

BIOENERGY DEVELOPMENT IN JÄMTLAND, 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 nearly 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).

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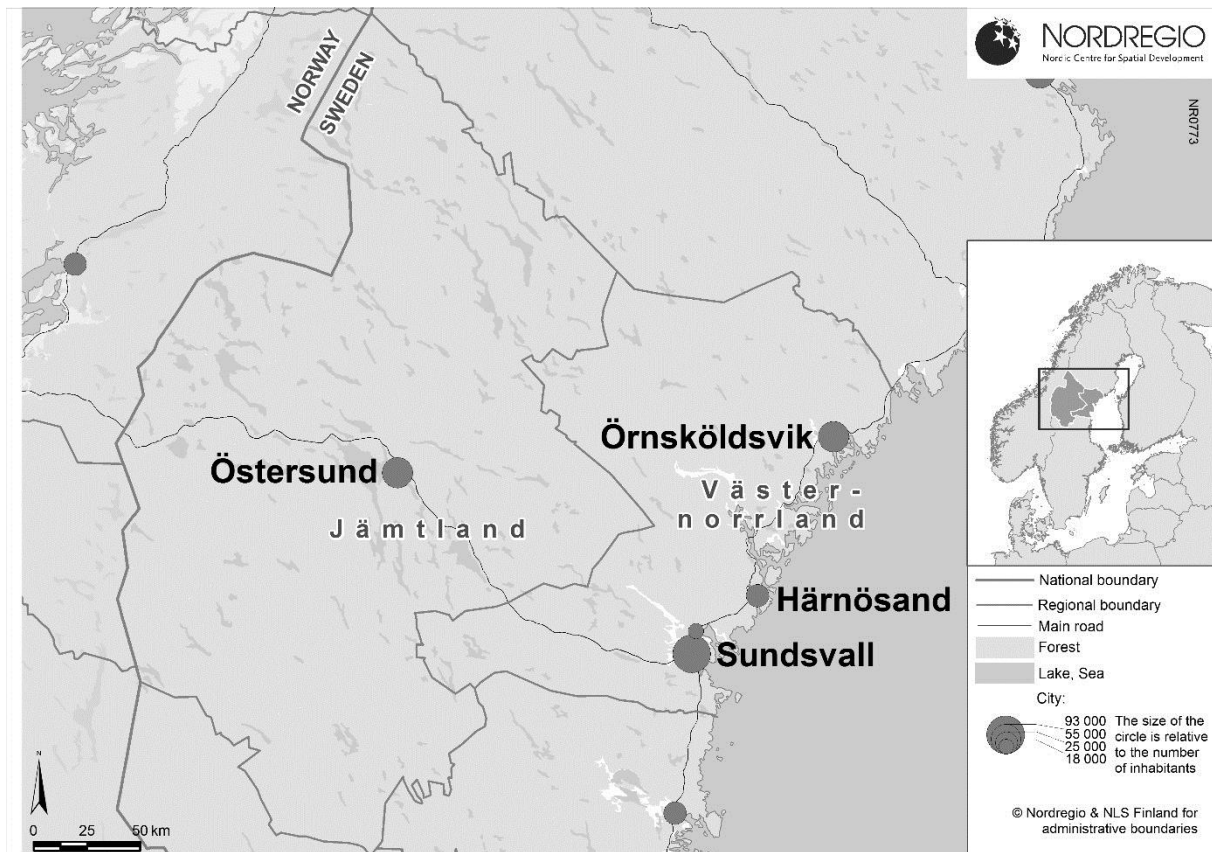
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1 BRIEF DESCRIPTION OF THE CASE STUDY AREA

Jämtland is a county in Sweden at NUTS3 level. It covers a total area of 34,009 km², which is about 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).

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



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).

Table 1 Facts about Jämtland County and Östersund municipality. Source: (Ekonomifakta, 2015; Regionfakta, 2016).

	Jämtland County	Östersund municipality
Population (2014)	127 376	61 066
Total area	34,009 km ²	2,221 km ²
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		

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 municipality 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.

1.1 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 County Administrative Board, 2012b; Perjo, 2013). The total volume of felled timber in Jämtland for the period 2006-2008 was 6 474 000 m³ annually which is the fourth highest in Sweden (Jämtland County Administrative Board, 2012b).

Table 2 Area of land use classes of Swedish Forest Act (and FAO) in Jämtland, 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		
Jämtland	2641	841	3482	841	395	1237	158	4916

Table 3 Forest protection in Jämtland. 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
Jämtland	1 513	2 391	54	797

When it comes to the ownership structure, about 42% of productive forest land is owned by the private-sector companies¹ and about 45% of forest is owned by the individual forest owners² in Jämtland. The remaining 12% and 5% is owned by 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).

Table 4 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
Jämtland	1 097	1 163	313	2573	471	442	156	1069

Table 5 Number of forest owners (owned by single owners) and management units (owned by single owners) in Jämtland, 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
Jämtland	5365	8633	13998	4605	1154	7559	13318

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

¹ Private-sector companies: company/corporation that is more than 50 percent privately owned, aktiebolag (Swedish Forest Agency, 2014).

