



NORDREGIO
Nordic Centre for Spatial Development

Bioeconomy in the Nordic region: Regional case studies

Jukka Teräs, Gunnar Lindberg, Ingrid H G Johnsen, Liisa Perjo
and Alberto Giacometti

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Stockholm, Sweden, 2014

Contents

Executive Summary	9
1. Introduction	11
1.1. Nordic bioeconomy in-depth study: Major goals.....	11
1.2. Bioeconomy: Definitions.....	11
1.3. Nordic bioeconomy in figures—the Nordic Innovation Report 2014.....	13
1.4. The structure of this report.....	14
2. An overview of bioeconomy in the Nordic countries	15
2.1. Denmark.....	15
2.2. Finland (including Åland).....	16
2.3. Iceland.....	17
2.4. Norway.....	18
2.5. Sweden.....	19
3. Regional case studies	21
3.1. Lolland, Denmark.....	21
3.1.1 Introduction.....	21
3.1.2 Description of the region.....	21
3.1.3 Administrative structure and governance.....	23
3.1.4 Policy framework.....	23
3.1.5 The bioeconomy of the Lolland Region.....	24
3.1.6 Enabling conditions.....	27
3.1.7 Impeding factors.....	27
3.1.8 Conclusions.....	27
3.2. Forssa, Finland.....	28
3.2.1. Introduction.....	28
3.2.2. Description of the region.....	28
3.2.3. Administrative structure and governance.....	29
3.2.4. Bioeconomy in the Forssa region.....	30
3.2.5. Policy framework in developing the bioeconomy in Forssa.....	32
3.2.6. Enabling conditions.....	33
3.2.7. Impeding factors.....	35
3.2.8. Conclusions.....	35
3.3. South Iceland.....	35
3.3.1. Introduction.....	35
3.3.2. Description of the region.....	36
3.3.3. Administrative structure and governance.....	36
3.3.4. Bioeconomy in South Iceland.....	37
3.3.5. Policy framework and main actors.....	39
3.3.6. Enabling conditions.....	41
3.3.7. Impeding factors.....	42
3.3.8. Concluding remarks.....	43
3.4. Østfold County, Norway.....	44
3.4.1. Introduction.....	44
3.4.2. Policy framework.....	45
3.4.3. Description of the region.....	46
3.4.4. Administrative structure.....	47
3.4.5. Development of a bio-based wood-processing industry.....	48
3.4.6. Opportunities/Challenges.....	51

3.4.7. Concluding remarks	53
3.5. Örnköldsvik, Sweden.....	53
3.5.1. Introduction	53
3.5.2. Description of the region	53
3.5.3. Administrative structure and governance	53
3.5.4. Bioeconomy in the Örnköldsvik region	55
3.5.5. Policy framework for developing the bioeconomy of Örnköldsvik	55
3.5.6. The Örnköldsvik Biorefinery of the Future Cluster	56
3.5.7. Bioeconomy in Örnköldsvik: evolution over time.....	60
3.5.8. Enabling conditions	60
3.5.9. Impeding factors.....	61
3.5.10. Conclusions.....	62
4. Conclusions	65
References	67

Executive summary

This report by Nordregio, commissioned by the Nordic Working Group on Green Growth—Innovation and Entrepreneurship of the Nordic Council of Ministers (NCM), contributes to the knowledge about bioeconomy in the Nordic countries by investigating different cases of regional bioeconomy in five Nordic countries. We have tried to describe and learn from the context, actions, and enabling and disabling factors specific to each region—but these are sometimes strikingly similar. We have focused on the development of specific bioeconomy activities while trying to broaden the analysis to include the implications of a bioeconomy for regional development and policy perspectives. The Nordic regions that have been analysed are Forssa in Finland, South Iceland, Østfold in Norway, Örnköldsvik in Sweden, and Lolland in Denmark.

Although the concept of bioeconomy has been operationalized for some time by the EU (not least within the so called European Bioeconomy Observatory, and as a part of the new EU Framework Programme for Research & Innovation Horizon 2020), it is evident in the Nordic case study regions that the understanding of the concept varies significantly. Some Nordic regions (and actors) have adopted the term “bioeconomy”, whereas other regions are only starting to become familiar with the term.

The intensity and scope of regional co-operation between actors varies significantly among the Nordic case study regions. This ranges from fully fledged regional cluster collaboration (as in Örnköldsvik) to an actor structure with a clear locomotive company without intensive regional co-operation (as in Østfold). Examples of activities taking place within a more fragmented actor structure, with smaller bioeconomy organizations, can be found in South Iceland. The historical development of the bioeconomy and its current path dependence when it comes to building on the strong previous activities colours the current co-operation in a region.

The Nordic cases illustrate the importance of long-term commitment in developing the regional bioeconomy. An arrangement such as VINNVÄXT in Örnköldsvik (a 10-year financial commitment to a future biorefinery initiative) makes it easier for several other actors to commit to regional bioeconomy initiatives. Similarly, the national bioeconomy strategies

(Finland) or important national documents (Danish Bioeconomy Panel) signal long-term commitment. These activities are important for stimulating action in the regions, firms and research centres. Public–private partnerships are frequently mentioned by the respondents in the studies as favourable for developing the bioeconomy in the Nordic regions. However, the public’s role in this must develop to create a favourable playing field for bioeconomy products and solutions. In the past, support has entailed collaborating in the triple helix of regional development, but what is now called for (in all cases) is the facilitation of markets, infrastructure and action by consumers.

Bioeconomy can be an engine for creating jobs and economic activities in rural regions while being beneficial for the environment. Although the cases show examples of successful entrepreneurship, cluster development, creation of specialist firms, and even what can be defined as successful regional innovation systems in a bioeconomy, it is difficult to assess their actual impact on regional development (in jobs or economic activities). Certainly, many jobs have been created and sustained, and this is obviously an extremely important factor in (rural) regional development. It has not been the explicit purpose of this project to count these jobs, but based on the results of the case studies, it is obvious that they are important from a local perspective. The Nordic cases illustrate the possibilities of a bioeconomy in providing jobs and regional growth, not only in an urban context but also in rural environments. However, the large-scale impacts of a bioeconomy development still hinge on the upscaling of market development and systemic changes that would need to take place in society. From a long-term perspective, the “glocal” nature of bioeconomy—global and local at the same time—also opens up new business opportunities for Nordic rural entrepreneurs.

From the case studies, we note a common need in the Nordic countries and regions for a focus on true implementation and definite action on the bioeconomy, including upscaling demonstration plants to larger-scale facilities, and opening up new export markets to bioeconomy products and services. That is, there needs to be a focus on specific policy in many sectors and public policy domains linked to these national strategies.

1. Introduction

1.1. Nordic bioeconomy in-depth study: Major goals

The concept of bioeconomy has become increasingly popular in regional, national and international policy discourse in Europe. Moreover, the concept has been extensively discussed and included in policy-making in Nordic countries. As an example, the Nordic Council of Ministers has among other efforts launched a Bioeconomy Initiative, and in 2013, Iceland chose bioeconomy as one of its main focus areas for its chairmanship of the Nordic Council of Ministers in 2014. Bioeconomy-related business and innovation activities are already under way in the Nordic countries and are currently being studied by various Nordic actors.

This report by Nordregio contributes to the discussion on bioeconomy in the Nordic countries by focusing on its implications for regional development and policy. Case studies conducted in each of the Nordic countries cover regional bioeconomy initiatives in different Nordic settings. Moreover, the report includes a brief overview of the role of policy support, governance structures and other factors in promoting bioeconomy in Nordic regions. The study aims to contribute to public policy development to support innovation and entrepreneurship for green growth at the regional level in the Nordic countries.

The report was commissioned by the Nordic Working Group on Green Growth—Innovation and Entrepreneurship 2013–2016 established by the Nordic Council of Ministers. The in-depth study of bioeconomy is intended to provide knowledge of a key topic of Green Growth by presenting an overview of instruments and by exploring “good practice” case studies of innovation and entrepreneurship in the field of bioeconomy at the national, regional and local levels.

1.2. Bioeconomy: Definitions

Even though the exact definitions of a bioeconomy vary between international actors and between national governments, the main focus of the definitions is often on developing an economy that is based on the sus-

tainable utilization of renewable resources to develop new processes and products. In policy-making, a bioeconomy is in many cases also seen as requiring a cross-sectoral approach that calls for a broad range of system-level changes and innovation.

The OECD has been a central actor in the bioeconomy discussion, and it defines bioeconomy in the following way.

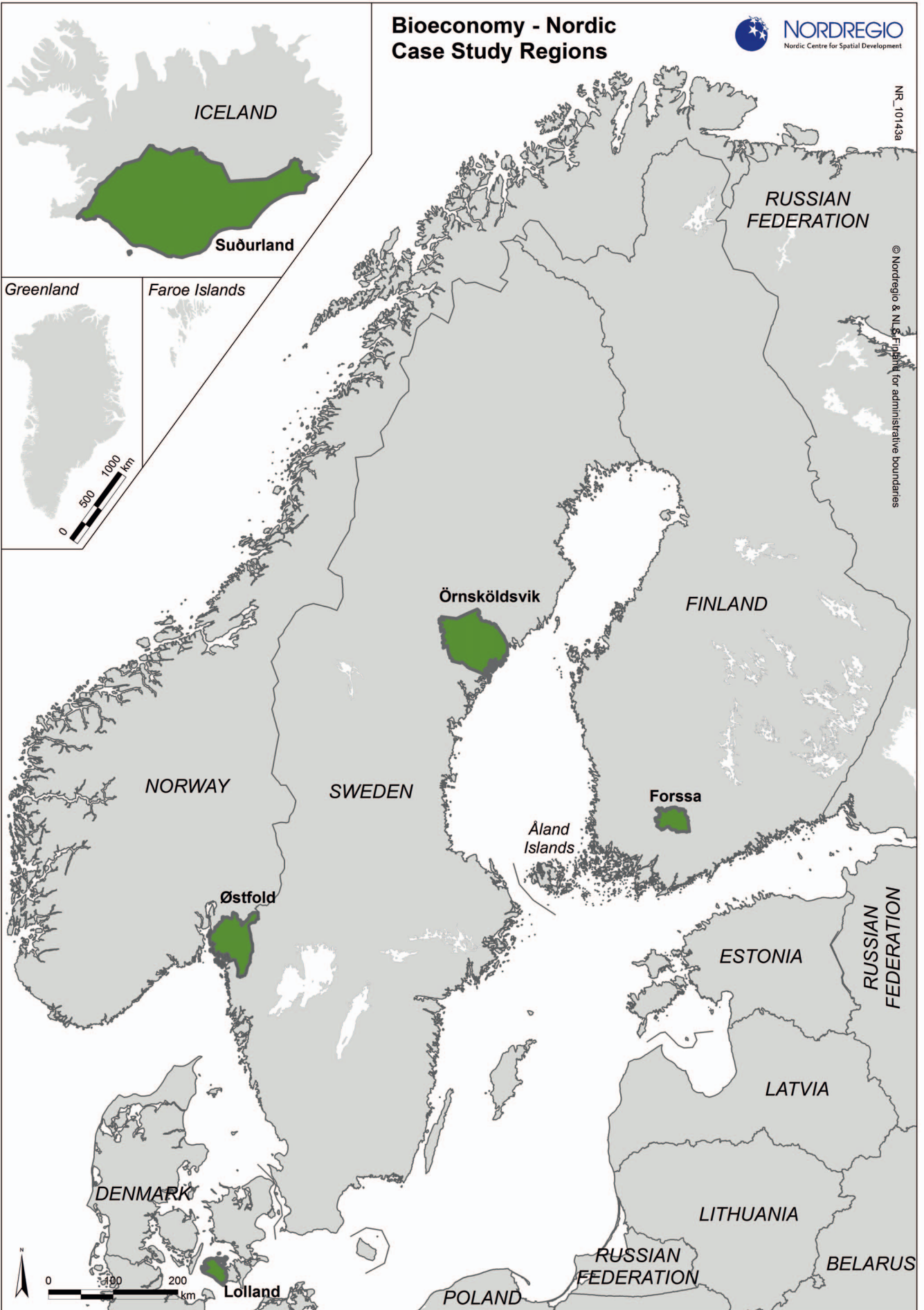
“A bioeconomy can be thought of as a world where biotechnology contributes to a significant share of economic output. The emerging bioeconomy is likely to involve three elements: the use of advanced knowledge of genes and complex cell processes to develop new processes and products, the use of renewable biomass and efficient bioprocesses to support sustainable production, and the integration of biotechnology knowledge and applications across sectors.”

For the OECD in its Bioeconomy 2030 strategy, the main sectors where biotechnology can be applied are agriculture, health and industry. The OECD emphasizes that the emergence of a bioeconomy requires an increased focus on innovation, and it puts weight on good policy decisions as the only way to ensure the development of a bioeconomy with social and economic benefits. In addition, the OECD stresses that the new business opportunities created by social, economic and technological factors will require new types of business models. (OECD 2009)

The European Commission has also prioritized the bioeconomy, which has grown in importance in EU policy. The EU has established a European Bioeconomy Observatory (European Bioeconomy Observatory 2014) and chosen the bioeconomy as a key area of its new Horizon 2020 programme (the EU Framework Programme for Research & Innovation).

According to the EU, “the bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy”. In its “Communication on Innovation for Sustainable Growth: A Bioeconomy in Europe”, the

Bioeconomy - Nordic Case Study Regions



EU considers the bioeconomy to consist of the sectors of food, agriculture, paper and pulp, forestry and wood industry, fisheries and aquaculture, bio-based industries, biochemicals and plastics, enzymes and biofuel sectors.

The EU considers the bioeconomy to have the potential to address some major societal challenges, such as food security and sustainable natural resource management, as well as to reduce dependence on non-renewable resources, creating jobs and maintaining European competitiveness.

Currently, the European bioeconomy has an annual turnover of approximately 2 trillion euros and employs 22 million people. The EU is found to have good potential for developing its bioeconomy, as it is largely self-sufficient in many agricultural, forestry and some marine products. The EU also has high potential for innovation in areas crucial to the bioeconomy. The EU emphasizes that innovation and research are at the core of the transition to a bioeconomy that with its cross-cutting nature can address complex and interconnected challenges while achieving economic growth. (EC 2012a; EC 2012b; EC 2013)

At the Nordic level, the Nordic Council of Ministers (NCM) established a bioeconomy initiative in 2013. In this initiative, a bioeconomy is defined as an economy based on the sustainable production of biomass with the overall objective of reducing climate effects and reducing the use of fossil-based materials. The bioeconomy is based on increased added value for biomass materials and the reduction of energy consumption with the aim of optimizing the value and contribution of ecosystem services to the economy (NKJ 2013).

According to the NCM, “the transformation to a bio-based economy means a transition from a fossil fuel-based economy to a more resource-efficient economy based on renewable materials produced through sustainable use of ecosystem services from land and water. A greater focus on research and innovation can provide us with new products developed from biomass that will replace fossil material, combat climate change, reduce waste and create new jobs.”

As noted, the international institutions at global, EU and Nordic levels seem to be optimistic about the opportunities of the bioeconomy and call for institutional support to fulfil its potential. However, a recent article on the bioeconomy in Europe, reviewing current academic discussions, also addresses the risks related to

large-scale utilization of biomass, stating that the challenge is to “increase the scale of activities in parallel to meeting the key sustainability goals”. The authors of the article emphasize that sustainability needs to be the guiding principle in policy-making to build a competitive European bioeconomy. (McCormick & Kautto 2013) Based on that notion, this report and the included case studies discuss issues related to economic, social and ecologic sustainability of various bioeconomy activities in several regions.

In this report, we adopt the Nordic Council of Ministers’ definition of a bioeconomy. The NCM definition of a bioeconomy is not sector specific; instead, it considers developing the bioeconomy as a toolbox for creating a sustainable society in terms of both production and consumption. (NKJ 2013) In particular in Denmark, Finland, Norway and Sweden, bioenergy in recent years has been the most important area of the bioeconomy, but activities are increasingly taking place in other fields as well. (Nordic Council of Ministers 2009)

1.3. Nordic bioeconomy in figures—the Nordic Innovation Report 2014

According to the Nordic Innovation report “Creating value from bioresources”, the total turnover of the key bioeconomy sectors in the Nordic countries is approximately €184 billion (including agriculture, fisheries and aquaculture, forestry, food industry, forest industry and bioenergy and biofuels). In total, this constitutes 10% of the total Nordic economy. According to the Nordic Innovation report (2014, p.97), the current volume of bioeconomy is 9% of the economy in Denmark, 12% in Finland, 18% in Iceland, 6% in Norway, and 10% in Sweden.

The above mentioned report considers the share of the economy represented by the bioeconomy to be highest in Iceland and lowest in Norway, while potential is identified in various sectors in all of the Nordic countries. It is identified that in the Nordic region, the largest innovation and growth potential in the bioeconomy area is found in its cross-cutting nature. Growth areas are found in a wide range of areas such as bio-based chemicals, biorefineries and industrial symbiosis. Crossing horizontal sectors is identified as a central factor in the development of the bioeconomy in the Nordic region. (Nordic Innovation 2014)

Figure 1: Nordic case study regions presented in this report (Map design by Julien Grunfelder)

1.4. The structure of this report

Chapter 2 presents the current “state of play” in the Nordic countries, in terms of bioeconomy activities already taking place. The overview is based on earlier studies, mainly commissioned by national authorities, which were available in the autumn of 2014.

After the national overview, Chapter 3 presents the case studies conducted in each Nordic country. Chapter 4 presents conclusions on the bioeconomy in Nordic regions and its implications for policy-making to support business and innovation in various bioeconomy fields.

2. An overview of bioeconomy in the Nordic countries

This chapter provides a short overview of current bioeconomy activities in each of the Nordic countries. The description is not exhaustive but is based on studies available in the autumn of 2014. The chapter discusses the main characteristics of the bioeconomy in the Nordic countries to build a framework to the in-depth regional case studies in each country.

2.1. Denmark

The following table offers a brief introduction to the bioeconomy in Denmark, including examples of innovative bioeconomy initiatives.

In 2012, a Growth Team, commissioned by the Ministry of Business and Growth in Denmark, emphasized that the production of advanced bio-based products has great business potential for the biotech industry, as well as for the agriculture, forestry and waste sectors as suppliers of biomass. (Vækstteam for vand, bio og miljøløsninger 2012) Because Denmark has a productive and efficient agricultural industry, which is also among the world's best in utilizing agricultural residues, it is predicted to obtain comparative advantages in relation to the establishment and development of new biorefineries. With approximately 1.5 million tonnes of straw available for biorefineries, Denmark could in principle serve 3–4 full-scale biorefineries of the size of Maabjerg Energy Concept (a biorefinery project that combines several energy (supply) purposes ac-

ording to a holistic systems concept). (Næss-Schmidt et al. 2013) To establish a strong biorefinery sector in Denmark, it needs further R&D in agriculture and forestry, and in the biological and chemical conversion of biomass. (Gylling et al. (2012); Quartz&co 2012)

The contribution from Danish agriculture to bioenergy is relatively high, because 12% of the national energy consumption comes from the utilization of residues such as straw, wood chips and manure—mainly through the use of residues from CHP (combined heat and power) plants. It is possible to quadruple or quintuple the production of biomass from agriculture for bioenergy without significant damage to the production of feed and food. There is a technical potential, but the electricity price from biogas is a barrier to its development, and it is uncertain whether farmers would find it sufficiently profitable to harvest the biomass. (Ministry for Food, Agriculture and Fisheries of Denmark 2008) The Energy Agreement of 2012 set a new objective of utilizing up to 50% of manure in Denmark for the production of biogas. An assessment of the operation and socio-economic costs of biogas production within the new framework provided by the agreement concludes that it is not likely that the objective of 50% will be realized, but with the Energy Agreement, the foundation has been built for increased production of biogas in future. (Jacobsen et al. 2013)

The Danish Bioeconomy Panel, consisting of 27 members representing Danish public and private or-

Table 1: Brief introduction to the bioeconomy of Denmark

Current key branches of the bioeconomy and areas with identified potential	The food industry and agriculture are the dominant sectors. Further bioeconomy development potential is identified in the biotech industry and agriculture, as well as in utilizing the biomass from agriculture, forestry and waste sectors
National bioeconomy strategies and initiatives	Danish Bioeconomy Panel Report 2014 Biorefining Alliance/Green strategy 2012
Examples of innovative bioeconomy activities	Maabjerg Energy Concept, biorefinery in Holstebro DuPont Nutrition Biosciences (Aarhus)

ganizations, published a document in 2014 stating that Denmark has all the necessary prerequisites to develop an even stronger national bioeconomy. The document highlights access to raw material, technology, and the spear-head competences that enable future bioeconomy development in Denmark. However, the document states clearly that certain major principles should be followed to develop the Danish bioeconomy, and it proposes an action plan for the Danish government to contribute to the development of the bioeconomy in Denmark. (The National Bioeconomy Panel 2014)

2.2. Finland (including Åland)

The following table gives a brief introduction to the bioeconomy in Finland and includes examples of innovative bioeconomy initiatives.

Finland has set a course for a low-carbon and resource-efficient society and a sustainable economy. A key role in reaching this goal is played by a sustainable bioeconomy. According to its bioeconomy strategy, Finland is well placed to become a pioneer of the global bioeconomy because it has plentiful renewable natural resources, a high level of expertise, and industrial strengths. The vision of the first Finnish bioeconomy strategy is that Finnish well-being and competitiveness would be based on sustainable bioeconomy solutions. (Ministry of Employment and the Economy 2014)

In 2014, when it published the first Finnish bioeconomy strategy, the government also decided that the bioeconomy would be a focus area of future Finnish economic growth.

According to the Finnish bioeconomy strategy, the bioeconomy's share of the Finnish national economy is 16%. The output of the Finnish bioeconomy currently

exceeds €60 billion, and more than 300,000 people are employed in the sector. The value of bioeconomy exports is currently €14 billion. Approximately 50% of the Finnish bioeconomy is based on forestry. The annual growth of Finnish forestry is more than 100 million m³, of which 55 million m³ is utilized by the industry. In terms of employment, the food sector is an important part of the Finnish bioeconomy. The agricultural sector employs 90,000 people, and the food industry employs 38,000 people.

The objective of the Finnish Bioeconomy Strategy is to increase Finnish bioeconomy output to €100 billion by 2025 and to create 100,000 new jobs. The aim of drafting the strategy was to engage stakeholders in a broad dialogue to contribute to its content. Its implementation is led by the Ministry of Employment and the Economy in co-operation with other ministries and stakeholders.

The strategic goals of the Finnish Bioeconomy Strategy are to achieve:

- a competitive operating environment for the bioeconomy
- new business from the bioeconomy,
- a strong bioeconomy competence base, and
- accessibility and sustainability of biomass.

New bioeconomy business opportunities in Finland will be based on the intelligent use of biomasses and water resources, the development of associated technologies, and high added-value products and services. (Ministry of Employment and the Economy 2014)

The total value of Finnish bioeconomy investments under implementation and planning exceeds two billion euros. Good examples of investments in new for-

Table 2: Brief introduction to the bioeconomy of Finland

<p>Current key branches of the bioeconomy and areas with identified potential</p>	<p>Approximately 50% of the bioeconomy is forest based. Agriculture and the food industry are also central. There is potential to increase the use of wood for fuel. Increasing the use of biofuels would provide opportunities for Finnish businesses. Agriculture has the potential to produce non-food products such as fibre plants for textiles and composites.</p>
<p>National bioeconomy strategies and initiatives</p>	<p>The Finnish Bioeconomy Strategy was published in 2014 and is based on broad stakeholder involvement and ambitious goals to develop the bioeconomy</p>
<p>Examples of innovative bioeconomy activities</p>	<p>Bio oil facility of Fortum in Joensuu Biogas facility of the Metsä Group in Joutseno Lignin refining facility of Stora Enso in Kotka Sybimar fish farming ecosystem, Uusikaupunki</p>

est-based bioproducts are the UPM investment in vehicle fuels in Lappeenranta (completed in 2014), the bio oil facility in Joensuu constructed by Fortum (completed in 2013), the biogas facility in Joutseno constructed by the Metsä Group (completed in 2014) and the lignin refining facility in Kotka built by Stora Enso (completed in 2015). In 2014, the Metsä Group announced a bioproduct facility investment of EUR 1.1 billion in Äänekoski.

In Åland, there is currently increased interest among policymakers in the opportunities for developing the Åland bioeconomy. The adapted strategy to achieve a sustainable society by 2051 provides a good starting point for developing the sector, especially in the fields of energy and food production.

Local bioenergy production has increased over the past decade, but the area is not without challenges because of issues related to technology and markets. A potential for development has been identified in greater utilization of forest resources.

In the traditional fish farming sector, the first project for land-based aquaculture is a good example of new production technology and methods adapted for a traditional sector. Local small-scale production of biodiesel from fisheries waste has increased awareness of alternative resource utilization and environmentally friendly fuels. The challenges faced by entrepreneurs in market confined by size and resources are not unique to Åland, but the constraints imposed by the surrounding sea perhaps make these more pronounced. In many areas, finding solutions implementable on a local scale demonstrates the need for broad local co-operation as well as external partnerships. (Ålands Teknologisentrum 2014)

2.3. Iceland

The following table gives a brief introduction to the bi-

oeconomy in Iceland and includes examples of innovative bioeconomy initiatives.

