Feasibility study on the sustainable energy potential of LECO pilot community Porjus

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Content

Introduction

The LECo-project shall respond on the needs of remote communes and settlements for a sustainable energy supply. For this purpose, an approach shall be developed to use as far as possible existing renewable resources for the energy supply improving building stock standards by combining new technologies with locally available natural resources. In order to create synergetic effects to the local economy and social coherence it is intended to base the project on Local Energy Communities (LECo) either as municipal enterprise or as a cooperative. As far as available local companies shall be involved in investments and thus upgrade their skills for future activities in the energy business. The project shall deliver a set of locally adapted concepts for Community based energy solutions in remote areas.

Ensuring a reliable, sustainable and affordable energy supply is particularly challenging in the remote and sparsely populated communities in Norrbotten, especially due to their low critical mass and issues linked to the harsh climatic conditions of many parts of the area. As consequence of access to relatively cheap energy historically a firm tradition of energy efficiency and high-yield insulation of buildings is missing.

LECO project intends to make use of the concept of “energy villages” which has been developed and implemented in a broad range of German and Austrian communities. These villages are often situated in rural and remote regions and face similar problems to communities in Northern Sweden, specifically problems of depopulation, a decrease of economic activity and a loss of jobs in the communities. By implementing local sustainable energy solutions and thus creating both added regional value and new innovative business concepts this trend could be stopped. An essential part of the work done was on empowerment of people.

Geography and climate

Jokkmokk is a city with the centre just over 110 km inland from the Gulf of Bothnia, situated at the Arctic Circle. Jokkmokk has ca. 5000 inhabitants on a large area of 19 474 km2. Around half of that area is National parks.

The big rivers in the municipality produce about 11-13 TWh electricity per year. However, the plants belong to the governmental company Vattenfall in Stockholm and taxes are paid there. Only a small compensation for the negative impacts of hydro power plants and dams are paid to local communities by Vattenfall.

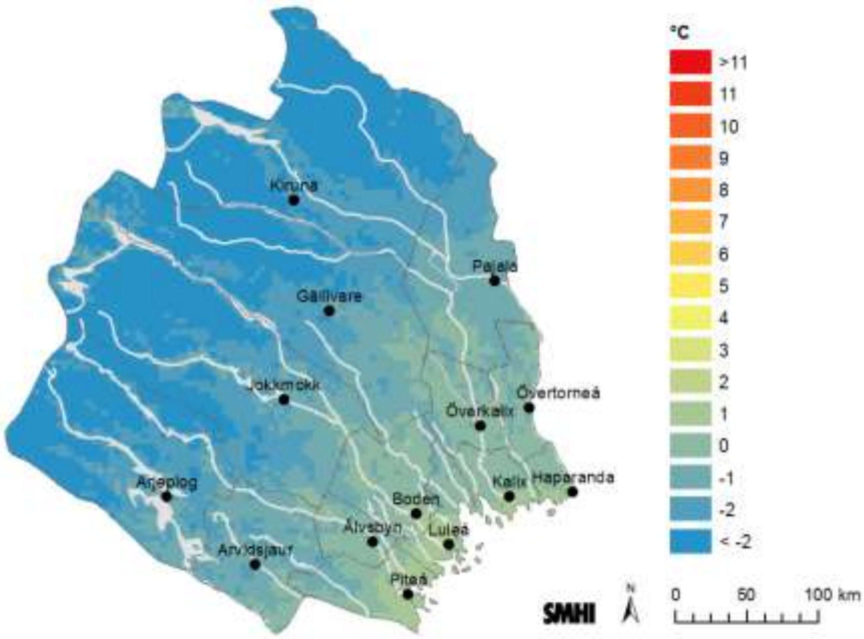
The pilot Porjus is a village within Jokkmokk municipality’s boundaries with about 350 inhabitants (2017). Porjus was Vattenfall's first large power plant in Jokkmokk municipality. From 1910 until today, there are clear traces of different stages in a successive hydropower expansion. It was not intended that Porjus should remain as a society, it would be dissolved when the power plant was completed, only the housing staff's housing would remain. But then the case was not. At the most, there have been 3000 registered residents as another power plant (Harsprånget) was built. In 1990, the National Heritage Board decided that Porjus community was of national interest for the cultural environment care, as it is the country's only preserved power plant community.

Today the hydro power plant can produce 1260 GWh per year, which places Porjus in third place among Vattenfall's all power stations in Sweden. Porjus has a school, sports hall, kiosk, petrol station, a small skiing area and hostels. In 2018, the municipality Jokkmokk sold one of the bigger facilities to a data centre company.

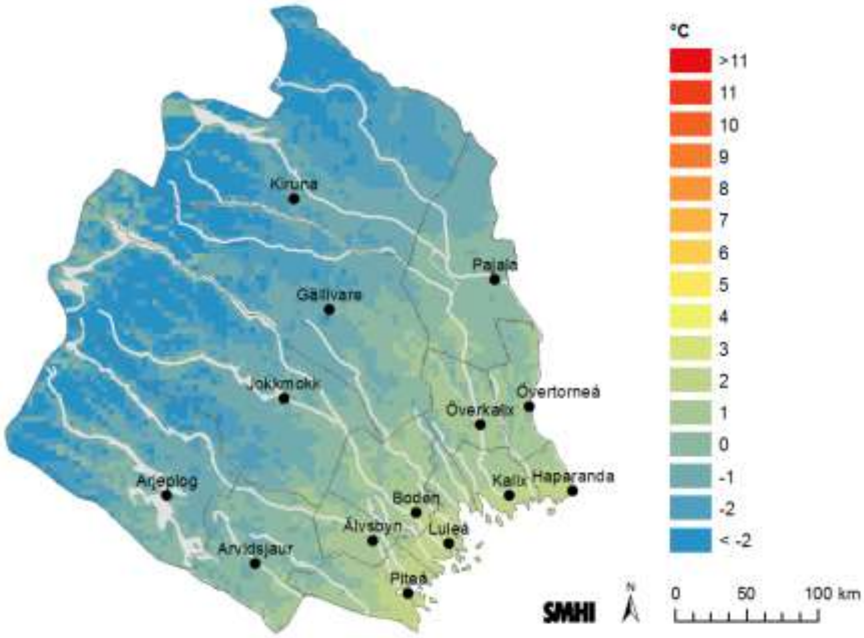
Map Porjus community. Source: Land-use plan Jokkmokk municipality

