Renewable Energies for Agriculture: investments and diffusion

Regional Self-assessment
AgroRES | Interreg Europe
COD. PROG: S3.a.1

Region: North Karelia, Finland

CONTENTS

1. Introduction

The agricultural sector accounts for almost 10% of greenhouse gas emissions in the EU, majority of which is caused by food production and transport. While there is an enormous potential to produce renewable energy on farms due to the availability of wind, sun, biomass and agricultural waste, important barriers and challenges remain.

The purpose of this report is to form an overall picture of renewable energy consumption and production in North Karelia and its agricultural sector. In addition to describing the current situation, the report discusses existing policies and actions that promote renewable energy production and use in agriculture. The strengths and weaknesses of these policy instruments are analysed. Based on the abovementioned data, the report analyses opportunities and threats connected to the spread of renewable energy in agriculture and suggests key measures to support positive development in this field.

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2. Regional socio-economic framework

This chapter provides information of North Karelia and its agricultural sector. It discusses regional energy production and consumption and gives an overview of agricultural energy use in North Karelia.

I. Regional overview

North Karelia is located in the Eastern Finland, see figure 1. The population of North Karelia is approximately 161 000 people and the regional capital of North Karelia is the city of Joensuu, with 75 000 inhabitants. There are over 2000 lakes in the region and lake Pielinen (located in the northern part of the region) is the 4th largest lake in Finland.

Figure 1. Location of North Karelia.

Leading industry sectors are forest and wood, food, plastic, metal, and tourism industries. There are also several major international companies located in the region, such as John Deere and Stora Enso Forestry. North Karelia is widely known for its knowhow in forestry and also the European Forest Institute headquarter is located in Joensuu.

Regional GDP per capita (2018) was 33 582 € and the Gross value added by the agricultural sector is around 40 million euros (see table 1).

North Karelia	
Area, km2	21 584
Population 31.12.2019 (total)	161 211
men	80 229
women	80 982
Regional GDP at current prices 2018 (mil. eur.)	5 461
Regional GDP at current prices 2018 (per capita, eur)	33 582
Average net household income 2018 (eur)	38 902
Gross value added by main economic sectors 2018 (total, mil. eur)	4 712
industry, mil. eur	892
services, mil. eur	3 020
agriculture, mil. eur	40

Total disposable income, net, 2018 at current prices (mil. eur)	3 244
Number of household dwelling units	83 389

Table 1. Fact summary of the Region of North Karelia

II. Analysis of regional agricultural sector's economy

Total amount of agricultural area in North Karelia is 900 km², which 860 km² (86 000 hectares) is used actively. Farm income is divided roughly in four categories (chart 1). 34 % of total income comes from the sales of products and services. Different kind of subsidies cover 28 % of the income. Typically, most of the active farmers are also forest owners and average size of forest is 56 hectares / farm. The significance of the forest income is notable as it covers 16 % of the total income. Finally, other types of side income such as cottage rent, accommodation, catering, and other services covers 1/5th of the total income. However, there is a big variance in the side income section depending on the particular farm.

On the chart 2 there is a visualization of farm sales income of different categories in 2018 in North Karelia. As it can be seen milk production is the most significant line of agricultural production with 59 % of the total production in euros. Meat production including beef and pork meat is altogether 23 %. Egg production is only 0,56 % and grain production approximately 4 % of the total income in euros. Number of other plants including different kind of agricultural plants such as potatoes, vegetables, berries field mustard, caraway and so on has been increasing in last decade and is nowadays approximately 13 % of total production in euros.

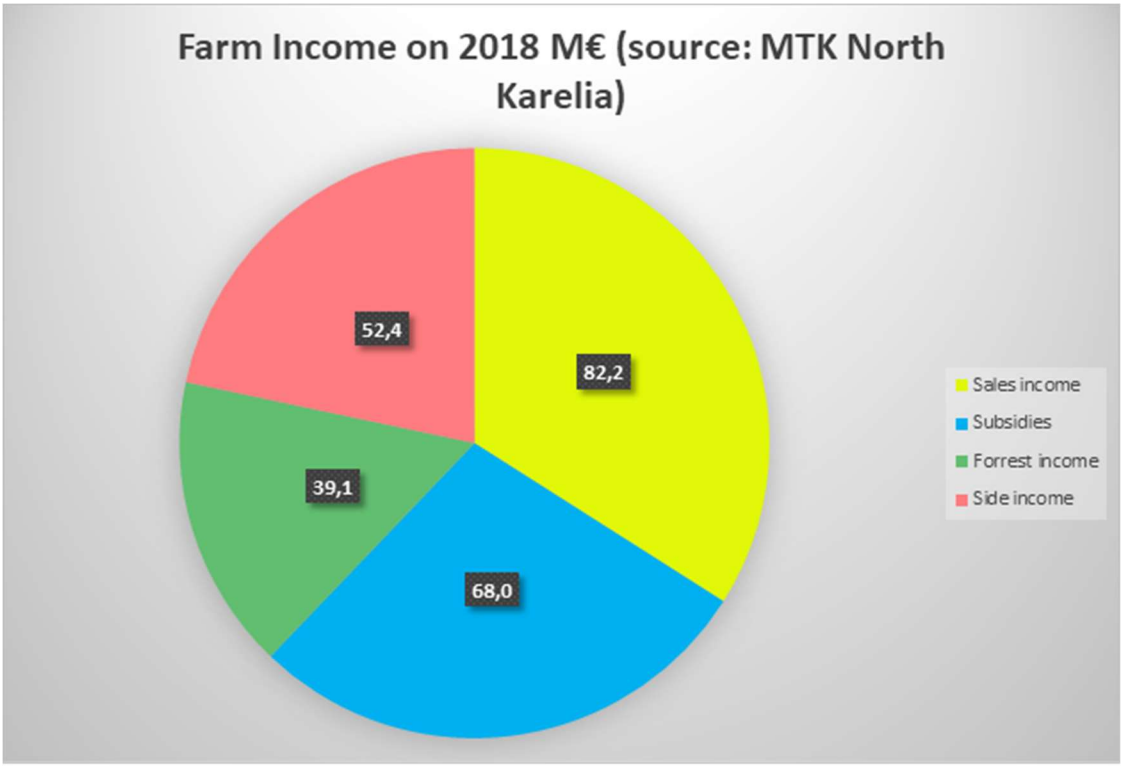


Chart 1. Farm income on 2018 (M€)

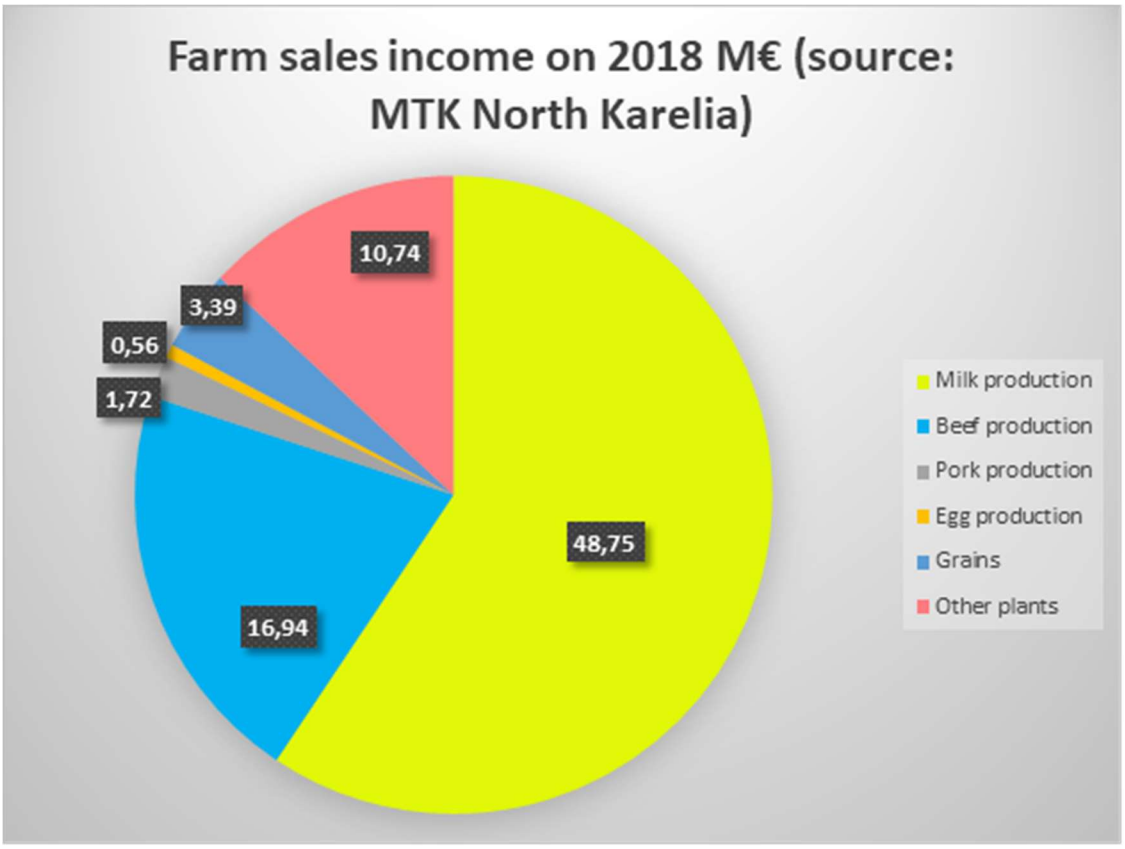


Chart 2. Farm sales income on 2018 (M€)

Number of farms in North Karelia has been steadily decreasing from the 1990s. Today there are 1932 active farms. At the same time average size of the farms has been increasing and nowadays it is approximately 44 hectares. In addition to this many farms have forest ownership as a side income source as it was described in previous chapter.