The OECD Territorial Review of the NORA region (The Faroe Islands, Greenland, Iceland and Coastal Norway) recommends that the region should capitalize on the strong knowledge base acquired through traditional fishing and fish processing activities by developing value-added food and non-food products from the marine sector, such as new nutrients, biomedicines and pharmaceutical products. Many opportunities linked to the better use of by-products, biotechnology, and marine resources have not yet been seized and could represent further opportunities. The blue biotechnology area is a growing sector worldwide, with the search for new biological principles and organisms that have not yet been exploited. Nordic collaboration could result in a combined effort to screen material obtained in the oceans and by-products from the seafood processing industry. (OECD 2011)

The Iceland 2020 Strategy (Prime Minister's Office 2011) includes eco-innovation and sustainability issues. The Icelandic government also chose the bioeconomy as a priority area during its year of chairmanship of the Nordic Council of Ministers, and the current government is also implementing and funding bioeconomy projects.

2.4. Norway

The following table gives a brief introduction to the bioeconomy in Norway and includes examples of innovative bioeconomy initiatives.

In the Norwegian context, the bioeconomy is defined as sustainable land use and the production and conversion of biomass into a host of food, health and fibre products, industrial products and energy (Norwegian Research Council 2012). Renewable biomass includes all biological resources (agricultural, forest-

Table 3: Brief introduction to the bioeconomy of Iceland

Current key branches of bioeconomy and areas with identified potential	Food industry dominates; other strong sectors: fisheries and aquaculture, food industry and agriculture Many opportunities for utilizing by-products, biotechnology and marine resources more efficiently
National bioeconomy strategies and initiatives	The Iceland 2020 strategy includes eco-innovation as one of the main future growth sectors
Examples of innovative bioeconomy activities	Utilizing by-products from fisheries, local-level food innovation Pink Iceland—bioeconomy services; e.g., tourism

based and animal-based, including fish) that are either products in their own right or raw materials for other products or processes.

The total consumption of bioenergy in Norway in 2006 was approximately 14.5 TWh when biofuel is included as an input in the production of district heating (Norwegian Ministry of Petroleum and Energy 2008). This represents 9% of total stationary energy consumption. Approximately half of biofuel use is linked to household consumption (mainly in the form of wood), while a large part of the remainder is associated with the combustion of self-generated biomass in wood and wood-processing industries to cover domestic thermal energy consumption. Norway consumes less bioenergy than Sweden, and this can be explained by structural conditions of industry but also by the fact that Sweden has far more extensive district heating than Norway (Langerud et al. 2007).

In 2008, The Ministry of Petroleum and Energy decided to increase the development of power production from bioenergy by 14 TWh by 2020 (Norwegian Ministry of Petroleum and Energy 2008). This requires the district heating network to be built with a capacity of at least 1.5 TWh per year. However, developments in recent years have been below the target.

The agriculture and the fisheries and aquaculture sectors have potential for the development of a bio-based economy in Norway. There is also a focus on sustainable production and consumption, emission reductions and adaptation to climate change, improved resource efficiency in new and existing biomass production, and full utilization of all biological resources in closed-loop systems. Norway also prioritizes the development of new processes, products and services, and enhanced value creation and competitiveness in the bio-based industries. (Norwegian Research Council 2012)

BIONÆR is Norway's Research Programme on Sustainable Innovation in Food and Bio-based Industries that runs for the period 2012–2021. The overall budget

was approximately NOK 200 million for 2013 (Nordic Innovation 2014). The primary objective of the programme is to promote research that increases the level, profitability and sustainability of production in the value chains of agriculture, forestry, nature-based industries and seafood from the time that raw materials are taken from the sea until they reach the consumer. The secondary and strategic action points addressed in the programme are as follows.

- Strengthen and develop
 - a. knowledge and expertise in selected areas to promote sustainable bio-based industry in Norway, and
 - b. research-based innovation in bio-based companies and bioresource management.
- Implement innovative work forms that involve actors in the research community, trade and industry, the public administration and special interest organizations.
- Use co-ordination and dissemination activities to enhance the benefits of knowledge and expertise gained by the industry and public administration.
- Participate in international co-operation in order to strengthen knowledge building and innovation in priority areas.

Under the BIONÆR Programme, there are four cross-cutting perspectives that apply to all activities, which include achieving complete biological closed-loop systems, incorporating the environmental, social and economic aspects of sustainability across the board, maintaining a consistent focus on market orientation and value creation in the Norwegian bio-based industries, and promoting interdisciplinarity to ensure the societal relevance of knowledge-building under the programme.

In the overall Norwegian context, there is a strong focus on developing existing industries and facilitating the establishment of new industrial activities in the fields of raw material production, processing and

Table 4: Brief introduction to the bioeconomy of Norway

Current key branches of the bioeconomy and areas with identified potential	The food industry is dominant. Other important sectors are fisheries, agriculture and forestry
National bioeconomy strategies and initiatives	BIONÆR 2012–2021, Norway's research programme on Sustainable Innovation in Food and Bio-based Industries
Examples of innovative bioeconomy activities	Borregaard biorefinery Østfold; NorZymeD - Enzyme development for Norwegian biomass

consumption associated with agriculture and nature-based value chains and seafood in the development of a bio-based economy. However a major challenge for increasing the extraction of raw materials for bioenergy from agriculture is primarily related to low profitability. Profitability is directly or indirectly related to market characteristics and conditions of the supply chain as a whole. Against this background, it will be important to facilitate increased feedstock production and the industry gain framework that makes it economically attractive to reap additional biomass suitable for bioenergy purposes.

2.5. Sweden

The following table gives a brief introduction to the bioeconomy in Sweden and includes examples of innovative bioeconomy initiatives.

In the Swedish Research and Innovation Strategy for a Bio-based Economy, the bio-based economy is defined as a resource-efficient economy based on raw materials produced through the sustainable use of ecosystem services from land and water. Life-cycle approaches are central to this endeavour, as well as approaches that take into account the cross-sectoral nature of the bioeconomy. Because of its natural geographical conditions, industry and infrastructure, Sweden has good potential to convert to a bio-based economy. (Formas 2012)

Current climate issues have already contributed to new areas of use for bio-based materials in Sweden. Bioenergy composes approximately one-fourth of the overall energy production of Sweden. The largest current source of bioenergy in Sweden is forestry, but bioenergy is also produced from waste and agricultural products. Fossil fuels for heating have already been replaced almost entirely by biofuels. While heating currently uses the largest share of bioenergy, the use and production of bioenergy in electricity is increasing.

There is also great potential for increasing the use of biofuels in the transport sector. (Formas 2012; LRF 2013)

There is potential for producing biogas from waste and sludge, and for increasing biogas production from sources already in use. Biogas production has been increasing, and biogas production from Swedish farms doubled between 2011 and 2012. Compared with other energy sources, biogas from rotting waste has unique potential in that it can “close” the production cycle. (IVL 2009; Energimyndigheten 2013)

In addition to industries based on agriculture and forestry, the potential for a bio-based economy lies in industries such as transport and the motor industry, construction and the chemical industry. Because a bio-based economy is seen as cross-sectoral, the potential for cross-sector system solutions (such as biorefineries in the form of collaboration between chemical industry, forestry and energy companies) is also important. There is also a great potential in increasing the added value of the renewable raw materials used by current process industries. For example, technology can refine or process raw materials into new products. (Formas 2012; Statistics Sweden 2012)

In terms of biofuels in transport, Sweden is already a forerunner, and 9.8% of the energy used in the transport sector in Sweden was derived from renewable sources in 2011. The use of all biofuels has increased notably (in particular biogas and biodiesel). (Energimyndigheten 2012) However, there remains potential to increase the production of biomass and the use of biofuels. The potential increase from 50 to 70 TWh per year corresponds to one-third of the current consumption of petrol and diesel for road transport. The greatest potential is in increased use of forest biomass for biofuels, but there is further potential in biofuels from agricultural sources. However, investments and financial incentives are needed to make the increase possible and to promote solutions that are environmentally efficient. (Börjesson et al. 2013)

Table 5: Brief introduction to the bioeconomy of Sweden

Current key branches of the bioeconomy and areas with identified potential	Bioenergy (especially from forestry), agriculture and biofuels. Great potential for developing biogas and increasing the added value of the renewable raw materials used by current process industries
National bioeconomy strategies and initiatives	Swedish Research and Innovation Strategy for a Bio-based Economy 2012
Examples of innovative bioeconomy activities	Örnsköldsvik biorefinery cluster Paper Province, Karlstad Advanced biomaterials ecosystem (Inventia)

3. Regional case studies

This chapter presents the regional bioeconomy case studies from each of the Nordic countries. The case study regions (the Lolland region of Denmark, the Forssa region of Finland, South Iceland, the Østfold region of Norway, and the Örnsköldsvik region of Sweden) were chosen in co-operation with the Nordic Working Group on Green Growth—Innovation and Entrepreneurship, with the aim of covering areas of varying characteristics. The major aim was not to compare their approaches but to survey bioeconomy activities in a variety of Nordic regions.

The case study regions were selected to provide rich data and examples of good practices on bioeconomy in Nordic regions for discussion and, where appropriate, adoption in other regions. The cases include regions with biorefinery initiatives in varying stages of development, regions with different approaches to regional clustering, and regions where the key companies take a variety of roles in the bioeconomy. They include regions where the bioeconomy concept has largely been adopted and those where the term is not yet very familiar. Although all the selected case study regions include several good practices in the field of bioeconomy, selecting the best performing or most advanced Nordic bioeconomy regions was not a criterion as such.

Moreover, the case studies focus specifically on regional-development-related aspects of a bioeconomy. Each case study presents the current and planned bioeconomy activities and policy and governance issues. The particular focus of these studies was the enabling conditions and impeding factors for developing a bioeconomy in a variety of regions with different existing conditions in factors such as geographic location, demography or institutional settings. The case studies were conducted by studies of secondary sources, literature reviews and document analyses, followed by study visits and interviews in each case study region in 2014.

3.1. Lolland, Denmark

By Gunnar Lindberg & Ingrid H G Johnsen & Alberto Giacometti

3.1.1 Introduction

The case study chosen for Denmark concentrates on the municipality of Lolland (which has a smaller geographical area than the entire island of Lolland).¹ Lolland Island is an interesting case considering that it is not located in the vicinity of Copenhagen with regard to aspects such as its labour market. Moreover, Lolland Island does not have a university of its own. As early as the 1980s, the region initiated green growth activities, particularly focused on wind energy installations, and it established a research centre (the Green Center). However, in recent years, green growth initiatives have diversified significantly, especially in the field of bioeconomy.

Region Zealand is known internationally as one of Europe's leading regions because of its work on climate issues, renewable energies (RE) and developing solutions for the future. This has called for innovative and practical solutions that promise not only alternative energy sources but also new jobs and improved quality of life. Zealand has taken the role of a model region in terms of sustainable economy and green growth, and this has influenced significantly its modes of governance, through strengthening co-operation between local communities, private companies, SMEs, cultural institutions, research institutions, municipalities and the region.

3.1.2 Description of the region

a. Region Zealand

Region Zealand is one of the five Danish regional administrative units created in 2007. It extends through most of the island of Zealand, except for the north-eastern area, which belongs to Region Hovedstaden or

1) Although Lolland Municipality is the main area of focus for the Danish case study, the names "Lolland Island" and "Region" are used interchangeably. "Region Zealand" is also used in the text because of relevant factors that affect the development of the Bioeconomy in Lolland Municipality.

Figure 2: The Lolland region of Denmark (Map design by Julien Grunfelder)



Greater Copenhagen. It covers several smaller islands, including Lolland and Falster. Region Zealand occupies a territory of 7,273 km² and has a population of approximately 820,000 inhabitants. The region also has an important education sector with approximately 16,000 students divided into two main universities, including the University College of Zealand and Roskilde University.

b. Lolland Municipality

Lolland Municipality, with an area of 892 km², covers approximately two-thirds of Lolland Island and has a population of approximately 46,000 inhabitants, which represents the lowest population density in Denmark. The largest towns in Lolland are Nakskov, with 12,866

residents, and Maribo, the second largest town, with 5,923 residents.

The labour market and population of Region Zealand are concentrated in the north of Zealand Island, extending from the area close to Copenhagen to the larger part of the island. An OECD report (2012) considers a major area of the Zealand Island to be part of the Copenhagen labour market. Peripheral locations of Region Zealand, such as Lolland, depend on their own labour market. The absence of universities or major industrial clusters in Lolland makes its economy more fragile and highly dependent on fewer economic activities. In fact, Lolland Island has been immersed in a strong economic depression that has left 2,000 skilled workers unemployed, which in turn has triggered

out-migration to larger metropolitan areas, and brain drain, increasing poverty, disinvestment and increased dependency on national subsidies (Magnoni and Bassi 2009). In 1994, unemployment reached a peak of 19.3%, and 10% of the island's population is estimated to have moved away between 1981 and 1998, leaving behind a region with a growing elderly population (Magnoni and Bassi 2009).

Nevertheless, a number of areas of Lolland and Region Zealand used to be home to important manufacturing powerhouses, which in a number of cases have been transformed to meet the expectations of today's markets. For instance, Lolland's tradition of shipbuilding fed into the production of wind turbines during the 1990s (OECD 2012). In 1999 and 2000, the Nakskov harbour underwent a number of transformations, including the demolition of old structures and a general clean-up, with the intention of attracting new industries and meeting new local needs.

In addition, the Nakskov Industry and Environment Park (NIMP) were developed in an area of 1.2 million m² by the Nakskov Municipality with land destined both for new industries and for agro-industrial purposes.

Today, Lolland has a growing industrial sector based mostly around green energies and agro-industry, and it is the leading region in the production of wind generator components. This is mainly because of the presence of Vestas Wind Systems, a world leading manufacturer in the wind energy sector, which settled in Lolland in 1999. Vestas is currently the largest industry of its type and is an important source of employment for the region.

The joint effort of Nakskov and Lolland together with other municipalities focusing on "green" sustainable development based on local resources and renewable energy has successfully attracted a number of firms and partnerships of various types. This in turn has resulted in a significant drop in unemployment and has played a role in bringing Lolland out of the severe economic recession in which it was immersed.

3.1.3 Administrative structure and governance

The regional structure of Denmark experienced a number of reforms in 2007, and five new regions were created in addition to six regional forums. This significant structural reform changed not only the physical boundaries but also the governance and the way in which regional development was managed. Under this new structure, the regions are responsible for producing Regional Development Plans, while the Growth Forums play a role in policy design and promotion of business opportunities in the region (Nordregio 2010).

The regional governments have a strong responsibility to co-ordinate the municipalities' actions and to prompt co-operation between levels of government and other actors in the region. These include municipalities, research institutions, private actors and civil society. Region Zealand has its own Growth Forum with a budget of approximately EUR 20 million and receives EU co-funding. In this institutional setting, the Growth Forum of Region Zealand has supported renewable energy projects financially and provided a platform on which to expand the business network.

Municipalities in Denmark have substantial administrative power. While the regional government has mostly an advisory function and a reduced budget of EUR 2 million per year, the municipalities are responsible for direct implementation and aiding policy.

3.1.4 Policy framework

In 2006, the European Commission issued a green paper entitled A European Strategy for Sustainable, Competitive and Secure Energy. The commission aimed to combat climate change in a more proactive manner by promoting renewable energy and energy efficiency, improving the European energy grid, and co-ordinating energy supply and demand at the EU level (OECD 2012). In 2007, the Renewable Energy Roadmap established a mandatory target of 20% of renewable energy in total energy consumption by 2020, and 10% of fuel consumption in the transport sector to be of biofuels. Although further alterations to original targets established individual targets for each member state, and thus the target for Denmark rose to 30% of total consumption to be of renewable energy by 2020 (OECD 2012). EU policy has been accompanied by financial support for particular areas such as Lolland, which is eligible for EU structural funds, and for INTERREG programmes to Region Zealand as part of the Öresund cross-border region. Lolland in particular has received financial contributions to initiate projects for the development of biomass and other renewables.

Denmark has been one of Europe's most committed countries regarding climate change. In fact, Denmark was the first nation to introduce a tax on CO₂ emissions, and upon ratification of the Kyoto protocol, the Danish government committed to a 21% reduction in GHG emissions by 2012 (Bassi 2013). This was translated into ambitious policies and specific initiatives to support the use of renewable energy and energy efficiency, especially because sizeable power plants using other sources or energy are not an option in Denmark. In addition to reducing carbon emissions, Denmark aims to become completely energy independent by specializing in clean technologies. In fact, Vestas and Sie-

mens combined have positioned Denmark as the world leader in wind energy installations with a 27% share of the global market in 2008 (OECD 2012). The long-term strategy of Denmark is to become a net exporter of energy and to achieve complete independence from fossil fuels by 2050. Despite a slight rise in energy consumption of 6.7% since 1990, the shift in energy sources has led to a significant reduction in CO2 emissions. In fact, the electricity sold in Denmark in 2007 generated 41.6% less emissions compared with 1990 (Bassi 2013).

After the recent restructuring of regional and local boundaries and responsibilities in Denmark in 2007, Region Zealand has developed a regional development strategy that places renewable energy as a core priority and catalyst for other developments. The strategy focuses on supporting SMEs in renewable energy sectors as well as on attracting companies from the region that can take advantage of the growing network and possible access to EU seed money (OECD 2012). Yet the actual role of aiding and implementing renewable energy policy lies at the municipal level. Therefore, municipal governments are directly involved in the development of this sector. Municipalities in Region Zealand have shown an outstanding engagement with responses to the climate and energy crisis. In fact, all 17 municipalities have signed the Covenant of Mayors, which is a European movement of regional and local governments voluntarily committed to improving energy efficiency and developing renewable energy solutions in their own territories. Municipalities in Region Zealand have also agreed to exceed the EU 2020 targets for carbon emission reductions (OECD 2012).

In 2007, the Lolland Community Testing Facilities (CTF) concept was developed after a unanimous

agreement of the Lolland District Council, which is a municipal policy commitment based on the use of renewable energy, preservation of natural capital and sustainability (Magnoni and Bassi 2009). The idea behind the CTF is to activate innovative partnerships in order to combine the interests of industry sectors for testing and demonstration with the Municipality's need for sustainable development and renewables. Under this arrangement, industries can test new technologies on a full scale and in real communities, which provides added value for industries and thus attracts investment in Lolland. The CTF provides an innovative and comprehensive vision for the development of Lolland, creating synergies between the private sector, research institutions and local authorities. Yet the CTF has built on the local community as a key actor in the long-term development strategy. This "quadruple helix" institutional setting, and specifically the CTF, has brought concrete benefits to the inhabitants, municipalities and private businesses for which renewable energy is the main growth driver. Table 6, from Magnoni and Bassi (2009), summarizes the benefits obtained in Lolland under this institutional arrangement with the CFT concept.

3.1.5 The bioeconomy of the Lolland Region

Region Zealand has specialized in the production of energy with a major focus on renewable sources. This sector benefits from proximity to Copenhagen, which has a large demand for energy, and increasingly that from renewable sources. There is a longer tradition of renewable energy in Region Zealand. However, there has been a boost in the diversification of sources and new projects since 2007, because of sustained support

Table 6: Lolland's CTF benefits (based on Magnoni & Bassi, 2009, p. 1156)

Lolland Municipality	Industry	R&D	Policies
<ul style="list-style-type: none"> ■ Sustainability ■ Branding ■ Economic Growth ■ Competitiveness ■ Population Growth ■ Job Creation New Education ■ Innovative Supply Systems 	<ul style="list-style-type: none"> ■ Branding ■ Cheaper Test & Demonstration ■ Faster Access to the Commercial Market ■ Society Tests ■ Real Situations, Real Systems, Real Population, Real Society 	<ul style="list-style-type: none"> ■ Full Scale Research ■ Technical Knowledge ■ Socio-Economic Analyses ■ Well-defined Geography, Demography, Economy and Energy Systems 	<ul style="list-style-type: none"> ■ Bottom-up Tools to Reach Macro-political Goals for Sustainability and Competitiveness ■ Growth in the Peripheral Areas of the EU

from the Growth Forum, which has invested more than EUR 30 million in 40 projects. (OECD 2012). Today, renewable energy resources in Region Zealand include wind, solar, biomass for biofuels and other sources, as well as experimental sources such as hydrogen. Lolland–Falster was the first Danish region to construct and install wind turbines in the 1980s.

Biomass represents 70% of renewable energy production in Denmark, with wind energy being the second most important source, accounting for more than 20% of total renewable energy. (Bassi 2013). From an early stage, Region Zealand transformed its landscape for intensive agriculture and thus has enormous potential for biomass production.

Region Zealand accounts for 18% of Denmark's total agricultural land. However, the agricultural sector has been affected by significant cuts in EU and national subsidies. For this reason, farmers are increasingly focusing their activities on the production of environmental services and specializing in the production of biomass. In this context, Lolland is known for its successful transformation into a "green region", which has led it not only to become a climate-neutral region but also to boost its economy, previously immersed in a deep economic depression. Lolland gradually capitalized on land availability and the existing network and experience developed through the CTF.

The bioeconomy and resource efficiency are clear priorities of Region Zealand and the island of Lolland. Biofuel production in Lolland was established in collaboration with public–private partnerships. The biofuels produced include rapeseed oil, biodiesel from algae cultivation and bioethanol from agricultural production.

Based on the information gained from a field study conducted in Lolland in 2014, the region is very pragmatic in regard to the bioeconomy: it has plant production, high-tech production and biotechnology, and it should be able to do much more. The ambition is to initiate more activities and to change fundamental structures in the long run, realizing that the bioeconomy is perceived to be about "what can be extracted from plants", "making the most of bio-based value chains", "optimizing and creating symbiosis" and "cascading-production". New types of products are probably the most difficult path, and this is seen more as a long-term strategy.

Companies (including farmers) are good at optimizing production. According to the respondents, what can be improved are the management of waste streams and the creation of synergies between firms. One regional dilemma is whether Lolland should focus more on large firms or smaller firms. What kind of firms can

potentially provide more employment? What can benefit the region (and its various parts) the most? Lolland is expected to focus more on the larger firms in the immediate future because it is believed that this is where the impact can be the greatest. Yet, focusing on the interests of large companies risks losing the original concept of supporting the interests of small communities and SMEs.

Plans for realizing the bioeconomy in Lolland consist of a combination of hands-on activities, strategies and visions. One structure that has already been implemented is the so-called regional advisory group, or "sparing group", for developing ideas and bringing projects to bodies such as the national Danish bioeconomy panel. Furthermore, the region is a member of a national innovation network, which allows them to utilize "catalysing" resources, such as project development, clustering advice, innovation networking, and an understanding of global trends, to help the firms in the region to develop in the field of bioeconomy. One long-term strategy is to improve regional "framework conditions" to participate in the national green economy/bioeconomy strategy; this includes removing any barriers to developing new ideas and activities. In addition, the strategy is intended to use outlooks (beyond Denmark and the EU) to provide strategic knowledge, methods and models for use by the regional actors. A Baltic perspective and knowledge of alternative experiences is desired.

The co-creation process is seen as an important "method" of realizing a bioeconomy in Lolland. This is envisaged to include meetings, development of clusters, and utilization of the quadruple helix concept.

Visionary work includes a toolbox (of examples) to visualize what could emerge from the bioeconomy in different settings and places. Back-casting—having a vision and thinking how to make it happen—is part of the process and is an exercise at both the macro and micro level.

Green Center, Lolland

The Green Center is a business and research unit working with agricultural, agribusiness and eco-technology industries in Lolland. The Green Center (GC) was founded 25 years ago in 1988 on Lolland Island to help farmers to innovate. The Green Center is part of the "Råhavegård" knowledge centre, yet it is an independent institution with 12 employees. The centre has modern laboratories, which offer biological, botanical and environmental analyses, and development facilities. It also has a separate GMP laboratory. The centre owns 250 acres of farmland, of which 70 acres are experimental fields. The Green Center's main tasks are

innovation in food and agroindustry, plant production and management assistance in general. Yet the centre also generates new products, production and management opportunities for its customers and business partners while focusing on sustainability. For instance, the Green Center focuses on optimizing the utilization of biomass and works with both naturally occurring and intensively produced biomass from agriculture.

The Green Center is trialling techniques to cultivate algae on a large scale. Intensive agriculture could produce CO² and nitrogen, which can be used in the production of algae. The potential uses of algae include purifying water by removing nitrate deposits from intensive farming, and sewage treatment. The Algae Innovation Centre, Lolland (AIC) was initiated by the Green Center in 2010 in partnership with Aalborg University and Roskilde University. “The project aims to establish a demonstration and pilot plant for algae cultivation experiments, and conduct research on how society and businesses can optimally utilize algae production technologies”. The AIC focuses on three main activities.

