BIOENERGY DEVELOPMENT IN VÄSTERNORRLAND, SWEDEN

NORDREGIO WORKING PAPER

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PREFACE

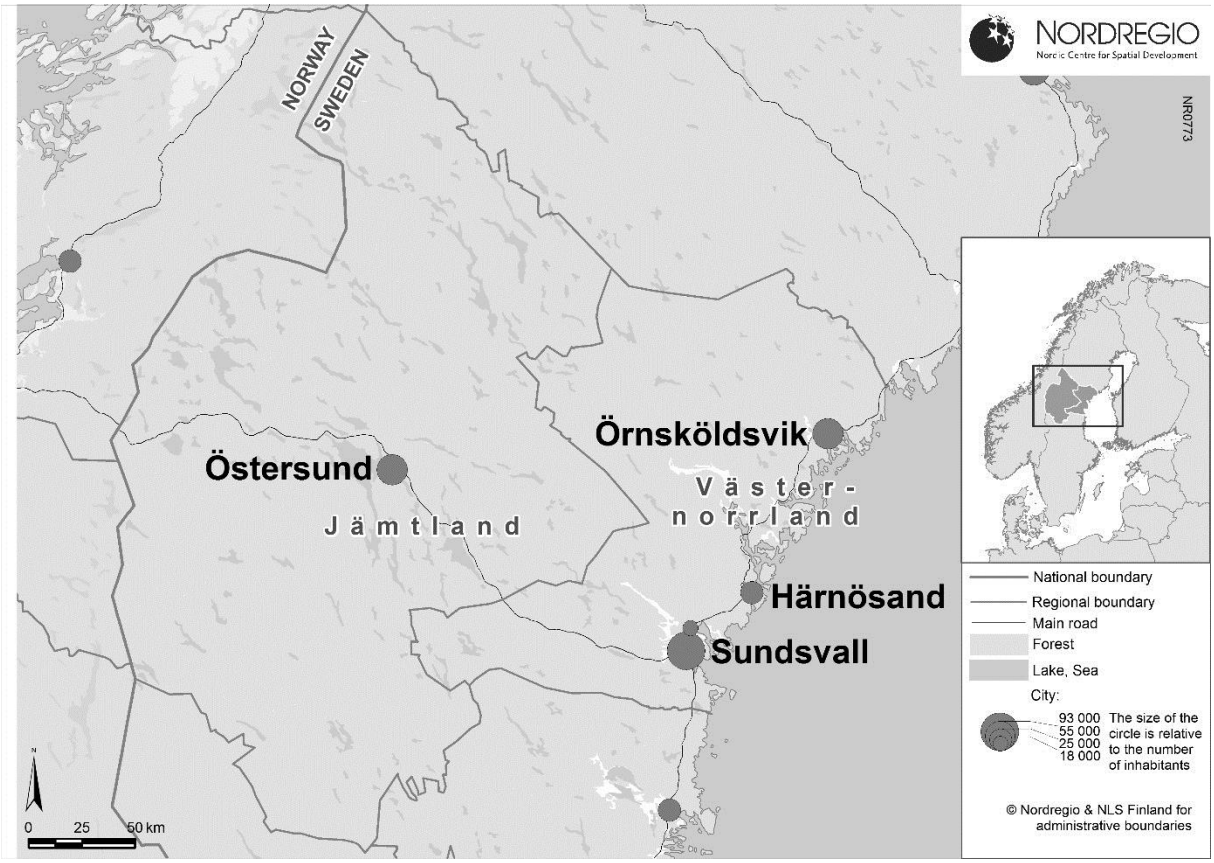
This Working Paper is one of the outputs of the TRIBORN project: Triple Bottom Line Outcomes for Bioenergy Development and Innovation in Rural Norway. TRIBORN was a 3,5 year inter-disciplinary project funded by the Norwegian Research Council. The Working Paper is a nealy final draft. The final version will be published later in 2017. 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).

CONTENTS

1 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%).

Map 1 The case study area. Map by Linus Rispling



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.

1.1 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) (Figure 1). 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 Örnsköldsvik 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.

