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Allan Dahl Andersen, Markus Bugge, Marco Capasso, Suyash Jolly,
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NIFU

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Preface

This working paper is an outcome of the research project "Where does the green economy grow? The Geography of Nordic Sustainability Transitions (GONST)", funded by the Nordic Green Growth Research and Innovation Programme (application number 83130). The project started in 2017 is to be finalised in 2020.

The working paper has been edited by Marc Capasso and Antje Klitkou and is based on a collection of eight case studies carried out in Denmark, Finland, Norway and Sweden, for each country two cases.

The authors of the case studies are as following: Suyash Jolly (Lund University) authored the case studies on Scania, Sweden, Värmland, Sweden, North Jutland, Denmark and Southern Denmark. Markku Sotarauta (Tampere University) and Nina Suvinen (Tampere University) wrote the two Finish case studies on Tampere and Central Finland. The case study on Hordaland, Norway was written by Allan Dahl Andersen (NIFU) and Markus Bugge (NIFU). The case study on Trøndelag, Norway was written by Marco Capasso (NIFU), Antje Klitkou (NIFU) and Markus Steen (Sintef).

Oslo, June 2019

Espen Solberg
Head of Research

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Content

Summary

This working paper summarises the results of eight comparative case studies on green growth in four Nordic countries: Northern Jutland and Southern Denmark in Denmark, Tampere and Central Finland for Finland, Hordaland and Trøndelag for Norway, and Scania and Värmland for Sweden.

The eight case studies give some background information and explain the industrial specialisation, natural endowments and other relevant information about the regions before they discuss barriers and drivers for regional growth, analyse the main actors and networks and the main processes of green growth in the respective region, and finalise with conclusions.

The focus of the eight regional case studies is different due to the different developments in the selected regions. We have several case studies which are dealing to some extent with developments in the bioeconomy, as in Scania, Värmland, Trøndelag and in Central Finland, while the case studies on Hordaland, Northern Jutland and Southern Denmark are more directed towards greening the maritime industry and offshore wind. The case study on Tampere is quite different with its focus on clean technologies.

Main sources for the cases were interviews and document analysis. The case studies have been discussed in the project group at different stages to facilitate comparative perspectives.

In the following here short summaries of the case studies:

The case study on *North Jutland* focuses on the greening of the maritime industry in this Danish region which evolved from the existing shipbuilding industry in the region. The case study describes the regional path creation processes for greening the maritime sector by emphasizing the role of intermediary organizations in the region but then also highlights the complex interplay between multiple actors at the local, regional, national, EU level and global level which often slows down greening of the maritime sector.

The case study on *Southern Denmark* addresses the development of the emerging offshore wind energy sector in Esbjerg in Southern Denmark. In this case study, the focus is mostly on explaining the emergence of the off-shore wind energy in-

dustry by discussing related linkages and interplay with the on-shore wind industry and the off-shore oil and gas industry. The report also emphasizes the role of key infrastructure resources such as the port of Esbjerg in facilitating the development of the offshore wind energy industry and the challenges involved in developing the industry further.

The case study of *Central Finland* has a focus on the bioeconomy. For over a century, Central Finland has been a forestry and forest industry region. The green economy (revolving around bioenergy, forestry and forest industry) has been emphasized in the regional strategies at least from the mid 2000's onwards. In Central Finland, the main development is revolving around the new bioproduct mill of Metsä Group, which is a 1.2 billion euro investment with an annual pulp production capacity of 1.3 million tons. The mill produces not only high-quality softwood and hardwood pulp but also a range of other bioproducts (tall oil, turpentine, bioelectricity, product gas and sulphuric acid). The institutional leader, Metsä Group, is building the first ring of the ecosystem around its bioproduct mill - its products as well as multiple material flows, including side streams and effluents the manufacturing process produces. Some of the first ring partners are converting side streams of the pulp production into bio products that either create additional value to the local community (district heat) or are new businesses in their own right (bioenergy). The local development actors are actively involved in constructing a second ecosystem ring. They work to mobilise companies from different industries like manufacturers related to bioeconomy, knowledge intensive services, logistics, maintenance services, housing, and so forth, and they also aim to induce scientific research to become members of the ecosystem and potentially also locate in the region. All in all, the bioproduct mill is seen as a platform for other organisations to experiment with and produce their own products.

The case study on *Tampere region* deals with cleantech. Tampere is the birthplace of the Finnish heavy industry and is one of the traditional industrial regions in Finland. It is the home of the machinery and automation industry, ICT and health technology industries. The region and the city have adopted several green path development-related concepts to frame local and regional development. These include the concepts of circular economy, cleantech and bioeconomy. In Tampere, both the City Government and the Regional Council aim to construct policy platforms to mobilise new kinds of ecosystems, and thus find novel ways to identify the policy contents as well as to organise interaction and communication between various actors. Among the main platforms are Kolmenkulma eco-industrial park and new residential area Hiedanranta. Kolmenkulma is a land-use project, in which a district is planned to become a home for companies operating in various fields of cleantech. The ambition is to maximise interaction between individual businesses for increased material and energy efficiency (to construct conditions

for industrial symbiosis) and development of eco-friendly concepts by sharing energy resources and services. Hiedanranta is planned to serve "as a development platform for experiments and projects that promote smart technology, sustainability and circular economy solutions".

The case study on *Trøndelag* addresses two main sectors of the evolving bioeconomy in the county: the aquaculture sector and the forestry sector, and also connected industries to the respective bioeconomy sectors. For aquaculture this is mainly the supplier industry producing equipment, ships/vessels and sustainable energy solutions. For the forestry sector this includes all the industries which are based on value creation from forest resources. To capture the circular bioeconomy, we also look into the interplay between the two sectors by addressing value creation from residues.

The case study on *Scania* analyses on the development of the biogas industry in this Swedish region. The case study highlights the reasons for the successful development of biogas in region Scania by showcasing the role of strong alignment with the waste management, agricultural and food sector and public transportation sectors in the region as well as strong system building activities by the regional stakeholders and strong political support by the regional government. Furthermore, the case study also highlights the gradual slow-down in the development of biogas in the region by emphasizing the role of key factors such as lack of diversification towards alternative markets by the regional biogas producers. The regional industry faced competition with the emergence of electric vehicles and import of cheap and double subsidized biogas from Denmark making it difficult for regional biogas producers to compete at the market rates.

The case study on *Värmland* addresses the development of bioeconomy in this Swedish region. The report presents the characteristics of the region and the framework for developing bioeconomy in region Värmland. The case study focusses on the role of broader set of actors and their different strategies for regional path development. Furthermore, this case study emphasizes the role of fringe actors such as civil society which advocate for alternative models of regional industrial path development.The report provides an overview of the key processes involved in developing bioeconomy in the region and the key barriers which hinder achieving the bioeconomy vision in the region.

The case study on *Hordaland* focuses on greening of the maritime industry in Western Norway in general and on electrification of ferries in the Hordaland region in particular. Although electrification of ferries reached a milestone with the commissioning of the first electric ferry in 2011 (MF Ampere) this should be understood in relation to the long-term development of alternative energy sources such as LNG from the 1990s. The maritime industry is a large industry in Norway

and is one of Norway's oldest industries. It is also one of the few Norwegian industries that are large on an international scale. The maritime industry should also be seen in relation to the strong tradition of fisheries and the oil and gas sector, which in sum constitutes a cluster of related maritime industrial activities that have emerged from Norway's comparative advantage given the vast coastline, ocean space and oil and gas reserves. The industry employs around 110,000 people and creates value for around NOK 175 billion annually. The public sector has taken a lead role in decarbonizing the industry with particular attention, so far, to electrification of short-distance passenger vessels. Innovative public procurement has been a vital policy instrument to the progress seen so far. The case can be interpreted as being primarily about greening of an existing industry, but it also has elements of new actors entering the existing industry; particularly in electric systems and equipment.

1 Introduction

This working paper summarises the results of eight comparative case studies on green growth in four Nordic countries: Northern Jutland and Southern Denmark in Denmark, Tampere and Central Finland for Finland, Hordaland and Trøndelag for Norway, and Scania and Värmland for Sweden (see Figure 1).

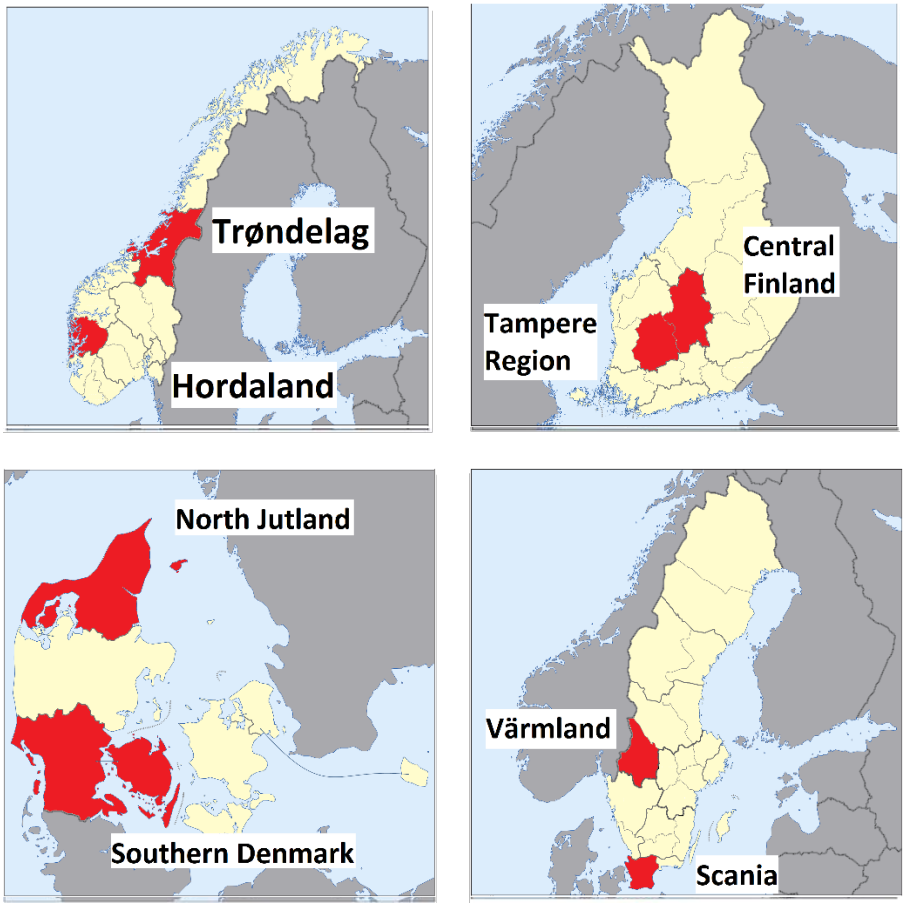

Figure 1: Location of the eight case studies

The selection of the case study regions has been the result of a longer process. While for each country one region was selected as central for green growth already

in the proposal to the programme committee: Scania, Northern Jutland, Tampere region and Trøndelag), the remaining four regions have been selected after considering quantitative research results of the GONST-project about green skills and green technologies.

To allow comparisons the eight case studies are structured in the same way: they give some background information and explain the industrial specialisation, natural endowments and other relevant information about the regions before they discuss barriers and drivers for regional growth, analyse the main actors and networks and the main processes of green growth in the respective region, and finalise with conclusions.

For each case study ca. 15 interviews and document analysis have been carried out. Existing statistics have been used as well. The case studies have been discussed in the project group at different stages to facilitate comparative perspectives.

The focus of the eight regional case studies is different due to the different developments in the selected regions. We have several case studies which are dealing to some extent with developments in the bioeconomy, as in Scania, Värmland, Trøndelag and in Central Finland, while the case studies on Hordaland, Northern Jutland and Southern Denmark are more directed towards ship building and offshore wind. The case study on Tampere is quite different with its focus on clean technologies.

The case studies will be used in different research papers focussing on different aspects of green growth. Here we just want to offer a short working paper to present the main findings in each of the case studies.

2 North Jutland: Green maritime development

Summary

This case study focuses on the greening of the maritime industry in North Jutland which evolved from the existing shipbuilding industry in the region. The case study describes the regional path creation processes for greening the maritime sector by emphasizing the role of intermediary organizations in the region but then also highlights the complex interplay between multiple actors at the local, regional, national, EU level and global level which often slows down greening of the maritime sector.

2.1 Background information

2.1.1 Geographical location

The North Jutland Region with 11 municipalities is located between Thisted in the West to Læsø in the East, and from Hobro in the South to Skagen in the North with the North Sea as its natural border. Aalborg city has played an important role in terms of being the centre of business development in the region with industrial activity in the region concentrated in Aalborg (Rushforth et al, 2006). The figure below shows the map of the region.

Figure 2: Map of region North Jutland (Source: KL Tema, 2016)

Furthermore, the region has had a well-functioning shipbuilding activity which gradually transformed into a hub for maritime equipment manufacturing and service provision. The region has a high concentration of maritime firms and formal maritime networks focussing on providing supply services from the older focus on shipbuilding activities in the region. The region also has a high concentration of knowledge organisations and educational institutions engaged in the development of new competencies and skills the workforce for the maritime industry (Gammelgaard et al, 2013; Ashiem et al, 2014).

2.1.2 Industrial specialization and path dependencies

Denmark has emerged as one of leading global nations for a vibrant maritime industry with Danish shipping firms such as A.P. Møller-Mærsk Group, DFDS, J. Lauritzen, Svitzer and DS Norden firms in leading positions in the global shipping. The Danish shipping industry has maintained its competitive edge over the years by building upon its highly specialized maritime know-how developed as a result of a historical tradition of maritime operations in Denmark and continuously investing in technologically advanced solutions and employing highly skilled workforce (Sornn-Friese & Hansen, 2012).

The region North Jutland is an old industrial region with traditional industry sectors such as shipbuilding, cement, engineering, food processing, textiles, electronics, wireless communication, and ICT. During the 1980s and 1990's the traditional

shipbuilding activities in the region gradually shifted from closure of B&W Shipyard and Aalborg Shipyard to development of a maritime equipment manufacturing and service sector and creation of some spinoff firms. These spinoffs were instrumental in creating several new jobs for the former employees of the shipbuilding industry (Olesen, 2013).

2.1.3 Regional green skills

The North Jutland region is average in terms of share of share and number of employees with green skills based on the analysis in the WP2 report. The region has around 0.59 % workforce working in the green sector and even 0.12 % of employees working in green occupations based on their educational background. The region also has low levels of green innovation and R&D when compared to other Danish regions.

2.1.4 Regional green technologies

The GONST WP3 report focuses on patenting activity at the NUTS2 level, but the North Jutland region is a NUTS3 level region (North Jutland, Code: DK050). The leading regions in Denmark concerning patenting activity include regions such as Central Denmark region, Capital region, and Southern Denmark. The region North Jutland is less active in green patenting activities than these regions but specializes in few activities such as technologies related to buildings, e.g., housing, house appliances or related end-user applications and energy efficiency in ICT.

2.1.5 Natural endowments or related information

The North Jutland region is located close to the North Sea, Kattegat and Limfjord thereby providing the region with a good geographical location for maritime industry and as a hub for transport of goods and people. The region is also located in the fringe of Denmark which also serves as an epicentre for connections across the Kattegat and Skagerrak to southern Norway and western Sweden. The different seaports in the region serve as vital infrastructure for supporting the maritime and other industrial activities in the region thereby contributing to regional growth and job creation.

2.1.6 Sources for the case study

The case study report utilizes a qualitative case study approach and is based on 15 semi-structured interviews and archival data sources such as academic articles,

policy reports, industry reports, websites of the different organizations and newspaper articles, etc. The details of the expert interviewees are mentioned in table 1.

Table 1: Details of expert interviews in North Jutland Region

Nr.	Position and designation of the interviewee	Type of organisation
1	Researcher	Regional University
2	Special consultant	Regional government authority
3	Head of the office	Regional government authority
4	Product manager	Regional maritime supplier firm
5	Business consultant and project manager	Regional cluster organisation
6	Director of development	Regional port authority
7	CEO	National maritime development centre
8	Professor	Regional University
9	Associate Professor	Regional University
10	Associate Professor	Regional University
11	Associate Professor	National Business School
12	Senior consultant	National environmental NGO
13	Head of technical affairs	National maritime industry association
14	Associate director	National maritime industry association
15	Head of the division	National maritime authority

The semi-structured interviews were conducted with different maritime stakeholders (e.g., regional government authorities, national maritime authorities, regional intermediaries, maritime equipment manufacturers, port authorities, academic researchers, maritime industry associations including shipowners and ship equipment manufacturers, civil society, etc. The insights from the semi-structured

interviews and the archival data sources were triangulated and summarized to present the main results of the case study.

2.1.7 Important policy documents considered for the case study

International, EU and national policies

Several maritime regulations and initiatives have been implemented at the global and national level by IMO (International Maritime Organization), EU and the Danish national government which have been discussed in different reports (Hermann et al, 2015; State of Green, 2016).

Regional policies

In Denmark, the regional policy has been conducted through EU Structural Fund programmes and initiatives as specialized regional policy has been de-emphasized considering the small size of the country and generally regionally well-balanced conditions. Specific regional policy measures have been targeted in peripheral rural areas and the government at the centre has concentrated on developing conditions for competitiveness and growth across all the regions. Furthermore, in 2007, a major change was introduced with the setting up of Regional Growth Forums for monitoring regional development, mapping new regional growth opportunities and creating opportunities for business development (Rushforth et al, 2006).

An important initiative for the future development of North Jutland includes the Regional Strategy for Growth and Development which set up the course for future development in North Jutland. In 2015, a policy document "The North Denmark of Opportunities – Strategy for Regional Growth and Development 2015–2018" for stimulating regional growth.[1] The regional authorities also introduced the "Blue Northern Jutland" for promoting the development of the maritime cluster and business activities in fishing, oil and gas, wind energy.

In 2019, the regional council in North Jutland, the regional council introduced a new climate action plan (2019–2022) for making North Denmark the greenest region in Denmark with the ambitious plan of reducing Denmark's CO_2 emissions of 40% by 2030. The new climate change plan will also focus on reducing energy consumption, enhancing waste minimization, making transport sustainable and increasing recycling.

[1] https://rn.dk/~/media/Rn_dk/Regional%20Udvikling/REVUS/RegionNordjylland_REVUS_2015_2018_engelsk.ashx

2.2 Barriers and drivers for regional green growth

2.2.1 Main barriers

Slow regulatory developments in the maritime sector: The regulatory landscape at the international, EU and Danish national level for greening the maritime sector has been lagging, fragmented between the different authorities and uncertain. Furthermore, although regulations are proposed for greening the maritime sector, their implementation is quite challenging. Another significant challenge is related to the significant amount of time involved in getting a new regulation passed at the IMO level as it is global organization and requires consensus between different member countries to pass a new regulation. While Denmark is at a leading position concerning greening the maritime sector, other maritime nations are quite slow making it less competitive for Danish shipping firms to adopt costly green technologies while shipping firms in other countries can earn more profits by not adopting costly green technologies. The slow development at the IMO level is problematic as they reduce the incentive for a maritime equipment manufacturer to develop new green products and services as they might not earn revenue on their investments (Hermann, 2015; Lister et al, 2015).

Lack of incentives for greening the maritime operations: Maritime stakeholders such as ship owners and maritime equipment manufacturers often face significant barriers in investing in green maritime technologies due to lack of relevant incentives. Ships registered in Denmark have to comply with more strict regulations than ships registered in Asian nations where maritime regulations are not strict. Companies buying the ship or the owners of the ship are different from the companies operating it. The differences in compliance of the regulations make it difficult for Danish firms to invest in green technologies as firms from other countries can earn more profit by not complying with regulations and Danish firms would lose out on global firms who offer lower prices to customers. Furthermore, due to the uncertainty involved with maritime regulations, it has become difficult to invest in green technologies for a long time and recover back the investments (Lister et al, 2015; Poulsen et al, 2016).

Lack of co-operation between the maritime stakeholders: The maritime industry has faced challenges in greening due to low levels of co-operation between the different stakeholders. Different interests of the regulatory authorities, ship owners, maritime equipment manufacturers and service providers, cargo owners, ship owners, and customers. Since the maritime sector is a multi-jurisdictional sector in nature, it is difficult to strongly penalize ship owners to comply with regulations and install costly green technologies as ship owners might flag out and

register themselves in another country where they are not required to comply with strong regulations. Cargo-owners have lacked knowledge related to environmental impacts of shipping and often reluctant to pay higher for meeting environmental regulations. Maritime equipment manufacturers have been reluctant to invest in developing new green technologies as often ship owners have been reluctant to adopt them thereby making them lose their investments. Furthermore, the increasing number of international regulations and industry self-regulatory efforts at different levels related to different aspects of the maritime sector have also created barriers to greening the maritime sector (Hermann et al, 2015; Poulsen et al, 2016).

2.2.2 Main drivers and enablers

International (IMO), EU and national (Danish) regulations: The regulatory initiatives at the international IMO (International Maritime Organization) level complemented with initiatives at the EU and Danish national level (e.g., State of Green) have provided a blueprint for driving the greening of the maritime sector. However, due to the global nature of the maritime industry with different stakeholders located in different jurisdictions and interests of different countries, driving green regulations in the maritime sector has been challenging. Over the years, different bodies have developed regulations in different maritime areas such as oil spills and garbage handling, energy efficiency, electric ferries, use of LNG, CO2 emissions, SOx, NOx and particulate, ballast water discharge and reduction of damage to critical marine ecosystems, etc.

Industry self-regulation and voluntary initiatives: Another significant driver of greening the maritime sector includes self-regulation, industry-wide partnerships and voluntary initiatives such as clean shipping index by the different maritime stakeholders. Shipping firms are becoming part of voluntary industry greening initiatives and multi-stakeholder initiatives as well as adopting voluntary standards due to increasing demands from customers and cargo owners.

Innovative pilot and demonstration projects and green business models: At the regional level maritime equipment manufacturers and service providers and intermediate organizations such as cluster organizations have actively engaged in developing new green products and services by working in close cooperation with end users and other firms thereby developing new partnerships leading to exchange of new knowledge and sharing of expertise. For example, a lot of novel pilot and demonstration projects have focussed on developing new product service sys-

tems for ballast water systems, development of electrical ferries or retrofitting existing ferries with green technologies, development of sulfur scrubbers for reducing smoke emissions and use of LNG as fuel for vessels.

2.3 Regional green growth

2.3.1 The main actors and networks for green growth in the region

National level actors

The Danish maritime industry is represented by different actors in the value chain including shipowner's maritime equipment manufacturers and suppliers, regulatory authorities, an industry association, government agencies, NGO's, financing agents and other types of service providers. In particular, the Danish shipowners include the largest container shipping company (Maersk), world-leading dry bulk carriers (Norden, JL) and important tanker companies (e.g., Torm, Esvagt, Switzer). The Danish maritime authority under the Ministry of Industry, Business and Financial Affairs have been responsible for maintaining the growth of the maritime sector, safety, survey and registration, and inspections.