- Establishment of a demonstration and pilot plant with algae cultivation experiments at the Green Center, Holeby
- Networking Activities: Identifying local, national and international partners
- General information activities

Network and Cluster Activities are a major part of the Green Center’s activities. The Green Center works on the development and growth of agriculture and the processing sector, focusing on business co-operation, experience exchange groups, product development, logistics and marketing, quality development, communication and branding. The Green Center serves as a catalyst by pulling together knowledge, core competences and the right partners. The Green Center co-ordinates a variety of activities aimed at facilitating the emergence of new technology applications and spin-off projects. Networks and clusters include From Cluster to Cluster, Agro Valley Denmark, Food Platform Zealand programmes, and contracts with regional partners.

The Green Center has a broad focus on “land” and “goods”: what can be produced, what can it be used for, and how can it be developed and integrated? From the outset, there was a regional development dimension built into the centre (considering factors such as employment, the economy and regional attractiveness). There was a decline in the number of jobs in rural areas, and local politicians thought of using farmland in a more innovative way. The direction of the centre

was business development based on new products and better utilization of existing production. Its current activities are strongly oriented towards “natural science”, but because it has an impact on regional development (and firms in this area), it takes a rural development perspective.

Today, integrated solutions (industrial symbiosis as well as industry–community interactions) are one important focus area in relation to developing the bioeconomy. This is strongly related to projects on “side current” management (flows of material or energy not yet utilised) and new products.

From a “cluster” perspective, the Green Center collaborates with (small) firms in their projects, and the knowledge permeates practices and the market in this way. It is less interested in actual patents but rather in allowing firms in the projects to develop solutions or products after the research projects. This may not be so different from organizations such as Processum in Sweden—the difference being that it is not such an organized cluster, and it does not have personnel such as a patent engineer. From a practical perspective, it should be mentioned that it also lends land (located close to the Green Center) for experiments and product development. Hence, there are some similarities to the activities studied in the Icelandic case study, in the sense that smaller producers can obtain resources and assistance to develop products and new processes or techniques in “field laboratory” settings.

As in most regions the issue of short-sightedness, not least politically, is mentioned as an impeding factor in developing the bioeconomy. There are few “low-hanging fruits” available, so the development of the bioeconomy will require long-term funding, and it should be allowed to develop just as other sectors have in the past. In fact, the interest in the region came initially from “above”, but once politicians realized that there were few “low-hanging fruits”, or short-term results in relation to the economy and jobs, their interest waned. According to the respondents, the bioeconomy should not be judged on short-term market possibilities alone. Some large-scale projects related to biomass have actually been abandoned owing to lack of funding, and today, many projects have to be “close to the market” to be financed. This is not always possible in the long-term development of solutions for realizing the bioeconomy.

In Lolland, the bioeconomy actors actively take a holistic perspective in the regional planning cycle. For example, they attempt to develop the idea that when the local biogas company is developed, there should be a focus on upgrading to transport gas by building a transport centre. To move their solutions “closer to the

market”, the enablers include regulations and economic incentives. For example, for the algae development project, this would imply taxes on nitrogen in the waste water, electricity taxes on sewage pumps, or anything in the field of technology rules. This would put a demand for new solutions on the market.

Concerning conflicts related to bioeconomy applications, it is important to consider that usually, when developing an innovation in the bioeconomy, the developer is generally competing with an established entity somewhere else in the economy. According to the respondents, there can be both explicit and implicit conflicts that oppose this development. This “thing” against which the innovator competes is probably an important part of a regional economy somewhere else. There may be short-run implications for that economy that must be considered, even though it may be contended that this region should also find something sustainable to develop. Areas with substantial energy resources (e.g., Norway) produce nitrogen fertilizers, while the Green Center is attempting to find substitutes, or to recycle such fertilizers from algae.

3.1.6 Enabling conditions

The potential for other sources of renewable energy, such as agricultural residues and related technologies for energy production as a way to create new employment opportunities, has been seen as important for the region. Currently, the production of renewable energy in Zealand includes wind, solar and agricultural biomass.

Zealand has managed to switch its focus from the deployment of renewable energy to technology development and the provision of testing facilities for renewable energy. This has proven to be a successful form of branding for the region, which local communities and municipalities support. This example suggests the importance of including local communities to gain support for the deployment of renewable energy. Local support from the business sector and local communities has also been a success factor in providing renewable energy testing facilities.

3.1.7 Impeding factors

A number of factors impeding the development of the bioeconomy have been identified in Lolland.

- Location disadvantages: lack of accessibility to economic activities and infrastructure
- Low density: difficult and expensive implementation of strategies that effectively improve the efficient use of resources (water, energy)
- Out-migration (particularly of young people)

- Weak urban networks: difficulty of connecting with neighbouring regions
- Fragile economic development
- Renewable energy sectors’ continued dependence on public subsidies. Renewable energy will not be an alternative to conventional fuels without large public subsidies

3.1.8 Conclusions

The Lolland region has focused on the green economy for a relatively long time. In addition to providing practical and innovative solutions for local and regional problems, the focus on the “green economy” represents a significant export potential for the larger region of Zealand. However, it should be stated that job creation and an economic boost from green economy renewable energies has occurred in Lolland, but the impact should not be exaggerated. The green growth is expected to offer only a limited solution to the structural challenges of Lolland. Having stated this, we note that actors in the region are at the forefront in thinking about new ways to structure industrial symbiosis. Today, in relation to developing the bioeconomy, integrated solutions (including symbiosis and industry–community interactions) represent one important focus area. This is closely related to projects dealing with side current management and new products—and being early in this field can potentially offer first mover advantages over other regions and large firms.

From a governance perspective, there is a feeling of “bottom up” or “involvement” in the way in which the bioeconomy is developed or explored. Co-creation processes are seen as an important “method” for realizing the bioeconomy, and this is envisaged to include meetings, development of clusters, and utilization of the quadruple helix concept. From an outside perspective, this is probably important because it helps to build a common vision and understanding of priorities and actions. However, we also notice that this is a sort of governmental organized bottom-up approach, where the main actor working to develop the bioeconomy is the region, and it seeks other actors. The region is also active at the top, and it participates in the national bioeconomy panel to devise strategies on the national scale.

Another interesting aspect of the region’s work with a bioeconomy for Zealand (and Lolland) is its plans to realize a bioeconomy, which are a combination of hands-on activities, strategies and visions. For instance, there are groups being formed for strategic work on the regional bioeconomy, and as part of this, there will be a collection of examples to inspire and

inform. Catalysing business and innovation resources are coming into the region to help to develop the firms, by consulting on ways to develop both techniques and market aspects. It is worth noting that there is an understanding that the framing conditions in the region are important if the bioeconomy is to develop and that these framing conditions can be changed. Such conditions can include rules, planning structures, financial sources, regional support and strategies.

The region of Lolland offers interesting insights into the process of developing the bioeconomy, in the larger regional context of Zealand. It shows a Green Center that is working on hands-on solutions and systemic change projects, and is experiencing the day-to-day aspects of the framing conditions and the problems associated with funding, time frames, marketability, and “fashion”. It is a region that is advanced in developing a bioeconomy “work programme” with components that we did not see in some other regions. This agenda will be interesting to follow and assess, to understand whether it can create an impact on the way in which the region develops.

Finally, it can be stated that the experience of Lolland can certainly be replicated in other rural communities elsewhere as long as the local conditions are duly taken into consideration. In this respect, it is important to realize that the economic resurgence of Lolland has mainly been a result of local initiatives rather than any sort of national-level intervention, although national overall policy towards a green economy has played a central role. Yet the success is remarkable considering the absence of universities or large industrial clusters in the region. Moreover, resources are not very specific in Lolland, and they differ little from those in many other Nordic regions. What can be learned is pragmatism towards the bioeconomy. In this region, there is a focus on both small and large firms, plant production and developing the basics of the bioeconomy, high-tech production and renewable energy systems solutions. In addition, linking the bioeconomy to societal development was built into the early strategies and actions. For instance, a regional development dimension was built into the Green Center, which was to contribute especially to employment, economic development, and regional attractiveness.

3.2. Forssa, Finland

By Jukka Teräs

3.2.1. Introduction

This case study introduces and analyses the bioeconomy in the Forssa sub-region of south-west Finland. Its

focus is on the analysis of innovation in green growth and the bioeconomy, and the concentration of environmental expertise in the region.

This case study report is based on a study of secondary sources and interviews with key stakeholders at the local, regional and national levels as well as representatives from private companies and educational facilities in 2014. The report presents the characteristics of the region and its economy, as well as the policy framework for developing bioeconomy in the Forssa region.

Based on information gathered in the interviews, the report outlines the main actors in the bioeconomy in the region and discusses the main drivers of development. It also discusses the main impeding factors to development and concludes by summarizing and discussing the current situation and future potential for developing the bioeconomy of the region.

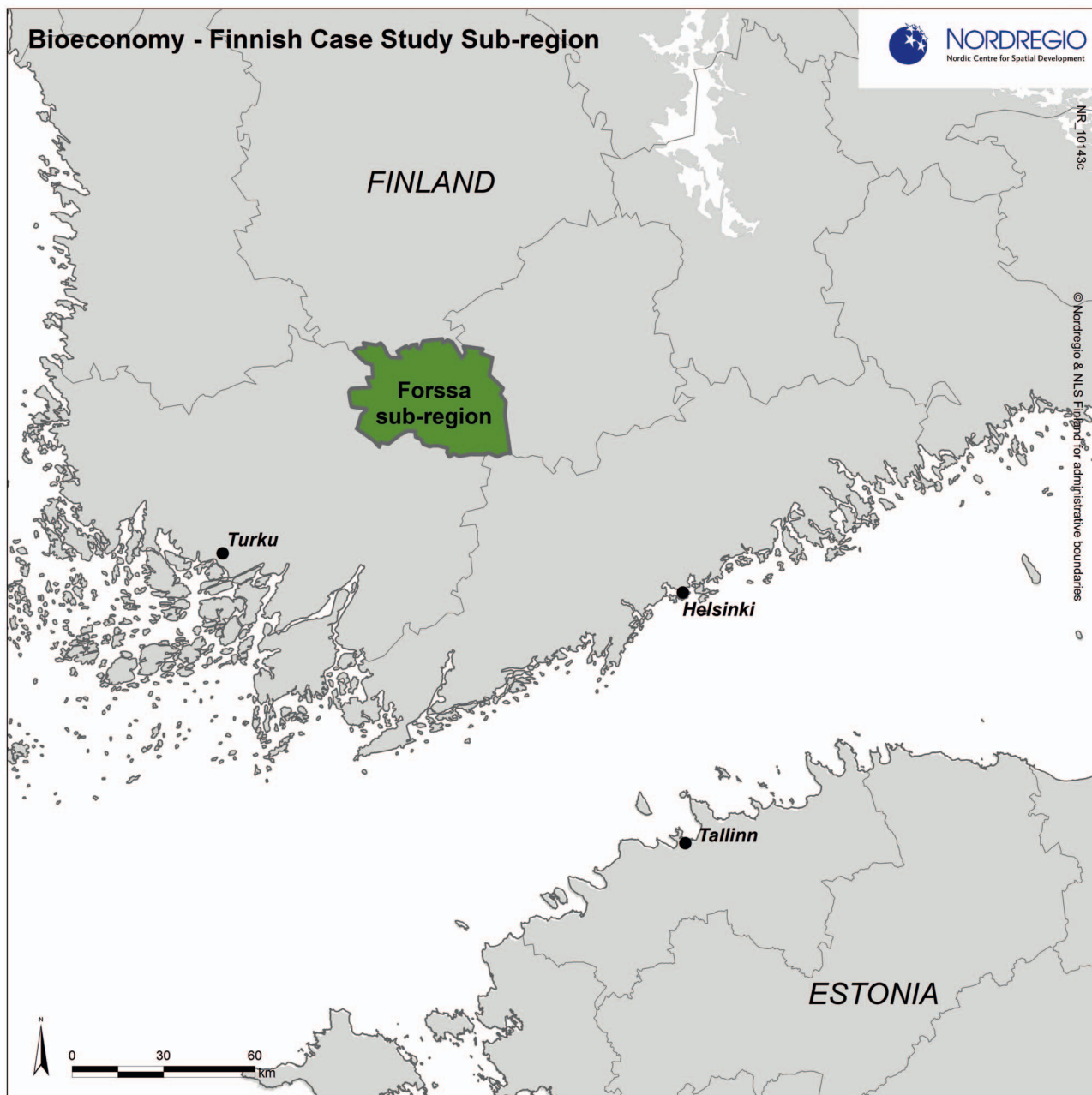
3.2.2. Description of the region

Forssa is located in South-west Finland, 100 km from Helsinki, and in a logistically favourable location at the midpoint between the three largest cities in Finland. The Forssa sub-region is one of the three sub-regions of the Häme region. It consists of the city of Forssa and four municipalities: Jokioinen, Tammela, Humppila and Ypäjä. There are approximately 37,000 inhabitants of the Forssa sub-region, of which 17,700 live in the city of Forssa.

The history of Forssa began in 1847, when the Swedish-born Axel Wilhelm Wahren founded a cotton mill by the side of the Loimijoki River. Industrialization gathered speed, and the town grew and developed alongside the factory. In addition to the factory buildings, Wahren arranged to build homes, a hospital, a library, a general store and a school. Forssa developed in the 19th century as a city associated with the textile industry. In the 20th century, the construction industry took off, especially in the 1960s. Currently, the key sectors of the local economy in Forssa include the following.

- The food industry
- The construction industry (manufacturing of construction products)
- Environmental technology (recycling, waste management, energy)
- Electronics
- Information and communication technology
- The metal industry
- The printing industry

Figure 3: Forssa sub-region (Map design by Julien Grunfelder)



3.2.3. Administrative structure and governance

National

Finland is a country in Northern Europe with a population of 5.45 million. Finland joined the European Union in 1995. Central and local governments are the basis of Finnish democracy. There were 336 municipalities in Finland in 2013.

The key local actors are the municipalities and the local companies or indigenous firms. The municipalities—often in co-operation with other regional and local actors—have established local development companies, technology centres and start-up company centres to promote local entrepreneurship. Regional councils play a significant role in the regional development of

Finland. The regional councils operate as regional development and regional planning authorities and are thus the units in charge of regional planning and looking after regional interests. They also conduct research, planning and analyses. The emphasis of the work of the regional councils is on both long-term planning and rapid reaction in current affairs. The councils also implement and co-ordinate a number of various national and EU projects. Two major regional state administrative bodies are the Centres for Economic Development, Transport and the Environment (ELY) and Regional State Administrative Agencies (AVI), responsible for basic public services, legal rights and permits, occupational safety and health, environmental permits, and safety. (Suomi 2014). The SRDAs (sub-regional devel-

opment agencies) are organizations between municipalities and regions.

In addition to the Finnish parliament and the government and ministries, the national interest groups include organizations of the Finnish National Innovation System, such as Tekes (The Finnish Funding Agency for Technology and Innovation), SITRA (The Finnish Innovation Fund), VTT (the Technical Research Centre of Finland), and the Invest in Finland office. SEKES is a national association of sub-regional development companies.

The Regional Council of Häme and Forssa Region Development Centre

The Regional Council of Häme, the members of which are municipalities around the Forssa, Hämeenlinna and Riihimäki areas, develops the region and supervises regional interest both in Finland and globally. The Regional Council of Häme gathers and processes various regional development perspectives and evaluates the feasibility of their implementation. The council works in close co-operation with municipalities, state officials and businesses as well as other development partners. (Hämeen liitto 2014).

The Development Centre of the Forssa Region

(FSKK) is owned by five municipalities: Forssa, Humpila, Jokioinen, Tammela and Ypäjä. The mission of the FSKK is to create operational conditions for diverse businesses and for the active development of the Forssa region. The main roles of the Development Centre are acting as an adviser of industry, regional economic planning and implementation in co-operation with the municipalities and businesses, marketing the region and undertaking development projects.

3.2.4. Bioeconomy in the Forssa region

“Bioeconomy” as a term is relatively new in the Forssa region. According to the interviews in the region, the Bioeconomy concept in Forssa was launched as part of the Forssa Brightgreen concept approximately five years ago. However, activities usually connected with the bioeconomy were already present in the Forssa region from the early stages of its industrialization. Axel Wilhen Wahren emphasized the symbiosis of agriculture and industry, even in the 1840s. The Mustiala agricultural institute was established in 1840. The MTT Agrifood Research Finland, the leading Finnish research institute operating under the Ministry of Agriculture and Forestry, located its main operations in Jokioinen in the Forssa region in the 1970s and early

Table 7: Key actors and activities of bioeconomy in the Forssa region

Sector/Activity	Main Actors	Description
Food industry	HK Ruokatalo Atria SME companies (e.g., Makuliha, Jokioisten Leipä)	2,000 jobs Large-scale investments in Forssa by large food companies Innovative SMEs, such as Lähiruoka
Envi Grow Park, Eco Industrial Park, Cleantech Companies	Envor Group, LHJ Group, Watrec FSKK, MTT, HAMK	Flagship project: a biorefinery with an estimated investment of €100 million, planned to open in 2015
MTT Center of Expertise	MTT Agrifood Research Agriculture, food, and circulation companies, TSKK, HAMK	Building on the long-term expertise of MTT Loimijoki Food Valley initiative by FSKK (planning stage)
Green logistics initiatives	Municipalities, HAMK, Regional Council of Häme	Green Growth & logistics-related development projects (e.g., HEA; Humpila Eco Airport and Logistics Centre)
Textile recycling	HAMK in co-operation with municipalities, VTT, LAMK, SYKE, National Consumer Research Centre, Envor	Public–private pilot projects (e.g. TexVex Humpila, R&D work)
Education and training/natural resources	HAMK, HAMI (Häme Vocational Institute)	Degree programmes and training with a focus on the bioeconomy Forssa is the pilot region.

1980s. In the 1990s, an important milestone was the establishment of the new dump and the municipally owned waste management company Loimi-Hämeen Jätehuolto. The University of Applied Science in Häme (HAMK) is the leading higher education institute specializing in natural resources (agriculture, horticulture, forestry), the agricultural unit (biggest and oldest in Finland) being Mustiala in the Forssa region. HAMK also began offering a sustainable development training programme in 2008 in Forssa, and the bioeconomy has been one of the strategic focus areas since 2006. Education on bioprocesses and environmental technology also supports the strategic focus of HAMK. HAMK has been able to create new combinations of skills to satisfy certain needs in the bioeconomy field. The Envor Group built the first industry-scale composting facility in 1997, and the biogas plant for packed food waste in 2009 (the first of its type in Europe). The biomethane fuelling station for vehicles was built by Envor in 2013.

Table 7 presents the major sectors and activities of the bioeconomy as illustrated by the respondents in the Nordregio study in 2014.

The food industry has been a flagship of the business life of Forssa for decades. In recent years, the food industry in Finland has been hurt by layoffs and closures. Despite the downturn, the food industry in the Forssa region remains one of the strongholds of the local business environment. Today, the most important food industry companies in the Forssa region are the following.

- HK Ruokatalo (HK Scan): Meat, poultry, meat product and convenience food businesses, with 500 jobs in Forssa in 2013
- Atria: Businesses producing meat and meat products, poultry and convenience food
- SMEs such as Makuliha (meat) and Jokioisten Leipä (bread)

In 2014, it is estimated that the food industry employs approximately 2,000 people in the Forssa region. In addition to food industry companies, the key companies of the Forssa bioeconomy include clean-tech/environmental technology companies such as Envor Group Oy. The Envor Group in Forssa is a family organization consisting of four companies: Envor Recycling Oy, Envor Processing Oy, Envor Palvelut (Envor Services) Oy and Envor Biotech Oy. Envor Recycling Oy began operations in 1964. Processing of paper, cardboard and cartons started in the 1970s (Envor Processing Oy). Processing of glass started in the 1980s (Envor Recycling Oy). Treatment of biowaste started in the 1990s

(Envor Biotech Oy) in addition to supply of comprehensive services in environmental management by Envor Group Oy. (Envor 2014).

LHJ Group. Originally the municipal operator of the dump, Loimi-Hämeen Jätehuolto is now the LHJ Group, a versatile expert in environmental and recycling operations for companies, the public sector and producer organizations. The LHJ Group's task is to take care of its customers' material flows responsibly and in an environmentally friendly manner. The group's main business areas are electronics recycling, data security material handling, industrial waste treatment, soil remediation, and municipal waste management as well as related collection, transport and expert services. (LHJ Group 2014)

Watrec Ltd. is a Finnish company specializing in clean-tech solutions. Its core competences lie in biogas technology, wastewater and process water treatment, and environmental and energy-related consultancy services. The company's focus is to provide its clients with tailored and cost-effective solutions that are in line with the principles of sustainable development, particularly on organic waste and wastewater treatment. The company works with its clients on the basis of long-term partnerships in several sectors, from primary production to heavy industry. (Watrec 2014)

The key educational and research institutes related to the bioeconomy in the Forssa region are as follows.

HAMK University of Applied Sciences. HAMK is one of Finland's largest universities of applied sciences, with units in six municipalities, two of them in the Forssa region, with a total of 1,200 students in the field of natural resources, and a correspondingly significant number of competent teachers and researchers. The sustainable development programme at the Forssa unit produces bachelor's degree graduates in environmental planning who have extensive knowledge of the sustainable use of natural resources, product life cycles, financially and culturally sustainable operating principles, applied environmental technology and chemistry as well as environmental management, legislation, business and management. Promising R&D fields include textile recycling in co-operation with regional and national public and private sector actors. Besides excellence in the bioeconomy, HAMK has a number of study programmes in technology supporting the bioeconomy. Food and bioprocesses, environment technology, logistics, automation and ICT, for example, are combined with natural resources to create the new skills needed in a bio-based circular economy. (Hamk 2014)

MTT Agrifood Research Finland is Finland's leading research institute in the field of agricultural and

food research, as well as agricultural environmental research.

It produces innovations and solutions related to renewable natural resources. MTT conducts research in eight research programmes permeating the entire organization.

The research promotes consumer welfare, the competitiveness of the agricultural and food industries, the sustainable use of natural resources, the quality of production and the living environment, and the vitality of rural regions. MTT employs approximately 750 researchers and other experts from 15 municipalities across Finland. The organization's head office and the large majority of the personnel are located in Jokioinen in the Forssa region. MTT Agrifood Research Finland, the Finnish Forest Research Institute (Metla), the Finnish Game and Fisheries Research Institute (RKTL) and the statistical services of the Information Centre of the Ministry of Agriculture and Forestry (Tike) are to be merged under a new entity called Natural Resources Institute Finland as of 1 January 2015. (MTT 2014).

The Envi Grow Park eco-industrial park is the flagship project of the Forssa bioeconomy. The idea of an Eco Industrial Park was launched in Brussels in 2007 (during a local brainstorming day and a study visit to EU Brussels offices). The business idea for the Envi Grow Park in Forssa is to implement closed circulation of energy and materials and to act as a top international centre of excellence in bio-based products and processes. The locomotive company for the Eco Industrial Park biorefinery is the Envor Group. Envor announced in March, 2014 that it plans to make a decision by the end of 2014 whether to invest in a biorefinery in Forssa that would harness almost 100,000 field hectares for ethanol production. The Envor biorefinery will be a versatile facility based on several interrelated processes producing sustainable energy and commercial products with the best available technology from natural renewable raw materials. The biorefinery is based on Envor Biotech Oy's experience of the existing biogas plant, which is the largest of its kind in Finland. As an input, the biorefinery would use up to 340,000 tonnes per year of energy grain (rye wheat/wheat/barley), the majority of which is to be collected from South-west Finland.

The Envi Grow Park concept combines waste treatment, renewable energy production/wind parks and development of new bio-based products, in an integral way (see Figure 4).

An important catalyst for the intercompany relationships in the Forssa region was the establishment of the Forssa Envitech Club in 2006. The club contributed significantly to activities such as the preparation of the

first subregional environment and energy strategy in 2007. The strategy paved the way for Forssa region cluster co-operation and the concept of Brightgreen Forssa. The club was active in the years 2006–2010, after which the cluster activities were co-ordinated by the Forssa Region Development Centre FSKK.

3.2.5. Policy framework in developing the bioeconomy in Forssa

National

The Finnish National Strategy on Bioeconomy, published in 2014, is intended to promote bioeconomy businesses and to improve Finland's competitiveness and welfare while at the same time decreasing the impact of climate change and improving resource efficiency. The priority areas of the strategy are to create a favourable operating environment for the bioeconomy, to support the creation of new bioeconomy business, to develop and ensure bioeconomy skills, and to ensure the sustainable use of renewable resources. The bioeconomy is already high on the agendas and strategies of many research organizations (such as Metla, MTT, and VTT), research funders (such as Tekes and Sitra), and several regional actors. The bioeconomy strategy has many linkages to, and synergies with, other national strategies for agriculture and forestry, energy and climate as well as natural resources, among other activities. In addition, the bioeconomy is one of the themes of the Innovative Cities Programme, which seeks to benefit from the strengths of the regions of Finland.