Number of livestock units in the region is 45 845 and usage of agricultural land is concentrated to lawn. That is natural consequence of the high emphasis on milk and meat production, which is the main category of agriculture in the region (see table 2).

Number of farms that organize some kind of additional activities (excluding forest) is 440. Basically, a little bit over 22 % of all farms have this kind of side income. That includes a big variety of different forms of services depending on the case.

Number of farms	1932
Size of farms	84 800 hectars - Average size 44 hectars
Farm labour	5220
Livestock unit	45 845
Use of agricultural land	Grain: 23,1 Lawn: 50,6 Other plants: 4,1 (1000 hectars)
Farmhouse Holiday	
Number of companies	440 (including all other activities)

Table 2. Agricultural sector facts in North Karelia

III. Analysis of regional energy mix

Regional energy production and consumption

There is limited number of recent statistics concerning energy production in North Karelia. However, there is a statistical data that energy self-sufficiency in 2016 was 43 %. In thermal sector energy production in the region is heavily concentrated on renewable wood energy. More than a half of region own electricity production comes from renewable sources such as waterpower. In thermal sector there is also production and usage of peat and oil, but total amount of this is decreasing in the future because of new regulations and climate targets. Imported electricity is also changing towards more greener sources.

In 2018 renewable energy consumption rate in the region was 67 %. That consists wood energy (51 %), renewable electricity (13 %), heat pumps and other sources of renewable energy (3%). There is a significant potential remaining to increase biomass, biogas and other renewable sources in energy production and consumption. North Karelia has set a target to be oil-free region by the year 2030 and active measures has been implemented recent years and public commitment towards the target is at good level.

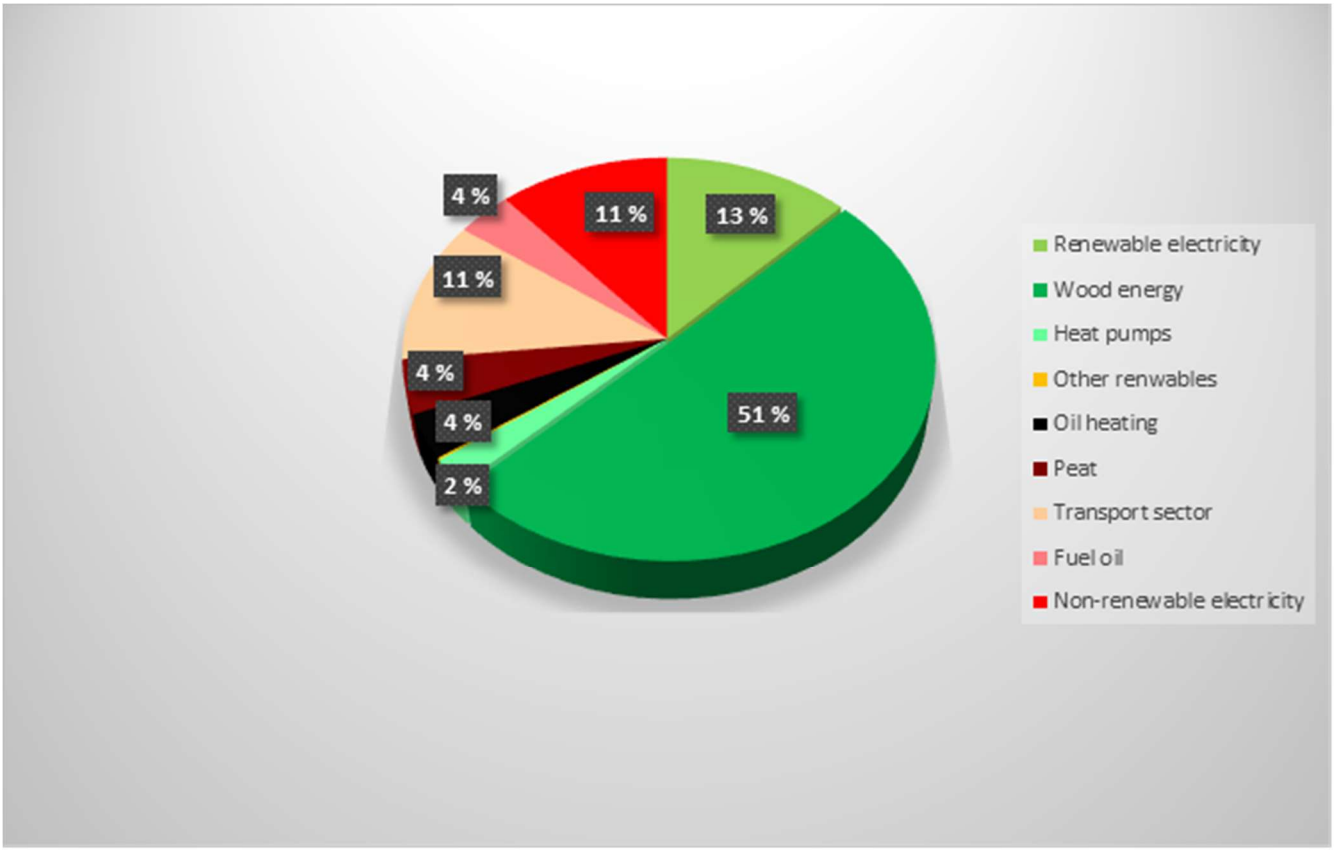


Chart 3. Energy consumption in North Karelia 2018 (GWh)

Agriculture energy consumption in North Karelia

Total amount of energy consumption in agriculture sector in North Karelia is presented below (see chart 4). Total amount of energy consumption is 284 GWh and it has decreased 9 % in a decade. Over 50 % of the total consumption comes from the machinery. One third comes from the electricity both consumption and heating. It is also notable that over 1/3 of total energy consumption is related to heating because of cold wintertime.

There is a significant potential in reducing energy consumption in machinery section. However, this is also the most difficult section to operate in terms of implementation. Because of the high demand of power throughout year in agriculture machinery it is more difficult to use electricity as a power source. It is also expensive to convert existing machinery towards renewable energy, so there is a need for comprehensive subsidy programs. Different kind of liquid biofuel and biogas could also be implemented, but there is a question marks also there in term of profitability and technical execution.

Electricity section is going towards greener direction despite the actions made in the agriculture sector. This is a logic consequence of electricity production becoming more related to renewing energy sources.