The Danish environmental agency has been responsible for enforcing control of emissions from ships. The industry associations, i.e., The Danish Ship Owners Association, has focussed on the meeting the concerns of the ship owners; Danske Maritime on meeting the concerns of the maritime equipment manufacturers and service providers and Danish Harbours. Apart from these organizations, there are industry partnerships such as the Partnership for Cleaner Shipping initiative managed by the Danish Environmental Protection Agency (Danish EPA) for supporting the development of cost-effective technologies for shipowners to comply with international regulations on air quality and the Green Ship of the Future (GSF) initiative. The Green Ship of the Future initiative is a private partnership involving maritime equipment and service providers for finding solutions to air emissions particularly CO_2, NO_x, and SO_x.

Regional actors

The regional authority Region North Jutland, the municipalities and the" Business Region North Denmark" have collaborated to stimulate economic development in the region, initiate new projects and support business development activities in the region.

The region also has the presence of intermediary organizations (Frederikshavn Business Council and Maritime Centre for Operations and Development, MARCOD) which have played a role in developing a common vision between the regional maritime suppliers, support the development of new pilot and demonstration projects, and creating opportunities for business development in the maritime sector in North Jutland.

The regional maritime equipment suppliers and equipment manufacturers (i.e., Alfa Laval, DESMI, MAN Diesel & Turbo, Wärtsilä), have engaged in value addition activities. Along with them, there are regional firms such as Vestergaard Marine Services, Scanel International and Orskov Yard A/S who subcontract other smaller firms to fulfil their assignments and tasks. Many supplier firms in the region have adopted an internationalization strategy to avoid being locked into the region. In recent years, maritime suppliers in Northern Denmark region also have a vast network of service networks initiated by the different harbours and municipalities in the region. The harbour administrators in the region have taken different initiatives to organize local maritime service firms such as Hirtshals Havn (Hjørring Municipality), Hanstholm (Thisted Municipality), Frederikshavn Havn A/S and Skagen Havn (Frederikshavn Municipality). Finally, another important regional actor is The Port of Aalborg (PoA) which is a multifunctional port offering a wide range of activities for the handling of cargo, transportation of bulk equipment, providing logistics support and supporting the activities of the maritime industry in the region (Hermann et al, 2015).

2.3.2 The main processes of green growth in the region – how have they unfold?

The main processes of green growth in the region have been the gradual development of the maritime equipment manufacturing and service networks after the gradual closure of the shipyards in the region due to their bankruptcy. Over the years, the spinoffs from the shipyards have created their competencies and managed to develop a vibrant ecosystem for maritime equipment manufacturing and service provision in the region. The maritime equipment service providers have contributed to developing new pilot and demonstration projects by working with other suppliers in the region for various maritime greening operations (Hermann et al, 2015).

The intermediary organizations, i.e., regional cluster organisations have played an essential role in facilitating business development in the maritime sector in the region, collaborating with the large firms, SME's and different suppliers for developing new pilot and demonstration projects and green business models. The intermediary organizations have supported green maritime activities by developing

new network of actors and involving end users, brokering information in the regional cluster, organizing matchmaking events for different suppliers to collaborate with each other, finding new collaboration partners for new green maritime projects and working together with national maritime authorities to solve the challenges faced by the regional firms (Hermann et al, 2015).

2.3.3 What industry sectors have been involved?

The maritime firms in the region after shifting their focus from the existing shipbuilding sector have had close relationships with the fishing, offshore oil and gas and offshore wind energy. In recent years, there have been several initiatives in collaboration with the electric transport sector, by developing eco-friendly small island ferries or retrofitting larger ferries with green technology as in the Læsø Green Ferry Retrofit. In the Northern Denmark region, the maritime sector has had close linkages with the existing industrial sectors such as the metal and machine industries in the region particularly. Other linkages include robots and automation technology, embedded software and electronics, ICT and sustainable energy (wind, hydrogen, wave, and biofuel). The region also has the presence of other types of regional clusters related to the agricultural and food sector, health and biotechnology, construction, intelligent transport including logistics and tourism and experience economy.

2.4 Conclusions

The maritime sector in Northern Denmark has grown considerably by adding new value-added business activities around maritime equipment manufacturing, and maritime service providers integrated into activities of four main industries, i.e., shipping, fishing, offshore oil and gas, and offshore wind power. Regional stakeholders and the maritime equipment and service suppliers in the region are gradually being involved in reducing barriers to greening the cluster. However, given the transnational nature of the maritime industry regarding environmental regulations set by IMO (International Maritime Organization) and EU for greening the maritime industry through a slow bureaucratic process and low level of co-operation between maritime stakeholders, greening the maritime cluster has been challenging. The greening of the maritime sector has been slow and gradual due to the uncertain nature of global and EU level regulations and different interests of shipping ports, shipowners, cargo owners, and maritime equipment manufacturers and suppliers. Due to the global nature of the maritime industry, it has been diffi-

cult for the region alone to take significant green initiatives except for few innovative demonstrations and test initiatives by the maritime equipment suppliers in the region.

An area of concern has been the presence of multiple local, regional and national actors providing a specialized type of services in similar functional domains to the regional cluster. The presence of multiple numbers of organizations has created ambiguities in terms of organizations doing duplicate work, serving individual interests and not coordinating with each other. The ongoing policy changes in terms of centralization and restructuring of the Danish regional planning and business development responsibilities of the regional development agencies to national level authorities have created uncertainties about future public support for business development in the region. The regional development agencies feel that the maritime suppliers in the region might face challenges in future without support from them as the central agencies at the national level might not understand the regional specificities in detail and address the bottlenecks faced by them.

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3 Southern Denmark: Offshore wind development

Summary

This case study addresses the development of the emerging offshore wind energy sector in Esbjerg in the region Southern Denmark. In this case study, the focus is mostly on explaining the emergence of the off-shore wind energy industry by discussing related linkages and interplay with the on-shore wind industry and the off-shore oil and gas industry. The report also emphasizes the role of key infrastructure resources such as the port of Esbjerg in facilitating the development of the offshore wind energy industry and the challenges involved in developing the industry further.

3.1 Background information

3.1.1 Geographical location

The region of Southern Denmark is located in the southern part of the Jutland peninsula in Denmark and is close to Northern Germany and cover a geographic area ranging from Vejle to Padborg in the south of the region, and from Esbjerg in the west to Nyborg in the east. Southern Denmark is a very dynamic region and has enjoyed a central location in the North Sea and proximity to Germany thereby providing suitable conditions for business activities. Odense, Esbjerg, and Vejle are the main major municipalities in the region with Esbjerg being the hub for offshore activities in Denmark. The figure below shows the map of the region

Esbjerg has always been Denmark's central location for energy and offshore activities since the 1970s, and it used to be a leading hub for fishing activities and export before the development of offshore oil and gas activities. Esbjerg also has natural advantages of being one of the central locations for offshore wind energy activities with proximity to offshore wind turbine manufacturers and international offshore companies due to the presence of Esbjerg port area.

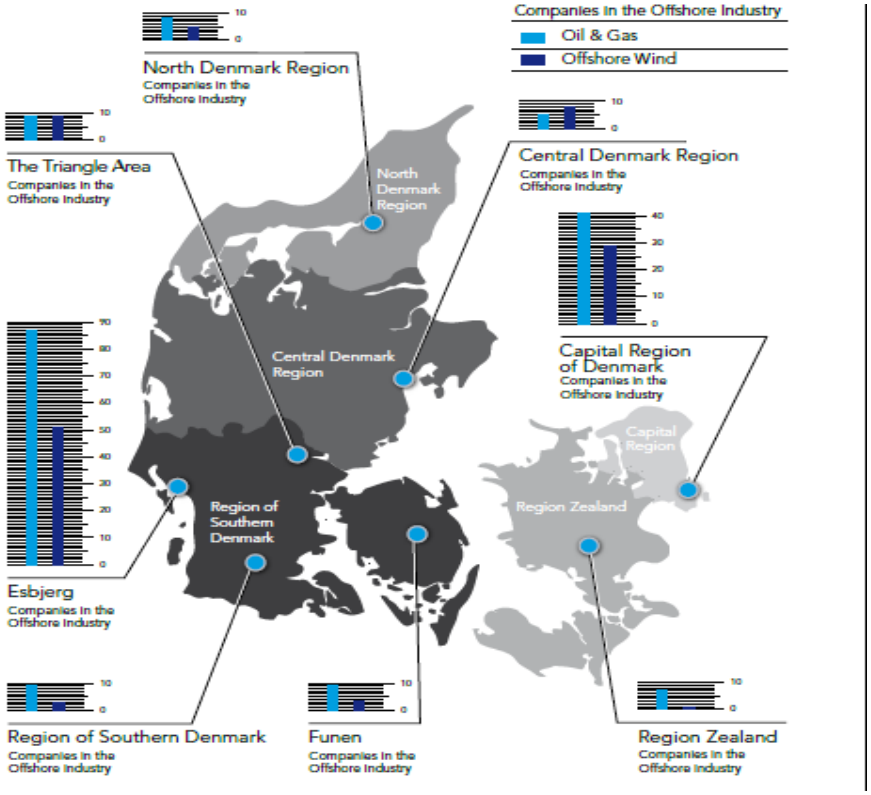

Figure 3: Map of the Southern Denmark region (Source: Esbjerg Kommune)

Esbjerg has always been Denmark's central location for energy and offshore activities since the 1970s, and it used to be a leading hub for fishing activities and export before the development of offshore oil and gas activities. Esbjerg also has natural advantages of being one of the central locations for offshore wind energy activities with proximity to offshore wind turbine manufacturers and international offshore companies due to the presence of Esbjerg port area.

3.1.2 Industrial specialization and path dependencies

The Esbjerg municipality started an important centre for fisheries with oil and gas activities starting in the early 1970s for exploring oil production. Large firms such as Danfeltet headed by Dansk Undergrunds Consortium (DUC), comprised of A.P. Møller, Gulf and Shell became instrumental in initiating the offshore oil and gas sector and Esbjerg becoming vibrant offshore oil and gas centre. The ongoing crises in the existing fishery industry contributed towards further development of the off-shore oil and gas industry as many workers, relevant skills and expertise and infrastructure from the fishery industry was useful for the offshore oil and gas industry as well. The competencies from the offshore oil and gas industry in the

region made it possible for the development of the first large scale offshore wind firm Horns Revs 1. Gradually Esbjerg became a leading centre for the development of the offshore wind energy by supporting the development of several offshore wind energy farms in the North Sea and the largest Danish port for offshore wind energy activities.

3.1.3 Regional green skills

The Southern Denmark region is fairly active in terms of share of share and number of employees with green skills. The region has around 0.77% workforce working in the green sector and even 0.06 % of employees working in green occupations based on their educational background. The region is also front runner along with the North Zealand region in supporting eco-innovations.

3.1.4 Regional green technologies

The GONST WP3 report focuses on patenting activity at the NUTS2 level, but the Southern Denmark region is a NUTS3 level region (Southern Denmark, Code: DK032). The leading regions in Denmark concerning patenting activity include regions such as Central Denmark region, Capital region, and Southern Denmark. The region Southern Denmark is quite active in green patenting activities in key areas such as CCM (Climate change mitigation) technologies such as waste management, energy capture, and storage, energy efficient buildings, transport as well as renewable energy.

3.1.5 Natural endowments or related information

Esbjerg municipality which is located in the region Southern Denmark has several advantages for the offshore wind industry in terms of presence of excellent port facilities, proximity to the major offshore wind turbine markets in the North Sea and closeness to the network of some suppliers and subcontractors with specialized knowledge in the offshore wind industry. The port of Esbjerg has played an important role in becoming the base port for multiple offshore wind farms located in the North Sea. The port was initially a strong fishery port but gradually has modified into an offshore oil and gas port and then gradually transformed into a leading hub for offshore wind energy (Poulsen, 2018). Within the municipality of Esbjerg, there are workers employed in both the oil and gas and the offshore wind industry. The Esbjerg municipality also has the presence of some engineering con-

sultancies, SME's working in the offshore wind and oil and gas sector with a significant presence of higher education institutions serving the offshore oil and gas and the wind energy sector.

3.1.6 Sources for the case study

The empirical study was conducted using 12 semi-structured interviews (see table 1 for an overview of the interviewees) with regional industry experts and archival data such as important policy documents, industry reports, academic articles, industry blogs, and newspaper articles, etc.

Table 2: Details of expert interviews in Southern Denmark Region

Nr.	Professor	Type of organisation
1	Regional development consultant	Regional University
2	Associate Professor	Regional government authority
3	Lecturer and researcher	Regional University
4	Business consultant	Regional University
5	Head of R&D, Wind energy	Regional business development centre
6	Director	Wind energy farm developer
7	Senior Vice President	Regional port authority
8	Head of offshore concepts and solutions	Leading offshore wind energy supplier and provider of turnkey solutions
9	Independent academic	Wind turbine manufacturer
10	CEO	Freelance writer and researcher, retired director of the regional fishery and maritime museum with experience in the oil and gas sector
11	Head of business development	Regional offshore wind and oil and gas energy cluster
12	Professor	Logistics specialist for the offshore wind energy industry

By summarizing insights from the different archival data sources, the case study data was prepared while the interviews were used to get clarification on important processes and mechanisms shaping the regional industry.

3.1.7 Important policy documents considered for the case study

National policies

The Danish government has initiated some policies, grid connection regulations, planning systems and permitting procedures at the national level for promotion of offshore wind energy. The Danish energy agency became the single point of contact for dealing with all types of bureaucratic procedures for offshore wind energy projects.

Some of the initiatives include:

An action plan for offshore wind farms in 1997, recommended focussing on large offshore wind energy development by conducting demonstration programs and identifying suitable areas for future offshore wind energy farms.

Promotion of Renewable Energy Act (Act no. 1392 of 27 December 2008) stimulated the development of offshore wind energy. Denmark also laid out plans to become fossil fuel free by 2050.

In the policy document "A visionary Danish energy policy 2025" from 2007, the Danish Government formulated a vision for the promotion of both onshore and offshore wind energy through careful spatial planning and infrastructure plan for offshore wind energy turbines.

A political decision was also taken by the Danish Parliament to significantly expand offshore wind capacity by 2020 and secure 50 % of electricity consumption by both offshore and onshore wind energy (Danish Energy Agency, 2017).

Regional policies

The Danish regional planning system was modified in 2007 which allowed strengthening of the mandate of regional development to the municipalities and the national government.

The Danish Parliament passed an amendment to the Business Promotion Act (Erhvervsfremmeloven) in 2014, for a new regional strategy for growth and development (Vækstog udviklingsstrategi). The business promotion act intended to

focus on growth and development at the regional level by having better coordination at the local, regional and national level.

The region of Southern Denmark has initiated the Southern Denmark Growth Forum for stimulating economic development in the region and for improving cooperation between the different firms in the regional cluster. The Growth Strategy 2020 focuses on keeping existing jobs in the region and creating new jobs as well through long term investment. The Growth Strategy also focuses on developing the energy sector in the region particularly the offshore oil and gas and wind energy and become an international leader in the development of offshore energy and also has set up 15 % growth in the sustainable energy business and 10 % growth in technology exports within sustainable energy business area.

In 2018 a proposal for centralizing the business promotion activities to the central government also created uncertainties for regional development agencies in Denmark. A new plan was about to be implemented where the regional growth forums would no longer be active. The regional authorities would no longer work on business promotion and the work on business development would be carried out by the central government by giving the responsibility to the National Business Promotion Board.

3.2 Barriers and drivers for regional green growth

3.2.1 Main barriers

Lack of clear political goals and plans: Since offshore wind energy is a more global industry, a lot of developments happening in the European offshore as well as global offshore wind energy market, impacts the development in the Southern Denmark region. The offshore wind energy industry has suffered from wait and watch attitude in terms of future policy developments which will guarantee the development of new offshore wind energy projects to reduce the costs further and decrease the uncertainty for the investors about future investments. The industry requires a clear pipeline of future projects. The port of Esbjerg also requires a clear indication of future projects to maintain investments from wind turbine manufacturers.

Challenges of cost reduction: While the costs for offshore wind energy are gradually reducing, there is still some way to go to reduce the costs further and produce electricity from offshore wind energy farms at competitive market prices by developing more integrated solutions and innovative wind turbine components (Brink et al., 2015).

Shifting of epicentre for offshore wind energy development to other nations and regions: While Denmark was a pioneer in the development of the offshore wind energy and Esbjerg region played an important role in developing a strong base for the industry, the developments are gradually shifting to other areas such as Cuxhaven in Germany and other countries like France, UK, U.S.A, and even Taiwan. The epicentre for offshore wind energy development is shifting to other regions, and nations and Esbjerg region is trying hard to remain competitive and the best region for providing services for offshore wind energy development. The region, as well as Denmark, needs to safeguard its leading position in the offshore wind energy global market and remain competitive in the future (Poulsen, 2018).

3.2.2 Main drivers and enablers

First mover advantages: In 1991, Denmark was the first country to develop offshore wind energy project Vindeby in the North Sea and region Southern Denmark was instrumental in supporting the world's first commercial wind farm Horns Rev 1. Up until 2010, Danish companies were significantly involved in offshore wind farms across the world, and many associated firms with relevant skills and competencies were based in Southern Denmark. Many of the associated competencies related to offshore wind energy are based in Southern Denmark – particularly as regards project planning, operation, maintenance, testing, and demonstration.

The region from the very beginning had first mover advantages in offshore energy and also access to related competencies from the offshore oil and gas industry in the region. The two regional clusters are also connected and embedded within a larger regional innovation system of related suppliers, consultancy firms, service providers, port, educational institutions thereby providing a clear first-mover advantage for the offshore wind industry in the region. The region also benefitted from the presence of existing onshore wind turbine manufacturers in the region and related competencies from the onshore wind turbine industry.

Proximity advantages: The Esbjerg municipality has also benefitted from proximity advantages as a result of presence of onshore wind manufacturing facilities, wind turbine testing facilities, presence of a large number of SME's and large firms serving the offshore wind energy and oil and gas industry, port area and other ports such as Cuxhaven in Germany. All different kinds of competences and services are easily available in the region which has made it easier for suppliers to take part in research and development, testing, contributing to the relevant know-how for the offshore wind industry. Over the years, geographical proximity and close collaboration in the offshore wind industry in the region has convinced many international companies for setting their base in Southern Denmark.

Competition and collaboration: Intense competition between the off-shore wind energy farm developers, wind turbine firms and suppliers is also reducing the costs further down. Intense competition within the industry is leading to the industrialization of the entire value chain and leading to a significant reduction in costs. The off-shore wind industry is also collaborating in all areas except which are proprietary to the firms such as the development of the wind turbine nacelles and the blades. The wind turbine manufacturers like Siemens Gamesa and MHI Vestas are continuously developing more large, efficient and powerful turbines to reduce costs further. The industry is also looking to develop better transmission infrastructure in the North Sea and develop common standards for vessel specifications, foundations, operation and maintenance services and health and safety for cutting down costs further. Across the entire value chain, different offshore wind energy suppliers are continuously working on cutting down the costs further (Brink et al., 2015).

Presence of suitable infrastructure such as Esbjerg port: The port of Esbjerg was increasingly involved in developing offshore wind supply chain by investing in upgradation and adaptation of existing port facilities as well as development of new infrastructure to help ports facilitate faster installation of offshore wind turbines as the components of offshore wind turbines become larger and bigger. The port of Esbjerg also attracted a lot of new firms and SME's in the region and played an important role in accommodating offshore wind energy activities, developing new facilities and expanding the port facility. The port authorities also have facilitated wind turbine manufacturers, wind farm developers, and suppliers and provided them with suitable infrastructure services and jointly working with them to solve problems facing the industry (Port of Esbjerg, 2018).

3.3 Regional green growth

3.3.1 The main actors and networks for green growth in the region

The regional government Region Southern Denmark and the regional Growth Forum has played an important role in regional development, creating opportunities for development of new SME's and firms and business development in the region and supporting the development of offshore wind and offshore oil and gas industry. There are also regional actors such as Esbjerg business development centre directly involved in creating enabling conditions for SME 's and firms in the offshore industry in the region

The two Danish wind turbine manufacturers, Siemens Wind Power, and MHI Vestas Offshore Wind dominate the global market for offshore wind turbines. The

next most powerful actors include the owners of offshore wind farms, such as Orsted and Vattenfall A/S. The region also has important universities such as Aalborg University and University of Southern Denmark collaborating with the regional industry and training the regional workforce. The port of Esbjerg has played a significant role in providing infrastructure services for the offshore wind industry.

Offshore Center Denmark has played an important role in facilitating interaction and linkages between the offshore oil and gas and the offshore wind energy industry. The regional cluster organization has improved interaction between large firms as well as small SME's in the region and lowering barriers to co-operation between firms in the region by conducting networking events and working on common problems faced by the firms (Poulsen, 2018).

The region also has a large number of offshore wind energy specialized suppliers including Bladt industries A/S specializing in the development of offshore substations and foundations; Niels Winther Shipping specializing in port agency services and Peter Madsen Rederi A/S in preparation of seabed preparation for offshore wind firms, pipe and cable works etc. The regional industry is also supported by maritime and logistics suppliers who supply to the maritime, shipping, fishing, offshore oil and gas and wind energy industry. Firms like Esvagt and Bluewater shipping have gradually moved from providing general logistics to specialized logistics for the offshore wind and offshore oil and gas industry. Another firm A2SEA, a project shipping, and a contracting firm focus on wind turbine installations. Most of the logistics firms do not classify themselves as specialized suppliers for offshore wind energy but as general logistics and maritime supplier for multiple industries. The general maritime and logistics suppliers often use their competencies in different segments to serve the offshore wind energy industry.

3.3.2 The main processes of green growth in the region – how have they unfold?

The main process of green growth in the region includes the development of offshore wind energy from two related industries, i.e., the on-shore wind energy in Denmark and offshore oil and gas industry in Esbjerg. The region had fishery, container shipping, and oil and gas industry in the past, the industrial base for the region changed again with the gradual emergence of the off-shore wind energy. Firms in the region working in the off-shore oil and gas sector saw new opportunities in the offshore wind energy and began diversifying their operations and develop a new industry.

The off-shore wind energy industry has grown in the region due to transfer of both tangible and intangible resources between the oil and gas industry and offshore wind industry at the individual level (i.e., people moving from offshore oil

and gas industry to offshore wind industry), firm level (i.e. one firm using knowledge from one industry to the other) and regional cluster level. In some instances, the transfer of resources has been unidirectional, i.e., from offshore oil and gas industry to offshore wind industry and from onshore wind industry to offshore wind industry for key components such as rotors, turbine blades, and nacelles (Ingstrup & Menzel, 2015).

At the same time, the rapid technological changes in the on-shore wind industry in terms of development in key components such as blades, towers, nacelles, gearboxes, control systems, and generators were also useful for the development of offshore wind energy as many components for the two industries are the same. The only substantive difference lies with the foundation structures which are placed on the seafloor. Few onshore wind manufacturers exclusively specialized in manufacturing offshore wind turbine components along with onshore wind components making it a specialized industry. Further, Danish onshore wind turbine manufacturers and specialized suppliers gradually moved to the Southern Denmark region to take advantage of the emerging offshore wind energy sector.