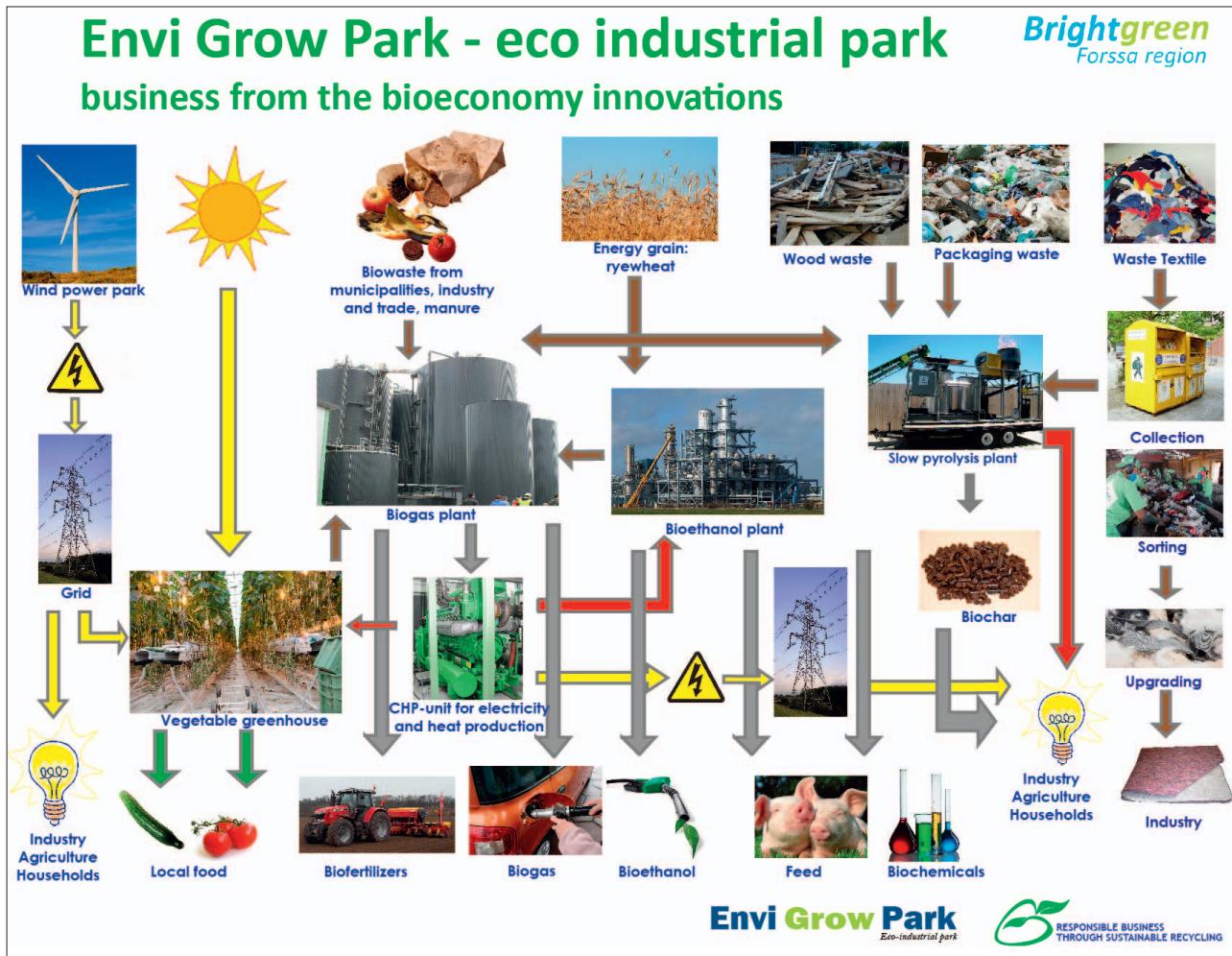
Finland has six strategic centres for science, technology and innovation (SHOK), all of which have their own research strategies. One of these, the Finnish Bioeconomy Cluster (FIBIC), is strongly focused on bioeconomy research and innovation, although other SHOKs are supporting the area as well (NIC 2014).

Regional/local

In 2013–2014, the Regional Council of Häme prepared a strategic programme for the Häme region, in which the bioeconomy and sustainable use of natural resources is one of the five strategic focal points. The strategic programme includes specific bioeconomy initiatives in the Forssa region, such as the Envi Grow Park project, and emphasizes new business environments for the bioeconomy.

In the Forssa region, a strategic programme has been developed and was most recently updated in 2014. The Brightgreen Forssa region strategy focuses strongly on the possibilities of the bioeconomy as one of the cornerstones of the Forssa region. (Brightgreen Forssa region 2012, 2014). The Brightgreen Forssa region, the new

Figure 4: Envi Grow Park eco-industrial park (Source: Pirkkamaa, FSKK)



business development strategy of the Forssa region—i.e., the municipalities of Forssa, Humppila, Jokioinen, Tammela and Ypäjä—is based on a “bright green” approach, focusing on business activities that are environmentally friendly and support sustainable development. The strategy, with a focus on environment and energy, wellness, green logistics, and technology is seen as an important success factor in the current development of Forssa green growth and the bioeconomy.

3.2.6. Enabling conditions

Natural resources

The region’s access to natural resources provides a good basis for developing the bioeconomy of the Forssa region. The region is located in the centre of Southern Finland, slightly over one hour away from the Helsinki capital region. From the view-point of biorefineries, the Forssa region has a favourable location regarding resources such as grains.

Co-operation between actors

Active and systematic co-operation between the public and private actors has been one of the key competitive advantages of the Forssa region in the field of green growth and the bioeconomy. The long-standing tradition of public-private co-operation was mentioned as an example of far-sightedness as early as 1996, when circular economy activities and energy businesses were made possible in Forssa in parallel to the development of the Kiimassuo dump.

An important catalyst for intercompany relationships and public-private co-operation was the establishment of the Forssa Envitech Club in 2006. The club contributed significantly in ways such as the preparation of the first subregional environment and energy strategy in 2007. The strategy paved the way for Forssa region cluster co-operation and the concept of Brightgreen Forssa.

The Forssa Envitech Club was active in the years 2006–2010, and since then, the cluster activities have been co-ordinated by FSKK. Currently, FSKK is the key

driving force for cluster co-operation in the field of bioeconomy. The respondents emphasize the importance of informal and frequent contacts between companies, FSKK, HAMK and the city of Forssa in the preparation of new public–private initiatives.

“The local and regional networking in the field of bioeconomy is one of the key assets: informal, daily contacts between public and private sector, city and the key companies jointly developing the Forssa bioeconomy, with acceptance of a common regional green growth strategy.”

Besides the local co-operation networks, the Forssa bioeconomy has important national and regional networks, especially via MTT, which has co-ordinated and/or participated in several EU and national-level bioeconomy initiatives. Other important actors to increase co-operation include bodies such as the FUAS network of universities of applied sciences, and key national actors and funding institutions, such as SITRA and Tekes. The Forssa region has actively strengthened international networks related to the bioeconomy, including close networking with the Norwegian city of Sarpsborg (a twin city with Forssa), and contacts with Gujarat, India and Serpuhov, Russia.

Funding

Based on information gathered in 2014, the Finnish funding system opens up a large number of potential funding opportunities for bioeconomy initiatives in the Forssa region. Moreover, the EU funding opportunities complement the national funding sources. From the view-point of Forssa, more effort and stronger co-operation networks are needed to raise large-scale funding from international funding sources.

“In fact, there is no lack of funding sources. To raise more funding for bioeconomy initiatives, we need to focus our resources, and we need to strengthen our international co-operation networks.”

Synergies between sectors

The Forssa region has a clear focus on green growth and sustainable development. Moreover, Forssa invests heavily in branding green growth (e.g., Brightgreen Forssa region). The bioeconomy is understood by the local actors to be the symbiosis of agriculture, forestry and industry.

“In our region, the bioeconomy is understood, depending on the respondent, as bio-waste treatment, the food industry, or agriculture and forestry.”

The bioeconomy is seen as an integral part of green growth, not as an isolated sector, but with interrelationships and synergies with several other sectors. The Envi Grow Park concept, for example, combines waste treatment, renewable energy production/wind parks and the development of new bio-based products in an integral way. The importance of a larger ecosystem of green growth and the bioeconomy in the Forssa region is emphasized.

“Our knowledge base and active entrepreneurship have generated an ecosystem that attracts broader interest. With the help of the ecosystem, we need to attract new experts and new companies, which would further strengthen the positive spiral of development”.

In the next 4–5 years, the bioeconomy know-how of the Forssa region is planned to be disseminated to the neighbouring regions in the Loimijoki river catchment area. The idea of Loimijoki Food Valley is to create a strong common platform located in one of Finland’s most important agri-food regions. The platform will be an area where local sustainable food production and aspects such as the use of bio-based fertilizers as well as good quality water shall be reached with the help of latest research methods and networking.

Communication & branding

The branding of regional/local bioeconomies is seen as one of the most important challenges in the near future.

“We need to invite all actors to join the Forssa bioeconomy initiative, including residents that are often suspicious of new initiatives. A common vision of Bright Green Forssa, which everybody understands, which everybody feels that this is our thing, and everybody commits to, is a key factor of success.”

The Forssa region has invested significantly in the branding process of the Envi Grow Park and the Forssa Brightgreen Region. Additional efforts to strengthen the branding work further were made in 2013. Until recently, the emphasis on branding work has been on businesses; now the focus will be more on citizens, the media and politicians. Future branding work efforts include aspects such as brand ownership and brand promises.

“The core group of the Forssa bioeconomy community has good development drive and we have been able to attract the interest of national-level actors

such as SITRA, TEKES, VTT.”

“The increased co-operation with other Nordic Green Growth and bioeconomy ecosystems would enable larger development projects. Moreover, it would strengthen our international business.”

3.2.7. Impeding factors

From the responses of the respondents, the following impeding factors have been identified. First, the bioeconomy faces the old mind-set. Many people have difficulties in rejecting the old “smokestack industry” economy that has faced difficulties because of factors such as globalization. Second, the significant growth of the bioeconomy in the Forssa region would require a qualified labour force with a sufficient educational level, which currently is not necessarily available despite efforts from organizations such as HAMK. Third, the bioeconomy community in the Forssa region would need additional high-growth companies to accumulate a critical mass in the regional bioeconomy cluster, and to provide inspirational case examples for potential future entrepreneurs in Forssa. Finally, the city of Forssa and other municipalities in the Forssa region face the national challenge of diminishing returns and increasing costs. Bioeconomy-based regional development requires public–private partnerships and pilot installations in the municipalities. The weakened financial situation of the Finnish municipalities makes it more difficult for the municipalities to provide financial support for bioeconomy-based development programmes and projects.

3.2.8. Conclusions

The Forssa region is an inspiring and promising example of a Nordic bioeconomy initiative with local and regional commitment and long-term systematic effort. However, even greater courage would be welcomed to see the bioeconomy as a sustainable success element and the international extension of the Forssa region, especially in terms of jobs and euros.

Forssa has the advantage of a long tradition of bioeconomy-related know-how and expertise, especially in agriculture. The region is definitively not starting from zero but building on previous knowledge.

Regarding the regional and local development bioeconomy initiatives, the key public and private actors have succeeded in preparing a common vision. Brightgreen Forssa provides a vision that should be relatively easy to understand and commit to. The Brightgreen regional/local vision is important for attracting new players and focusing on joint development efforts.

The Forssa region may face a relatively common risk

among smaller city regions of diversifying its limited financial and human resources into too many development fields and programmes. If properly executed, the Brightgreen Forssa programme is an instrument for focusing on, rather than spear-heading, programmes and key priorities of the bioeconomy. Dividing the development resources into numerous small programmes to avoid causing displeasure does not usually bring long-term success.

The bioeconomy is an area where patience and long-term development pay off in the long run. However, short-term “victories” are needed in addition to rapid development steps— gradual slow development is insufficient. The balance between a “sense of urgency” and strategic thinking is hard to find—most likely, this is also true in the Forssa region.

Finally, it is important to note that the development of bioeconomy activities in the Forssa region, although systematically supported by public sector initiatives, has been and remains crucially dependent on private sector initiatives. Public sector actors can and should provide development platforms, but in the long run, they cannot act as key locomotives of regional bioeconomy initiatives.

3.3. South Iceland

By Liisa Perjo

3.3.1. Introduction

This case study examines the bioeconomy in the South Iceland region, focusing particularly on innovation in agriculture and fisheries, and especially on food development innovation. Agriculture and fisheries (together with tourism) are the largest economic sectors in the region. The region’s ambition is to increase the level of processing and utilization of agricultural and fisheries products through food innovation and development.

This case study report is based on a study of secondary sources, document analysis and qualitative interviews with key stakeholders at the local, regional and national levels, as well as with representatives from private companies and educational facilities. The report presents the characteristics of the region and its economy, as well as a policy framework for developing the bioeconomy (and especially food innovation) in the region.

Based on information gathered in the interviews, the report outlines the main actors involved in the bioeconomy in the region and discusses the main drivers of development. It also discusses the main impeding factors of development, and it concludes by summarizing and discussing the current situation and future

potential for developing the bioeconomy of the region.

3.3.2. Description of the region

Iceland has approximately 320,000 inhabitants, and more than 60% of the population live in the capital region around Reykjavík. The country is divided into two NUTS 3 regions (the capital area is one NUTS 3 region and the rest of the country is another), and it has eight LAU 1 areas. South Iceland (or “Sudurland”) is one of the LAU 1 areas and is the focus area of this case study.

The South Iceland region covers a large area of 30,966 km² across the southern and south-eastern coast of Iceland. The region has approximately 26,000 inhabitants (2012) and is divided into 15 municipalities. Agriculture is an important sector, with 40% of the agricultural production from Iceland coming from the region. However, fisheries have a more important role in the regional economy, and there are three fishing harbours located in the region (Icelandic Regional Development Institute 2013).

There are great differences between the parts of the region in terms of local characteristics and issues such as the local economy, employment, demography, education and infrastructure. Fisheries have a major role in the coastal municipalities with fishing harbours, while agriculture and/or tourism are more important for inland municipalities. Tourism in general is expanding across the whole of Iceland and is also of growing significance for the economy of South Iceland. In 2013, tourism was for the first time the largest export sector of Iceland (followed by fisheries and aluminium). Revenue from tourism corresponded to 15.4% of GDP in 2013, and it is expected that the number of tourists in Iceland will increase by 18% in 2014 and by 15% in 2015 (Icelandic Regional Development Institute 2013; News of Iceland 2014).

The unemployment rate in the region for both men and women was 5.4% in 2011. The educational level in the region is lower than the Icelandic average, while the proportion of women with higher education is larger than that of men in the region (Icelandic Regional Development Institute 2013).

The population of South Iceland is concentrated along the coastline and the main national road of Iceland (Route 1) runs across the region, connecting the various parts with each other and with the capital area. There are also two airports in the area (Selfoss and Höfn í Hornafjörður) with domestic flight connections.

3.3.3. Administrative structure and governance

Iceland has a two-level administrative system consisting of the central government (national level) and municipalities (local level).

The Ministry for Industries and Innovation is the main national-level actor responsible for regional policy. It has a sub authority, the Icelandic Regional Development Institute, which acts as an implementation body for regional policy and, among other functions, monitors and supports regional development and allocates funding.

Also, the Innovation Centre Iceland works under the auspices of the Ministry for Industries and Innovation, and functions as an R&D and business support institute to promote innovation by conducting research and supporting businesses. It has offices in eight locations around Iceland that support innovation in those areas.

At the national level, Matís Ltd.—Icelandic Food and Biotech R&D—has an important role, particularly in the development of the bioeconomy. Matís is a government-owned but independent research company that specializes in R&D in food and biotechnology. In addition to its own research projects, it runs food innovation centres in a variety of locations around Iceland where it provides development facilities and business support and expertise in food innovation.

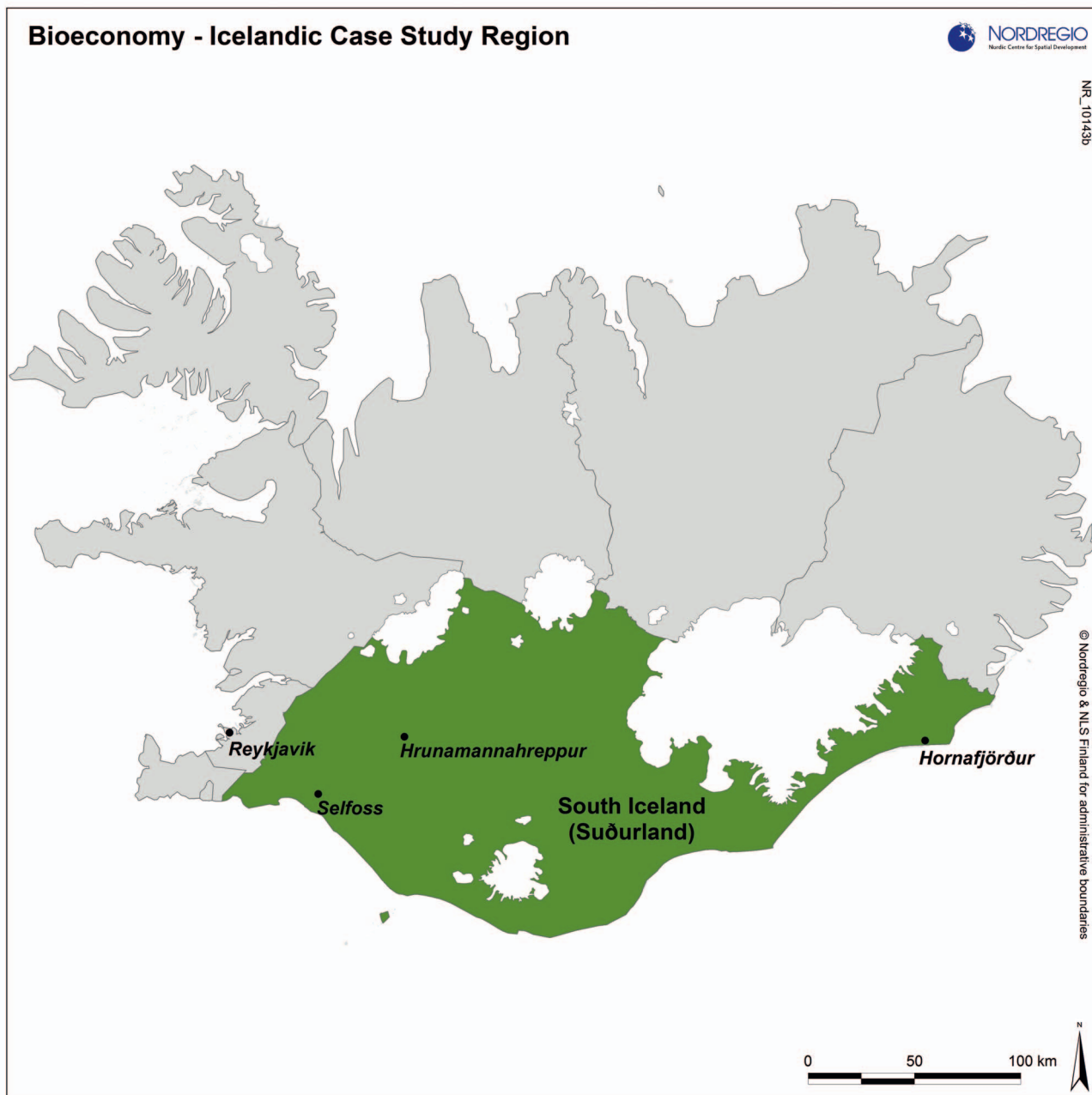
At the regional level, Iceland does not have public authorities as such, but each of the eight LAU 1 regions has a regional association of local governments. It is stated in the Local Government Act that “local governments may establish regional associations to work for the interest of the inhabitants in each region”. The regional development activities of the regional associations are partly financially supported by the state.

At the local level, municipalities are self-governing, and all of them, independent of their size, have the same duties and responsibilities. The major tasks of the municipalities concern education and social services. (Icelandic Association of Local Governments, 2014)

Currently, Iceland is in the process of reforming its regional development policy and the governance system around it. The aim is to strengthen the role of the local governments (co-operating through the regional associations of local authorities) and to adopt a more holistic and integrated approach to strategic regional development, replacing the earlier and more ad hoc approach to responding to challenges in specific areas (interviews, 2014).

The central government will publish a national regional development strategy in 2014, and the regions will prepare their own regional development strategies based on this strategy and their own regional specificities. Based on these strategies, contracts will be made between the state and the regions as a basis for allocating state funding to regional programmes and projects. The aim is to adopt an approach where the development of a region is based on the specific challenges

Figure 5: The region of South Iceland (Map design by Julien Grunfelder)



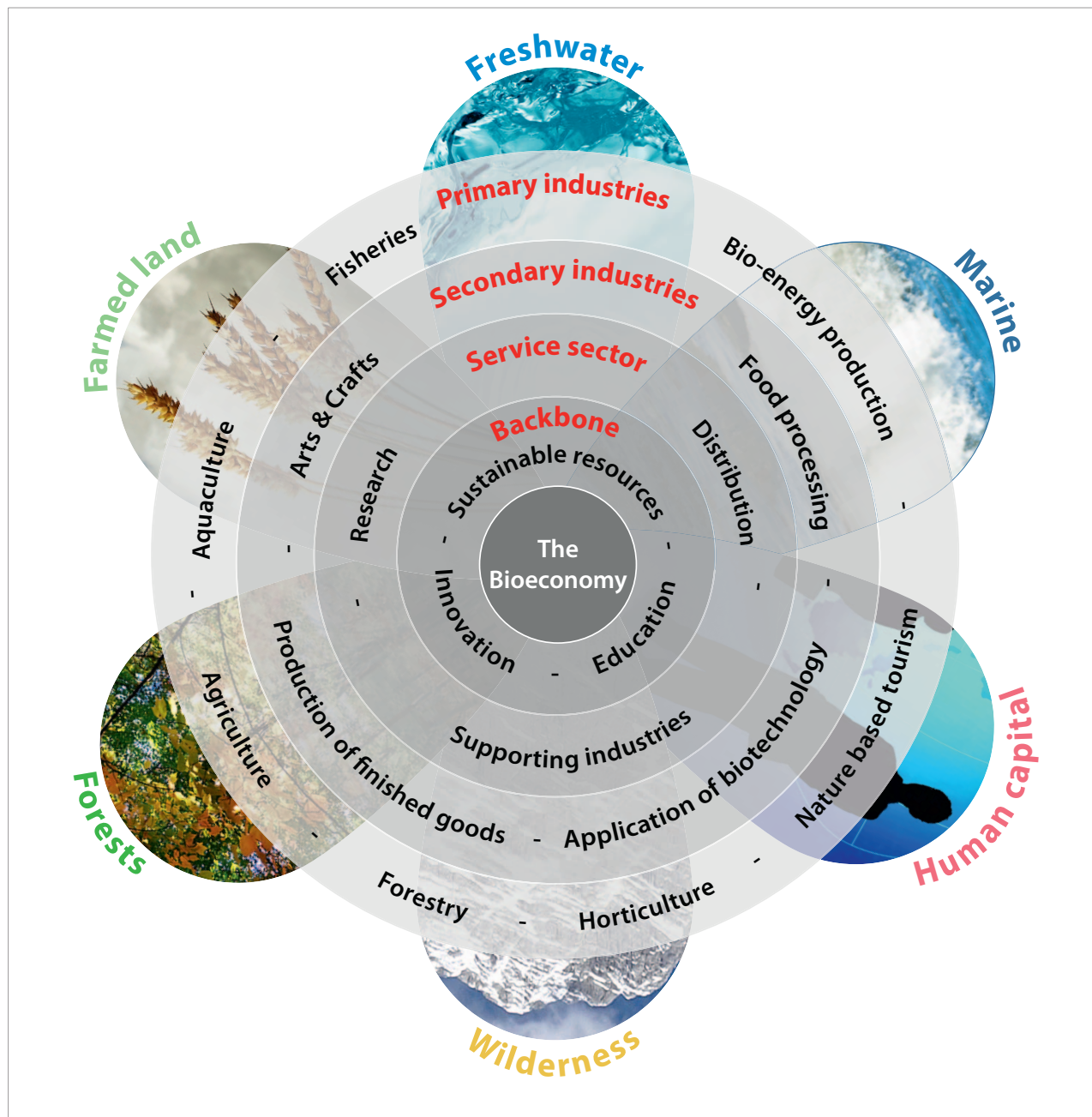
and potentials of the region as identified by local and regional actors. More decision-making power would also be transferred to the regional associations of local governments (interviews, 2014).

3.3.4. Bioeconomy in South Iceland

According to a study by Kemp Stefánsdóttir (2014), the bioeconomy contributes to 13% of the entire Icelandic GDP (2010). The majority of this stems from the marine sector, which has traditionally been a basic indus-

try in Iceland that in total contributes 26% of the Icelandic GDP. Approximately one-fourth of the resource-based exports in Iceland have been from the fishing industry. The marine sector is the most important sector in Iceland, with the greatest potential for the bioeconomy, while the potential for a land-based bioeconomy utilizing the biological resources on land is lower in comparison with other Nordic countries (Kemp Stefánsdóttir 2014).

Figure 6: Illustration of the Icelandic definition of bioeconomy (Source: Matís Ltd.)



According to the interviewees, the Icelandic bioeconomy has good potential, especially for further processing of by-products from fisheries and agriculture. Algae, and to some extent local forest resources, are the only main resource in the Icelandic bioeconomy that is not yet utilized. The main potential is therefore linked to more efficient use of the existing resources as well as creating ways to utilize and process these resources to create higher value added (interviews, 2014).

