denmark, n.d.). However, Sweden has a robust hydropower generation dating back to the 19th century (Fortrum, 2020, p. 15). In order to create a flexible system, Sweden has a strong position in developing hydrogen fuel cells, given its high share of hydrogen generation and the crucial commitment of stakeholders along the whole value chain, such as the Scandinavian Hydrogen Highway Partnership. This partnership aims to be the first in Europe to pave the way for access to hydrogen used in a network of refueling stations. The estimated potential for supply of technical variable renewable electricity production in Sweden is almost ten times higher than expected Swedish electricity demand in 2030, hence promotes great potential for developing hydropower (FCH 2 JU, 2020, p. 6).

Despite wind energy being the cheapest and fastest growing resource, it is categorized as variable energy sources (VRE), which relies on weather conditions (Mæland, 2018). Forecasting the future, VRE's will probably be stored in batteries. Yet in today's market, VRE must harmonize with conventional power generation, which in many markets means fossil-fuels or nuclear power, hence not able to fully replace fossil-fuels. Hydropower in contrast, has the key advantage of being both renewable and flexible. Future smart systems, digital solutions, hydrogen storage, transmission cables and better grids will, in the future, improve flexibility solutions for Europe (Mæland, 2018). Meanwhile, hydropower is the best solution. Looking towards the Nordic Power Market, there is a need for research in hydropower plants to use when VRE are not present. Compared to wind energy, hydropower is also cheap and produces little emission, while provides security of supply. Hydropower is key in energy systems where the generation of VRE increases rapidly. Swedish hydropower, for instance, combined with large-scale wind deployment in Denmark, will provide cheap energy benefitting both countries (Cruciani, 2016, p. 26).

Cost-efficiency

Aiming at increased interconnectivity, both countries are already deeply engaged in Nordic energy research co-operation. Primarily through land-cables-connections to Finland and Norway, and high voltage sea cables to Denmark and Finland, Sweden is well interconnected with its neighboring countries (IEA, 2019, p. 95). Denmark, on the other hand, imports electricity mainly from Norway and Sweden, while exports to Germany. Conducted through the Nordic Council of Minister dialogue, cooperation, and coordination between the Nordic countries is finding place. An ad-hoc team is established to coordinate national energy and climate plans in the Nordic region. This team discusses common interests and exchange knowledge (The Ministry of Infrastructure, 2020, p. 13). With strong interconnection, prices tend to unify, which currently vary between different markets (Cruciani, 2016, p. 36). Currently, Denmark is focusing on integrating and functioning electricity markets and wants to strengthen and further expand cross-border markets for balancing products. Examples of this are the cooperation with Svenska Kraftnät for the Swedish interconnectors and the offshore wind farm at Kriegers Flak related to Germany (IEA, 2017, p. 77). Sweden also aims at expanding their interconnections by strongly participating in the international company Statkraft, which actively contributes to the SDGs. Here, Sweden is considered as the strongest contributor of hydrogen, and through this partnership, get the opportunity to exchange and develop knowledge (Rynning-Tønnessen, 2019).

Close cooperation and geographical proximity in the wind industry has opened the eyes of many international enterprises to the advantages of settling in Denmark. Denmark's developments in this sector and the export of turbines and technology, are important givers to the national economy. Years of dedication seems to finally pay off. Growing political will, price decrease and technological developments means expansion of clean energy (State of Green, 2021). Sweden, however, developed hydropower before the electricity sector was liberalized, at a time when only ownership of territorial monopolies facilitated access to funding. While investors in Denmark meet more stability, the Swedish system has, however, been criticized for uncertainty around the earnings so investors must increase their risk premiums, which costs more than installations conducted under a system with fixed prices. In spite of risks, Sweden has successfully applied this system and is among the cheapest in the EU. These provisions create stability, hence, inspires confidence among economic-oriented stakeholders (Cruciani, 2016, pp. 38-39).

The investment attractiveness depends, according to CE, largely on the scaling potential. Denmark is at the forefront at financing new wind farms. Private-public partnerships are investing heavily in wind farms around the world, partly because danish wind power is considered a very safe investment. A legal requirement in Denmark is that new onshore wind turbines must be co-financed by private local investors. This is unique to Denmark and regarded as a durable infrastructure investment. This is an example of a successful CE implementation. Furthermore, local investors have part-ownership of their local wind turbines. Combining this strong investment-will with the political vision builds a stable framework for further development of the wind industry (DWIA, 2014, p. 9). Despite less investment capital, Swedish industrial consumers gain from some of the lowest electricity prices in Europe. While local 'district heating' plants use excess heat in producing over 75% of the warmth to the Swedish households, the country also combines the world's highest carbon taxes with relatively cheap energy prices. However, consumers will also experience varying prices depending on season and precipitation affecting the electricity generation. Still, within the Nordic market, the fleet of hydraulic power stations serves nearly 50% of total installed capacity, therefore, hydropower provides safe dedication for investors (Cruciani, 2016, p. 26).