The annual mean temperature in Jokkmokk has been –2C in the period 1961-1990, but due to climate change, the average temperature is increasing in the last decaded and is expected to do so even over the next decades. Maps are showing annual mean temperature. Together with the annual average precipitation, it is the most widely used index to describe the climate.

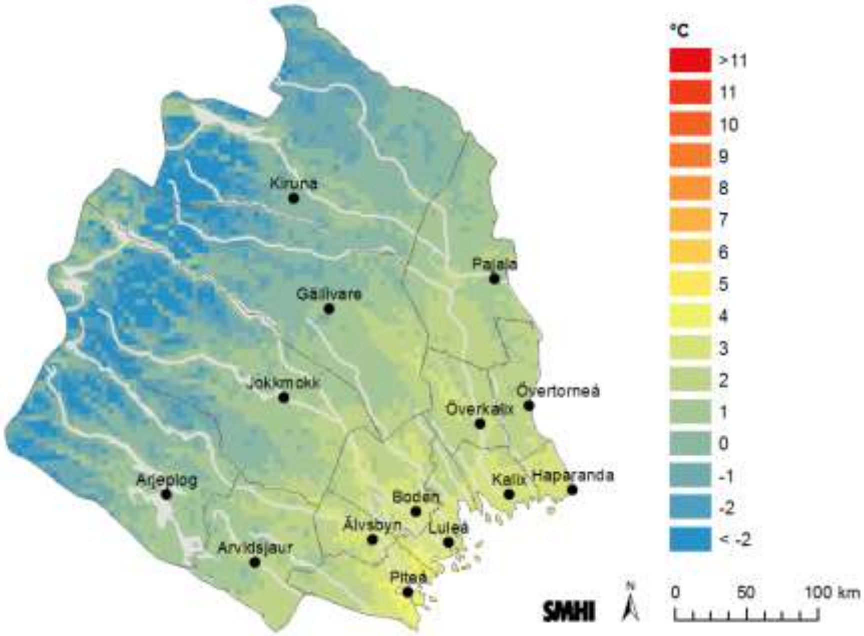
Map 1: Observations 1961-1990, Source SMHI



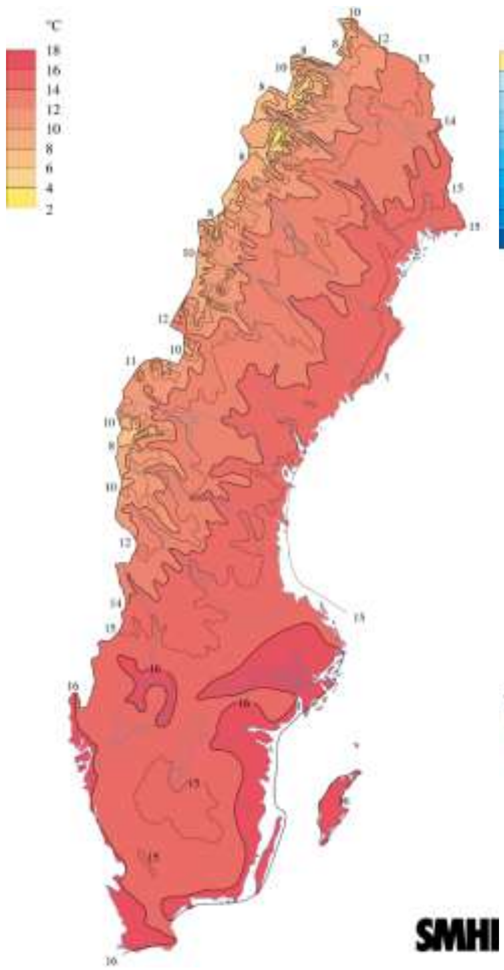
Map 2: Observations 1991-2013, Source SMHI