The potential is high, not only when it comes to utilizing unused material but also in developing ways to utilize the by-products in a way that creates more value added. In many cases, the by-products are already utilized, but the value added and the level of processing is

low. There is a good potential for increased value added in processing the products further instead of exporting unprocessed raw materials (interviews, 2014).

In Iceland, the bioeconomy has a good potential for developing the regions located outside the capital region—85% of the workplaces in the bioeconomy are outside the Reykjavik region, and these comprise a significant part of the total number of workplaces in the regions (Interviews, 2014).

In the South Iceland region, figures or estimations of bioeconomy potential and innovation as such are not available. However, as noted above, fisheries and agriculture are large and important sectors. Unlike Iceland as a whole, the region is strong in agriculture

and has an important national role in the sector. Tourism is also expanding in the region, bringing new opportunities and challenges.

This case study focuses on bioeconomy innovation in the South Iceland region related to fisheries and agriculture, and in particular to food innovation. Food innovation has been promoted in the region by the state-owned Matis Ltd., Innovation Centre Iceland, as well as local and regional actors. The innovations developed in agriculture and fisheries and food innovations are often small in scale but may have the potential to contribute to the development of companies and the regional economy as well as to increase the efficiency of the use of natural resources (interviews, 2014).

The innovation activities related to food or agriculture and fisheries are based on both product and process innovations. There have been many small-scale innovation activities taking place in the food innovation centres of Matis. These include developing ways to export cod liver, developing green “kale snacks”, “potato chocolate” and other innovative snack products, dried fish products as souvenirs, raw goat sausages and the development of hot smoked mackerel products. Furthermore, the farmers in the region are interested in the possibility of cultivating rapeseed in Iceland, and one farmer is producing rapeseed oil while using the waste from the production methods to produce feed for his livestock (interviews, 2014).

The use of waste flows has been developed in connection with fisheries. There was a development project on using fish waste as fertilizer, but the activity did not continue after the project ended. However, some of the fisheries are currently supplying their waste to a fish oil producer free of charge, while they earlier had to pay to dispose of the waste. The lobster industry is important in many parts of the region, and the companies have developed ways to utilize the lobster parts

that previously were wasted and to make them into bouillon. In Hornafjörður, the farmers co-operate with a local grocery store that supplies them with waste to use as feed and fertilizer which is another example of an activity aiming to increase resource efficiency. (interviews, 2014)

3.3.5. Policy framework and main actors

Iceland has traditionally been dependent on natural resources, but the idea of promoting innovative ways to utilize the existing resources more efficiently to increase the added value of the product has systematically been prioritized at the national level since the early 2000s. A specialized national funding instrument to increase the value of marine products (AVS) was established in 2002. This illustrates the government’s wish to stimulate further processing of fish products, which is an important part of the Icelandic bioeconomy (interviews, 2014).

Currently, bioeconomy activities are prioritized as an important area for national funds for R&D. Moreover, in the national business strategy that is currently in preparation, the bioeconomy is expected to have a central role. One of the latest developments in bioeconomy policy has been the establishment of the bioeconomy as a main focus area of the Icelandic presidency of the Nordic Council of Ministers. The preparations began three years before the presidency year of 2014, and they were an important step for the development of the bioeconomy in the country because during the preparation phase, all business sectors co-operated and agreed that the bioeconomy is a significant opportunity and an important issue for Iceland to prioritize (interviews, 2014).

As a small country, most of the important policy-related developments on the bioeconomy in Iceland have taken place at the national level; even though the

Table 8: Examples of food-related innovation activities in South Iceland

Examples of food-related innovation activities in South Iceland
■ Developing innovative ways to utilize and increase the added value from the by-products of fish processing
■ Developing new types of lobster packaging to enable more efficient transport
■ Developing different types of small-scale food products to be sold to tourists and visitors and in some cases to export (e.g., sheep milk cheese, smoked eel, smoked mutton sausages, hot smoked mackerel, raw goat meat sausages, vegetable snacks, smoked goose)
■ Growing rapeseed (not traditionally grown in Iceland) and utilizing the by-products from rapeseed oil production
■ Experimenting with using fish waste as fertilizer
■ Direct retailing of fresh fish from the local area to inhabitants, visitors and hotels (in most cases, it is only possible to buy frozen fish in supermarkets, even in fishing villages)

country is now aiming to strengthen the role of the subnational levels (see the following chapter on regional policy). Approaches to the bioeconomy have been included in earlier strategies, such as the Iceland 2020 strategy of 2011, which among other priorities emphasized the importance of eco-innovation. According to a Nordic Innovation report entitled *Innovation in the Nordic Bioeconomy*, the Iceland 2020 strategy is an important policy document for developing the bioeconomy, but according to the interviews conducted in connection with this case study, the strategy is no longer in all cases very actively followed in policy-making or implementation. There was a change of government following the elections of 2013, and the strategies and plans of the new government are still being prepared (Prime Minister's Office 2011; Interviews 2014; Nordic Innovation 2014).

The establishment of Mátis Ltd. in 2007, merging three previous research institutes, has been a stepping stone in developing the bioeconomy, and the role of the institute in the development of the Icelandic bioecon-

omy has been central. In general, the regional actors consider the Mátis Food Innovation Centres crucial for the development of food innovation in their areas. It has been found to be important that the centres provide not only business support and consultancy but also opportunities for companies to “get their hands dirty” and in practice develop products in co-operation with the Mátis experts (interviews, 2014).

Some of the municipalities in the region have actively supported the work of Mátis. For example in Hornafjörður, the municipality has supported Mátis financially and has provided a house for testing facilities at a lower rent. In Hrunamannahreppur, the municipality is attempting to include more neighbouring municipalities to support the local food innovation centre to ensure that it is possible for the centre to continue its activities in the area (interviews, 2014).

The University Centre of South Iceland, owned by the municipalities of the region, is also becoming an increasingly important actor in food innovation in the region. It already provides the inhabitants with op-

Table 9: *Mátis – Icelandic food and biotech R&D*

Mátis—Icelandic food and biotech R&D
<p>Mátis is a government-owned, independent research company, founded in 2007 following the merger of three former public research institutes. The company supports the industry and government in improving the way in which limited resources are used and minimizing generation of waste by improving utilization.</p>
<p>Mátis focuses on the development and improvement of methods of sustainable production and utilization of products to stimulate innovation and the economy, and to reduce strain on the environment. The company also helps businesses in the food and biotech industries to increase the value of food processing and food production through research, development, and dissemination of knowledge and consultancy, as well as to ensure the safety and quality of food and feed products.</p>
<p>Approximately 100 people are employed in Mátis's offices, laboratories or food innovation centres located in eight cities or towns around Iceland. The turn-over in 2013 was around \$USD11.5 million, of which 30% comes from the Icelandic Government.</p>
<p>Mátis' employees include many of Iceland's most competent scientists in the fields of food technology, food research and testing, and biotechnology. Mátis' specialized fields include bioeconomy, biotechnology, enzyme isolation, processing technology, traceability, genetic analysis, chemical and microbiological testing, investigating the physical and chemical properties of food, quality and safety of aquatic and marine catches, and feed technology for aquaculture and environmental research.</p>
<p>Main assignments:</p> <ul style="list-style-type: none"> ■ Analysis and consulting ■ Biotechnology and biomolecules ■ Food safety, environment and genetics ■ Resources and products
<p>Website: www.matis.is/english</p>

portunities to participate in distance studies at many universities around Iceland, and it has contributed to increasing the education level of the region. At the moment, it is preparing a specific education programme (two-year diploma education) in food development and innovation. The programme will be developed in co-operation with companies that can participate in shaping it to fit their needs and those of their employees who participate. The programme is funded by the municipalities and the companies that pay for their employees' participation. Matís also has an important role here, as its experts will organize the content of the courses (interviews, 2014).

The Regional Association of Local Authorities in the region (SASS) also provides business with support and helps companies with innovative ideas to "take the next steps", and in that way also contributes to developing the bioeconomy. Among other functions, it assists companies with strategic budgets and marketing plans. SASS has offices in several parts of the region and co-operates with Matís in reaching out to the smaller, more remote municipalities with few innovation activities and encourages innovation by providing education and courses. When Matís can provide the content expertise concerning food development and innovation, SASS has the resources to help the companies with project applications so that they have opportunities, for example, to develop their products further with help from Matís (interviews, 2014).

3.3.6. Enabling conditions

Natural resources

Access to natural resources provides a good basis for developing the bioeconomy of South Iceland. The region has a strong tradition of agriculture and fisheries, which provide a basis for innovative activities to pursue goals such as increasing the efficiency of resource use or the value added of products. The bioeconomy is of particular interest for a country like Iceland, which cannot compete with other European countries in areas such as industry and relies on its natural resources. Increasing the level of processing of natural resources and thereby increasing their profitability therefore has good potential for Iceland. The profitability of developing the value added of natural resources is an important factor driving the development and increasing interest in the bioeconomy of Iceland (interviews, 2014).

The access to energy from geothermal hot water is another natural resource-related driver of the bioeconomy. For example, the greenhouse industry is important for the municipality of Hrunamannahreppur, and the development of the greenhouse industry and thus

the local economy is greatly dependent on the geothermal water supply. Now the ambition of the municipality is to promote innovations in the greenhouse industry with the help of the Matís food innovation centres as a way to increase the value added from the industry (interviews, 2014).

Co-operation between actors

Matís has been especially actively in promoting co-operation between actors in the local communities. Matís has the capacity to work with local companies and employees, and to encourage and support their innovative ideas. It is emphasized that it is much easier to start developing new ideas if support and the facilities needed are available "next door" instead of Reykjavík. This link between the public R&D institute Matís and the private sector SMEs has been found to be essential. In many cases, it seems that that the opportunities for increased innovation activities are considered to be highly dependent on whether Matís (and its food innovation centres) and/or Innovation Centre Iceland are physically located in the local area (interviews, 2014).

Matís has actively encouraged parties such as farmers or food processing companies to develop their ideas further and has encouraged more people to use the food innovation facilities. This has not always proved to be the most suitable approach because it is difficult to activate people who lack the drive and interest to continue with their ideas after the first stages. Therefore, Matís now focuses on finding people with innovative food development ideas and matching them with those who have access to the necessary materials (farmers and fisheries). This approach is expected to yield better results, and it may also promote co-operation between actors. However, it is stated that it would be desirable if the municipalities and other actors in the local communities to participate more actively in promoting food innovation and attracting the inhabitants to use the food development facilities (interviews, 2014).

As an example of good practice, the Nyheimar house in Hornafjörður promotes co-operation between different types of actors and has successfully created links between actors at the local, regional and state levels. In the house, they have the opportunity to work together. The offices include employees from organizations such as Matís, the Innovation Centre Iceland, the University Centre of the University of Iceland, and companies in need of office space to develop their businesses (interviews, 2014).

Funding

Funding from the state level through the Innovation Centre Iceland and other organizations is an important

driver and is especially necessary for smaller companies. Funding is available particularly for the starting stages of innovative initiatives as well as for exporting. Funding can be applied for from national cross-sectoral funds for research and development, general funds for purposes such as agriculture or specific funds such as the AVS fund (for increasing the value of marine products). The municipality of Hornafjörður has invested in innovation in its territory by establishing its own fund for innovation, which has functioned as a driver for innovative projects in the area (interviews, 2014).

In 2014, Matís has had access to funding from the Icelandic Nordic Council of Ministers' NordBio presidency programme, which among other provisions allows Matís to support companies in their food development ideas without each company applying for funding separately. The NordBio programme as such consists of various projects involving several sectors, and innovation and sustainability in food production are important areas under the "Innovation in the Nordic bioeconomy" project. The current subproject on food innovation that Matís is implementing is a pre-project, and in future, the project will be extended to all Nordic countries (interviews, 2014).

In the spring of 2014, Matís made an open call for ideas. The applicants described their specific challenges with their ideas, and Matís would then assist them. The issues with which the applicants would need assistance cover a wide variety of specific problems in areas such as packaging or measuring and testing products. Usually, the companies have to apply for funding separately, with assistance from Matís and SASS, but this new approach decreases the bureaucracy and increases efficiency as it removes several steps. Therefore, Matís has also applied for funding from the central government to continue this approach (interviews, 2014).

Synergies between sectors

There are already clear interrelations and synergies between the sectors of fisheries and agriculture in the region in terms of activities such as utilizing waste streams. The regional actors also link the development of food innovation to the development of tourism. Agriculture in Iceland has previously focused on mass production intended to make Iceland self-sufficient, but now there is expected to be potential in exports, and in particular in selling products to tourists. Food innovation has great potential in connection to increasing tourism, and it has been noted that many local hotels and restaurants already use local food products. Many of the food innovation products developed are sold particularly to tourists, and there is clear interest

in the region in strengthening the link between tourism and local food production (interviews, 2014).

3.3.7. Impeding factors

Some challenges for the development of bioeconomy in Iceland and in the South Iceland region in particular have also been identified. Some of these challenges are specific to the South Iceland region and are related to its specific characteristics, while others are more general.

One of the impeding factors identified by many of the interviewees is related to company culture or innovation culture. The companies are often small, and therefore they prioritize a focus on their core business. This has been found to have an effect on the innovation culture. Therefore, encouragement from experts and their help in applying for funding and handling the related bureaucracy are essential to promote innovation (interviews, 2014).

Policy and governance

In terms of policy and governance-related aspects, it has been noted that the Icelandic governance system with majority governments can have a negative effect on strategic working, as changes in government often result in the cancellation of plans and programmes established by the previous government without a broad political consensus (interviews, 2014).

The regional policy framework in Iceland has not been a strong focus area, but it is now being reformed (see chapter 2). The aim of this policy reform is to establish regional development strategies based on the potential and challenges identified by local and regional actors. (interviews 2014)

However, formulating and implementing regional policy is challenging in a country with a small population and a low population density. Many regions (including the South Iceland region) are geographically large with very different types of areas in terms of factors such as population density, economy and proximity to Reykjavík. (interviews, 2014)

In South Iceland, developing a joint strategy for the entire region will be challenging, as the parts of the region have very different characteristics and so have different potentials and needs. For example, the town of Selfoss is nearly an urban area close to Reykjavík, whereas most parts of the region along the south coast are extremely sparsely populated rural areas with small settlements. However, because of the sparse population, it is not possible to make specific plans for the various parts of the region either, as many large areas have very few inhabitants. From a regional development perspective, this is a governance challenge for developing a

bioeconomy in a large and varied region with sparse population (interviews, 2014).

From a policy perspective, it has also been noted that although the expanding tourism sector brings great opportunities—for example, by creating markets for food innovation—policymakers need to ensure that conflicts between sectors do not arise over increasing tourism. For example in land use planning, there is a need to consider the sustainability of tourism and to ensure the availability of good land for agriculture (interviews, 2014).

Human resources

In South Iceland, the lack of an educated labour force is identified as a factor with a negative influence on innovation. The education level in the region is below the Icelandic average, which is why the competence of the experts from Mátís and Innovation Centre Iceland is considered to be very valuable in the region. There is a University Centre providing distance learning opportunities in many locations across the region, but the competence supply could be strengthened by international co-operation and networking with international experts (interviews, 2014).

The local communities are very small; therefore, they are vulnerable to out-migration of individual employees, and it is often not possible to find new people to fill positions. Since Mátís's previous expert in Hornafjörður moved, nobody else has been employed, which is also related to the resources of Mátís. At the moment, it is unclear whether there will be a new employee in Hornafjörður, but the municipality is working actively to make it possible (interviews, 2014).

Another example concerns the lobster cluster of Iceland, where a very active employee at the Regional Association of Local Governments (SASS) was co-ordinating the joint R&D projects of the lobster companies. Since the employee resigned, the lobster cluster has been much less active. The small size and lack of critical mass mean that in-migration or out-migration of an individual highly qualified employee can have a significant impact (interviews, 2014).

Funding

Some challenges concerning the availability of funding were highlighted by the interviewees. As noted above, funding is accessible in the first stages of innovation processes as well as in the export stages. However, there is a gap in scaling up innovation, and it is difficult to obtain funding for purposes such as buying machinery or marketing. It is important to have funding for the intermediate stages between the first idea and export, as it has been found that often before they can export,

companies should build their markets in Iceland (interviews, 2014).

In food innovation, the level of innovation required by the Innovation Centre Iceland for funding can also be a challenge. The requirement for the novelty of the product can be too ambitious in cases where the idea is not entirely new (which is often the case in food innovation) but may still have the potential to contribute to the local economy, for example when new methods are applied in the local context (interviews, 2014).

It has also been emphasized that a lack of public funding resulting from the financial crisis is naturally a barrier for the development of bioeconomy. There is a need to increase the availability of funding both for companies and for regional development in general (interviews, 2014). It has also been noted in a report from Nordic Innovation on Nordic bioeconomy that the Icelandic market is characterized by small companies with limited resources where access to financing often is the main barrier to innovation.

3.3.8. Concluding remarks

The region of South Iceland has a long tradition of primary production in agriculture and fisheries, and the interviewees are positive about the potential of the region to increase the added value of the biomass materials of agriculture and fisheries. They also find potential for using the resources more efficiently and utilizing waste flows. These factors can increase the value of ecosystem services for the regional and local economies of South Iceland.

Innovation is central for contributing to the development of the bioeconomy and finding ways to increase the added value of goods such as agricultural products. Food innovation is particularly relevant to the rural and sparsely populated region of South Iceland, as it can build on local competences and knowledge of primary production but does not necessarily require high technology competence or facilities. These factors make food innovation ideal for this type of rural region, even though the generally low education levels still hinder development. In South Iceland, innovative approaches have been taken to both developing new food products and utilizing waste streams.

The innovative projects in South Iceland are mostly not based on high technology or entirely novel innovations. Instead, they are small-scale innovations where the role of local knowledge and the competence of the local people are central. However, although the innovations are often small in scale, they are important for the local and regional economies, as they have the potential for positive outcomes, such as increased profits. At the same time, utilizing the biomass more efficiently

also contributes to improved environmental sustainability. This clearly illustrates how developing bioeconomy does not necessarily have to rely on high technology and advanced large-scale solutions. It shows that local solutions based on local knowledge can also be important in their specific context. In South Iceland, companies also have a great need for outside expertise and support to engage in innovative activities. This is related to both the small size of the companies, challenges in human resources and the overall low education level. The importance of the experts representing the national-level actors, Matís and Innovation Centre Iceland, is continually emphasized, and the innovation potential of the region is found to depend on their presence in the region close to where the companies are located.

In the case study, it becomes clear that in addition to providing expertise and support in local communities, policy-making in rural regions also needs to focus on educational factors such as developing the skills and competences of the local companies. In South Iceland, an education programme at the University Centre has been planned. The planned programme will focus on food development and will be financed by the municipalities. This could be an important step in increasing the competence level in the food industry.

In addition to the need for consultancy and support, the companies with innovative ideas also require access to funding. This is particularly essential in predominantly rural areas that are mainly based on primary production, such as South Iceland, because most companies are very small and have very limited resources. In general, the funding available from the state is an important driver of the bioeconomy in the region. However access to funding for scaling up production and marketing has been lacking, which has created a gap in financing. It has also been noted that the requirements for funding for innovations may in many cases be too strict and thus not suitable for food innovation projects. If the bioeconomy in rural regions is to be promoted, it is important to ensure that suitable funding instruments are available not only for projects with very high overall innovation value but also for those that are innovative in their own regional contexts.

The subproject of the NordBio project (within the Icelandic Nordic Council of Ministers Presidency programme) is a good example of an approach where support is made available for companies with less bureaucracy and increased efficiency. In this project, companies can apply for direct assistance and support from Matís, which has been granted funding for this purpose. The outcomes of the projects will be presented

in the summer of 2014, but it is clear that these alternative ways of funding and supporting companies may have significant potential especially for food innovation in SMEs.

At the national policy level, the regional policy framework is currently under revision, and it seems that the new regional policy approach could be beneficial for developing the bioeconomy. The framework is intended to move away from sector-based policy-making towards a more cross-sectoral and holistic regional development approach, which is well in line with the integrated and cross-sectoral approaches that are required to develop the bioeconomy. Another aim of reforming the regional policy framework is to strengthen the role of the local and regional levels and to decentralize policy-making, which may further contribute to ensuring that regional policies are properly anchored in the characteristics and opportunities of each region. This would also be beneficial for developing the bioeconomy where knowledge of the local and regional needs and potential is needed.

3.4. Østfold County, Norway

By Ingrid H G Johnsen

3.4.1. Introduction

This case study focuses on wood processing as part of the bioeconomy of Østfold County in Norway, and specifically on one of the world's most advanced biorefineries, Borregaard.

The European Commission refers to the bioeconomy as an important element of Europe's reply to the challenges ahead regarding concerns such as limited and finite natural resources and climate change (European Commission, 2014). The bioeconomy encompasses the sustainable production of renewable resources from land, fisheries and aquaculture environments and their conversion into food, feed, fibre bio-based products, and bioenergy as well as related public goods. It includes primary production, such as agriculture, forestry, fisheries and aquaculture, and industries using/processing biological resources, such as the food and pulp and paper industries, and parts of the chemical, biotechnological and energy industries.

According to a study on the bioeconomy of the Nordic countries (2014), the forestry industry comprises 14% of the total bioeconomy of Norway (Nordic Innovation, 2014, p. 15). The forestry industry is a generic term used for a large group of industries that all have wood as their main raw material. The industry can be divided into two main groups: (1) timber/lumber, and (2) pulp/paper.

Over recent years, the pulp and paper industry has struggled with low profitability for reasons such as tougher market conditions and tighter regulations. This has resulted in multiple closures and layoffs. Greater competitiveness and profitability is vital for the wood-processing industry to adjust to new market conditions, and there has been a focus on upgrading the industry towards more sustainable and innovation-intensive activities that can contribute to resource efficiency, including reduced costs and a smaller environmental footprint. Such a shift involves moving away from classical mass production towards a highly knowledge-intensive and innovation-oriented industry.

Østfold is the home of the biorefinery, Borregaard, which is located in the county's administrative seat, Sarpsborg. Biorefineries produce bio-based chemicals, biomaterials, biofuels and bioenergy from bio-based raw materials, side streams and waste in highly optimized and resource-efficient processes as a part of local and global value chains and business ecosystems (Nordic Innovation, 2014). Borregaard has developed from a traditional wood-processing company to an advanced manufacturer of bio-based chemicals. This makes it an interesting case that illustrates how companies can change their knowledge base and make a transition to the bioeconomy. A relevant question in this regard is the role of the regional support system and the extent of regional spill-over. This case study focuses on identifying the key network actors linked to wood processing and the role of the region in supporting the development of this sector.

The findings of the report are based on secondary sources and qualitative interviews with representatives from the Country Council and Borregaard. The next section provides an overview of the policy framework related to the bioeconomy of Norway. The overview is followed by a description of the Østfold region, including the administrative structure, including a more detailed description of the development of the wood-processing industry and Borregaard as a relevant case in this regard. The last two sections conclude the findings and discuss the opportunities and challenges for the region to develop the bioeconomy further.

3.4.2. Policy framework

Norway has particularly strong competences in the biotechnology field, and its long-term strategy is to create a knowledge-based economy using renewable raw materials from the agricultural, forestry and marine sectors. This is specifically stated in the National Strategy for Biotechnology. The Ministry of Education, in collaboration with the Ministries of Health & Care Ser-

vices, Agriculture & Food, Fisheries & Coastal Affairs, Trade & Industry, and Environment, as well as The Norwegian Research Council and Innovation Norway, led the strategy development.

The National Strategy for Biotechnology (2011–2020) has its origins in the research report (White Paper no. 30, 2008–2009), where it was determined that a balanced strategy for fundamental research, industrial research, and the development and commercialization of biotechnology should be developed. The strategy identifies four thematic priority areas where biotechnology can address social challenges and where Norway has national advantages. The four areas are as follows:

- Aquaculture, seafood and management of the marine environment
- Agro-food and biomass production
- Environmentally friendly industrial processes and products
- Health, health care and health-related industries

The main aim of the strategy is not only to ensure continued investment in research, development and the commercialization of biotechnology but also to ensure that biotechnology is applicable in various sectors across the country. To achieve this, there is a need for updated regulations, good interaction between research and technology communities and those who apply the knowledge, and good interaction between research and society.

Wood is an important natural resource in Norway, with the pulp and paper industry being the sixth largest industry in Norway, accounting for approximately 6% of total national exports (Oxford Research, 2013). However, over recent years, the sector has struggled with low profitability, and employment throughout the forest industry has fallen drastically. This particular crisis places great focus on the development of advanced material technologies and their commercialization, involving a shift from classical mass production towards a knowledge-intensive and innovation-oriented industry (Ibid.). Such a shift has been encouraged through research, development, innovation and investment projects directed towards the forest industry and financed by the companies but is also supported by the Research Council of Norway, Innovation Norway and other actors.