Sweden looks towards the possibilities to utilize know-how of hydro-technology and establish infrastructure at the power plants for hydropower production. Many of the power plants are 100 years old and need to be constantly updated, which is costly. Investors in Sweden meet therefore more uncertainty than Denmark who is leading its field. While Sweden invests in upgrading, Denmark invests in innovation, giving Denmark more export opportunities. That said, Sweden also invests in the power plants' dams to remain safe, both for the local environment and employees. In this way, the power plants and its capacity will also be ensured in the future (Fortum, 2020, p. 10-15). That said, investment in renewables are growing, but not fast enough. Despite progress, policies and stakeholders continue to be intertwined with fossil-fuels, because Denmark cannot fully rely on wind. Hydropower is more reliable, but strongly connected to nuclear power (FCH 2 JU, 2020. p. 10). These solutions do not go hand in hand with the desire of a 100%

renewable electricity generation. Thus, drastic interventions are vital to adjust investment into transformative action (OECD, 2020, p. 126).

Security of supply

Denmark and Sweden want to contribute to reduce GHG-emissions beyond borders. Exporting energy based on comparative advantage can support this and increase energy security. By integrating energy markets in Europe, one can increase the scale of renewables while maintaining high security of supply (The Ministry of Infrastructure, 2020, p. 75) (Danish Ministry of Climate, Energy and Utilities, 2020, s. 86). In recent years, export of energy technology has increased. Denmark's rise in use of renewable energy and cooperation with neighboring countries ensures a continued high level of energy security, because of less dependence on import from third countries (Danish Ministry of Climate, Energy and Utilities, 2019, p. 6). Moreover, a functional society demands uninterrupted and reliable energy supply. While Denmark exports wind because of the great conditions, Sweden has good opportunities balancing VRE's by expanding hydropower export. The flexibility of hydropower is urgent in securing the electricity systems and power grids to balance energy price fluctuations and energy consumption peaks (Fortum, 2020, p. 28). Additionally, trading is also rising with countries that need daily energy balancing services, such as the Netherlands.

Predicting how much balancing capacity will be needed in the future is difficult, as this will depend on different elements, such as the variation in speed, energy usage levels, surplus in other countries, river inflow levels and transmission capacity across nations (IVA, 2016, pp. 10-11). The prime advantage is that hydropower is almost inexhaustible. Water in lakes and rivers will keep flowing, making a source that already has been used for decades and will continue to be used. Danish electricity generation depends on the wind conditions during that year and Sweden depends on the amount of rain or snow. Compared to Denmark, Sweden provides more security on their electricity supply generated by hydropower (Flanders, 2020, p. 6). Because hydropower is easier to store, it manages to regulate energy when the other renewable sources cannot produce energy. When the need for power increases, or when wind and solar cannot produce electricity, more production capacity is required. Hydropower plants are able to regulate water flow following changes in production or demand, offering much-needed flexibility without increasing GHG-emissions. The more flexible hydropower is being produced, the more generating choices are proposed. The water that is needed is stored in ponds, which makes the production team very reliable. In addition to making the electricity grid stable, it also keeps electricity prices stable (Fortum, 2020. p. 10).

Sweden has succeeded in the energy transition through market-based policies, notably CO2 taxation, which has helped drive decarbonization across several sectors (The Ministry of Infrastructure, 2020, p. 7). Danish wind industry is successful as the result of expertise throughout the supply chain, by developing unique technical solutions, for which there is global demand (DWIA, 2014, p. 9). Furthermore, both countries have high ambitions continuing on the same path by increasing the share of renewables and improving efficiency from already high levels. As a result of persistent and active energy policies, Danish and Swedish energy consumption are among the lowest globally relative to GDP. Their economies are among the world's most energy efficient ones (Danish Energy Agency, 2020. p. 4) (IEA, 2019, p. 11). However, the pace of the acceleration is not satisfactory enough, meaning neither Denmark nor Sweden is on track delivering SDG 7. Both countries have good prospects achieving SDG 7, still reliability needs improvement, especially Denmark depending on wind, which currently scales-up. Fortunately, there is time left. The key message of this section is that despite good progress, further acceleration is needed. However, acceleration requires further developments of renewable energy sources requires, extension and reinforcements of the grid. Voluntary agreements, standardization of performance, taxation, and undoubtably R&D support are among the used tools, which will continue to be crucial moving forward (Nordic Energy Research, 2020, p. 17). All this will be crucial for making the SDGs become achieved on time.