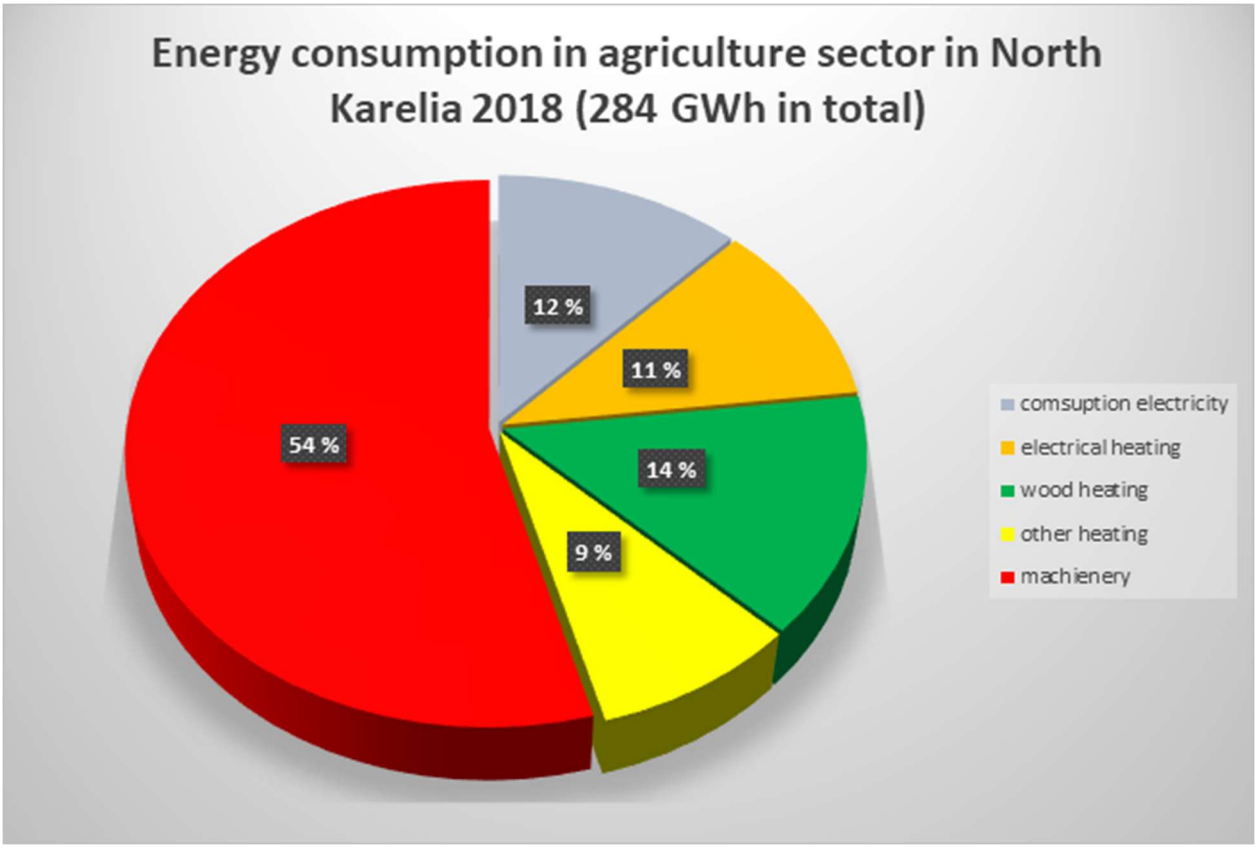


Chart 4. Energy consumption in agriculture sector North Karelia 2018 (GWh)

3. Development of renewable energy use in North Karelia

North Karelia has experience of long-term strategic work on renewable energy and forest bioeconomy. The region's first bioenergy programmes and projects were launched already in the 1990s and the first Climate and Energy Programme of North Karelia 2020 was launched in 2011. This was followed by a strategic document called the Roadmap Towards Oil-Free and Low-Carbon North Karelia by 2040 that defines the steps for achieving the region's goals in climate and energy sector. North Karelia decided to abandon fossil oil used for energy production and in traffic by 2030, and the share of renewable energy is expected to rise from 66% (year 2014) to 100%. In addition, the region aims to reduce greenhouse gas (GHG) emissions by 80% from 2007 level to 2030 as an action of "Towards Carbon Neutral Municipalities (HINKU)" - Network. These strategic development targets have played a key role in the spread of renewable energy use in the region. These policy instruments have guided the use of development funds in the region. Since 1990s, the region has implemented several EU and nationally co-financed projects to increase renewable energy use in the region. These have included also project that have been targeted at farms. To name a few, Power from Biomass project (EAFRD), UusiutuWat (EAFRD), Towards Oil-Free and Low-Carbon North Karelia (ERDF) have promoted the production and use of decentralized renewable energy in North Karelia.

In addition to the abovementioned strategies, policies and projects, the Agricultural investment aid financed through the Rural Development Programme for Mainland Finland has been an important instrument for increasing renewable energy use and production in North Karelian farms, along with other support instruments that are available for companies and communities. More information on these options in Chapter 4.

Year	2008	2010	2012	2014	2016	2018
Total energy consumed (GWh)	10 046	11 843	11 390	12 066	11819	11789
Share of renewable energy, %	62,6	63,3	67	65,8	63,9	67

Table 3. Renewable energy used in North Karelia between 2008 and 2018.

I. Production of renewable energy in agriculture

There is no statistical data on farms that have renewable energy plants or installations in North Karelia. As stated before, agricultural investment aid financed through the Rural Development Programme for Mainland Finland 2014-2020 has been an important enabling tool for renewable energy investments in the region's agricultural sector. By studying the on-farm investments supported through this programme, we may get a clearer picture of the types of renewable energy technologies that are most employed in farms in North Karelia.

According to a data provided by the Centre for Economic Development, Transport and the Environment in North Karelia, between 2014 and the end of 2020, 25 farms in North Karelia received

support for 27 renewable energy investments under the Rural Development Programme for Mainland Finland.

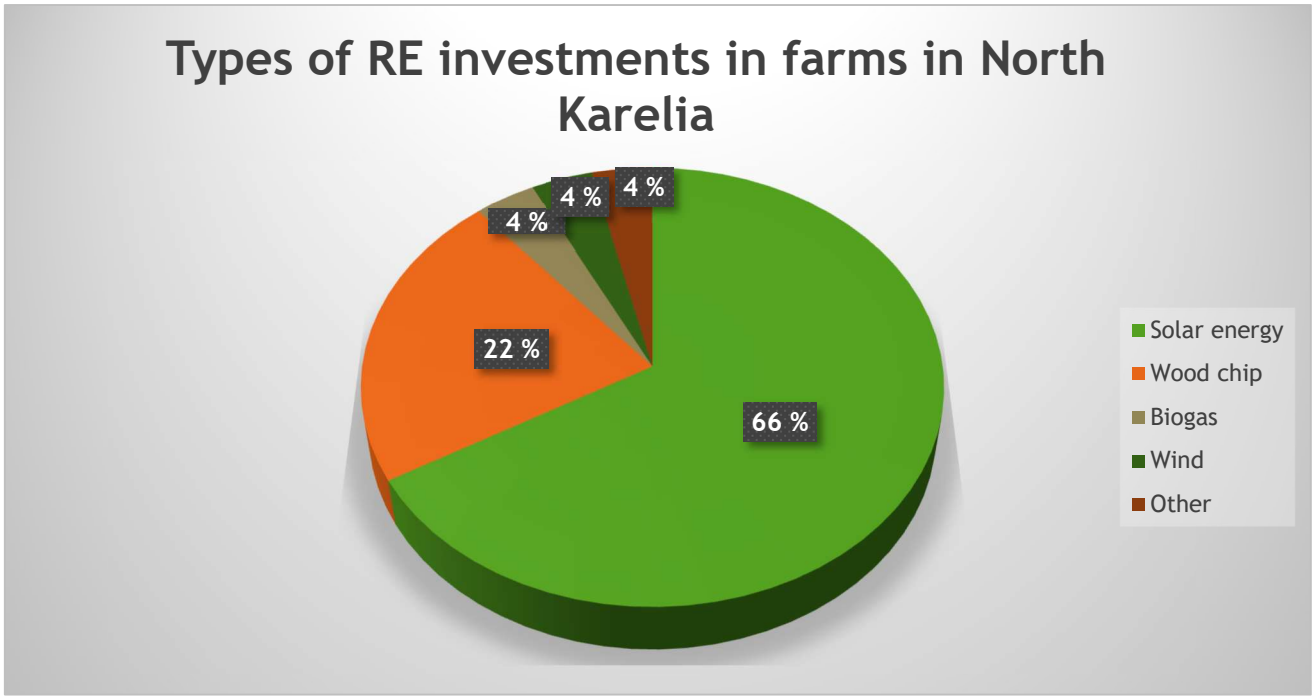


Chart 5. Farm investments supported through EAFRD between 2014-2020 in North Karelia

The renewable energy investments that received financing between 2014-2020 included 18 solar energy installations. Their total eligible costs were 396,250 euros. 40 per cent of this (158,412 €) was covered through agricultural investment aid. In two of the cases, the investment included also a purchase of another renewable energy technology (wood chip and wind). In addition, 5 wood chip heating plants, one biogas plant and one heating plant using some other renewable energy source received agricultural investment aid under the Rural Development Programme of Mainland Finland 2014-2020. Total eligible costs of the 5 wood chip plants were 659,787 euros and the grant received for the investments amounted to 263,914 euros (40%). The biogas plant and heating plant received a total of 114,200 euros of energy aid, which was 40 % of the total eligible investment costs (285,500 €). The total budget of these 25 investments was around 1,1 million euros and the financial support granted for them reached up to 0,5 million euros.

Based on the data on agricultural investment aid, majority of on-farm RES investments that have been implemented in North Karelia in the recent years are solar energy installations. This may be due to their relatively low price and the fact that solar panels require very little maintenance to function. In addition, farm buildings often have large roof space that are well suited to solar energy installations.