The firms involved in both the off-shore oil and gas and wind energy industry started to connect in common areas such as installation of the substations, foundations, and cables, operation and maintenance services. The firms in the two industries also engaged in knowledge exchange through common industry forums, seminars, matchmaking events, labour mobility programs, and firm-level diversifications to take advantage of new market opportunities in both the industries (Damgaard et al., 2013).

3.3.3 What industry sectors have been involved?

Some of the other industry sectors involved with the offshore wind sector in the region include offshore oil and gas, wave technology and bioenergy. The current transformations in the offshore wind industry are related to existing competencies, relevant know-how and development in the offshore oil and gas industry with significant linkages between them. Also, the region also has some cluster initiatives in welfare technology, energy efficiency cluster, design cluster, offshore cluster centre, and growth forum food initiatives.

3.4 Conclusions

The offshore wind industry in the region developed from the existing offshore oil and gas industry in the region and the on-shore wind industry in Denmark. Both these industries have contributed to the development of the offshore wind indus-

try. As the expert interviews suggest, the role of the Esbjerg port and infrastructure has crucially contributed to the development of the offshore wind industry. Relatedness to existing industries in the region, the presence of relevant know-how and skills, implementation of specific regional policies and program have been considered as essential factors for regional path development. The emergence of the offshore wind industry in the region Southern Denmark benefitted from the symbiotic relationship with the offshore oil and gas industry, developments in the onshore wind industry and the presence of suitable infrastructure conditions provided by the Esbjerg port area.

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4 Bioeconomy in Central Finland

Summary

For over a century, Central Finland has been a forestry and forest industry region. The green economy (revolving around bioenergy, forestry and forest industry) has been emphasized in the regional strategies at least from the mid 2000's onwards. With the new bioproduct mill investment of the Metsä Group, a new bio- and circular economy concentration has started to develop in the Northern part of Central Finland. The new bioproduct mill of Metsä Group is a 1.2 billion Euro investment with an annual pulp production capacity of 1.3 million tons. The mill produces not only high-quality softwood and hardwood pulp but also a range of other bioproducts (tall oil, turpentine, bioelectricity, product gas and sulphuric acid).

The institutional leader, Metsä Group, is building the first ring of the ecosystem around its bioproduct mill - its products as well as multiple material flows, including side streams and effluents the manufacturing process produces. Some of the first ring partners are converting side streams of the pulp production into bio products that either create additional value to the local community (district heat) or are new businesses in their own right (bioenergy). The local development actors are actively involved in constructing a second ecosystem ring. They work to mobilise companies from different industries like manufacturers related to bioeconomy, knowledge intensive services, logistics, maintenance services, and so forth, and they also aim to induce scientific research to become members of the ecosystem and potentially also locate in the region. All in all, the bioproduct mill is seen as a platform for other organisations to experiment with and produce their own products.

4.1 Background information

Central Finland includes City of Jyväskylä and 22 smaller municipalities. According to Statistics of Finland, population of the region was 276.021 in 2017, and in City Region of Jyväskylä it was 184.333. Jyväskylä hosts the University of Jyväskylä ja Jyväskylä University of Applied Sciences as well as several lower level educational

institutions. Jyväskylä likes to label itself as the “Athens of Finland” because of its cultural and sports facilities and its long tradition in education.

4.1.1 Geographical location

As the name of the region suggests, it is centrally located in Finland but is not elemental part of the so-called golden triangle of Finland: Helsinki-Tampere-Turku. It is fairly well connected by rail but does not have an international airport.

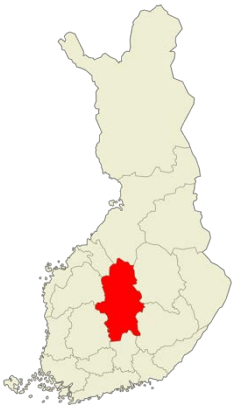

Figure 4: Map of Finland with location of Central Finland region

4.1.2 Industrial specialization and path dependencies

The region hosts traditional forest and machine production industries as well as new technology and bioenergy companies. As the region is one of the traditional Finnish forest regions and as over 80% of its territory is covered by forest, bioeconomy has quite naturally emerged as the core organising concept in policy making. Even though the measurement of bioeconomy has proven difficult, without any question it is one of the economic cores of the region. According to Mikkola’s et al. estimate, the bioeconomy provides roughly 15.000 jobs in the region including production of pulp, paper, cellulose, cardboard, and wood products, as well as food and energy production (Mikkola et al 2016).

The severe economic recession which ravaged Finland in the 1990’s hit Central Finland fairly hard. In the early 1990s, many enterprises went bankrupt or downsized their activities. Job losses represented more than one fifth of the total number of jobs. The region has not yet reached the employment level of the early 1990’s but is fairly average among the Finnish regions.

4.1.3 Regional green skills

Central Finland is fairly average in its shares of green occupation and green education as well as environmental goods and services sector firms.

4.1.4 Regional green technologies

As the GONST WP3 report on regional distribution of green growth patents operates at NUTS2 level and Central Finland is a NUTS3 level region, it is not possible to say anything specific about its patenting activity. However, it does not belong to Helsinki-Uusimaa or Western Finland (Länsi-Suomi) but to North/East Finland, which is not specifically active in patenting.

4.1.5 Natural endowments or related information

85 % of Central Finland is covered by forest which is 10 %-units more than Finnish average. All the natural endowments are related to forest and field biomass.

4.1.6 Sources for the case study

The empirical study began with a literature review of relevant material describing and analysing the overall development of the case region or some specific features of it. This included written material from the Internet, relevant journals, related newspaper articles, and most notably respective policy documents. Drawing on thus collected secondary data, the overall understanding of the main features of the case was constructed as well as the main policy approaches were identified. Additionally, the analysis of the Cleantech Finland member firms provided additional pieces of information about growth and export oriented Finnish firms building, one way or another, their business on 'green products and/or services'. Eleven of the 201 Cleantech Finland member firms are located in Central Finland.

The main aim of the first round of data collection was to describe the cases and their institutional set-up for the second round of data collection. The first phase identified a generic path development patterns and the main policy instruments and other actions for interviews. Next, ten case related and five national level thematic (semi-structured) interviews were carried out. The interviewees represented following organisations: local and regional authorities, firms, a research institution, the university of applied sciences, a vocational school, the Ministry of Employment and Economy and national funding bodies.

4.1.7 Important policy documents considered for the case study

National policies

- In its 'Government Programme' (Finland, a land of solutions, 2018), Prime Minister Juha Sipilä's Government (2015–2019) proclaimed that it will, among other ambitions, bring the Finnish economy onto a path of sustainable growth. Several policy documents precede this proclamation, on the one hand, and specify it on the other hand.
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Regional policies

- Central Finland's Regional Plan 2030 "Central-Finland of co-operation, entrepreneurship, and expertise" (draft; A proposal to regional assembly by the regional board in 19.05.2010)
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4.2 Barriers and drivers for regional green growth

4.2.1 Main barriers

The analysis of policy documents did not reveal many general level barriers or barriers particularly related to green business. Instead, the interviews revealed certain barriers for the green economy.

First, **the political environment** especially at the EU-level but partly also at the national level as well as the international circumstances were mentioned as sources of significant barriers. For example, slow and unstable political decision-making followed by delayed changes in legislation do not provide businesses with clear and stable long-term prospects. This in turn reduces the motivation of companies to make new investments. In addition, policy making, and political decision making are unbalanced, as multiple environmental decisions are continuously made and these, naturally, have to be taken into account in businesses. Moreover, environmental and industrial policies may produce conflicting regulation. Although the criticism in the interviews was mainly targeted at EU level policy, recent national level policies were also criticised; for example, unstable energy policy was raised as a case in point. It was argued that each government introduces new subsidies for bioenergy and energy taxes, which makes the regulative cycle too fast for firms to follow. Finally, the recent trends in international politics both in the east and the west, and the unknown future directions related to them, were seen to produce unstable operational environment and thus clouding future prospects for the export driven forest bioeconomy.

Raw material supply for industrial needs was brought up as a potential barrier. It consists of, at least, the following: (a) 2/3 of all forests are privately owned and multiple wood suppliers may fragment the markets (in spite of the supplier co-operatives), and (b) increasingly wet weather conditions can cause forest soil and lower level roads to soften so much that they cannot withstand heavy forest machines and trucks as well as earlier was the case.

The potential **shortage of labour supply** was also mentioned in the interviews, there already are increasing difficulties in recruiting students and professionals to forestry related occupations and logistical tasks.

Also, the **lack of funding for pilot and demonstration projects** and commercialisation of inventions were mentioned as bottlenecks. Importantly, unpredictable and fluctuating political decision making was underlined in most of the interviews.

4.2.2 Main drivers and enablers

Market demand for forest bioeconomy products is one of the main drivers. While there is an increasing global demand for the traditional products like pulp and packaging materials, there simultaneously is more and more demand for sustainable products as well as increasing interest towards new wood material solutions. Demand for, and deployment of, renewable energy in the region was also highlighted as an enabler.

Raw material and expertise. Ample wood resources accompanied with the use of side-flows clearly is a driver. Relatedly, long-term evolution of expertise both in the business and the research/education sectors in forest related fields as well as in the energy issues was seen as a strength and driving force.

New technologies for new business solutions are actively searched for and developed at the regional and national research organisations (local buzz in the field). New technology is also actively searched for from international research organisations (global pipelines are constructed). All these sources of knowledge are also providing new technologies for commercial use, either as independent products and/or services or in connection with forest bioeconomy products and services.

Funding. There has been a strong and long-term public funding for bioeconomy in Finland. In the region, the public funding sources include the EU structural funds and national funding sources. Also the region and municipalities have been engaged in funding bioeconomy related projects. Significant sums of special EU and national finance have been directed to our special case - the bioproduct mill in the Northern part of Central Finland.

New ecosystem thinking and related policies and practices promote green growth in a variety of sectors while connecting these to development of sustainable production systems and products and use of bioenergy/biofuels. In this way, many independent activities are connected to systems of material circulation and sustainable logistical arrangements.

Despite the fact that **policy-making** was criticised for being one of the main barriers, there also are important examples of smooth national, regional and local policy initiatives and tools enabling the forest bioeconomy to develop well in Central Finland. These include (a) various subsidies and other forms of funding for firms, building infrastructure and bioeconomy related education/training, (b) quick public permission processes related to the forest and energy industry, (c) special permissions for particular materials usage, (d) improvements of infrastructure; such as roads, railway and harbours (still a lot of criticism here too), (e) political decisions directing both the consumer demand and public procurement to support sustainability. All in all, the strong policy will at all levels of governance

(EU, national, regional, local) has been enabling both the Finland's and Central Finland's efforts to boost bioeconomy; the focus is especially on the growth of the forest bioeconomy and related energy solutions.

4.3 Regional green growth

4.3.1 The main actors and networks for green growth in the region

The main actors include two of the three main Finnish forestry companies (Metsä Group and UPM Kymmene), three key Finnish machine and equipment manufacturers (all operating globally), VTT Technical Research Centre of Finland, Jyväskylä University and Jyväskylä University of Applied Sciences, ministries especially the Ministry of Economic Affairs and Employment, Ministry of Agriculture and Forestry of Finland, European Union, local authorities/policy-makers and regional development agencies.

In a typical Finnish fashion, all sorts of networks among these players are constructed ranging from strategic to focused ones. In Central Finland, as elsewhere in Finland too, the concepts of ecosystem and platform are used as the key organising policy concepts. Thus, the case is about an innovation ecosystem related to forest bioeconomy and the business ecosystem attached to it as well as a variety of service providers.

4.3.2 The main processes of green growth in the region – how have they unfold?

Policy push is manifested in repeated regional strategy processes (environmental strategies and general regional development plans), which provide regional development agencies and politicians, firms and research/education representatives, and inhabitants of the region with a platform to discuss the regional vision, ambitions and strategic intents, which in turn have been promoted by a series of development projects. The regional ambition to promote sustainable urban structures, sustainable every-day living, and also green regional economy has been gradually emerging in various regional development plans (strategies), programmes and implementation schedules since mid-1990's. In the mid 00's, the bioenergy production and forestry, forest industry, machine manufacturing were the core concepts, but since 2010, the policy discourse has been rephrased, and bioenergy in variety of its forms as well as the renewal of the basic/export industries (forest and technology industries) have been highlighted. Public funding directed to projects pro-

moting environmentally sustainable developments in the three focal points - forestry, forest industry and bioenergy - in variety of forms have been clearly emphasized in the regional strategies at least since 2005.

Research and education are among the drivers, as there are, and have been for a while, a strong and continuously evolving expertise in forestry and forest industry and also in issues related to energy, which are elemental parts of the bioeconomy development in the region (see above the drivers). In addition, both the vocational and higher education institutions provide skilled workforce for needs of the bioeconomy and its support industries.

Well established bio-business development both in the energy and forest industries. The main processes related to the forest bioeconomy - the search for new directions in the forest industry - have clearly been led by the forest companies. For example, the nationally prominent investment of Metsä Group in its next-generation bioproduct mill in the northern part of Central Finland began around 2012. The investment was not decided, or the project launched in co-operation with the local or regional actors but was carried out in collaboration with partners (consultants, industrial and production planners, machine and equipment suppliers and other b-to-b partners) operating at national and/or global levels. Additionally, funding from EU and various national sources were connected with the corporate investment in the construction phase. The regional and local authorities were involved in the process gradually since 2014, as they are the ones providing various planning and construction permits. Local actors have also facilitated specific needs that emerged during the construction phase. The mill was constructed in 2015-2017 and it was opened in 2017. It is producing not only high-quality softwood and hardwood pulp but also a range of other bioproducts (tall oil, turpentine, bioelectricity, product gas and sulphuric acid). In addition, many partners convert pulp production side streams into bioproducts that also create additional value to a local community (heat) and in a form of new businesses.

Similarly, as in the case of Tampere region, also Central Finland is relying on **platform and ecosystem thinking.** If in Tampere, the lead is taken by the City of Tampere, in Northern Central Finland, the lead was first taken by an individual corporation, Metsä Group. The bioproduct mill is seen as a platform for other organisations to experiment with and produce their own products, and thus an innovation and business ecosystems have been and are to be constructed on it. After the opening of the mill, local actors, representatives of the mill, consultants and the ministries have collaborated **to enlarge the current industrial business ecosystem to boost the growth of a wider concentration for bioeconomy.** In this phase, the lead is taken by the local policy-makers, yet in close collaboration with business and research/education actors currently operating in the area. The gen-

eration of a well-formulated plan and operational model for the larger system enable local policy-makers to co-ordinate the construction of the bio-concentration and mobilise actors to join the ecosystem. At the core of this phase is mobilisation of companies from different industries like manufacturers related to bio-economy, knowledge intensive services, logistics, maintenance services, accommodation etc. There also is a plan that scientific research could locate themselves in the region and become members of the ecosystem or provide support services for ecosystem members. There is also an aim to form a special business park to support the industrial business ecosystem in general and in addition to generation of innovations and new business.

4.3.3 What industry sectors have been involved?

Bioeconomy is the main organising concept in Central Finland. It includes a variety of sectors including forestry and forest industry, energy, agriculture, waste and water management, research and education, and touches, one way or another, also sectors such as machinery, logistics and tourism. In many policy and business discourses, it is an overarching and ubiquitous concept with slightly differing meanings depending on the specific context.

4.4 Conclusions

The forest bioeconomy draws on the region's long industrial tradition, and hence it is strongly rooted in the region's (industrial) culture. However, with new forest bioeconomy and ecosystem approaches, the forest industry (sawmilling, pulp, paper and board) are not only connected with their traditions (forestry, wood construction, chemical industry, paper and pulp, energy and logistics) but more and more also with other industries such as, for example, textile and fertiliser industries. For these reasons, the concept of ecosystem has emerged central both in policy making and business. Perhaps, all this signifies the transition - begun some time ago - from a single company, industry and cluster emphasis to something different – at this stage described with the concept of ecosystem.

4.5 References

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5 Cleantech in Tampere region

Summary

Tampere is the birthplace of the Finnish heavy industry and is one of the traditional industrial regions in Finland. It is the home of the machinery and automation industry, ICT and health technology industries. The region and the city have adopted several green path development-related concepts to frame local and regional development. These include the concepts of circular economy, cleantech and bioeconomy. In this report, we focus on cleantech, but acknowledge the difficulties in measuring economies according to these thematic concepts as well as the problems of their often-fuzzy use in policy circles. In Tampere, both the City Government and the Regional Council aim to construct policy platforms to mobilise new kinds of ecosystems, and thus find novel ways to identify the policy contents as well as to organise interaction and communication between various actors. Among the main platforms are Kolmenkulma eco-industrial park and new residential area Hiedanranta. Kolmenkulma is a land-use project, in which a district is planned to become a home for companies operating in various fields of cleantech. The ambition is to maximise interaction between individual businesses for increased material and energy efficiency (to construct conditions for industrial symbiosis) and development of eco-friendly concepts by sharing energy resources and services. Hiedanranta is planned to serve "as a development platform for experiments and projects that promote smart technology, sustainability and circular economy solutions".

5.1 Background information

Tampere Region (Pirkanmaa) includes City of Tampere and 21 smaller municipalities. The region had a population of 512.081 in 2017 and City Region of Tampere had 402.467. Tampere is the biggest inland city in the Nordic countries and the second largest city region in Finland. It is generally seen as the birthplace of the Finnish heavy industry.

Tampere Region is a traditional Finnish industrial region that has, since late 1800th century, been developing favourably especially drawing upon forest, engineering and metal industries, and since the 1990's also upon ICT, medical technologies and media.

City of Tampere has reinvented itself economically during the past three decades. It was one of the first industrialized cities in the world but has restructured significantly in recent decades based upon intensive national-local innovation systems. In the process, the service and knowledge sectors have become more important, but manufacturing remains strong partly due its heavy reliance on automation, new technologies and advanced engineering capabilities. During the last 20 years, Tampere city region has been among the fastest growing sub-regions in Finland. Smaller municipalities in the outer rim of Tampere region have been losing population.

5.1.1 Geographical location

Tampere Region is centrally located in Southern Finland and is an elemental part of the so-called golden triangle of Finland: Helsinki-Tampere-Turku. It is very well connected by rail and it has a small international airport but a fairly short distance by land to the Helsinki-Vantaa airport.

Figure 5: Map of the Finland with location of Tampere region

5.1.2 Industrial specialization and path dependencies

As said in the first section, Tampere is the birthplace of the Finnish heavy industry and is one of the traditional industrial regions in Finland. It is most notably the home of the machinery and automation industry, ICT and health technology industries. In many ways, the city of Tampere is dominant in the region, even though

there are several smaller traditional forest industry towns in the region (especially Mänttä-Vilppula and Valkeakoski).

The severe economic recession which ravaged Finland in the early 1990's hit also Tampere region hard and the unemployment rate was appr 25 % at that time. In the early 1990s, many enterprises went bankrupt or downsized their activities. The region, especially the city-region, recovered well and become a major hub of Nokia-led ICT industry with Helsinki Metropolitan Area, Oulu and Salo. In 2010's, the city and region faced again hard times due to decreased exports to Russia and reorganisation of Nokia's mobile phone division, and eventual closure of all Microsoft's (formerly Nokia's) R&D units in Tampere. After all the difficulties, Tampere Region has proven to be more resilient than most of the Finnish regions and has been developing well.

Martin's (2010) canonical path-dependence model of spatial industrial evolution is here used to describe the industrial specialization and path dependencies in Tampere. Tampere's industrial paths consist of three main developments (with several more specific sub-trajectories not discussed here). First, the earlier dominant textile industry faced difficulties and declined in the 1970s, and Tampere faced a 'life-cycle type trajectory', per Martin's model (2010, 10). Second, Tampere went through 'rejuvenation' (Martin 2010; Kostiainen & Sotarauta, 2003), as the engineering industry faced severe difficulties in the early 1990s but was able to renew itself and maintain its position by infusing new technology and services into its product portfolio. The third of the main economic trajectories was the rapid growth of the ICT cluster in the 1990s. Since the 2000s and the 2010s, Tampere has faced Nokia's and Microsoft's reorganisation and struggled to renew itself. For its part, it experienced an 'ongoing change and mutation' (Martin 2010). Parkinson et al. (2012) conclude that the continuous reinvention of Tampere has been influenced by proactive local development policies, business sector activities and forward-looking, relatively young universities (Benneworth 2007).

5.1.3 Regional green skills

In absolute terms, the majority of people working in 'green occupations' are located in the core regions of Finland; Uusimaa, Tampere Region, Southwest Finland and Northern Ostrobothnia. In relative terms, Tampere Region is among the regions having slightly more people working in green occupations than the other regions. Tampere Region also has, in absolute terms, more employees with green education than most of the Finnish regions, and in relative terms, it has the highest number of people with green education.

In absolute terms, EGSS firms employ most in Uusimaa and Tampere regions, which is not surprising, as these are the two largest regions in Finland. When viewing the relative share of EGGS firms, Tampere Region is not among the top regions. The majority of Finnish EGGS firms are fairly small in size, but among the exceptions is the Nokian Tyres Plc, a major international tyre company headquartered in Nokia. It belongs to 'manufacturing of rubber tyres and tubes; rethreading and rebuilding of rubber tyres' category.

For our own amusement and for the entertainment of the GONST WP2 investigators, we constructed a ranking list of the green regions in Finland using the relative measures as well as the position in the Cleantech Finland network. Tampere region is topping the list. Hence its selection as a case region receives support from numbers.

5.1.4 Regional green technologies

As the GONST WP3 report on regional distribution of green growth patents operates at NUTS2 level and Tampere Region is a NUTS3 level region, it is not possible to say anything specific about its patenting activity. However, it belongs to Western Finland (Länsi-Suomi), which is the leading Finnish NUTS2 region in these respects after Helsinki-Uusimaa, and we have every reason to assume that the firms and research institutions in Tampere form the core of patenting activity on Western Finland.

5.1.5 Natural endowments or related information

Tampere region is covered by forest as is Finland as a whole. There are plenty of natural endowments (agri/earth, forest, aqua, food, variety of recycled and circulated materials) to be used in a sustainable way. However, the competitive edge of the region is more based on technological capabilities than natural endowments.

5.1.6 Sources for the case study

The empirical study began with a literature review of relevant material describing and analysing the overall development of the case region or some specific features of it. This included written material from the Internet, relevant journals, related newspaper articles, and most notably respective policy documents. Drawing on thus collected secondary data, the overall understanding of the main features of the case was constructed as well as the main policy approaches were identified. Moreover, the analysis of the Cleantech Finland member firms provided additional pieces of information about growth and export oriented Finnish firms building,

one way or another, their business on 'green products and/or services'. 16 of the 201 Cleantech Finland member firms are located in Tampere region.