4.3. The future European energy system

With efforts paving the way for a sustainable future, Sweden and Denmark continuously strive to improve its production processes and energy supply (State of Green, 2016). Since they already are among the world's greenest countries, being climate neutral will not affect the global climate significantly. Therefore, the governments' aim to lead others by example. However, further incremental energy efficiency initiatives are more challenging and demand technological innovation (Lanvin et al., 2020, p. 14). The aim of the innovation cycle is to bring solutions to the market. Sweden and Denmark manage to produce relatively cost-effective renewable energy, which increases their competitiveness (Danish Ministry of Climate, Energy and Utilities, 2020, pp. 4, 65). European energy system needs frontrunners in developing the first commercial applications of breakthrough technologies by 2030. Priority areas include further energy utilization (European Commission, 2021). This section will focus on a small selection of initiatives for regional development and *how Denmark and Sweden can become at the forefront in accelerating the energy transition?*

4.3.1. Internal Energy Market and Interconnectivity

Europeans are well represented among the world's biggest clean-tech companies, according to the New Energy Global Innovation Index (2020). Danish companies such as Orsted A/S (wind and solar) and Vestas Wind Systems A/S (Wind) are both placed among the top five innovative clean-tech companies. The Swedish companies Nibe Industrier AB (heating) and Eolus Vind AB (wind) are also rated further below (Wilderhill, 2020, pp. 50-54). On the overall Innovation Index ranked by countries, Sweden places second, after Switzerland, and Denmark takes sixth place. This does not only make climate change a particular challenge, but also a business opportunity if addressed in the right manner. Where Sweden's place has been relatively stable, Denmark's ranking in 2020 has increased from 2019, where the indicator on knowledge and technology and environmental performance, among others, has contributed to this increase (Lanvin et al., 2020. pp. 23-25, 63). This facilitates a good position to lead the energy transition.

Firstly, access to finance and insurance is crucial. Emerging new technologies for energy efficiency are risky and capital intensive. It is difficult to produce supply that no one demands. Therefore, improvement of energy efficiency requires stabile, intensive and continuous investments in science and technology (S&T) (Lanvin et al., 2020, p. 27). However, Denmark will increase its budget from 580 mill. DKK in 2020 and 1 bill. DKK in 2024 on research, development, and demonstration (R&D) of new technologies in the energy sector (Danish Ministry of Climate, Energy and Utilities, 2019, p. 7). Swedish National Energy Research and Innovation Programme had, in 2020, a budget of 1,6 billion SEK, a rise from 1.3 billion in 2017 (The Ministry of Infrastructure, 2020, p. 39). Strong investment-will provides new opportunities to lead the development and export of new technologies and circular solutions advancing this progress. Promoting future electricity production based on renewable energy free from subsidies, is therefore a strong political objective.

EUDP and Innovation Fund Denmark support a broad range of projects such as new test facilities at Lindoe Offshore Renewables Center (LORC) (Danish Ministry of Climate, Energy and Utilities, 2019, p. 124). EUDP also supports universities and private companies to develop new energy technologies, such as hydrogen and energy storage. The public-private sector's commitment to renewable energy and the strong wind power industry are two main reasons why international businesses find the best conditions in advancing and testing new technology in Denmark (Ministry of Environment and Food, 2018, pp. 22-24). Sweden has, on the other hand, no technology-oriented policies for developing hydrogen fuel-cell vehicles. With less demonstration, the emergence of new technology develops slower in Sweden. Positioned at the forefront in "Hydrogen Breakthrough Ironmaking Technology"- research, Sweden may address regulatory barriers to the deployment of hydrogen applications, considering measures at EU level. Hence, given the ambitious climate targets, the market is expected to drive low carbon technologies and solutions. Policy instruments such as carbon pricing and car taxation shall further address and stimulate hydrogen (FCH 2 JU, 2020, p. 14). While in Denmark, research and demonstration shall develop offshore wind.

Secondly, to strengthen their competitiveness, they also need to contribute and take advantage of international cooperation, which, in a CE perspective, includes increased interaction between various sectors such as public-private relations and cross-border corporations (The Ministry of Infrastructure, 2020, pp. 14, 110). Meeting the very ambitious target of a 100% renewable-powered future with high shares of VRE, coordinated initiatives to create synergies across climate, energy and innovation policies are required in order to create a flexible system. However, every stakeholder involved in the power sector is essential. Synergies among different innovations and enabling technologies, new regulations in terms of design, innovative business models and new system operation practices, may reduce the need for investments and increase welfare benefits (IRENA, 2020, p. 11). The Swedish firm Nilsson Energy, together with Denmark's Better Energy, cooperates on the world´s first energy sufficient housing complex, fully-grid, in the Swedish municipality Vårgårda. Here, solar and hydropower will generate 172 departments and rely on long-term hydrogen storage to provide electricity during winter (Nilsson Energy & Better Energy, 2019).