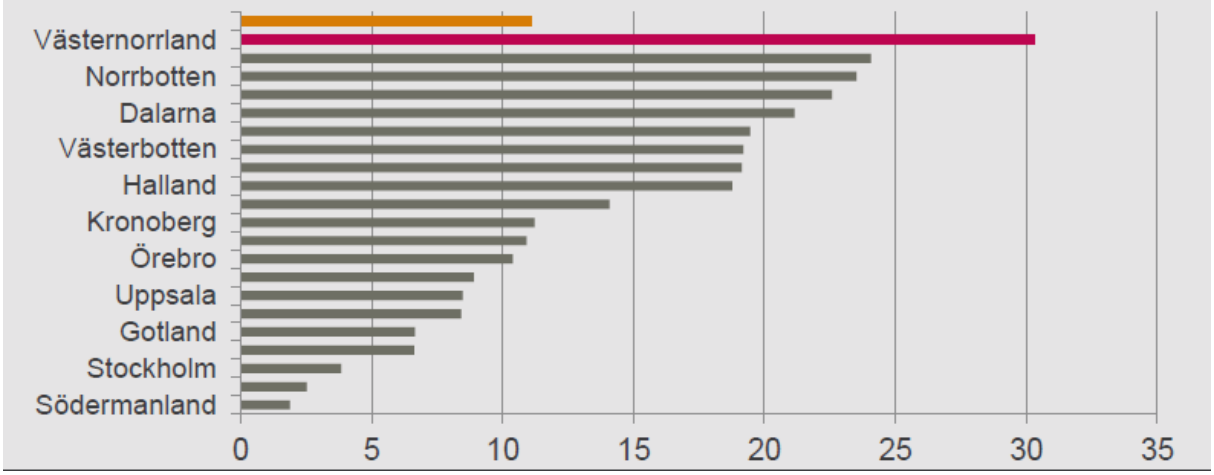


Figure 1 Employment in the forestry sector as % of total employment in the industry sector. Source: BioBusiness Arena 2015.

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 Source: (Swedish Forest Agency, 2014).

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		
Västernorrland	1672	186	1859	186	42	228	146	2099

Table 2 Forest protection in Västernorrland. Source: (Swedish Forest Agency, 2014).

	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

Table 3 Area of productive forest land and non-productive forest land in Jämtland and ownership classes, 2009-2013 (excluding protected land). Source: (Swedish Forest Agency, 2014).

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

Table 4 Number of forest owners (owned by single owners) and management units (owned by single owners) in Västernorrland, year 2012. Source: (Swedish Forest Agency, 2014)

	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	9661	13 443

When it comes to the ownership structure, about 55% of productive forest land is owned by private-sector companies[1] in Västernorrland. About 39% of forest is owned by individual forest owners[2] in 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

[1] Private-sector companies: company/corporation that is more than 50 percent privately owned, aktiebolag (Forest Statistics Yearbook 2014)

[2] Individual owners: single owner, estates and small companies (sole trader) (Forest Statistics Yearbook 2014)

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 m3 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 m3 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).

1.2 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 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 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.

2 THE EVOLUTION OF A LOCAL BIOENERGY MARKET

2.1 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 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.

2.2 THE ROLE OF DIFFERENT ACTORS AND THEIR GOALS

2.2.1 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).

2.2.2 HEMAB - HÄRNÖSAND ENERGY AND ENVIRONMENT AB

HEMAB is a municipally owned compaasny 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. Source (Svensk Fjärrvärme, 2014)

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

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).

Goals within the biogas refinery project:

- Gradually substitute gas and diesel to vehicles run on electricity and biogas
- Production of approx 300 m^3 biodiesel/year
- Expected reduction of CO_2 is 900 tonnes/year
- Reduction of inceneration costs by 2/3, which results in SEK 1.5 million savings for the municipality.

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).

2.2.3 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_2 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^3 and capacity of 80,000 m^3. 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 CO2 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.

2.2.4 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, lignosulfonate, 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 CO2
- 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 Örnsköldsvik 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. Speciality 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

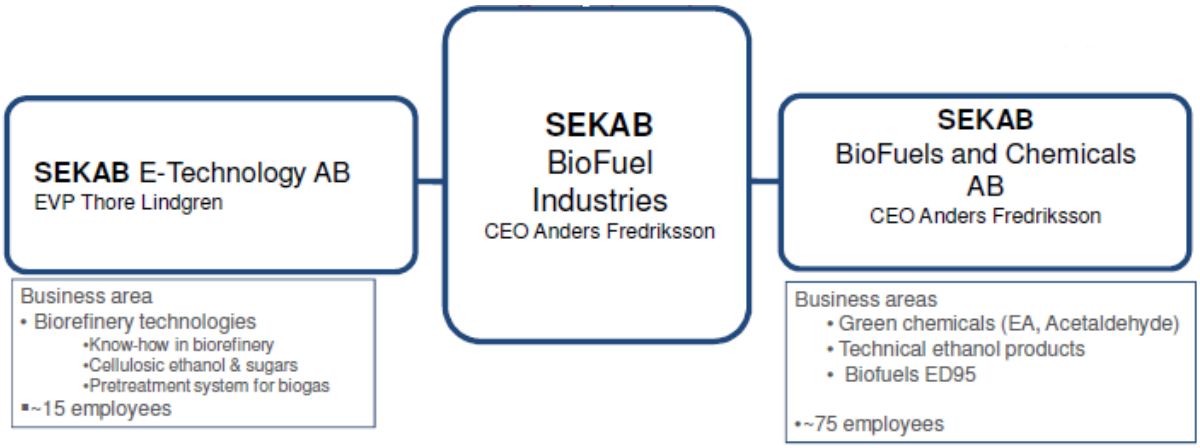
environmentally superior fuel for modified diesel engines while the primary use for methanol as fuel is as a renewable gasoline blend component or as a component of biodiesel» (CHEMREC, 2008).