The main aim of the first round of data collection was to describe the cases and their institutional set-up for the second round of data collection. The first phase identified a generic path development patterns and the main policy instruments and other actions for interviews. Next, 15 case related and five national level thematic (semi-structured) interviews were carried out. The interviewees represented following organisations: local and regional authorities, firms, a research institution, the university, the Ministry of Employment and Economy and national funding bodies.

5.1.7 Important policy documents considered for the case study

National policies

- In its 'Government Programme' (Finland, a land of solutions, 2018), Prime Minister Juha Sipilä's Government (2015–2019) proclaimed that it will, among other ambitions, bring the Finnish economy onto a path of sustainable growth. Several policy documents precede this proclamation, on the one hand, and specify it, on the other hand.
- The Finnish Bioeconomy Strategy. Sustainable growth from bioeconomy, http://biotalous.fi/wp-content/uploads/2014/08/The_Finnish_Bioeconomy_Strategy_110620141.pdf
- Energy and Climate Roadmap 2050. Report of the Parliamentary Committee on Energy and Climate Issues 16th October 2014. Työ- ja elinkeinoministeriön julkaisuja, Energia ja ilmasto 31/2014. Helsinki
- Leading the cycle – Finnish road map to a circular economy 2016–2025. Sitra Studies 121, Sitra: Helsinki.
- National Forest Strategy 2025 – Government Resolution of 12 February 2015. Ministry of Agriculture and Forestry 6b/2015.

Regional policies

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covers in this document the first 10 pages and is then followed with the regional programme for 2014-2017 in the pages 11-16.

- Pirkanmaan ympäristöohjelma 2011-2016. Pirkanmaan liitto. Sarja D, Julkaisu no 95 / 2011: Tampere. (Pirkanmaa Environmental Programme 2011–2016. Council of Tampere Region. Serie D, Publication no 95, 2011: Tampere)
- Ympäristöviisas Pirkanmaa 2040. Pirkanmaan ympäristöohjelma. Pirkanmaan liitto, 2017: Tampere. (Environment wise Pirkanmaa 2040. The Environment programme for Pirkanmaa. Council of Tampere Region, 2010: Tampere)

5.2 Barriers and drivers for regional green growth

5.2.1 Main barriers

Lack of new capabilities and skills. The general challenge is the growing need for knowledgeable and skilled labour force. The interviewees emphasised in particular growing need for expertise related to internet of things. As cleantech and circular economy are cross-cutting fields of activity integrating knowledge and expertise from several disciplines as well as industries, it is not easy to find ready-made skilled experts. In a way, 'synthesising engineers' are in great demand.

Difficulties in entering the global markets. Responding to new emerging demands is always a risk, and some of the local players are not prepared for global markets with their products and services. One of the barriers is start-up firms' lack of references from local or national markets. Additionally, the latent nature of demand for 'green products and services' means that customers are not aware of novel solutions/products/services or a traditional industry simply is reluctant to experiment with anything new. Also, higher prices of green products are a barrier for potential users of regionally developed solutions. It is worth noting that most of the regional cleantech companies are operating in b-to-b -markets.

The green economy, and its growth, is not an autonomous and self-organising nor self-evident direction. Moving to circular economy technologies, for example in production sites, require large-scale investments, and these quite naturally call for difficult decisions in individual firms. In b-to-b markets, new materials are costly and testing of new materials is time consuming, and therefore, in spite of the growing demand, many of the firms are hesitant to move to global markets.

Policy. Issues related to difficulties in assessing the impacts of new green products and services slow many processes (for example, usage of new materials and their impacts on the systems more broadly). Especially local government is struggling to understand the emerging future responsibilities. Additionally, uncertainties of actual manifestations of green economy make local policy making risk-

averse even though in general supportive. Consequently, policy making becomes short-term and somewhat bouncy, which adds uncertainty to markets and diminishes willingness to take risk. The complexity of public decision-making processes causes difficulties for businesses.

Regulation. There is a multiple jungle of legislation and other forms of regulation related to environmental, material, product, energy, building etc. activities, which all independently and especially together create challenges for businesses; the institutional messages are conflicting and in essence difficult to read and comply to, or to take benefit of. What makes the situation more challenging is the fact the lead businesses and thus also their suppliers operate globally, which requires them to comply to a myriad of political decisions and related regulation. This causes uncertainty and risk aversion.

Physical resources. The traditional fossil alternatives are cheaper than new energy solutions. The supply of recycled materials for production of green products is still fairly limited.

5.2.2 Main drivers and enablers

Capabilities and skills. Tampere region is the second in size when it comes to education and research in Finland, and its universities serve businesses with many of the basic capacities needed in green economy (automation, ICT, management, green accounting, etc.). The data highlights the importance of existing reservoir of highly educated professional in general and in such fields as energy, environmental policy and business, cleantech, wood construction and renovation, and highly developed practices in multi-disciplinary co-operation, in particular. In general, the interviewees appreciated the high-level technical education and expertise in the region. Tampere University is the leading Finnish university with Aalto University in many technology areas and engineering.

Technologies. Tampere region is one of the leading Finnish places for research, development and commercialisation of environmental and energy efficient technology, energy efficient solutions for construction and residential use, industrial processes, and machines and equipment. The technological capacity embedded in the region serves businesses and society well in integration of different technologies and smart technology in machines, traffic, infrastructure, buildings, industrial IoT, digital business concepts, and biotechnology.

Natura endowments. There are plenty of natural endowments (agri/earth, forest, aqua, food, variety of recycled and circulated materials) to be used in sustainable way. In practice, the competitiveness of the regions draws more on technological capabilities than natural endowments.

Markets. Regional markets are tiny and national markets are not much bigger, and therefore there is a shared understanding that all solutions targeted at solving

environmental issues need to access global markets; they are globally in high demand. Roughly, Tampere's 'green markets' may be divided into two categories depending on their targeted markets: (a) local/regional oriented firms focusing on serving local needs and gaining references for global markets, and (b) globally oriented firms with growth ambitions. Rapidly improving understanding of global markets among regional actors and required expertise to access them boost both the green economy to grow and the construction of ecosystems.

Public actors aim to create and facilitate green markets by public procurement but also by aiming at constructing innovation platforms to boost experimentation. In ecosystems, collaboration in all sorts of b-to-b constellations are at the core in all sectors, and especially in the context of circular economy.

Lifecycle thinking is one of the core thinking patterns that ubiquitously supports sustainable development in general and the search for specific green solutions in particular.

Platform thinking. During the previous policy era, cluster policies were constructed around multi-year and multi-actor development programs aim being to use them as vehicles of mobilization. Now, Finland and especially Tampere have moved to the era of platform policies (Sotarauta & Suvinen, 2019).

In the innovation ecosystem literature, ecosystems are expected to be connected to a lead firm but in Tampere, it is the City of Tampere that have adopted a respective role. In its efforts to construct ecosystems it is aiming to take a similar position in green growth-related innovation as Apple has in its ecosystem revolving around its operating system. Consequently, instead of using development programmes, platform policy is constructed on something that would be done anyway - in principle, anything can be a platform.

For example, Kolmenkulma eco-industrial park is a land-use project that is one of the nominated policy platforms. Kolmenkulma is a district, which is planned to become a home for companies operating in various fields of cleantech. The actors related to the ECO3 industrial site (so called waste to value site) – a part of Kolmenkulma – focuses on bio- and circular economy businesses like refining ashes, recycling plastics and rubber, biogas production, biomass terminal and wastewater management. The ambition is to maximize interaction between individual businesses for increased material and energy efficiency (to construct conditions for industrial symbiosis) and development of eco-friendly concepts by sharing of energy resources and services. ECO3 is to mobilise and put together companies and research and development activities in a designated location so that they would form a place-based innovation ecosystem connecting the organisations through material and knowledge flows.

In line with ecosystem thinking and platform policy, a new residential area Hiedanranta is supposed to "serve as a development platform for experiments and

projects that promote smart technology, sustainability and circular economy solutions." For example, among the dozens of already launched projects, the commercial production of carbon-negative district heating has begun. Hiedanranta is an innovation platform for Carbofex Ltd to produce district heating alongside its main product that is biochar (see for more, Tampere's Hiedanranta).

On the one hand, platforms are designated to serve experimentation and emergence of an innovation ecosystem on them. It is a way to enable newly established or small firms to connect with incumbent companies and develop their green solutions/products to serve b-to-b markets. On the other hand, platforms are expected to serve policy making and related practices to support environmentally sustainable development.

Regulation directs green growth at all spatial levels simultaneously creating markets for Finnish green companies. It pressurises and provides conflicting messages but also enables private sector to make long-term investments in order to reach the set targets.

Policies. Local and regional development policies nowadays more or less all focus on boosting green growth, one way or another.

5.3 Regional green growth

The core theme in Tampere is to improve cleantech but also the concept of circular economy is used as a guiding metaphor. Cleantech is by nature a cross-cutting field used in many sectors, it is based on the historical strongholds of the region, especially machine building but also ICT.

"Cleantech refers to products, services, processes and solutions which improve productive and sustainable use of natural resources while reducing emissions and other negative environmental impacts … cleantech is not tied to any specific sectors but can be seen more as an asset to promote green growth in any field and in any resource use" (Annala & Teräs, 2017, 7).

5.3.1 The main actors and networks for green growth in the region

The regional cleantech and energy cluster (2013-2018) which included 111 companies from the region representing energy, industry, built environment, water and wastewater, and waste management sectors is an example of a focused network of actors working to boost green growth. Currently there are several platform specific networks involving all the main local and regional actors (see above).

5.3.2 The main processes of green growth in the region – how have they unfold?

Policy push. In Tampere region, green path development has several policy drivers. The local/regional intention to promote sustainable urban structure, mobility (traffic), regional economy and every-day living are expressed in different regional development plans (strategies), programmes and implementation schedules. The greening of the economy has gradually become more and more established since the mid 1990's. Perhaps the first policy act towards this end was when City of Tampere signed the Aalborg declaration in 1995. However, the City Council accepted the Aalborg's principles to guide its sustainable development only in 2007. At the regional level, environmentally sustainable development, also in connection with economic activities, has been promoted since the beginning of 2000's with the special environmental / climate strategies or programmes. The policy actors are also creating markets for green business with emphasis on locality and sustainability in their procurement and in the deployment of renewables.

The public funding directed to projects promoting environmentally sustainable developments focuses on the following three focal points:

- The cleantech focused local policy continues the work of the Centre of Expertise (CoE) (1994-2013) that in Tampere focused on such industries as manufacturing, smart machines, ICT, cleantech and energy, and nanotechnology. CoE programme was followed by the cleantech and energy (2013-2018) cluster, which involved companies from energy, industry, built environment, water and wastewater, and waste management sectors.
- Creation of Kolmenkulma Eco Industrial Park with overlapping cleantech and bio/circular economy industry networks and sites. Cleantech is based on the region's long-term tradition on machine and equipment manufacturing (appr. two centuries) and strong technology industries. The actors related to the ECO3 industrial site (waste to value) focuses on bio- and circular economy business like refining ashes, recycling plastics and rubber, biogas production, biomass terminal and wastewater management.
- Building of new residential areas as platforms to connect established and new firms with construction of sustainable living areas.

Platforms, ecosystems and industrial sites/networks. The above-mentioned platform policy is the core in the late 2010's. All the current key processes are related to designated platforms and ecosystems on them or generic strategy and policy making processes providing these with directions. Compared to cluster era, the

difference is, that current networks are more porous and thus supposedly more agile than earlier.

Business activities related to manufacturing of machines and equipment as well as energy and developing and using digital solutions like smart technologies in buildings and machines, and industrial internet solutions, are highlighted. Also the use of cleantech solutions in bio-energy production and waste-to-value production are underlined.

Research and education providing new technologies, business and experts to the region (see above the main drivers).

5.3.3 What industry sectors have been involved?

Energy, construction, manufacturing of machines and equipment, packaging, rubber and plastic industries, technology industry, waste management and also regional and municipal planning and zoning, transportation, infrastructure construction.

5.4 Conclusions

As our interviewees fairly unanimously saw, the ambition of using platforms as policy vehicles is to contribute to building value chains, enhancing their quality, introducing innovation and creating additional value. Land-use planning, main infrastructure projects and waste management are used as innovation platforms to build innovation ecosystems, i.e. to mobilise heterogenous groups of actors to benefit from each other's competencies. From policy perspective, the core actor is the City of Tampere, and at an operational level the infrastructure actors are seen as anchor organisations. Interestingly, it is much more common than in a cluster policy to have some kind of infrastructure related organisations (waste management enterprises, energy enterprises, electricity companies, land-use planning), to take a central role in specific projects. Earlier, in the context of a development programmes, the lead was often taken by the main industrial companies or universities. This represents a clear deviation from the earlier local innovation policy approach that was constructed around multi-year and multi-actor development programmes to identifying policy platforms on something city is doing anyway.

Otherwise, our very tentative analyses suggest the main drivers and barriers are more or less the same in the green economy as in other fields of economy. It is the main ambition and objectives of both private and public actors that are changing. The industrial processes in manufacturing and engineering-oriented Finland have changed less but it seems that platform policy is changing the ways policy is

designed and implemented, and thus also interaction patterns are in flux. Platform policies and efforts to construct green innovation ecosystems may serve green growth well or not. It is too early to assess.

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6 Trøndelag

Summary

This case study is comprised of two sub-cases, and as such addresses two main sectors of the evolving bioeconomy in the Trøndelag county: the aquaculture sector and the forestry sector. The case study also considers connected industries to the respective bioeconomy sectors. For aquaculture this is mainly the supplier industry producing equipment, ships/vessels and sustainable energy solutions. For the forestry sector this includes all the industries which are based on value creation from forest resources. To capture the circular bioeconomy, we also explore the interplay between the two sectors by addressing value creation from residues.

6.1 Background information

6.1.1 Geographical location

Trøndelag county is located in Mid-Norway (see Figure 8). Earlier the county was separated into Northern and Southern Trøndelag but since 2018 these two merged into one county. The county has a land area of about 38,614 km^2 and thereby Norway's second largest county by land area (SSB). Trøndelag has 462,503 inhabitants (SSB, 31.12.2018),[2] a number that has increased each year since 2009 (421,985) with an average growth rate about 1.01.

In 2018 there were 232,129 people employed in Trøndelag in the age between 15 and 74 (SSB)[3]. There were about 25K enterprises in S-Trøndelag with a turnover of almost 200,000 million NOK and 13,4K enterprises in N-Trøndelag with a turnover of 60,900 million NOK.

[2] https://www.ssb.no/statbank/table/05231/tableViewLayout1/
[3] https://www.ssb.no/arbeid-og-lonn/statistikker/regsys/aar

Trøndelag has by November 2018 4,474 registered unemployed people in the age between 15 and 74 (SSB)[4]. Compared to 2015 when the two counties had together 5,830 registered unemployed, this is a reduction of almost one quart.[5]

The largest city in Trøndelag is Trondheim, whereas the administrative centre is Steinkjer. In 2018Trondheim had a population of 196,331 inhabitants (SSB)[6], making it the third largest city in Norway.

6.1.2 Industrial specialization and path dependencies

Compared with other regions in Norway, Trøndelag is relatively strong (regional specialisations) in agriculture, forestry, seafood (esp. aquaculture), various technology sectors and R&D. The latter is in particular due to the presence of the Norwegian University of Science and Technology (NTNU) and the applied research institute SINTEF (private, non-commercial), both located in Trondheim.

Within Trøndelag there is substantial inter-regional variation in importance of different industries/sectors in subregions, with aquaculture naturally being important for value creation and employment in coastal areas, whereas forestry and forestry-based activities are more significant in inland parts of the region (Sand et al. 2017).

Historically, important bioeconomy-based industries in Trøndelag have been agriculture, forestry and fishing. Today, aquaculture accounts for half of Trøndelag's export value. The two largest fish farming companies are SalMar and SinkabergHansen, and there is a large supply industry serving aquaculture.

Beside the bioeconomy, the oil and gas industry is significant in Trøndelag, with Equinor's operating administration at Stjørdal and the research centre in Trondheim as the largest units. Much of the manufacturing industry in Trøndelag is oriented towards aquaculture and offshore, especially at Verdalsøra and Orkanger.

Trøndelag has a significant hydropower power production that supports power-intensive process industries such as the pulp and paper plant Norske Skog Skogn, Wacker's Holla Metall and Elkem Thamshavn, both producing silicon and microsilica and Washington Mills producing silicon carbide. In addition, many firms in the region are active within renewable energy, as seen in both the Trondheim-based Renewable Energy Cluster, and the Verdal-based Windcluster Norway.

[4] https://www.ssb.no/arbeid-og-lonn/statistikker/regledig/aar
[5] https://www.ssb.no/statbank/table/10594/tableViewLayout1/
[6] https://www.ssb.no/statbank/table/05231/tableViewLayout1/

Forestry and forest-based industries

The forest-based industry combines several value chains in Trøndelag and collaborates with strong competence centres in Trøndelag and outside the region.

Forest properties are highly fragmented in Norway and the same applies to Trøndelag (see Table 3). The specialisation in forestry is slightly higher in Northern Trøndelag than in Southern Trøndelag (see Table 4). Forest owners are interacting with forest entrepreneurs responsible for felling and logging the trees: the potential for annual harvesting is 1.1 mill. m^3, while just 0.84 mill. m^3 are harvested.

We can distinguish between following main activities of the industry actors, some of them still at a R&D stage:

Logistic systems for planning, coordination, transport and quality control the streams of sawn timber

The timber industry has saw mills at Steinkjer, Verdal, Snåsa, Selbu, Støren and Namsos. There is a stable turnover in S-Trøndelag and an increased turnover in N-Trøndelag, but the number of enterprises and employees is decreasing.

Wood fibre-processing industry

- Pulp and paper industry with just a few enterprises: Norske Skog Skogn and MM FollaCell in Verran
- Composite materials with activities at Norske Skog Saugbruk

Fish feed for aquaculture – MMK FollaCell and SalMar

Table 3: Forest properties and commercial roundwood removal in cubic metre and by size class (Source: SSB)[7]

		Commercial roundwood removal. Cubic metre		Number of forest properties	
		S-Trøndelag	N-Trøndelag	S-Trøndelag	N-Trøndelag
Size class by productive forest area in decares	25-99 decares	13558	13292	46	54
	100-249 decares	26961	49725	84	126
	250-499 decares	47675	68749	115	161
	500-999 decares	81472	70413	191	180
	1000-1999 decares	93305	74948	169	144
	2000-4999 decares	57005	65178	72	128
	5000-19999 decares	7198	34087	9	35
	20 000 decares or more	19868	47399	9	15
	Total	347042	423791	695	843

[7] https://www.ssb.no/en/jord-skog-jakt-og-fiskeri/statistikker/stskog/aar

Table 4: Forestry-based enterprises, turnover and persons employed in 2015 (Source: SSB)

		Enterprises	Turnover (mill. NOK)	Persons employed
S-Trøndelag	Forestry & logging	514	184	298
	Manufacture of wood and products of wood	126	1 226	803
	Manufacture of paper and paper products	5	182	67
N-Trøndelag	Forestry & logging	621	815	790
	Manufacture of wood and products of wood	73	1,228	479
	Manufacture of paper and paper products	3	…	451

Construction industry

This is Trøndelag's largest land-based industry. However, the construction industry is still dominated by concrete, steel and glass. However, it includes also the production and usage of wooden construction elements based on laminated wood or massive wood, fibre-based isolation, modules, multi-storey wooden houses, bridges etc. The use of wood in Norwegian construction industry can at least be increased from today's 3 mill. m^3 to 5.5 mill. m^3 annually by 2030. This means increased wood use for 800 million NOK in Trøndelag and 8 billion NOK in Norway (Source: Arena Skog).

Aquaculture

Aquaculture constitutes various types of seafood production, whereas the focus here is on the farming of salmon and (in volumes to much lesser extent) trout. Experimentation with salmon sea farming began in Norway in the late 1960s and early 1970s. Trøndelag has been central in the development of the Norwegian aquaculture industry since the early beginnings. For example, the open net system was developed in the late 1960s by entrepreneurs on the island of Hitra in Trøndelag. Subsequently Trøndelag became the dominant region in terms of developing and supplying technology to salmon farming from the early 1970s (Hersoug, Mikkelsen, and Karlsen 2018). The regional supplier industry constitutes a range of different companies that supply various products and services to the aquaculture industry.

As illustrated by Figure 6, the number of licenses for hatcheries and fish production are slightly higher in the southern than the northern parts of Trøndelag.

Overall, however, it is fair to say that aquaculture constitutes an important economic activity along the entire (outer) coastline of Trøndelag. Figure 7 illustrates that the number of employees in aquaculture similarly to licenses is fairly higher in southern than northern parts of the county.

10 of the 35 million seafood meal equivalents that were exported daily from Norway in 2017 came from Trøndelag, and foresight studies suggest that this could be expanded to 50 million seafood meals from Trøndelag alone by 2050 (Olafsen et al. 2012). This "growth vision" is high on both policy and industry agendas both in the region and nationally. There are, however, concerns regarding various environmental issues that need to be solved in order to allow for upscaling. This also explains the relatively stable number of licenses (Figure 6) for aquaculture production since the beginning of the decade.

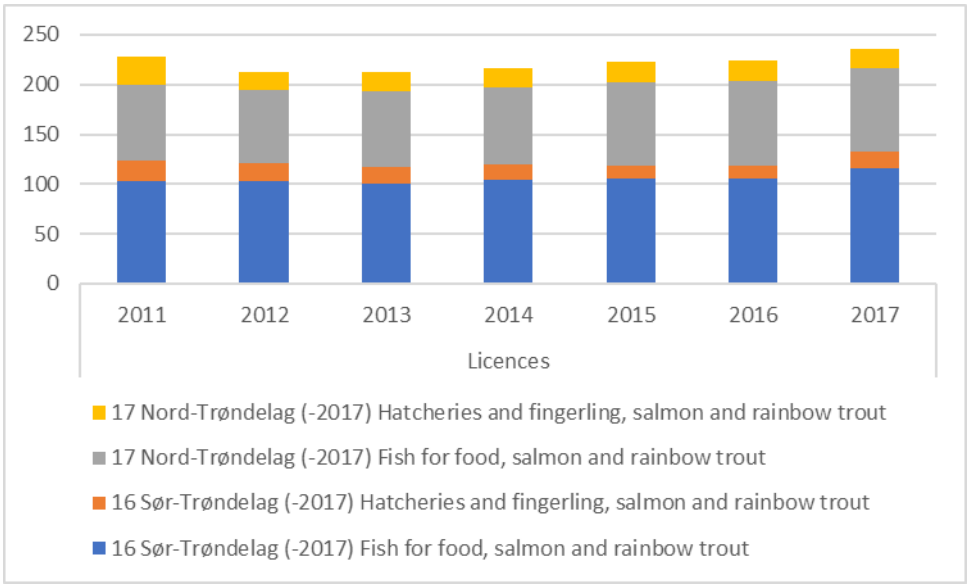

Figure 6: Licenses for aquaculture in Trøndelag in 2017 (Source: SSB)

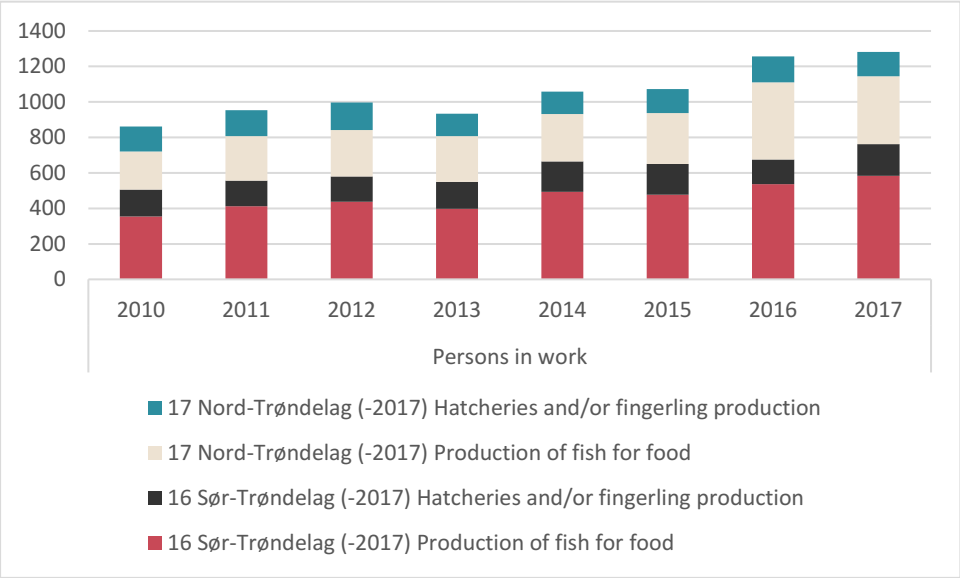

Figure 7: Persons in work in aquaculture in Trøndelag in 2017 (Source: SSB)

6.1.3 Regional green skills

Trøndelag is divided into S-Trøndelag and N-Trøndelag in the statistical analysis. S-Trøndelag is fairly average in its shares of green occupation and green education while N-Trøndelag is below the average in terms of green occupations, but not with regard to green education.