The Nordic Power Market

The Nordic power market is an excellent example of how countries can benefit from closer cooperation. Individually, the Nordic countries have very different, but complementary electricity mixes. Nordic electricity production is two thirds renewable. This is due to the large amount of hydropower in Sweden, and the fact that Denmark has the highest share of wind power in the world. Further market integration in Europe opens up for VRE's to participate on the market with stable sources. Moreover, sharing knowledge and technology managed in a “smart” way, can provide a flexible energy system which benefit all participants (IRENA, 2020, p. 10). Similar to Denmark, Sweden has no targets for interconnection in 2030, but the Energy Agreement has ambitions to increase Swedish network connections with other nations. In 2019 they had already exceeded the EU´s target by interconnectivity level of 27%. Thus, both countries are highly valuing a cross-border energy market – not just to increase decarbonization and energy efficiency, but also for security (The Ministry of Infrastructure, 2020, pp. 7. 36).

The Nordic countries gained substantial benefits from the energy transmission to renewables. However, the trade of electricity on the Nordic electricity market is administered by price variations between price areas. Electricity generation varies with demand through the year and peaks in the winter. Additionally, as low-cost hydropower makes up the largest source in Sweden and the Nordic market, trade flows are heavily determined by precipitation levels, while wind determines the demand for Danish heat (IEA, 2019, p. 96) (IEA, 2017, pp. 74-75). This price fluctuations from hydropower and wind affects the international wholesale price level significantly. Both Sweden and Denmark are members of the North Seas Energy Cooperation (NSEC), where the main goal is to produce common strategies for cost-effective expansion of renewable energy, especially offshore wind power in the North Sea region (The Ministry of Infrastructure, 2020, pp. 13-14).

Already taken steps towards a more CE, Denmark has established a green research strategy working on research efforts in the areas with most potential for development of green technology. Offshore wind is considered as a crucial renewable energy source for the future European energy system. Denmark has developed a great expertise on this area and is planning several measures in order to reduce its consumption and fulfil the energy saving obligation (Danish Ministry of Climate, Energy and Utilities, 2019, p. 6). Denmark has agreed on an offshore wind farm, constructed as an energy island in the North Sea. This public-private owned energy hub functions as a cross-border project (Wind Europe, 2021). The North Sea Wind Power Hub is cost effective, technically feasible and practices long term security of supply, which improves integration of Europe’s power grids and boost electricity production from renewable energy (State of Green, 2012). Based on extensive use of hydropower, nuclear power and biomass, the Swedish power system is almost entirely decarbonized already. This has also strengthened Sweden’s industrial infra-structure and technical cutting-edge skills. In contrast to Denmark, Sweden believes it is most cost-effective to depend on market developments to determine what technologies should be used, instead of setting specific national targets. So, the future Swedish competitiveness and profitability in renewable energy depends on the market (The Ministry of Infrastructure, 2020, p. 20).

Still, there is a way to go before offshore wind accomplishes grid parity. Despite that onshore wind has become very cheap, offshore wind remains slightly more expensive. The main challenge for this industry and the stakeholders is to reduce the entire cost for building and running offshore wind farms in order to reduce the energy price (DWIA, 2014, p. 19). Further development of offshore wind, however, demands several offshore wind clusters with different physical conditions. Constructing hubs can maximize synergies with inland and coastal demand centers, for instance gather wind and hydrogen through electricity transmission to shore. This project provides flexibility to integrate increasing shares of renewable energy by connecting markets across the larger North Sea region and increases interconnections between countries to distribute renewable energy. This CE change in supply and demand patterns, requires a flexible energy system to maintain security of supply. The increased peak generation capacity of renewable energy sources in Europe will, at times, significantly exceed demand. Successful integration of offshore wind and transmission to inland demand centers therefore relies on cross energy coupling to other sectors like hydrogen to build a flexible system (North Sea Wind Power Hub, 2019, p. 2-4).

4.3.2. Recommendations

Smart energy systems

The previous section demonstrated some ways Danish and Swedish companies lead the energy transition through CE solutions, and their potential to deliver the global need for this solution. Achieving 100% renewable energy by 2050 has been proven to be both economically and technically feasible in the Nordic area, provided that effective management is adopted, making full use of smart grids and its technologies. Smart systems are sustainable, secure and cost-efficient energy systems where production of renewable energy, consumption and infrastructure are coordinated through energy services, users and enabling technologies. Smart grids, for instance, harmonize with a CE strategy because they are designed to distribute energy from a range of renewable sources (Leal-Arcas et al., 2017, pp. 299-300).