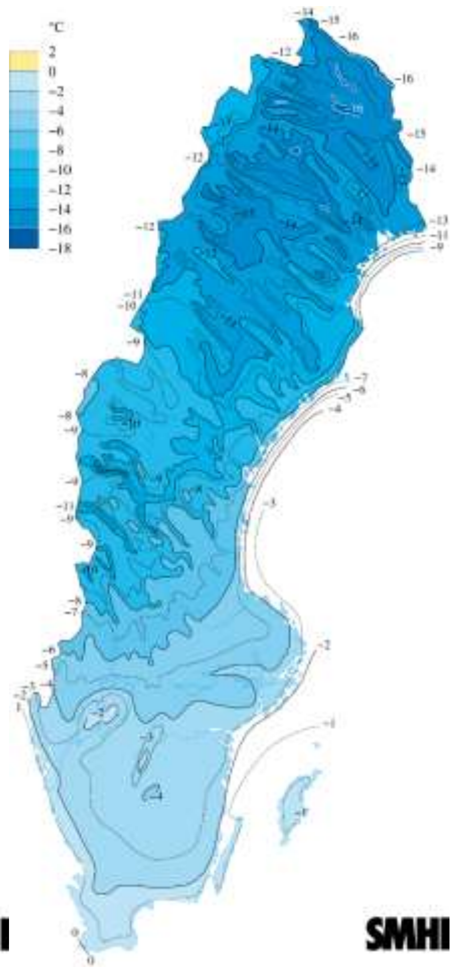


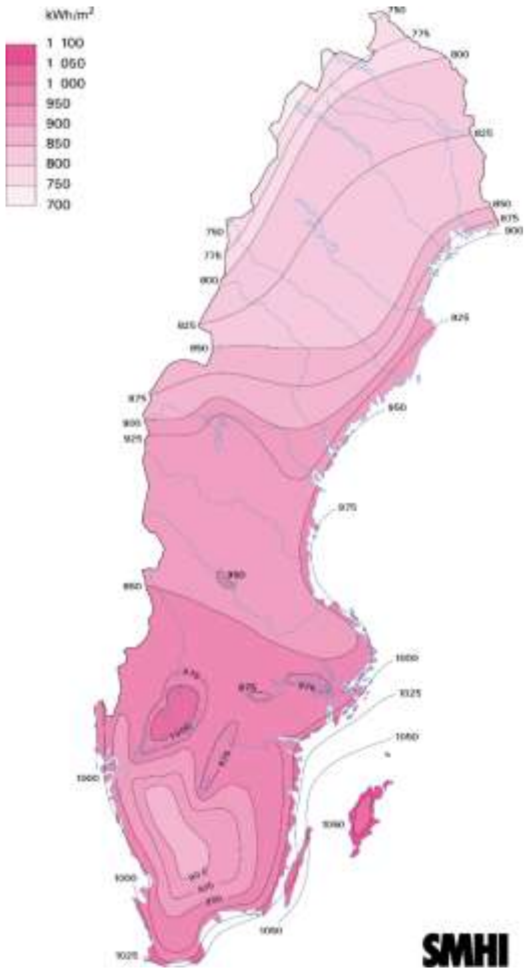
Map 1: Future development according to IPCC scenario scenario RCP 4.5, Source SMHI



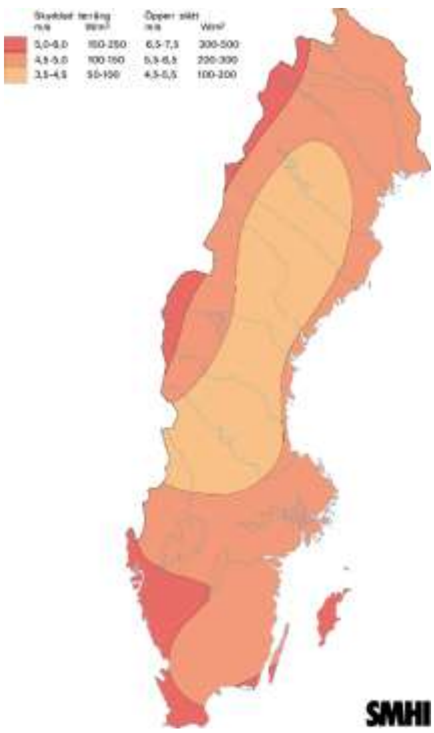
Temperature differs significantly over the year, as the following two maps show:
Map 1: Mean average temperature in July (1961-1990)
Map 2: Mean average temperature in January (1961-1990)