Innovation Norway, a state-owned company working to promote innovation and development of Norwegian enterprises and industry, supports bioeconomy activities through a network called Industrial Biotech Network Norway. The network comprises 36 actors, including Innovation Norway, the Research Council of

Norway and SIVA (The Industrial Development Corporation of Norway). The network's main task is to contribute to increased innovation through cross-sectoral co-operation, dissemination of knowledge, and stimulating new projects and industrial partnerships. The network is instrumental in realizing the Government's national strategy for biotechnology, and it establishes contact with international research institutions and markets. SIVA especially works to connect communities on the regional, national and international scenes so that they can work together to find solutions to the challenges related to activities such as food production, raw material shortages, environmental pollution, energy supply, and climate change. New technologies, especially biotechnology, and the need to replace petroleum with renewable raw materials are the two main driving forces behind the focus on bioeconomy in Norway.

Innovation Norway also has three support schemes related to bioeconomy; namely, programmes on environmental technology, biorefineries and bioenergy. The programme on environmental technology provides subsidies for Norwegian companies for established projects focusing on purification, environmentally friendly products and production processes, more efficient resource management, and technology systems that reduce environmental impact. The biorefineries programme provides support for companies in an early pilot phase of processing biomass. Finally, the bioenergy programme is intended to encourage agricultural and forest users to produce, to use and to supply bioenergy in the form of fuel or heat.

The Research Council of Norway also focuses on the bioeconomy through the BIONÆR programme. The scope of BIONÆR does not cover the entire bioeconomy, and there are other programmes and funding instruments through the Research Council that provide funding for research activities that concern the bioeconomy.

3.4.3. Description of the region

Østfold County is situated in south-eastern Norway, bordering Akershus and south-western Sweden (Västra Götaland County and Värmland), and covers an area of 4,182 km². It is one of the 19 NUTS 2 regions in Norway and part of the larger NUTS 3 region of Sør-Østlandet (NO03) together with the counties of Buskerud, Vestfold and Telemark.

The total population of Østfold County is approximately 285,000, with Sarpsborg and Fredrikstad comprising the fifth largest urban area in Norway (with a total population of approximately 130,000). Østfold is relatively densely populated, with 70 people per km². Only Oslo, Akershus and Vestfold Counties have a

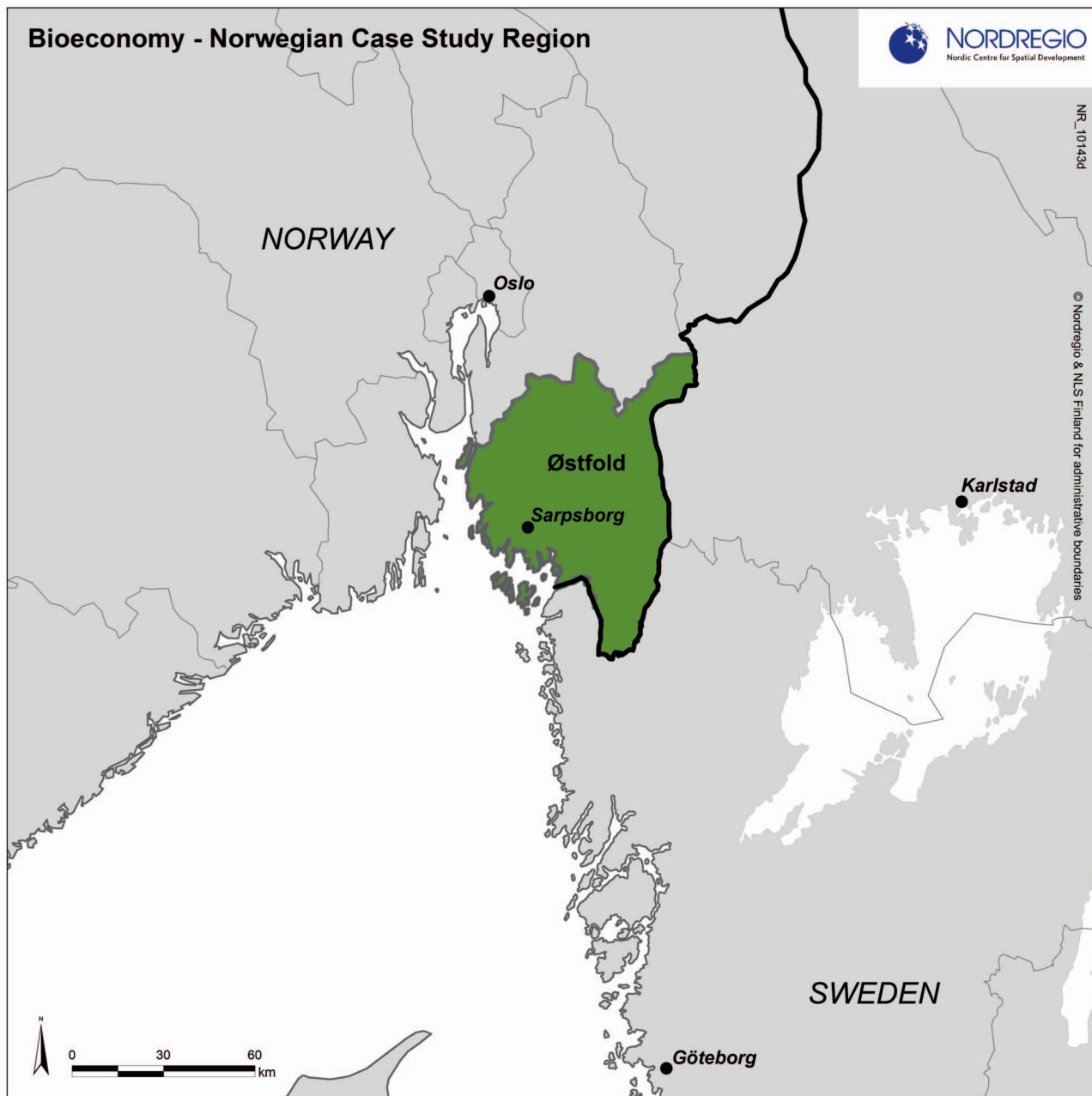
higher population density (Østfold Analyse, 2014a). Furthermore, although agriculture makes up an important part of the economic activity in the region, 83% of the population live in urban areas (Ibid.).

Norway is divided into 160 functional labour market regions (Gundersen and Juvkam, 2011). Borregaard is located in Sarpsborg, which is part of the functional labour market region of Fredrikstad/Sarpsborg, which includes Hvaler, Rakkestad and Råde. (NIBR report 2013:1). While Fredrikstad/Sarpsborg is the core of its own labour market region, a significant number of people commute to Oslo from these cities. For instance, in 2009, 14,213 people commuted from Østfold county to other domestic counties, while 6,713 commuted to Østfold country from other domestic counties. In addition, in 2008, 2,096 people commuted from Sweden to Østfold and 310 people from Østfold to Sweden (Østfold Analyse, 2014b). This demonstrates that Borregaard is located in a region that belongs to a large functional labour market, including the capital region of Oslo.

Traditionally, Østfold has been dominated by manufacturing industries; however, there have been major changes in industry structure over the past 30–40 years, where the county has gone from being dominated by a large processing industry (including wood processing) and commodity production to having a more diverse employment structure. In manufacturing, the number of jobs has decreased by more than 10,000 over the past 25 years. Moreover, while there has been a decline in manufacturing employment and to some extent in primary industries and transport/communications sectors, there has been an increase in the number of jobs in all other sectors. The largest growth has been in the public service, merchandising, financial and commercial activities and private services.

Although Østfold has seen the sharpest decline in the number of jobs in manufacturing, the population is growing, and there is a large net inflow from other counties to Østfold (Vareide and Storm, 2012). It is the attractiveness of the county as a place of residence that is the main driver of Østfold's population growth (Hauger, 2011). However, there is a deficit in the number of jobs in the region, especially related to management and academic professions. Approximately 30% of the labour deficit is related to workplaces occupied by people with university or college degrees. It is particularly in the natural and engineering sciences, social sciences and law that the labour deficit is greatest and has increased the most in Østfold over the past 10 years (Ibid.). As a consequence, many people choose to commute to the neighbouring regions to work (e.g., Oslo and Akershus in Norway or Västra Götaland County

Figure 7: Østfold County (Map design by Julien Grunfelder)



and Värmland in Sweden). Figure 8 provides an overview of Østfold County and its municipalities.

3.4.4. Administrative structure

Norway is divided into two administrative levels in addition to the central administration: counties and municipalities. Both of these administrative levels are governed by elected bodies, county and municipal councils. A council and a mayor head each municipality.

The county council is responsible for maintaining some public management and service-producing tasks within the county. The county council is directly elected by county residents at the municipal and county elections. The politically elected bodies of the county

correspond to those of the municipalities: county council (municipal council), county executive board (municipal executive board) and chairman of the county council (mayor). Some counties also have a county government. Among the counties' duties are maintenance of county roads, planning and support for public transport, secondary education, public health, cultural heritage, cultural work, regional development and land management.

At the national level, it is the Ministry of Trade and Industry that has overall responsibility for industrial and innovation policy. The Ministry's overall objective regarding business and innovation policy is to promote value creation in the Norwegian economy. In White

Paper No. 7 (2008–2009) entitled “An innovative and Sustainable Norway”, it is stated that industrial policies are related both to research and education policy and to rural and regional policy. The white paper is the first in which the Government promotes guidelines for initiatives to facilitate long-term sustainable value creation. In the paper, it is stated that sustainable value creation will be achieved by promoting:

- a creative society with good conditions and a good climate for innovation,
- creative people who are able to develop their resources and expertise and put them into practice, and
- creative enterprises with public and private organizations that develop profitable innovations.

The various ministries’ objectives, initiatives and instruments constitute the framework that is referred to as the innovation system. The various ministries generally use the same instruments, such as Innovation Norway (the Norwegian Government’s instrument for innovation and development of Norwegian enterprises and industries), the Research Council of Norway, SIVA (the Industrial Development Corporation of Norway, dealing with the establishment and development of innovation networks consisting of business parks, incubators and science parks), and the county councils in promoting and managing their programmes and initiatives, and public funding agencies that play an important role in the regional economic development. The four main public stakeholders are as follows.

- Innovation Norway
- The county council
- The county governor
- The municipalities

The various public stakeholders have different focus areas and priorities but seek a synchronized regional development through co-operation in joint ventures where possible and appropriate. The regions that see the largest effect of the public support system are those that succeed in regional co-operation between industry, government and other actors, and where the support instruments can be utilized optimally based on an appropriate policy and innovation strategy.

3.4.5. Development of a bio-based wood-processing industry

Traditionally, wood processing has had a stronghold in Østfold County with three large factories—Borregaard in Sarpsborg, Norske Skog Saugbrugs in Halden and Peterson² in Moss. These factories mainly have produced paper pulp, wood-based chemicals and wood fibre. However, in recent years, multiple closures and sales in the Norwegian pulp and paper industry because of increased global competition and low profitability have characterized the industry. For instance, Norske Skog, which is one of the largest and most modern production units for newsprint and magazine paper in the world, has been forced to shut down its activity in the plant in Follum in central and eastern Norway. Borregaard, on the other hand, has moved away from paper production and has instead upgraded its knowledge base and invested heavily in the chemicals market.

Borregaard, headquartered in Sarpsborg, operates globally and has subsidiaries in 20 countries. It has a turnover of 500 million EUR³ and has 1,050 employees in plants and sales offices in 16 countries throughout Europe, the Americas, Asia and Africa.

The Kellner Partington Paper Pulp Co. Ltd. was established in Manchester in 1889, and the construction of pulp and paper mills in Sarpsborg started soon afterwards. The first pulp mill was completed in 1891. The early years were characterized by strong development and by the construction of mills, a carbide plant and a hydropower plant. In 1909, Borregaard was already Norway’s largest industrial employer. In 1918, the company was bought by Borregaard for 100 million NOK. This purchase was designated a major national event in which the Forest Owners’ Association played a key role. Hjalmar Wessel became the first director general of the company. Borregaard bought Denofa–Lilleborg (a Norwegian industrial company that produced oil and fatty acids for food processing, among other purposes) in 1959 and Stabburet (a Norwegian food producer) in 1975.

In 1986, Borregaard merged with the chemical division of the Orkla Group (a Norwegian conglomerate operating in the branded consumer goods, aluminium solutions and financial investment sectors). The company was owned by the Orkla Group until it was listed on the stock exchange in October 2012.

2) The company was closed in 2012

3) 400 billion NOK

Development towards knowledge-intensive activities

High-cost countries are becoming increasingly internationalized and technologically advanced, and consequently knowledge plays a key role in corporate competitiveness. The knowledge economy emphasizes “production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence” (Powell and Snellman, 2004). This is especially relevant for Norwegian companies, many of which have a far higher cost than firms in most other countries.

Over the years, Borregaard has changed its product base from cellulose for paper to the production of chemicals such as lignin and vanillin. In the 1980s, the company had already started to specialize its production and to create a narrower product base. At the same time, its production became increasingly complex. In the 1990s, Borregaard restructured the world market by acquiring competitors in the lignin market. The background for this was that the market had become dominated by small enterprises competing against each other, which led to low profitability. By acquiring the competitors, Borregaard became sufficiently large to focus on research and development (R&D), and the Sarpsborg headquarters became the centre of R&D. The specialization strategy allowed the company to enter markets with more stable and higher prices.

The activities conducted in the headquarters in Sarpsborg are highly knowledge intensive, with a strong focus on R&D and ways to produce new and sustainable products from wood. In line with its strategy for specialization and increased value creation, Borregaard invests considerable resources in R&D; 3–4% of its turnover is used for innovation (compared with 0.5% in the traditional wood-processing industries), and 9% of Borregaard’s employees work in R&D.

Extensive investment in R&D is directed towards the development of value-added products from renewable raw materials. This explains how Borregaard has managed to upgrade its product portfolio and become a world leading biorefinery.

Product base

The restructuring of the product base has been a gradual process, and the company has developed from producing paper and pulp to becoming a spruce-based biorefinery focusing on wood chemistry and other selected niches of organic chemistry, using wood (mainly Norwegian spruce but also storm-felled wood from Sweden) as the main raw material. Today, Borregaard is one of the world’s most advanced and sustainable biorefineries. Its production is based on renewable

energy and is completely independent of fuel oil. The concentrated residues from the production processes are used for heat and power production, and the diluted residues are converted to biogas for its own heating purposes. In the end, only 2–3% of the raw material exits as waste.

The main strategy of Borregaard has always been to exploit the raw material in the best possible way. The business model thus focuses on exploiting the whole bioresource for value-added products. The company develops and supplies specialty products for a variety of applications in the specialty cellulose, lignin, fine chemicals and food additive industries. The raw material comes mostly from within a radius of 10 km from the headquarters in Sarpsborg, avoiding expensive and environmentally harmful transport and creating jobs locally. Nevertheless, transport/logistics comprise one-third of the cost of raw materials.

By using natural, sustainable raw materials, Borregaard produces advanced and environmentally friendly biochemicals, biomaterials and bioethanol that can replace oil-based products. The company also holds strong positions in the market for ingredients and fine chemicals. The activities are related to many value chains in the business ecosystem, and the end products are not produced alone but in co-operation with, and tailored for, the companies producing the end products.

The company’s current product base can be divided into four main groups: (1) cellulose, (2) lignin, (3) vanillin and (4) second-generation bioethanol. The products are made from both cellulose and lignin, and unconvertible remnants are used for biogas production or for bioenergy. The main product from cellulose is specialty cellulose, which is used in the production of cellulose ethers and acetates, and has markets in Europe and Asia. The hemicellulose fraction is the raw material used in the production of bioethanol, which has markets in Norway and the EU. Of the bioethanol production, 80% is used by industry and 20% as biofuel, which is a result of the market conditions for biofuels in Norway. Lignin is sold around the world and at all quality grades, and it is the raw material for vanillin production.

Regional and national collaboration

The future competitiveness of the wood-processing industry is largely dependent on significant research efforts. Borregaard’s production and services are largely based on R&D-intensive activities, which require extensive expertise, knowledge, research skills and facilities. Most of the R&D is conducted in the company’s own laboratories, although research projects are also

conducted in collaboration with the regional research organization Østfold Research as well as by other research institutions such as the NTNU and Sintef. However, the concentration of knowledge and competence is largely limited to Borregaard, which employs highly skilled engineers to work in its in-house R&D department. The highly skilled employees are largely recruited from abroad, and recruitment is facilitated by Borregaard's well-known international brand, which makes it easy to attract foreign employees to the region. Technicians who work in the plant in Sarpsborg, on the other hand, are often recruited locally.

It is evident from the interviews that Borregaard is a highly self-sufficient company and that there is little collaboration between the company and regional stakeholders such as the county council. However, Borregaard contributes to the local environment through a variety of development projects. One such project is its collaboration with the local high schools through the initiative called Kunnskapsfabrikken ("the Knowledge Factory"). The Knowledge Factory is a place where Borregaard welcomes visiting students from middle schools and high schools. The plant is designed to be a showroom for Sarpsborg and Borregaard's history, production and end products, and demonstrates educational and career paths linked to a career at Borregaard. The initiative is an important measure for competence development and future recruitment of local young people. Furthermore, Borregaard has sponsored the Ispiria science centre in Sarpsborg, a learning centre focusing on mathematics, science and technology. The aim is to encourage more young people to choose science, as well as to highlight the importance of an understanding of, and knowledge about, science and technology.

Borregaard is collaborating extensively with organizations outside the region. To recruit highly trained engineers, the company has established a trainee programme together with the NTNU in Trondheim. The summer trainee programme in process chemistry welcomes four to six students each year to work in Borregaard's research labs.

The regional collaboration also involves local forest owners, who provide Borregaard with raw material for their production. The competitive advantage is thus based on proximity between the suppliers in the region and the large industrial companies like Borregaard. Among other advantages, this contributes to efficient trading of timber and lower transportation costs than in other counties. However, there is still little collaboration between Borregaard and other related companies in the regional business environment.

The public support system

Because of its location close to the capital region, Østfold does not receive district funds ("distriktsmidler"). However, the county council receives regional development funds that are allocated to projects that match the priority goals and strategies in the regional development programme (Østfold County Council, 2012). One such priority area has been competence development and investigating how the region can attract highly skilled workers. The region also has a strategy for the increased utilization of biogas. However, Borregaard is not involved in this project, as it mainly produces bioethanol for export to Switzerland.

Borregaard has received extensive support from government schemes. The public support system has been especially important for the development of new technology for the production of bioethanol and green chemicals from biomass, because the development of bioethanol is still characterized by high costs and technological risks. One way that Borregaard has managed to distribute this risk is to rely on a diverse product portfolio of value-added products, with bioethanol being one important by-product (Klitkou, 2013).

Innovation Norway is the strongest support instrument of the public sector, and Borregaard is part of its regional board. In 2010, the company received 58 million NOK from Innovation Norway to support construction of the BALI Biorefinery Pilot plant for second-generation bioethanol in Sarpsborg. The background for receiving the funding was the development of new technology to produce biofuels and valuable green chemicals from forest waste, straw and wood chips. The goal was to recover the tree-strengthening material lignin from almost any wood-based raw material. In 2014, Borregaard received an additional NOK 18.8 million in support through the BIONÆR programme, administered by the Norwegian Research Council (Borregaard, 2014).

In 2009, Borregaard received public funding to conduct a life cycle assessment study of cellulose, ethanol, lignin and vanillin together with Østfold Research (Klitkou, 2013). In the same year, Borregaard received 19 million NOK from the Research Council of Norway for a five-year project entitled Biomass2Products. The main objective was to develop a biorefinery concept for production of marketable products and cost-efficient processes for production from biomass. The project involved research partners from NTNU, the independent research organization Sintef, and the Norwegian University of Life Sciences (NMBU). In the same year, Borregaard received NOK 35 million in EU FP7 funding for two project proposals sent in response to the Joint Biorefinery Call (Ibid.). Borregaard has used some of

the funding to build the BALI plant.

There have also been more extensive efforts to develop the biorefining industry in Østfold. Innovation Norway at one point initiated the development of a biorefinery cluster through the Norwegian Centres of Expertise Programme (NCE), which is intended to enhance clusters. However, the process was stopped after a clear recommendation from Borregaard that the NCE programme would not be beneficial for the development of the industry.

While Borregaard has the advanced technology and knowledge to develop by-products such as bioethanol, it is still dependent on public support both to finance the initial stages of the product development process and to drive the development of alternative and environmentally friendly products. Its location in Norway creates challenges in terms of high wood prices as well as the Norwegian government's unpredictable biofuel policy, which lacks incentives for producing products such as bioethanol.

The projects that have been supported financially by the public support system are also firmly based on co-operation with other research institutions and can be seen to have a positive impact on knowledge sharing and networks between Borregaard and external partners.

Network characteristics

The business and technology infrastructure at Borregaard currently includes a number of elements usually attached to successful clusters and regional innovation systems.

According to the academic literature, a cluster can be defined as “a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities” (Porter, 2000, p.254). In general, the cluster can be regarded as a form of network that occurs in a geographic location, in which the proximity of firms and institutions ensures certain forms of commonality and increases the frequency and impact of interactions (Porter, 1998). This definition means that a cluster requires a group of firms and related economic actors and institutions located close together that draw productive advantage from their mutual proximity and connections.

In addition to the characteristics of a cluster, a Regional Innovation System (RIS) often has organizations that work with the development and spread of knowledge, such as universities and colleges, R&D institutes, technological centres, incubators and science parks (Isaksen and Asheim, 2008). An RIS can be characterized as interacting knowledge generation and

exploitation subsystems linked to global, national and other regional systems (Cooke, 2004). The cluster concept is narrower than the RIS concept because clusters tend to be sector specific, while an RIS can encompass multiple sectors. Often, clusters and RISs coexist in the same territory.

Although Borregaard itself possesses many of the characteristics of a cluster in that the company has research divisions, financial institutions, and connections with the public support system and with higher education actors, there is no established regional cluster related to biorefining in Østfold. The reason for this is that Borregaard is only one company, while a cluster is normally linked to other companies within the same industry. Furthermore, the company itself controls most of the value chain, and there is weak collaboration with actors such as other companies and research institutions in the region. One could argue that the activities of Borregaard are more integrated with the national innovation system, where innovation activity takes place in co-operation with actors outside the region, such as science parks with R&D departments that are related to larger organizations or public research institutes (Asheim and Gertler, 2005). In the case of Borregaard, R&D intensive activities either happen within the internal R&D department or in projects (often supported by the public system) and/or together with larger research institutions located outside the region, such as NTNU in Trondheim. This demonstrates that there is little direct collaboration between Borregaard and other actors in the region. Rather, the collaboration happens in networks at the national and international levels.

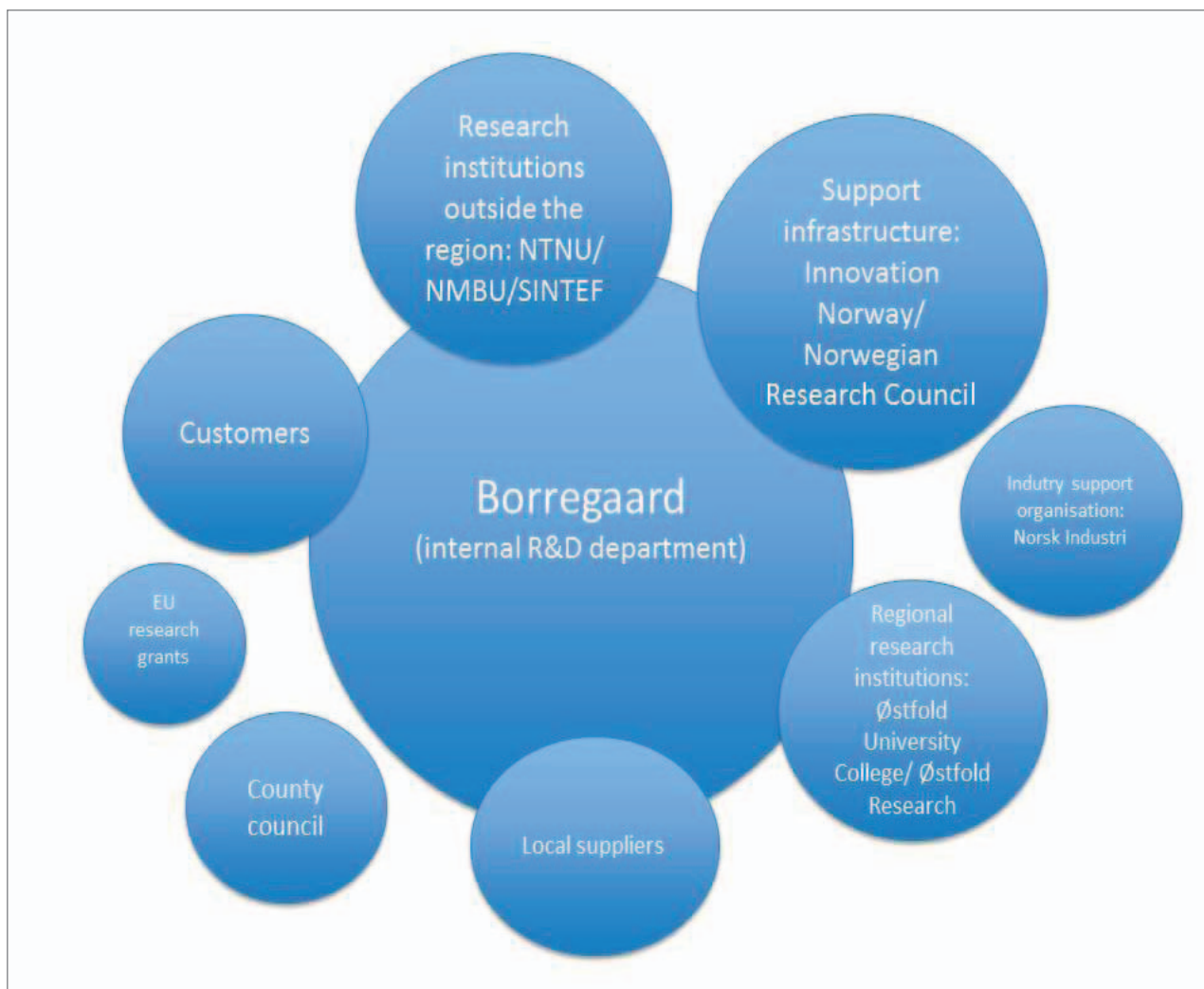
Figure 9 illustrates the importance and closeness of the various resources to which the Borregaard R&D department relates (closeness and importance are illustrated by proximity and size of the circles). It is rather inaccurate, but it is a way to illustrate our impression from the case study.

