



# Bioenergy Development in Finland and Sweden:

The cases of North Karelia,  
Jämtland, and Västernorrland

Anna Berlina and Nelli Mikkola

NORDREGIO WORKING PAPER 2017:6

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# Preface

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This working paper looks into rural bioenergy development in Finland and Sweden.

The first chapter provides insight into bioenergy development in North Karelia in Finland. It aims at identifying the enabling factors behind the relatively successful local bioenergy development and considers how the bioenergy development has impacted sustainable local and regional development in North Karelia. The working paper is based on desk studies and interviews conducted with stakeholders in North Karelia in 2016.

The second chapter provides insight into bioenergy development in Jämtland region, Sweden. It highlights the key drivers as well as factors impeding bioenergy development, the key actors involved and bioenergy embeddedness in the community. The chapter is based on desk studies and interviews conducted in 2015.

The third chapter provides insight into bioenergy development in Västernorrland region, Sweden. It highlights the key drivers as well as factors impeding bioenergy development, the key actors involved

and bioenergy embeddedness in the community. The chapter is based on desk studies and interviews conducted in 2015–2016.

This working paper is one of the outputs of the TRIBORN project: Triple Bottom Line Outcomes for Bioenergy Development and Innovation in Rural Norway. The project investigates how to increase the production of bioenergy in ways that promote sustainable rural development understood as positive economic, social and environmental outcomes. The Working Paper provided valuable input into the development of the Policy recommendations on Bioenergy and rural development in Europe (Nordregio Policy Brief 2017:3).

The TRIBORN (Securing triple bottom line outcomes from bioenergy development and innovation in rural Norway, project no 233640/E50) is a research project funded by the Research Council of Norway (2014-2017).

Read more about the TRIBORN Project here: <http://www.nibio.no/prosjekter/triborn>

# 1. The case of North Karelia, Finland

## by Nelli Mikkola

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### 1.1 Introduction

North Karelia – sometimes entitled as the forest region of Europe – is one of 19 regions in Finland. It is located in the easternmost part of the country, and shares a 296 km border with Russia. The total population reported is 164,300 (2016) in an area of 21 585 km<sup>2</sup> (Statistics Finland, 2016) North Karelia is a predominantly rural region and the region's 164,300 inhabitants are sparsely distributed (7.7 inhabitants per square kilometre).

North Karelia is divided in 14 municipalities and three sub regions of Pielinen Karelia, Joensuu and Central Karelia. The main urban centre and economic capital of the region is the city of Joensuu with approximately 30% of the total population. (Statistics Finland, 2016)

North Karelia is often considered as a Finnish forerunner in renewable energy, largely thanks to innovations emerging from its robust forestry industry. Renewable energy accounts for 63% of total energy use in North Karelia (28.5% in Finland as a whole), with 82% of this coming from wood-based sources.

### 1.2 Forest industry and bioenergy development in north karelia

#### 1.2.1 Motivation arising from local assets

Due to its vast forest resources and accumulated expertise in forestry, a large scope of upstream and downstream activities of forestry value chains is present in North Karelia today.

The region hosts a number of multinational forestry-related industry actors, including e.g. Outokumpu, John Deere, UPM Kymmene, and Stora Enso. A large number of smaller actors are operating around these major actors, providing services and material across the forest industry value chain and also developing businesses stemming from the industry side streams.

For instance, the region specialises in timber construction, and Eastern Finland produces most of the forest machines sold in Europe. The forestry industry also specialises in pulp and biomass

as well as the processing and use of ash collected from wood-fired power plants. Additionally, expertise in forest measurement and other aspects of forest development are exported by local companies.

Furthermore, a large portion of the companies that make up North Karelia's forestry industry are locally owned by co-operative private firms, individuals and municipalities. For instance, there are 22 000 non-industrial forest owners and more than 5 000 people working in the forestry supply chain. Thus, the profits and natural resource rents are to a significant extent recycled back into the local economy. (Regional Council of North Karelia, 2016)

Due to the strategic importance of forest industry, the forest industries and local forestry associations have been and still are quick to pinpoint any policies affecting forest activities at the local level and the incentive system for renewable energy is adjusted in a reciprocal manner. Incentives for thinning of the wood and producing renewable energy from forest resources, as well as permitting (with controls) the re-use of wood ash as a forest fertiliser, are deemed beneficial because they positively impact the wellbeing of forests and the quality of wood derived from the forest.

In North Karelia, the development of bioenergy is happening through formal and informal networks connecting private enterprises and energy co-operatives with the public sector, regional research institutions and consumers in a quadruple-helix manner. According to the estimates by the Regional Council of North Karelia, this network, or a bioeconomy cluster as the Regional Council of North Karelia entitles it, involves around 500 companies, has generated 6 000 jobs and has an approximate turnover of €1,7billion. Simultaneously the cluster constitutes the backbone for the high regional levels of renewable energy consumption, equalling up to a 63% share of renewable energy in the total regional energy mix (with 82% of this coming from wood-based sources), which is well beyond the Finnish and EU average, reaching

29,4% and 12,5% share of renewable energy respectively. In addition, the cluster's approach has contributed to the lowering of the North Karelia's CO2 emissions around 21 % between 2007 – 2012. (Regional Council of North Karelia, 2016)

The Regional Council of North Karelia estimates that at least 120 companies are concentrated in the "bioenergy and renewable energy" sector, which had a turnover of about EUR 200 million in 2010. Between 2004 and 2010, turnover and employment in the renewable energy sector (mostly woody biomass) grew by about 130% (turnover) and 60% (employment). Direct employment in this bioenergy cluster is about 1 300 man-years, and the regional multiplier for employment in the forest supply chain is estimated at 2.3. (OECD 2012)

A profound factor advancing North Karelia's progress in the bioenergy sector has been the long-term strategic work undertaken by the Regional Council with a focus on the development of local value chains, legitimacy of locally produced renewable energy, R&D and innovation activities and attracting investments. In addition, the local universities and research institutions are strongly linked with business in North Karelia through a substantial regional innovation network. This ensures that research objectives evolve in response to specific needs within the region, which contributes directly to the competitiveness of the forestry industry. Most importantly, these benefits are achieved in a cooperative, consensus-oriented manner between the regional actors and residents, and with a minimal impact to the landscape and environment, which is a vital asset in the region's tourism industry and environmental sustainability.

“ Over 10% of workplaces are in the regional forest bioeconomy ... about 25% of our turnover in North Karelia is coming from forest-based bioeconomy, equalling up to 1.7 billion euros.

**REGIONAL COUNCIL OF NORTH KARELIA (INTERVIEW)**

One particular example of a joint learning and innovation is the Wood-Energy Network (WENET) that was an 8-year joint programme for regional bioenergy actors. Once the program was officially ended, the structures and networks carried on and the overall benefits proved sustainable in long term. (Interview)

**1.2.2 Long-term strategic work pays back**

An important part of the development process of North Karelia's bioenergy and bioeconomy sector is the long-term strategic work undertaken by the regional quadruple helix actors under the coordination of the Regional Council of North Karelia. Building on North Karelia's regional strengths and competitive advantages as a forestry region, including bioenergy deployment, is strongly viewed as a regional development priority administered by a regional policy. This persistent strategy work has paid off in investments, more sustainable energy consumption and additional revenues for local forest owners.

The Regional Council has applied an integra-

The Forest Bio-economy sector in North Karelia		
Sector	Workplaces	The revenue
Forest Economy	200	300 M€
<b>Renewable Energy (mainly Bioenergy)</b>	<b>1350</b>	<b>160 M€</b>
Wooded products and wood based construction	1000	400 M€
Pulp and board based industry	200	330 M€
Technology industry	1200	400 M€
R&D&E, Management	400	50 M€
Travelling and eco-system services	N/A	2–5 M€
<b>Total</b>	<b>6300</b>	<b>&gt;1600 M€</b>

Figure 1: Forest bioeconomy sector in North Karelia in 2012 (Regional Council of North Karelia, 2012)

tive strategy approach which connects several regional ambitions and policies. A number of bioenergy strategies have been implemented in North Karelia since the 1990s. The current direction of the region is established through a number key documents: Regional Strategy 2030, Regional Programme 2017, Smart Specialisation Strategy, Regional Climate and Environmental Programme 2020 and Regional Land Use Plan 2030. One of the main ambitions guiding the strategy work is the target of North Karelia becoming a completely fossil fuel-free region by 2030. Forest bioeconomy is one of the three spearheads of the Regional Smart Specialisation Strategy of North Karelia, defining this theme as one of the development priorities when the regional authorities allocate national and European regional development funds into the regional projects. (Interview)

The regional strategy aims at reducing dependence on oil and replacing it with renewable energy. A specific focus is given to liquid fuels from woody biomass in order to apply the fossil-free thinking also to regional transport and to reduce transportation costs. Moreover, the strategy highlights the importance of forest-based products, biorefining, forest energy technology, improvement of local value chains and strong entrepreneurship as foundations for energy self-sufficiency and ambitious export targets. (OECD, 2012)

“ The municipalities are taking advantage of North Karelia’s Regional Strategy, and using it to convince companies to come into the municipalities.

**THE REGIONAL COUNCIL OF NORTH KARELIA (INTERVIEW)**

Several concrete goals set for North Karelia for 2030 are directly related to the development of the bioenergy industry and request for more innovation, including targets such as increase in the revenue from the bioeconomy by EUR1 billion, net decrease of greenhouse gas emissions by 80% (2007 baseline) and the abandonment of fossil fuels in the region (Climate and Environmental Programme of North Karelia 2020). The efforts for realising a fossil-free region is coordinated by the Regional Council which works in a very practical manner with the regional stakeholders, including businesses and municipalities. This has involved establishing a direct link and continuous dialogue regarding the ambition for and foreseen benefits of a fossil fuel-free region as well as very hands-on work from the Regional Council’s side in order to inform, motivate and equip the regional actors to

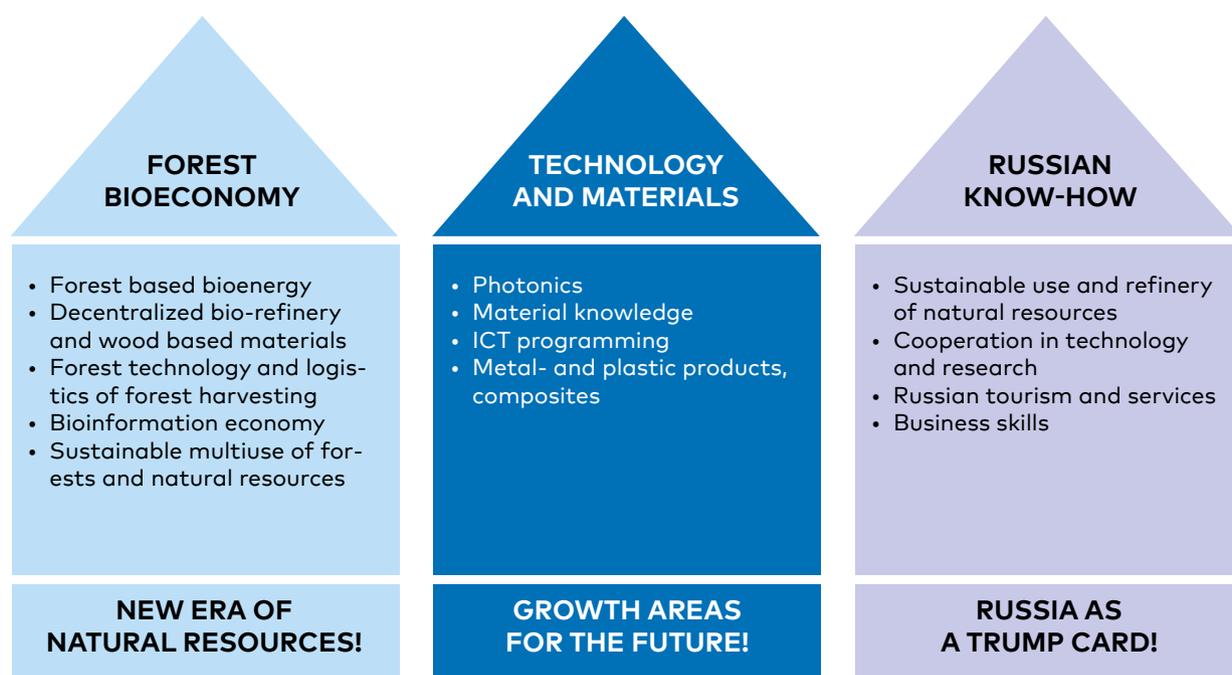


Figure 2: Spearheads of North Karelia’s Smart Specialisation Programme (RIS3) (North Karelia’s Smart Specialisation Programme 2013)

## Bioeconomy investments in North Karelia 2013-2015

(Only during last 2 years more than 100 M€ invested + planned more than 300 M€)

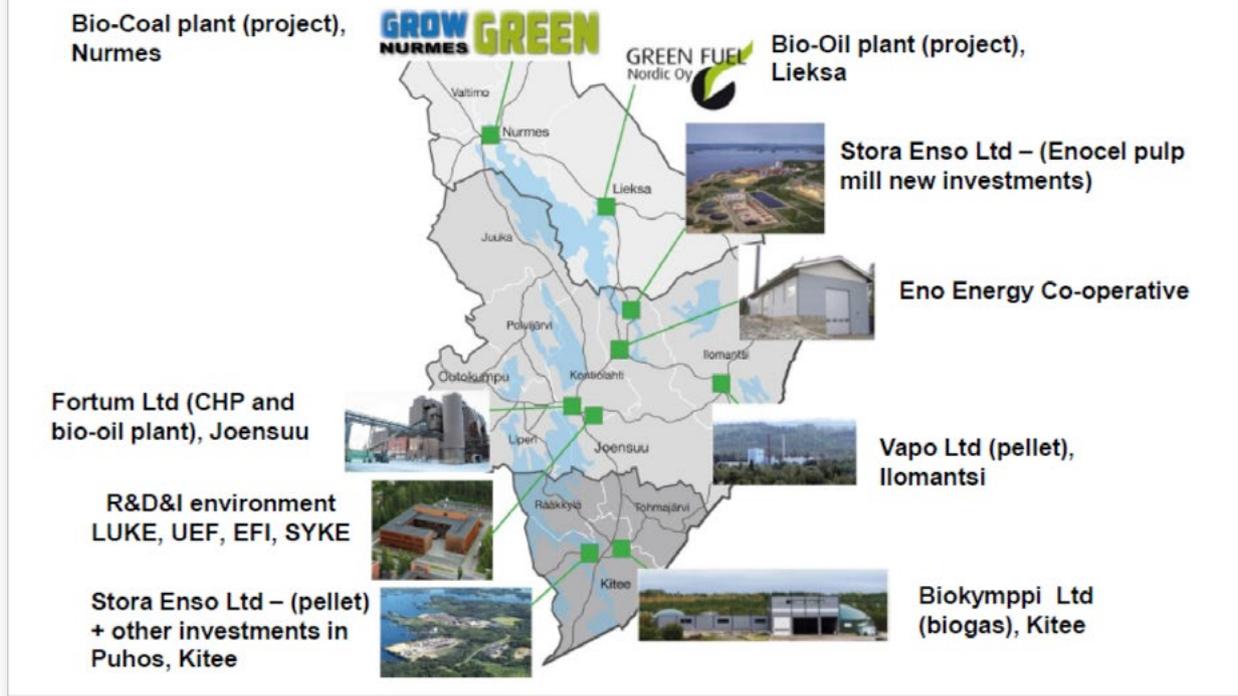


Figure 3: Bioeconomy investments in North Karelia 2013–2015. (Regional Council of North Karelia)

realise their part in the quest for a carbon-neutral region. (Interview)

The capital investments directed to the region's bioenergy and bioeconomy sector have been relatively high between 2013 and 2015, when more than EUR100 million were invested in biogas, bio-oil plants and RDI networks in the region. The success in attracting private investments to North Karelia is denominated both to the long-term regional strategy work and accumulated local expertise in the forestry sector, including the presence of internationally competitive knowledge institutions and supply of skills. Two additional projects with significant investment needs are planned in Nurmes (bio-coal plant) and Lieksa (bio-oil plant). (Regional Council of North Karelia 2016; Interview)

The Climate and Energy Programme 2020 of North Karelia presents a plan of action for the North Karelia region on climate change mitigation and adaptation. The programme was drafted in cooperation with all regional actors under the coordination of the Regional Council and it sets a common vision of the desired future. The pro-

gramme focuses on the sectors of energy production and consumption, transport, community structure and land use planning, construction, waste management, agriculture and forestry, including regional energy consumption targets for 2020 (see figure 6). As is required from these types of regional development programmes in Finland, the programme of North Karelia also includes an impact assessment of the programme targets in relation to economic, social and environmental well-being in North Karelia (see figure 10).

Majority of North Karelian households used to be relying heavily on oil heating, but today local bioenergy is proving an effective alternative, reducing heating costs significantly. The Regional Council has even established a call centre which provides information and guidance for local residents wanting to switch from oil heating to the local district heating system. Consequently, the money invested in local renewable energy stays in the region, instead of being used to buy oil which comes outside the region (OECD, 2012). At the same this, this approach is widely considered to

contribute to regional energy security and climate change mitigation which has increased the legitimacy of locally produced bioenergy further.

This has enabled North Karelian forest owners to diversify their production by using forest residues as feedstock for district heating systems in local towns and villages. By owning district heating plants, the forest owners and cooperatives of forest owners are able to capture additional revenue from the forest. Although the impact on job creation is not dramatic, the diversification has offered small forest owner co-operatives a new source of revenue. (OECD, 2012).

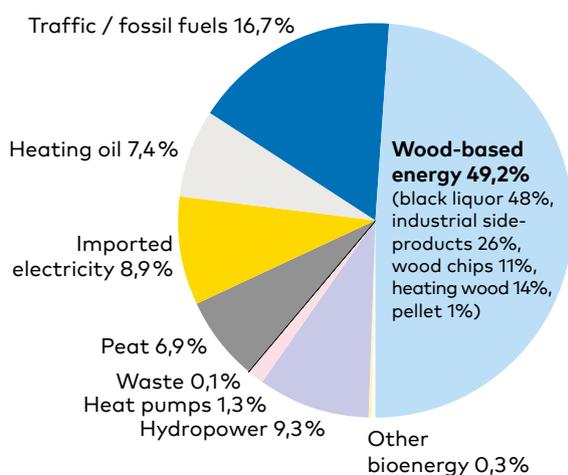


Figure 4: Target lines for the share of different energy resources by % in North Karelia in 2020 (North Karelia's Climate and Environmental Programme 2020)

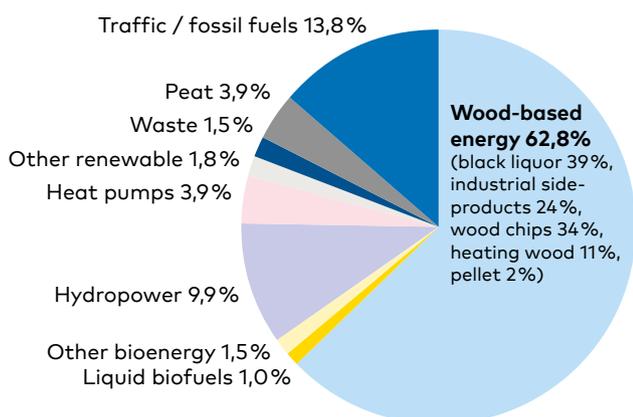


Figure 5: Share of different energy resources by % in North Karelia in 2008 (North Karelia's Climate and Environmental Programme 2020)

Regional district heating systems are often based on small-scale installations with a limited impact on the environment and landscape, which is also deemed important for local life quality and maintaining the tourism industry of the region (OECD, 2012).

### 1.3 Cross-sectoral cooperation as a driver for bioenergy development

The bioenergy network of North Karelia integrates several types of regional and local actors who all collaborate in an effort to work together on the development of regional bioenergy sector and for-

Energy consumption in North-Karelia (GWh)		
	Year 2008	Year 2020
Black liquor	2 400	2 500
Other industrial by-products	1300	1 500
Forest chips	550	1 500
Biofuels		200
Fire wood	700	720
Pellets	50	150
Field biomass	17	50
Biogas	14	100
Waste	10	150
Hydropower	940	1 000
Windpower		150
Solar	<1	20
Heat pumps	130	400
Geothermic		10
Peat	700	300
Oil (traffic)	1 700	1 400
Oil (heating)	750	0
Import of renewable electricity	270	
Import av nonrenewable electricity	630	
<b>Total</b>	<b>10 161</b>	<b>10 200</b>
Renewables (%)	62,7	80,2
Self sufficiency	69,7	86,2

Figure 6: Target lines for energy consumption in North Karelia (Climate and Environmental Programme of North Karelia 2020)

est industries. The most important actors in the regional bioenergy/bioeconomy network are discussed below.

**The Regional Council of North Karelia** (comprised of 14 municipalities) is responsible for regional planning and coordination of regional development programmes and strategies as well as management of most national and EU Structural Funds at the regional level. The main responsibilities of the Regional Council include fostering co-operation, outlining regional development targets, key projects and measures through the main planning documents as well as undertaking international activities. It is also responsible for regional energy policy and coordinating and implementing the strategy for North Karelia as a 'Fossil-Free Region' by 2030. The highest decision-making body in the regional administration is the Regional Council Assembly, which is elected by delegates from the member local municipalities. Executive functions are carried out by the Administrative Board, which is elected by the Assembly. The work of the Regional Council is further supported by the Regional State Administrative Agency for Eastern Finland and the Centre for Economic Development, Transport and Environment of North Karelia.

The **regional business community** includes several key associates. The region hosts a number of multinational forest-related industry actors, including e.g. Outokumpu, John Deere, UPM Kymmene, and Stora Enso. A large number of smaller actors are operating around these major actors, providing services and material across the forest industry value chain and also developing businesses stemming from the industry side streams. North Karelia has around 22 000 **non-industrial forest owners** and over 500 **companies** in the forest sector. Local **co-operatives**, assembling local forest entrepreneurs, dominate the forest industry and play a key role in bioenergy technology deployment by providing small forest owners with information on the most profitable way to collect and put biomass on the market, and reducing transaction costs and facilitating collective action. Some of these co-operatives have entered the business of district heating systems to take advantage of the woody biomass they produce. (OECD, 2012)

Another important aspect of the co-operatives is their positive impact on social capital. This is mainly because they involve a large number of actors, produce common rules and build trust, there-

by facilitating business interactions and reducing transaction costs. They provide the necessary organisation and coordination to collect biomass and organise its sustainable use at a reasonable cost (OECD, 2012).