6.1.4 Regional green technologies

When looking at patenting activities across different regions of Norway, Trøndelag appears to occupy relevant positions in green patenting rankings. For instance, for what concerns "Energy storage and emissions mitigation" technologies (patent group Y02E 60, according to the Y02-Y04S tagging scheme developed by the European Patent Office), the patenting activities of Trøndelag feature prominently, together with the Oslo region and South Eastern Norway. Analogously, patent applications in energy generation (Y02E 10) are often associated to Trøndelag, as well as to the Oslo region and to the region around Stavager and Kristiansand (Rogaland and Agder). Green patents associated to the chemical industry (Y02P 20) seem instead to suggest a lower relevance of Trøndelag in comparison to other Norwegian regions, while applications for 'Technologies relating to the production processes of final/consumer goods' (Y02P 70) are spread almost evenly across the whole country. Norwegian green patenting in the area of buildings (Y02B 10; Y02B 30; Y02B 60; Y02B 70) sees again Trøndelag in a notable position, together with

Oslo and with Agder and Rogaland, which appear to play a leading role. Green technologies related to transport (Y02T, and subgroups) are also well included in Trøndelag's patenting activities, although to a much lower extent than other Norwegian regions like Vestlandet.

6.1.5 Natural endowments or related information

Forestry and forest-based industries

On average 23% of Norwegian land area is covered by productive forest area (). The total productive forest area for Trøndelag is 20.437 km2 (share 27%). In N-Trøndelag this is 6,514 km2 (share 32%) and in S-Trøndelag this is 3,923 km2 (share 22%).

Figure 8: Forestry area of Norway by county with focus on Trøndelag – share of total land area in %, Source: SSB, 2016 data

Aquaculture

An important reason why Trøndelag is home to substantial sea farming activities is indeed the natural conditions. On the one hand, the Trøndelag coastline offers

very good production locations in proximity to shore. On the other hand, the ocean temperatures are regarded as very fitting for salmon/trout farming, since winter temperatures are relatively high whereas summer temperatures are low.

Compared with other production regions in Norway, the parasitic sea lice (that has had a detrimental effect on increasing production volumes from Norwegian fish farming in recent years), appears to be less of a challenge in Trøndelag than in some other regions in the country. This is also evident in Figure 9, which illustrates the regulatory system for aquaculture production regions in Norway, wherein green regions can upscale production, yellow regions are "on hold" in terms of increasing production, whereas production needs to decrease in red regions.

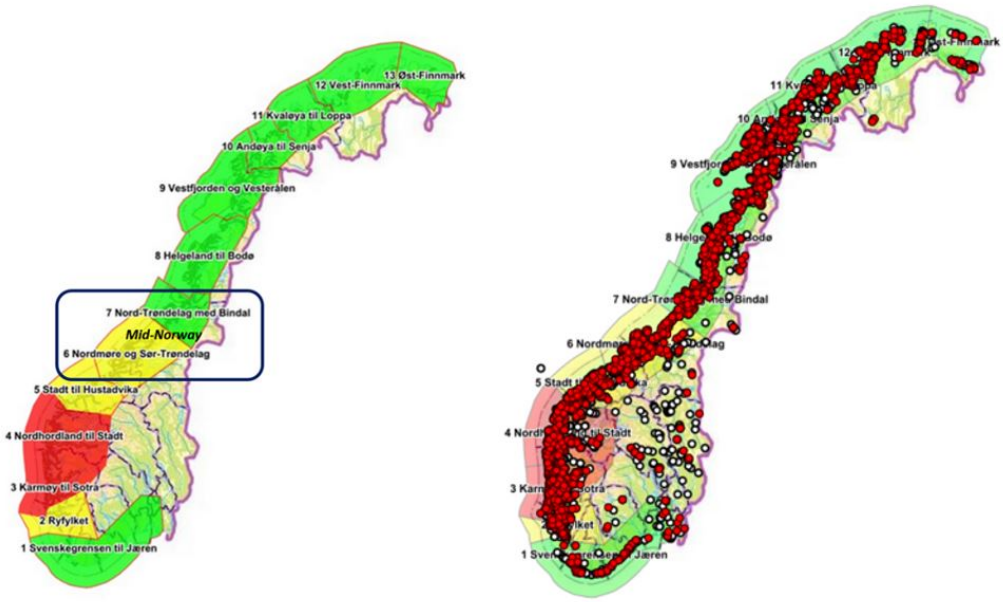

Figure 9: Norwegian aquaculture production zones with traffic light system (left) and salmon farming production sites (red dots, right). Source: Fiskeridirektoratet (2018)

6.1.6 Sources for the case study

This case study is based on interviews with representatives from the two bioeconomy sectors and with representatives from public agencies, on the analysis of secondary materials such as reports, media articles and policy documents, statistics, and participation at seminars and workshops. All interviews were conducted in Norwegian and subsequently transcribed and translated into English. Most interviews were conducted via telephone/Skype.

Forestry and forest-based industries

Beside the interviews listed in Table 5 we visited Norske Skog Skogn and Biokraft in Skogn and got guided tours of both plants, we conducted a media analysis based on articles in selected newspapers and relevant magazines: Adresseavisen, Trønder-Avisa, Teknisk ukeblad, Aftenposten, Klassekampen and Norsk Skogbruk, and we participated at seminars on forest industry development and on biogas development. Statistics from SSB and firm data from purehelp were used as well.

Table 5: Details of expert interviews in Trøndelag Region for forestry

Nr.	Position	Organisation	Type of organisation
1	Scientist	Sintef	Research institute
2	CEO	Norske Skog Skogn	Pulp and paper plant
3	Factory manager	Biokraft	Biogas company
4	Financial manager	Biokraft	Biogas company
5	Cluster manager	Arena Skog	Cluster organisation
6	Tredriveren i Trøndelag	Innovation Norway	Public agency
7	Senior advisor	Wood-based Innovation Programme in Innovation Norway	Public agency

Aquaculture

Interviews focusing on 'green upscaling' of the aquaculture industry in the region of Trøndelag/Mid-Norway were conducted in 2018 and 2019 with altogether 10 firm and non-firm organisations (see Table 6). The informants represent different types of firms along the aquaculture value chain and also non-firm (or 'system') actors. The informants all hold senior positions within their respective organisations.

The analysis also draws on presentations and discussions from various events focusing on "maritime cleantech", and also from an aquaculture event co-organized between SINTEF and the NCE Aquatech Cluster 13-14 November 2018 focusing on emission reductions.

Table 6: Details of expert interviews in Trøndelag Region for aquaculture

Nr.	Position	Organisation	Type of organisation
1	Regional Director	Marine Harvest	Aquaculture company (world's largest)
2	Senior Advisor	Enova	State support agency for energy efficiency and GHG emission reductions
3	Environment and Development Manager	Måsøval	Aquaculture company
4	Cluster manager	Fornybarklyngen	Regional renewable energy cluster
5	Senior Advisor	NCE Aquatech Cluster	Regional aquaculture cluster (technology supplier focused)
6	General manager	Ørnli Slipp	Specialised ship yard/boat builder
7	Senior Advisor	Trøndelag County Municipality	Regional authorities
8	Senior Advisor	Bellona	Environmental NGO (national)
9	CEO	Williksen	Salmon processing company
10	Manager Strategy and Business Development	NTS ASA	Aquaculture company

6.1.7 Important policy documents considered for the case study

National policies

Innovasjon Norge: Drømmeløftet 2017: Bioøkonomi. Innspillsrapport om verdiskaping fra fornybare biologiske ressurser.

This report is a contribution to the overall innovation strategy for Norway developed by Innovation Norway. Other contributions focussed on the ocean, renewable energy, health and welfare, smart society, and creative industry and tourism. The Bioeconomy strategy has concluded in four innovation policy recommendations: (a) more industrial processing of biological resources in Norway, not just their export, (b) better access to competent capital to ensure industry development, (c) public procurement as a driver for bio-based innovation, and (d) the contribution to the circular economy. Industry development relevant for this case study is highlighted in the report as well, as the wooden construction industry and the industrial valorisation of wood for different purposes based on improved competitiveness of the manufacturers of lumber and other wood-based building materials due to digitalisation, more effective logistics and effectiveness.

For aquaculture, the last **White Paper on the aquaculture industry (NFD, 2015)** highlights the importance of aquaculture in Norway and stresses the growth ambition. It does however not discuss energy- or climate-related issues related to aquaculture, apart from noting that climate change may have detrimental effects on the natural growth conditions for aquaculture. Also previous energy and climate strategies for Trøndelag do not mention energy savings or greenhouse gas emission reductions in the aquaculture sector.

Regional policies

Regional planstrategi for Trøndelag: Utfordringer, muligheter og prioriterte planoppgaver i Trøndelag 2016-2020. Vedtatt i fylkestinget i Sør-Trøndelag 15.06.2016, sak 62/16, Vedtatt i fylkestinget i Nord-Trøndelag 16.06.2016, sak 42/16.

The strategy has focus on a balanced development based on interaction of societal actors in the whole region which is to be achieved by ecological, economic and social sustainability. A regional plan strategy is a necessary element for local planning processes. The regional plan strategy has to define important regional development characteristics, challenges for development and highlighting priorities. Climate, renewable energy and environment are at the core of the plan strategy. Here green transformation is highlighting not just the need for more renewable energy but also the need for the development of the bioeconomy. Here the valorisation of waste and rest-resources for sustainable industry development has been addressed in the strategy plan (p. 11). At the end of the plan strategy is an overview over existing plans for Trøndelag county.

Et verdiskapende Trøndelag: Strategi for innovasjon og verdiskaping i Trøndelag. Vedtatt av fylkestinget 14.12.2017.

This strategy is the first joint strategy for the merged county of Trøndelag. The strategy points out five priority areas: bioeconomy, circular economy, ocean, smart society and experience economy. The strategy points out for the bioeconomy it is necessary to use product areas in an optimal way, to strengthen the interaction across traditional value chains, such as between the blue and the green sector, and to improve the collaboration between industry and knowledge institutions. With regard to the circular economy the strategy highlights new business models for effective production and usage of resources, the increased valorisation of rest-resources based on collaboration of firms and innovation, and to replace fossil-based products with bio-based ones.

With regard to forest resources the strategy points out that the forest industry demands more timber than it is provided by the forestry sector of Trøndelag. Therefore, long-term improvements are necessary to ensure the access to the resources for the forest-based industries of Trøndelag (p. 6). The county has Norway's only Arena cluster for forestry and will address these challenges.

Aquaculture is central in regional development strategies pertaining to the bioeconomy and ocean space. An accompanying 'action plan' to realize the strategy (TFK, 2018, p. 4) points out a number of areas in which to improve the sustainability of aquaculture, including "to stimulate more environmentally friendly propulsion systems in the maritime industry that provides services to aquaculture."

Regionalt skog- og klimaprogram for Trøndelag, 2019-2021. Fylkesmannen i Trøndelag. Steinkjer.

This regional forestry and climate programme for Trøndelag was developed by the county man of Trøndelag. There are established three main goals for the forestry sector: (a) forest management must adapt to future climate changes and environmental commitments, (b) Trøndelag shall develop good collaboration solutions at the regional level, in municipalities and between municipalities, and (c) Trøndelag shall be a strong forest region with complete value chains and a clear effort for increased use of wood and wood fibre. The report analyses challenges regarding reduced future wood production, carbon uptake and storage.

6.2 Barriers and drivers for regional green growth

In this section we first present forestry and forest-based industries, then aquaculture, before discussing also cross-sectoral linkages.

6.2.1 Main barriers for forestry and forest-based industries

Access to forest resources from the region is limited by poor infrastructure and logistic systems in the forestry sector. Beside the land transport also sea transport

possibilities have to be improved, by building quays etc. The standard of the existing bridges and roads allows only limited transport of forest resources and is much worse compared to Sweden where they have better road standards and receive subsidies for the transportation of wood.

Political framework conditions are often challenging, such as changing taxes and fees which do not provide stability. For biogas it has been difficult to compete with other technologies, such as with natural gas which received subsidies, electrical mobility and hydrogen which are regarded as renewable by definition while biogas had to struggle a lot. There have been different attitudes for supporting for example biogas: while the local municipality was very positive and helpful the county administration did not support this new industry. First after changes of the national regulations this changed.

There is a **lack of financial capital** to give funding for larger technological projects. And the forest owners need more financial means to secure new planting after harvesting. The fragmented ownership in the forestry sector is not positive for the access to such financial means and contributes as well to reduced access to local forest resources for the forest-based industry.

The recruitment of relevant personnel is challenging in the whole value chain, from forestry to forest-based industry. The sector needs more competence building with focus on enabling technologies and future demand for such competencies.

It is challenging to **develop new products** to reasonable prices which allow them to find a market.

6.2.2 Main drivers and enablers for forestry and forest-based industries

Policy instruments: There are several policy instruments under Innovation Norway which have been and are very supportive for the forest-based industry in Trøndelag: Arena-programme supporting cluster development, Wood innovation programme providing loans and funding and Tredrivere facilitating entrepreneurship for SMEs. Other important instruments are Enova for financing energy efficiency measures and public procurement for the wooden construction industry.

Enabling technologies: Digitalisation and automation contribute to improved logistics and more effective forest-based industry. This allows higher competitiveness because of lower costs for employees.

Policy prioritising: The valorisation of rest resources across established sectors has been prioritised in bioeconomy strategy but also in regional policy documents.

This allows a very good argumentation for industry projects targeting such valorisation, such as the Biokraft project at Skogn.

Market: There must exist a market to attract capital and private firms which have the power to create a demand for new types of products as the role of AGA as a main enabler for the liquified biogas project has shown.

Knowledge: For the regional cluster the access to knowledge organisation in the region (NTNU, Sintef, PFI-RISE etc.) has been very important, but also the collaboration with important R&D organisation in other countries, such as Sweden (through PFI) and Denmark.

6.2.3 Main barriers for aquaculture

The main current barrier confronting growth in aquaculture (in terms of increasing production volumes) are ecological and biological issues related especially to the sea lice. It is important here to differentiate between steps taken to solve biological/ecological challenges vs the more emerging energy/emission challenge because the two relate to fundamentally different problems in terms of innovation, institutions etc. Without doubt both innovation activities, policy and industrial attention are focused on biological/ecological challenges rather than energy/climate challenges. However, interviews and events clearly suggest that there is growing attention to the 'carbon footprint' from aquaculture, in part due to expectations of changing market preferences. It should also be noted that there is increasing attention in the industry to using waste from aquaculture to e.g. biogas production, which could also be relatively low-scale and ideally be consumed locally.

Regarding energy/emissions, a key finding in this case is that there appears to be an 'environmental-fix-paradox' in aquaculture. That is, due to today's open-pen-based near-shore salmon farming, it appears that the energy/emission challenge could indeed be solved despite existing barriers. Solutions include power-from-shore, battery systems installed on production site feed barges, and a shift from diesel-powered engines to battery-electric or hybrid solutions on vessels. However, with a move to offshore farming (i.e. larger aquaculture production structures) further from shore, it appears that addressing the energy/emissions will be more challenging – at least with current technological solutions, market dynamics and cost levels. For the two large development projects for large-scale salmon farming in harsher conditions looked into in the Mid-Norway region (Aquatraz by NTS and Ocean Farm by Salmar) the energy/emission issue has not been integrated in design etc. Moreover, the energy/emissions issue is not part of

the current licensing (production regulatory) system, neither for commercial nor "green" or "development licenses".

The main barrier for a greening of aquaculture in terms of energy use and GHG emissions appear to be that **other environmental challenges are deemed more important**. In other words, the industry is focused on solving biological and ecological problems that currently stand in the way of increasing production volumes. One informant bluntly stated that "nobody will be doing anything about emissions in this industry as long as the sea louse is around." It should be noted that there is reason to be more optimistic, and that there are indeed many initiatives and concrete investments that suggest the opposite.

For production sites/feed barges: power-from-shore is currently not feasible for sites that are located far from a sufficiently good grid connection point. Actors (suppliers, aquaculture companies etc.) are exploring "island solutions" for production sites that to not have easy access to grid connection, i.e. hybrid systems with solar PV, wind power, battery systems and also conventional fossil fuel diesel generators. Some actors mention regulatory issues with grid companies as a barrier.

For vessels: battery-electric solutions (full or hybrid) are regarded as highly suitable for workboats servicing many aquaculture production sites, yet market pull is currently rather low. The world's first full-electric workboat was introduced to the market in 2017 (on a production site in Mid-Norway), however it currently remains the only one. Actors seem to be not wholly convinced by the performance of the new technology and safety aspects are also an important element. However, many actors suggest that they expect this to change very soon. For other vessel types, i.e. fish carriers and feed carriers, the situation is a bit different. These vessels do not typically have fixed routes on which they operate but serve larger geographical markets which in terms of energy implies flexibility. Hybrid solutions are being introduced for these vessel types, as is the use of liquified natural gas (LNG).

There is a lack of attention to emission reductions in aquaculture licensing.

6.2.4 Main drivers and enablers for aquaculture

There are no requirements in aquaculture licensing for production companies to reduce their energy use and GHG emissions. Nonetheless, it *appears* that many aquaculture companies are concerned with doing something about this issue, and especially the switch from diesel generators to power-from-shore on production sites seems to be well on its way, aided by financial support from state agency

Enova. According to an informant (Bellona), approx. 70% of all sites in Mid-Norway now have power-from-shore. Allegedly this is the highest share in Norwegian production regions. It is partly due to a beneficial situation in terms of many production sites being geographically concentrated and located in proximity to grid connections, the latter being a barrier in more Northern parts of Norway. Hence investment costs are reduced. State agency ENOVA has introduced programmes to support this change. It is a relatively low-cost investment that has a short payback time. Aquaculture companies report reduced energy costs, and improved working (HSE) conditions (sound, vibrations, smell, etc.) on the feed barges. Concerns about oil spills etc. are also reduced. For vessels the picture is a bit different (see below) but changes seem to be underway, and many actors argue that change is underway.

In Trøndelag, the county municipality currently provides funding to a collaboration project on new energy solutions that involves the regional aquaculture and renewable energy clusters.

6.3 Regional green growth

6.3.1 The main actors and networks for green growth in the region

Forestry and forest-based industries

Arena Skog: The cluster for forest-based industry in Trøndelag was established in 2004 and from 2014 to 2016 the cluster developed a proposal for getting the status of an Arena under the umbrella of Innovation Norway, SIVA and the Research Council of Norway. In 2016 this was accomplished. The cluster includes not just traditional forestry actors, but also industry companies specialised in processing wooden resources, such as pulp and paper plants, and companies which can process residues from those companies, such as a company specialised in producing biogas. There are 15 core members (4 forestry companies, 7 wood processing companies, 3 forestry entrepreneurs and 1 intermediary – see appendix), 10 cluster companies and 12 R&D organisations. Arena Skog collaborates also with other industry clusters: Future biorefinery (Sweden), NCE Aquaculture, Norwegian Wood (started 2017), Paper Province (Sweden), Foods of Norway (NMBU) etc. The cluster has three focus areas: (1) the use of wood and wooden fibre in new products and value chains: (a) as a feedstock for fish and animals, (b) for composite materials and (c) for packaging, hygiene and tissues, (2) increased use of wood through standardised products, and (3) increased felling activities and improved logistic systems to ensure a better supply with regional forest resources.

Promising pathways appear in connection with the "blue" aquaculture sector. The Biokraft plant located at Skogn, which produces biogas on the basis of residues from the forest-based industry (paper factory from Norske Skog Skogn), the aquaculture industry (ScanBio) and other industries (chicken production, agriculture), has recently become operative. The factory opened in summer 2018, and has already almost reached its full production capacity; the turnover for year 2019 is supposed to be around 250 million NOK, and there already plans for extending the plant's capacity (new investments for 300 million NOK are going to add on an initial investment of 500 million NOK). The factory is owned at 50% by the Swedish Scandinavian Biogas Fuels AB; Trønderenergi owns around 45%, while the last 5% is owned privately by the factory managers. The public sector, in the form of the agencies Innovation Norway and Enova, has contributed to the investments up to around 142 million NOK (counting both loans and grants). The Biokraft factory seems to open the way for other forms of "blue-green" interactions: related projects are in preparation in Trøndelag, thanks to cross-sectoral collaborations among different cluster organisations.

Aquaculture

The main actors in the aquaculture industry are the **production companies** (e.g. Marine Harvest, Salmar, NTS, Måsøval, SinkabergHansen). Informants argue that Mid-Norway compared with other production regions in Norway have a beneficial mix and number of production companies in terms of size and ownership. In short, it appears that this mix of actors allows for productive collaboration on tackling environmental challenges, and also on land (or sea) use issues as production areas are moved from time to time. This culture of collaboration between production companies may potentially provide more fertile ground for dealing with the energy/emission challenge compared with the situation in other regions, particularly because the successful tackling of biological and ecological issues may give more leeway for dealing with less pressing issues (for the aquaculture industry) such as greenhouse gas emissions.

Mid-Norway is also regarded as having a strong aquaculture supplier industry, based on technological capabilities from various industries (e.g. marine, maritime, offshore energy) and from the strong technological R&D knowledge and research institutions in the region (Winther et al., 2017).