3.4.6. Opportunities/Challenges

There are opportunities to develop further the area of the bioeconomy in Østfold that is related to wood processing. The Borregaard case shows that by investing in knowledge-intensive activities and the development of niche products, it is possible to be located in Norway and at the same time to have a competitive advantage in the global market. In addition, the public support system has created conditions for Borregaard to develop products that are less economically beneficial (e.g., biofuel) but that ease the transition from dependence on fossil fuels to bio-based fuels.

However, there are still challenges for the future de-

Figure 8: Mapping of key resources related to Borregaard's R&D department



velopment of the industry. At the national level, these challenges are related to the general framework conditions; high costs in Norway make it difficult to compete in the global market, and Norway does not have competitive framework conditions at the same level as other countries. Lack of predictability is another important challenge that should be addressed at the national level, especially in relation to the production of biofuels. In its current state, the biofuel policy in Norway is unpredictable and lacks incentives for companies to produce bioethanol (Klitkou, 2013). According to the interviews it is impossible to compete with the fossil fuels because the carbon tax on fossil fuels in Norway is too low, and the costs of the biomass are too high. However, Borregaard's diversified product base is a good strategy to ensure that the company remains competitive. Compared with bioethanol, higher profits can be achieved for products such as lignin chemicals and other value-added products. To meet these challenges, the national authorities can maintain and facilitate a competitive

wood-processing industry by creating good market conditions for future growth and encouraging greater willingness and opportunities for innovation/R&D in firms.

At the regional level, limited access to raw materials is another important challenge related to the development of the wood-processing industry, as expressed by one of the interviewees. Borregaard depends on raw material from the local forestry industry, which is quite costly compared with that from other countries, and there are specific challenges in transporting the wood from the forest. Upgrading the forestry value chain therefore requires substantial investments in infrastructure to ensure access to wood. Regarding regional collaboration, there is also a challenge in increasing the knowledge spill-over between related companies. The regions that see the largest effect of the public support system are those that succeed in regional co-operation between industry, government and other actors. Therefore, increased collaboration can be seen as an impor-

tant way to strengthen the wood-processing industry in Østfold.

3.4.7. Concluding remarks

The Norwegian bioeconomy case study of the Østfold County is an example of a strong locomotive company dominating the bioeconomy activities in the region without significant regional cluster formation. The locomotive company, Borregaard, could be regarded as more globally/nationally based than a regionally based company. However, Borregaard contributes to the local environment through various development projects such as the Kunnskapsfabrikken (Knowledge Factory) initiative.

There is no significant regional cluster formation around Borregaard. Rather, the Borregaard company controls the whole value chain from extracting wood/forest residues to the end products (e.g., cellulose, lignin, fine and basic chemicals, food ingredients, and ethanol). As such, Borregaard's overall organization resembles that of a cluster, where the parts of the value chain can be seen as a form of network that occurs within a geographic location, where proximity ensures certain forms of commonality and increases the frequency and impact of interactions.

The relative low average education level in the region does not seem to be a major challenge from the viewpoint of Borregaard, because its international brand and reputation allow it to attract highly skilled engineers. There is some co-operation with the local colleges to educate technicians to work at the plants.

Despite the global approach of Borregaard, support from the state-level support system (Innovation Norway) has been important for developing bioethanol in the region. Moreover, it should be noticed that the local forest owners that provide Borregaard with raw material for their production are important regional actors in the Østfold bioeconomy.

3.5. Örnsköldsvik, Sweden

By Gunnar Lindberg & Jukka Teräs

3.5.1. Introduction

This case study focuses on the bioeconomy in the Örnsköldsvik region in Sweden. The focus is on the analysis of innovation in Green Growth and the bioeconomy, and the concentration of environmental expertise in the region.

This case study report is based on secondary sources and interviews with key stakeholders at the local, regional and national levels as well as representatives from private companies and educational facilities. The

report presents the characteristics of the region and its economy as well as the policy framework for developing the bioeconomy of the Örnsköldsvik region.

The report is based on information gathered in interviews, and it outlines the main actors in bioeconomy in the region and discusses the main drivers of development. It also discusses the main factors that may impede development and concludes with a summary and discussion of the current situation and future potential for developing the bioeconomy of the region.

3.5.2. Description of the region

Örnsköldsvik is located in Sweden, 550 km from Stockholm. There are approximately 55,000 inhabitants of Örnsköldsviks Kommun or the Municipality of Örnsköldsvik. The Municipality has a much larger population than the central town, as the municipality is vast with very large forest areas and minor areas of agriculture. It consists of several rural communities in the countryside.

Historically, the most important economic activity of Örnsköldsvik has been trade and heavy industry. The major industrial ventures include MoDo, a pulp, paper and logging enterprise established in 1903 by Frans Kempe's company, Mo, and Domsjö AB. Another historically important industrial company is Hägglunds, a heavy industrial company. Currently, M-Real (formerly MoDo) operates a pulp mill in Husum, 30 km north of Örnsköldsvik City, and Domsjö Fabriker (another ex-Modo mill) operates a specialty cellulose mill in Örnsköldsvik. Other notable companies based in Örnsköldsvik include Svensk Etanol kemi (ethanol products) and Fjällräven (outdoor equipment and clothing).

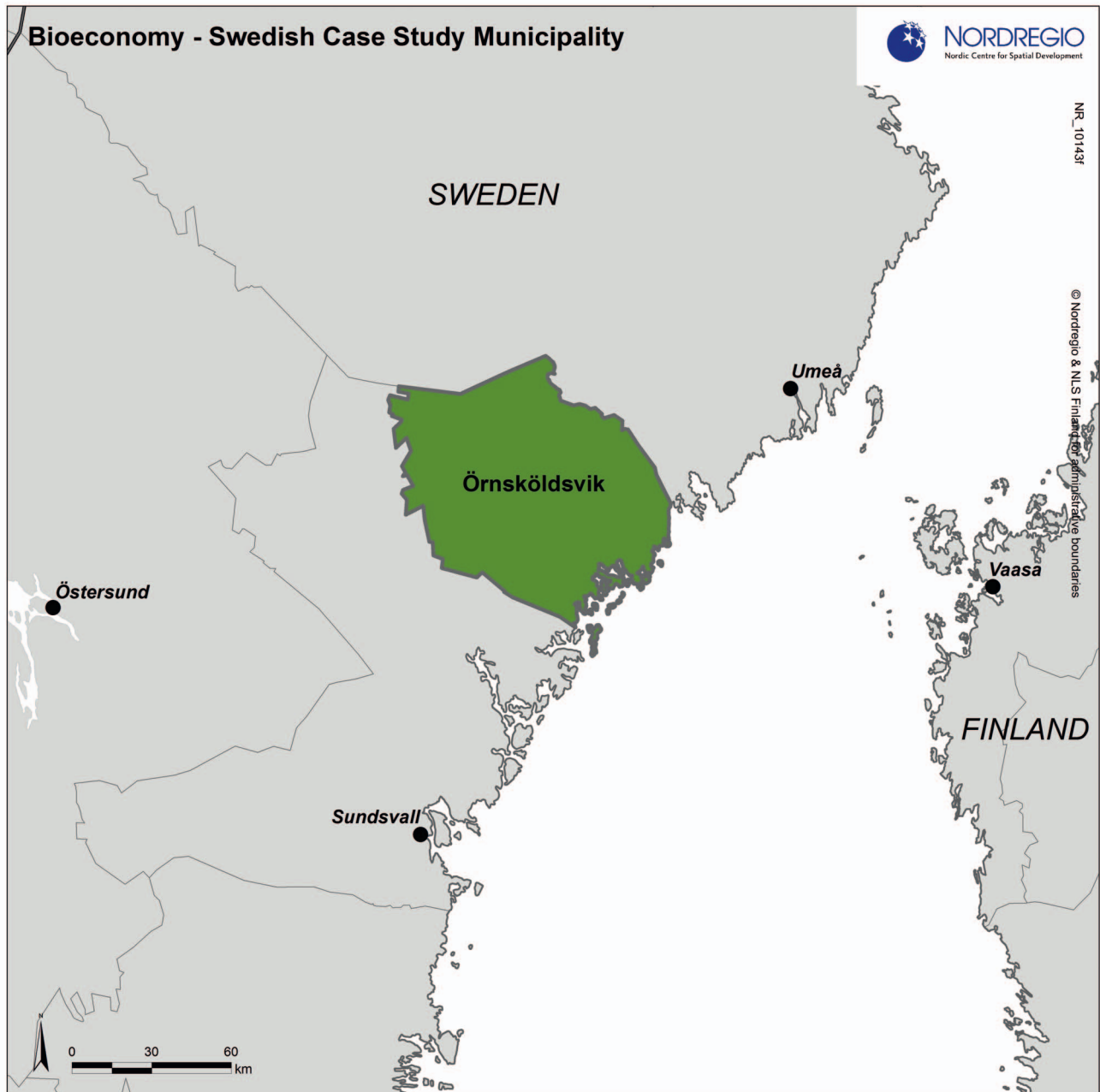
Today, a large part of the bioeconomy-related activities in the Örnsköldsvik region form a cluster built around the pulp mill in Domsjö.

3.5.3. Administrative structure and governance

National

Sweden is a country in Northern Europe with a population of just over 9 million people and a geographical area of 450,000 km². Sweden has a history of strong local government involvement in public affairs. The Swedish Constitution and the Swedish Local Government Act state that Sweden has municipalities and county councils. There are 290 municipalities (kommuner) and 20 county councils (landstingen), which are sometimes called "regions". There are also 21 county administrative boards (CABs), which are a branch of the central administration headed by a state-appointed governor, with their main responsibilities being eco-

Figure 9: Örnsköldsvik municipality (Map design by Julien Grunfelder)



conomic planning and regional development. Since 2003, their board members have been appointed by the central government. The CABs are entrusted with primary responsibility for co-ordinating activities at the county level. They command a strategic view of relations between bodies at the local, county and central levels and can therefore act as a link between central and local authorities. CABs are also responsible for ensuring that the county's development proceeds in a way that facilitates the achievement of national goals while taking account of specific regional conditions and requirements. (Council of Europe 2014).

Local authorities in Sweden, but especially the municipalities, have a wide range of functions. Some of these are exclusive to the municipalities (all primary

and secondary education, most social welfare functions, town planning, water and sewage, environmental protection, refuse collection, parks and open spaces). Others are shared with the county councils, the CABs and/or the central government (e.g., regional/spatial planning, some culture and leisure activities).

Most innovation policy issues in Sweden are managed by the Ministry of Enterprise. VINNOVA (the Swedish Governmental Agency for Innovation Systems) executes innovation policy on a national level through funding needs-driven research, development and demonstrations as well as strengthening networks, which are a necessary part of innovation activities. Issues concerning energy and restructuring of the energy system are handled by the Swedish Energy Agency.

This work is complemented by two semi-public research foundations: the Knowledge Foundation and the Foundation for Strategic Research. Policy issues concerning universities are handled by the Ministry of Education and Research. The Swedish Research Council is the main body for funding curiosity-driven research. (Inno/Erawatch 2011).

Västernorrland County and the Örnsköldsvik region
Västernorrland County is a county (or län in Swedish) bordered by the counties of Gävleborg, Jämtland and Västerbotten, and the Gulf of Bothnia. Örnsköldsvik is one of the municipalities of Västernorrland County. The current Örnsköldsvik municipality was created in 1971 by the amalgamation of the city of Örnsköldsvik with seven former rural municipalities.

3.5.4. Bioeconomy in the Örnsköldsvik region

Forestry industries have been important for the Örnsköldsvik area since the late 19th century. The bioeconomy concentration in the Örnsköldsvik region has a long tradition, originating from pulp mill activities in the early 20th century (especially the pulp mill in Domsjö established by Mo and Domsjö AB). The main products have been paper and pulp, with energy production from less refined parts of the raw material as a side product. The production of chemicals, chlorine and ethanol entered the scene in the 1930s, when the region's leading pulp & paper company established what can be seen as an early version of a biorefinery. (Coenen 2013). A major development phase in the Örnsköldsvik region took place during the Second World War, when importing chemical products into Sweden was difficult. The MoDo company took the initiative to develop R&D facilities to create chemicals from the local forest supply. This industry in the Örnsköldsvik region was one of the first to combine pulp production

with production of ethanol and a large number of chemicals.

The Örnsköldsvik region faced a serious downturn period during the 1990s, when many local businesses closed, down-sized, or relocated to more central regions of Sweden. This resulted in the loss of around 5,000 jobs in the Örnsköldsvik region (Arbuthnott 2011). However, the regional decline created among the local actors a sense of urgency to create new industries and jobs in the Örnsköldsvik region. The idea of building a cluster and technology park based on the novel biorefinery initiative, together with the increasing popularity and awareness of clustering initiatives, paved the way to regional biorefinery cluster formation in the Örnsköldsvik region. The cluster company Processum as early as 2003 started to gather the local and regional forces behind a joint clustering initiative in the field of biorefining. The cluster development received an additional boost in 2005 when Processum received the first VINNVÄXT funding for the development work for the "Biorefinery of the Future". In 2013, the industrial research institute SP (a Swedish equivalent of companies such as Germany's Fraunhofer) bought 60% of Processum shares.

The following table lists major actors of the bioeconomy in the Örnsköldsvik region, with a focus on biorefining activities.

3.5.5. Policy framework for developing the bioeconomy of Örnsköldsvik

National

In the Swedish Research and Innovation Strategy for a Bio-based Economy, the bio-based economy is defined as a resource-efficient economy based on raw materials that are produced through the sustainable use of ecosystem services from land and water. Because of the

Table 10: Key actors of bioeconomy/biorefining in the Örnsköldsvik region

Sector/Activity	Main Actors
Key companies	Aditya Birla Domsjö Fabriker (pulp and biorefinery) Akzo Nobel (specialty chemicals) Holmen (Printing paper, paperboard, forestry and energy production operations) SEKAB (Ethanol R&D and production)
R&D, education institutes	Umeå University Mid-Sweden University
Clustering initiatives	SP Processum

natural geographic conditions, industry and infrastructure, Sweden has good conditions for conversion to a bio-based economy.

Bioenergy comprises approximately one-fourth of the overall energy production in Sweden. The biggest current source of bioenergy in Sweden is forestry, but bioenergy is also produced from waste and agriculture. In heating, fossil fuels have already been replaced almost entirely by biofuels. While heating is the biggest user of bioenergy at present, the use and production of bioenergy in electricity is increasing. There is also great potential in increasing the use of biofuels in the transport sector.

In addition to industries based on agriculture and forestry, the potential for a bio-based economy lies in, for example, transport and the motor industry, the construction sector and the chemical industry. As a bio-based economy is seen as cross-sectoral, the potential for cross-sector system solutions is emphasized (such as biorefineries in the form of collaboration between the chemical industry, forestry industry and energy companies). There is great potential for increasing the added value of the renewable raw materials used by current process industries.

In terms of biofuels in transport, Sweden is already a forerunner, and 9.8% of the energy used in the transport sector in Sweden was derived from renewable sources in 2011. The use of all biofuels has increased notably (in particular biogas and biodiesel). However, there is further potential in increasing the production of biomass and the use of biofuels.

Regional/local bioeconomy framework

The regional and local actors that were interviewed in Örnsköldsvik considered the bioeconomy issues to be important. It is perceived that the bioeconomy and the forest sector in general have a strong position in the regional development programme and that there is also some positive impact of the structural funds in developing this field. Moreover, there are many municipalities, counties, firms and universities in the region that have the same ambition. Together, they are working on branding the region and are focusing on the social, technical and economic side of the regional bioeconomy. However, the bioeconomy does not seem to have a crucial impact on the visions of the future development of the region. The bioeconomy (mainly understood as the forest sector and value-added industry) are deemed to be important, but the vision for these sectors does not seem to be explicit in the long run and in regional planning. It was perhaps more so in the past—but perhaps it has been relegated to a lower priority because of the downfall of the ethanol venture.

There are organized broader initiatives, such as the “Biofuel Region” project that takes a regional perspective; this is an established platform that gathers actors from four northern counties. (Biofuel Region 2014). They are co-operating to develop the bioeconomy (much larger than the biorefinery cluster) within the larger region—for instance, in running vehicles on gas, and in developing the larger concept of sustainable municipalities with energy as a focal point. The municipality of Örnsköldsvik has always been an early participant in these processes; for example, by adopting the first ethanol buses and cars, and providing municipal heating in the suburbs. Furthermore the municipality itself supports the bioeconomy cluster in Örnsköldsvik with SEK 500,000 annually (now as a part financing of a structural funds project) and it has a member on the board of directors for the cluster. The municipality is also an actor in the cluster through some of its municipal firms (an energy firm and an ethanol producer).

In the development of a vision of where Örnsköldsvik should be in 2050, the field of energy, climate and raw materials is one important aspect. Moreover, there is a vision that it will be a world leader in this field. There is an aim of branding the region, acting as a facilitator and having it on the political agenda. If there are external visitors (national or global), they are taken to the biorefinery, and there is a strong focus on the forest sectors and all its aspects. However, for citizens and in the everyday life of the municipality and all its actors, the bioeconomy is not a major issue. Not everyone knows that this is a bioeconomy region. Many people in the city do not know the function of the biorefinery area or the Processum cluster. There is a visitor’s centre in the factory area, partly financed by the municipality, but it has not been widely used so far.

3.5.6. The Örnsköldsvik Biorefinery of the Future Cluster

A recent trend in the Swedish forestry industry is increased interest in completely new technologies. This could include processes for the production of products such as biofuels, chemicals and animal feed. This new interest from the forest industry is explained by a declining demand for paper, especially newsprint but also office paper. As a consequence, the price of woody biomass is falling in Sweden. This structural shift in demand for mature products is now accelerating research activities into completely new processes.

SP Processum’s and VINNVÄXT’s “Biorefinery of the Future” project is the flagship project of the Örnsköldsvik bioeconomy. The purpose of the Biorefinery of the Future is to accelerate development in the field of biorefining woody biomass—in other words, together

with its member companies, academic partners and the local community, to create, promote and invent products and processes based on lignocellulosic feedstock in a triple helix setup. To do this, 80% of the project funding is devoted to research and development. The majority of this is directed towards innovation and development rather than more fundamental research. All research is done in an open innovation network setting. The remaining 20% is devoted to building the innovation system. In the past three years, substantial resources have been devoted to scaling up promising projects. The project leaders have invested in a set of pilot equipment that can take technologies from the laboratory scale to a first demonstration scale and have created a regional test bed.

The Örnsköldsvik Biorefinery of the Future Cluster has 20 member companies. Most of the Cluster companies are in some way connected to the forest industry, the chemical industry or the energy industry (Figure 10). They base many new ideas on existing capital investments in the mills of the pulp and paper industry. A greenfield investment in an average sized biorefinery could easily amount to 1.5 billion euros. For this reason, a large number of endeavours in biorefining are dedicated to turning existing mills and infrastructure into biorefineries. The same reasoning applies to energy sector utilities. The cluster's main strategy in biorefining is to improve the existing mills to create more value, new chemicals, and new materials, and to turn residual streams into products and thereby to increase both the economic efficiency and that of the feedstock usage. In other words, once woody biomass has been processed into the main product (e.g., pulp and paper), the number of complementary products and complementary streams in a biorefinery set-up are maximized. This process will also decrease the generation of waste from the production sites and improve the environmental footprint of the industry even further.

Sweden's innovation agency VINNOVA spends SEK 6 million each year on the Biorefinery of the Future, and regional actors contribute an equal amount to match this funding. This results in a total of SEK 12 million per year for the period 2011–2014. The average yearly turnover for SP-Processum has been SEK 23.5 million per year. The activities are devoted to biorefining R&D and cluster development. An extra SEK 12 million per year has thus been supplied from EU structural funds, member companies, and public and private research funds (regional and national) as well as funding from FP7 and similar EU sources. The VINNOVA funding has been approximately quadrupled with money from other financiers for the years 2012 and 2013. In addition, the cluster companies supply valuable research

equipment or in-kind work on many projects. This work is not included in the above calculations.

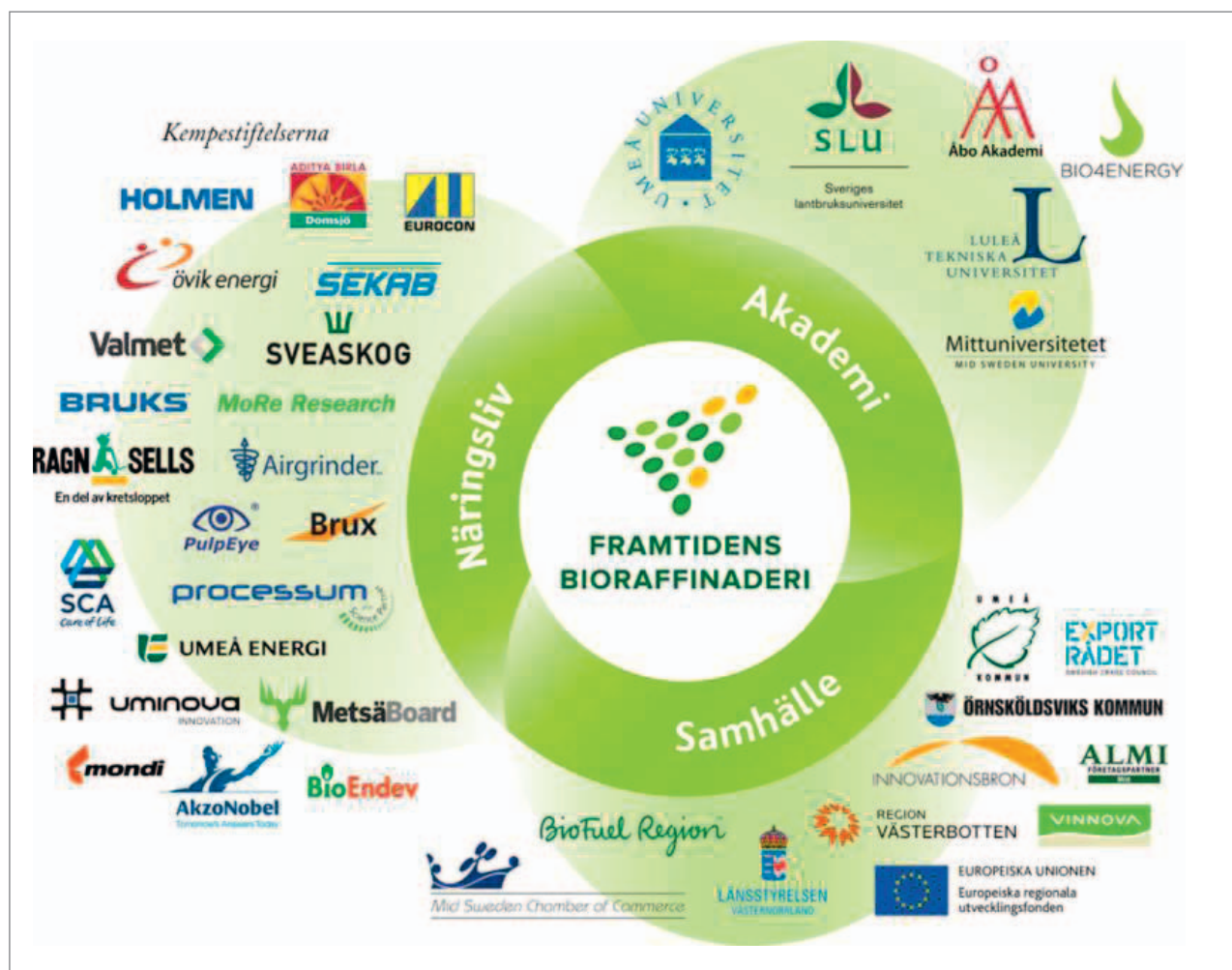
Geographically, the focus of the cluster is along the coastal area of northern Sweden. The original cluster started in the Domsjö Development Area in Örnsköldsvik but now extends from Piteå in the north to Iggesund in the south. The core of the cluster in number of companies is today in the region of Örnsköldsvik–Umeå. Many of the member companies are multinational, which means that the core region sometimes extends as far as Brazil, India or Canada. Over the past two years, intense co-operation with the chemical industries on the west coast of Sweden has been initiated by the Processum cluster and the “Hållbar kemi” cluster in Stenungsund.