The connection between regional companies and co-operatives is strong. Organisations such as Kontio-Energia Osuuskunta (Kontio Energy Co-operative, established in 1998), have deployed municipal wood-chip heat plants to produce and sell thermal energy. Kontio Energy co-operative, located in the North Karelian municipality of Kontiolahhti, sub-contracts local companies for the required activities like wood harvesting, chipping and transport. Another example is the Eno Energy Group from the Eno municipality, which is a co-operative currently owned by around 50 forest owners. This company also delivers thermal energy derived from wood chips from local producers.

The **regional research system** is comprised of a number of institutions (Figure 7). The research is conducted by a series of bodies and organizations with headquarters or regional offices in North Karelia, which work in close collaboration with the regional businesses, the Regional Council and are also involved in many trans-European and Nordic collaborative projects. The research institutions

“ The change (for bio-economic thinking) starts from the kids ... vocational school might be even too late ... it should start from the infancy.

**BIOFEM PROJECT, NORTH KARELIA  
UNIVERSITY OF APPLIED (INTERVIEW)**

are strongly linked with business in North Karelia through a substantial regional innovation network. This ensures that research objectives evolve in response to specific needs within the region, contributing directly to the competitiveness of the forestry industry. The regional research network is currently working around areas which could have a decisive impact on future bioenergy, for example liquid fuel from pyrolysis; diesel oil from cellulose; ethanol from cellulose; optimal logistics for biomass flows; measurement of forest resources using lasers; and transport and logistics equipment amongst others. Certain research projects also focus on the social science side of bioenergy and

Name of organisation	Type of organisation	Brief Description
Karelia University of Applied Sciences (NKUAS)	National university	Main areas of focus: renewable energy, wood construction, Russia-competence, precision engineering, multi-media services and competence in aging
The European Forest Institute (EFI)	International organisation	Focused on generating information for policy-making on forest and forestry issues. 125 member organisations from 37 countries.
Natural Resources Institute Finland (LUKE)	Government research institute	Main forest research institution in Finland and one of the biggest in Europe with a goal to "promote, through research, the economical, ecological, and socially sustainable management and use of forests"
University of Eastern Finland (incl. e.g. the School of Forest Science)	National university	International PhD program in bioenergy, research projects including forest sciences, environment, energy, social sciences and health
North Karelia Municipal Education and Training Consortium	Vocational college	Basic forestry education (drivers and mechanics)

Figure 7: Key Research and Education Institutions in North Karelia

bioeconomy, including topics such as legitimacy, female entrepreneurship, regional innovation systems etc.

One of the main benefits the regional research institutions bring about is their capacity to incentivise investors into adopting new technologies. North Karelia's research institutions play an important role in demonstrating and evaluating vanguard technologies and introducing them to interested investors. The perceived risk is a common issue regarding private investments for bioenergy development, especially in terms of novel technologies, and the regional research institutions have a core function in mediating the uncertainty factor. (Interview)

Regions taking up the challenge of bioeconomy transition cannot disregard that the bioeconomy is knowledge intensive and part of the challenge is to build a scientifically skilled labour force in peripheral regions. The regional education institutions of North Karelia, in collaboration with regional companies and the Regional Council, have come to play a key role in providing relevant curricula and also in-service training e.g. for the regional bioenergy entrepreneurs.

**Public development organisations** also play a role in North Karelian innovation platform as they connect and mediate among government authorities, research centers and businesses. These services may be focused on consultancy services and joint facilities, as is the case for Joensuu Science Park (owned by the city of Joensuu and the Regional Council of North Karelia), targeting technology

transfer, business development and commercialisation services and scaling up research findings for the benefit of businesses. Three regional development agencies are present in the region: the Joensuu Regional Development Company which is a non-profit association owned by seven North Karelian municipalities; the Pielinen Karelia Develop-

“ We have quite a competition for establishing new biorefineries. Almost in every location across the region there is some plan for a biorefinery, which are all competing for the state grants and European grants.

#### NORTH KARELIA UNIVERSITY OF APPLIED SCIENCE (INTERVIEW)

ment Centre serving the municipalities of Nurmes, Lieksa and Valtimo, located further away from the regional capital; and Central Karelia Development Company, a business promotion and development company owned by three municipalities in Central Karelia: Kitee, Rääkkylä and Tohmajärvi.

These intermediate organisations play a major role in coordinating the regional bioenergy development across a larger geographical scope in order to find inter-regional synergies and joint benefits and to gather critical masses.

The function of the **local citizens** in the regional innovation platform comes in the form of valuable consumer and public feedback, setting the local market priorities for the businesses and industry while influencing also the course of regional research priorities and actions of the regional governance. **Local politics** do play a role in the bioenergy development as well, which is well illustrated by different uptake levels of bioenergy and bioeconomy across the municipalities in North Karelia. While certain municipalities, such as Nurmes, are strongly targeting bioeconomy as a local development strategy, have political prioritisations and scarce resources hampered the development of bioenergy and bioeconomy in some other municipalities.

### **1.3.1 The interplay between regional and sub-regional innovation platforms**

North Karelia depicts a case of geographically uneven development within the region itself. Whilst a major share of the regional economic development is concentrated in Joensuu, the more rural parts of North Karelia are lagging behind as the spill-overs from the regional capital reach the more peripheral municipalities only in a sub-optimal manner. sub-region concentrates most of the economic development of North Karelia. Consequently, **sub-regions**, such as Pielinen Karelia, and **individual municipalities** are increasing their efforts to attract business and investment into their bioenergy sector in order to mitigate their particular development problems related to demographic challenges and decreasing employment opportunities (Lehtonen & Okkonen 2016).

Municipalities and sub-regions that have taken an active role in developing their own innovation platforms may be analysed as partially independent sub-regional platforms embedded in the major regional platform. One example, the municipality of Nurmes, is discussed in the following section.

### **1.3.2 Case nurmes (based on a stakeholder interview)**

Nurmes is a municipality in the North Karelian sub-region of Pielinen Karelia. As many other rural regions in Finland, Nurmes is experiencing asymmetrical development compared to more urban regions, facing typical challenges for sparsely-populated rural areas, such as low employment and negative net migration (Lehtonen & Okkonen, 2016).

Since 2000, the population of Nurmes has de-

creased from 9,781 inhabitants to 7,996. In 2016, the municipal unemployment rate was 18% (the national average in Finland being 13%).

The economic industry structure of Nurmes relies heavily on services (63,6%), with the majority of jobs provided by Nurmes municipality and the Valtimo Health Care Joint Authority. Manufacturing amounts to 20,0% of the local economy, with textile, metal and wood-based companies included. Primary production (15.7%) is focused on wood-harvesting and farm production. (Nurmes municipality, 2016).

In 2014, Nurmes municipality joined the programme of Carbon Neutral Municipalities of Finland (known as the HINKU network), with an aim to reduce their greenhouse gas emission with 80% by 2030 in comparison to 2007 levels. Adhering to the HINKU program was not an isolated action since in 2011 Nurmes municipality has set its strategic focus on developing the bioeconomy industry and increasing the attractiveness of the municipality and Pielinen Karelia region (Lehtonen & Okkonen, 2016). This approach has since become evident through two main drivers: the "green" industrial area development, and the Pielinen Karelia Development Center. The local bioeconomy development is also strongly anchored to the municipal leadership of Nurmes, which is knowledgeable of forest industry and bioeconomy development.

In 2013, 28 hectares of municipal land were set apart for a "green industrial zone" of Nurmes. The industrial area was established as there was a shortage in Nurmes of large industrial plots and the existing plots were scattered. The green industrial plan promotes bioeconomy and relevant upstream and downstream industries by advocating for industrial symbiosis approaches. The area was named an area of green industry by bioeconomy companies that would be located in the area and according to Nurmes' carbon neutrality objectives. As is indicated by the name, companies that located in the area will follow the principles of sustainable development in their operations in order to produce products and services in a way that is low-emission, resource-efficient and environment-friendly. The area that consists of 28 hectares of land is divided into nine plots, out of which a couple are still available. Plans for the area include a biorefinery, a bioterminal, a CHP plant, a wood dryer, and a loading and unloading site for the railway.

Since 2015, a bioterminal has been operating

in the green industrial zone, collecting and selling energy-wood. A maintenance facility for specialised wood transportation is under construction and building of a biorefinery is expected to start in 2017. Investments for the development of local bioeconomy sector in Nurmes have come from multiple sources of funding, i.e. from the local government funds, from the Regional Council of North Karelia and the Finnish Transport Agency.

One of the main enabling conditions that allow the municipality of Nurmes to pursue a sub-regional innovation platform and green industry hub is the presence of foreign investment. International capital is playing a significant role for developing the municipality. However, this also calls for striking the balance between the foreign investments and make sure that the strategic inclusion of the local society in order to ensure that a share of the benefits will be recirculated into the local society and economy.

A critical element in the development trajectory in Nurmes has been the Pielinen Karelia Development Center (PIKES), an intermediate company that is partly owned by the three municipalities that form the sub-region, namely Nurmes, Lieksa and Valtimo, which focuses on business services, project development and monitoring focused on regional development. PIKES brings together various quadruple helix actors around the regional development issues of Pielinen Karelia sub-region, not only the key stakeholders from Pielinen Karelia but also from around the regional capital region of Joensuu. Current projects ran by PIKES cover a broad range of topics, from e.g. food industry modernization to bioenergy technology development and the green industry park in Nurmes.

Although there is a clear inclination of sustainably sound investments taking place in Nurmes at the moment, it is yet too early to feasibly assess the outcomes for societal, economic and environmental sustainability of the local development approach adopted in Nurmes.

### **Key learnings from Nurmes**

A key observation that can be drawn from the case of Nurmes is the limitation posed to a grounded innovation platform by geographical distances and concentration of innovation actors in the urban areas and regional capitals. The case of Nurmes and the sub-region of Pielinen Karelia however demonstrate that this issue can be mediated by the es-

“ I think this is the key point: Does the municipality have a strategy? And can the municipality follow its strategy for many years? Not only for one, two or three years, but for a longer period, because getting and demonstrating real results takes time.

### **MAYOR OF NURMES**

establishment a more local, sub-regional, platform for peripheral actors that would otherwise face the risk of being short of the benefits stemming from the major regional innovation hub. In North Karelia, the major innovation platform around Joensuu area and the sub-regional platform of Pielinen Karelia have emerged as mutually supportive and complimentary structures, which are partially intertwined and inseparable. An important role is played by the different regional and local actors, in this case especially the Pielinen Karelia development center PIKES guarding the interest of the more peripheral municipalities, that facilitate the dialogue and collaboration between the regional capital region and Pielinen Karelia. Simultaneously, this type of an approach is in the interest of the regional developers in the Regional Council as well as it has the potential to further enhance the balanced regional development across the entire region of North Karelia.

Another worthwhile factor in advancing bioenergy development in areas such as Nurmes is the interplay between regional strategies and local-level municipal strategies. A core factor for the successful attraction of investment into the green industrial park of Nurmes, for example, has been a detailed, long-term municipal strategy backed by a strong political and social will in the municipality. Simultaneously, the local strategy is aligned with the regional strategies and committed to the goals and targets set out by the Regional Council of North Karelia, the Carbon Neutral Municipalities of Finland and the programme for a Fossil-Fuel Free Region of North Karelia. This method has contributed to the creation of trust among public and private investors as well as local citizens regarding the green growth plans of Nurmes.

## 1.4 Key characteristics of sustainable bio-innovation in North Karelia

Based on the approach applied in the TRIBORN project, an innovation platform can be considered as grounded if the objectives pursued and obtained from this network are aimed towards achieving triple bottom line (TBL) outcomes, referring to environmental, economic and social objectives while acknowledging regional peculiarities and specialising strategically on regional assets. The bioenergy cluster of North Karelia indicates that these three-fold outcomes are achievable.

For example, North Karelia's local energy cooperatives have demonstrated that heat produced from bioenergy is cheaper for the consumer compared to light fuel oil. Switching from oil heating to local renewable energy has generated savings worth EUR 2 million for the local economy while providing an annual additional employment equivalent to 7–10 man years. Simultaneously it prevents the burning of approximately 2 million litres of fossil oil, reducing regional CO<sub>2</sub> emissions around 5 million kilos per year. (Regional Council of North Karelia 2016)

The economic impact of the bioenergy cluster on the region is evident: the renewable energy sector alone (mostly forest-based bioenergy) equalled up to 20% of the regional employment and has a share of 10% of the regional revenue. From 2008 to 2012, the turnover of bioenergy sector increased 37% while the number of jobs increased by 25% with the technology and services branch experiencing the largest growth. In addition, the strategy work undertaken by the Regional Council of North Karelia and strong regional knowledge base in forestry and bioenergy-related matters has helped in attracting private investments to the region. (Regional Council of North Karelia 2016)

North Karelia has gained several environmental benefits due to its specialisation in bioenergy. In 2012, 63% of the energy consumption<sup>1</sup> came from renewables with 82% of this supply produced by wood-based sources. The regional CO<sub>2</sub> emissions have decreased by 21 % between 2007 – 2012 and the carbon footprint of a North Karelian inhabitant is 34 % smaller than the footprint of an average Finn (2012) and the greenhouse gas emission per capita is also lower compared to national average. Simultaneously, the consensus-oriented local

<sup>1</sup> Including heat, power, private households and traffic

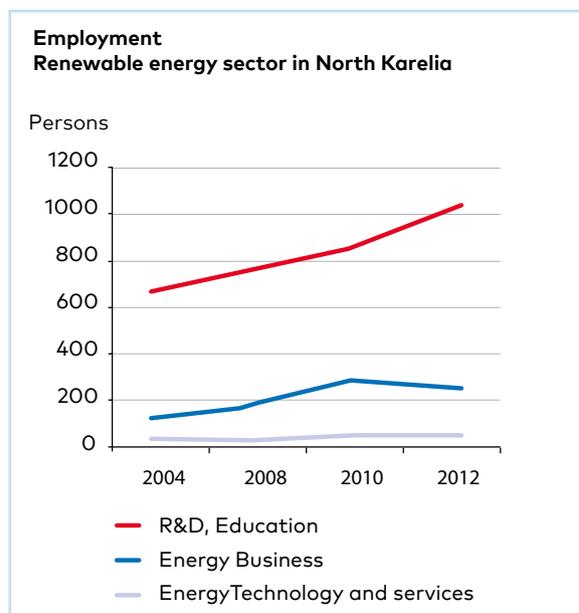


Figure 8: Employment (in persons) of renewable energy sector in North Karelia (Regional Council of North Karelia, 2012)

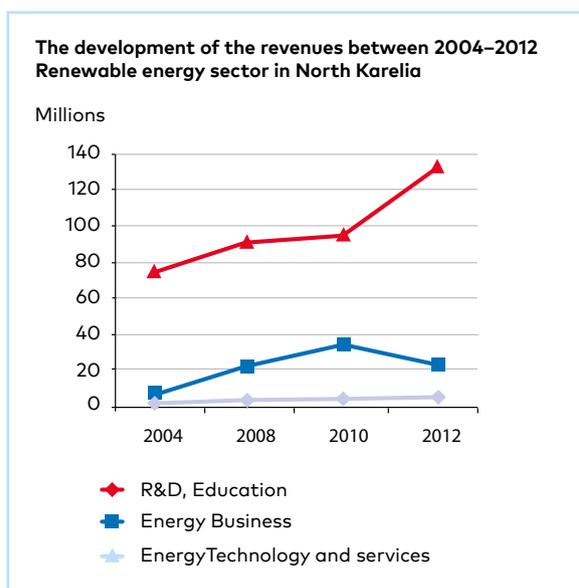


Figure 9: Turnover (€) of renewable energy sector in North Karelia (Regional Council of North Karelia, 2012)

method of bioenergy production based on small-scale installations and sustainable forest cutting has not altered the regional recreational values and nature tourism.

The social benefits of the regional bioenergy development are capitalised in large part because of the high percentage of ownership by the public and private regional actors, and besides job creation the profits and natural resource rents

are largely recycled back into the local economy (OECD, 2012). Furthermore, the European Forest Institute (EFI) has indicated that improved use of biomass in North Karelia would have large impacts on the labour market and positive effects in the region due to the reduced imports of fossil fuels. It has been studied, that the impact of renewable energy on employment creation tends to be larger when the energy process depends on a raw material. This applies in the case of biomass, which likely to have higher income and employment benefits than other energy sources where the main input is free (solar, wind, tidal) and/or where the benefits from these inputs are captured by external interests. (OECD, 2012)

The expected social, economic and environmental outcomes of North Karelia's regional strategy and target lines for the further development of the regional forestry bioeconomy cluster and fossil-free region are outlined in the Impact Assessment of North Karelia's Climate and Environmental Programme 2020 (see figure 10). A requirement for assessing the impact of regional development programmes is outlined in the Finnish law. The impact assessment of North Karelia's Climate and Environmental Programme was conducted by a regional committee responsible for assessing the potential impacts of different re-

gional lines of strategy and action in a coherent and streamlined manner. The committee consists of representatives from the Regional Council of North Karelia, The Regional State Administrative Agency for Eastern Finland, The Centre for Economic Development, Transport and Environment of North Karelia and the University of Eastern Finland.

### 1.4.1 Lessons learned and ways forward

The sustainable success of bioenergy development and innovation in North Karelia depends also on capacity to engage in a learning process that can transform initial challenges into opportunities. For instance, the use of biomass for renewable energy was not an immediate success in the region. It took time to penetrate the market and convince households to switch from oil to wood-generated energy. Generating trust and collaboration between regional actors and stakeholders has also taken time and required consistent actions and open dialogue from the regional strategists.

Overall, the North Karelian innovation platform has been identified as a constantly evolving concept and as an ongoing learning process that takes time but delivers clear benefits for its participants.

Certain regional conditions such as the pres-

Impact assessment of North Karelia's Climate and Environmental Programme 2020		
	Impact ++/+/0/-/--	Description
<b>I Social Impacts</b>		
Impact on living conditions and their quality	+	Increasing the use of renewable energy sources improves local employment, which has indirect positive impact on people's well-being
Impact on health and security	+	Increasing the use of renewable energy sources improves local employment, which has indirect positive impact on people's health
Impacts on equality: - Equality between men and women, equality between regions and societal groups	++	Increasing the use and production of renewable energy helps to secure balanced regional development and the equality of citizens residing in sparsely-populated rural regions
Impacts on citizens' possibilities to influence	0	

Figure 10: Impact assessment of North Karelia's Climate and Environmental Programme 2020

Figure 10 continues →

<b>II Environmental Impacts</b>		
Emissions to air, water and land	++	Reducing the use of fossil fuels reduces the amount of emissions to air.
Impact on natural environment, natural diversity and protected areas	-	Strong increase in the production of bioenergy can have negative impacts on natural diversity
Impacts on climate change mitigation and adaptation	++	All targets of the programme have a positive impact on climate change mitigation and adaptation
Impact on the use of natural resources - Increasing the sources of renewable energy  - Increasing material and energy efficiency	++  ++	The programme increases the use of renewable natural resources while decreasing the use of non-renewable (fossil) fuels The programme has positive impacts on energy and material efficiency by e.g. developing low-energy construction
Impact on landscape and cultural heritage	0	
Impact on the amount and quality of waste	++	Reducing waste is one of the core targets in the programme, which can contribute to reducing of greenhouse gas emissions
Impact on traffic - Forms of transport, public transport - Transport – and mobility needs	++  ++	The programme aims at enhancing the infrastructure and improving the conditions for public transport By improving the infrastructure and implementing complementary construction different transport needs can be reduced
Impacts on the environmental health	-	The micro particles created by the burning of wood-based fuels have a negative impact on environmental health especially in small-house areas
<b>III Economic Impacts</b>		
Households	+	The approach presented in the programme increases rural employment which in turn has positive impacts on the household economies
Companies	++	The programme targets support the creation of new business opportunities, which affects corporate economies positively; e.g. increased use of wood-based energy, development of wood construction and traffic biofuels
Regional Economy	++	The programme targets support the creation of new business opportunities, which has a positive impact on regional economy; e.g. increased use of wood-based energy, development of wood construction and traffic biofuels.

Figure 10 (continued): Impact assessment of North Karelia's Climate and Environmental Programme 2020

Figure 10 continues →

IV Other Impacts		
Research, development and innovation activities	++	The programme goals increase positive impacts on research, development and innovation activities especially through the uptake of renewable energy resources, wood construction and forest research
Regional development impacts - County/regional level: businesses, services, employment - Sub-regional level: businesses, services, employment - Countryside, rural areas: businesses, services, employment	++  ++	The programme supports regional development on all regional levels E.g. Increased turnover and employment for the renewable energy cluster and wood construction sector  E.g. De-centralised and self-sufficient energy production and related fuel maintenance support rural businesses and consequently the vitality of the rural countryside

Figure 10 (continued): Impact assessment of North Karelia's Climate and Environmental Programme 2020

ence of a large, managed forest resource, cold temperatures and high-cost energy alternatives provide a strong financial incentive to develop the local bioenergy as a means to increase the local value creation and reduce the cost of energy while at the same time ensuring that the profits generated from energy sales remain in the local economy.

Many favourable institutional factors for regional innovation are in place in North Karelia: strong local government with willingness to act, local ownership of power utilities, presence of strong research institutes and education facilities, tradition of co-operative organization, legitimacy of local bioenergy production and presence of local and regional actors in several stages in the supply chain (OECD, 2012).

One key for successful bioenergy and bioecon-

omy innovation in North Karelia lies in the embeddedness of the regional, internationally leading forest science base that is strongly connected to the export industry as well as the local environment and local companies. This can further create 'glocal' opportunities for North Karelian innovation, with the potential of tackling local problems and simultaneously contributing with products and services for global exportation.

Key constraints for development of forest-based bioenergy in North Karelia are unfavorable national and EU-level policies and regulations causing market distortion and unfavourable conditions for the use of forest biomass as energy. Such examples, relevant especially for North Karelia have been wind energy subsidies and policies that favor large-scale installations which fit poorly to the North Karelian setting of de-centralised, small-scale energy production units. Another aspect is balancing the citizens' approval of large projects by considering the landscape of the area and the impact these large projects may have on the tourism industry (OECD, 2012).

Also the profitability issue of harvesting young energy wood remains pertinent. In order to further increase the share of renewable energy from the forest and achieve the regional and national targets of forest chip use (in North Karelia from 550GWh in 2008 to 1500 GWh in 2020), more and more focus will need to be directed towards young forests and small scale wood. Currently, energy wood harvesting from young stands is seldom perceived as profitable from an entrepreneur's point of view. Main barriers for profitable harvesting are linked to the insecurity of substitutes, small tree size, bad preparation of stand and difficult forest

“ Wood-Energy Network (WENET) was 8 years of joint development cooperation between companies and research and development organisations in this region. We had joint projects and also engaged in the promotion of export of local products ... Not competing with each other but developing things together.