NCE Aquatech: the members of this cluster organisation are primarily suppliers, but also some production companies, R&D etc. This cluster organisation is the result of two previous cluster organisations (akvArena and Smart Water Cluster) from the region joining forces. The cluster focuses on technology rather than biological issues.

SFI Exposed: a centre for research-driven innovation led by SINTEF Ocean that focuses on aquaculture farming in more exposed areas (i.e. further offshore than current practices).

The **regional government** (county municipality) appears to be heavily involved in industry developments, partly due to its several roles that impact directly and indirectly on sectoral development. That is, the regional government is both regulator (e.g. coastal planning), developer (e.g. education programmes) and funder (the county has its own development fund). In terms of energy and emissions, the county municipality however appears to have a relatively minor role and interviews suggest that there is limited interest from policy makers to include e.g. emissions licensing policy. As an example of funding, the region is currently funding a "pre-project" on reducing energy use/emissions from the industry. This is a joint project between NCE Aquaculture and the Renewable Energy Cluster in Trøndelag.

6.3.2 The main processes of green growth in the region – how have they unfold?

Forestry and forest-based industries

Ideas for new products, or for innovative modifications of existing products, have often appeared in forest-related sectors in Trøndelag, but the development of such ideas has encountered difficulties. Knowledge of the potential markets has sometimes not been available to innovators; this is true both in terms of intermediate markets and in terms of end markets: in other terms, it is difficult for inventors in the sector to grasp the needs and desires of end-users. Potential markets, often located abroad, are not always recognizable to inventors. From the supply-side, international collaboration seems to occur more easily; for instance, machines for wood felling are often Finnish or Swedish; Swedish-owned actors, like PFI, or Austrian-owned actors, like Kartong FollaCell, have joined regional industry clusters in Trøndelag; industrial R&D projects have involved Denmark and Sweden, for instance on wood construction. These types of supply-side collaborations have helped on the demand-side, by creating channels towards international markets.

Digitalisation can have a strong impact in the future for improving logistics. Value chains in forest-related sectors are diverse and involve both small and big actors; therefore, while logistics improvements would be welcome, some coordination effort will be needed to fully exploit the potential of digitalisation. In particular, information gathered on forest-based industries in connection to felling and transportation may be sensitive; large R&D projects can thus help to win resistances for what concerns the processes of information sharing along the whole

chains. Efforts are currently devoted to build and guarantee such information sharing in the future.

Attempts to involve the whole value chain in R&D projects are becoming possible also thanks to sectoral clusters. Arena Skog is an important example in this direction; interviewees point out that, in forest-related sectors, a huge lift is needed which could not be achieved by a single business. There are promising R&D directions involving new uses of wood-fibres: wood-fibre based fish and animal feed, as well as other wood-fibre composites; the main challenge here is represented by developing these new types of fibre-based products at a cost that will be profitable in a realistic market. At the same time, entering the expanding market of wood construction products, especially through the standardisation of products for wood construction, is becoming a priority. A general need for exploring all these directions is ensuring a stable supply of raw materials both on the long and the short term.

In terms of funding, R&D projects are built through an intelligent allocation of funds; one of the interviewees, from Innovation Norway, has explained how "case processing" activities involve understanding which funding source would be most appropriate for each project. In other words, when there is a valuable idea for a project, it becomes essential to understand which particular funding line, or combination of funding lines could be used, taking into account the legal and political constraints to public funding. The fact that the wood business has received much positive attention in recent and current times makes it much easier to reach funds for promising projects, even in comparison with only ten years ago. For the particular case of funds coming to forest-related firms through Innovation Norway, which administers both lending and direct funding, the praxis is for loans to cover physical investments, mostly for buildings and machines, and for direct funding to cover non-material investments, especially in relation to development projects.

When considering new projects, and in general the restructuring of the forest-based sectors toward new valorisation pathways, it becomes essential to distinguish between the needs and possibilities of big actors and of small actors. Platforms like Arena Skog involve several large and diverse actors; such comprehensive clusters can define new paths for the whole sector and can shape entirely new value chains. A large potential for innovations can be disclosed, since large actors already possess many of the necessary connections to overcome the typical obstacles and can thus focus more easily on more radical innovation processes. On the other hand, new and/or small actors in forest-related sectors need external help on a much wider range of issues; specific external actors, like "Tredriver", must then support minor firms on issues regarding markets, collaborations, policies, machinery imports and even employee education and recruitment. However,

small actors in the sector can be more dynamic than large ones: even if more advice is needed for them, they can move very fast along with technological and organizational changes.

Aquaculture

The development and introduction of new energy solutions for fish farming production activities/sites and the various vessels that are used in the aquaculture industry appears to be driven primarily by economic and environmental concerns from within the industry itself. Energy technology suppliers (e.g. ABB) and environmental NGOs (e.g. Bellona) have played important roles in setting greenhouse gas emission reduction on the agenda for the aquaculture industry.

Technological solutions that are mature, such as power-from-shore to feed barges, have to considerable extent been implemented in aquaculture in the region. An added benefit of substituting diesel generators with electrical solutions is that it improves HSE conditions for personnel (e.g. less vibration and noise) and also reduced risks of oil or diesel spills. However, new solutions are needed for sea farming sites that are further from shore, or where connection to onshore grids for other reasons is not feasible. The cluster organisation NCE Aquatech alongside the regional renewable energy cluster (Fornybarklyngen) have recently set this issue on the agenda.

Regulatory push to reduce emissions from the aquaculture industry is currently lacking and does not appear to be on the agenda of policy makers in the region nor nationally.

Aquaculture companies appear to have new energy solutions also for various types of vessels (workboats, fish and feed carriers) on the agenda, but also seem to be cautious in terms of making investments. A main concern is that new energy solutions (e.g. battery-electric solutions) are not sufficiently proven and robust, creating insecurity regarding both safety issues for crew and personnel (e.g. on work boats), and potential problems with power systems on fish carriers.

This case (understood as a regional industry development path) should not be regarded as path creation (i.e. the emergence of a new industrial development path), but rather path transformation or upgrading. This is because innovations – both in farming technologies and energy solutions – appear to be brought into the established aquaculture socio-technical system without major disruption to the system as such.

6.3.3 What industry sectors have been involved?

In the case of forestry and forest-based industries, several industries have been involved, such as biogas and the interacting industries (aquaculture and pulp and paper plants etc. as sources of the feedstock and transport sector as the sector deploying the biogas and agriculture using the biorest from the biogas production).

- Aquaculture (dead fish)
- Pulp and paper plant (Norske Skog Skogn)
- Recycling
- Chicken production
- Biogas production (Biokraft)
- Biogas distribution (AGA)
- Transport sector (use of LBG)
- Agriculture (biorest for farmers)

For aquaculture, the current transformations in the aquaculture sector in terms of developing and implementing more environmentally-friendly energy solutions seems to be driven mainly by initiatives in the industry itself (with support from public funding agencies such as ENOVA), with new solutions both on farming equipment and energy/emission issues leading to new types of linkages between sectors. Most notably this involves

- technological know-how from the offshore O&G and maritime sector to large-scale offshore constructions,
- technological learning from the maritime sector for vessels, and
- new linkages with the energy sector as a result of e.g. power-from-shore and the need for grid connection.

6.4 Conclusions

The case study is about the bioeconomy in the Trøndelag county, here we studied two very different parts of the bioeconomy: forestry and forest-based industries and aquaculture. While in the forest-related bioeconomy case value creation was focused on value creation from forest resources, the aquaculture case focused on the transformation of the sector towards more sustainable energy solutions. However, we have also addressed some linkages between the two industries: mainly the valorisation of residues, both from aquaculture and from pulp and paper production links these two cases.

For both industries the development of cluster organisations has been essential: Arena Skog for the forest-based industry and NCE Aquatech Cluster for aquaculture. These cluster organisations appear to be important in terms of facilitating interaction and collaboration across traditional sector boundaries.

Aquaculture constitutes a large and important sector in Norway, both in terms of export earnings, employment (particularly in many coastal peripheral regions) and as an important market for various technology suppliers and service providers. There are clear visions and expectations that the aquaculture industry will expand both in Trøndelag and elsewhere in Norway. However, future growth critically hinges on the industry being able to meet a series of pressing environmental challenges, of which biological and ecological issues (e.g. fish health, local pollution) currently are the most pertinent. Reducing the carbon footprint constitutes an emerging challenge that the industry appears to be conscious of, however it is not currently high on the agenda in the industry as a whole. The lack of policy awareness *per se* appears to represent more of a lacking driver than a barrier to green growth in aquaculture, although including emission targets in aquaculture licenses would clearly give clear incentives for industry actors to contribute more to the development and implementation of new energy solutions. Aquaculture actors in Trøndelag have set new energy solutions on the agenda and several initiatives to develop and implement new solutions are underway, whereas solutions such as power-from-shore (to production sites) are now regarded as mature. Upscaling of aquaculture – and the development of much aquaculture activities further from shore – will require other technological solutions for energy provision than those that are currently available.

6.5 References

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7 Hordaland: Green Maritime

Summary

This case study focuses on greening of the maritime industry in Western Norway in general and on electrification of ferries in the Hordaland region in particular. Although electrification of ferries reached a milestone with the commissioning of the first electric ferry in 2011 (MF Ampere) this should be understood in relation to the long-term development of alternative energy sources such as LNG from the 1990s. The maritime industry is a large industry in Norway and is one of Norway's oldest industries. It is also one of the few Norwegian industries that are large on an international scale (DNV-GL 2016). The maritime industry should also be seen in relation to the strong tradition of fisheries and the oil and gas sector, which in sum constitutes a cluster of related maritime industrial activities that have emerged from Norway's comparative advantage given the vast coastline, ocean space and oil and gas reserves. The industry employs around 110,000 people and creates value for around NOK 175 billion annually (Menon 2015). The public sector has taken a lead role in decarbonizing the industry with particular attention, so far, to electrification of short-distance passenger vessels. Innovative public procurement has been a vital policy instrument to the progress seen so far. The case can be interpreted as being primarily about greening of an existing industry, but it also has elements of new actors entering the existing industry; particularly in electric systems and equipment.

7.1 Background information

7.1.1 Geographical location

Shipbuilding and shipping are among Norway's oldest forms of business activities. The topography and the long, fjord-cut coastline made the coastal road the most natural mode of transport. In addition, boats were needed to exploit the rich fishing resources (Jakobsen and Espelien 2011). The maritime industry has been and

is still of great importance for settlement, value creation and employment, especially in rural areas.

Figure 10: Map of Hordaland, a narrow geographical reading of the demarcation of the case study

Figure 11: Map of Western Norway, a discretionary geographical reading of the demarcation of the case study

The case study on electrification of the maritime sector in Norway is from the outset defined as primarily focusing on the Hordaland County. One reason for using national county lines for setting boundaries to the case study is to make the case comparable and in line with the other respective case studies to be accomplished under the GONST umbrella. However, in order to do justice to the case on understanding the greening of the Norwegian maritime sector in general, and electrification of ferries in particular, it is necessary to expand the analytical scope to also include other parts of the national coastline. This expanded lens will then naturally cover the four counties that constitute Western Norway; i.e. Rogaland south of Hordaland, and Sogn og Fjordane and Møre og Romsdal north of Hordaland, and even also to some extent Trøndeland and Nordland. Such a discretionary reading of the geographical demarcation of the case study still constitutes a region within the national context but transcending the county lines of Hordaland.

7.1.2 Industrial specialization and path dependencies

The Norwegian economy has traditionally been resource intensive and has been specialised around the subtraction, processing and exports of raw materials such as oil, gas and fish, and energy intensive processing industries such as metals and chemicals. The maritime industry is one of Norway's oldest industries and currently it employs around 110,000 people and creates value for a total of NOK 175 billion annually (Menon 2015). The strong position of the maritime industry in Norway should be seen as a result of the strong tradition of fisheries and the oil and gas sector, which in sum constitutes a cluster of related maritime industrial activities that have emerged from Norway's comparative advantage given the vast coastline, ocean space and oil and gas reserves.

The maritime industry is defined as 'businesses that design, develop, build, delivers, maintains, modifies, owns, operates and sells ships, equipment and specialized services for all types of ships and other floating units' (Jakobsen and Espelien 2011). The maritime industry consists of four main groups of activities; 1) shipowners (deep-sea, short-sea, offshore and drilling), 2) shipyards (shipbuilding, maintenance, repairs and modifications), 3) maritime equipment suppliers (mechanics, electronics and operating control systems), and 4) maritime services (design, brokering, finance, engineering, classification, R&D, and logistics) (Ibid.).

Norwegian maritime businesses have to a large extent specialized in high-tech market segments, including dry bulk, chemical tankers, offshore supply ships and car freight, and are in the forefront internationally in the development and use of cleaner energy solutions, such as liquid natural gas (LNG) and battery (Regjeringen 2018). Norway is one of the few high-cost countries that still build ships. In return, these are very high-tech and advanced, which is an important competitive

advantage for the shipyards. The equipment suppliers are responsible for deliveries of products within.

An important characteristic of the maritime industry is that it is international in nature and with great exports of goods and services. In 2013, the maritime industry was Norway's second largest export industry succeeding oil and gas, and accounted for 38 per cent of Norway's total exports, excluding oil and gas (Menon 2015). The industry's share of total value creation in Norwegian industries is 11 per cent, excluding oil and gas (Ibid).

Norway is the world's 5th largest shipping nation in terms of value, the world's 7th largest shipping nation measured in terms of the number of ships, and the world's 11th largest shipping nation measured in tonnage (UNCTAD 2016). The maritime industry has long been directed towards the petroleum activities, and the decline in the level of activity on the Norwegian shelf also affects the maritime industry.

The importance of maritime industry is greatest in Western and southern Norway. In Møre og Romsdal the maritime industry accounts for more than 30 per cent of total value added from industry, whereas in Hordaland, Rogaland, Vest-Agder and Aust-Agder the share is around 20 percent. Throughout the last 10-20 years the industry has become more concentrated in regional and specialized industry clusters (Regjeringen 2015; Menon 2015). At the same time the industry is very internationally oriented and has high export rates (Ibid). The economic growth in the maritime industry has been strongest in the regions that are closely affiliated with the offshore industry, such as Møre og Romsdal and Rogaland. Hordaland, which is being characterised by a concentration around international and industrial shipping (Regjeringen 2015; Menon 2015), the economic growth has been weaker. However, the growth seen in this region can be linked to growing offshore activities (Ibid).

7.1.3 Sources for the case study

- 2 scoping interviews
- Media analysis, Retriever / both qualitatively and quantitatively
- Document analysis
- Participation at industry/policy seminar on zero emission fjords and renewable maritime sector, ZERO and NCE Maritime CleanTech, Oslo, 10.04.18
- Participation at ZERO conference on electrification of the maritime sector, Bergen, 15.10.18
- Observation of industry/policy workshop online: https://www.regjeringen.no/no/aktuelt/innspillsmote-om-infrastruktur-for-alternative-drivstoff-i-transport/id2593430/

- Accomplished 24 semi-structured interviews with representatives from both policy and industry:

Table 7: Details of expert interviews in Hordaland

Nr.	Organisation	Sector	Location
1	GREENSTAT	Industry	Hordaland
2	Siemens	Industry	National
3	ABB	Industry	National
4	NCE Maritime CleanTech	Industry cluster	Hordaland
5	Maritimt Forum Nordvest	Industry cluster	Møre & Romsdal
6	County administration	Public authority	Hordaland
7	Norwegian Maritime Authority	Public authority	National
8	Norwegian Public Roads Administration	Public authority	National
9	ENOVA	Public agency	National
10	NVE	Public authority	National
11	Bergen Havn	Public authority	Hordaland
12	KS Bedrift	Interest organisation	National
13	Mørenett, Tafjord	Industry	Møre og Romsdal
14	Trondheim Havn	Public authority	Trøndelag
15	Skyss	Public authority	Hordaland
16	BKK	Industry	Hordaland
17	Torghatten	Industry	Nordland
18	Rasjonell Elektrisk Nettvirksomhet AS	Industry	Hordaland
19	Innovation Norway	Public agency	Hordaland
20	DNV-GL	Industry	National
21	ZERO	Interest organisation	National
22	The Fjords	Industry	Sogn og Fjordane

23	Maritime Bergen	Industry cluster	Hordaland
24	Green Coastal Shipping Programme	Public-private	National

In addition, this case plans to draw on interview data from the GREENFLEET and TRAZEPO projects.

7.1.4 Important policy documents considered for the case study

National policies

- Meld. St. 41. 2016-2017. Klimastrategi for 2030 – norsk omstilling i europeisk samarbeid
- Regjeringen. 2015. Maritime muligheter – blå vekst for grønn fremtid. Regjeringens maritime strategi, ed. NFD.
- Regjeringen. 2018. Maritim næring. www.regjeringen.no.

Regional policies

- Bergen Kommune. 2016. Grønn Strategi. Klima- og Energihandlingsplan for Bergen.
- Hordaland Fylkeskommune. 2014. Klimaplan for Hordaland 2014-2030. Regional klima- og energiplan.

7.2 Barriers and drivers for regional green growth

Barriers and drivers for regional green growth in this case relates to the achieved as well as the planned electrification of the short-distance ferry segment of the maritime transport sector (see 3.4). The extent of this electrification is indicated by the figure above (Sjøtun 2018).

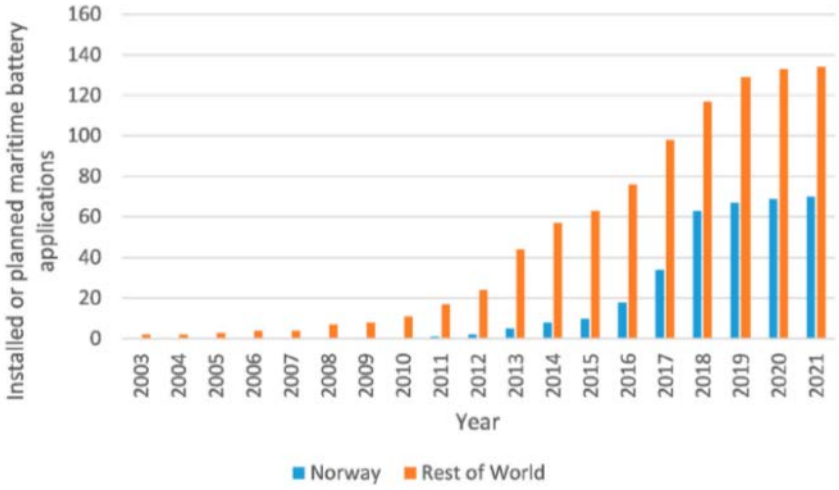

Figure 12: Development of maritime battery ship applications in Norway and the 'Rest of the World' (Reproduced with permission from the Maritime Battery Forum)

7.2.1 Main barriers

Following potential barriers for the electrification of the maritime passenger segment in Western Norway have been identified:

In the maritime sector in Western Norway the structure of the short-sea passenger transport segment of the industry poses some challenges. It consists of many SMEs with limited financial resources, both due to their size and due to the limited duration of operating contracts, which makes it hard for some of these actors to invest in and upgrade their fleet.

Barriers are also found in the **power sector**. The incentive structure underpinning the electricity grid providers (nettselskapene) in the energy sector constitutes another barrier to the developments and upscaling of the electrification of the maritime sector, in the sense that they do not have any economic incentives for investing in infrastructures for electrification of ferry harbours. This is due to the incentive structure provided by the network regulator (NVE); particularly the so-called "Inntektsrammemodell" which the grid providers are subject to, and in which they receive allowance for the total number of customers they serve, and where each new ferry harbour represents huge investment costs but only counts as one new customer. The regulator is reviewing its practices and planning to make changes to allow diffusion of electric vessels to move faster. Also, the industry structure of the energy sector, which consists of many small actors, both grid companies ('nettselskaper') and power suppliers ('kraftselskaper') in sum represents a frag-

mented industry structure and that may hinder coordinated development and innovation. The issue of power sector regulation is essentially national although the regulatory regime in particular proves insufficient in these concrete local contexts in Western Norway. This is due to the uniqueness of the challenge. To upgrade peripheral grids to serve one major, volatile customer simply doesn't make much sense within the existing regulatory paradigm.

Technology: In general, the capacity, performance, and price of lithium batteries set a limit to which types of transport that can be electrified. The energy use profiles of vessels also influence the feasibility of installing battery-electric systems on ships. It is however still an open question which types of hybrid vessels will come to dominate vessels operating at longer distances. This seems a balance between electric battery and hydrogen solutions, whereas also LNG and biogas are potential low-carbon options. These issues are however not barriers to the already planned electric ferries.

7.2.2 Main drivers and enablers

Government regulations in terms of aims for reduction in climate gas emissions at international, national and regional levels:

- Internationally: The regulatory regime developed by IMO (International Maritime Organization) provides a blueprint for countries to develop their maritime transport infrastructure in a safe, efficient and environmentally sound manner. IMO aims to halve CO2 emissions by 2050 and has established 14 Particularly Sensitive Sea Areas (PSSAs) as well as global regimes for greener and cleaner ship recycling. IMO has also established a regime to prevent air pollution from ships and to regulate emissions of greenhouse gases (IMO 2015).
- Nationally: The White Paper on transition of the Norwegian economy emphasizes that the transport sector constitutes a substantial part of Norwegian CO2 emissions and aims to reduce emissions from the transport sectors with 35–40 percent by 2030 compared to 2005. (Meld. St. 41 2016-2017).
- Regionally: Emissions of greenhouse gases in Hordaland shall be reduced by 22% by 2020 in relation to 1991 and 40% by 2030 in relation to 1991. Energy use in Hordaland shall be reduced with 20% by 2020 and with 30% by 2030 in relation to 2007 (Hordaland Fylkeskommune 2014).
- Municipal: Differentiated harbour taxes by Port of Bergen.

Innovative public procurement at national level orchestrated by the Norwegian Public Roads Administration (NPRA) whose 'procurement model' was subsequently imitated by Skyss and Hordaland County Council at the regional level. Through their early adoption of the procurement model of the National Public

Roads Administration Skyss and Hordaland County was pioneers among national counties.

- Did this model contain support for R&D? Could their application contain R&D elements?

Support for R&D and innovation

- Regional: NCE's (NCE Maritime CleanTech)
- National: ENOVA, a public organization dedicated to supporting low-carbon innovation, played a crucial role in providing finance for developing electric charging infrastructure. According to network regulation, the new buyer of power that causes new investments to the power grid, must pay for the expenses. In some cases, this significant amount was provided by ENOVA. This proved important for getting the supporting infrastructure in place. Enova have different support programmes, i.e. for power-from-shore infrastructure, new energy solutions on vessels/ships etc.
- National: The Pilot-E scheme: a new R&D-innovation support programme jointly established by the Research Council of Norway, Innovation Norway and Enova. In the first round (2015), maritime transport was the focus area. The idea is to provide 'streamlined' policy support throughout the innovation journey, i.e. from R&D through to (potential) commercialisation.
- National/regional: Demonstration projects: The first full-electric ferry, Ampere, served as a demonstration project that created widespread legitimacy and political momentum for this solution (Sjøtun 2018).