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).



Source: (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 largest share comes from Brazil. Biorefinery needs roughly 120 000 m^3 ethanol per year. Approximately 20 000 m^3/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* (Närodlad 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'sresearchers 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 utilization 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 qualitites 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 Icelandic partners of the project (Matis and Saebyli) 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).

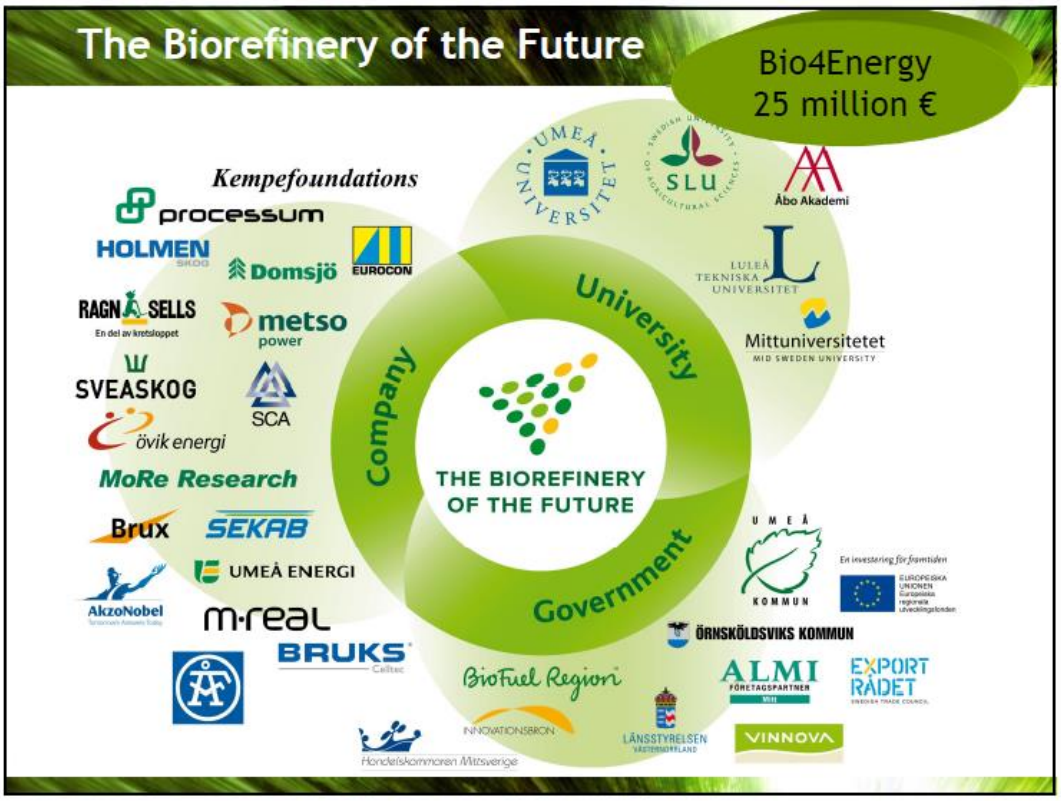
BIOREFINERY OF THE FUTURE

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.



Source: (Lindstedt, 2015).

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 Bioreginery 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).

2.2.5 KNOWELDGE 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 BioBusiess Arena) or become integrated at Mid Sweden University.

2.2.6 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 Vinnväxt 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 Paper Province, SP Processum and textile university from Borås. The pilot study is referred to as 'samverkansprojekt'. 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, Elfordon 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 THE ACTIVITIES AND MEASURES CARRIED OUT BY THE DIFFERENT ACTORS

3.1 PUBLIC SUPPORT INSTRUMENTS

3.1.1 ENERGY PRICES

Providing energy at low price to the customers has been an important prioity 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 loosing their customers if the oil price remains low, as the customers might choose other heating options than district heating.

3.1.2 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 Västernorrland, 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).

3.1.3 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)

3.1.4 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.

3.2 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 indsutrial 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 stablity 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.

4 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 Örnsköldsivk 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).

4.1 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 intercompany 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 reginal 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.

4.2 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.

4.3 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 growing 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.

Among the enabling factors has been a favourable industrial environment in the Örnsköldsvik area with a high level of competence, intercompany contacts and cooperation in a triple-helix set-up (CHEMREC, 2008).

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