Implementing sustainable wind power into an integrated energy system is an exciting development which affects every part of the system. Research and innovation are urgent for utilizing the full potential of wind energy and realizing the value of wind in achieving the SDGs. The challenge research and demonstration (R&D) in the wind power industry is no longer reducing costs. Today, R&D must, according to CE, balance sustainable energy production, the cost of generating electricity and the value of the supply (Wind Denmark, 2018, pp. 8-9). Replacing the traditional energy system with smart systems seems to be a well-suited recommendation to Sweden and Denmark's CE strategies. Connecting infrastructure on wind and hydropower one can combine the two into one smart grid and manage the power generated from each. By supplementing one source with the other, energy efficiency will improve and increase the use-value of the sources. For instance, when wind is not accessible, stored hydropower can be used to generate electricity. Combining wind and hydro between Sweden and Denmark offers a great opportunity due to their geographical close location and their strong infrastructure. Along with large-scale deployment of renewable sources in the electricity network, smart grids bear significant potential to limit GHG-emissions. Additionally, it provides secure, cheap, accessible and competitive energy (Leal-Arcas et al., 2017, p. 300). This link between the Swedish area with hydropower along with Danish wind capacity has actually already been investigated in the Nordic Grip Development Plan (2019), where the result made it seem beneficial to increase the capacities between them. That said, such smart grids call for stronger research and cooperation in order to become a reality (Statnett, 2019, pp. 42-43). Whether they reach the deadline in time remains to be seen.

5. Conclusion

This thesis has elaborated on the importance of CE in the energy transition, introducing the energy systems and trends shaping them. The energy system is undergoing a profound transformation, being formed by various dynamic and up-scaling trends, such as decentralization of energy markets, and increased diversity and stakeholders. The main challenge of accelerating the energy transition arises from the need for flexible renewable sources while reducing environmental impact to meet the SDGs. Flexibility demands the development of new technology to transfer electricity surplus into other components of the energy system. By developing hydro storage for utilization, and energy hubs providing efficiency, Sweden and Denmark highly prioritize innovation.

Expressing ambitious long-term goals towards SD, in particular with strong regard to fossil-free electricity generation and CE, the countries' investment- and political will, appears to be able to shape the energy system. Significant progress has been achieved through market coupling, yet a fully integrated internal market is not reached. Denmark's main barrier is the VRE challenge, demanding balancing sources. In contrast to Denmark, Sweden has been careful not to set restrictively excessive short-term goals and sticks with general EU-guidelines. Therefore, Sweden meets stronger economic barriers because Denmark is already leading its field. Further progress is needed to develop a flexible system such as cross-border connections and balancing market, in order to prevent overshoot of SDG 7.

The key message of this thesis is that both countries are well-positioned to lead further acceleration, but their CE strategies are not ubiquitous, meaning their current institutional conditions will not fulfill the SDG 7. Utilization of Danish wind power, along with increased use of Swedish mobile hydropower and energy efficiency measures, offer these countries the possibility to play a stronger European role. Meeting the SDGs, integrated smart systems can actively support increased energy efficacy and energy access. Whether SDG 7 is delivered by 2030, is still unknown. However, there is no doubt that Sweden and Denmark are highly prioritizing the energy transition, the question is whether they will overcome their barriers in time.

6. Bibliography

Arent, D., Arndt, C., Miller, M., Tarp, F, & Zinaman, O. (2017). *The Political Economy of Clean Energy Transitions: UNU-WIDER Studies in Development Economics.* Oxford University Press.

Ashby, A., Callegaro, A. M., Adeyeye, K, & Granados, M. (2019). The Spiral Economy: A Socially Progressive Circular Economy Model?. I Yakovleva, N., Frei, R., & Murthy, S.R (Red.), *Greening of Industry Networks Studies: Sustainable Development Goals and Sustainable Supply Chains in the Post-global Economy,* 67-94. Springer.

Avdiushchenko, A., & Zając, P. (2019). Circular Economy Indicators as a Supporting Tool for European Regional Development Policies. *Sustainability, 19*(11), 1-22, https://doi.org/10.3390/su11113025.

Wilderhill. (2020). *Q4 2020 Quarterly Report: Wilderhill Clean Energy Index* (4). https://wildershares.com/pdf/2020%20Indexes%20Report.pdf

Bartlett, L., & Vavrus, F. (2017). *Rethinking Case Study Research: A Comparative Approach.* New York: Taylor & Francis.