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“ The most challenges are based on just the economy – is it viable? How much money you are going to save? How big risks are you willing to take? Are those risks mostly related to technology?

#### **NORTH KARELIA UNIVERSITY OF APPLIED SCIENCE INTERVIEW (INTERVIEW)**

hauling as well as lack of time and funding. From the viewpoint of an energy producer, using forest chip is challenging compared for example to using fossil oil, and a number of quality and delivery issues need to be tackled in this regard as quality of raw material and secure supplies are essential factors for a profitable heat plant. Besides consistent energy policy, forest entrepreneurs in North Karelia have pinpointed better land use and building planning from the authorities as well as more education about accounting, taxing, subsidies and generation change as key actions for improving the status of forest-based bioenergy. (Bioenergy Promotion Project, 2014)

Another of the major aspects hindering the transition towards a stronger bioeconomy in North Karelia is related to access to risk finance and other economic challenges facing especially local small and medium-sized enterprises. SMEs may lack the seed-funding to start their innovation programs which consequently hinders the overall performance of the GRIP. More effective governmental strategies together with more foreign investment and small-scale technology demonstrations may help counter the issue. (Interview)

North Karelia is also facing the challenge of ageing population. The question of generation change is a salient issue for many forest and bioenergy entrepreneurs and depends on the profitability of local renewable energy production and silviculture as well as about the perception of bioenergy business in the eyes of the younger generation, especially with regards to the required education and understanding of innovation possibilities within bioenergy and bioeconomy as well as the attractiveness of the sector, including the question of female actors in the field.

One issue is the question of openness of the current innovation platform for innovation and development around other thematic areas than forestry and bioenergy. Despite North Karelia's strategic advantage in these particular areas, it could prove beneficial to explore other potential areas of regional bioeconomy, such as agri-food. The domination of wood-based bioenergy in the regional innovation ecosystem has been pinpointed by several regional actors. (Interview).

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## Interviews

Title	Organisation	Date of interview
Researcher	University of Eastern Finland, Faculty of Social Sciences	18 February 2016
Specialist	Pielinen Karelia Development Center PIKES	17 February 2016
Project Manager	Regional Council of North Karelia	18 February 2016
Development Specialist	North Karelia University of Applied Sciences	18 February 2016
Business Consultant	Joensuu Regional Development Company JOSEK	17 February 2016
Chairperson	Energy co-operative Kontio-Energia Osuuskunta	17 February 2016
Bioeconomy coordinator	North Karelia University of Applied Sciences	18 February 2016
Professor	University of Eastern Finland, School of Forest Sciences	18 February 2016
Regional Planning Manager	Regional Council of North Karelia	18 February 2016
Senior Project Manager	North Karelia University of Applied Sciences	18 February 2016
City Mayor	Regional municipality	17 February 2016
Development Director	Joensuu Science Park	18 February 2016

# 2. The case of Jämtland, Sweden

By Anna Berlina

## 2.1 Introduction

Jämtland is a rural forest-rich region that demonstrates good regional practice in the development of bioenergy. Biomass from forests is used for production of heat, electricity, pellets and other bio-fuels. An extensive share of the wood is exported from Jämtland unprocessed while a small share is processed in a few large and several small saw-mills in the county.

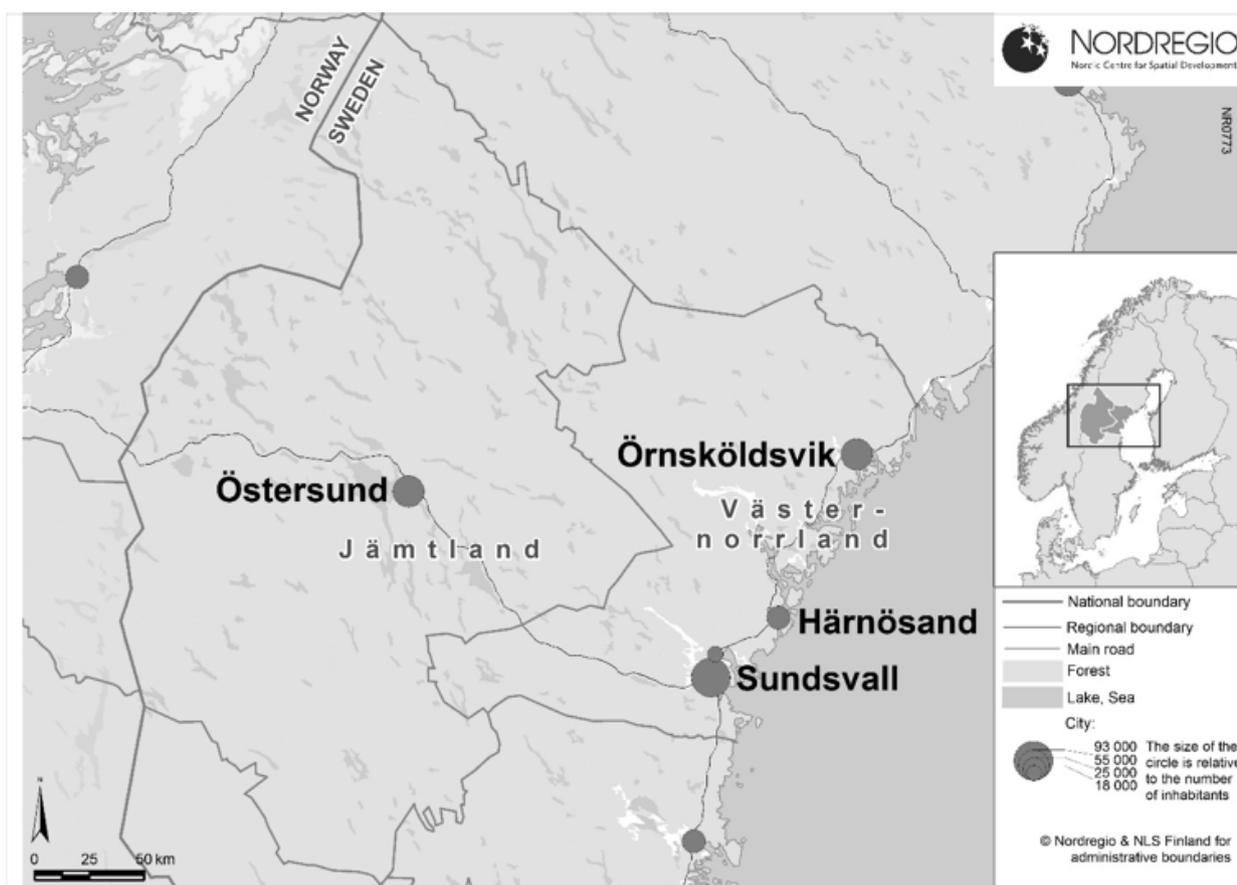
In Östersund municipality, low value biomass from the area is converted to heat and power by a municipal utility Jämtkraft. District heating here is almost entirely biomass-fuelled, making use of forest residues, wood chips, recycled construction wood, peat and bark that mainly comes from the

area near-by. The bioenergy value chains in Jämtland also include the production of wood pellets and vehicle gas from wastewater sludge at Göviken wastewater treatment plant in Östersund.

The local authorities have facilitated the expansion of the bioenergy sector through strong leadership and commitment to reducing greenhouse gas emissions, supporting fossil fuel free transportation (e.g. Green Highway initiative) and green public procurement practices.

## 2.2 Brief description of the case study area

Jämtland is a county in Sweden at NUTS3 level. It covers a total area of 34,009 km<sup>2</sup>, which is about



Map 1 Swedish case study area. Source: Nordregio 2016.

12% of the Swedish territory (Regionfakta, 2016). Jämtland is a predominantly rural county and is among the most sparsely populated regions in both Sweden and in the EU (OECD, 2012). The county was home to 127 376 people in 2015, which corresponds to about 1,5% of the population in Sweden (Regionfakta, 2016). Half of the population is concentrated in the municipality of Östersund having 61 066 inhabitants in 2015 (Ekonomifakta, 2014; Östersund municipality, 2016a).

More than 50% of the territory is covered with large boreal forests. The natural assets together with the mild climate provide good preconditions for forestry, agriculture, tourism and outdoor activities as well as for renewable energy production (Perjo, 2013). Forest based industries have a long tradition in the region, along with some mining (in the past) and hydropower although the county has no big industries. The primary sector employed about 6% of the population in 2014 which is three times higher than the national average (Regionfakta, 2015). Tourism industry (winter sports and recreation) contributes significantly to the regional economy with a turnover of about EUR 270 million (OECD, 2012). The unemployment rate in Östersund was 7.3% in 2015 which is slightly lower than the national average of 7.8% (Ekonomifakta, 2015).

### Infrastructure

Due to long distances and a sparsely populated settlement structure the region is highly car-dependent. Jämtland has among the longest average distance travelled per person per year in Sweden with a high consumption of vehicle fuel (Jämtland County Administrative Board, 2014a).

Two national highways (E14 and E45) and two train lines surpass the municipality of Östersund. The has an airport at Åre located about 11 km west of Östersund and 94 km east of Åre, mainly connecting Östersund to other regions in Sweden.

### 2.2.1 The forestry industry

Forest is the most important natural resource in the region in several ways. 4293 persons or 6,8 % of all employed in Jämtland were employed in silviculture in 2015. However, the forest sector does not include the whole value chain and therefore the forest is basis for a higher economic contribution. Biomass from forests is used for production of heat, electricity, pellets and other bio-fuels. An extensive share of the wood is exported from Jämtland unprocessed while a small share is processed in a few large and several small sawmills in the county. The raw material is mostly delivered to saw mills, but also to production of chipboard and biofuel (Jämtland County Administrative Board, 2012a; Perjo, 2013).

Most of the paper mills have been historically located in the neighbour county Västernorrland, which is bordering the coast and therefore has had better access to the market. Today there are no paper mills left in Jämtland. Due to lack of large forest industries the felling volumes are modest in Jämtland.

There is about 2 641 thousand ha of productive forest land in Jämtland and 841 000 ha unproductive forest land (Table 2). 1 567 ha is protected under habitat protection, 3188 ha under nature conservation agreements (Table 3) and 400 016 ha are designated Nature 2000 sites (Jämtland

**Table 1. Facts about Jämtland County and Östersund municipality**

	Jämtland County	Östersund municipality
Population (2014)	127 376	61 066
Total area	34,009 km <sup>2</sup>	2,221 km <sup>2</sup>
GRP per employed (2014)	SEK 733 000 (88% of national average)	
BRP per inhabitant (2014)	SEK 332 000 (82% of national average)	367 000 (90% of national average)
Median income, SEK (2014)	236 854	248 716
Employment rate		

Source: (Ekonomifakta, 2015; Regionfakta, 2016).

**Table 2. Area of land use classes of Swedish Forest Act (and FAO) in Jämtland, 2009–2013**

County	Forest land			Non-productive forest land			Other land	Total
	1000 hectares							
	Productive forest land	Unprod. Forest Land	Total	Unprod. forest land	Other wooded land	Total		
Jämtland	2 641	841	3 482	841	395	1 237	158	4 916

Source: (Swedish Forest Agency, 2014).

**Table 3. Forest protection in Jämtland.**

County	Productive forest land (ha)			Non-productive forest land (ha)	
	Habitat protection areas		Nature conservation agreements	Habitat protection areas	Nature conservation agreements
Jämtland	1 513		2 391	54	797

Source: (Swedish Forest Agency, 2014).

**Table 4 Area of productive forest land and non-productive forest land in Jämtland and ownership classes, 2009–2013 (excluding protected land).**

County	Productive forest land (1000 ha)				Non-productive forest land (1000 ha)			
	<b>Ownership class</b>							
	Private sector companies	Individual owners	Other owners	All classes	Private sector companies	Individual owners	Other owners	All classes
Jämtland	1 097	1 163	313	2 573	471	442	156	1 069

Source: (Swedish Forest Agency, 2014).

**Table 5. Number of forest owners (owned by single owners) and management units (owned by single owners) in Jämtland, year 2012.**

County	Forest owners (number)			Management units (number)			
	<b>Ownership class</b>						
	Female	Male	Total	Owned by non-resident	Partly owned by non-resident	Locally owned	Total
Jämtland	5 365	8 633	13 998	4 605	1 154	7 559	13 318

Source: (Swedish Forest Agency, 2014).

County Administrative Board, 2012b; Perjo, 2013). The total volume of felled timber in Jämtland for the period 2006–2008 was 6 474 000 m<sup>3</sup> annually which is the fourth highest in Sweden (Jämtland County Administrative Board, 2012b).

When it comes to the ownership structure, about 42% of productive forest land is owned by

the private-sector companies<sup>2</sup> and about 45% of forest is owned by the individual forest owners<sup>3</sup> in Jämtland. The remaining 12% and 5% is owned by

<sup>2</sup> Private-sector companies: company/corporation that is more than 50 percent privately owned, aktiebolag (Swedish Forest Agency, 2014).

<sup>3</sup> Individual owners: single owner, estates and small companies (sole trader) (Swedish Forest Agency, 2014)

other public and private owners, among those are foundations and funds, the Swedish Church etc. (Swedish Forest Agency, 2014). A very small share of forest land is state-owned (Table 4). There are about 14 000 private entrepreneurs in the forest industry in the county (Table 5). When it comes to gender distribution, nearly 40% of the private forest owners are women (Jämtland County Administrative Board, 2012a).

The forestry sector has undergone a major structural change over the past five decades. Due to optimized farming and management methods, cost-effective transport systems and the development of processing companies the profitability of forestry in the region has increased. The forestry sector employs considerably fewer people than before but the wood processing rate has increased. In Jämtland, forestry sector employs approximately 5% of the work force (Perjo, 2013). While the number of forest entrepreneurs is decreasing the companies are becoming larger in size.

The regional actors note that forestry has been and still is a core industry in the region and that there is a continuous interest among the young people in the industry. They also note that interest in the private forest ownership has not declined. Forest ownership has traditionally been a family business and passes on from generation to generation (interview 2015).

### 2.2.2 The energy situation

The local production of energy has become an important regional specialisation in Jämtland. Out of 12 TWh electricity produced about 10 TWh is exported from the region annually. The energy sector's share in GRP was 10.8% in 2012, which is the highest among other counties in Sweden (Regionfakta, 2016).

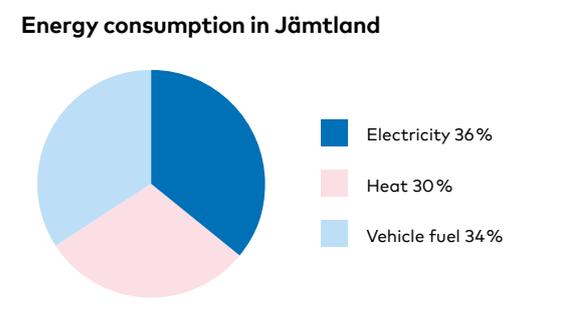
The largest share of electricity production in Jämtland (93%) is generated from hydropower (11.2 TWh in 2013). The county has 83 hydropower plants, of which three are located in Östersund municipality (Jämtland County Administrative Board, 2014c). The remaining 5% of electricity generation is based on wind power (0.6 TWh in 2014) and 2% is based on bioenergy (0.2 TWh) (Region Jämtland Härjedalen, 2015).

Wind power production capacity is 130 MW in Jämtland. In 2012, there were 118 wind turbines in Jämtland. According to the OECD study (2012), 38% of the areas of national interest when it comes to wind power generation are located in

**Table 6. Energy consumption in Jämtland County.**

<p><b>Electricity: 1.7 TWh</b>  <b>Fuel for heating: 1.3 TWh</b></p> <ul style="list-style-type: none"> <li>■ 92.5% renewables</li> <li>■ 2.5 % peat</li> <li>■ 5 % fossil fuel</li> </ul>	<p><b>Vehicle fuel: 1.6 TWh</b></p> <ul style="list-style-type: none"> <li>■ 1 % renewables (excl. low admixture of ethanol/biodiesel, electricity and train)</li> <li>■ Biogas produced at wastewater treatment plant in Östersund</li> </ul>
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*Adapted from: (Region Jämtland Härjedalen, 2015)*



Jämtland (OECD, 2012). Jämtland has a goal to produce 3 TWh of electricity from wind power by 2020 against 0.6 TWh in 2014 (Jämtland County Administrative Board, 2014a).

Total energy consumption in Jämtland is 4.6 TWh, of which 64% is renewable energy (see Table 4). Of the total electricity consumption in Jämtland, only 15.5% accounted for industrial use (2014). Jämtland is the county with the second lowest electricity consumption in Sweden, primarily due to lack of energy-intensive industries in the county (Regionfakta, 2014).

### 2.2.3 Bioenergy

The energy company Jämtkraft located in Östersund is one of the key energy producers in Jämtland. In 2002 the biomass-fuelled combined heat and power (CHP) plant was inaugurated. The CHP plant produces both electricity and heat and uses return wood, peat, forest residues and logging residues, such as branches and tops that mainly comes from the area around Östersund. A minor share of return wood is imported from Norway (interview, 2015). In 2014, 1% of oil was used at the CHP plant, while the remaining 99% were renewable sources. Today, bioenergy accounts for about 15% of total electricity produced at Jämtkraft.

SCA Skog and Skogsägarna Norrskog have been supplying logging residues to the CHP plant in Östersund and to some other energy companies in the area. About 55 tons of logging residues

have been used for bioenergy production in Jämtland until some years ago. Some logging residues have also been exported to district heating plants in Southern Sweden where it is possible to sell the wood residue for a higher price than it can be sold locally (OECD, 2011; Perjo, 2013). According to the estimations, up to 400 000 tonnes of logging residues could be removed in Jämtland per year, which is equivalent to 2 TWh (Jämtland County Administrative Board, 2012a). However, due to current low energy prices collecting and selling logging residues is not economically viable. Almost no energy crops are cultivated in the region today (OECD, 2011).

Östersund is one of Norrland's biogas pioneers. Biogas as a vehicle fuel is produced from wastewater sludge at Göviken wastewater treatment plant in Östersund which was established in 2007. Vehicle gas produced in Jämtland is 100% biogas and does not contain a mixture of fossil natural gas. In Östersund, there are approximately 300 vehicles running on biogas, one third of which are privately owned (interview 2015). It is estimated that the use of biogas as a vehicle fuel contributed to CO<sub>2</sub> equivalent emissions reduction by 1038 tons in 2012 (Perjo, 2013).

Small scale biogas plants on farms are quite widespread in the region and farmers are interested in participating in such development. There are in total 9 farm-based biogas plants in Jämtland built during 2010-2015, producing 5 GWh of electricity and heat, and using about 33 000 tons of manure (Region Jämtland Härjedalen, 2015). The production is still small compared to the biogas plants in the south of Sweden where more substrate is available.

## **2.3 The evolution of a local bioenergy market**

### **2.3.1 A historical perspective – key milestones**

People in the area have been using firewood to heat their homes for centuries. Since the establishment of Jämtkraft in 1889 the firewood has been used for electricity production in Östersund municipality. Later on the biofuels have been replaced with oil heating and the county council had oil-fired central heating in 84% of its premises in the 1970s.

District heating has undergone a strong expansion in Sweden in the 1960s and 1970s with the purpose of improving air quality and reduction of air emissions from individual furnaces and boilers. Since

the beginning of 1980s oil boilers have been gradually converted to wood-fuelled biomass boilers.

In the aftermath of the oil crisis in 1973 the state took action to support the diversification of energy sources. As a rather cheap energy source forest biomass has been particularly appreciated. The municipalities across Sweden have performed assessments and evaluation studies on the potentials of local bioenergy production and have extensively supported building up the district heating systems. The use of biomass for energy production has been facilitated through availability of local resources and their low cost, and prompted by increased taxes on oil consumption and the introduction of the CO<sub>2</sub> tax. The development of bioenergy was one of the strategic priorities following the decision on nuclear power phase-out in 1980.

Since the late 1980s the district heating in Östersund relies almost entirely on renewable sources. In 2002 the biomass-fuelled CHP plant was inaugurated, which has been prompted by increased electricity prices and the introduction of the Swedish scheme for tradable renewable electricity certificates in 2003 (OECD, 2012).

### **2.3.2 The role of different actors and their goals**

The role of local political and individual leadership for bioenergy development has also been important in the context of Östersund municipality. While the bioenergy development is largely influenced by the national agenda and EU policies, which indicate the top-down processes, the lower levels of governance have important responsibilities and role in steering bioenergy development. The regional and local governments develop their own agenda linked to the national and EU objectives. They use 'soft' forms of regulation i.e. non-binding municipal and regional strategies, which are often more ambitious than the national strategies and targets.

#### **2.3.2.1 Östersund municipal government**

The municipality of Östersund is among the pioneers in Sweden when it comes to climate work. Strong leadership and commitment among the local politicians to reducing greenhouse gas (GHG) emissions and supporting fossil fuel free transportation have facilitated the development of the bioenergy sector in Östersund (interview 2015). Östersund municipality was nominated as Swe-

den's best climate municipality in 2010 by the Swedish Society for Nature Conservation (The city of Östersund, 2011).

Östersund municipality's climate goal is to reduce the GHG emissions by 60% between 1990 and 2020. A 48% reduction has already been achieved and the main focus for the next years is on greening the transport sector. In Jämtland, the transport sector accounts for 67% of all GHG emissions (2011) (Region Jämtland Härjedalen, 2015). The transport sector is lagging behind in terms of renewable fuels use and is still highly dependent on fossil fuels (County Administrative Board Västernorrland, 2013). Östersund municipality is committed to making the transport sector in the municipality fossil fuel independent by 2030. The actions to achieve this include a greater admixture of biofuels in fossil fuels and increased use of liquid biofuels, through for instance Green Highway initiative.

Östersund municipality has been actively working with a public procurement tool for promoting the use of green vehicles (see more 3.1.3). The municipal council requires that all new vehicles purchased by the municipal units to be electric, biogas or ethanol fuelled cars. Today, the municipal vehicle fleet consists of 41 chargeable, 130 biogas and 50 ethanol cars (Region Jämtland Härjedalen, 2015; interview 2015).

Ethanol-run buses have been promoted through public procurement. There are seven buses in the municipality run on ethanol and 23 buses are using RME biodiesel. In setting up the transportation service contracts the municipal government demands the contractors to use 80% of renewable transport fuels and 50% biogas. Biofuels use is also promoted in procuring food delivery service to school canteens.

First electric taxis are starting to emerge (interview 2015). The municipal government is also planning to replace the gas tanks at the filling station for trucks in the municipality with Hydro-treated Vegetable Oil (HVO) tanks (synthetic diesel) (interview 2015).