Despite this development, the main source of renewable energy produced in the region's farms can be estimated to be wood biomass. See Chart 4 for energy consumption in agriculture in North Karelia. 89 % of the region's land area is covered by forests and they are utilised in energy production. Wood in its different forms (chips, pellets etc.) provides a good source of energy also for farms. Biogas, wind power and hydro-energy plants are still rare in the region's agriculture.

Selling of self-produced energy is not profitable in Finland due to low compensation received for the sold energy. This would suggest that majority of renewable energy produced in the region's agricultural sector is also self-consumed.

II. *Renewable energy consumption in agriculture*

There is no statistical data on renewable energy consumed in farms in North Karelia. However, the statistics on energy consumption in Finnish agriculture suggests that, also in this case, wood is a dominant renewable energy source.

According to Natural Resources Institute Finland, wood and field biomass-based energy represented 44 per cent of the total energy consumption in Finnish agricultural and horticultural companies in 2016. At that time, 27 per cent (3,017 GWh) of energy consumed in the sectors was wood energy produced from wood chips and 14 per cent was from wood energy from chopped firewood or other whole wood.

Energy source	Unit	Consumption	Consumption, GWh [3]	Share of total consumption, %
Electricity	GWh	1 727	1 727	15
Of which self-produced	GWh	14	14	
Motor fuel oil	1000 l	244 622	2 451	22
Heating fuel oil	1000 l	20 287	203	2
Fuel oil for the drying of cereals	1000 l	72 163	723	6
Heavy fuel oil	1000 kg	8 121	102	1
Wood [1]	***1000 loose m³***	**1 076**	**1 614**	**14**
Wood pellets and briquettes	1000 kg	18 371	86	1
Wood chip [2]	***1000 loose m³***	**3 771**	**3 017**	**27**
Field biomass				
Seed yield	1000 kg	13 306	48	0
Straw and others	1000 m³	522	298	3
Milled peat	*1000 loose m³*	96	86	1
Sod peat	1000 m³	339	475	4
Peat pellets	1000 kg	363	2	0
Purchased heat energy	GWh	549	549	5
Total			**11 381**	**100**

[1] *Firewood, chopped firewood, and other whole wood*

[2] *Forest residue chips or chippings, other wood chips*

[3] *The energy source usage amounts have been converted to GWh*

Source: OSF: Natural Resources Institute Finland, Energy consumption of agriculture and horticulture

Table 4. Energy consumption of agriculture and horticulture by source of energy in 2016 in Finland.

Consumption of electricity has been increasing in agricultural and horticultural companies. This is partly due to an increase in the technology used in production facilities, but also largely due to the increase of lighted greenhouse production. Electricity represents 15 percent of the total energy consumption. According to the calculations of Statistics Finland, in 2016, 45 per cent of electricity in Finland was produced with renewable energy. Therefore, 777 GWh of the electrical energy consumed by agriculture and horticulture can be estimated to be renewable.

The table below shows the development of energy consumption in the agriculture and horticulture between 2010 and 2016 in Finland. As the table indicates, the use of wood has increased notably since 2010, while there has been a decrease in the use of heavy fuel oil and heating fuel oil.

Energy source	2010	2013	2016	
	Consumption, GWh [3]	*Consumption, GWh*	*Consumption, GWh*	*Change 2016 - 2010* , GWh
Electricity	1,674	1,509	1,727	53
Of which self-produced	..	..	14	..
Motor fuel oil	2,295	2,304	2,451	156
Heating fuel oil	436	274	203	-233
Fuel oil for the drying of cereals	577	682	723	146
Heavy fuel oil	365	154	102	-263
Wood [1]	**980**	**939**	**1,614**	**634**
Wood pellets and briquettes	81	91	86	5
Wood chip [2]	3,117	3,061	3,017	-100
Field biomass				
Seed yield	41	242	48	7
Straw and others	59	202	298	239
Milled peat	53	168	86	33
Sod peat	496	362	475	-21
Peat pellets	43	42	2	-41
Purchased heat energy	..	..	549	..
Total	**10,217**	**10,030**	**11,381**	**1164**

[1] *Firewood, chopped firewood, and other whole wood*

[2] *Forest residue chips or chippings, other wood chips*

[3] *The energy source usage amounts have been converted to GWh*

Source: OSF: Natural Resources Institute Finland, Energy consumption of agriculture and horticulture

Table 5. Energy consumption of agriculture and horticulture by source of energy in 2010, 2013 and 2016.

See Chapter 2. for information on the use of energy in agriculture in North Karelia. Majority of the energy consumed is used for farm machinery (fossil fuels).

4. Policies and actions promoting renewable energy production in farms and enterprises

In Finland, farmers can receive aid for renewable energy investments mainly through the support systems of Rural Development Programme. Enterprises, on the other hand, can apply funding for renewable energy investments or projects from Business Finland operating under the Ministry of Economic Affairs and Employment or Finnvera which provides financing and guarantees for renewable energy projects. Also, Leader funding is available for smaller renewable energy investments made by associations, foundations, municipalities and small companies if the Leader local action group has prioritised these activities in their local strategies.

I. Support under the Rural Development Programme for Mainland Finland 2014-2020

The 2014–2020 Rural Development Programme for Mainland Finland includes several support forms targeted at farmers:

- investments and setting-up support for young farmers
- environment payments
- organic farming payments
- natural constraint payments
- animal welfare payments.

The programme supports energy efficiency and renewable energy investments in farms (priority 5). **As farms are not eligible for energy aid, this is the only available support system for the abovementioned measures in farms**. The use of payment schemes and other farm development activities are supported through **training and advisory services** for farms, such as Neuvo2020 service.

The Finnish Food Authority (Ruokavirasto) operating under the Ministry of Agriculture and Forestry of Finland is responsible for the use of agricultural and rural development funds in Finland. Applications are submitted to the Centre for Economic Development, Transport and the Environment (regional state administrative authority).

The Rural Development Programme for Mainland Finland 2014–2020 is put into effect through regional rural development strategies and plans. These have been drawn up under the leadership of the Center for Economic Development, Transport and the Environment (ELY center) and they define development priorities for each region. The ELY centers grant funds for the programme on the basis of their own plan. Thus, each region has a slightly different emphasis for utilisation of EAFRD and national funds.

The national and regional plans take into account EU-level and national climate targets. One of the priorities in the Rural Development Strategy of North Karelia 2014 - 2020 is to use natural resources in a sustainable and smart way. This includes utilisation of renewable energy from local resources and decentralized energy production.

Target groups	farms, small and medium-sized enterprises in rural areas, people living in rural areas, communities, development organisations and municipalities
Funding	Public funding for the Rural Development Programme for Mainland Finland 2014-2020 is 8,365 billion euros. The programme is funded under the European Agricultural Fund for Rural Development (EAFRD) and national contributions. Public funding for the Rural Development Strategy of North Karelia 2014-2020 is 344 million euros.

Agricultural investment aid

The agricultural investment aid can be used for construction investments in agriculture and for purchasing machines and equipment needed in farming. It can also be used for construction of on-farm energy plants or for heating systems that are used for drying agricultural products. The investment is eligible only if the energy is used in agricultural production activities. The plant must utilise renewable energy. If aid is granted for an investment which main purpose is to produce electricity from biomass, at least 10 % of the total energy production must be thermal energy.

Target groups	farmers, private bodies engaged in farming, associations of farmers
Amount of funding granted for investments	Renewable energy investment aid covers 40 % of total investment costs. The amount of support is always over 7,000 euros. Maximum grant per farm over a period of 3 tax years is 1,5 million €.
Funding	The total budget for agricultural investments under the Rural Development Programme for Mainland Finland 2014-2020 is 1 104 million euros. Out of this, 656 million euros is national funds. This budget covers all agricultural investments. In North Karelia, around 21 million euros of public funds is reserved for agricultural investments under the Rural Development Strategy of North Karelia 2014-2020.
Managing authority	Ministry of Agriculture and Forestry of Finland, Center for Economic Development, Transport and the Environment
Results	According to an evaluation made by the Ministry of Agriculture and Forestry of Finland in 2019, between 2015 and 2018, the total investments in renewable energy production within the programme were around 22,5 million euros in Mainland Finland. Thanks to the programme, the use of renewable energy increased by 342,4 GWh a year by the end of 2018. Between 2016 and mid-2020, 27 renewable energy investments were supported in North Karelia under the Rural Development Strategy of North Karelia. See Chapter 3 for more information.

State guarantee for investments

The state may guarantee a farm's loan that is connected to renewable energy investment. The maximum amount of state guarantee per investment is 500,000 €. The state guarantee may cover up to 80% of the loan.