Botezat, E., Dodescu, A., Văduva, S., & Fotea, S. (2018). An Exploration of Circular Economy Practices and Performance among Romanian Producers. *Sustainability, 10* (3191). DOI: 10.3390/su10093191

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal 9*(2), 27-40. DOI: 10.3316/QRJ0902027.

Byrne, J., & Lund, P. D. (2017). Clean energy transition—our urgent challenge: an editorial assay. *Wiley Interdisciplinary Reviews: Energy and Environment, 6*(1). DOI: 10.1002/wene.243.

Creswell, J. W. (2009). *Research Design - Qualitative, Quantitative, and Mixed Methods Approaches* (3. ed.). London: SAGE Publications Ltd.

Cruciani, M. (2016). The energy transition in Sweden. *Études de l'ifri.* https://www.ifri.org/sites/default/files/atoms/files/etude_suede_gd_ok-db2_complet.pdf: Ifri - Center of Energy.

Danish Energy Agency. (03.28.2020). *The Danish Energy Model Agency: Innoative, efficient and sustainable.* Danish Energy Agency. https://ens.dk/en/our-responsibilities/global-cooperation/danish-energy-model

Danish Ministry of Climate, Energy and Utilities. (2019). *Denmark's Integrated National Energy and Climate Plan.* Regulation of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action. https://kefm.dk/media/7095/denmarks-national-energy-and-climate-plan.pdf

Danish Ministry of Climate Energy and Utilities. (2020). *Climate Programme 2020: Denmark's Mid-century, Long-term Low Greenhouse Gas Emmission Development Strategy.* https://unfccc.int/sites/default/files/resource/ClimateProgramme2020-Denmarks-LTS-under-the%20ParisAgreement_December2020_.pdf

Danish Winds Industy Association. (2014). *Profile of the Danish wind industry: Denmark - Wind Energy Hub.*

https://winddenmark.dk/sites/windpower.org/files/media/document/Profile_of_the_Danish_Wind_Industry.pdf

Ellen MacArthur Foundation. (2013). *Towards the Circular Economy: Economic and business rationale for an accelerated transition.* https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

Ellen MacArthur Foundation. (2019b). *Completing the Picture: How the Circular Economy Tackles Climate Change.* Chttps://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy-_Tackles_Climate_Change_V3_26_September.pdf

Ellen MacArthur Foundation. (2015). *Growth within: A circular economy vision for a competetive Europe.* https://www.ellenmacarthurfoundation.org/assets/downloads/circular-economy/Growth-Within-Report.pdf

Ellen Macarthur Fundation. (2019a). *Completing the Picture: How the Circular Economy Tackles Climate Change.* https://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy_Tackles_Climate_Change_V3_26_September.pdf

European Commission. (2020b, March 11). *Circular Economy Action Plan: For a cleaner and more competetive Europe.* DOI: 10.2775/458852.

European Commission. (2021). *Horizon Europe first strategic plan 2021-2024 - Analysis.* Publications Office of the European Union https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_horizon-europe-strategic-plan-2021-24-analysis.pdf.

European Commission. (2020a). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our*. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52020DC0562: EU Publicications.

Fuel cells and hydrogen. (2020). *Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans.* Fuel Cells and Hydrogen Joint Undertaking. https://www.fch.europa.eu/sites/default/files/file_attach/Brochure%20FCH%20Sweden%20%28ID%209474490%29.pdf: Fuel Cells and Hydrogen 2 Joint Undertaking.

Flanders. (2020). *The Energy Sector in Sweden.* https://www.flandersinvestmentandtrade.com/export/sites/trade/files/market_studies/2020-Report%20energy%20sector%20Sweden.pdf

Fortum. (2020). *Sustainability 2020.* https://www.fortum.com/files/fortum-sustainability-2020/download#page=8: Fortum.

Geissdoerfer, M. e. (2017, Elsevier Ltd http://dx.doi.org/10.1016/j.jclepro.2016.12.048). The Circular EconomyeA new sustainability paradigm? *Journal of Cleaner Production 1143*, ss. 757-768.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay og environmental and economic systems. *J Clean Production 114*, 11-32.

Ghisselini, P., Cialini, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, Vol. 114*, 11-32, https://doi.org/10.1016/j.jclepro.2015.09.007.

Goodrick, D. (2014). Comparative Case Studies. *Methodological Briefs: Impact Evaluation 9,*. Florence: UNICEF Office of Research. http://www.dmeforpeace.org/wp-content/uploads/2017/06/Comparative_Case_Studies_ENG.pdf

GWEC. (2021b, March 23). *GWEC releases Globale Wind Turbine Supplier Ranking for 2020.* Global Wind Energy Council. https://gwec.net/gwec-releases-global-wind-turbine-supplier-ranking-for-2020/

GWEC. (2021a). *GWEC - Global Wind Report 2021.* https://gwec.net/wp-content/uploads/2021/03/GWEC-Global-Wind-Report-2021.pdf

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: radical social transformation in a resource-scarce world. *Futures 82*, 15-25. https://doi.org/10.1016/j.futures.2016.05.012.