Free parking, and later on reduced parking fees for green vehicles, have been among the support instruments used by the local authorities in driving the demand for green cars. Since 2014 a reduced parking fee for green vehicles has been abolished as the supreme administrative court found this exemption illegal. Currently, the exemption from

parking fees only applies to electric cars and plug-in hybrid vehicles (Rudeklint, 2016).

The municipality of Östersund is among 35 municipalities in Sweden that are members of Climate municipalities network (Klimatkommunerna), which demonstrates its high ambition level and leading role in local climate change initiatives. The network aims to influence national policies and plans on i.e. energy issues, and "to show the great strength in local action taken by the cities and regions" thereby contributing to national policy development from bottom-up (Klimatkommunerna, 2015). At the regional level, Region Jämtland Härjedalen is involved in lobbying efforts regarding i.e. biofuels issues through participation in Europaforum Norra Sverige which is a representation of the four northernmost Swedish counties in Brussels (Europaforum 2015) (interview 2015).

### Green Highway initiative

The Green Highway initiative has become a trademark of the region. It promotes fossil fuel free transportation and aims at boosting investments in green technology. It has been initiated as one of the measures to reach the target set by the government that there should be 150 000 electric cars in Sweden by 2020.

The Green Highway transport corridor is a 450 km highway, which is part of the E14 road connecting Östersund and Sundsvall in Sweden and Trondheim in Norway.2015).

The project was funded by the EU Interreg Sweden-Norway programme and supported by the Trans-European Transport Networks (TEN-T). The highway is specifically designed for 'green vehicles' with charging stations for electric cars along the road and renewable fuels (biogas, ethanol and rapeseed diesel). The Green Highway also has testing facilities for 'green vehicles' (OECD, 2012; Tepecik Diş, 2012). The project also aims at increasing awareness of sustainable transport solutions through informational campaigns and other initiatives.

The Green Highway is a cross-border initiative driven by the municipality of Östersund together with Sundsvall and Trondheim with Jämtkraft, Sundsvall Energy and several other municipalities among the partners. Jämtkraft, Sundsvall El-nät and Mittuniversitetet have invested SEK 16.6 million in charging infrastructure (Svensk Energi, 2013). Another SEK 7.4 million comes from the

Swedish Energy Agency (Energimyndigheten).

In total, there are 13 electric vehicle rapid chargers and 209 electric vehicle charging points built along the Green Highway until today of which more than 80 electric vehicle charging points is located in Östersund municipality (table 6). Jämtland County has among the highest number of electric vehicle charging outlets per capita in Sweden. In total, there were 158 electric vehicle charging outlets and 51 charging stations in Jämtland in 2016 (Region Jämtland Härjedalen, 2015).

There has been a fast increase in the use of green vehicles in Östersund, from 47 in the beginning of 2014 to 165 in the end of 2015 (table 6).

Mid Sweden University (Mittuniversitet) has been involved in the Green Highway project by performing a study on the societal and individual attitudes to the infrastructure for the electric vehicles, as well as the overall influence of the 'green corridor' on the region, including the environmental, social and economic impacts (Svensk Energi, 2013; interview, 2015).

**Table 7. Number of chargeable vehicles (electric cars and plug-in hybrid electric vehicles (PHEV) in Östersund municipality and Jämtland County.**

Date	Östersund municipality	Jämtland County
2014-01-01	47	59
2014-07-31	77	104
2014-12-31	88	120
2015-07-31	127	194
2015-12-31	165	251

Source: (Östersund municipality, 2016b).

In the current phase of the project (2015-2018) the focus is on developing the Liquefied Biogas (LBG), on promoting electric transportation and hydrogen-fuel cells, and establishing a Sustainable Business Hub. Biokraft in Trondheim, Norway, is building the largest production plant for LBG in northern Europe which is planned to be operational in 2017. The raw materials for this biogas production will come from waste and by-products from industry, including aquaculture and forestry. Biogas production capacity is about 25 million Nm<sup>3</sup> per year (Biokraft, 2016; Green Highway, 2016). LBG can be used as a fuel in heavy vehicles, which would contribute to making the next major step in reducing the dependency of the transport

sector in the municipalities along the Green Highway on fossil fuels (Region Jämtland Härjedalen, 2015).

Among the challenges for further development of infrastructure for green vehicles in the Green Highway area is a limited financial support available for comprehensive road networks. The Green Highway which is part of the European comprehensive route E14 is not eligible for TEN-T co-funding (interview 2015).

### 2.3.2.2 Region Jämtland Härjedalen

Region Jämtland Härjedalen was formed when Jämtland's Regional Council, the County Council and some departments of Jämtland's County Administrative Board were merged on 1 January 2015. Its task is to coordinate and make the regional development work in the county more efficient. Region Jämtland Härjedalen works with a broad range of issues, including assistance and support in developing new business ideas, facilitating knowledge transfer, and taking decision on how national funding for regional development is used and working with applications for grants from the EU structural funds (interview 2015).

Region Jämtland Härjedalen works also with energy issues and manages an Energy Agency (Energikontoret Region Jämtland Härjedalen). The Energy Agency works on behalf of municipalities in the county and the Swedish Energy Agency. It runs several projects and initiatives, e.g. providing advice to private persons and businesses on energy efficiency and renewable energy issues. It ran a project on small scale electricity production encouraging the residents to produce their own electricity. Region Jämtland Härjedalen has also financed smaller research projects, such as a feasibility study on small-scale sanitation and pasteurization of slaughter house waste and fish waste (interview 2015). It has also facilitated knowledge transfer on small scale biogas production by organizing thematic seminars and bringing together farmers, dairy companies, energy companies and fish companies (Region Jämtland Härjedalen, 2015). The region cooperates with Mid Sweden University and Umeå University and is part of an R&D-lab for industrial and business development in Jämtland. Tests in the biogas lab included, for instance, mixing cow manure with whey permeate, fish- and slaughter house waste, silage liquid etc. in order to improve its qualities (interview 2015; Region Jämtland Härjedalen, 2015).

The region is trying to influence the policies at the national and EU level regarding the issues that are relevant for them, such as the use of forest biomass for biofuels production. The region cooperates with Europaforum Norra Sverige which is a co-operation among four northern counties in Sweden aiming at influencing politics at an EU level (Europaforum, 2015). At the regional level, Region Jämtland Härjedalen has been lobbying for replacing the fossil fuels in the public transport in the county with HVO renewable diesel (interview 2015).

### 2.3.2.3 Jämtkraft – the municipal energy company

The municipal energy company Jämtkraft AB plays a key role in active development of bioenergy in the region. It is owned by three municipalities (Östersund (98%), Krokoms (1%) and Åre (1%) and provides cheap electricity and heat, a resilient and evolving grid, district heating and other services such as broadband.

Hydropower represents the main share of power supply by Jämtkraft. In 2014 Jämtkraft produced approximately 1 163 GWh electricity, of which 75% accounted for hydropower produced at 17 hydro-electric plants, 15% to bioenergy and 10% to wind power, and about 675 GWh of heat (Jämtkraft, 2015; interview 2015).

In 2002 a CHP-plant was inaugurated that is 99% fuelled by biomass Jämtkraft 2015a. The CHP-plant was a EUR 56 million investment. Today, about 90% of fuels used at a CHP plant in Lugnvik come from the nearby area. The main type of energy sources are forest residues (50%), industrial wood waste (30%), recycled construction wood (10%) and peat (10%). The remaining 10% is purchased from Norway (Jämtkraft, 2015a). The company has long term contracts with the forest associations regarding the forest biomass delivery (interview 2015). The resources are supplied by SCA Skog and SCA Norrbränslen, as well as by private forest owners who are paid by the energy content, not the volume of biomass. The CHP plant covers about 80% of the district heating needs in Östersund (600 GWh) and about 15% of the total electricity production (200 GWh).

Almost all residential houses are connected to the district heating in Östersund municipality. The municipality provides indirect support to Jämtkraft by facilitating expansion of the district heating system. The costs for the installation of the district heating pipes in new residential areas are added to the cost of the site when it is being

sold to the customers. Therefore Jämtkraft does not invest in the installation of the pipeline. While district heating is still the most preferred and reliable heating method in the municipality, there is a competition with electrically powered heat pumps (which are getting more and more efficient) and shallow drilling (interviews, 2015).

While the revenues of the company declined by more than three times from 2010 until 2015 as a result of declining demand for heating and losing the revenues from green certificates, the company still has positive economic outcomes (interviews, 2015).

Jämtkraft has also invested in infrastructure for green vehicles (charging stations and biogas filling stations) along the Green Highway since 2009. Jämtkraft has been supporting the popularization of electric cars in Jämtland since 2009. In the framework of the Green Highway project the company has built charging stations for electric cars with both Asian and EU standards. In addition, 186 charging points have been installed in Jämtland and Västernorrland in 2014 as part of the national charging infrastructure project 2014-2015 commissioned by the Swedish Energy Agency. The project was implemented by Jämtkraft in cooperation with Jämtkraft Elnät, Sundsvall Elnät and Mid Sweden University (Jämtkraft, 2014).

In 2015 Jämtkraft became a co-owner of a company CLEVER Sverige which offers fast charging stations to European electric vehicle charging

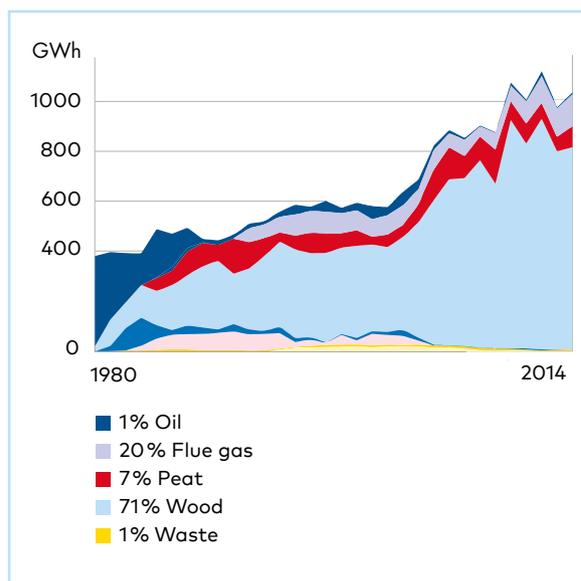


Figure 1. The fuel switch from fossil to biomass in Jämtkraft AB, 1980–2014. Source: Unpublished material provided by Jämtkraft AB

infrastructure. CLEVER is a leading electric mobility operator in Denmark (interview 2015).

Jämtkraft has also installed an accumulator tank Arctura which contains 26 million litres hot water in 2003. It increases production and delivery reliability while reduces emissions. It works as battery and is an important component of energy supply in the region (Jämtkraft, 2015b).

Due to a high concentration of heavy metals in the soil the spread of ashes from energy production is not allowed in Jämtland. However, Jämtkraft has a local agreement with the Board of Forestry (Skogsstyrelsen) according to which the company is allowed to spread the ash that comes from wood based biofuel, and not from any other biomass sources (interview 2015).

#### 2.3.2.4 Göviken – biogas production

At Göviken wastewater treatment plant, biogas as vehicle fuel is produced from sewage sludge since 2013. A biogas filling station is located nearby. The wastewater treatment plant treats wastewater from 65 000 person-equivalents. Out of approximately 1 000 000 m<sup>3</sup> of raw methane produced per year, about 600 000 m<sup>3</sup> is converted into vehicle fuel. The surplus is utilized at Jämtkraft CHP plant to generate heat and electricity. Vehicle fuel sales have been around 450 000 m<sup>3</sup> in 2013 which is enough for powering about 350 biogas cars (Jervidal, 2013).

Biogas that is produced in Östersund is 100% methane without any blending of natural gas. Prices on biogas in Östersund are among the lowest in the country (interview 2015). Fertilizers are not produced at Göviken wastewater treatment plant, as farmers are concerned with a high content of heavy metals. Due to lack of demand the excessive amount of biogas produced at nights

and on weekends has to be burnt. Transport of raw gas is so far not a viable solution as it is too expensive. Another challenge is the lack of storage for biogas, so if anything goes wrong with the plant the vehicles cannot be fuelled (interview 2015).

The biogas plant at Göviken is close to reaching its maximum production capacity. In order to provide vehicle fuel for more biogas cars in Östersund there is a need for investments in upgrading the plant (LTZ, 2012). It is stated in the Climate Strategy for Jämtland 2014-2020 that the county could become a producer of renewable vehicle fuels by increasing the production of biogas and producing synthetic diesel or methanol from wood, forest residues, agricultural and food waste. Construction of new facilities and pilot plants is encouraged in the strategy (Jämtland County Administrative Board, 2014a).

The political majority in Östersund municipality has taken a decision to develop a biogas strategy to promote biogas production and making sure that there is a market for it (LTZ, 2012). The strategy was adopted in 2012 and according to the strategy SEK 2 million was budgeted to upgrade the biogas plant at Göviken. It is also stated in the strategy that the municipality intends to support biogas use through public procurement in the public transport (Östersund municipality, 2012). The implementation of the strategy was postponed due to rapid changes on the market for electric vehicles. The local politicians are currently undecided whether they should continue supporting biogas or shift focus to the electric vehicles. It was decided to wait for a few years and observe the development at the EU level. The lack of strategic plan in the municipality when it comes to biogas use and new developments is seen as a major challenge today (interview 2015).

#### 2.3.2.5 Small-scale biogas production

Small-scale biogas production in Jämtland was facilitated by the Federation of Swedish Farmers (LRF) within the framework of 'Biogasaffärer på gården' project during 2010-2012. The investments in biogas plants at farm level were also made available during the Rural Development Programme 2007-2013 programming period. Some of the farm-based biogas plants in Jämtland received financial support covering 50% of the investment costs which made the construction possible.

In total, there are nine farm-based biogas

**Table 8 Environmental impact of Jämtkraft AB, 2014.**

Resource use	Emissions of GHG	Percentage of fossil fuels
Primary Energy Factor 0,17	Combustion  33 g CO <sub>2</sub> ekv/kWh	1%
	Transport and production of fuels 7 g CO <sub>2</sub> ekv/kWh	

Source (Svensk Fjärrvärme, 2014)

plants in Östersund area (2014) utilizing 33 000 tons of manure and producing 5 GWh of energy. The owners of the biogas facilities are entitled to receive electricity certificates for every MWh of renewable electricity produced from biogas (0.2 SEK/kWh). The pay-off time for the investments is approximately 15 years or 9 years with the production support (electricity certificates) (Region Jämtland Härjedalen, 2015).

Small-scale biogas production has been driven by an active local farmer Mats Gustavsson, who developed his own concept for a farm-based biogas plant and later established a biogas consultancy MMG Konsult. Most of the farm-based biogas plants in Jämtland were built using Mats Gustavsson's concept. His technological competencies and enthusiasm have been important factors driving the small-scale biogas development in Jämtland (Meurling, 2015).

#### **2.3.2.6 SCA Skog – forest company**

SCA (Svenska Cellulosa Aktiebolaget) is a global hygiene and forest products company. It was founded in 1929 as a pure forest company but today only about 20% of SCA's turnover come from the forest products (interview 2015). Since then it has evolved to a company that also offers personal care and tissue products (SCA Skog, 2011).

SCA Skog is the second largest private forest owner in Sweden after Sveaskog AB (Swedish Forest Agency, 2015) and is the largest private forest owner in Jämtland (interview 2015). Final felling by SCA Skog in Jämtland and Västernorrland is about 4 million m<sup>3</sup> per year, which includes felling of own forest and forest felling purchased from other private owners. SCA Skog employs about 900 persons in Jämtland and Västernorrland with many central and administrative functions located in Sundsvall. Another 500-1000 persons are employed as seasonal workers in tree care and maintenance and different planning works in the forests, as well as additional 2 000 employed in SCA forest industries (interview 2015).

SCA Skog in Jämtland is responsible for management of the SCA's forest holding comprising 791 000 hectares of land, of which 600 000 hectares are productive forest land. Care and harvesting is done entirely using contractors. SCA Skog also purchases logs from private forest owners in the area and provides services such as forestry plans, felling, thinning, silviculture and road

building to private forest owners in Jämtland. SCA Skog has a direct contact with forest owners in the region as a buyer of the logs. The company signs short-term contracts with the forest owners regarding felling and logging residues removal (SCA Skog, 2015; interview 2015).

SCA Skog in Jämtland also comprises a timber procurement unit and SCA Norrbränslen. SCA Skog's timber procurement unit is responsible for offering cost-efficient solutions for timber transport to SCA's units in northern Sweden. SCA Norrbränslen is one of Europe's largest suppliers of forest-based biofuels. In 2014 the production volume reached 3 TWh. SCA Norrbränslen utilizes both forest-based products such as fuel wood, logging residues, peat, as well as bio-residues from industrial processes, such as bark and sawdust from sawmills processed into pellets and briquettes (SCA Skog, 2015).

In Jämtland, SCA Skog delivers about 40 000 tonnes of logging residues annually to the CHP plant in Lugnvik and to Strömsund district heating boiler. SCA purchases a large share of logging residues from the private forest owners in the Östersund area. While SCA owns large forest areas in other parts of Jämtland County, the forest in Östersund area is primarily owned by smaller private forest owners. The closeness to the CHP plant reduces the transportation costs and it makes bio-energy production from logging residues economically feasible. The private forest owners do not get much revenue from selling the logging residues but there are some additional benefits from the forest management perspective (interview 2015).

In Jämtland, SCA invests about SEK 25 million per year in road infrastructure development in forests. In some remote areas in the county there are still gravel roads and it is impossible to drive with trucks.

SCA has its own research department at Mid Sweden University. The research interest is within the technological improvement of existing industrial processes.

SCA Skog is planning to double its production at Östrand pulp mill in Timrå municipality in Västernorrland from 430 000 tons to 900 000 tons annually by 2018, which would make it the largest pulp mill in Sweden and one of the largest worldwide. The investment cost is about SEK 7.8 billion (SCA Skog, 2016).

#### **2.3.2.7 Skogsägarna Norrskog – forest owners**



Figure 2. Area covered by Skogsägarna Norrskog is in light brown colour. Source: Norrskog, 2015.

#### association

Skogsägarna Norrskog is an economic association of forest owners in Jämtland, Medelpad, Ångermanland and southern Lapland. The association operates in a large forest area of approximately 3.8 million ha, which stands for about 16% of Sweden's productive forest area. The felling volume is about 12 million m<sup>3</sup> per year and the annual growth of forest is about 17 million m<sup>3</sup> per year. Some additional information is presented in the table below.

Skogsägarna Norrskog association consists of about 13 000 members, mainly family businesses, owning approximately 950 000 ha of forest. Additional 31 000 ha is in the ownership of the Association (Table 8). The association has 200 elected trustees. About 38% of forest owners of the association are women (interview 2015).

Skogsägarna Norrskog owns three sawmills, two of which are located in Jämtland and one in Västernorrland. Sawmills produce approximately

Table 9. Facts and figures about Skogsägarna Norrskog

Member forest area	960 000 ha
Own forest area	31 000 ha
Sawn timber	450 000 m <sup>3</sup> (70 % fir, 30 % pine)
Refined timber	120 000 m <sup>3</sup>
Turnover	2 billion SEK
Employed	287 persons (14% are women)
Sawmills /planning mills	5 industries
Members	13 000+ families ~ 50 000 persons
End customers	3 500
Transport	300 million SEK
Bioenergy production	620 GWh per year

Adapted from: Norrskog, 2015.

450 000 m<sup>3</sup> of timber per year. The products include panels, mouldings and furniture, window and door elements. The by-products from sawmills (e.g. wood chips) are then sold as raw material to the fibre manufacturing industry and to pulp- and paper industry (Skogsägarna Norrskog, 2015).

The organization also owns two planing mills located in Jämtland. The mills produce exterior panelling which are painted in the mill's own workshop and timber for construction of applications and impregnation.

The production of bioenergy by Skogsägarna Norrskog is about 620 GWh per year, which is being sold to the CHP plant in Östersund and to some other energy companies in the area. From 2002 until recently the organization was buying logging residues from the forest owners, but not since the energy price dropped significantly (interview 2015).

#### 2.3.2.8 Educational institutions

Jämtland offers relevant university education at Mid Sweden University (Mittuniversitetet) and conducts research in the environmental science and other relevant fields. The university has campuses in Härnösand, Sundsvall and Östersund. Campus Östersund was inaugurated in 2002 and the main educational focus at Campus Östersund lies within the social sciences, the natural sciences and technology. It has several programmes in the field of environmental technology and renewable

energy, social work, tourism and destination development and teacher training.

A range of Bachelor's Programmes are offered at the Campus Östersund, such as the Bachelor's Programme in Ecotechnology, in Eco-engineering, in Eco-entrepreneurship for sustainable development, in Mechanical Engineering. There is also the International Master's Programme in Ecotechnology and Sustainable Development (Mid Sweden University, 2016).

Mid Sweden University has research activities in the field of raw material from the forest and has an established co-operation with the regional actors. The university has also been involved in the Green Highway initiative by conducting a follow-up evaluation of the project and its contribution to the regional development. Although many large forest businesses in the region have their own R&D activities, some co-operation with Mid Sweden University also takes place. SCA for instance has its own research unit at Mid Sweden University.

## **2.4 The activities and measures carried out by the different actors**

### **2.4.1 Public support instruments**

#### **2.4.1.1 Energy prices**

Jämtkraft AB provides low cost electricity to its customers. In 2014, the electricity price was 70 cent/KWh in Östersund while the average electricity price in Jämtland County was 86.4 cent/KWh, including VAT tax (Jämtkraft, 2014). This is also about 15% lower than the national average. From 1 January 2016 electricity price was raised by 34 SEK/month for cottages and by about 7 SEK/month for apartments (Jämtkraft, 2015c).

Since 2015 Jämtkraft is no longer eligible to selling the renewable electricity certificates as the right to selling certificates has expired. Despite losing the revenues from sales, the company does not intend to raise the electricity price by more than 0.5% during 2016 and is aiming at a 0% increase in price during 2017 (Jämtkraft, 2014).

#### **2.4.1.2 EU and national investment support**

From the national authority level Sweden aims at becoming carbon neutral in 2045 and having a fossil fuel independent car-fleet by 2030. The expansion of bioenergy is a key component in achieving these goals. Also at the local level, the municipalities have been involved in facilitating the national efforts to meet EU targets regarding the transi-

tion to low carbon economy, and have contributed to building up the social acceptance and political legitimacy of bioenergy (McCormic et al., 2012).