Neither the universities in the region nor the regional financing bodies and development authorities are members of “Processums Intresseförening” (the association). However, they co-operate intensively with these sectors of the helix as well. They are represented on the board of Processum and take part in activities such as membership meetings and project meetings. Thus, the structure is open to all parties of the helix. Non-member companies can also take part in the structure at several levels. However, the only formal owners are SP and Processums Intresseförening.

A very important area of reducing technical risk and demonstrating promising technical solutions concerns the scaling up of biorefineries. It is a great challenge going from the laboratory to the pilot scale, and eventually to industrial scale, using thermochemical, chemical and biotechnical processes. Often the conditions change drastically in the processes when scaling up. This almost always creates new challenges and a need for new solutions in terms of factors such as stability of the process, incrustation, energy efficiency, drying, and grinding. Therefore, the initiative has devoted considerable resources to financing, building and finalizing a pilot park. The scale of the pilots, 10–100 litres, makes it possible to take the first step in scaling up for promising technologies. The pilots have been built using structural funds from two consecutive projects. This development has been very important as a complement to VINNVÄXT. In this way, Processum has created and opened a test bed that can be used by member companies as well as universities. The pilots are geographically situated in Umeå and Örnsköldsvik.

The Pilot Park currently consists of 11 pilot units and is still growing. A total investment of SEK 15 million has been made in the pilots. Considerable time was devoted to picking pilot technologies that could not be found elsewhere in Sweden, and at the same time, pilots that are needed to scale up biorefining technologies.

Figure 10: The Members of the Biorefinery of the Future cluster (source: SP Processum)



The pilots are: Algae pilot, Pilot bioreactor, Decanter centrifuge, Dryer pilot, Filter press, Grinder, Chemical synthesis reactors, High speed centrifuge, Spinning pilot, Unit for continuous liquid–liquid extraction, and Torrefaction pilot.

The influence of the cluster on the national innovation system

According to Processum (2014), an important aspect of the cluster is its national influence in Sweden. When the VINNVÄXT project was started, many of the large pulp and paper companies in Sweden were relatively uninterested in the biorefinery field. The example of Domsjö and the VINNVÄXT cluster, combined with a decline in the demand for paper products, has inverted the situation. Today, almost all the large pulp and paper companies have entire units working on biorefining and new businesses, and the Swedish chemical industry has taken a bio-based route. Processum was a very early and successful example in Sweden, and this has inspired others and sped up this development.

The main challenge has been on the political side.

According to interviews, the political will for change is partly lacking in terms of factors such as tax incentives and biofuel quotas. The technologies are ready to scale up, but the demand for green solutions is insufficient. Two years ago, almost all the planned scale-ups to industrial scale were aborted. One of these was the large gasification plant planned at the Domsjö mill. The failure to invest in Domsjö has been a very clear example of these challenges.

There is an ongoing discussion of the value creation of the bioeconomy related to the size of the companies. SP Processum foresees that a large part of value creation and development in its cluster will take place in existing companies rather than in start-ups. This is mainly related to the huge investment costs and the economies of scale in its industry. However, the recent trends with new technologies and the need for entrepreneurs to develop businesses around waste stream conversion makes it clear that new businesses and entrepreneurships need to be developed. These new businesses have proven to be more important than previously believed in realizing new processes and products on the market.

The large global companies will be unable to integrate this systematic change into the bioeconomy by themselves.

The importance of the bioeconomy cluster for the region today

According to the evaluation of Processum (2014), biorefining and the bioeconomy are a focus for many regional development actors along the coast of northern Sweden, including the business incubator Åkroken in Sundsvall, SP Processum AB, Solander Science Park, ETC, Biofuel Region, Uminova and Bio4Energy. However, the current challenges include the administrative borders and the awkward fact that for certain initiatives, Processum needs to apply for funding in each of three counties. In any case, biorefineries and the bioeconomy are well represented in the documents; for example, in the EU structural fund programmes.

Processum has taken a specialist role in the regional innovation system for biorefineries. Three years ago, Processum hired a patent engineer—a function co-financed by VINNVÄXT and five member companies. Since 2011, 77 patents have been filed. The patent service is open to external regional partners. The fact that SP bought Processum is in itself an improvement and a change in the innovation system in Västernorrland. Processum now constitutes the first RISE (Research Institutes of Sweden) institute in the region.

The bioeconomy is an important sector or activity for Örnsköldsvik today. For the larger region, the coastal and inland region of two counties, the bioeconomy is less important as a part of the economy. North of Örnsköldsvik, the large city of Umeå has a diverse economy and is a large university centre. This city is striving to be more of an urban centre than an industrial city. In this region, the bioeconomy does not have as large a role as it does in some of the other cities in the region. The universities (a technical university as well as a branch of the agricultural and forestry university) obviously know what is occurring in Örnsköldsvik's bioeconomy development, and one aspect of this is that the region is integrated, with respect to factors such as the labour market, because high-tech employment is created in Örnsköldsvik, and people commute from Umeå for these opportunities. In recent years, Örnsköldsvik has been somewhat transformed from a charmless industrial city to a more attractive place, but the main difference is rather the creation of cultural and sport facilities as well as the train (Botniabanan) linking the city with larger centres in the north and south. The bioeconomy is not perceived to play a large part in this process yet, but the interaction with Umeå, as well as nationally and globally, in this field can po-

tentially contribute in the long run. The perception is that this will spill over into other sectors as well, with an increase in interaction between the two cities.

Perceptions of the cluster

When the old MoDo establishment in Örnsköldsvik was split up, there was a discussion about the development of a technology park around the new firms that emerged, and around the large player Domsjö, which was still there. As one of the actors, the municipality was invited to participate, and (obviously) this kind of development is important for the municipality to stimulate and take part in. The municipality is geographically large and has plentiful forest resources, and it is beneficial for the municipality if these are processed in the region because this creates firms, employment and tax revenue. Eventually, the technology park became a biorefinery cluster that was set up around the Domsjö biorefinery.

Co-operation between the firms and other actors (municipality and academia primarily) regarding the cluster application of VINNOVA (funded by VINNVÄXT) was formalized as part of the establishment of the triple helix. The municipality has a responsibility for relations with other governmental actors (such as the county board) and can work on issues such as education and relationships with citizens. It is also important for the municipality to create a business environment where the firms feel welcome and can develop in the region.

Based on the interviews, the cluster was very much a technology park in the beginning, but it has grown to become a cluster about biotechnology focusing on research and patents as well as traditional cluster activities such as interaction of firms and addressing their needs, such as the labour market and finances. For a while, the cluster was becoming rather “narrow” around a few firms, and the benefits accrued mainly to those actors. This was perceived to be somewhat problematic because it excluded some actors, and for a period, it was perhaps not as dynamic as it could have been. Perhaps this even reduced the possibility of impacting the regional economy as much as it could have—because it was so much about developing some individual firms. Now it has again become broader and more inclusive. However, with the shift to biotechnology (almost a narrower field than bioeconomy), some actors are not as active as they were before; for instance, the municipal energy firm. The fact that biorefinery has become the focus means that this cluster is rather place specific. The benefit of this is that it is very “clear” for the participants what the boundaries are (it also provides boundaries for applying for money and linking

with scientists). However, the bioeconomy is broader than the refinery, and the impact on regional development cannot be broad if this is the focus. The challenge is to also retain the actors that are less involved in the detailed research, and the refinery aspect of the cluster. At least one respondent reported that the cluster is perceived to be much more “complicated” today than it was a few years previously. What kinds of ideas are needed to bring actors into the cluster? Is it only about detailed research, or the wider picture of supply chains, developing firms in practical ways, new energy systems or the socio-economic aspects of the bioeconomy?

From the outset, the cluster has had the character of industrial resource-based supply chain integration and value creation. The firms are integrated and own resources such as forests, process industries, energy industries, refineries and chemical industries. Some firms are obviously more integrated than others, but the municipal energy firm is a player in many steps of the forest value chain. Moreover, many of the actors/people in the firms have worked in a variety of positions in a number of firms throughout the years and move back and forth between the firms. This obviously provides for easy co-operation between the actors of the bioeconomy in the Örnköldsvik region.

3.5.7. Bioeconomy in Örnköldsvik: evolution over time

Evolution of the regional bioeconomy over time—observations

The participants in this study emphasized the importance of being realistic about the market and the potential of the bioeconomy in the short and long runs. The establishment of the sector and market will take some time. In the early stages of the Örnköldsvik biorefinery cluster formation, there was a belief that it would happen very rapidly, and there was momentum in the region and among the actors to expand rapidly and to invest. However, the market and demand side were not really there. Hence there were some problems with over-investment, and both the municipality and private actors lost a large sum of money. Part of the problem was that the research and development took time to develop and that the incentive structures (from the government) were not as ambitious and long term as was necessary to develop aspects such as the use of ethanol in the car fleet rapidly. One lesson from this experience was to have a realistic view about the development of the bioeconomy, but at the same time, the municipality and regional actors need to make a new start and not neglect the field because of problems in

the past. The cluster is definitely a potential centre for this new development.

A new development in the cluster is that more global actors are present through their ownership of formerly Swedish firms. From one perspective, this is good, and it brings in new actors and ideas. It also opens the global markets and offers opportunities to co-operate with firms abroad. However, the potential impact on the future benefits for both the region and the firms must be considered. Where will the patents be filed? Who will benefit from the licences? Where will the production plants to develop new products be built?

In 2012–2013, there was increased interest in biorefining from many companies in the pulp and paper industry as well as the chemical industry in Sweden, which is looking for new feedstock with attractive environmental and climate properties. The increasing interest in biorefining is a clear trend in all major forest companies with specific new product units being established. However, a disappointment in this field is that almost all planned major scaling up of new biorefinery processes to full-sized factories has been put on hold or aborted. These major investments in green technology, often in the order of several billion Swedish crowns, have proven to be much more difficult to achieve than anticipated.

The demand for green, climate-friendly solutions has so far proven to be insufficient to overcome the costs and risks involved in investing in new technology. In the political landscape, the necessary support to kick-start the bioeconomy is perceived to be weaker today in Sweden than it was five years ago. In addition, the rapid technological development of production of unconventional oil and gas (e.g., oil sands and shale gas) has contributed to lowering the price of fossil feedstocks, which makes long-term investment in green technologies more difficult. Nevertheless, production of unconventional oil and gas is a short-term solution, and the oil price will presumably continue to rise in the long run. However, current production of unconventional oil and gas is hindering the transition to a bioeconomy. This is especially true for full-scale greenfield plants, and it is valid for all developments in the bioeconomy area in Sweden as well as in Europe.

3.5.8. Enabling conditions

Natural resources

Access to natural resources provides a good basis for developing the bioeconomy in the Örnköldsvik region.

Co-operation between actors

The active and systematic co-operation between the public and private actors has been a key competitive advantage of the Örnsköldsvik region in the field of green growth and bioeconomy. An important catalyst for the intercompany relationships, and the public-private co-operation was established by the Processum Cluster.

It is interesting to note that the Örnsköldsvik case does not represent a classic case of a cluster with intensive co-operation and head-to-head competition in a regional setting. Co-operation plays a significantly more important role than competition in Örnsköldsvik. Competition focuses on outperforming other regions. Arbuthnott (2011) states that competition at the intraregional level has not been perceived by the Övik cluster core actors as positive for their development.

Despite the high visibility of the Processum cluster, there are challenges in sharing a common, great vision of the future for bioeconomy development in the Örnsköldsvik region. The interviews in 2014 reveal no major conflicts or disagreements between the key actors, but the ambitious forward-looking common vision remains a challenge. When prompted about the need for brokerage between the private and public sectors, it was stated that conflicts or controversies were not a perceived problem for the bioeconomy of the region.

Funding

The bioeconomy and related initiatives have strengthened in importance and attracted both public- and private-sector investments. Processum activities and visibility have played an important role in fund raising. The 10-year VINVÄXT programme has been strategically important in convincing the investors to make a long-term commitment to the biorefinery activities.

“In fact, there is no lack of funding sources. To raise more funding for bioeconomy initiatives, we need to focus our resources and we need to strengthen our international co-operation networks.”

Synergies between sectors

The bioeconomy is seen as an integral part of green growth, not as an isolated sector but with interrelationships and synergies with several other sectors.

Communication & branding

The importance of the Processum initiative has been significant in the creation and development of the current bioeconomy community in the Örnsköldsvik region. The structural industrial change in the 1990s created a loss of thousands of industrial jobs, and some

local residents described the regional community as “Dövik”, or “Dead Bay” in English (Arbuthnott 2011). The timing of the Processum initiative was correct in that the sense of urgency “to do something new” was there because of the industrial layoffs.

The interviews in 2014 suggest that the great communication and branding challenge today is related to the need to scale up the activities. According to many respondents, some politicians think that much has already been done to renew the industrial structure of Örnsköldsvik. Yet there is also much to be done by the politicians to guarantee the future success of the bioeconomy in the region.

Industrial symbiosis

It could be argued that there has always been a high degree of “industrial symbiosis” in this cluster, but that this aspect is becoming increasingly institutionalized in terms of interactions (deliveries, values, prices). The Örnsköldsvik case is seen as an example of successful Industrial symbiosis by several researchers and analysts. Previously, there were many more ad hoc solutions, and sometimes the flows were not even valued (it was a trade of goods and services), but now these aspects are becoming more regulated. Concerning industrial symbiosis, one respondent stated that the linkages are rather vulnerable in the sense that as soon as there is some other use/value for the products that they use (residue from trees), these streams will cease, and they will need to find new residues to burn for central heating and energy production. However, they are constantly looking into other waste streams that are no longer useful.

3.5.9. Impeding factors

The discussion of public sector investments and the Örnsköldsvik bioeconomy

The enthusiasm of the local actors in Örnsköldsvik faced a setback in the 2000s when some of the bioeconomy investments in which the public sector, especially the municipality of Örnsköldsvik, had played a significant role as an investor turned out to be unprofitable. The explanations include money being lost because the market was not ready, consumers not being ready, and the government not providing the necessary support and structures. Hence, one limitation for future development is that the actors will actually move much slower now, and in the future. Is there a lesson for other regions to learn from the experience of Örnsköldsvik in the 2000s? Some respondents advise slower moves and “not putting all the visionaries in the same room”. Actors should be prepared for the process

to take some time and should be sure to keep an eye on the market as well.

“We can’t afford any more risk at this moment.”

“We have to focus on the main production that we do (energy production that we have established today) and perhaps some pilot ventures on the side with streams/resources that we already have. But not the large paradigm-shifting projects.”

“It is the same for some of the other firms; they won’t do the big shift unless the structures change. Who has the “endurance” to develop the projects that are in the range of 10–15 years? Is it only the state?”

In terms of incentives, structures or visions, it was mentioned by the respondents that there are regional funds, there is national innovation support (VINNOVA) available, and there is some possibility of financial support. However, it is for consumers to change the structures. The government could dictate and support a more stable path away from fossil fuels towards renewables. Consumers are obviously short-sighted, so the government needs to correct market failures.

The municipality of Örnsköldsvik is expected to have rather few financial opportunities to support the development of the bioeconomy, compared with large firms or the national government, but it is focusing on the aspects that it can work with. For instance, the municipality desires to improve the standard of chemistry education in upper secondary schools to stimulate students to continue in this field at university and in the long run to contribute to the development of the bioeconomy. The municipality is also attempting to act as a “door opener” whenever possible between firms and the government, and to create a favourable business climate for firms to develop or to be established in the region. The most direct impacts of this development are much the same as those of wood, paper and pulp production in the region discussed above—clear felling, transport, industrial complexes close to harbours, and the smell.

3.5.10. Conclusions

The Örnsköldsvik bioeconomy, especially the build-up phase of the biorefinery initiative, is an essential part of the regional change story, and it is based on accumulated knowledge and natural resources in the region. The down-turn in the industries in the 1990s paved the way for the biorefinery initiative; a “sense of urgency” was present.

Processum, as the institution for collaboration (IFC)

and the cluster organization, has acted as the key regional development tool in bringing actors together. Processum has been able to deliver and communicate a systematic, long-term approach that is definitively needed in bioeconomy regional initiatives. The role of the VINNOVA national institute has been significant in guaranteeing the long-term approach in the Örnsköldsvik bioeconomy.

The bioeconomy sectors are considered to be important. It is perceived that the bioeconomy and the forest sector in general have a strong position in the regional development programme. However, in terms of strategy and the “new” bioeconomy beyond the traditional forest sector, it does not seem to be included in an explicit way in the visions of the future development of the region. For the larger region, which dictates some of the regional development plans, the bioeconomy does not have a large role in the economy, which is rather diversified and in which other sectors are also important (e.g., in the Umeå urban region). However, there are some parallel activities that could probably be better synchronized from a regional development perspective. These include initiatives such as the “Biofuel Region” project—an established platform that collects actors from four northern counties around a biofuel vision—which could be linked to the biorefinery cluster and included more in the regional development visions. From a structural perspective beyond the cluster and factory area in Örnsköldsvik, the interaction with Umeå, as well as nationally and globally in the field of bioeconomy, could in the long run develop new parts of the regional economy. People are already commuting between Umeå and Örnsköldsvik for work because of the bioeconomy, and this has a potential to spill over into other sectors as well, with an increase in interaction between places and activities.

As the situation currently stands, the major challenge remaining in the Örnsköldsvik bioeconomy cluster is the scaling up of the emerging biorefinery development. That is, what are the next specific steps? The respondents in this study emphasized the importance of being realistic about the market and the potential for the bioeconomy in the short and long runs. The establishment of the sector and market will take some time. Historically, the region and some actors have been “burned” by market mistakes in relation to ethanol. One lesson to learn from this is to have a realistic view of the development of the bioeconomy, but at the same time, the municipality and regional actors need to make a new start and not to neglect the field because of problems in the past.

One important regional development aspect of the current development of the bioeconomy in Örnskölds-

vik is that more global actors are present through their ownership of formerly Swedish firms. From one perspective, this is good, and it brings in new actors and ideas. It also opens global markets and offers opportunities to co-operate with firms abroad. However, it must be considered that this can have an impact on future benefits for both the region and the firms. Where will the patents be filed? Who will benefit from the licences? Where will the production plants to develop new products be built?

From a bioeconomy perspective, the biorefinery cluster in Örnsköldsvik is definitely a success story. However, the question is how much regional development impact this “geographically” confined and rather high-technology cluster has on employment, on multiplier effects for the economy, societal systemic change and development of other sectors. It is a fact that firms have been created (and sustained), and they are opening up new ways to make use of the forest in the region,

which in the long run may not be required for paper. However, there is a challenge in linking such a knowledge-intensive cluster with “wider” aspects of rural and regional development. If markets and funding were available, there would probably be more job creation, as plants would be built for other forms of refinement of the forest products. The scale of production would increase for those firms developing products such as ethanol, coal and proteins. Moreover, there is obviously a temporal dimension to the question of regional development. In the long run, the region may have firms to build economic activities, attractiveness and labour markets because of “narrow” growth taking place today. An integrated vision for the region would seem to be a good tool for enabling this and would consider what challenges are present that need to be addressed, whether they are related to competence in the workforce, national rules and markets, or something else.

4. Conclusions

Based on the analysis of the bioeconomy in the Nordic case study regions, the following conclusions and findings can be presented.

This report by Nordregio, commissioned by the Nordic Working Group on Green Growth— Innovation and Entrepreneurship by the Nordic Council of Ministers (NCM), contributes to the understanding of bioeconomy in the Nordic countries by investigating several cases of bioeconomy in five Nordic countries. We have attempted to describe and learn from the context, actions, and enabling and disabling factors that are specific to each region but sometimes strikingly similar. We have focused on the development of specific bioeconomy activities while seeking to broaden the analysis to the implications of the bioeconomy for regional development and policy perspectives.

Although the concept of the bioeconomy has been operationalized for some time by the EU (not least by the so-called Bioeconomy Observatory, and as a part of the new EU Framework Programme for Research and Innovation Horizon 2020), it is evident in the Nordic case study regions that the understanding of the concept varies significantly. Some Nordic regions (and actors) have adopted the term “bioeconomy”, whereas other regions are only becoming familiar with the term.

As expected, in the case study regions, the bioeconomy concept is more familiar among public sector actors and large-scale industries than among smaller companies. This is interesting in itself for a number of reasons. First, a common understanding of a concept and its content can have an impact on factors such as the ambitions, visions, tools, and sectors involved in regional development work. Second, a signal of understanding and adaption to the concept could be a measure of the ability to adopt and benefit from EU support measures, in the form of conceptual support, tools and methods, as well as funding.

The intensity and scope of regional co-operation between actors varies significantly among the Nordic case study regions, ranging from fully fledged regional cluster collaboration (as in Örnköldsvik) to an actor structure with a clear locomotive company without intensive regional co-operation (as in Østfold). Examples

of activities taking place in a more fragmented actor structure, with numerous smaller bioeconomy organizations, can be found in South Iceland, where the role of national-level actors is central in supporting innovation. It would seem that the historical development of the bioeconomy, and its current path dependence in building on strong previous activities, colours current co-operation in the region. In Örnköldsvik, the cluster has developed from an old industrial site, and co-operation with the authorities follows this industry’s previous position in the regional economy and community. In Iceland, the development is based on agriculture, tourism and fisheries, which are on a smaller scale and widely dispersed in the region. Hence, co-operation is initiated by an actor with a helicopter view seeking to create synergies and to facilitate innovations in this particular system.

What the Nordic cases illustrate is the importance of long-term commitment in developing a regional bioeconomy. An arrangement such as VINVÄXT by VINNOVA in Örnköldsvik (a 10-year financial commitment to a future biorefinery initiative) makes it easier for several other actors to commit to regional bioeconomy initiatives. Similarly, the development of a Danish Bioeconomy Panel signals a long-term commitment — and together with appropriate actions, it will create a nationwide platform for bioeconomy development. These activities are important for stimulating action in the regions, firms and research centres. The case study interviews reveal the (perceived) need in the regions to pick the “low-hanging fruit”, or to harvest short-term successes, in regional bioeconomy projects. However, the study respondents emphasize that a long-term persistent and systematic approach is probably more important in the long run. It would seem important to find a way to combine these perspectives and to make sure that the former contributes to an overall strategy for the latter.

The public–private partnerships are frequently mentioned by the respondents in the studies as favourable in developing the bioeconomy in the Nordic regions. However, the public’s role in this must develop to create a favourable playing field for bioeconomy products and solutions—in the past, the support has been in col-

laborating in the triple helix of regional development, but what is now called for (in all cases) is facilitation of markets, infrastructure and action by consumers.

The general impression of the bioeconomy is that it can be a motor for creating jobs and economic activities in rural regions while being beneficial for the environment. Although the cases show examples of successful entrepreneurship, cluster development, creation of some specialist firms and even what can be defined as successful regional innovation systems around the bioeconomy, it is very difficult to assess the actual impact on regional development (in terms of jobs or economic activities). Certainly, many jobs have been created and/or sustained, and this is obviously one extremely important factor in (rural) regional development. It has not been the explicit purpose of the project to count these jobs, but based on the results of the case studies, it is obvious that they are important from a local perspective. What can definitely be concluded is that the Nordic cases illustrate the possibilities of the bioeconomy in improving employment and regional growth, not only in an urban context but also in a rural environment. However, the large-scale impacts of the bioeconomy development still hinge on the upscaling, market development and systemic changes that would need to take place in society. From a long-term perspective, the “glocal” nature of the bioeconomy—global and local at the same time—opens up new business opportunities for Nordic rural entrepreneurs too.

Is it then possible to transfer the experiences and good practices in bioeconomy initiatives of one Nor-

dic region to another? The answer should be positive. Among the case study respondents, there has been considerable interest in learning from other Nordic actors and also in building co-operative relationships. Nordic institutions should act as intermediaries, especially to initiate the first contact to enable co-operation between Nordic actors. The increased international visibility of Nordic bioeconomy actors from the efforts of Nordic institutions is also welcomed. For larger-scale R&D efforts and bioeconomy investments, intensified Nordic co-operation may offer new opportunities; for example, to upscale the regionally/nationally developed prototypes or pilot plants. The Nordic cooperation should include joint learning, too, between the Nordic countries and regions. The work by the Nordic Council of Ministers contributes to joint Nordic learning in the field of bioeconomy.

From the Nordic view-point, some countries have recently launched national bioeconomy strategies (Finland) or important documents to have an impact on the national bioeconomy policy (Bioeconomy panel Denmark). From the case studies, we note that there is a common need in the Nordic countries and regions for a focus on true implementation and definite action on the bioeconomy, including measures such as upscaling demonstrator plants to larger-scale facilities, and opening up new export markets to bioeconomy products and services. That is, there needs to be a focus on specific policy in many sectors and public policy domains linked to these national strategies.

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