IEA. (2017). *Energy Policies of IEA Countries: Denmark 2017 Review.* https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=dbd73235-8680-b067-2e12-fd53f9427f0a&forceDialog=0: International Energy Agency.

IEA. (2019). *Energy Policies of IEA Countries: Sweden 2019 review.* https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/Energy_Policies_of_IEA_Countries_Sweden_2019_Review.pdf

IEA. (2020). *Renewables 2020.* https://www.iea.org/reports/renewables-2020

IVA. (2016). *IVA's Electricity Crossroad project: Electricity production in Sweden.* ISBN: 978-91-7082-920-8

Kravchenko, M., McAlonee, T. C., & Pigosso, D. C. A. (2019). Implications of developing a tool for sustainability screening of circular economy initiatives. *Procedia CIRP 80*, Vol. 80, 625-630. https://doi.org/10.1016/j.procir.2019.01.044

Kravchenko, M., Pigosso, D., & McAloone, T. (2020). A Procedure to Support Systematic Selection of Leading Indicators for Sustainability Performance Measurement of Circular Economy Initiatives. *Sustainability 12(3)*, 951. https://doi.org/10.3390/su12030951.

Krehl, A., & Weck, S. (2020). Doing comparative case study research in urban and regional studies: what can be learnt from practice? *European Planning Studies, 28*(9), 1858-1876. DOI: 10.1080/09654313.2019.1699909.

Lanvin, B., Dutta, S., & Wunsch-Vincent, S. (2020). *Global Innovation Index 2020: Who Will Finance Innovation?* (13th ed.). https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020.pdf

Leal-Arcas, R., Lesniewska, F., & Proedrou, F. (2017). Smart grids in the European Union: Assessing energy security, regulation & social and ethical considerations. *COLUMBIA JOURNAL OF EUROPEAN LAW, Vol. 24*, 295-367, https://www.researchgate.net/publication/320798354_Smart_grids_in_the_European_Union_Assessing_energy_security_regulation_social_and_ethical_considerations.

McDowall, W., Geng, Y., Huang, B., Bartekova, E., Bleischwitz, R., Turkeli, S., & Domenech, T. (2017). Circular Economy Policies in China and Europe. *J. Ind. Ecol. 2017, 21*, 651-661. https://doi.org/10.1111/jiec.12597

Mæland, A. (2018). *Energy production: Hydropower has a unique value.* Statkraft. https://www.statkraft.com/newsroom/news-and-stories/archive/2018/energy-production-hydropower-has-a-unique-value/

Ministry of Environment and Food. (2018). *Strategy for Circular Economy: More value and better environment through design, consumption, and recycling.* The Danish Government. ISBN digital: 978-87-93635-91-3

Ministry of Foreig Affairs of Denmark. (2019, November 23). *Green thinking: Pioners in clean energy.* Denmark. https://denmark.dk/innovation-and-design/clean-energy

Ministry of Foreign Affairs of Denmark. (n.d). *JOIN OUR POWERHOUSE FOR WIND POWER TECHNOLOGY*. Invest in Denmark. https://investindk.com/set-up-a-business/cleantech/wind-power

Ministry of the Environment. (2020). *Circular economy - Strategy for the Transition in Sweden.* https://www.government.se/4ad42c/contentassets/d5ab250cf59a47b38feb8239eca1f6ab/circular-economy--strategy-for-the-transition-in-sweden.

Moreau, V., Sahakian, M., Van Griethuysen, P., & Vuille, F. (2017). Coming full circle: why social and institutional dimentions matter for the circular economy. *J Industrial Ecology, 21*(3) , 497-506. https://doi.org/10.1111/jiec.12598

Nilsen, H. R. (2010). The join discourse "reflexive sustainable developement" - From weak towards strong developement. *Ecological Economies, 69(3)*. http://dx.doi.org/10.1016/j.ecolecon.2009.11.011

Nilsen, H. R. (2019). The hierarchy of resource use for a sustainable circular economy. *International Journal of Social Economics, 47*(1), 27-40. http://dx.doi.org/10.1108/IJSE-02-2019-0103

Nilsson Energy & Better Energy. (2019). Swedish housing block powered 100% off-grid by sun and hydrogen. *Fuel Cells Bulletin, Vol. 2019 (2)*, 7-8, https://doi.org/10.1016/S1464-2859(19)30058-6.