Neuvo2020 service

Advisory services are available to farmers, for example, on the following issues:

- environmental matters: opportunity to have an environmental plan drawn up, addressing a wide range of farm-related environmental issues
- health and welfare of production animals: opportunity to have a health care plan drawn up for production animals
- more efficient energy use and renewable energy: opportunity to have an energy plan drawn up to enhance the farm's energy efficiency

Advisory services are an inexpensive option for farms. They are expected to increase the positive environmental impact of farms, increase the health and welfare of farm animals, improve competitiveness and increase energy efficiency and climate friendliness. In addition, farmers knowledge of available support systems is expected to increase.

Target groups	farms
Amount of funding granted for farms	In 2015 to 2020, a farm may use a total of EUR 10,000 euros for advisory services. The maximum cost of one advisory visit may be 1,500 euros. Farms pay only the share of value-added tax.
Funding	The funding reserved for advisory services under the Rural Development Programme for Mainland Finland 2014-2020 is 29 million euros. (Reference).
Managing authority	Finnish food Authority, service provided by Centre for Economic Development, Transport and the Environment
Results	By the end of December 2019, 18 715 farms in the Mainland Finland used advisory services and around 60 000 visits were made to farms by the advisors approved in the advisory register. (Reference). According to a study commissioned by the Ministry of Agriculture and Forestry of Finland (Reference), the advice service has been useful in terms of complying with the farm support conditions, crop planning and the making of future plans for the farm. However, there have been some regional differences in the availability of farm advisors. Finding suitable advisors in some areas has proven to be difficult. In addition, majority of the advisory services provided between 2015-2018 dealt with water use management including the use of fertilisers and pesticides, improving the economic performance and competitiveness of primary producers. Only a small share of farms used the service for renewable energy issues (364 farms out of 32 177).

Leader funding

Leader is one of the tools of the Rural Development Programme for Mainland Finland 2014–2020. In Finland, Leader local action groups (LAGs) are registered associations that develop rural areas by funding local rural development projects and supporting local enterprises. Each group covers a number of municipalities. Projects to be funded must meet the objectives stated in local leader group's development strategy. Leader funding can be granted to development or investments projects that benefit rural communities, their residents and companies. Support may be given to acquisition of materials and supplies for construction or repair or extension of a building or structure. This may include renewable energy installations.

Target groups	Associations, companies with less than 10 employees, municipalities, educational institutions, foundations.

Amount of funding granted for projects	Grant rates are between 20-100% of eligible costs depending on the type of activity.
Funding	Between 2014 and 2020, funding allocated to individual groups will range from 2.9 to 11.1 million euros. Public funding for the Leader groups operating in Mainland Finland amounts to 300 million euros.
Managing authority	Ministry of Agriculture and Forestry of Finland, Leader local action groups
Results	In North Karelia, there are four local leader groups. In programme period 2014 – 2020, they have funded some projects that included installing renewable energy systems, such as solar PV panels or heat pumps, at village halls and other community buildings. Separate calls have been organised for projects that support investments in sustainable energy solutions.

II. Policies and support instruments for enterprises

These policies are targeted mainly at enterprises and communities. Farms are eligible for funding only in exceptional cases.

Energy aid

Based on its assessment the Ministry of Economic Affairs and Employment can grant aid for innovative energy projects. The key aim of energy aid is to promote the development of innovative solutions for replacing the energy system with a low-carbon alternative in the long term. Energy aid can be granted for investment and investigation projects.

Types of intervention:
Energy aid can be granted to investment projects and studies that:

- promote the production or use of renewable energy
- promote energy savings or increase the efficiency of energy generation or use
- or otherwise promote the transition towards a low-carbon energy system.

Investments in renewable energy use that are eligible for support:

- small-scale electricity and heat production projects
- projects producing biofuels for transportation
- demonstration projects for new technology

Investments in energy savings and energy efficiency that are eligible for support:

- projects involving conventional technology for beneficiaries that have signed an energy efficiency agreement
- demonstration projects for new technology
- ESCO projects

Aid can also be granted to energy audits and analyses.
More information: Energy aid - Business Finland

Target groups	companies of all sizes, including self-employed persons, traders and sole traders, communities and organisations, such as municipalities, parishes and foundations. The aid is not granted to farms, with the exception of projects where 80 % of the energy produced is used outside of the farm.
Amount of funding granted for investments	The investment costs of the projects entitled to the aid must be at least 10,000 euros. Support rates vary between 10-30 % depending on the project type. For example, biogas projects may be granted support for 20-30% of total investment costs. For investigation projects, the maximum support rate is 40 % of eligible costs.
Funding	In the state budget proposal for 2020, the budget for energy aid is 60,750,000 euros. It has been evaluated that in 2019 47,250,000 euros was used for the aid. In 2018, the used budget was 30,708,102 euros. (Reference).
Managing authority	Ministry of Economic Affairs and Employment in cooperation with Business Finland which process all aid applications.
Results	Approximately 393 million euros of energy aid has been paid in 2013-2019. Out of this, around 270 million euros was used for renewable energy investments and 123 million euros for improvement of energy efficiency. (Reference).

Large-scale demonstration projects

Ministry of Economic Affairs and Employment grants funding also for large-scale energy demonstration projects. This aid is granted to investments that are over 5 million euros and it is intended for energy solutions that help achieve national and EU-level energy targets for 2030. Supported projects should fit into the following categories: 1. renewable transport fuels, 2. non-combustion heat production, 3. projects demonstrating other emerging energy technologies.

Target groups	companies and communities, such as municipalities. Farms are not eligible for funding.
Amount of funding granted for projects	The aid may be up to 40% of total eligible costs.
Funding	Same as in energy aid.
Managing authority	Ministry of Economic Affairs and Employment in cooperation with Business Finland.
Results	Same as above.

Financing from Finnvera

Finnvera provides financing for the start, growth and internationalisation of enterprises and guarantees against risks arising from exports. Finnvera strengthens the operating potential and competitiveness of Finnish enterprises by offering loans, domestic guarantees, export credit guarantees and other services associated with the financing of exports.

Finnvera grants environmental guarantees as security for credits that are used for environmental protection investments, renewable energy projects or projects improving energy efficiency. Suitable uses for the guarantee are, for instance, investments improving water or air protection or the recycling of wastes, as well as renewable energy projects undertaken by companies that need financing for investments in wind power parks, biofuel facilities, thermal power plants utilising forest energy, or other similar applications. The Guarantee can however not be granted for financing that is used to manufacture the devices in the aforementioned projects.

Target groups	The Environmental Guarantee is mainly targeted for large enterprises engaged in industry or in similar production.
Amount of guarantee	Finnvera's coverage of the guaranteed credit is at most 80%.
Managing authority	Finnvera is a specialised financing company owned by the State of Finland and it is the official Export Credit Agency (ECA) of Finland.

III. Other policies for renewable energy investments

In addition to the abovementioned support schemes, feed-in tariff system and premium scheme are available for electricity suppliers for production of renewable energy. The Finnish government supports also private households in replacing oil heating systems.

Feed-in tariffs

In Finland, the Energy Authority is responsible for the implementation of the EU renewable energy policy and the national renewable energy policy. The Energy Authority governs the feed-in tariff scheme for renewable energy subsidies, arranges auctions for renewable energy subsidies and transport infrastructure projects, as well as collects wind power charges.

Feed-in tariffs support production of electricity in power plants fuelled with wind, biogas, forest chips and wood-based fuels. The feed-in tariff is paid for 12 years, starting from the year when the plant is approved in the system. Since 1st November 2017, new wind power plants are not accepted in the feed-in tariff system and the system closed for new biogas and wood fuel power plants on 1st January 2019. Wood chip power plants may be included in the system until 1st February 2021.

Target groups	Electricity suppliers
Amount of funding granted for projects	The subsidy varies on the basis of a three-month electricity market price or the market price of emission allowances.
Funding	For 2020, the Finnish Government has budgeted 232 550 000 euros for renewable energy production aid. This includes both feed-in tariff and premium schemes.
Managing authority	Energy Authority operating under the Ministry of Employment and the Economy
Results	Information on power plants approved in the feed-in tariff system (in Finnish): https://tuotantotuki.emvi.fi/Installations

Premium scheme for renewable energy

Finland's premium scheme for renewable energy is a combination of a sliding and fixed premium and applies to wind power, solar power, wave power, biogas and wood fuel power. The operating aid is awarded to successful projects on the basis of call for tenders. Aid will be paid for a period of 12 years.

All electricity suppliers eligible for feed-in premium will receive a premium based on their respective tenders (pay-as-bid). A full premium is paid when the average of the three-month market price of

electricity is equal to or lower than the reference price of EUR 30 per MWh. If the market price exceeds the reference price, a sliding scale will be used. No aid will be paid if the market price is higher than the sum of the reference price and the approved premium.