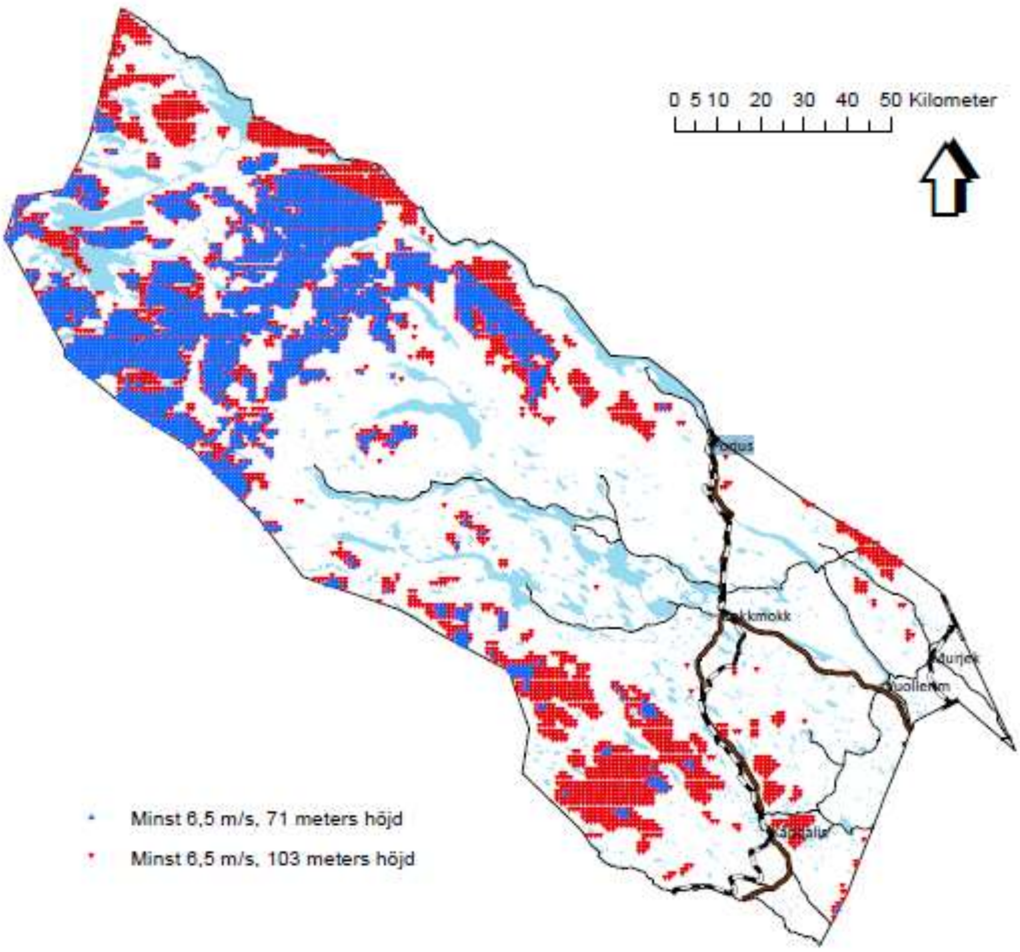


Mean global radiation in Jokkmokk municipality is around 800 kWh/m2 with a slightly higher value in the areas closer to the coast and lower in the mountain regions (Source: SMHI).



The wind energy with measurements in 50 m heights, Source SMHI, lies about 4.5 - 5,0 m/s and 100-150 W/m2 in sheltered areas and 5.5-6,5 and 200-300 W/m2 in more open areas.

Uppsala University did a more detailed map which shows higher wind speed an average in some areas for Jokkmokk municipality.

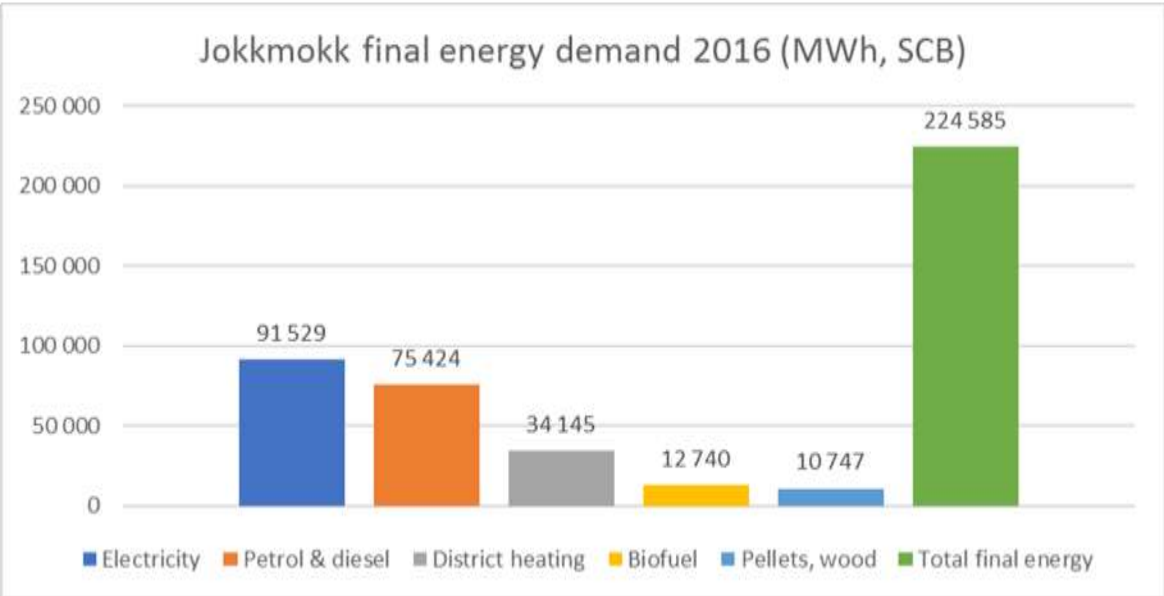


Source: Land-use plan Jokkmokk municipality 2011

Final energy use baseline inventory

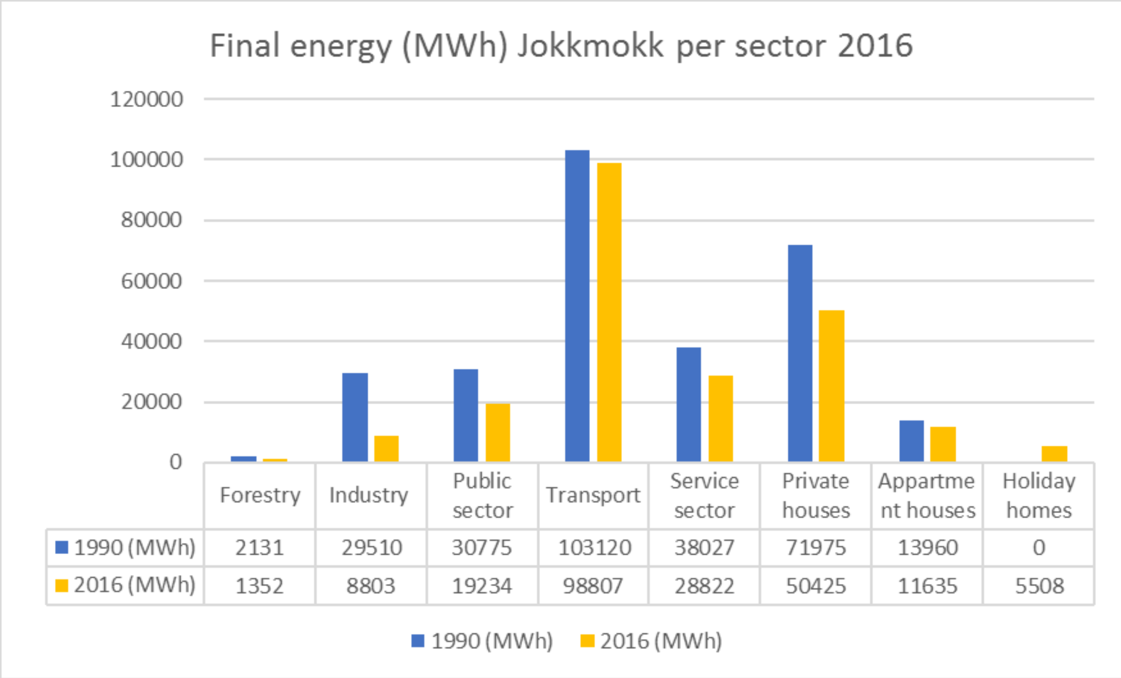
As a first step in the feasibility study a final energy baseline inventory has been done for both Jokkmokk municipality and for Porjus community more specific.