Nordic Energy Research . (2020). *Tracking Nordic Energy Progress 2020.* https://www.nordicenergy.org/wordpress/wp-content/uploads/2020/04/Tracking-Nordic-Clean-Energy-Progress-2020.pdf

Nordic Energy System. (2018, September 18). *The Nordics: The Nordic energy system's role in Europe.* Nordic Energy Research. https://www.nordicenergy.org/figure/the-nordic-energy-systems-role-in-europe/

Nordregio. (2017). *White Paper on Nordic Sustainable Cities*. DOI: http://doi.org/10.30689/R2017:3.1403-2503

North Sea Wind Power Hub. (2019). *Modular Hub-and-Spoke concept to faciliate large scale offshore wind.* https://northseawindpowerhub.eu/wp content/uploads/2019/11/NSWPH-Drieluik-Herdruk_v01.pdf

OECDa. (2019). *OECD Environmental Performance Reviews: Denmark 2019, OECD Environmental Performance Reviews.* OECD Environmental Performance Reviews. https://doi.org/10.1787/1eeec492-en

OECD. (2020). *Managing Environmental and Energy Transitions for Regions and Cities.* https://doi.org/10.1787/f0c6621f-en

O'Reilly, B. (2018, April 12). *Ending the depression of planned obsolescence.* Circular Glasgow. https://www.circularglasgow.com/ending-the-depression-of-planned-obsolescence/

Rynning-Tønnessen, C. (2019, April 23). *Sustainability.* Statkraft. https://www.statkraft.com/sustainability/

Scheinberg, A., Nesic, J., Savain, R., Luppi, P., Sinnott, P., Petean, F., & Pop, F. (2018). From collision to collaboration—Integrating informal recyclers and re-use operators in Europe: A review. *Waste Management & Research. 2018, 34(9)*, 820-839. doi.org/10.1177/0734242X16657608

Schroeder, P., Anggraeni, K., & Weber, U. (2018). The Relevance of Circular Economy Practices to the Sustainable Development Goals. *Journal of Industrial Ecology, Vol 23(1)*, 77-95. Doi.org/10.1111/jiec.12732

Smol, M., Marcinek, P., Duda, J., & Szołdrowska, D. (2020). "Importance of Sustainable Mineral Resource Management in Implementing the Circular Economy (CE) Model and the European Green Deal Strategy". *Resources, 9*(5), 55. Doi.org/10.3390/resources9050055.

State of Green. (2018). *Circular Economy: Denmark as a circular economy solution hub.* State of Green. https://stateofgreen.com/en/uploads/2016/11/Circular-Economy.pdf

State of Green. (2021, February 04). *North Sea Energy island will supply green electricity to millions of households*. State of Green. https://stateofgreen.com/en/partners/state-of-green/news/north-sea-energy-island-will-supply-green-electricity-to-millions-of-households/

Statnett. (2019). *Nordic Grip Developement Plan 2019.* https://www.statnett.no/contentassets/61e33bec85804310a0feef41387da2c0/nordic-grid-development-plan-2019-for-web.pdf: Statnett, Fingrid, Energinet & Svenska Kraftät.

T.E.T. Dantas, E.D. de-Souza, I.R. Destro, G. Hammes, C.M.T. Rodriguez, S.R. Soares, (2021). How the combination of Circular Economy and Industry 4.0 can contribute towards achieving the Sustainable Development Goals,. *Sustainable Production and Consumption, Vol. 26*, 213-227, https://doi.org/10.1016/j.spc.2020.10.005.

The Ministry of Infrastructure. (2020). *Sweden's Integrated National Energy and Climate Plan.* https://ec.europa.eu/energy/sites/ener/files/documents/se_final_necp_main_en.pdf

UN. (2015, May 23). *Sustainable Development Goals: Knowledge Platform.* United Nations Sustainable Development Goals. https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals

WEF. (2021, April 10.). *2030Vision.* World Economic Forum. https://www.weforum.org/projects/frontier-2030

Wijkman, A., & Skånberg, K. (2016). *The Circular Economy and Benefits of Society: Jobs and Climate Clear Winners in an Economy Based on Renewable Energy and Resource Effiency.* https://clubofrome.org/wp-content/uploads/2020/03/The-Circular-Economy-and-Benefits-for-Society.pdf: The Club of Rome.

Wind Europe. (2021, February 18.). *Denmark to build energy island: cross-border "hybrid" offshore wind farms are on their way.* Wind Europe. https://windeurope.org/newsroom/news/denmark-to-build-energy-island-cross-border-hybrid-offshore-wind-farms-are-on-their-way/

NTNU
Norwegian University of
Science and Technology