Access to financing has played a central role in facilitating for development of the bioenergy sector in Östersund. Investment subsidies have been provided from two government-funded subsidy schemes:

- LIP: The Local Investment Programme (1998 – 2002)

- KLIMP: The Climate Investment Programme (2003–2008)

In total, the municipality of Östersund received SEK 73 million of investment support through the LIP and the Klimp programme combined.

District heating projects have been an important element in the awarded LIP grants. The municipality of Östersund completed 12 LIP projects supporting the extension of district heating lines, improved energy efficiency in municipal buildings, information and training for tenants (Carbourn Climate Registry, 2012).

The idea of Klimp was to encourage long-term investments that reduce environmental and climate impact and strengthen local involvement and local initiatives in climate work. The programme has mainly been used for physical investment. The municipality of Östersund has 23 completed projects with Klimp funding, including biogas production as vehicle fuel, grants for new biogas vehicles, small-scale district heating, energy efficiency in municipal buildings, training in eco-driving, etc. About 70% of the construction costs of the biogas plant at Göviken sewerage plant were covered through a Klimp grant (interview 2015).

Despite an important contribution, Klimp has been criticised for low cost effectiveness and the limited added value (OECD, 2014; SEPA, 2013). The municipalities with already strong environmental profile have had higher chances to receive funding, which had also been criticised. According to the post-evaluations of Klimp up to 40% of projects that were financed would have occurred without Klimp support, which was also found true in case of Östersund municipality (Fjellström, 2015; SEPA, 2013).

Other national financing measures have also been used, including Vinnova financing (Sweden's innovation agency), the European Regional Development Fund (ERDF), Rural Development Pro-

gramme and Interreg programmes. For instance, the Federation of Swedish Farmers (LRF) offered help and consultancy for farmers interested in investing in biogas infrastructure in the framework of 'Biogasaffärer på gården' project during 2010-2012. The investments in biogas plants at a farm level were also provided under the Rural Development Programme 2007-2013 programming period.

#### 2.4.1.3 Regional instruments and strategies

At the local level, the municipality of Östersund has gradually incorporating environmental considerations into the procurement process. The idea behind green public procurement (GPP) is to use regulatory policies in order to promote greener solutions, boost innovation and create incentives for continuous improvement of the environmental performance of private sector companies (Wickenberg, 2004). Public procurement tool has been effectively used by the municipality of Östersund to support the use of green vehicles in the municipal vehicle fleet, as well as in other areas, such as delivery of school catering. The municipality has been gradually increasing the level of environmental requirements in public contracts (taxi, city buses) by placing demand on the use of biofuels and green vehicles (section 2.2.1) (interview 2015).

The regional development strategy for Jämtland county 2014–2030 Jämtland/Härjedalen 2030: innovative and attractive covers seven priority areas which are closely linked to the objectives of the EU 2020 Strategy: 1) smart growth in entrepreneurship, innovation, research and development; 2) smart growth in skills and knowledge development; 3) smart growth in resource efficiency and effectivity; 4) sustainable growth in tourism; 5) sustainable growth in infrastructure and community services; 6) social inclusion and healthy lifestyles, and 7) demographic opportunities (Region Jämtland Härjedalen, 2014).

Commercialisation of advanced biofuels for transportation is among the national priorities in Sweden, as the government has set a target of 'a fossil-fuel independent transport sector by 2030'. Emissions reduction within the transport sector and promotion of biofuels in transportation are among the key priorities in the 'Climate Change Strategy for Jämtland 2014-2020' coordinated by Jämtland County Administrative Board. The Strategy promotes the production of renewable fuels for vehicles based on forest resources, agricultural residues and waste (Jämtland County Ad-

ministrative Board, 2014a).

The 'Climate Change Strategy for Jämtland 2014–2020' aims at a fossil free economy by 2030, and at becoming a leading exporter of renewable energy. Among the goals for 2020 are:

- a 50% GHG emissions reduction against 1990 levels;
- a 30 % increase in energy efficiency against 1990 levels and
- an increased export of renewable energy by 25% against 2012 levels.

The objectives are to be achieved through sustainable public procurement, promoting sustainable consumption and production of renewable fuels, etc. (Jämtland County Administrative Board, 2014a; Region Jämtland Härjedalen, 2015).

Among the concrete targets in Jämtland's Climate Change Strategy 2014–2020 are:

- increased use of chargeable cars (5 000) by 2020;
- increased renewable mix in diesel (35% by 2020 compared to 5% biofuel concentration in 2011);
- increased biofuel mix in gasoline (20% by 2020 compared to 5% in 2011) (Jämtland County Administrative Board, 2014a).

It is also stated in the Strategy that along with increased use of forest resources for bioenergy and in bio-based industries, protecting the biodiversity should not be underestimated. Therefore forest biomass should be used as efficient as possible.

Development 2011–2020	1000 tonnes CO2-equiv
Total emissions 2011	878
10% decrease in transport	-59
5000 chargeable cars replacing fossil fuel cars	-25
10% more efficient vehicles	-50
35% mix of renewable in diesel	-85
20% mix of renewable in gasoline	-21
Reduced emissions in other sectors	-38
<b>Total reduction</b>	<b>-48%</b>

Figure 3 GHG emissions reduction and greening status of the transport sector 2011–2020.

Source: (Region Jämtland Härjedalen, 2015)

Agriculture is mentioned as a possible energy supplier in Jämtland in connection to the expansion of biogas production from manure and crop residues (Jämtland County Administrative Board, 2014a).

#### 2.4.1.4 Other economic instruments and regulations

The instruments deployed to support bioenergy production in Sweden include a quota system based on a certificate trading system and tax regulation mechanisms. Sweden introduced a green tax reform in 1991, followed by the introduction of a CO<sub>2</sub>-tax (Nilsson et al., 2004; RES LEGAL, 2014; Söderberg, 2014). Together with the energy tax on fossil fuels, the instruments increased the demand for bioenergy.

#### Electricity certificate system

The electricity certificate is a market-based support system for electricity production from production from renewable energy sources and peat which has played a key role in encouraging the expansion of bioenergy production and making it more cost-efficient. The system was introduced in 2003 and was intended to replace earlier public grants and subsidy systems. Jämtkraft has been receiving electricity certificates for renewable electricity produced at the CHP plant at Lugnvik for the past 10 years. In 2010 Jämtkraft received SEK 137 million for selling electricity and extra income of SEK 59 million due to the electricity certificates (Figure 4). The electricity certificates are sold in a market where supply and demand de-

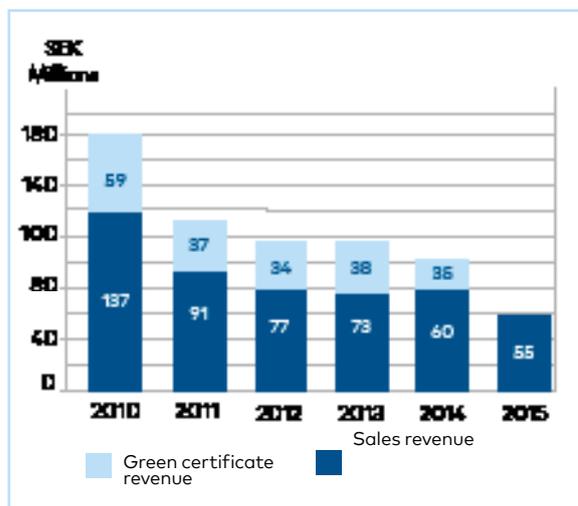


Figure 4 Revenues of Jämtkraft from green certificates and sales, 2010–15. SEK million. Source: Unpublished material provided by Jämtkraft.

termine the price (Swedish Energy Agency, 2012; Östersund municipality, 2009). Over the past few years the electricity price has dropped and the renewable electricity certificates went down in value from SEK 97 million to SEK 50 million. The right to receive certificates is time limited and from the end of 2014 Jämtkraft is no longer entitled to receive certificates. This had a dramatic effect on the economic situation at Jämtkraft (Figure 4).

#### Tax exemptions

A tax on carbon dioxide emissions was introduced in Sweden in 1991 as a complement to the existing energy tax on fossil fuels. Sweden has one of the highest CO<sub>2</sub> taxes in the world (International Energy Agency, 2013).

### BOX 1. THE ELECTRICITY CERTIFICATE SYSTEM EXPLAINED

“For every MWh of electricity produced by an approved facility from a renewable energy source, the owner of the facility receives an electricity certificate that then has a resale value. The buyers of electricity certificates are organisations that have what is known as a quota obligation. These are electricity suppliers and certain electricity users who are obliged to buy a certain proportion of electricity certificates in relation to their electricity sales or electricity use. The size of this proportion is set through a percentage rate (quota) for each year” (Swedish Energy Agency, 2015).

### BOX 2. BIODIESEL IN THE SWEDISH MARKET: FAME AND HVO

- FAME is usually produced from rapeseed oil in Sweden. The use of low-admixture FAME has increased since 2005. High-admixture FAME is known as B100.
- HVO is mainly produced from slaughterhouse waste, crude tall oil and palm oil. Appeared on the Swedish market in 2011. In 2013 it was the most widely used transport biofuel in Sweden accounting for 36% of all transport biofuels (Swedish Energy Agency, 2015).

Energy and CO<sub>2</sub> taxes are levied on the supply, import and production of fossil fuels for heating purposes while renewable energy sources are exempt from these taxes (RES LEGAL, 2014). Neither energy nor carbon tax is imposed on fuels used for electricity generation. Carbon tax is believed to have boosted the use of biomass in the Swedish district heating systems, and encouraged the development of new methods for utilizing wood fuels. In order to promote greening initiatives, the environmental taxes have repeatedly been altered since the year 2000 (International Energy Agency, 2013).

Heat production in CHP has tax incentives, currently with a 30% energy tax and 7% CO<sub>2</sub> tax, while other heat plants are taxed with a 100% energy tax and a 94% CO<sub>2</sub> tax. The use of renewable energy sources in transport is promoted through tax incentives and blending. Biofuels (including peat) have been a subject to full tax exemption in Sweden until recent years (International Energy Agency, 2013; NyTeknik, 2015a).

#### **Compulsory quota system for biofuels (blending)**

In 2014, a compulsory biofuel quota system aiming to increase the proportion of low-blended renewable fuels in petrol and diesel was introduced. Fuel companies are required to have a certain minimum percentage of renewable fuel in the gas and diesel they sell. The compulsory quota of renewable fuel is set to 9,5% for diesel and to 7% for gasoline (Gröna Bilister, 2013; UPI, 2013).

The EU Commission does not approve of the Swedish blending proposal because it considered the proposal to be State support which is redundant when there already is a CO<sub>2</sub> tax exemption. In order to avoid penalties imposed on Swedish companies, the Swedish government decreased the energy tax exemption for FAME from 1 January 2015: for low blends from 84% to 8% and B100 from 100% to 8% (Square Commodities, 2014) (Box 3). The present system has been extended to 2018 at which time a new solution will be proposed.

The municipal employees in Östersund claim that these measures considerably hit FAME competitiveness and affect both fuel producers, suppliers, vehicle manufacturers, transport companies and consumers (Lundin, 2015; interview 2015) (see section 3.2). The actors stress that it is crucial to continue supporting renewable fuels and green

### **BOX 3. NEW TAXES FOR BIOFUELS IN SWEDEN SINCE 1 JANUARY 2015**

“The energy tax on low-admixture ethanol was increased from 0.34 to 0.36 per litre, as a result of the energy tax on petrol being raised. The energy tax for low-admixture FAME was increased by SEK 1.4 per litre and amounted to SEK 1,686 per litre. High-admixture FAME, which previously had been fully tax exempt, was at the same time subjected to an energy tax of SEK 1,026 per litre. All biofuels remain fully exempt from carbon dioxide tax.

The Government proposes that the energy tax on low-admixture ethanol and E85 be raised from 1 December 2015 so as not to be in breach of the EU’s state aid rules. It is further proposed that the energy tax on petrol and fossil diesel be raised, which means additional increases for low-admixture ethanol and E85 as well as low- and high-admixture FAME, as these tax exemptions are based on the energy tax on the fossil counterpart. However, the Council on Legislation’s submission also proposes that the tax exemption for high-admixture FAME be increased from 46 to 50 per cent, while HVO, biogas, ED95 and other transport biofuels or biocomponents continue to be fully tax exempt.

It has been also proposed that the limit for the blending of ethanol in petrol and FAME in diesel – which is currently set at max 5 per cent – be abolished. This means that even FAME, which is blended in over 5 per cent by volume, will be subject to a tax reduction” (Swedish Energy Agency, 2015).

vehicles. They claim that tax incentives are some of the efficient measures that had proven to work. Extending Swedish tax exemption for renewable biofuels, including biogas and E84, is seen crucial by them for making the transition to a fossil fuel free transportation possible.

In the end of 2015 the European Commission approved Sweden’s request to continue exempt biofuels from tax until the end of 2018 and biogas until the end of 2020. During this period Sweden is expected to develop a proposal for long-term rules on taxation of renewable fuels which are in line with EU rules on free competition (F3 Centre, 2015; Mid Sweden European Office, 2015).

## 2.4.2 Possible barriers for bioenergy development

The interviewed actors agree anonymously that the technological barriers have been significantly diminished, and the main obstacles today for the bio-based industries are related to an uncertain framework at the EU and national level and low energy prices.

The uncertainty of EU regulations and in the attitude towards biofuels coupled with uncertainties and a lack of clear strategies and action plans at national level are deterring investors, so that the sector is facing slowing down in development. For instance, the forest owners' association Skogsägarna Norrskog claimed that they would be interested in producing transport biofuels if there was a stable and long-term regulatory framework for biofuels in the EU (interview 2015).

Another important barrier that has been argued by the municipal authorities in Östersund and the regional authorities in Jämtland is a frail biomass market and incoherent support for technological solutions. Regarding the latter, there has been a rapid increase in the interest in electric and fuel cell vehicles, which questions the role of biofuels in future. This changed interest has affected the local authorities now finding themselves unable to take decisions on transport solutions.

For instance, the local politicians in Östersund municipality have been in favour of biogas development for several years and followed up in the local biogas strategy, until the EU started actively promoting electric vehicles as a result of a fast technological breakthrough. This left the local government in Östersund indecisive about the best technological choice and development priorities (interview 2015).

Moreover, low energy prices have affected Jämtkraft AB and Skogsägarna Norrskog. Due to current low energy prices collecting and selling logging residues became economically non-viable (interviews 2015).

When it comes to other barriers, the utility Jämtkraft AB noted that the energy production is highly weather-dependent, as the CHP plant is controlled by heat demand. While in 2010 Jämtkraft produced about 240 GWh of electricity, in recent years the production of electricity declined to 190 GWh due to warmer winters (interview 2015). Due to these factors the CHP plant was closed down two weeks earlier and reopened two weeks later this year.

For Jämtkraft AB, a challenge for the expansion of the activities is inherent within the municipal regulation that limits the municipally owned energy companies from selling their services outside the municipality. Due to these regulations Jämtkraft is not allowed to provide district heating or broadband services in other parts of Sweden, outside the three municipalities in Jämtland, which is currently an issue of conflict (interview 2015).

Finally, Jämtland's remote location with no access to coastal areas and a long distance from the market can be considered as a limiting factor for growth of the bio-based or other industries, especially when it comes to setting up a large industrial production (interview 2015). From the geographical perspective a neighbouring Västernorrland region is in a more favourable position. Sparse settlement structure, long travel distances and uneven supply of substrate also affect the biogas production.

### Conflicts of interest

There are a many uses of forest biomass such as paper based products, sawn wood products and solid fuels, as well as new innovative materials, liquid and gaseous fuels. Moreover, non-material uses of forest include ecosystem services such as, biodiversity, fishing, hunting, recreation, berry picking etc. (Höglund et al., 2013). Competition for the use of forest biomass may take place between different uses and the related interest groups.

It is pointed out in the Climate Change Strategy for Jämtland 2014-2020 that in the process of out-phasing the fossil fuels the demand for forest biomass for energy production is growing, which may imply more intensive forest management and require new harvesting methods. This may in turn have negative impact the biodiversity, social values, cultural heritage and tourism of the forest (Jämtland County Administrative Board, 2014a).

The municipal employee in Östersund municipality pointed out that conflicts of interest have been fairly rare in the area. A debated issue in Östersund municipality today is biogas production – about where more biogas should be produced? The opposition group, including some residents, has been against investment in a joint biogas plant in Sundsvall municipality, arguing that local development should be prioritised. Östersund has historically provided raw materials to the industries in Sundsvall and the local population has not been in favour of such development. They lobby for local utilization of food waste or for development

of a peat digestion facility in Östersund, in order to provide new jobs. The main problem is however a lack of substrate in the municipality for feeding a potential local biogas plant, which has been the main reason for seeking cooperation with Sundsvall by the municipal authorities (interview 2015).

According to Region Jämtland Härjedalen, some conflicts between the forestry industries and the environmental organizations have been observed in the region. The discussion mainly takes place between the interest organizations and a few individuals, whereas no conflicts among authorities have been observed so far (interview 2015).

Some negative attitudes among the local population have been expressed in connection with import of return wood from abroad. The local inhabitants have been sceptical to this development as they would like to support local entrepreneurs (interview 2015).

## **2.5 Bioenergy and the community**

### **2.5.1 Cooperation, competence and knowledge**

The interviewed authorities from the regional administration and the energy utility in Jämtland claim that the presence of the Mid Sweden University has a positive impact on the competence level in the field of forestry in the region. However, it was also mentioned by them that far more important factors in driving the bio-based development in the region have been a strong tradition in the forestry industry and available knowledge and technology (interviews, 2015).

Besides the university, there are several other actors in the region that contribute to competence development and knowledge-building in the field of bioenergy and bio-based development through networking and organizing seminars and trainings, such as Region Jämtland Härjedalen, BioFuel Region and the Federation of Swedish Farmers (LRF).

None of the interviewed actors identified that there are significant labour-related challenges in the forestry sector today, both when it comes to highly-qualified and low-skilled labour in the region. The interviewees note, however, that despite the acquired knowledge base in the field of forestry, the biggest challenge is to attract the people with technical university education to remote and rural areas. The forest company and the regional administration representatives noted that

attracting and retaining people to perform low-skilled jobs, such as driving machines in the forest, may also become a challenge in future (interviews 2015).

### **Cooperation in small-scale biogas production**

Mats Gustavsson (a biogas consultant) has arranged a series of knowledge building and knowledge exchange events both for the local farmers interested in biogas and for the owners of the farm-based biogas plants. The technological issues, but also legislation and regulations, as well as the possibilities for joint projects development have been discussed at the meetings (Meurling, 2015).

The biogas consultant also runs a Facebook group which is being used to discuss technical problems and questions related to biogas production. The cooperation between Mats Gustavsson and other nine farm-based biogas plants owners has so far been informal. It has also been stressed by both farmers and the consultant that the informal cooperation structure enables building of trust and provides flexibility in collaboration. Communication is however affected by long travel distances and for example spontaneous meetings between the participants are difficult to organize (Meurling, 2015).

### **2.5.2 The embeddedness of bioenergy**

According to the forest owners' association, forest company and the energy utility, there has been a high community acceptance and pride of local achievements in bioenergy development in Jämtland which has been explained by a historical presence of the forest industries and the important role that the industries have played in the employment in the area (interviews 2016). It is difficult to measure but the municipal employee in Östersund and the energy utility indicated that the consumers in Östersund are more willing to pay for energy from local sources (interviews 2015).

A high level of embeddedness of bioenergy in the local community could also be attributed to among other to proactive work with sustainability issues by the municipal and regional authorities over a long period of time, e.g. through setting ambitious climate targets. At the organizational level, the Jämtkraft AB pursues a sustainable development agenda, including social objectives far beyond delivering cheap heat to their customers and returns on capital to their owners.

### **2.5.3 Gender and forest industry**

There is a space for improvement of gender equality in the forestry industries (County Administrative Board of Västerbotten, 2012). Traditional forestry, forest industry and heat generation is often men's work, but with modern machinery and work processes, there is no reason for continuing such a marginalisation in the future. In order to meet the future challenges of the forestry sector with regard to increasing demand for labour and various competencies in transition to the bio-based economy, and ensure its long-term socio-economic sustainability, promoting gender equality in the forestry sector has been an important issue on the political agenda, in the research field and among businesses concerned (Andersson, 2015). In response to this challenge the Swedish national gender equality strategy for the forestry sector 'Competitiveness requires equality' was launched by the Swedish Ministry for Rural Affairs in 2011 (Andersson, 2015). The region bordering Mid Sweden to the north (Västerbotten) was the first one in Sweden to develop a regional gender equality strategy for the forestry sector, seen as part of the efforts to strengthen the attractiveness of the region as a place to live and work (County Administrative Board of Västerbotten, 2012).

Forestry and energy companies in Jämtland have also been engaged in promoting gender equality, e.g. Skogsägarna Norrskog drives a network 'Norrskogs women' (Skogsägarna Norrskog 2016; Rolfsson, 2006) and Jämtkraft AB supports gender equality work by taking part in a leadership development programme for gender equality in energy industry called Qraftsamling. The work in Jämtland also encompasses awareness raising activities about forest issues among the population, e.g. by organizing forest camps for girls. The activities are moreover aiming at increasing attractiveness of the forestry sector as a field of work and study for women (Skogsstyrelsen, 2015).

### **2.5.4 The future of bioenergy**

The authorities at the Region Jämtland Härjedalen claim that there is much of unused potential for bioenergy expansion in the region. According to the OECD (2012) bioenergy production from forest biomass is expected to increase in Jämtland in the future (OECD, 2012).

It is also stated in the Climate Strategy for Jämtland 2014-2020 that growing energy crops on a smaller scale could be an alternative for farmers

willing to diversify their production. Using the agricultural residues and manure for biogas production also has a good potential in the region and can be increased. The production of vehicle gas from grass and manure is planned in future (Jämtland County Administrative Board, 2014a).

Moreover, the study commissioned by the Region Jämtland Härjedalen showed that there is about 10 000 tons/year whey permeate that can be used for biogas production, but also 70-500 tons/year of fish waste and 500-700 tons/year of slaughter house waste, 6-7 tons/year whey cheese, as well as grass silage, chicken manure, horse manure and fruit and vegetables from grocery stores (Region Jämtland Härjedalen, 2015).

While the local energy company and forestry industries are interested in diversifying their production and tapping opportunities in the emerging bioeconomy, they claim that investment climate is unfavourable at the moment due to uncertainties regarding the future of biofuels and a low oil price. The investment costs in bio-based industries are often are high, and therefore needs risk-taking entrepreneurs to start-up.

For instance, Jämtkraft AB claimed that the company is interested in developing new opportunities for forest biomass based value chains and innovations in bioenergy technologies. The company is particularly interested in innovative solutions which are less weather-dependent. However, starting large projects in the current unstable regulatory environment and considering low oil price was perceived rather risky (interview 2015).