Sweden Statistics is providing data on a municipal level, that means for Jokkmokk municipality. The total final energy demand was 224 585 MWh in 2016. The main energy sources are electricity followed by petrol and diesel, mainly for transport. Jokkmokk centre has a district heating plant which serves about 522 customers including most of the municipal buildings. A calculation with average energy prices shows that energy costs for the whole municipality is about 292 000 000 SEK (2016).



Source: SCB data, own graphic

An analysis about the final energy demand per sector shows the high energy demand in the transport sector. The total energy demand has decreased between 1990 and 2016, which is partly due to the decrease in population from 6726 (1990) to 5105 (2016) and the decrease in industrial energy use due to the close down of several bigger industrial production facilities.

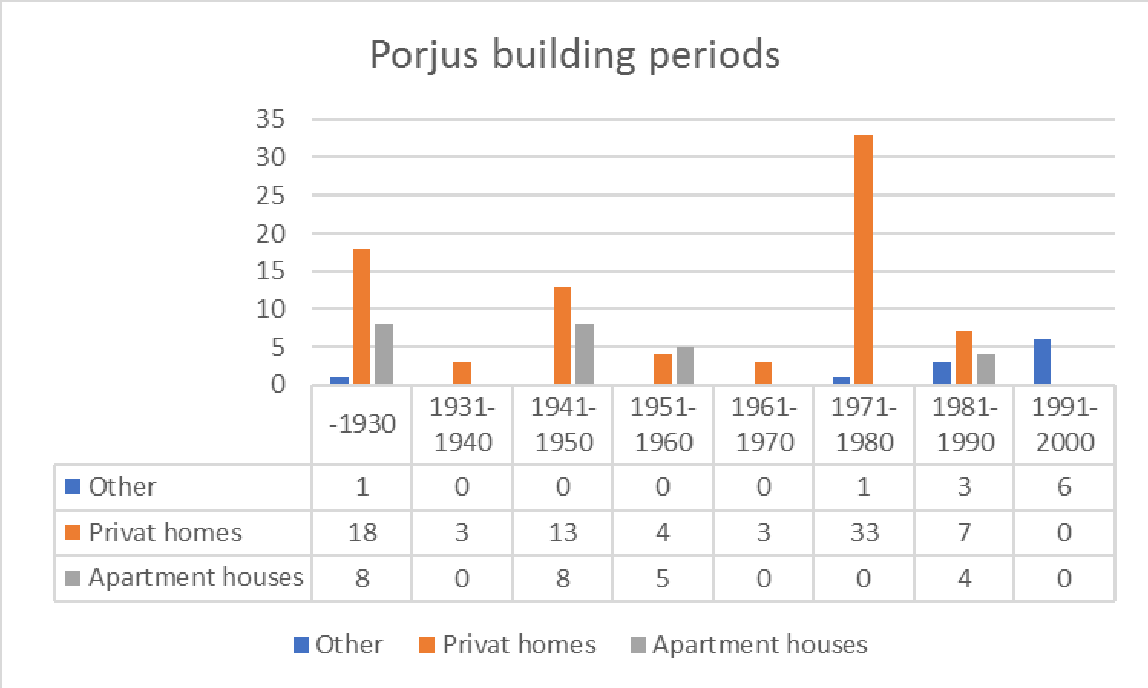


Pilot community Porjus final energy use

There is no official energy statistic on the level of villages in Sweden. Therefore, as approximation based on several different data sources has been done in collaboration with LECO partner LTU.

Public buildings and facilities:
Jokkmokk municipality owns a range of facilities in Porjus including water, waste water treatment facilities.

Private houses and apartment houses:
Porjus grew significantly when Vattenfall built the hydro power plants. Therefore, a lot of the private houses in Porjus are built in these periods. Over the last years, the number of inhabitants has decreased and there are no new-builts now for almost two decades.



Source: SCB, own graphic

LTU has done a calculation about average energy use in buildings based on the building year.

Energy for heating private homes in Porjus (kWh/year)			
Area	Others	Private houses	Apartment houses
31-40	0	0	10 532
41-50	0	0	13 541
51-60	0	25 933	91 025
61-70	26 900	30 648	39 118
71-80	0	53 044	0
81-90	0	60 117	0
91-100	0	134 378	28 586
101-110	0	99 016	15 798
111-120	0	122 001	34 605
121-130	17 244	44 203	0
131-140	18 623	159 132	20 311
141-150	0	51 276	0
151-160	0	109 624	0
161-170	0	38 899	0
171-180	0	20 628	0
181-190	0	21 807	0
191-200	0	0	0
> 200	0	117 876	0
No data	0	41 412	0
Total	62 766	1 129 993	253 517

Source: SCB data, LTU calculation and table.