Target groups	Electricity suppliers
Funding	For 2020, the Finnish Government has budgeted 232,550,000 euros for renewable energy production aid. This includes both feed-in tariff and premium schemes.
Managing authority	Energy Authority operating under the Ministry of Employment and the Economy
Results	Support for seven projects awarded through auction - Energiavirasto

Grant for replacing oil heating systems

The Finnish government provides support for replacement of oil heating systems with other forms of heating in detached houses. In order to be eligible for the grant, the new system cannot be fuelled with fossil fuels.

Target groups	Private individuals who own a detached house or an apartment in a detached house. The house must be in a year-round residential use.
Amount of funding granted for households	The grant is either 2,500 or 4,000 euros depending on the new form of heating. If the oil heating system is replaced with district heating, geothermal heat pump or air to water heat pump, the grant awarded is 4,000 euros. In other cases, the grant is 2,500 euros
Funding	Approximately 28 million euros was allocated for the grant in 2020 and around 9,4 million euros has been set aside in the state budget for this support instrument in 2021.
Managing authority	Pirkanmaa Centre for Economic Development, Transport and the Environment (ELY-Centre)
Results	By December 2020, 7,567 grant applications were submitted to the Pirkanmaa ELY-Centre. So far, 1,902 detached houses have been approved to receive the grant.

Development Fund for Agriculture and Forestry (Makera)

The Development Fund for Agriculture and Forestry (Makera) grants R&D funding for research activities that have broad-ranging benefits for the agri-food sector. The main focus is on research concerning the sustainable development of the profitability and competitiveness of livelihoods. Makera also provides funding for research on reindeer husbandry, natural means of livelihood and development activities in the Skolt Sámi area and rural research and development projects.

Target groups	Universities, universities of applied sciences and state-funded research institutes, research and guidance organisations that are outside of state finances and may receive state funding, private consulting companies.
Amount of funding granted for projects	The share of funding granted by the Ministry of Agriculture and Forestry for research and development projects is discretionary. The Ministry funds projects either fully or partially (co-funded projects).
Funding	State funding for the projects is around 4 million euros a year. In 2021, the Development Fund will finance 17 new agricultural, food and research projects with a total of c. 3,95 million euros.
Managing authority	Ministry of Agriculture and Forestry

IV. *Strengths of policies promoting renewable energy production in the agricultural sector*

The use of renewable energy is promoted in a variety of ways and through different authorities. However, farm RE investments are funded mainly through the Rural Development Programme for Mainland Finland. Management of these different support systems (agricultural investment aid, Neuvo2020 services) is, therefore, well-coordinated and their results are monitored regularly.

Rural Development Programme's agricultural investment aid is suitable for different kinds of renewable energy investments. The funding rate (40% in 2020-2021) is fairly high which promotes purchase of technologies that have short payback periods and good profitability. These include solar energy installations and wood chip plants. For biogas plants, the investment aid should be higher.

In addition to support policies that are targeted directly at farms, there are policies that fund renewable energy investments of rural enterprises or households. Also, different development projects have been implemented to investigate the possibilities of energy production and use in farms. All of these policies are needed to promote the spread of renewable energy in the agricultural sector.

Finland has made changes to its tax regime to boost small-scale renewable energy sector. Currently small-scale renewable electricity producers (capacity less than 100 kVA) are exempt from energy taxation.

V. *Weaknesses of policies promoting renewable energy production in the agricultural sector*

Following weaknesses have been identified in the abovementioned policies and other regulations and policies affecting the use and production of renewable energy:

- Agricultural investment aid is granted only for investments where the energy is used in agricultural production activities. Thus, it prevents selling of energy.
- There are no policies on sale of energy. The compensation received for energy that is sold to national grid is very low.
- Majority of advisors that work in the Neuvo2020 advisory service are experts in environmental and competitiveness themes. There are fewer advisors that can provide guidance in energy issues and organic farming. There are also some regional differences in the number of advisors available.
- Biogas plants do not receive gate fee (feedstock reception) for taking in manure. This has decreased the use of manure or cattle slurry in biogas plants that are not located in farm sites. Transporting manure from farms to biogas plants is expensive.
- Permit procedures for biogas plants are complicated. Different laws and regulations need to be considered in order to get a permission for the use, production or storage of biogas. Permit procedures should be made less complicated and less time-consuming.

- If diesel-fuelled machines are converted to biogas, they are still taxed based on their previous power source. See tax levels here: https://www.traficom.fi/en/transport/road/structure-and-quantity-vehicle-tax
- Under the Act on promoting the use of biofuels for transport (446/2007), a distributor of transport fuels liable to pay tax has the obligation to supply biofuels for consumption. By 2029 the share of the total energy content of the petrol, diesel oil and biofuels supplied by the distributor for consumption to be accounted for by the energy content of biofuels will steadily increase to 30 per cent (distribution obligation). Biogas (methane & biomethane) is not included in this distribution obligation. It concerns only liquid biofuels.

VI. Coherence of policies with respect to the goals of reducing greenhouse gas emissions.

The key pillar of Finland's national climate policy is the Climate Change Act that entered into force on 1 June 2015. According to the Act, Finland must reduce its greenhouse gas emissions by at least 80% by 2050 from the levels in 1990. The Climate Change Act will be reformed to meet the new objectives set by the Prime Minister Sanna Marin's Government. Finland aims to become carbon-neutral in 2035 and carbon-negative soon after that. The Act will be reformed in such a way that the targets concerning carbon neutrality, i.e. a balance between emissions and sinks, by 2035 will be reached. The Climate and Energy Strategy and Medium-term Climate Change Policy Plan (KAISU) will also be updated during 2021. (Reference).

The climate policy planning system under the Climate Change Act consists of the Long-term Climate Change Policy Plan, Medium-term Climate Change Policy Plan and Adaptation Plan, and a separate Energy and Climate Strategy. The Medium-term Climate Change Policy Plan presents the measures to mitigate greenhouse gas emissions caused by human activity in building-specific heating and cooling, agriculture, transport and waste management and in terms of industrial F-gases, as well as estimates of the trends in greenhouse gas emissions and impacts of policy actions on these. (Reference).

All of the abovementioned support systems and other policies that have not been discussed in this report (e.g. policies targeted at other sectors) have played their part in Finland's adaptation to climate change. By 2019 Finland's carbon emissions had reduced by 26 % from the levels in 1990. More effective measures are needed to eliminate greenhouse gas emissions by 2035.

Although the policies and incentives support the production of renewable energy in agriculture and rural communities, new policies are needed to increase the use and production of biogas. Biogas has a key role in the efforts of achieving carbon-free transport and significant reduction in GHG emissions in Finland. It also improves circular economy and secures energy supply. Still, the current instruments do not unlock the full potential of biogas. New investment, energy and production aids are needed to develop biogas production and improve its profitability. Improvements in the distribution infrastructure and commitment from public organisations are also required. For instance, use of biogas in public transportation could promote development and increase demand.

The competitiveness of biogas in the transport sector would improve if biogas (methane & biomethane) were included in the national distribution obligation under the Act on promoting the use of biofuels for transport (446/2007). This would put biogas on an equal footing with other fuels.

Although there is great potential to produce biogas from agricultural side streams (manure, energy crops), farm-scale biogas plants are still quite rare in Finland. This is due to their high investment costs, long payback time and profitability. Financing options should be developed, and permit procedures made more flexible to encourage farm-scale biogas production.

Key measures to increase renewable energy use in the agricultural sector in North Karelia

According to a study on the renewable energy potential in the agricultural sector in North Karelia (2021), additional measures are needed to increase the use of renewable energy in agriculture and, thus, reduce the sector's greenhouse gas emissions. Most significant results would be gained through policies that encourage farm-scale biogas production, decrease use of fossil fuels in heating and promote replacing diesel engines in farm machines. More detailed actions to promote these three measures are listed in Table 6.

Abandoning fossil fuels in heating

- Identifying alternative heating solutions for sites that use fossil fuels
- Influencing the operating environment, e.g. to increase investment subsidies
- Reduction of heating demand and energy efficiency measures
- Guidance and advisory services to increase know-how on the benefits of new heating methods
- Grants to support and accelerate investments

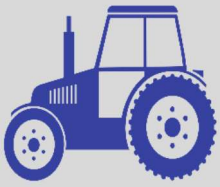
- **Key players**: farmers, advocacy groups, government, manufacturers

Farm-scale biogas production

- Influencing the operating environment, e.g. promotion of various investment, energy and production subsidies to improve profitability
- Incentives to replace natural gas with biogas
- Making the permit process less complicated
- Biomethane as part of national distribution obligation
- Improving investment aid eligibility criteria: also investments that produce energy to other than agricultural production activities should be allowed
- Improving financing possibilities
- Increasing the use of biogas in transport, e.g. in public transport

- **Key players**: farmers, advocacy groups, state administration, biogas plant suppliers

Replacing diesel in agricultural machinery



- Development and support of alternative technological solutions
- Increasing the use of renewable, biodiesel
- Influencing the operating environment, e.g. to improve subsidies for the purchase of machinery
- Development of machine leasing solutions and offer.
- Support for gas filling stations and distribution infrastructure
- Registration of biogas tractors for road use
- Promoting the production and use of hydrogen

- **Key players:** farmers, advocacy groups, government, manufacturers

Table 6. Measures to decrease GHG emissions in the agricultural sector in North Karelia.