According to Skogsägarna Norrskog, setting up large industrial businesses has no potential in Jämtland at the moment as it is highly costly and there is no market for the products. At the same time increasing the local processing of the forest resources by for instance strengthening the sawmill industry and planing could be more realistic and economically viable (interview 2015).

### **2.5.5 Conclusions and lessons learned**

Jämtland is characterized by presence of abundant forest resources and a long tradition in the forestry industry. There is a well-developed infrastructure in forests, expertise in logistics and good feedstock properties. The presence of district heating has created a large and stable demand for wood residue.

Bioenergy production has generally enjoyed a strong political support and backing by the mu-

municipal and regional authorities. In Östersund municipality, the development has been facilitated by ambitious climate change policies and targets and proactive municipal leadership. There is a high interest among the municipal and regional actors in tapping the new opportunities for utilizing forest- and waste-based biomass in the bioeconomy.

The success of bioenergy expansion in Jämtland can be attributed among other to a well-developed favourable public support and use of economic instruments such as a carbon dioxide tax, green electricity certificates, tax exemption for biofuels in transport, and direct investment support. Support for bioenergy started already in the 80s' when investment grants were given to convert boilers and heat plants from oil to other fuels, including biofuels (Andersson, 2012).

A wide range of actors and stakeholders are involved in bioenergy development in the region: municipalities and their local energy companies, forest owners associations, networks and knowledge institutions. A bottom-up approach based on the involvement of a broad range of stakeholders enabled the municipalities to seize their local opportunities and formulate agendas for development bioenergy.

Stable EU and national regulatory frameworks is a fundamental pillar for advancing the bio-based industries in Jämtland and Sweden in general, and is crucial for stimulating investors' confidence for commercial deployment of biofuels. The municipal employee in Östersund and the Region Jämtland Härjedalen stressed that there is a need for extra support to innovation and market development of biofuels and that tax incentives have proved to be effective measures.

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## Interviews

- Jämtkraft, Östersund, 9-06-2015 and 03-12-2015
- Jämtland County Government Administrative Board / Region Jämtland Härjedalen, Östersund, 9-06-2015
- Gövikens biogas plant, Östersund, 9-06-2015
- SCA Skog AB, Östersund, 23-10-2015
- Östersund municipality, Östersund, 03-12-2015
- Region Jämtland Härjedalen, Östersund, 03-12-2015
- Skogsägarna Norrskog, Östersund, 03-12-2015

## Annex 1. Transport biofuels explained (Swedish Energy Agency, 2015).

Transport biofuels	
Ethanol	E5, E85, ED95, ETBE
Biodiesel	B5, B100, RME, FAME, HVO
CNG	Collective name for methane gases: biogases, natural gas and mixtures thereof
Liquid biofuels	Biological oils: Rapeseed oil, palm oil, tall oil, waste oils, MFA, LBG
Other gaseous transport biofuels	DME
Fuel explanation	
FAME	Fatty acid methyl esters
HVO	Hydrotreated vegetable oils
ETBE	Ethyl tertiary butyl ether
DME	Dimethyl ether
RME	Rapeseed methyl ester
E5	95 per cent petrol and 5 per cent ethanol
E85	85 per cent ethanol and 15 per cent petrol (summertime) or 75 per cent ethanol and 25 per cent petrol (wintertime)
ED95	95 per cent ethanol plus ignition improver and an anti-corrosion agent
B5	Fuel consisting of 5 per cent biodiesel and 95 per cent diesel
B100	Pure biodiesel
MFA	Mixed fatty acids
LBG	Liquefied Biogas

# 3. The case of Västernorrland, Sweden

## By Anna Berlina

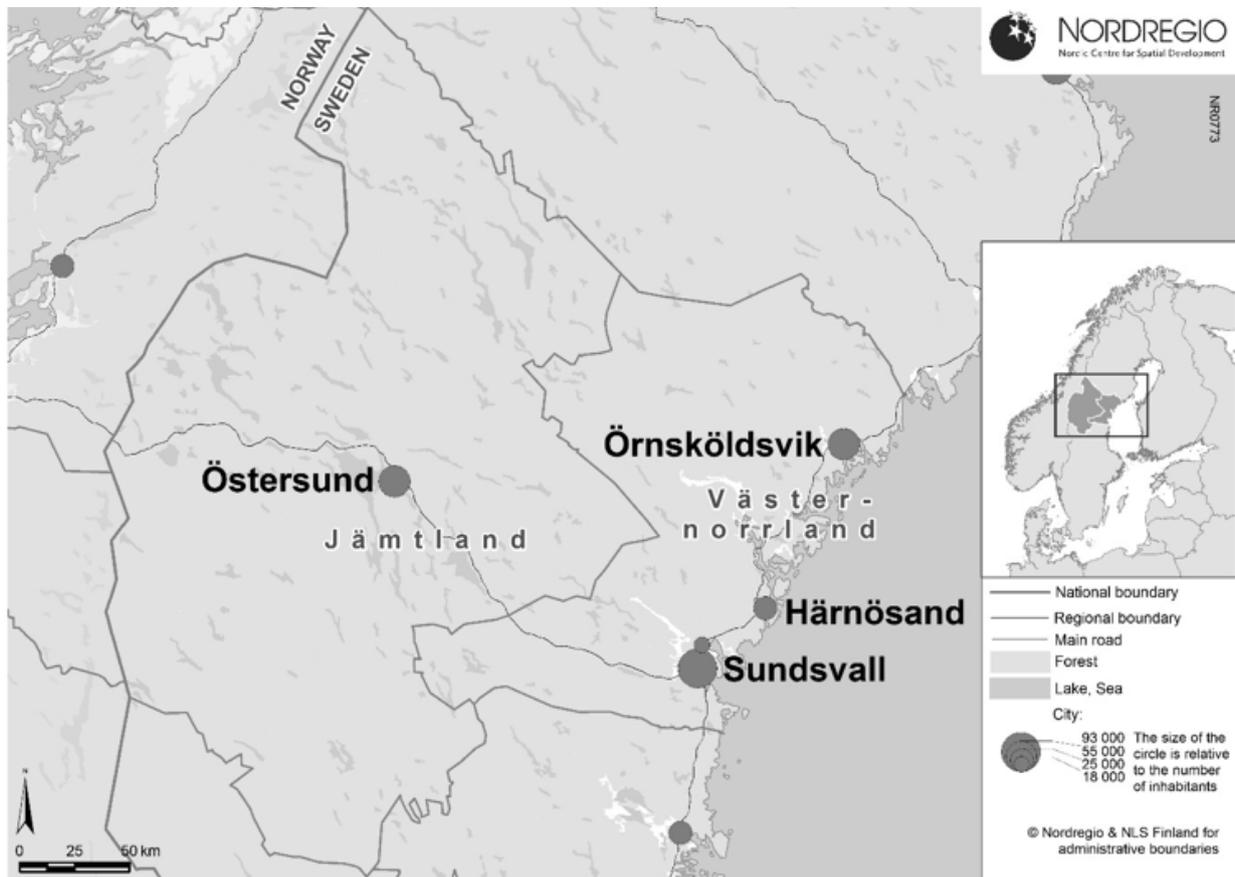
### 3.1 Introduction

Västernorrland's economy has its basis in raw materials extraction and processing. The county specializes in pulp and paper industry and has a high concentration of manufacturing and chemical industries. Forest based industries have a long tradition in the region, along with mining and hydro power production. Sundsvall city in Västernorrland was referred to as the Swedish "Gold Coast" in the 19th century attributed to the development of the sawmill industry.

There are 13 biogas plants in Västernorrland (2011), of which four are landfill plants and one is an industrial plant. Domsjö Fabriker AB in Örn-

sköldsvik is Sweden's largest biogas producer which uses biogas primarily for internal processes while the surplus is sent to Övik Energi's CHP plant. In Härnösand, biogas has been used in the district heating system since the 1994. Since 2014 biogas has also been produced from food waste and upgraded to vehicle gas.

The region has received international recognition due to its biorefinery activities in Örnköldsvik. Upgrading the pulp mill to a biorefinery in 2005 was coordinated by SP Processum in a close cooperation between the chemical, forest and paper industries at the industrial site, academic partners and the local government in a triple-helix set-up.



Map 1 The case study area. Map by Linus Rispling

### 3.2 Brief presentation of the case area

The county of Västernorrland is a semi-peripheral area in Europe that is sparsely populated and rich in natural resources. With its 244 000 residents (2016), the county is home to less than 2.5% of Sweden's population, but covers 5.3 % of the land area in Sweden. The population density is 11.2 inhabitants per square kilometre, which is half the national level. The coastal area and Sundsvall/Timrå have the highest population density (County Administrative Board of Västernorrland, 2011). The largest cities are Sundsvall, Örnsköldsvik and Härnösand. The majority of the territory is covered by large boreal forests (56%).

Just like other Northern regions, the urbanization is increasing in Västernorrland, which affects the demographic structure of the areas outside of the major city regions. Youth unemployment and outmigration, ageing population, a lagging state of health in sparsely populated areas are identified among the challenges for the county (County Administrative Board of Västernorrland, 2011).

In contrast to neighbouring Jämtland that is poorly industrialized, Västernorrland is home to industrialised cities Sundsvall and Örnsköldsvik which host sectors that are intensive in electricity use (paper mills and metal industries).

The county's economy has its basis in raw materials extraction and processing. Forest based industries have a long tradition in the region, along with mining and hydro power production. These export oriented industries continue to play an important role in the regional economy today. Västernorrland specializes in pulp and paper industry and has a high concentration of manufacturing and chemical industries. According to the Regional Strategy for Västernorrland 2011–2020, there is rather good diversification in economic activities, relatively low dependence on international companies and a high number of people working in knowledge intensive industries (County Administrative Board of Västernorrland, 2011).

The economic downturn in the Örnsköldsvik area in the 1990s resulted in loss of around 5 000 jobs in the region. Many local businesses were closed, downsized, or relocated to more central regions of Sweden. The regional decline created a sense of urgency among the local actors, who united their efforts to create new industries and jobs in the region. The focus has shifted towards clean tech and environmental solutions and activities based on the biorefinery initiative (Lindberg &

Teräs, 2014). An extensive mill area in Örnsköldsvik has been transformed and is now a leading example within green growth.

#### Infrastructure

Due to long distances and a dispersed settlement structure the region is highly car-dependent. Västernorrland has a high consumption of vehicle fuel and among the longest average distance travelled per person per year in Sweden. Long travel distances have traditionally represented a challenge for the labour market. In recent years due to improvement of the road infrastructure and development of transport communications, the commuting between Umeå-Sundsvall-Härnösand has become easier and more common (County Administrative Board of Västernorrland, 2011).

The regional actors have flagged the need for improving train infrastructure. The railway from Gävle-Sundsvall/Härnösand is experiencing problems with capacity and speed and a double track railway is needed for this rail line. The Central railway line/Meråker Line has undergone some improvements in order to take over a large flow of the E14's freight and passenger transport. There is also a need to improve the carrying capacity of the smaller inland roads particularly for use by heavy trucks transporting timber (County Administrative Board of Västernorrland, 2011). Other challenges include inefficient broadband capacity in some rural areas, limited access to capital and limited transmission of electricity.

#### 3.2.1 The forest industry

It is said that Sweden's forest industry started with a steam driven saw in Sundsvall, the administrative capital of Västernorrland, in 1840. In the 19th century the prosperity of the region was attributed to the development of the sawmill industry. Sundsvall became the first major industrial centre in Sweden and was referred to as the Swedish "Gold Coast". The region attracted entrepreneurs and skilled labour from Germany and other parts of Europe.

The BioBusiness Arena network claimed in the interview that there is a strong entrepreneurial spirit in Västernorrland that in combination with good access to natural resources enabled the development of the forestry sector in the region and have created a strong export industry (interviews 2015). In the past, there were 80 paper mills in Västernorrland, whereas today there is only one

paper and one pulp mill left (interview, 2015). Despite this fact, the forestry sector continues to play an important role in the economy of the region, now producing not only pulp but also biofuels, innovative bio-based products and biochemicals.

The forest, the wood and the pulp and paper industry together is the dominating export sector in Västernorrland, accounting for 62% of the export corresponding to a total value of SEK 24 billion and represents 12% of Sweden's total exports of forest products. Of all employed in the industry sector in the region, the forest industry stands for about 30% of employment, which is the highest share in Sweden (BioBusiness Arena, 2015). Silviculture employed 4428 persons or 3,8% of all employed in Västernorrland (SCB 2017).

Today, the forestry business sector in the region is dominated by big companies with many small companies in the supply chain. Among the large forest industries in the region are:

- Domsjö Fabriker AB
- The Husum Paper mill and Sulphate pulp mill which was founded in 1919 by Mo och Domsjö AB and was later acquired by Metsä Board of Finland (2000). It is among the main employers in Örn-sköldsvik municipality.
- SCA's Ortviken paper mill
- SCA's Östrand pulp mill
- SCA's Tunadal and Bollsta sawmills

Among the smaller forest industries in Västernorrland are Norrlands trä and SCA Bionorr.

There is 1672 000 ha of productive forest land in Västernorrland and about 186 000 ha of unproductive forest land (Table 1). 887 ha is protected under habitat protection, 1258 ha under nature conservation agreements (Table 2) and 64 682 ha are designated Natura sites (Swedish Forest Agency, 2014).

**Table 1. Area of land use classes of Swedish Forest Act (and FAO) in Västernorrland, 2009–2013**

County	Forest land			Non-productive forest land			Other land	Total
	1000 hectares							
	Productive forest land	Un-prod. Forest Land	Total	Un-prod. forest land	Other wooded land	Total		
Västernorrland	1 672	186	1 859	186	42	228	146	2 099

Source: (Swedish Forest Agency, 2014).

**Table 2. Forest protection in Västernorrland.**

County	Productive forest land (ha)		Non-productive forest land (ha)	
	Habitat protection areas	Nature conservation agreements	Habitat protection areas	Nature conservation agreements
Västernorrland	851	1 213	36	246

Source: (Swedish Forest Agency, 2014).

**Table 3. Area of productive forest land and non-productive forest land in Jämtland and ownership classes, 2009–2013 (excluding protected land).**

County	Productive forest land (1000 ha)			Non-productive forest land (1000 ha)				
	Ownership class							
	Private sector companies	Individual owners	Other owners	All classes	Private sector companies	Individual owners	Other owners	All classes
Västernorrland	910	652	94	1 656	162	103	7	272

Source: (Swedish Forest Agency, 2014).

**Table 4. Number of forest owners (owned by single owners) and management units (owned by single owners) in Västernorrland, year 2012.**

County	Forest owners (number)			Management units (number)			
	Female	Male	Total	Owned by non-resident	Partly owned by non-resident	Locally owned	Total
Västernorrland	6 573	10 241	16 814	2 969	813	9 661	13 443

Source: (Swedish Forest Agency, 2014)

When it comes to the ownership structure, about 55% of productive forest land is owned by private-sector companies<sup>4</sup> in Västernorrland. About 39% of forest is owned by individual forest owners<sup>5</sup> in Västernorrland. The remaining 12% and 5% is owned by other public and private owners, among those are foundations and funds, the Swedish Church etc. A very small share of forest land is state-owned (County Administrative Board of Västernorrland, 2013a). In Västernorrland, there are about 13 000 private entrepreneurs in the forest industry (Table 3). When it comes to gender distribution, nearly 40% of the private forest owners are women.

Mean annual volume increment on forest land is 5.05 m<sup>3</sup> per ha in Västernorrland (Swedish Forest Agency, 2014). According to the County Administrative Board of Västernorrland, taking into account the environmental considerations, it is possible to sustainably increase the felling by about 0.5 million m<sup>3</sup> per year (County Administrative Board of Västernorrland, 2013a).

The forest sector has undergone major structural change over the past decades. Due to optimized farming and logging methods, more cost-effective transport systems and development of processing companies the profitability of forestry in the region has increased. The structural changes also include a decrease in the number of forest entrepreneurs and an increase in the size of the companies. The forest companies interviewed have not observed a decline in the interest in the forest industry. The interviewees note that the interest in private forest ownership is still high today. Traditionally forest ownership has been a family business (interview 2016).

<sup>4</sup> Private-sector companies: company/corporation that is more than 50 percent privately owned, aktiebolag (Forest Statistics Yearbook 2014)  
<sup>5</sup> Individual owners: single owner, estates and small companies (sole trader) (Forest Statistics Yearbook 2014)

### 3.2.2 The energy situation

The region has a high demand for heating due to its northern location. Electricity consumption in Västernorrland is among the highest in Sweden with 10 149 TWh (2013) of which industrial electricity consumption is 7 690 GWh. Hydropower constitutes approximately 70% of the total yearly generation of electricity in the Jämtland and Västernorrland region, with a production capacity of 5 500 MW (25 TWh/year) (OECD, 2012).

Several biomass-fuelled combined heat and power (CHP) plants were inaugurated in the region in the beginning of 2000s allowing for production of both renewable electricity and heat through cogeneration. The CHP plants make use of forest residues, wood chips, recycled construction wood, peat and bark, as well as household waste (Sundsvall Energi). The feedstock is supplied by the near-by industries, and by private forest owners. The CHP plants and local district heating systems are managed by the local utilities owned by the municipal authorities. The key energy utilities in Västernorrland are Övik Energi, Sundsvall Energi and HEMAB.

The CHP plants utilize industrial waste heat from SCA Ortviken paper mill, SCA Östrand pulp mill and SCA Bionorr pellets factory which is fed into the local district heating system and enables to save primary energy and environmental benefits (Sundsvall Energy, 2016; Svensk Fjärrvärme, 2014).

There are 13 biogas plants in Västernorrland (2011), of which four are landfill plants and one is an industrial plant (County Administrative Board of Västernorrland, 2013b). Biogas for heat and electricity production takes place at Domsjö Fabriker AB in Örnsköldsvik and by HEMAB in the municipality of Härnösand, as well as at several farm-based biogas plants. Domsjö Fabriker AB has utilized the residual streams from the near-by chemical industries and from a pulp mill for biogas production since 1985. Domsjö Fabriker AB is Swe-

den's largest biogas producer which uses biogas primarily for internal processes while the surplus is sent to Övik Energi's CHP plant. In Härnösand, biogas has been based on landfill gas (3.5 GWh per year) which has been used in the district heating system since the 1994 (Nordqvist 2015). Small scale biogas plants on farms for heat and electricity production are widespread in the region and farmers are interested in participating in such development.

Örnsköldsvik area has more than hundred years of experience in sulphite ethanol production. Cellulosic ethanol is being produced by SEKAB (Swedish Ethanol Chemistry AB) and Domsjö Fabriker AB in Örnsköldsvik. The main substrate for ethanol production is pulp waste products from Domsjö Biorefinery. SEKAB produces ethanol based ED 95 fuel that can be used in diesel engines in heavy trucks.

### **3.3 The evolution of a local bioenergy market**

#### **3.3.1 A historical perspective – key milestones**

In the 1980s' oil-fuelled furnaces have been exchanged for wood-chip systems, which reduced heating costs and saved fossil fuel, particularly when the oil price was high (Andersson, 2012).

Despite the reduction in the number of sawmills in Västernorrland, the production volumes have increased due to improved efficiency in the processes. Thus the amount of by-products and residues from production continues to grow, which has triggered development of new forest based value chains. Forest products are today converted into wood-chips and firewood – and ultimately into heat. Since the 1990s' residues from the sawmills have been used for pellets production at SCA Energy. Process water from pulp mill and chemical industry is used for biogas production at Domsjö Fabriker while biorefinery and organic waste in Härnösand is used for biogas production as a vehicle fuel. In addition, biomass value chain includes green chemicals production from kraft pulp rest products containing lignin and ethanol at Biorefinery plant in Örnsköldsvik.

Several initiatives have been established, including the Green Highway fossil fuel free transport corridor from Sundsvall to Trondheim in Norway.

#### **3.3.2 The role of different actors and their goals**

##### **3.3.2.1 County administration board of Västernorrland**

The County Administrative Board of Västernorrland is located in Härnösand. The organization is responsible for coordinating and for supporting the regional development work in the county through providing support to businesses, ideas and initiatives, and facilitating networking activities. The County Administrative Board has a task to develop and coordinate the implementation of the regional development strategy and energy and climate strategies in Västernorrland.

As reflected by the regional authorities, Västernorrland region could benefit from increasing the use of green public procurement tool to promote 'greener' development (interview 2015). Härnösand is a good example in this regard, since the municipality promotes use of renewable fuels in transport through public procurement. The municipality has 100% renewable fuel in the public vehicle fleet, mainly using electric vehicles and HVO renewable diesel fuel (interview, 2016).

##### **3.3.2.2 HEMAB – Härnösand Energy and Environment AB**

HEMAB is a municipally owned company in Härnösand which provides district heating, waste management, recycling, soil treatment, water and sewage, electricity network, wind energy and biogas, broadband network and electricity distribution. The company is run as private company and is not supposed to run in deficit. It has about 125 employees and an annual turnover of about SEK 300 million (HEMAB, 2012).

HEMAB started to develop district heating in 1974. At first oil boilers was used which then later was connected and extended. Later on oil was substituted with forest resources. At that time a low price of biomass was the main driving factor behind changing from oil to biomass district heating (interview, 2016). Since 1999 waste heat from the pellets production plant has been used.

Today, about 95% of the housing properties in Härnösand are connected to the district heating and about 50% of the cottages. Other common heating sources used in the premises are heat pumps, oil, electric boilers and pellets. Although

small-scale district heating is not economically profitable for HEMAB, the company still offers this option. The return on investment for small-scale district heating for HEMAB is about 20 years.

A combined heat and power plant (CHP) was built in Härnösand in 2002 with financial support from the state. The resources fed into the HEMAB CHP plant are mainly wood chips, peat and bark coming from a radius of about 100 km. The company also purchases some rest products and bark from the SCA (interview, 2016). In 2013 and 2014 two new boilers were built. The CHP plant produces about 164 GWh district heating and 33 GWh of electricity (2014) (HEMAB, 2015).

In total, HEMAB produces about 55 GWh of electricity (wind power, CHP and solar) which corresponds to the electricity consumption of the municipality (HEMAB, 2016).

HEMAB owns a peat company Kommunbränsle i Ådalen together with Övik Energi. Peat accounts for about 20% of fuel used by HEMAB. The costs for peat equals other biofuels but adding peat to the fuel mix helps to protect the furnace from corrosion. HEMAB has been using waste heat from SCA Bionorr for the past 20-25 years. The price for waste heat differ from SEK 0 to 160 per MWh. When the electricity price is high HEMAB gets waste heat almost for free, and vice versa (interview, 2016).