Private companies:
There is a range of private companies in Porjus, however, no statistic data on energy use are available. Some of the companies which have shown interest in becoming an active part of the LECO project have provided data. An average energy use for companies in Porjus is estimated to 150 000 kWh a year. These serves as basis for calculation on total energy demand for private companies.

Compilation of estimated total final energy use in Porjus :

	MWh (2016)
Public buildings	9511*
Private homes	2 006**
Private companies	1500
Sum	13017

*Including the industrial facility which now is a server hall. No data available for the new demand of energy.
** Including 5000 kWh Household Electricity/ household

Pilot community Porjus Renewable Energy Potential

An analysis on the renewable energy potential for Jokkmokks municipality has been done by the regional energy agency Energikontor Norr and LTU in 2010. The results are listed below:

	Today	Technical potential
Hydropower	12,500,000 MWh/ year	+2,400,000 MWh/year
Forest biomass	60,000 MWh/year	500,000 MWh/year
Wind power	1,800 MWh/year	+20,000,000 MWh/year
Agricultural biomass	0	+25,00,000 MWh/year
Solar (PV and heating)	Small	Big
Heat pump	Unknown	Big
Waste heat	Small	Relevant

However, these are rough estimations, and as one can see significant data are lacking in the field of solar, heat pump and waste heat. This is still the case. Beyond, the study shows only the technical potential, but there are limitations from a legal perspective when it comes to both hydropower, forest and wind power in Jokkmokk municipality. It is also important to consider conflicts with other interests like biodiversity and cultural heritage when planning for new renewable energy:

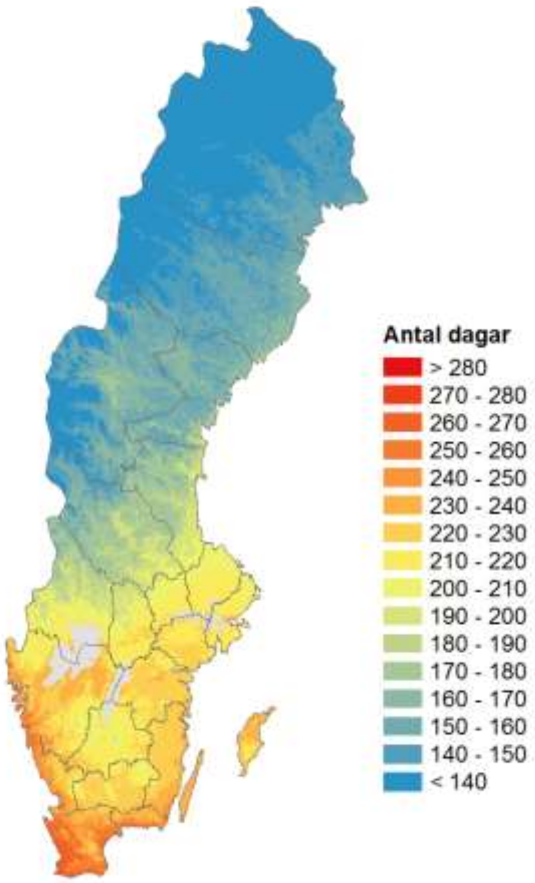
Hydropower: Jokkmokk municipality's big rivers are heavily used to produce electricity. However, a potential for more production in the future is there, due to higher precipitation in the future and more efficient technology in existing plants. Hydropower plants are owned by governmentally owned Vattenfall and do not belong to the community. Hydropower will therefore not be considered in this feasibility study.

Forest biomass: Sweden is one of the forerunners in the use of forest biomass and of residual products from pulp mills etc to produce biofuels. Even the share of bioenergy for heating is high. However, there are target conflicts with both traditional reindeer herding and biodiversity. Therefore, this feasibility study will only calculate projects which can be implemented with sustainable forest biomass.

Wind power: Legal restrictions for the use of wind power in Jokkmokk municipality are high due to an airforce base close by and the huge areas which are national parks. So far, only one single wind power plant has been built, all other planned projects have not been realised. However, this feasibility study will take into account a small community owned windpark and will look into the possibility of small-scale wind power.

Agricultural biomass

This is an interesting option specifically in case of Porjus , which has some agricultural used land and where also the only farm in Jokkmokk (milk cows) is located.



However, due to its Arctic climate, the growing season is relatively short, as the map shows (around 150 days), and trees are growing slowly. However, studies have been done in Northern Sweden with crop growing of Phalaris arundinacea, sometimes known as reed canary grass. It is a tall, perennial bunchgrass, which grows good on poor soils and can easily be turned into bricks or pellets for burning in biomass power stations.

However, there is limited access to farming machines and equipment as well as interest or local knowledge.Therefore, this feasibility study will not include agricultural biomass.

Source: SMHI

Heat pump

In a study from 2017, Petter Johansson (KTH) says that "Currently, more than half of all Swedish single-family houses have an installed heat pump and more heat is supplied by heat pumps in Sweden than in any other nation. […] As of 2015, Sweden had the greatest amount of heat production from heat pumps per capita of any European nation, and many heat pump markets in other European countries are 10 to 20 years behind the Swedish market in development.[1]

Even in Jokkmokk municipality, heat pumps are used frequently. Many houses which have direct electric heating have been complemented with air-to-air heat pumps. There is no register over these installations. Geothermal heat-pumps and downhole heat exchanger become more and more frequent. Officially, installations have to be announced and approved by the municipality, but in fact, many installations are not registered.