Close collaboration across the public sector and industry

Networking and arenas for joint reflexivity and coordination

- Industry/policy seminars on green maritime (Organized by e.g. the environmental NGO ZERO and DNV-GL)
- Green Coastal Shipping Program 2015-2030 (Coordinated by DNV-GL)
- And several more, e.g. Maritime Battery Forum (administered by DNV-GL)

Innovation in adjacent industries: Reducing emissions from the maritime transport sector has been discussed for decades. Recent technological innovations however helped change the landscape and feasibility of different technological solutions. A key game changer was the rapidly falling cost and improving performance of lithium-ion batteries e.g. through application in electric vehicles. This changed the cost and not least expectations to future cost dramatically, and made actors reconsider the battery option. The performance improvements in battery manufacturing are a global phenomenon.

The existing industry specialisation in shipbuilding: Prior specialization may in some cases pose barriers to change. In this case, the existing knowledge underpinning the maritime sector provided a key platform for building electric vessels. A main reason being that relatively minor changes / innovations were needed. Both ferries and also other ships are furthermore retrofitted with batteries. Therefore, the electric ferries being developed in Norway do not constitute a 'disruptive' game changer in shipbuilding. The practice-oriented and incremental innovation model observed in the Norwegian maritime industry may be contrasted by a more R&D intensive innovation strategy in terms of developing electric vessels that may represent more radical innovation to shipbuilding i.e. new whole system design vessels including new materials, structure, etc. Indeed, the business sector including suppliers and operators lobbied extensively for stricter public regulation to create a niche market for electric ferries (Sjøtun 2018). In other words, green growth is promoted by incumbent players generating patterns similar to a 'transformation pathway' (Geels and Schot 2007).

7.3 Regional green growth

7.3.1 The main actors and networks for green growth in the region

- NCE Maritime Cleantech
- Skyss
- Hordaland County Council
- The municipality of Bergen
- Maritime Bergen
- Innovation Norway, Bergen

7.3.2 The main processes of green growth in the region – how have they unfold?

The public sector has taken a lead role in the electrification of ferries, and the use of innovative public procurement has been important to the development. The green developments seen can be characterised as the public sector demanding new and more environmentally friendly technologies for the ferry routes they have been responsible for. The Norwegian Public Roads Administration (Statens Vegvesen) in charge of several ferry routes along the coast took a lead role by commissioning green solutions for their procurement of new ferries. In 2010 the Norwegian Public Roads Administration's decided to announce an environmentally ambitious development contract, and in 2015 MF Ampere was in operation, as the

world's first 100% battery-powered car ferry. In the development contract environmental requirements was used actively as an award criterion for the purchase of ferry services, and environmental performance is weighted up to 30%.

The insights and experiences generated from this initial round of development paved the way for further greening of the maritime industry (Sjøtun 2018), and subsequently they trickled down to both ferry operators, shipyards, the supplier industry and to the regional public administrations. In Hordaland, Skyss, an agency owned by the Country Council continued with the green development contracts initiated by the Norwegian Public Roads Administration and ensured a similar green profile in their procurement of ferries to operate the 17 coastal routes they are in charge of. In addition to the Hordaland County Council the municipality of Bergen has also played a proactive role in relation to the electrification of the maritime sector. As ship traffic accounts for a significant part of the local air pollution in Bergen the municipality and Bergen Port Control (Bergen Havn) have contributed proactively to the greening of the maritime sector through electrification of the harbour and by introducing environmentally differentiated port charges in Bergen (Bergen Kommune 2016).

Succeeding the development of MF Ampere the Norwegian Public Roads Administration has continued the same type of innovative procurement for another 11 ferry routes. By 2021 there are expected to be more than 60 ferries in operation with battery installations on board. In parallel with a strong state setting the direction for greening of the maritime industry, existing industry actors such as DNV-GL has played a central role in advising the public authorities in the procurement processes. The electrification of the maritime industry should also be understood in relation to the long-term commitment and development of alternative energy sources such as LNG from the 1990s. For many years, the Norwegian Public Roads Administration has worked on environmentally friendly ferries. MF Glutra was put into operation in 2000, and today 21 LNG operated ferries are operating in the Norwegian ferry market.

In addition to innovative public procurement, other policy instruments, such as the Research Council of Norway, Innovation Norway, Enova, the Nox Fund, all contribute to a number of measures being taken in ongoing ferry contracts to implement new environmentally friendly technologies; e.g. rebuilding of existing ferries for full or partial electrical operations, and arranging for new ferries prepared for hybridization or full-electric operation.

7.3.3 What industry sectors have been involved?

The transport sector is our focal sector. Within it, we further focus on the maritime sector subsystem whose main function is to provide short-distance passenger

transport. Within this segment, our focus is on understanding the development and diffusion of battery-electric ferries (i.e. our focal technology). Involved in development and diffusion of battery-electric ferries are several different types of sectors. First, networks of industry actors from a range of different sectors such as manufacturing, engineering, and electrical equipment. Second, actors from both public, private and civic sectors and their interaction have been important. Third, as electrification of ferries implies changes to the electricity network, the relationship between the transport sector and the power sector becomes crucial.

7.4 Conclusions

The case study is a story about a successful accomplishment of low-hanging fruits. The short-sea segment which has been electrified only constitutes less than one third of total CO_2 emissions from the maritime industry, so there are still huge technological barriers and challenges in terms of reducing emissions within the deep-sea segment of the industry. Still, spearheaded by Ampere the case has proved that it is possible to make significant progress, and which has given further impetus and political legitimacy for decarbonizing the maritime sector.

The case study has three main findings:

First, it highlights how various actors from private, public and civic sectors have all been proactively pushing for and created legitimacy for green policies, which have been seen as a way to ensure increased competitiveness for the maritime industry. There has been a close collaboration between diverse actors towards common goals.

Second, in terms of policy and regulation, international regulation and climate strategies from IMO have trickled down and been succeeded and complemented industry initiatives and national policies (e.g. White papers in 2014 and 2015, and innovative public procurement), regional policies (innovative public procurement) and municipal policies.

Third, the success of the case should be understood as a consequence of the strong position of the maritime industry in Western Norway. Longstanding collaboration, networks and arenas constitutes an important industry platform for the green shift witnessed in the ferry segment. In this sense the case may be interpreted as exemplifying how directionality has been assigned to an existing system of innovation.

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8 Scania: Biogas development

Summary

This case study addresses the development of the biogas industry in Region Scania (in Swedish Skåne). The case study highlights the reasons for the successful development of biogas in region Scania by showcasing the role of strong alignment with the waste management, agricultural and food sector and public transportation sectors in the region as well as strong system building activities by the regional stakeholders and strong political support by the regional government. Furthermore, the case study also highlights the gradual slow-down in the development of biogas in the region by emphasizing the role of key factors such as lack of diversification for alternative markets by the regional biogas producers, competition with electric vehicles and import of cheap and double subsidized biogas from Denmark making it difficult for regional biogas producers to compete at the market rates.

8.1 Background information

8.1.1 Geographical location

The region Scania located in Southern Sweden is one of the densest populated regions in Sweden, and due to its strategic location, it has also been a transit region for movement of goods and people in Scandinavia. Figure 1 shows a map of the region.

Scania has a high urban density with important hubs such as Malmö, Lund, Helsingborg, Landskrona, Ystad, Hässleholm and Kristianstad. Geographically, these seven localities are spread throughout Scania. The region was created in the year 1997 with the merging of the Kristianstad County and Malmöhus County and Scania becoming a self-governing region with a regional council. Scania also has been the part of the dynamic Öresund Region and becoming a strategic hub between Europe and the Scandinavia.

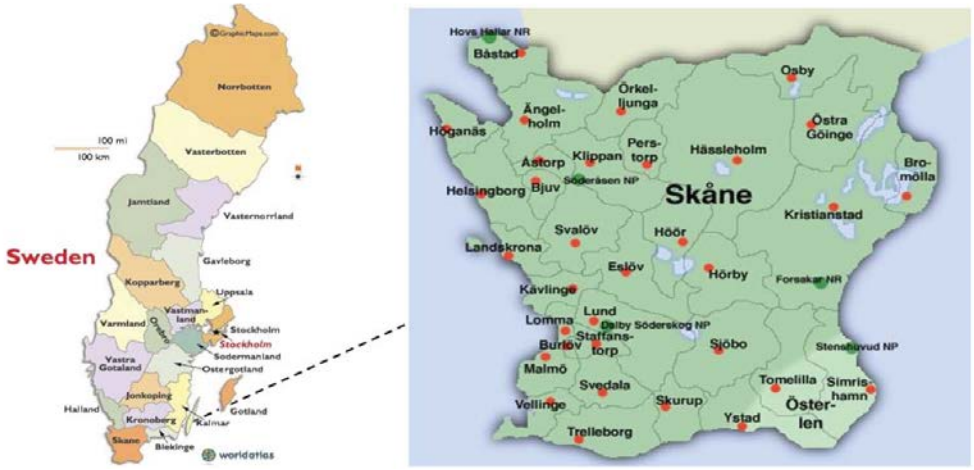

Figure 13: Map of the Scania region (Source: Ericsson et al., 2013)

8.1.2 Industrial specialization and path dependencies

The region Scania already had favourable preconditions for the development of the biogas industry due to accumulated competencies in the agricultural and food industries and exploitation of waste residuals from the industries. The biogas industry also benefited from established competencies in wastewater treatment plants in the region as many municipalities in the region also planned to utilize wastewater treatment plants for biogas production. The presence of other related supportive industries such as equipment and gas vehicle manufacturers, engineering consultancy firms, plant engineering companies offering turnkey biogas plants and equipment for biogas upgrading, wastewater treatment and waste handling firms was useful for supporting the emerging biogas industry. Furthermore, the presence of prominent firms such as E. ON and Malmberg Water, Purac Läckeby, in the region helped to support biogas development in region Scania strongly (Ericsson et al., 2013; Martin & Coenen, 2015).

8.1.3 Regional green skills

The Scania region is fairly average in terms of share of share and number of employees with green skills. The region has a workforce working in the green sector and even 0.17 % of employees working in green occupations based on their educational background. The region is behind leading and specialized regions such as Västernorrland and Östergötland.

8.1.4 Regional green technologies

The GONST WP3 report focuses on patenting activity at the NUTS2 level, but the Scania region is a NUTS3 level region (South Sweden, Code: SE044). It is therefore difficult to say anything specific about this region in terms of its patenting activity. The leading regions in Sweden concerning patenting activity include regions such as Stockholm, Västsverige, Småland and Östra Mellansverige. The Scania region lags behind the leading regions in Sweden in green patenting activity.

8.1.5 Natural endowments or related information

The region Scania has been blessed with good natural conditions for the development of the biogas sector. The region is characterized by high amount of biomass through stronghold in the agriculture and food industries in the region as well as a good waste management system which ensures the availability of household and industrial waste for the production of biogas in the region. The availability of organic residual waste from farms and a high population density of the region also facilitated the development of the biogas sector. Furthermore, the region Scania has also benefitted from the availability of good infrastructure regarding the presence of gas network through the western part of the region as well as the presence of companies providing distribution infrastructure for biogas (Ericsson et al., 2013; Martin & Coenen, 2015; Martin & Martin, 2017).

8.1.6 Sources for the case study

The empirical case study is based on expert interviews as well as archival data sources. For the study 13 experts, semi-structured interviews were carried out to understand the opinions and perspectives of different regional stakeholders. The details of the expert interviewees are mentioned in table 1.

Table 8: Details of expert interviews in Scania Region

Nr.	Professional designation	Type of organisation
1	Environmental strategists	Regional government agency (interview with four experts)
2	Senior Lecturer	Regional University
3	University lecturer	Regional University
4	Doctoral student	Regional University
5	Researcher	Environmental research institute
6	Environmental strategist	Regional government authority

7	Strategy manager	Regional government authority
8	Project manager	Energy agency
9	Project manager	National gas agency
10	Senior advisor and managing director	Regional waste management and recycling (interview with two experts)
11	University Lecturer	Regional University
12	Director	Regional biogas association
13	Regional politician	Regional political party and regional council

Apart from the semi-structured interviews, different types of archival data sources such as industry reports, academic articles, government policy documents, regional strategy documents, newspaper articles, etc. were utilized. The insights from the semi-structured interviews and the archival data sources were combined to discuss the main results from the case study.

8.1.7 Important policy documents considered for the case study

National policies

The LIP and KLIMP programs by the Swedish government offered significant support to biogas development. The Local Investment Programme (LIP) which ran between 1998-2002 and the subsequent Climate Investment Programme (KLIMP) between 2003-2008 supported several local projects including biogas projects for reducing energy use and greenhouse gas emissions in Swedish municipalities. The KLIMP program offered significant support to biogas projects by targeting municipalities who could receive grants and subsidies for creating long term support for biogas development.

In 2009, the EU adopted the renewable energy directive which set a target for achieving 20 % renewable energy sources in the EU and use of 10 % renewable energy in the transport sector by 2020.

In January 2018, the Swedish government's new climate policy also came out which advocated for new climate goals and long-term stable policy to reduce emissions in transport by 70 percent by 2030 and new biogas; the committee was also announced. The Swedish gas association working together with the biogas industry also has proposed a new biogas strategy to achieve 15TWh biogas by 2030 and advocating for long term stable policy framework for biogas development in the future.

Regional policies

In 2007, the regional government announced a new public plan for all public transport in the region and for meeting the target for fossil fuel free region by 2020. The regional public transport organization Skånetrafiken decided to invest in biogas and use it in the regional public transport due to some economic and environmental advantages offered by biogas.

In 2010, the County Administrative Board of Scania (Lansstyrelsen) set up a climate goal for the region while keeping biogas as a key solution for achieving the targets. Climate collaboration was also initiated between Region Scania the regional authority, county administrative board of Scania and the local municipalities for working together on climate change challenges in the region.

In 2009, region Scania also released the fuel strategy for transition to renewable energy and became free of fossil fuels by 2020.[8]

In 2015, the regional government introduced a roadmap for biogas development in close collaboration with the regional biogas association Biogas Syd with the target of 3 TWh by 2020. Multiple political parties in the region agreed with the overall purpose of the roadmap and future opportunities for biogas in the region, steps to be taken for implementing the targets and how Scania can become a frontrunner concerning biogas development.[9]

In 2018, the County Administrative Board of Scania together with region Scania and municipalities in the region developed a climate and energy strategy for Scania.[10]

In 2018 a proposal for centralizing the business promotion activities to the central government also created uncertainties for regional development agencies in Denmark. A new plan was about to be implemented where the regional growth forums would no longer be active. The regional authorities would no longer work on business promotion and the work on business development would be carried out by the central government by giving the responsibility to the National Business Promotion Board.

[8]https://www.skane.se/globalassets/styrandedokument/rs__215_09_branslestrategi.pdf?highlight=fordonsgas

[9] Skånes färdplan for biogas in 2015: https://utveckling.skane.se/siteassets/publikationer_dokument/skanes_fardplan_for_biogas_strategisk_del.pdf

[10] Ett klimatneutralt och fossilbränslefritt Skåne – Klimat- och energistrategi för Skåne. Länsstyrelsen Skåne (https://www.lansstyrelsen.se/download/18.2e0f9f621636c84402734c0d/1528979328191/Klimat-%20och%20energistrategi%202018.pdf

8.2 Barriers and drivers for regional green growth

8.2.1 Main barriers

Over-reliance on a single customer and lack of demand diversification: The biogas industry in the region has exclusively relied on the public transport agency Skånetrafiken as its sole buyer which required a stable demand for biogas for public transport in the region. However, there was a gradual shift when the regional transport agency decided to shift its focus from biogas alone to a more diversified focus on all types of renewable fuels and use of electric vehicles as well for achieving the regional climate goals. The biogas producers in the region did not put significant efforts in diversifying their customer base and exclusively relied on the regional government agency thereby facing difficulties when the regional government agency modified its public procurement rules.

Competition with alternative industrial paths: Biogas development in the region has faced significant competition with the emergence of electric buses as the regional transport agency Skånetrafiken decided to also use electric vehicles for achieving the emission goals set by the region. The regional politicians, transport authorities and the general public also started seeing biogas as an inferior solution for meeting regional transportation needs when compared to electric buses due to better environmental benefits, reduced noise, and minimum exhaust emissions. The perception of biogas as a strategic fuel for meeting regional energy, transportation, and economic needs suddenly changed to an old and traditional solution no longer useful. Electric buses were pushed as a solution to regional climate and transport challenges thereby leading to loss of legitimacy for the once promising biogas industry in the region.

Competition with cheap subsidized biogas from Denmark: During 2017, the import of biogas increased to region Scania as the several industries in Scania decided to import biogas from Denmark as it was cheaper due to double subsidy it received as a result of production subsidy in Denmark and also benefits of exemption of tax on biogas when imported into Sweden. The problems occurred due to different support mechanisms for biogas than the rest of the EU as Sweden did not support biogas development using production subsidies like most other EU nations. The cheaper imported biogas thereby created problems for locally produced biogas as it became less competitive and expensive for potential buyers. The unfair competition between the locally produced biogas and cheaper imported biogas from Denmark pushed the market price to such an extent that it was no longer possible to maintain the delivery agreements with public transport authorities when the contract expires. Furthermore, Swedish biogas producers would be

forced to shut down their business due to lack of long-term commitments from potential buyers (Smith, 2017).

8.2.2 Main drivers and enablers

Positive interaction with the existing regional sectors: A key initial trigger of biogas development in the region was related to the availability of suitable infrastructure (presence of natural gas grid and availability of infrastructure for production, transport and distribution of biogas) in the region and presence of supportive industries such as equipment and gas vehicle manufacturers, plant engineering companies offering turnkey biogas plants and equipment for pre-treatment and biogas upgrading, wastewater treatment and waste handling firms. However, the most important driver for biogas development has been the strong positive interaction between the biogas industry and broader regional sectors such as waste management, agricultural and food production and regional public transport.

For instance, the waste management companies in the region and the municipalities committed to providing waste from households, wastewater treatment plants and slaughterhouses for biogas production. Commitment from the local farmers and food production companies provided access to agricultural residues for biogas development. Similarly, the strong commitment from the regional transport authorities helped to use biogas for regional transportation for reducing the greenhouse gas emissions, reducing traffic noise and improving the urban air quality provided a long-term support mechanism for biogas. The regional transport authority Skånetrafiken was also instrumental in procuring biogas for using it in the regional public buses from the regional biogas producers through the public procurement process (Martin & Martin, 2017).

Strong regional political support: The emergence of the biogas industry in Scania was triggered due to support from both national and regional policy initiatives such as the LIP and KLIMP programs during the earlier phases and enhancing legitimacy for the regional biogas industry. The municipalities in the Scania region also received far more grant than municipalities in other Swedish regions for supporting new biogas initiatives (Martin & Martin, 2017). These programs were followed by several regional initiatives and programs such as goals for fossil fuel free region and developing a roadmap for biogas thereby showing the clear commitment of the regional government to support biogas as it would help them solve problems of regional transportation, meeting emission targets, and waste management (Region Skåne, 2015). A considerable risk taken by the regional government was to buy the biogas produced by regional biogas producers through a public

procurement process and guarantee a stable market framework for biogas in the region (Aldenius & Khan, 2017).

8.3 Regional green growth

8.3.1 The main actors and networks for green growth in the region

A large number of actors and networks have been involved for biogas development in region Scania. Concerning the regional government authorities, region Scania is the highest political organization responsible for regional development, development of business, public transport and environment and climate issues. Another regional organization, the County Administrative Board of Scania has extensively focussed on climate and energy issues by developing energy and climate strategies and ensuring their implementation.

Furthermore, the municipalities within the region have supported biogas development by providing access to regional waste for biogas development by being responsible for collection and transport of waste as well as providing access to waste from wastewater treatment plants and slaughterhouses. Skånetrafiken is a particularly important actor for public transportation within the region and also becoming the main buyer of the regionally produced biogas. Further, there are some waste collection and management organizations such as Sysav and NSR and municipal wastewater treatment firms which have played an important role in providing the substrate for biogas production.

Biogas Syd, the regional biogas association has worked with promoting biogas in the region and focussed on facilitating knowledge exchange between public and private actors in the regional biogas value chain, carrying out studies and developing new biogas roadmaps with other stakeholders and even carrying out advocacy work for ensuring long term policy support for biogas by working together with national biogas and Swedish gas association. The region Scania also has the regional cleantech cluster organization Sustainable Business Hub with some private firms engaged in different types of activities related to the cleantech sector.

The biogas value chain in the Scania region consisted of a range of actors including feedstock producers such as farmers and industrial food processors involved in the supply of the feedstock to biogas plants. The natural gas grid in Scania is managed by Lunds Energikoncernen and Öresundskraft utilities and energy companies like E. ON, Lunds Energikoncernen and Öresundskraft involved in downstream segments of the biogas value chain, i.e., biogas upgrading, distribution, and retail. The biogas value chain has relied on many supporting activities by actors such as plant engineering firms involved in development and upgrading of biogas plants like Purac Läckeby, Norups Gård, and Malmberg Water, equipment

and gas vehicle manufacturers, engineering and consultancy firms involved in providing technical services (Ericsson et al, 2013; Martin & Coenen, 2015).

8.3.2 The main processes of green growth in the region – how have they unfold?

The main processes of regional green growth in the region include close collaboration between different regional stakeholders including regional government agencies like Region Scania, County Administrative Board of Scania, regional council, regional transport organization Skånetrafiken, regional universities like Lund working closely with the biogas stakeholders, waste management firms, industry associations and several actors which are part of the biogas value chain (Martin & Coenen, 2015). Biogas development in the region triggered because of strong interaction between the emerging biogas industry and the existing sectors in the region such as the agricultural and food sector, waste management and public transportation. Positive support for an emerging regional industry due to strong alignment with the wider political structures such as support for biogas development at the EU level and supportive policies by the Swedish government at the national level accelerated biogas development in the region (Martin & Martin, 2017).

The other key process for green growth in the region also include the decision of the regional government to target fossil fuel transport by 2020, and the regional transport authority Skånetrafiken and transport operator Nobina decided to invest in biogas for running public transport in the region and buying the biogas produced in the region through a public procurement process. This decision proved to be very crucial as it created a strong regional market for biogas, push for development of renewables in the region and push the agenda for developing a bigger market for biogas in the region.

By using very specific criteria instead of a general functional criterion for procurement of regionally produced biogas, the regional authorities were also supporting biogas despite the increase in costs as a result of using specific criteria during public procurement of biogas. The regional politicians in Scania accepted the increased costs for biogas by introducing specific requirements during public procurement process as they took a long-term perspective and believed in the immense potential of biogas for enhancing regional economic growth in the region as well as meeting the environmental goals (Aldenius & Khan, 2017).