5. Analysis of the operational environment

The study on renewable energy potential in the agricultural sector in North Karelia (2021) by Gaia Consulting Ltd. identified measures that would increase renewable energy use in the region's agricultural sector. The study analysed the potential of different measures based on political, economic, social, technological, environmental and legal factors. See the analysis below in tables 7-9.

	Political	Economic	Social	Technological	Environmental	Legal	Potential	Feasibility
Production of biogas from field biomass	Investment aid available for production of energy for farm activities. Investment support available for larger installations. The state is developing incentives to replace natural gas with biogas in industrial processes. Amendments to investment aid have been proposed to increase large-scale investments. Same certification system for off-grid as for on-grid gas production and opening of the European certificate market.	Distribution obligation and inclusion in taxation may increase the price of biogas. Maintenance of energy crops costs, while utilisation of uncultivated fields and sidestreams is less expensive. Production in small plants is not yet cost-effective. Transportation to distribution points weakens profitability.		High potential in raw materials, up to 5-12 TWh from uncultivated fields.	Production of grass biomass can be increased by 10-15 % by 2050, also the share of biogas produced from this biomass can be increased. Processed material (digestate) can be used as biofertiliser and soil conditioner.	Currently, aid is granted only to investment that produce energy for agricultural activities.		
Production of biogas from manure	Support has been proposed for recycling of manure and nutrient cycle.	Biogas plants do not receive gate fee for manure, transporting of manure is relatively expensive. Same remarks as above.	Decreases odour nuisance caused by manure that is used as fertiliser in fields, there might be some odours near the plant.	High potential in raw materials, 3 TWh a year in Finland	Enables more effective nutrient cycle in agriculture. Reduces methane emissions.	Streamlining permit processes could promote production in the future. Same remarks as above.		
Wood bioenergy	Decisions concerning carbon sinks and harvesting volumes impact on the availability of raw material and its price.	Farms often already have a suitable boiler for heating. Availability of wood chips depends on regional harvesting volumes. Price is low compared to oil or natural gas.	Raw material is often local. Use of local raw materials has positive effects on regional economy.	Technology exists, efficiency could be improved. CHP production is possible. Forest industry improves its efficiency in terms of raw material use. This reduces side-streams, i.e. available raw material for energy production.	Especially chips made of logging residues reduce carbon dioxide emissions caused by heating.			

Table 7. Operational environment: energy production from biomass.

	Political	Economic	Social	Technological	Environmental	Potential	Feasibility
Solar energy	Energy communities improve profitability of large investments. In the future, the investment aid may allow selling of electricity. Taxation of self-produced electricity determines profitability.	Investment costs will decrease in the future. Suitable especially for sites where electricity consumption is significant also in spring/summer and during the day, such as animal & dairy farms. Possibility to purchase renewable energy certificates instead of producing own energy.	Interest towards energy communities and energy self-sufficiency is on the rise. This will increase interest towards solar power.	Hourly-based net-metering would decrease taxation of sale and purchase.	Solar energy's direct carbon footprint is zero, lifetime emissions are low. On-grid electricity's carbon footprint will decrease notably in the 2020s. I.e. environmental impact of solar energy will not be as notable as it currently is.		
Geothermal energy and other heat pumps	Possibility to get investment aid.	High initial investment costs. Low operating costs from heating.	Installing systems in sludge lagoon/container decreases odours.	Flexibility provided by heat pump systems in terms of energy demand.	Small carbon footprint compared to fossil heating systems and district heating, especially as the on-grid electricity is becoming carbon neutral.		
Wind energy	Same remarks as for solar energy.	Large-scale wind farms are profitable. Possibility to purchase renewable energy certificates instead of producing own energy.	Building wind plants close to residential or recreational areas is problematic. Restrictions set by the Finnish Defence Force (wind farm's effect on military surveillance radars).	Hourly-based net-metering would decrease taxation of sale and purchase.	Same remarks as for solar energy.		
Replacing light fuel oil (LFO) in grain drying	Possibility to get investment aid.	High power demand and investment costs. Using renewable fuel also for other heating purposes may increase profitability. Replacing is profitable if drying volumes are high.	Shared dryers equal shared investment costs. Use of wood chips from own forests.	Alternative energy sources incl. wood chips, straw, peat, biogas and district heating. Possibility to use another fuel for additional heat production.	Solid biofuels, district heating and electric heating reduce carbon emissions.		

Table 8. Operational environment: energy production from other renewable sources.

	Political	Economic	Social	Technological	Environmental	Potential	Feasibility
Electric and more energy-efficient farm machinery	Possibility to get investment aid. Energy-efficiency agreements.	Utilisation rate of the current machinery is low and purchasing new machines is expensive. If machinery is renewed, leasing options could be more profitable.	Guidance and advisory services.	Development of battery technology and electrification of transportation support this market.	Emissions from the use of machinery decrease. Ecological impact at the manufacturing phase and at the end of the machine's lifecycle may be significant (batteries).		
Liquid biofuels in farm machinery	10% distribution obligation for biofuels increases the share of renewable energy.	Does not require new machinery.		High share of biofuels may cause problems in engines and fuel systems.	Emission reduction potential depends on the mixing ratio of biofuel.		
Biogas in farm machinery	Investment aid available for new investment or modifications. Grant system may be established for development of distribution infrastructure for biogas filling stations. Subsidy for purchasing fuel-powered heavy vehicles is being planned.	Renewal of machinery and modifications are relatively expensive. If machinery is renewed, leasing options could be more profitable. There are only few biogas filling stations in Finland.		Technology exists but it is not mass produced. Potential of raw material is high.	Carbon footprint of biogas is very small compared to fossil fuels.		

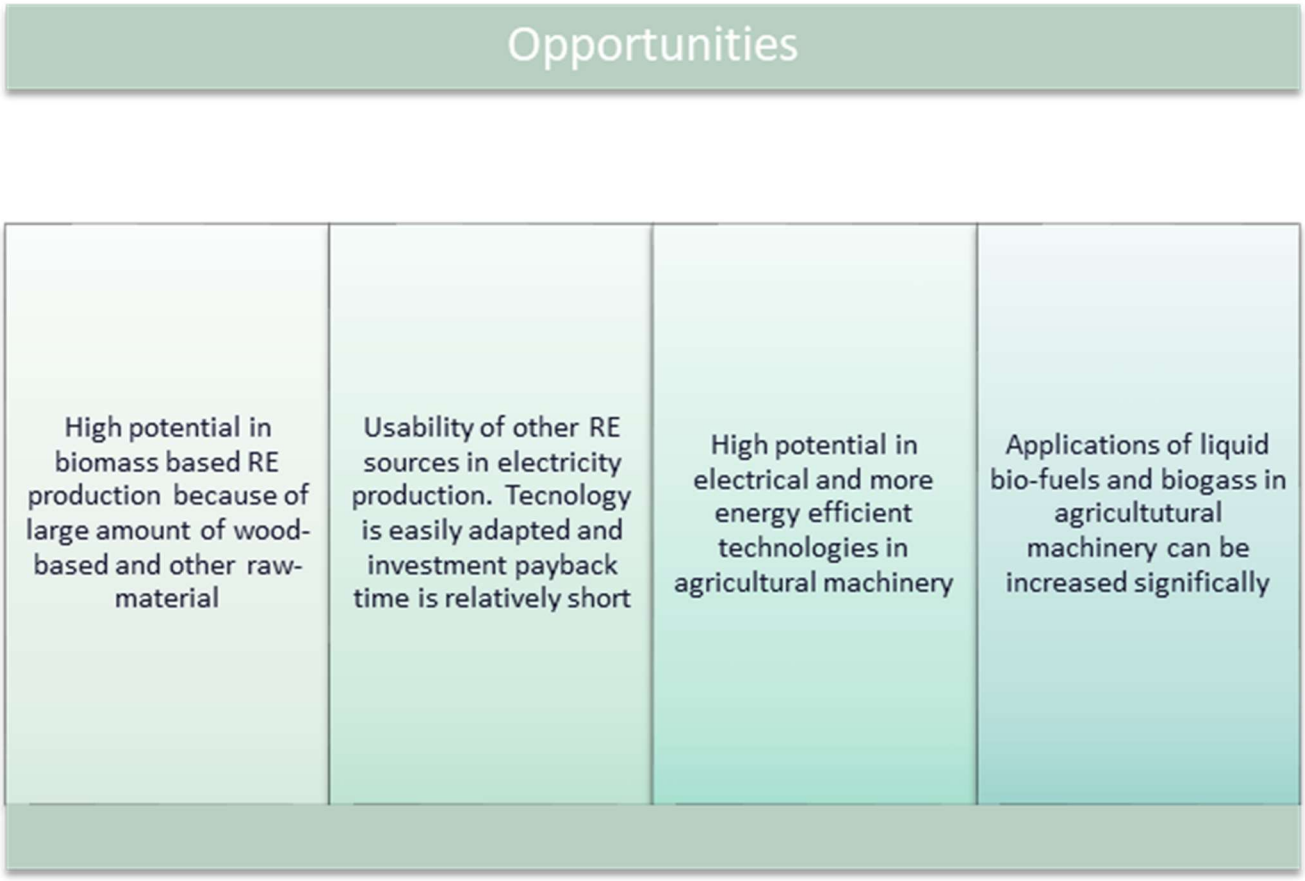
Table 9. Operational environment: farm machinery.