However, there is a technical potential for more heat pumps, incl. heat pumps taking energy from lakes, possibly even ground-water. A calculation for both air-to-air heat pump and for geothermal heat pump for a private home (120 m2) in Porjus shows that both investments are profitable with a pay-back of 4 years for air-to-air and 8 years for geothermal heat pump.

Air-to-Air heat pump	
Saving kWh/year	4 000
Electricity price SEK	1,5
Saving SEK/year	6 000
Investment SEK	25 000
Pay back in years	4
Geothermal Heat pump	
Saving kWh/year	17 750
Electricity price SEK	1,5
Saving SEK/year	26 625
Investment SEK	200 000
Pay back in years	8

[1] Johansson, Petter KTH, Skolan för industriell teknik och management (ITM), Industriell ekonomi och organisation (Inst.), Hållbarhet och industriell dynamik.ORCID-id: 0000-0002-2748-7993 http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1151181&dswid=5826

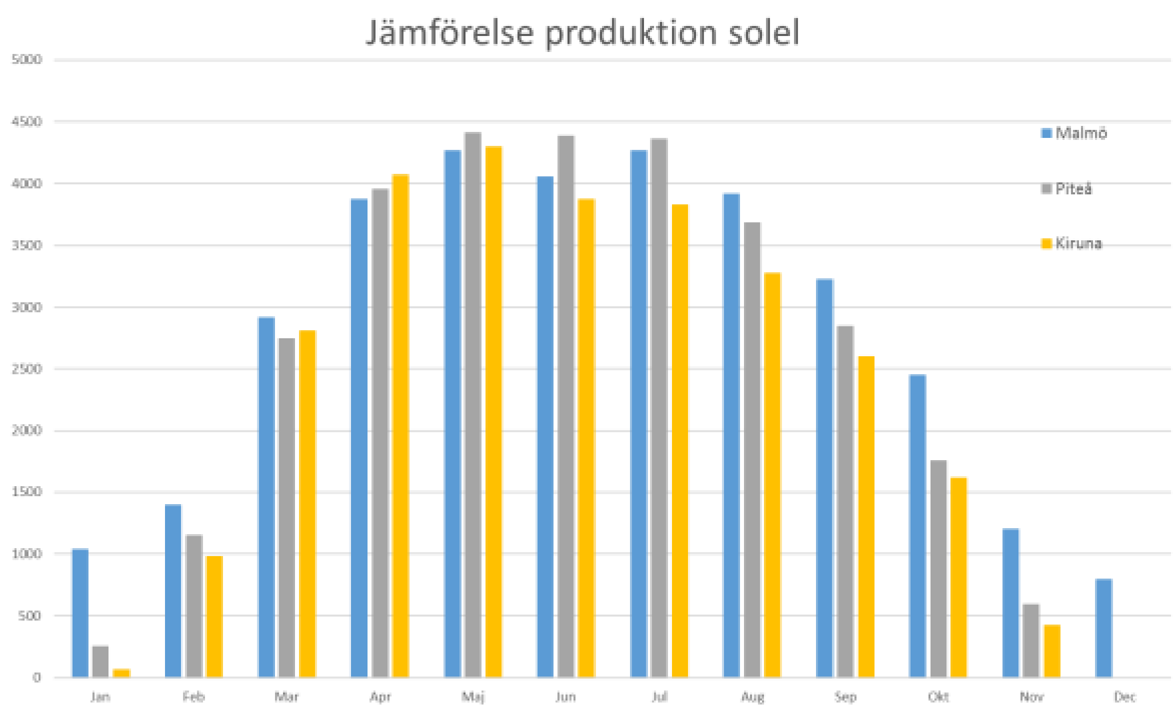
Pellet or wood stove

As mentioned above, private homes in Porjus might not have central heating, but direct electric heating. However, a number of houses has a chimney which can be used to combine with a pellet or wood stove. This is a possibility if an investment in a central heating system is too expensive. On the downside is that both pellets and wood stoves need work. If assuming that it is possible to use a modern stove regularly in winter times the following savings are possible:

Energy demand	30000
Saving kWh/year	9 000
Electricity price SEK	1,5
Savings SEK/year	7 290
Investment SEK	30 000
Pay back years	4

Solar energy

Solar energy can be used to produce electricity (PV) and to produce warm water for heating or shower etc. However, due to the high latitude (67 degree) number of solar hours during winter are small to zero. Comparing the production of PV in Malmö (southern Sweden) and Kiruna (northern Sweden inland) shows that there is despite this fact a significant potential for PV production.