² Individual owners: single owner, estates and small companies (sole trader) (Swedish Forest Agency, 2014)

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).

1.2 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).

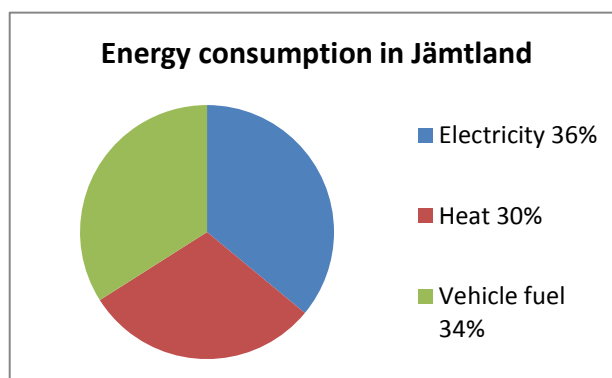
The largest share of electricity production in Jämtland (93%) is generated from hydropower (11.2 TWh in 2013). The county has 83 hydropower plants, of which three are located in Östersund municipality (Jämtland County Administrative Board, 2014c). The remaining 5% of electricity generation is based on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

Table 6 Energy consumption in Jämtland County. Adapted from: (Region Jämtland Härjedalen, 2015)

Electricity: 1.7 TWh
Fuel for heating: 1.3 TWh
– 92.5% renewables
– 2.5 % peat
– 5 % fossil fuel
Vehicle fuel: 1.6 TWh
– 1 % renewables (excl. low admixture of ethanol/biodiesel, electricity and train)
– Biogas produced at wastewater treatment plant in Östersund



1.2.1 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 (**Error! Reference source not found.**). 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 CO₂ 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 THE EVOLUTION OF A LOCAL BIOENERGY MARKET

2.1 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 CO₂ 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).

2.2 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.

2.2.1 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 Sweden'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 Hydrotreated 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 Elnät 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).

Table 7 Number of chargeable vehicles (electric cars and plug-in hybrid electric vehicles (PHEV) in Östersund municipality and Jämtland County. Source: (Östersund municipality, 2016b).

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

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).

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 Nm³ 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).

2.2.2 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).

2.2.3 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%), Krokom (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 (**Error! Reference source not found.**). 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 (Hagman, 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 infrastructure. CLEVER is a leading electric mobility operator in Denmark (interview 2015).

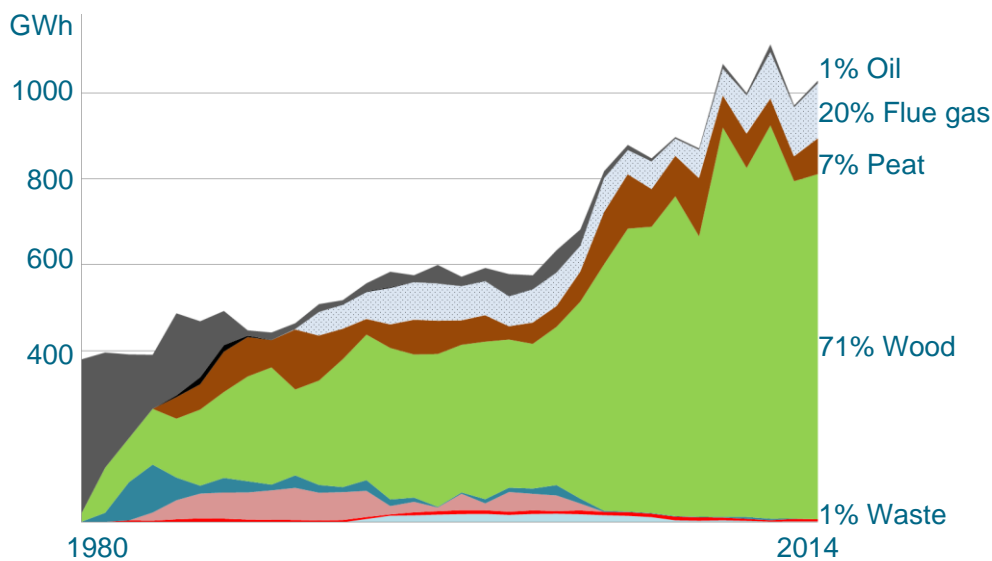


Figure 1 The fuel switch from fossil to biomass in Jämtkraft AB, 1980-2014. Source: Unpublished material provided by Jämtkraft AB

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).

Table 8 Environmental impact of Jämtkraft AB, 2014. Source (Svensk Fjärrvärme, 2014)

Resource use	Emissions of GHG	Percentage of fossil fuels
Primary Energy Factor	Combustion	
0,17	33 g CO2 ekv/kWh	1%
	Transport and production of fuels	
	7 g CO2 ekv/kWh	

2.2.4 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 m³ of raw methane produced per year, about 600 000 m³ 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 m³ 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).