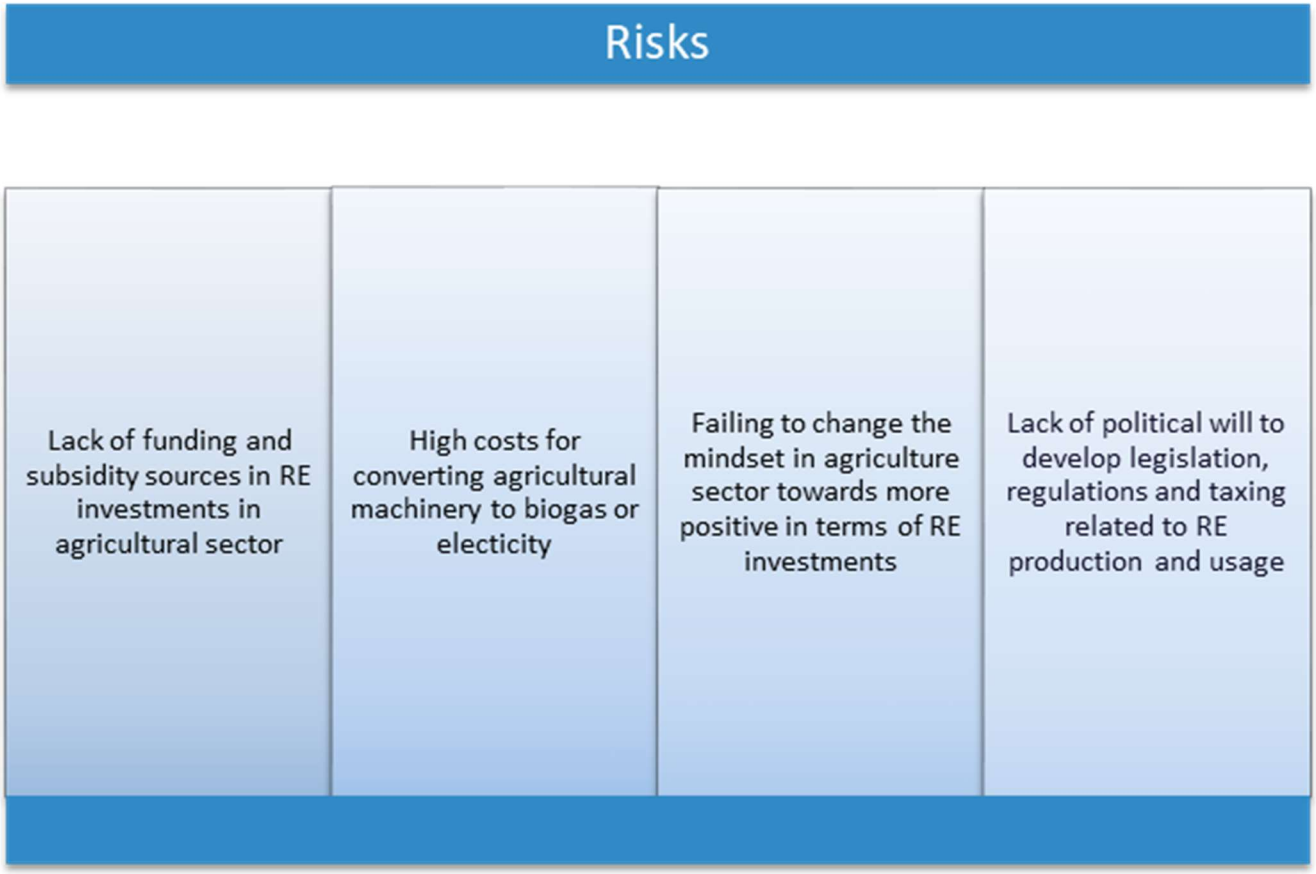
6. Risks and opportunities from policies and market for the spread of renewable energy in agriculture

From the spring 2020 there has been impact of the COVID-19 also in region of North Karelia. Although situation has been quite good in terms of infection numbers, there has been a need for different kind of actions and restrictions to protect also agricultural sector. Most visible impact has been a lack of availability for seasonal workforce needed in harvesting.

Situation has also raised a public question of need for certain level for self-sufficiency of groceries and there is a high level of common acceptance towards this. In long term there might be some positive impacts in terms of funding directed to agriculture because of this. Digitalization is already a part of everyday life also in agriculture and it is going to be even more actively used now, so perhaps some development will be achieved also in that sector – both technical and knowledgeable.

Our recent survey has identified both risks and opportunities in terms of renewable energy development and diffusion in the agriculture sector of the North Karelia region. They are categorized separately in a summary tables below.





In order to change the general mind-set toward more positive in terms of renewable energy investments it requires lot of work and actions in EU and national level. Legislation, regulations and subsidy-systems need to be updated and developed. Guidance and sources of funding need to be easily available, because usually even on farm-scale investments requirements are relatively high compared to advantage received. These investments need to be competitive also compared to the "old" way of doing things in order them to succeed.

Nordic countries have a special conditions also in terms of climate. Growth season in northern parts of Finland is shorter and there is a larger demand for heating because of cold and long wintertime. This has to be taken account when planning implementation and technical applications in all sectors, including agriculture.

Agriculture sector in Finland and North Karelia have a long history of using wood and forest application in heat production. All RE innovations related to this might be more easily adapted and accepted among the sector. It seems that concentrating and emphasising on this could be a successful route towards RE implementation.

7. Conclusions

As a conclusion for diffusion of RE production in agricultural sector in the region results can be presented in a SWOT-analysis. Recent study we completed as a part of AgroRES project implementation has given us a lot of interesting and valuable data from the agricultural sector in our region. It has also provided two different scenarios for the future depending on the actions made for promoting diffusion of RE production. We have recognized the most potential aspects (opportunities) and notable risks for the future. The current status of RE in agricultural sector in North Karelia is also now made visible for everyone.

Main strengths and opportunities of the subject are heavily related to long experience and high level of RDI expertise in wood and forest industry. All RE applications that are somehow related to this are more easily accepted also among agriculture sector. There is a significant potential especially in biomass-based biogas production and also liquid biofuels. National and regional strategies also support these measures and there is a good amount of technical and advisory support available for the subject.

STRENGTHS	WEAKNESSES
- The use of RE in the agricultural sector is promoted in a variety of ways and through different authorities - Rural Development Programme's agricultural investment aid is suitable for different kinds of RE investments - Finland has made changes to its tax regime to boost small-scale renewable energy sector	- Agricultural investment aid is granted only for investments where the energy is used in agricultural production activities. Thus, it prevents selling of energy - Biogas plants do not receive gate fee (feedstock reception) for taking in manure - Permit procedures for biogas plants are complicated
OPPORTUNITIES	**THREATS**
- High potential in biomass based RE production - High potential in electricity and liquid bio-fuels in agricutural machinery - High level of knowledge and RDI of wood and forest industry in the region	- Lack of funding and subsidity sources in RE investments in agricultural sector - Failing to change the mindset in agriculture sector towards more positive in terms of RE investments - Lack of political will to develop legislation, regulations and taxing related to RE production and usage

Table 10. SWOT analysis for diffusion of RE in agricultural sector in North Karelia.

Weaknesses and threats for the renewable energy diffusion in the region are related strongly to sufficient funding, legislation and financial support for the investments. Because of the high potential in biogas one crucial question is how to make farm scale biogas investments economically relevant. Investment payback time need to be reduced in all RE applications in order to make them more acceptable and tempting.

There is also a need for update and renewing the taxation and other regulation for RE production at the national level. Permit procedures need to be simplified and solid guidance has to be available for farms. Changing the general mindset towards more positive for RE is a slower process and it contain many different aspects.

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