Furthermore, biogas development in the region has benefitted from collective system building activities to enhance the legitimacy of the industry. At the same time, biogas industry in the region has suffered and faced challenges due to the presence of competing for industrial paths such as the development of electric vehicles for serving the public transportation needs with support for one industrial

path undermining the development of another industrial path. Another setback and challenge to the regional industry have happened due to positive development in a similar industry at a different geographical scale, i.e., Denmark (Smith, 2017).

8.3.3 What industry sectors have been involved?

The biogas industry in region Scania has had close linkages with the regional agricultural and food sector, public transport sector and waste management sectors. Apart from close linkages with these sectors, there are other promising sectors in region Scania including life sciences with some bio-business, moving media, and gaming, ICT and cleantech. The biogas sector in the region also has benefitted from cross-fertilization with the regional cleantech cluster called sustainable business hub which has around 80 members specializing in recycling, waste management as well as sustainable transportation. Although the member organizations in the sustainable business hub belong to different industries, they still share common linkages in terms of contributing to climate change and the development of sustainable innovations.

8.4 Conclusions

Although the biogas industry in Scania began with a promising start and scaled up rapidly until 2011, it faced significant challenges due to strong competition with the emerging electric vehicle sector and direct competition with cheaply imported biogas from a neighboring country Denmark. In the recent years, the biogas sector in the region saw a considerable reduction in investment with biogas producers not being able to sell their biogas due to overreliance on a single buyer, i.e., regional public transport authority Skånetrafiken. For the future of the regional industry, there is a need for more stable and transparent rules at the national level in terms of long-term support mechanisms and stable incentives to reduce uncertainty for future investments in the regional biogas industry.

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9 Värmland: Bioeconomy development

Summary

This case study addresses the development of bioeconomy in the Swedish region of Värmland. The report presents the characteristics of the region and the framework for developing bioeconomy in region Värmland. The case study focusses on the role of broader set of actors and their different strategies for regional path development. Furthermore, this case study emphasizes the role of fringe actors such as civil society which advocate for alternative models of regional industrial path development. The case study is based on 11 semi-structured interviews with regional experts and archival data sources. The report provides an overview of the key processes involved in developing bioeconomy in the region and the key barriers which hinder achieving the bioeconomy vision in the region.

9.1 Background information

9.1.1 Geographical location

The Swedish region Värmland is located in the western part of central Sweden and has traditionally dependent on natural forest resources. The region Värmland has close links with western Sweden, i.e., Goteborg, and it is also located in between Stockholm and Oslo thus forming an important connection between Sweden and Norway. The figure below shows the map of the region Värmland.

Forests cover a large part of region Värmland, and it is also located on the banks of the large lake Vanern which has been useful for efficient transportation of transport and for generating hydroelectricity for the mills in the early 19th century (Sölvell, 2009).

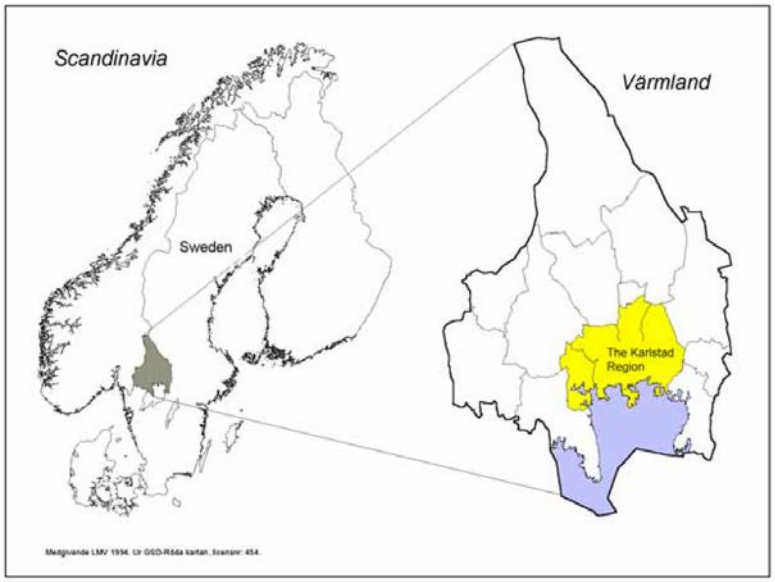

Figure 14: Map of the Värmland region (Source: OECD, 2006)

9.1.2 Industrial specialization and path dependencies

The Värmland region has specialized in pulp and paper mill activities from a long time, and the mature industrial structure in the region contributed to the development of pulp and machinery activities in the region. From the 1930s, the region had some engineering firms building machinery for the pulp and paper industry and equipment suppliers of process equipment for the regional industry. The equipment manufacturers were located within a few regional municipalities such as Karlstad, Hagfors, and Säffle with the employment centers in Karlstad, Kristinehamn, and Storfors. Beyond a few large pulp and paper firms and SME's related to the pulp and paper industry in the region, there was also a prominent iron and steel industry in the region (Sölvell, 2009).

Furthermore, exchange of personnel between the different industries in proximity to each other has also helped to create a fertile, innovative environment in the region. The unique presence of skills and competencies from the paper and pulp industry and the different suppliers and SME's in the region has led to the development of a pulp and paper industry with a strong historical tradition in the region. The small size of the region also meant that there had been an informal culture of collaboration between the different industries in the region for gaining access to relevant tacit knowledge and exchange the skilled workforce. However, the pulp and paper industry faced a decline as a result of structural challenges in the 1990s leading to loss of profitability for the industry.

9.1.3 Regional green skills

The Värmland region is fairly average in terms of share of share and number of employees with green skills. The region has around 1.58 % workforce working in the green sector and even 0.19 % of employees working in green occupations based on their educational background. However, the region is behind leading and specialized regions such as Västernorrland and Östergötland.

9.1.4 Regional green technologies

The GONST WP3 report focuses on patenting activity at the NUTS2 level, but the Värmland region is a NUTS3 level region (South Sweden, Code: SE061). It is therefore difficult to say anything specific about this region in terms of its patenting activity. The leading regions in Sweden concerning patenting activity include regions such as Stockholm, Västsverige and Östra Mellansverige. The Värmland region lags behind the leading regions in green patenting activity.

9.1.5 Natural endowments or related information

The pulp and paper industry in the Värmland have had a long-term tradition in the region Värmland due to the rich natural resource base in the region as a result of large forest over in the region and increasing annual growth of forest volume in the region. The pulp and paper industry in Värmland started to grow during the beginning of the 19th century due to easy access to timber, efficient water transportation due to the presence of Lake Vanern as well as access to cheap hydroelectricity. Due to the good location of Värmland around the banks of the Lake Vanern, the pulp and paper firms, iron ore and the mining industry have developed in the region. As Värmland region has been located near the banks of a large lake Vanern, many industries such as forestry, iron, and steel were developed along the shores of the lake often providing access to easy transportation for raw material and for generating cheap hydroelectricity for the mills in the region. Region Värmland also had a unique combination of assets for pursuing the bioeconomy sector in terms of access to relevant natural resources, industrial infrastructure; technical know-how and access to relevant skills and people and organizations within the forest bioeconomy.

9.1.6 Sources for the case study

The data for this case study is based on 11 semi-structured interviews (see table 1) with regional experts and extensive archival data sources such as scientific ar-

ticles, documents, newspaper articles, industry newsletters, regional strategy reports, legal documents, policy documents, and video material in regional policy events.

Table 9: Details of expert interviews in Värmland Region

Nr.	Professional designation	Type of organisation
1	Strategist, Regional growth development	Regional development agency
2	CEO	Regional cluster organization
3	Director, Business Development	Research Institute
4	Strategist, Energy, and Environment	Regional development agency
5	Professor	Regional University
6	Consultant	Pulp, and Paper Industry
7	Innovation Manager, Municipality and Project coordinator	Open testbed initiative
8	Independent consultant	Consultancy on cluster development and smart specialization
9	Mill Director	Pulp and paper firm
10	Researcher	Regional University
11	Former CEO	Pulp and paper firm and business consultant

Apart from the archival data sources and the semi-structured interviews, observations were also made in public forums related to bioeconomy in Värmland. The insights from the semi-structured interviews and the archival data sources were combined to present the main results of the case study.

9.1.7 Important policy documents considered for the case study

National policies

The Swedish government has emphasized the need for a comprehensive policy approach for developing bioeconomy and one of the five strategic groups appointed

by the Prime Minister focuses on the realization of the circular and bio-based economy. In 2012, the Swedish government agency FORMAS in consultation with the innovation agency VINNOVA released a report for the development of a bio-based economy.[11]

The Nordic Council of Ministers also has run several programs such as the Nordic Bioeconomy Panel related to bioeconomy. Furthermore, at the EU level, the economy has received special emphasis in the Horizon2020 framework program and different European technology platform such as the forest-based sector technology platform. The vast number of European RIS3 (Regional smart specialization strategy) support different bioeconomy initiatives and a wide variety of instruments ranging from promotion of networks and clusters, development of physical infrastructure, training and capacity building and technology transfer.

Regional policies

At the regional level, some initiatives have been implemented in Värmland. Värmland has implemented the cluster initiative Paper Province for the pulp and paper industry in the region with financing provided from the regional authority Region Värmland and the regional pulp and paper firms. The sources for financing the innovation system in Värmland today are EU ERDF (EU Regional Development Fund) (Interreg), Vinnova (Swedish innovation Agency), Tillväxtverket (Swedish Agency for Economic and Regional Growth) with support from region Värmland, regional municipalities in Värmland, Karlstad University, research institutes such as Innventia and SP Research Institute. In Värmland, the Academy of Smart Specialization has been funded €15 million over five years based on funds from the region and academia.

The national innovation agency VIINOVA has also been instrumental in providing funds for bioeconomy related activities. In 2013, the regional cluster organization Paper Province in Värmland received approximately funding of €13 million over ten years intending to transform the pulp and paper industry in Värmland into a forestry-based Bioeconomy from the Vinnväxt program under VINNOVA. Forest-based bioeconomy became a high priority under this program in region Värmland. In 2015, the regional development authority Region Värmland developed the Värmlands Research and Innovation Strategy for Smart Specialization (2015–2020), which was organized together with Karlstad University.[12]

[11] https://www.formas.se/download/18.462d60ec167c69393b91e60f/1549956092919/Strategy_Biobased_Ekonomy_hela.pdf
[12] http://s3platform.jrc.ec.europa.eu/documents/20182/232763/SE_V%C3%A4rmland_RIS3_2015_Final.pdf/9235776f-2438-4fa3-b91e-7748234b9633

In 2016, a new initiative the Academy of Smart Specialization also received €15 million over five years for transformation. The Forest-based Bioeconomy is one of six areas that serve as the foundation of the Academy for Smart Specialisation.

9.2 Barriers and drivers for regional green growth

9.2.1 Main barriers

Peripheral nature of the Värmland region: The Värmland region has faced challenges similar to many non-metropolitan regions such as relatively low participation in higher education and difficulties in attracting skilled workforce to the region, an aging population, challenges related to rural-urban migration and gender imbalance in the workforce. Värmland has gone through a long period of change where the number of people working in the region has declined due to mechanization of industries in the region as the young people in the region have often moved out of the region to seek higher education and employment opportunities in other regions. The labuor market in the region has been gender-segregated with women and men in different sectors and industries and women often not finding enough opportunities to work in the male-dominated pulp and paper industry in the region (Kempton, 2015; Henriksson, 2016).

Limited attention to values and perspective from civil society: The transition towards a bioeconomy in the Värmland region has also been criticized for often ignoring values and perspective from environmental organizations and civil society thus often excluding certain key sections of the society. There are very limited provisions for involving the civil society, consumers and environmental organizations in the transition to bioeconomy. The civil society including the forest associations in the region has often advocated for prioritizing other values such as tourism, outdoor life and recreation, hunting and fishing and leisure for promoting bioeconomy rather than just commercial and industrial exploitation of the forests in the region. The forest associations and civil society has also advocated for more participation in the regional smart specialization process and to provide more opportunities for women as forest owners and engineers in the traditionally gender segregated and male-dominated pulp and paper industry. However, there are also debates regarding too much involvement of the civil society and environmental organizations in the regional policy process as the firms might consider them to be activists and as a threat to their business activities thereby impeding collaboration with the different regional stakeholders (Grundel & Dahlström, 2016).

Tendency for structural maintenance in the regional pulp and paper industry: The pulp and paper firms in the Värmland region are quite mature and have developed well-established competencies in the industry which often makes it difficult for them to suddenly shift their activities to bioeconomy as they are also interested in deepening their existing specializations. The large pulp and paper firms in the region have continuously invested in improving their energy usage, reducing water consumption and reutilize waste streams in the paper mills. They are also co-operating in different testbed initiatives for extracting lignin and developing high value-added products. They are also developing more open innovation initiatives where they can collaborate with start-ups. However, despite these promising initiatives, there is not very radical pressure for change as the incumbent firms tend to still focus on deepening their existing specializations. Furthermore, the large firms are still reluctant to co-operate with their competitors on key issues which impact their overall profitability in the long run. They are often not willing to share their trade secrets with the cluster initiative Paper province and tend to be still conservative about the new bioeconomy initiatives in terms of completely modifying their existing business models.

9.2.2 Main drivers and enablers

Crises in the regional pulp and paper industry in the 1990s: The dominant pulp and paper industry in the Värmland region experienced crises during the 1990s created an urgency to improve the financial productivity of the industry, replace older machines and equipment with new technological solutions and utilize the waste streams in the mills thereby making the mills more energy efficient. Furthermore, the rapid advent of digital media and internet also led to a reduction in demand for newspaper print and printing paper leading to the closure of multiple firms. On the other hand, the demand for other types of papers such as packaging cardboard and liquid board increased gradually (Sölvell, 2009).

Cluster-based specialization and smart specialization strategies: In the Värmland region, a key driver has been the different cluster initiatives for promoting the forest-based bioeconomy. In Värmland, one of the earliest cluster initiatives was the Paper Province, established as a unique business cluster of prominent pulp and paper firms in the region seven established as a member organization for firms in the pulp and paper industry, regional authorities, civil society organizations and SME's providing different types of services. The vision of the Paper Province is to become a leading centre for promoting forest-based bioeconomy in Europe and to demonstrate bioeconomy in practice. Furthermore, the region Värmland has also adopted the Regional Smart Specialisation Strategy (RIS3) for promoting forest-based bioeconomy in the region. The region also adopted the new

cluster strategy Värmland 2.0 for regional growth and for promoting bioeconomy in the region (Academy of smart specialization, 2016).

9.3 Regional green growth

9.3.1 The main actors and networks for green growth in the region

The region Värmland has some actors and networks directly involved in the bioeconomy sector. The Pulp and Paper Industry in Värmland has a large number of paper mills and packaging production units operated by Stora Enso, Billerud, Rottneros, Nordic Paper, Tetra Pak and major machinery and process systems suppliers such as Metso, Andritz, Voith, and consultants. The successful exploitation of the forest areas in the region created a unique cluster initiative such as Paper Province in the region. The cluster initiative Paper Province established as a unique cluster of firms, regional organizations, a university in the region thereby creating a unique platform for all the regional stakeholders to interact with each other.

The regional government authority Region Värmland has been responsible for promoting regional development, create competitiveness for the region and promote sustainable growth. Other regional public organizations include the County Administrative Board of Värmland which serves as a link to the central government and the municipalities and is also responsible for planning regional development.

The University of Karlstad (Värmland) has also played an important role in being an important knowledge source and innovation partner for the regional industry. Karlstad University has undertaken co-operative research with the pulp and paper industry in pulp, pulp and printing technology, and material and chemical engineering and contributed to the regional path development process.

Other important regional actors include the research institute RISE institute Inventia which has collaborated with the municipality of Kristinehamn, Vinnova, firm Nordic paper, Paper Province and other different stakeholders for developing the open innovation site Ligno city for developing new products such as lignin, carbon fibre, etc. Furthermore, there are emerging innovative start-ups such as Modvion developing wind tower technology by replacing steel and concrete constructions with an environmentally friendly wood-based material; Re:newcell developing solutions for converting used cotton and other natural fibres into new biodegradable pulp and Drinor which focuses on solutions that allow for higher utilization of biomass through an innovative mechanical dewatering process.

9.3.2 The main processes of green growth in the region – how have they unfold?

The main processes of green growth in the region include the strong partnership and close co-operation between the regional government, industry and Karlstad university for promoting the bioeconomy vision in the region. The main processes of green growth in the region have been focussed on first utilizing the opportunity gained from the crises and the decline in the regional pulp and paper industry in the region in the 1990s to create the cluster organization, Paper Province. The crises in the regional industry were used as a means to stimulate collective action between uninterested pulp and paper firms in the region to come together for saving the regional pulp and paper industry from crises.

The strong collaborative culture within the region between the regional authorities, pulp and paper firms, equipment manufacturing and engineering companies, knowledge-intensive consulting services, SME's and Karlstad University also helped in creating a strong infrastructure for bioeconomy development in the region. The regional public authorities have also exhibited leadership by setting up a strong agenda and vision for bioeconomy development in the region and also influencing the EU level and Swedish regulations for supporting the bioeconomy in the region. However, the incumbent firms in the region have mostly focused on maintaining existing institutional structures by focusing more on short term incentives by continuing to exploit existing profitable opportunities in the pulp and paper industry. However, they are also contributing to the development of bioeconomy by co-operating in different testbed initiatives and pilot projects for developing new high value-added products. Further, innovative entrepreneurs are also contributing to green growth in the region by utilizing waste streams from the pulp and paper industry and collaborating with the large firms in the region on different pilot projects.

9.3.3 What industry sectors have been involved?

In the region Värmlad, apart from the pulp and paper and bioeconomy industry, some other industries have been involved which include iron and steel, mining, timber, steel and engineering products, ICT and service sector, food and packaging and design. The region also has a number of different industry cluster initiatives such as in pulp and paper (The Paper Province), ICT and telecom (Compare), packaging (The Packaging Arena), steel and engineering (Steel & Engineering), tourism (Visit Värmland), local food (Nordic Innovation Food Arena) and healthcare (Innovation Hub VIVAN Health Care). The cluster initiatives are based on co-operation between firms, public organizations, educational institutions and other intermediary associations in the region Värmland.

9.4 Conclusions

The bioeconomy sector is an essential part of the regional economy in Värmland in the future as the crises in the existing pulp and paper industry in the 1990s paved the way for the development of bioeconomy in the region. It is perceived that the bioeconomy sector will have a strong position in the regional development program in the future but there are still some critical challenges such as (1) peripheral nature of the region Värmland making it difficult to attract high quality skilled workers; (2) vested interests of the incumbent pulp and paper manufacturing firms in structural maintenance and exclusive focus on exploiting existing competencies and ; lack of involvement of civil society and other fringe actors in the regional bioeconomy vision despite the strong partnerships between the regional industry, university and the regional authorities. The main lesson is to have a realistic vision of the future of bioeconomy in the region by developing consensus between the regional actors for gradually reducing the barriers.

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10 Concluding remarks

This working paper summarises the results of eight comparative case studies on green growth in four Nordic countries: Northern Jutland and Southern Denmark in Denmark, Tampere and Central Finland for Finland, Hordaland and Trøndelag for Norway, and Scania and Värmland for Sweden.

The eight case studies give some background information and explain the industrial specialisation, natural endowments and other relevant information about the regions before they discuss barriers and drivers for regional growth, analyse the main actors and networks and the main processes of green growth in the respective region, and finalise with conclusions.

The focus of the eight regional case studies is different due to the different developments in the selected regions. We have several case studies which are dealing to some extent with developments in the bioeconomy, as in Scania, Värmland, Trøndelag and in Central Finland, while the case studies on Hordaland, Northern Jutland and Southern Denmark are more directed towards greening the maritime sector and towards offshore wind. The case study on Tampere is quite different with its focus on clean technologies.

The case studies have shown how natural endowments and existing industrial specialisation have influenced the options for new path development in the eight regions, while the cases also show that the entrepreneurship of the regional industries and policy makers have played a decisive role in the chosen focus on the way forward.

Important has been and will be how crises are addressed and new direction be chosen, and actors motivated to collaborate in clusters (Värmland, Trøndelag, Hordaland) or joined platforms (Tampere Region and Central Finland).

It has also been interesting to see that the cases often involve collaboration across several sectors, such as between energy and ship building in the Danish cases and in Hordaland and Trøndelag, or between different bioeconomy sectors, such as in Central Finland, Trøndelag, Scania and Värmland.

Collaboration between the industry and the regional authorities has been shown to be important in all the cases, e.g. in Tampere region, Värmland, Trøndelag, Scania, Hordaland etc.

Some of the cases have shown that new competition can result in challenges for previously successful regional path development, as the case of biogas in Scania has shown. The competitiveness of the region will depend on new ways to address these challenges.

Slow decision making, and slow regulative changes or lack of incentives can be barriers for new path development, as the examples of North Jutland – lacking incentives for further greening of the maritime industry - and of Trøndelag - emission reductions are not prioritised in licences for aquaculture - have shown.

The access to skilled labour has been highlighted in several cases as a challenge for new path development, such as in the two Finnish cases.

Future comparative research will have to address the role of path dependencies, institutional entrepreneurship and policy learning for green growth. The case studies have shown a regional diversification in green growth, which can be explained by different forms of relatedness in the regional context: beside technological relatedness we find relatedness of regional natural resources, regional markets and regional institutions and policies.

Appendix: Core business members of the Arena Skog cluster in Trøndelag

(Source: Purehelp.no)

Name and main characteristic	Operating profit in 2017 in million NOK	Number of employees in 2017
Forestry companies:		
Allskog SA (cooperative of forest owners in four counties: Trøndelag, Møre og Romsdal, Nordland and Troms	20,5	133
Norskog, a cooperative of forest owners working for improved framework conditions	6,1	22
SB Skog, a nationwide company within forest management, timber sales, forest culture and forest clearing	-1,1	53
SF Statskog, a state-owned forestry company, owning large share of Norwegian forests	77,6	110
Forest-based industry:		
InnTre AS, a company producing annually ca 100.000 m3 lumber	7,1	98
InnTre Energi AS, a bioenergy company located in Verdal and Steinkjer	3,5	0
Kjeldstad Trelast AS, specialised in the production of lumber and wooden construction elements, located in Selbu, Støren and Levanger	15,5	131
Moelven Van Severen AS, a sawmill with planer and a member of the wood division in Moelven industry group	5,8	72
Støren Treindustri AS, specialised in prefabricated private houses and public buildings	6,6	129
Norske Skog Skogn AS, with three paper machines Norway's largest producer of news print	-400,3	404
MM Karton Follacell AS, a pulp and paper producer owned by Mayr-Melnhof Karton and located at Follafoss	87,5	67
Entrepreneurs:		
Transportselskapet Nord AS, a transport company owned by ALLSKOG, Norske Skog, Moelven and InnTre	-0,3	5
Monrad Lassemo a forestry entrepreneur mainly for Allskog	n,a	10
Sørli Skog AS, a forestry entrepreneur for SB Skog in Trøndelag.	-0,5	8
Intermediary organisation:		
Skogselskapet Trøndelag, a non-profit organisation promoting the importance of the forest, sustainable forest management and increased value creation.	-1,2	9

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