2.2.5 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 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).

2.2.6 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 m³ 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 bioenergy 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).

2.2.7 SKOGSÄGARNA NORRSKOG – FOREST OWNERS ASSOCIATION



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

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 m³ per year and the annual growth of forest is about 17 million m³ 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).

Table 9 Facts and figures about Skogsägarna Norrskog. Adapted from: Norrskog, 2015.

Member forest area	960 000 ha
Own forest area	31 000 ha
Sawn timber	450 000 m ³ (70 % fir, 30 % pine)

Refined timber	120 000 m ³
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

Skogsägarna Norrskog owns three sawmills, two of which are located in Jämtland and one in Västernorrland. Sawmills produce approximately 450 000 m³ 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 a 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).

2.2.8 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.

3 THE ACTIVITIES AND MEASURES CARRIED OUT BY THE DIFFERENT ACTORS

3.1 PUBLIC SUPPORT INSTRUMENTS

3.1.1 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).

3.1.2 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 transition 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 (Carbomm 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 Programme 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.

3.1.3 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 Administrative 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. 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).

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
Total reduction	48%

Figure 3 GHG emissions reduction and greening status of the transport sector 2011-2020. Source: (Region Jämtland Härjedalen, 2015)

3.1.3 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 CO₂-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 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 determine 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).

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).

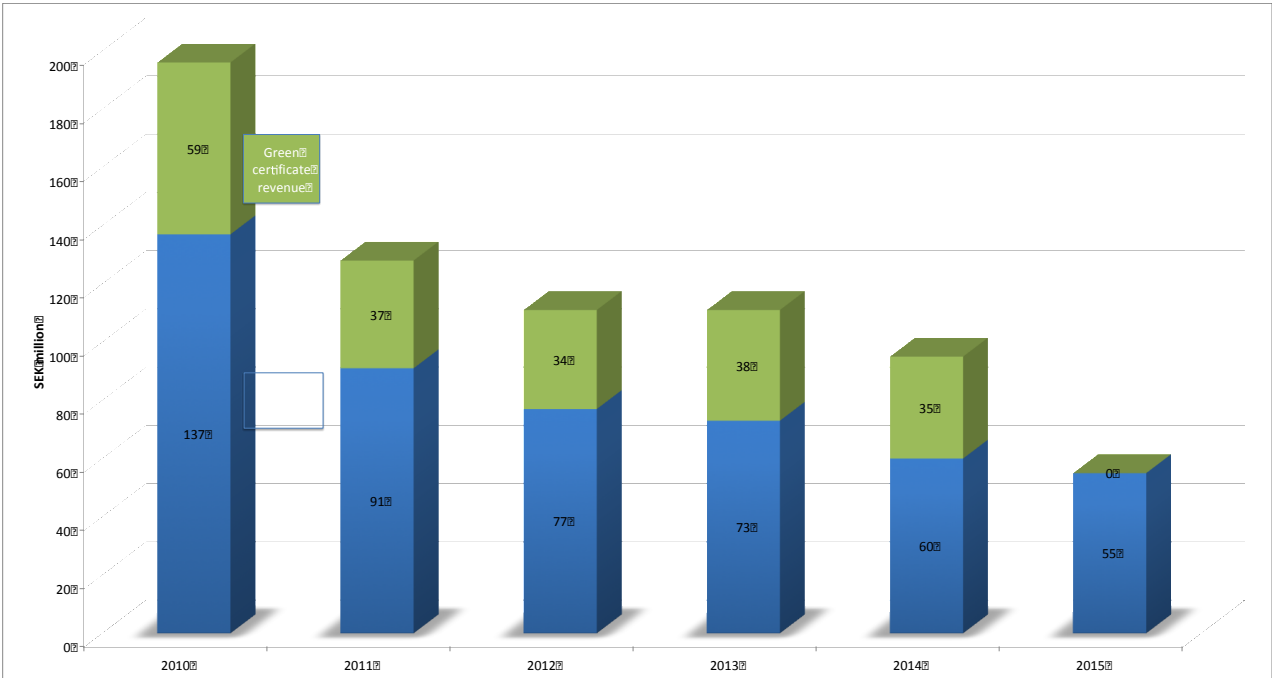


Figure 4 Revenues of Jämtkraft from green certificates and sales, 2010-15. SEK million. Source: Unpublished material provided by Jämtkraft.

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 CO₂ taxes in the world (International Energy Agency, 2013).

Energy and CO₂ 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).

**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).

Heat production in CHP has tax incentives, currently with a 30% energy tax and 7% CO₂ tax, while other heat plants are taxed with a 100% energy tax and a 94% CO₂ 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 CO₂ 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 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.

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).

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).

3.2 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).

4 BIOENERGY AND THE COMMUNITY

4.1 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).

4.2 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.

4.3 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).

4.4 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 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).

4.5 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 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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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: biogas, 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