Since 2008 HEMAB has aimed to maintain the energy prices to its customers. The aim is to provide the lowest energy price in Västernorrland and the company has succeeded in that until now. At the same time HEMAB aims to invest in providing good working environment and competitive salaries for their employees (interview, 2016).

**Table 5. Environmental impact, HEMAB, 2014**

Resource use	Emissions of GHG	Percentage of fossil fuels
Primary Energy Factor 0,12	Combustion 37 g CO2 ekv/kWh	0%
	Transport and production of fuels 8 g CO2 ekv/kWh	

Source (Svensk Fjärrvärme, 2014)

## GOALS WITHIN THE BIOGAS REFINERY PROJECT:

- Gradually substitute gas and diesel to vehicles run on electricity and biogas
- Production of approx 300 m3 biodiesel/year
- Expected reduction of CO2 is 900 tonnes/year
- Reduction of inceneration costs by 2/3, which results in SEK 1.5 million savings for the municipality.

### Biogas production at HEMAB

Since the 80s' biogas in the municipality has been produced based on landfill gas (3.5 GWh year) which has been burnt and sent to the district heating system. Since 2014 biogas has also been produced from food waste coming from the municipality of Härnösand and the neighbouring Sundsvall (interview, 2015).

The municipality was granted a SEK 15 million funding from the Swedish Energy Agency in 2013 to support completion of a small scale biogas refinery using dry fermentation digestion technology. The total cost of the project is about SEK 45 million. The biogas will be upgraded to vehicle gas using membrane technique, and then compressed and shipped to the gas fuelling station by the main road E4 (part of the Green Highway). The facility is expected to be operational in September 2016. 5000 tons/year of sewage sludge and food waste is fed into the plant, but the production capacity of the plant is higher if there is a demand. The investments are expected to be paid back in approximately 15-17 years (interview, 2015; interview, 2016).

The residues from the biogas production will be used at a landfill, as the final waste is inappropriate to use as a fertilizer due to remains of plastic left in the material (interview, 2015).

During the decision-making process HEMAB was considering other alternatives to vehicle fuel production, such as electricity production based on biogas. The evaluation showed that production of renewable vehicle fuel is more economically profitable and that the environmental benefits are higher (interview, 2016).

Härnösand municipality is a partner in the project *Biomethane and LNG in the North for growth and competitiveness in EU* (BioGaC) which has

been initiated by the BioFuel Region. The purpose of the project is to develop and evaluate a business model for easy and quick market establishment of vehicle gas. The further purpose is to increase supply and capacity of vehicle gas in Skellefteå and Sundsvall/Härnösand by improving the conditions for more vehicle gas establishments along the E4 and parts of the countryside.

For many years there have been ongoing discussions about building a large-scale biogas plant in Sundsvall in cooperation with Östersund. The biogas plant is planned to handle industrial bio sludge and organic waste and produce vehicle gas. Securing enough digestible material in the region is one of the main reasons for engaging several municipalities and local industries in a joint project. The council and the administration in Härnösand municipality have also been backing up the project but at the end it was decided to invest in an own and smaller facility in the municipality. The benefits of local production, small scale and the possibility to use its resources have been some of the driving factors. Local production has also been a preferred alternative for the residents of Härnösand due to the direct impact of waste recycling and own contributions and the economic values created (interview, 2016).

### Food waste recycling

During the period 2014–2016 the municipality and HEMAB are running food recycling project. After 2016, food waste recycling in the municipality will become mandatory for households, private companies and the public sector. To make recycling mandatory for everybody without a choice of not recycling food waste has been a strategic decision. The residents are provided with two alternatives: a) 8-10 sections recycling containers; b) 2 recycling containers for food waste and residual waste.

The trucks for collection of waste in the municipality are 100% biogas-powered. If waste is not sorted properly, the households may be charged a higher price, as in case of poor quality the waste must be sent to the incineration plant in Sundsvall (interview, 2015).

HEMAB finds their decision to making food recycling mandatory crucial for success, as it is important for them to be able to collect enough substrate for the new biogas plant, so that the investment becomes profitable. In the neighbouring Sundsvall food waste recycling is made voluntary. Today, both cities collect about the same volumes

of food waste, although Sundsvall has four times the population of Härnösand (interview, 2016).

### 3.3.2.3 SCA – Swedish cellulose company

SCA has several entities located in Västernorrland, including the headquarters of SCA Forest Products, SCA Timber and SCA Bionorr.

At Ortviken paper mill SCA has been producing Lightweight coated paper (LWC) since 1990s. LWC is a thin paper made from ground spruce pulpwood, reinforced with a small proportion of sulphite pulp to add strength. Ortviken Paper Mill is SCA's largest mill

SCA's Östrand pulp mill has 215 employees and is located in Timrå municipality, Västernorrland. SCA Östrand intends to double its production capacity from 430 000 to 900 000 tonnes and will in that case get the biggest production line for bleached sulphite pulp in the world. SCA has invested about SEK 7.8 billion in the upgrade of the factory. The new factory, which is planned to be inaugurated in October 2018, will become leading factory worldwide in terms of product quality, environment and competitiveness (SCA Skog, 2016).

The pulp mill produces bleached kraft paper that is used for manufacturing of publication papers and hygiene products, and also produces 95 000 tons of chemical thermo-mechanical pulping for hygiene, packaging and other products (SCA Skog, 2016).

Since 2013 both SCA Östrand and Ortviken deliver recycled energy (secondary heating) to Sundsvall Energy district heating. SCA Östrand also supplies secondary heat to Timrå Municipality district heating networks. In 2015 the delivery from SCA Östrand amounted to about 79.4 GWh. Such cooperation contributes to reduction in oil consumption by about 25 000 tonnes of oil per year and a reduction of CO<sub>2</sub> emissions by about 70 000 tons per year (SCA, 2016).

SCA Timber has five sawmills two of which is located in Västernorrland. Tunadal sawmill is located in Sundsvall and has a saw capacity of 500 000 m<sup>3</sup> and capacity of 80,000 m<sup>3</sup>. Bollsta sawmill is located in Bollstabruk, Kramfors municipality and has slightly larger saw and planing capacity. The by-products from the sawmills are sold on to the local market, primarily to HEMAB's CHP plant, as well as used internally for energy production at their own industries (pulp and paper mills).

SCA has a cooperation project with the Swedish Energy Agency and Umeå Energy on producing

torrefied and densified biomass. SCA co-finances the construction of an Industrial Demonstration Unit which is starting its production during 2016. The Industrial Demonstration Unit is being built outside Umeå, with an annual capacity of 16 kton black pellets. Prior to up-scaling of the technology, the Pilot plant was built in 2007 with an objective to develop a cost-efficient torrefaction process. The Pilot plant was a joint venture between Umeå University, the Swedish University of Agricultural Sciences, Processum and was later acquired by BioEndev company. BioEndev's mission is to develop and supply high-tech systems that enable the most efficient refining of biomass for use in CHP systems, conversion to fuels and production of green chemicals (BioEndev, 2014).

### SCA Bionorr

Heating with pellets is competitive compared to district heating, heat pumps and electric heating. The main driving force for the introduction of heating with pellets in Sweden has been the CO<sub>2</sub> tax, as well as national investment grants to households converting from oil and electric heating to heating with pellets (Andersson, 2012).

With an increased production at sawmills in the area in the 90s' larger volumes of sawdust have been generated. Sawdust has not been used efficiently and there has been a demand for utilizing this resource. Stockholm Energi needed a good supply of sawdust at their wood pellets factory and established Bioenergi i Norrland AB in Härnösand in 1992, which was a predecessor of SCA Bionorr (interview, 2016; SCA Bionorr, 2012). For about a decade the company has been mainly used as a supplier of pellets to Hässelbyverket in Stockholm (interview, 2016).

In 2003 the company became fully owned by SCA and a new production line was introduced to double the production of pellets. With increased production the local market for pellets also grew, and the households became increasingly interested in buying pellets. SCA Bionorr produces wood pellets at plants in Härnösand and Stugun. Wood pellets are produced from sawdust which is a by-product from two SCA sawmills in Västernorrland (Tunadal and Bollsta). SCA Bionorr has about 120 retailers across Sweden, Norway, Denmark and Finland (SCA Bionorr, 2012). In 2005 -2006 SCA's forests were FSC-labeled, and hence Bionorr wood pellets were certified as well. In 2007 about

SEK 20 million was invested in capacity and quality increase at SCA Bionorr.

SCA does not remove logging residues from the forest nowadays, as there is enough substrate available for pellets production due to increased production at sawmills. Moreover, due to increased efficiency of the processes the industries do not need as much energy for the production processes as before. In addition the winters have been mild over the past few years. Despite these limitations, the demand for wood pellets on the market has been rather stable.

SCA has its own research and development centre and a laboratory that is connected to Mid Sweden University in Sundsvall, and a close collaboration with Umeå University.

### 3.3.2.4 Domsjö Development Area

Örnsköldsvik has an extensive mill area which has been formed throughout a hundred years of industrial history. The mill was established in 1903. Now the area is transforming towards a leading example of green development with active companies engaged in the cooperation.

The site is a vivid example of an industrial symbiosis with a closed cycle and almost no residues. There are many agreements between the companies located here regarding electricity supply, steam, maintenance, use of laboratories etc. The cooperation structure is rather informal. The companies meet few times per year to inform each other about what happens on the site and discuss future developments. The cooperation is facilitated and coordinated by SP Processum.

The Övik industrial site brings together different co-located companies working with ethanol, speciality cellulose, energy, liginosulfonate, biogas with a purpose to develop mutually beneficial cooperation. The companies at the industrial site producing different products include:

- Linde Gas, which works with upgrading and sell of CO<sub>2</sub>
- AGA
- MoReResearch
- Processum
- Aditya Birla Group- a supplier of feedstock to different processes
- Sekab
- AkzoNobel
- Holmen skog

- Eurocon
- Brux
- Umeå Universitet
- Övik energi

In total about 1 200- 1 300 people is employed at the industrial site. The industrial park in Örn-sköldsvik has four largest industries:

- Domsjö Fabriker AB
- SEKAB
- Akzo Nobel producing cellulose derivative that is used as a thickener in construction industry and food industry (e.g. ketchup)
- Övik Energy produces electricity and heat. The main source for heat production is wood based fuel (54%), followed by fuel gas condensation (30%) and peat and peat briquettes (8%) (Svensk Fjärrvärme, 2014).

#### Domsjö Fabriker AB

Domsjö Fabriker AB. Domsjö Fabriker used to be a pulp mill but has been upgraded to a biorefinery. Today, Domsjö has three core business areas: specialty cellulose, ethanol and lignosulfonate that are produced from wood raw material. Specialty cellulose is used in production of viscose, but also sausage skins and other products. "A fourth business line will emerge with the production of renewable engine fuels. Two fuel products will be produced, bioDME and biomethanol. DME is an environmentally superior fuel for modified diesel engines while the primary use for methanol as fuel is as a renewable gasoline blend component or as a component of biodiesel" (CHEMREC, 2008).

Reducing the environmental impact has over 20 years been on the agenda of Domsjö Fabriker. Today, Domsjö mill is a closed-loop bleach plant without any discharge and was the first worldwide to produce fully bleached cellulose without any use of chlorine compounds. Wastewater from the mill is treated biologically and biogas is produced (CHEMREC, 2008). Domsjö is the largest biogas actor in Mid Sweden producing about 80 GWh of biogas per year. The largest share of biogas is used for internal processes and the surplus is sold to Övik Energi CHP plant. No vehicle fuel is produced from biogas (County Administrative Board of Västernorrland, 2013b).

#### SEKAB

SEKAB stands for Swedish Ethanol Chemistry AB. The company was established in 1985 although the production of the sulphite ethanol at the plant started in 1939. After WWII it was decided to keep ethanol plant for national security reasons, although it has not been profitable. Until early 2000 the forest company MoDo owned the site and was responsible for development. Since new owners took over the sulphite plant 'sustainability' has been introduced as a market tool and the transformation of the plant to a biorefinery began.

The company has several units which are presented on figure below (Lindstedt, 2015).

SEKAB has an annual turnover of approximately EUR 100 million (2013) and is owned by local energy companies (70%) and 30% by a private group. SEKAB is mainly a technology provider and is not a big ethanol producer itself. SEKAB is buying some ethanol from Domsjö Fabriker, but the

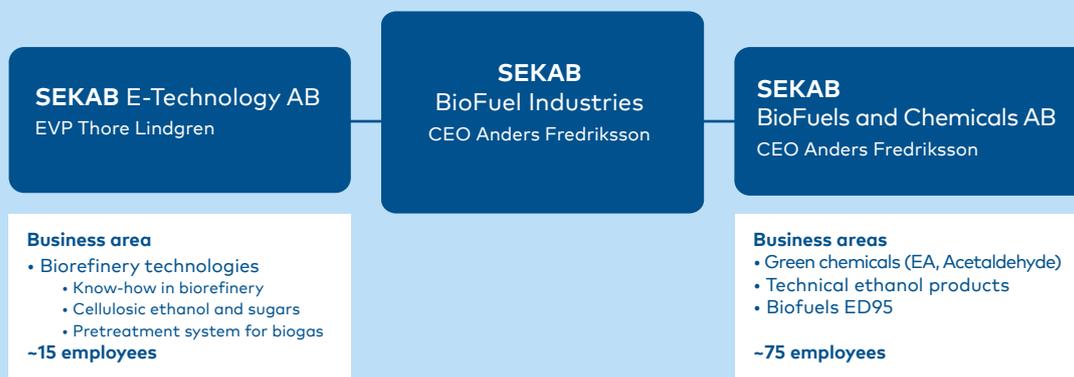


Figure 1. Structure of SEKAB. Source: Source: (Lindstedt, 2015).

largest share comes from Brazil. Biorefinery needs roughly 120 000 m<sup>3</sup> ethanol per year. Approximately 20 000 m<sup>3</sup>/year is produced at the plant which covers about 1/6 of the demand for ethanol.

Ethanol is used to produce green chemicals (ethyl acetate and acetaldehyde) and ED 95 fuel. SEKAB has been producing ED 95 fuel for the past 25-30 years. ED 95 consists of 95% ethanol and 5% water and can be used in 9 litre diesel engines developed by Scania. These engines are mainly used in trucks but have also been tested in small cars with diesel engines. The engine has to be rebuilt since ethanol is more corrosive than diesel (interview, 2015).

Green chemicals is the main focus area of SEKAB. Locally grown plastics (Närodplad plast) is a new cooperation project between SEKAB, Sveaskog, Holmen, Södra, Borealis, Trioplast, Tetra Pak and SP Processum (the main funder of the project). The partnership includes the entire manufacturing chain for bio-based plastics – from the forest industry to packaging producers. The project examines the feasibility of building a European industry, where the forestry biomass is collected and converted into bio-based plastic products, such as supermarket carrier bags or caps for Tetra Pak's milk cartons (SEKAB, 2014).

An increasing interest in green chemicals is driven by the consumers. Tetra Pak is a good example of that. Today, the packaging inside is made of polyten but the consumers would like to get it produced from renewables, which the above mentioned project can help realizing.

Since 2015 SEKAB and bio- and forest industry company UPM cooperate in a project aimed at demonstrating processes for the production of green chemicals from forest raw materials that can be used in paints, coatings and personal-care items. ValChem (Value added chemical building blocks and lignin from wood) project received EUR 13.1 million funding from the European Union. SEKAB is participating and contributing with technology to convert forest product residues into sugars and lignin (SEKAB, 2015).

### SP Processum

When the large forest concern Mo och Domsjö AB (MoDo) was split into few smaller companies, there was an interest in the region to continue the cooperation among these actors, and the idea of Processum was born. SP Processum AB was

founded in 2003 as a cluster company to gather local and regional actors in a triple helix structure. Since then it has developed from a technology park owned by the local industries to a biorefinery initiative.

In 2013 the Swedish Industrial Research Institute (SP) acquired 60% of Processum's shares, and the cluster is now part of the Swedish government's science partner initiative (Lindberg & Teräs, 2014). Other 40% of the shares is owned by the 21 member companies forming the Processum Interest Group (SP Processum, 2016). The member companies include large forest and paper industries, chemical industry and the energy industry, but also smaller research and technology firms.

In 2005 SP Processum received VINNVÄXT funding for the development of the Biorefinery of the Future project which has been their main activity for many years. VINNVÄXT is the Swedish innovation agency's (Vinnova) programme for 'regional growth through dynamic innovation systems', and it provides up to a 10-year funding to develop competitive research and innovation milieus.

Becoming part of SP has been a positive development for Processum, as the company received access to more than thousand of SP's researchers and experts, and its global network. By hiring own researchers SP Processum has become a 'mini' research institute and is now also running its own applied research projects. Considering that Vinnväxt funding runs out in autumn 2016 being SP's subsidiary contributes to the financial stability of SP Processum (interview, 2016). Together with SP, Processum has better preconditions for developing activities in the region.

SP Processum's goal is to 'create conditions for long-term sustainable and competitive production for two of Sweden's primary industrial areas by developing new forest-based value chains for production of chemicals and materials. SP Processum's activities include initiating, performing and providing support to R&D within biorefining. The business is working with development of new products based on renewable wood raw material as well as on residual streams from existing or future processes. The main focus is on upscaling the processes and finding the ways to commercialize them (development of a business case). SP Processum has been the main partner in the market development. The company has been able to run

efficient pilot and demo scale trials together with relevant industrial partners along the whole value chain (SP Processum, 2014).

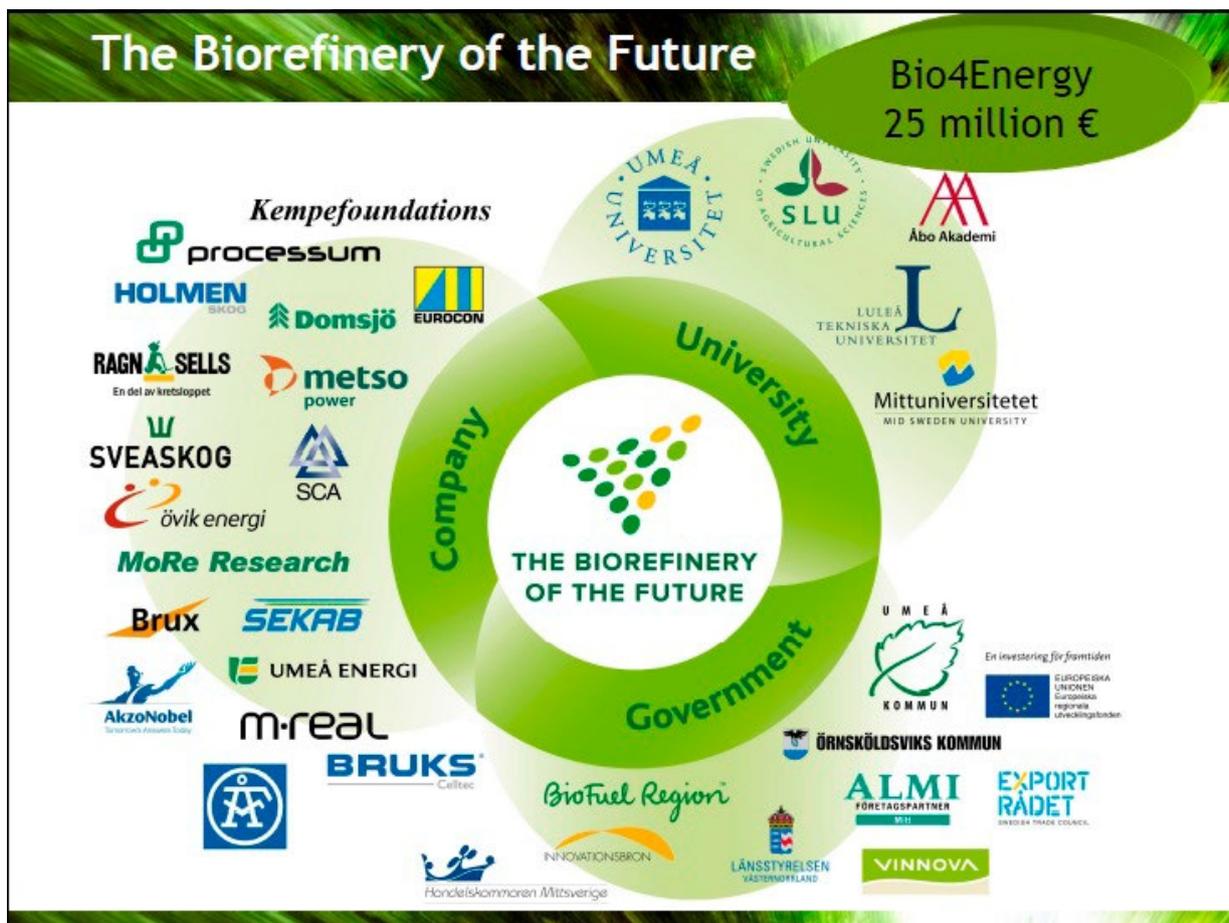
SP Processum contributes to financing promising ideas in the biorefinery area through the SP Processum R&D council (SP Processum, 2016). The project should involve at least two companies in the cooperation, and at least one of them should be a member of the Processum Interest Group. In recent years SP Processum started to develop other research projects.

SP Processum is a project leader of Forest Methanol project (2015-2017), which is a demonstration project for methanol recovery from a sulphate mill. The project is the cooperation between the industry and research actors and is being tested in the industrial environment (Husum Paper mill and Sulphate pulp mill). Methanol is a building block chemical that can be used in a wide range of products and is a potential transportation fuel (Vinnova, 2015). Another example of an ongoing initiative by SP Processum is the utiliza-

tion of sludge from pulp mills being used in covering mining landfills.

Manufacturing materials containing nanocellulose has a good potential according to SP Processum. The properties of nanocellulose makes it an interesting material for many applications, including the area of paper and paperboard manufacture, composite, water purification and even food. Bioplastics, on the other hand, have the same product qualities as the regular plastics and there are no real incentives for the industries to use them. Therefore support measures are crucial for bioplastic (interview, 2016).

In 2014, SP Processum was awarded European innovation price for fish feed protein. In the framework of the project GreenFeed a method to produce Single cell protein from a residual stream from the Domsjö mill has been developed for use in fish feed. It is the first time for a Swedish project to be awarded this price. The technology and the process have been verified in the SP Biorefinery Demo Plant in Örnsköldsvik. Furthermore, the Ice-



Source: (Lindstedt, 2015).

landic partners of the project (Matis and Saebly) have produced fish feed from the Single cell protein and have carried out successful feeding trials, which have showed good results. The next step is to proceed with large scale tests and development of a business concept for this product, which requires marketing and new investments (SP Processum, 2014).

### **Biorefinery of the future**

Biorefinery development was initiated by the business sector in the Örnsköldsvik area. It started as a cooperation between different companies which was facilitated by existing close ties between people in the area, who shared common ideas and visions, and a long-term thinking.

The Biorefinery of the Future for which SP Processum being the host company, received a 10 year VINNVÄXT funding in 2005. Its purpose is to accelerate development in the field of biorefining woody biomass in a close cooperation between the member companies, academic partners and the local government in a triple-helix set-up (Lindberg & Teräs, 2014).

The cluster uses the largest share of its funds for research and innovation, which is conducted in an open innovation network setting. The funds are also used for supporting the innovation system, helping to develop the member firms and scaling up promising projects (Lindberg & Teräs, 2014).

The Biorefinery of the Future project receives SEK 6 million per year from VINNOVA, and regional actors put up an equal amount to match this funding. An extra 12 million SEK per year has 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 (Lindberg & Teräs, 2014). The group is currently working mainly with development of different R&D projects, but is increasingly interested in establishing closer contacts to the business world and attracting venture capital and investments.

A Biorefinery Demo Plant for upscaling of industrial biotechnology processes is managed by SP. It is mainly used for ethanol and lignin production. Different types of raw materials for ethanol and sugar production have been tested and verified in the Demo Plant, including softwood (spruce, birch, pine) and agricultural feedstock. The idea was to have the plant as small as possible but big enough to have normal suppliers like in a real plant. Most of the equipment used at the

demo plant is already developed in the pulp-and paper business. SP is also responsible for getting customers while SEKAB's involvement has gradually become less today. The demo plant is often used for testing and evaluating of new yeast or enzymes (Lindstedt, 2015).

Within The Biorefinery of the Future project the 21 member companies have formal meetings twice a year. SP Processum also arranges open seminars where all members are invited and have an opportunity to discuss other pressing issues. A patent policy has been an important tool used by SP Processum for creating prerequisites for a commercial outcome of the project results and for avoiding possible conflicts among the partners, as it defines how the outcomes and results will be shared (interview, 2016).

### **3.3.2.5 Knowledge institutions Mid Sweden University**

The region hosts educational centres related specifically to renewable energy. Mid Sweden University has several programmes in the field of environmental technology and renewable energy. It has campuses in Härnösand, Sundsvall and Östersund. In Sundsvall, there is a 3-year bachelor programme in energy engineering with approximately 50 students each year. The programme is considered to be among the best programmes in the energy field in Sweden due to long history and highly competent teaching staff. There is also a 5-year programme in the engineering chemistry, which focuses on developing new materials, technologies, and using environmentally friendly manufacturing. The programmes provide a good base and historical overview of the energy systems and possibilities for their optimization, but also insight in renewable energy carriers (interview, 2015).

### **Fibre Science and Communication Network (FSCN)**

Fibre Science and Communication Network (FSCN) is a research unit at Mid Sweden University specialized in industrial technologies and new products that improve the profitability of the forest-based industry and open new business opportunities for sustainable forest-based bio-materials. FSCN's research is focusing on finding new ways to use forest and wood fibres (FSCN, 2014).

The research is done in close collaboration with Biobusiness Arena and the forest industry in the region. Some of the research is funded by the companies themselves in the field that is relevant to

them. In this case the companies have property rights on the processes. The priority has been given to research projects that have a potential for scaling-up.

FSCN has a collaboration agreement with the municipality of Sundsvall. They realize joint projects in the area of bioenergy, housing and city environment with financing coming both from the university and the municipality (SEK 30 million each). Given the limited resources and time, the main focus of FSCB is on pure academic research (interview, 2015).

#### **A gasification lab**

A gasification lab at Mid Sweden University was established in 2007, starting with gasification of waste to produce heat for industrial processes. In the process of gasification advanced biofuels can be produced, such as diesel substitutes that can be used directly in the car tank. The researchers are investigating how to decrease the cost of the gasification process (interview, 2015).

#### **Åkroken Science Park**

Åkroken Science Park is located in Sundsvall and provides a good environment for start-ups. It is a regional incubator financed by VINNOVA, County Government of Västernorrland and Sundsvall municipality. Åkroken is a member based organization and includes companies such as BioBusiness Arena, Packbridge, Åkroken business incubator. Åkroken Science Park is involved several R&D projects on energy efficiency improvements in mechanic pulp mills and in wood chipping processes, design of new fibre-based materials. Science Park also has a seed funding role. When the companies become profitable they go to the market (including BioBusiness Arena) or become integrated at Mid Sweden University.

#### **3.3.2.6 Networks**

##### **BioBusiness arena – a forest cluster**

BioBusiness Arena (BBA) is a member based network driving the renewal of the region's industrial ecosystem and sustainable growth in the bioeconomy. Its long-term vision is to become a global hub for bioeconomy renewal. BBA has been focusing on creating an environment and building a platform in the region for the companies working with bio-businesses. The goal is to encourage cooperation between different actors and to develop

new bio-based businesses through empowerment, showing good practices, building confidence, arranging workshops for the companies etc. BioBusiness Arena is contributing to building network and roads between academy, business and society, and is working on building stronger links between the private and public sector. BBA is working on creating a new cooperation culture in the region and building trust. BBA provides support to the members in finding project funding and assisting with project applications, thereby functioning as a 'grant office'. BioBusiness Arena is integrated in Åkroken Science Park.

BBA was founded in 2013 with funding provided by the County Government of Västernorrland, Sundsvall municipality and Vinnova. BBA received a four year funding of SEK 4 million from Vinnova and SEK 4 million from other regional actors for the start-up activities, a so called 'mobilization phase'. An idea to establish a platform for working with bio businesses came from the members of Åkroken Science Park consisting of many enterprises.

SP Processum in Örnsköldsvik received Vinnvåxt programme funding in 2005 for Biorefinery of the Future. SP Processum has a more narrow focus on R&D whereas BBA focus more on access to the market. In this way the initiatives would complement each other.

BBA has arranged networking events for the members. First, the intention was to bring all actors together in a larger group in order to encourage the exchange of ideas and emergence of a new constellation of actors, and then, bringing together actors with similar interest in smaller groups in order to discuss more specific topics and thematic fields. There have been some positive outcomes of such discussions resulting in joint projects and activities.

BBA is involved in a pilot study financed by the Swedish Growth Agency together with Papper Province, SP Processum and textile university from Borås. The pilot study is referred to as 'samarverkansprojekt'. Together create national spets in bioeconomy development: by making use of research, competency and metodik. Share the competencies, working process, identify the strength among the project partners and decide how they can make use of their knowledge and competencies together (interview, 2015).

## BioFuel Region

BioFuel Region is a member-owned non-profit organization founded by the regional actors in four Swedish northernmost counties (Norrbotten, Västerbotten, Västernorrland and Jämtland) in 2003. Its mission is to support and coordinate initiatives in the field of sustainable transport fuels and new product and energy solutions based on forest raw material in northern Sweden.

BioFuel Region brings together actors from the public sector, industry and research and development sector. BioFuel Region facilitates and promotes networking and knowledge exchange among the members, and works with profiling of the region abroad. The main activities are carried out through projects. BioFuel Region has initiated several networks, such as Biogas Norr, Elfördon Norr (electric vehicles), Skogsnätverk (Forest Network).

In 2013 BioFuel Region initiated the project Biogas Botnia, which promotes exchange of experience within biogas production among the actors in northern Sweden and northern Finland. There are good opportunities in the area when it comes to refining biogas and production of biodiesel. Domsjö Fabriker alone has a capacity to use biogas as vehicle fuel that corresponds to 5 million litre diesel annually.

Biogas Norr is another initiative by BioFuel Region. Biogas Norr promotes increased biogas production and market in northern Sweden. The network brings together actors from academia and business sector from Jämtland, Västernorrland, Norrbotten and Västerbotten (County Administrative Board Västernorrland, 2013).

## 3.4 The activities and measures carried out by the different actors

### 3.4.1 Public support instruments

#### 3.4.1.1 Energy prices

Providing energy at low price to the customers has been an important priority for the local energy companies in Västernorrland. Low energy price is seen as crucial for strengthening the region's competitiveness and ability to attract commercial and industrial establishments but also individuals (Sundsvall Municipality, 2014).

In 2008 HEMAB set a long-term objective to maintain low energy price for its customers. The aim is to provide the lowest energy price in Västernorrland and the company has managed to succeed with this goal until now. HEMAB's goal is to maintain low prices but at the same time cope

with investments to be able to provide good working environment and competitive salary for the personnel.

At the same time energy producers have been affected by low electricity prices over the past years. Local energy companies expressed a concern about losing their customers if the oil price remains low, as the customers might choose other heating options than district heating.

#### 3.4.1.2 EU and national investment support

The energy utility and the companies at Domsjö development area emphasize the importance of both national and EU funding in developing the bioenergy value chains. It has been stressed that getting financing for R&D project is relatively easy nowadays if one has a good project idea. The companies in Domsjö note, however, that the main challenge is finding funding for deployment, demonstration phase and commercialization (interview, 2016).

VINNOVA's funding through Vinnväxt programme has been crucial in enabling the development of the biorefinery activities in Örnsköldsvik. Moreover, it was highlighted in the interviews with the County Administration Board of Västernorrland that the support provided under the state funded local investment programme (LIP) and the climate investment programme (Klimp) has contributed to an increased focus on energy efficiency and renewable fuels in the region (interview 2015).

SP Processum, SEKAB and BioFuel Region stressed the importance of local support for the projects. Örnsköldsvik Municipality has provided long term support both as a cooperating partner and as a financier (interview, 2016). As an owner of Övik Energy the municipality has been positive towards developing the cooperation with the industries. The industrial symbiosis and biorefinery activities at the Övik industrial site have triggered the international recognition and interest which has also facilitated further development.

The forest cluster representatives claim, however, that the municipal authorities in Sundsvall could be more actively involved in the transition to a bioeconomy (interview, 2016).

Although not directly linked to bioenergy support system, the ongoing investments in the Bothnia and Central railway lines and the European route E4 south of Sundsvall have contributed to growth within the county and across the county borders (County Administrative Board Västernor-

land, 2013). Due to infrastructure improvement traveling between Sundsvall-Örnsköldsvik-Umeå has become easier, which has also increased the attractiveness of the area as a workplace. According to the private company interviewed, it has become easier to attract qualified personnel to the region than for 20 years ago, which has been important for developing the bio-businesses. Attractiveness of the area for establishing the new companies has also increased (interview, 2016).

#### **3.4.1.3 Regional instruments and strategies**

"The Regional Development Strategy for Västernorrland 2011–2020" promotes strategic regional growth and development efforts in Västernorrland. The Strategy Vision is: 'A proud Västernorrland – functional and attractive'. The general objectives for 2020 are: Positive population growth, Increased accessibility, and Strengthened innovative ability. The Strategy includes action plans for various regional sectorial programmes, including transportation, gender equality, demography and local business. The Strategy provides guidance for national and regional resource allocation, including the applications for the EU Structural Funds (County Administrative Board of Västernorrland, 2011). Different regional actors are involved in the realization of the action plan, including Åkroken Science Park, Mid Sweden University, Processum and BioFuel Region. The county government is also trying to engage local actors in specific fields of cooperation. There is approximately SEK 110 million available for different projects to support the regional development in Västernorrland (Lindgren interview, 2015).

The four prioritised focus areas in the Strategy are: the individual as a driving force; competence supply as a driving force; innovation as a driving force and accessibility and infrastructure as a driving force. The Strategy promotes taking target-oriented efforts in the field of green industries, which would result in the creation and development of new markets. According to the Strategy, the county aims to become an important producer and exporter of renewable energy and environmental technology linked to the county's agriculture and forest industries, such as energy crops, biogas and local foods. The main emphasis in developing the county's innovation system is on the existing processing industry, based on raw forest materials and electric power, and a systematic support of collaboration processes within the

strategic networks is encouraged (including SP Processum – Biorefinery of the Future, Fibre Network/FSCN (The Forest as a Resource), Packaging Mid Sweden (The Forest as a Resource) (County Administrative Board of Västernorrland, 2011)

#### **3.4.1.4 Role of economic instruments and support schemes**

Carbon dioxide tax, tax exemptions on biofuels, electricity certificates and EU emissions trading system have made important contributions to development of local bioenergy system in Västernorrland.

Renewable electricity certificate system has been an important support mechanism for the local electricity producers. HEMAB's CHP plant has been receiving the certificates until 2014. Tax exemptions on biofuels in Sweden have been identified as an important driving factor for pellets production at SCA Bionorr.

#### **3.4.2 Possible barriers for bioenergy development**

##### **Low fossil energy prices**

Local utilities see their main challenges to be related to low fossil energy prices and losing the revenues from green electricity certificates sales. In these conditions, living up to the environmental goals while ensuring competitive salaries and maintaining a goal of low energy price may be challenging. Moreover, rapidly advancing alternative technologies, such as heat pumps could become competitive with district heating if the fossil fuel price remains low, which is also seen as a possible challenge in future.

##### **Political uncertainty and a lack of long-term commitment**

The actors at the Domsjö industrial site and the forest cluster claim that political uncertainty (unstable regulation, tax system) and a lack of long-term commitment is the biggest threat to the bio-businesses. When it comes to the biorefining activities in Örnsköldsvik, bioethanol production has become more contested and controversial from the environmental perspective with the introduction of the EU 2009 sustainability criteria for biofuels. This discussion had an impact on the sub-national level, where the focus in Mid Sweden has broadened its scope from cellulose-based ethanol production to more diversified types of renewable energy, such as biogas (Söderberg, 2011).

Another reason behind a broadened focus has been a potential conflict of interest between the wood industry and the ethanol industry regarding raw material (Söderberg, 2014).

#### **Attracting investors: taking the project from R&D to an industrial scale**

Lack of long term rules and regulations for sustainable demand and use of biofuels and other bio products such as green chemicals are perceived by the local utilities, the forest cluster and companies at Domsjö site as the main obstacles for investments. For the entrepreneurs it is important to know how the products will be taxed for many years ahead. That is why it is challenging to take a project from a pilot to full scale plant. The investment costs in new facilities and demo projects are high, and so are the risks, while the profits are too low and the pay back period is long. Few investors dare to make larger investments in this climate.

SEKAB has been a co-owner of an ethanol plant in Poland. The project got funding from the EU but has not been successful in finding co-financers for over 3-4 years. Banks and larger companies have been sceptical, arguing that the EU regulations and rules are unclear for the next years and the uncertainty is too high (interview, 2016).

Sweden made large investments in high blend ethanol (E85) and flexi fuel cars, as well as infrastructure (E85 pumps) and distribution network in the beginning of 2000s. However, according to SEKAB, cellulose-based ethanol is connected with large political uncertainty today which is why it became less interesting for the companies. E 85 ethanol has been highly affected by the removed tax exemptions and it's consumption is going down due to low oil price (interview, 2016). Sales of E85 dropped by 77% over one year (January 2015- January 2016) (SVEBIO, 2016).

#### **Different views on forest resources in the EU**

Another challenge in the European Union is to reach a common understanding among the Member States about what forest is. The understanding of forest depends very much on the country of origin. Some of the Member States are only focusing on protection and growing of trees, and have difficulties to understand the Swedish and Finnish perspectives. For a thorough understanding of the issues raised see Nordregio Policy brief 2017:3.

Environmental NGOs and other lobby organizations have been quite successful in Brussels

over the past years, passing through their sceptical opinions on the use of bioenergy, both when it comes to bioenergy production from crops and other sources (interview, 2016). Oil companies are part of this game, adding to the conflict in cooperation with environmental NGOs (interview, 2015).

Currently there is a 7% limit on biofuels produced from crops in the Renewable Energy Directive. According to SEKAB, the forest industries are concerned about that the limitations might also be extended on biofuels from forest resources (interview, 2016). The requirements on sustainability in biofuels are high right now. In the RED there are rules about how one should estimate and evaluate the sustainability of biofuels produced, at the same time there are no accounting system where oil is coming from.

#### **Lack of support to renewable chemicals**

According to the interviewed actors at Domsjö industrial site, current policies favour renewable fuels over renewable chemicals. Several policy measures target renewable energy usage but few address green chemicals. Complex policy situation is perceived as low stability and high risk, and specific support measures are missing. The actors claim that there should be additional national support measures applied to other bioeconomy products.

### **3.5 Bioenergy and the community**

According to the actors at Domsjö industrial site, the development of the bioenergy system has been characterised by a strong support from the local population, which can be explained by a historical presence of the forest industries in the local community and the important role that the industries play for the employment in the area (interview, 2016). The diversification of the forest-based businesses contributed to creation of new jobs in the region. The regional biorefinery in Örnsköldsvik alone employs 300 people. About 200 yearly jobs have been created in Mid Sweden to harvest the biomass residues, and about 50 jobs in related transport activities (OECD, 2012).

The residents in Härnösand municipality have been positive about the food waste recycling initiative introduced by HEMAB. Public campaigns and awareness raising events have made a positive contribution to it. Maintaining an efficient communication and providing information about the ongoing and planned measures, and the benefits for the residents and the environment have

been important. The municipality and HEMAB have managed to create acceptance, understanding and trust among the residents over years. The energy utility claims that Härnösand inhabitants are proud of being 'green' (interview, 2016).

According to the customer satisfaction survey conducted by HEMAB in 2014, the residents have a high level of satisfaction with the company's actions related to reduction of the environmental impact of its operations and contribution to the local development. About 60% of the respondents are highly satisfied and 25% satisfied with the district heating provided by HEMAB, and 68% are highly satisfied with the delivery reliability of the district heating. About 36% of the respondents are highly satisfied with waste management in the municipality in general and 42% are satisfied. The satisfaction level when it comes to the information provided by HEMAB on how to sort household waste is also fairly high (27% are highly satisfied; 41% satisfied). About 76% respondents feel positive about the investment in Härnösand Energy Park (HEMAB, 2014).

According to SCB (Statistics Sweden) Härnösand municipality was rated the best in Sweden in 2015 when it comes to accessibility to recycling park (tillgänglighet till återvinningscentral). According to HEMAB's own customer satisfaction survey (2014), about 64% of the residents were highly satisfied with the recycling park (physical accessibility, personnel, cleanness etc.) (interview, 2016; HEMAB, 2014).

### **3.5.1 Cooperation, competence and knowledge**

#### **Trust and openness**

Companies at the Domsjö Development Area claim that openness, positive atmosphere and a strong cooperation spirit in the Örnsköldsvik area have been important preconditions for establishing the cooperation among the industrial actors and other actors in the area. Cooperation exists not only between the companies, but also academic partners and the local community, spurring development in a triple-helix set-up (interviews, 2016).

A high level of trust has been a key component behind the success for bio-businesses development in the Örnsköldsvik area. Companies at the Domsjö Development Area argue that trust has been built over many years through strong inter-

company contacts and longstanding relationships among the industrial actors in the region. Among the main facilitating factors for trust building has been a small size of the local community, existing close ties between people in the area, but also a common interest in a positive development of the region. During the years of the economic downturn there has been a common understanding of the need to support the core industries in the area and make use of the existing competencies and available experience (interviews, 2016).

According to the forest cluster representatives, forest industries have become more open to innovation and increasingly interested in developing new bio-businesses besides their core area in recent years. This has been induced by the structural changes in the forest industries, associated with decline in printed newspaper, which triggered the industries to look for alternative business models, and is linked to the bioeconomy development. The forest industries participate in regional clusters and networks together with the local utilities, academia partners and local government representatives (interview, 2016). Moreover, large forest industries such as SCA have their own research units and are working on improving the production efficiency and product quality (interview, 2016).

#### **Cooperation with university and other knowledge institutions**

Closeness to the university and access to knowledge have been important from the perspective of a local utility particularly in a form of future labour supply and competences provision. As to the technological solutions, the private companies are mainly interested in commercially mature technologies and have a limited cooperation with the university in technology development (interview, 2016). Physical proximity to the university has been of high importance for SP Processum, which makes it possible to arrange physical meetings with researchers and have access to the labs (interview, 2016).

Mid Sweden University and its research units indicate that they feel a big responsibility in helping the region to renew its image and spur innovative thinking. This refers both to helping the industrial manufacturers to increase the profitability and efficiency of processes as well as developing new business opportunities. In this connection, collaboration with the industry is assigned a great importance (interview, 2015).

## Competence

During the 90s' it has not been easy to recruit skilled labour to the Örnsköldsvik area due to the overall economic downturn and closing down of important businesses. Over the past decade a positive development has been observed and attracting highly skilled labour has no longer been indicated as a problem by the actors at Domsjö Development Area interviewed. Among the important facilitating factors has been infrastructure improvements and reduced commuting time which helped to create a more attractive and dynamic labour market.

### 3.5.2 The future of bioenergy

Future opportunities within more advanced and 'new' forest-based bioeconomy in Västernorrland are closely linked to the forthcoming decisions and political support at the national and EU level. The actors at Domsjö site and the forest cluster note that a critical thing today is to deal with the political dimension and market constraints, not the technology. The biggest threat to the bio-businesses is unstable regulation, tax system and lack of long-term political commitment. What is going to be the role of biomass in the post EU 2030 framework is unclear. There is a need to develop a national support system that would be compatible with the EU support rules. Lack of thereof is among the main obstacles for investments.

It has been brought up by the FSCN during the interview that the university, city and industry in Västernorrland share the same challenge, as to how to increase attractiveness. There is a need to promote a more dynamic development which would be based on new, more diverse and higher value added products from the forestry sector. It is critical to foster such development in the region and move away from being a supplier of biomass in a form of fibre, chemicals and fuel mainly.

### 3.5.3 Conclusions and lessons learned

An important precondition for developing the bioenergy system in the region has been the existing forest industries which ensured a stable supply of the feedstock for bioenergy production. Development of biorefineries in the region was induced by the economic downturn in the 90s' and the structural changes in pulp and paper industry. "The regional decline created a sense of urgency among the local actors to create new industries and jobs in the region." The regional actors have seen grow-

ing potentials for the use of residual energy flows in forest-based processing plants (Halvarsson & Rönnqvist, 2012; Lindberg & Teräs, 2014). During the past decade Örnsköldsvik and Sundsvall were transformed from traditional industrial cities to ones systematically working with green growth which has added new dimensions to the region's economic development.

The bio-based cluster in Örnsköldsvik depends strongly on innovation of inter-relations and related synergies between enterprises and processes. Among the enabling factors has been a favourable industrial environment in the Örnsköldsvik area with a high level of competence, intercompany contacts and strong local and regional support. Supporting cluster innovation platforms like this has been a key strategy of innovation authorities for a longer period of time, and they show obvious organisational responses to the challenge of a sustainable expansion of forest based value chains.

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