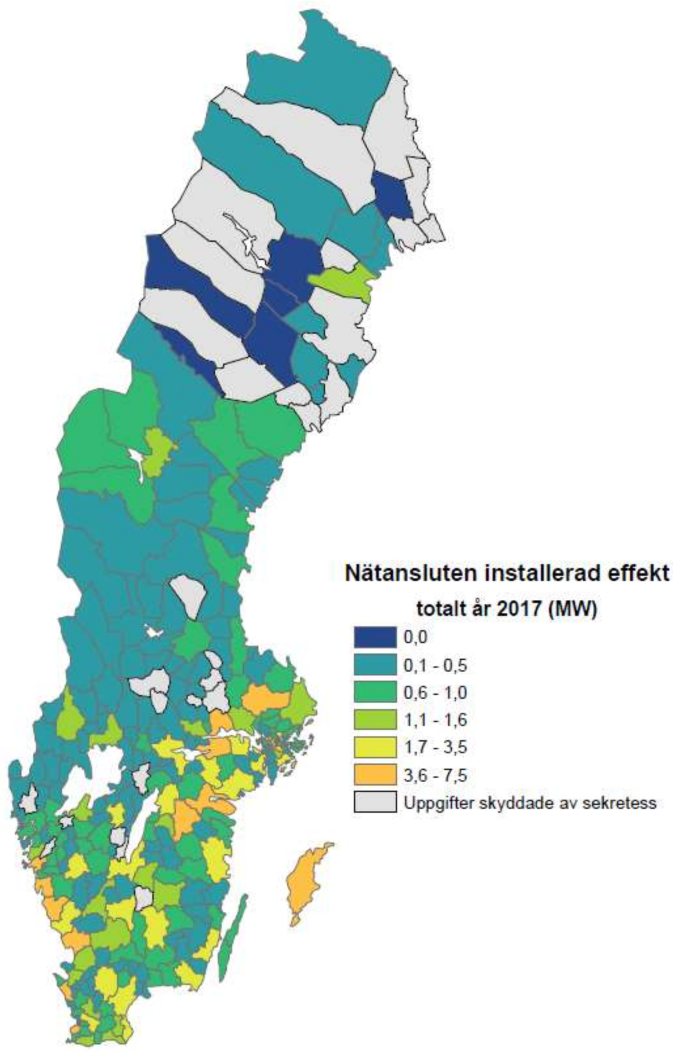
Source: Piteå Energi

Solar heating

A calculation for solar heating for private homes shows that an investment is profitable, however, the pay back time is relatively long. There are no subsidies for solar heating.

Solar heating incl. Warm water boiler SEK	45 000
Energy production kWh/year	2 500
Income per kWh	1,5
Income per year	3 750
Lifetime	25
Total income	93 750
Payback	12

Photovoltaic



Sweden is lagging behind in PV development, in general, but even more in Northern Regions as the map shows. This is also due to the subsidy system: Sweden does not have a system of guaranteed feed in tariffs. Instead, income from PV plants comes from a variety of sources and is limited by a set of rules to some extent. More details below.

Swedish subsidy and support system for Photovoltaic
There used to be a subsidy on the investment of 30% for plants up to a certain size and production, but the future is unclear in the very moment of writing this feasibility study due to a change in government after 2018 years' elections.

When it comes to the operational income, so is the Swedish subsidy system designed to encourage the use of the produced electricity in the own building rather than selling it to the grid. The value of a single kWh produced PV electricity which is used in the own building varies significantly between buildings and operation. It depends on what this kWh would have cost if it has been bought. It also depends on how much electricity is used and when. A restaurant with a high use of electricity lunch time during summer might have good use of PV other types of business or community buildings might not have.

It is important to know that the price per kWh electricity usually varies in Sweden between summer and winter and for different types of supply contract. As PV production is on top in summer, it is when a bought kWh probably is cheaper than in winter. However, an important part of electricity costs are the costs for the grid. When a PV kWh is used in the own building, part of these costs will not be accounted for which increase the profit of PV production. However, the system makes it difficult to calculate profit in a general way for all types of buildings.

In the following table one can read details on possible income and/or cost reduction from PV:

What?	Limits to get subsidy
30% investment subsidy	Maximum cost of 37 000 plus VAT per kWp; max 1,2 miljon SEK per plant.
Tax reduction of 60 öre per kWh for electricity sold to the grid.	Tax reduction will be given only for that much as the user is also buying from the grid in kWh. Max. 18.000 SEK per year. Max fuse 100 ampere.
No costs for channeling PV electricity in the grid	PV plant max 43,5 kWp and main fuse not more than 63 ampere. You may not channel more electricity to the grid than what you buy from the grid within a year.
No tax on PV electricity	PV plant may not be bigger than 255 kW
No VAT	You may sell electricity (and other services, goods etc) for not more than 30 000 SEK per year (exklusive VAT).
No income tax	Income from selling PV incl. other income from the building may not be more than 40 000 kronor per year.
Electricity certificate	Price for certificate is market base. One certficate per MWh, income for 15 years.
Origin certificate	Price for certificate is market base. One certficate per MWh.
Selling electricity	Usually a higher price the first year, than spot price

Compensation for benefits for the grid	Grid owner have to pay for the benefit of not using the grid by producing and using own produced PV
Using own produced electricity instead of buying	Corresponding with the cost you would have paid for electricity, besides the cost that you have for being connected to the grid.

Calculation: PV plants for family homes in Porjus

A calculation for a PV plant for private homes in Porjus shows that the investment is profitable in case of a south to south-east oriented roof, however, with a relatively long pay-back time. The income per kWh is depending on a range of factors and can be lower. No replacement of the power inverter nor other repairs nor degradation have been taken into account.

PV plant 5kW, incl. 30% subsidy in SEK	70 000
Energy production kWh/year	3 360
Income per kWh	1,5
Income per year	5 040
Lifetime	30
Pay back	14

Calculation for bigger buildings

A calculation for PV plant for a bigger building, south-oriented roof, 45 degree, would result in the following with a payback of about 9 years, under the same economic framework as for the private homes. Solar plant: 13 kW

Investment, 30% subsidy in SEK	150 000
Energy production kWh/year	11 122
Income per kWh	1,5
Income per year	16 683
Lifetime	30
Total income	500 490
Profit	350 490
Pay back	9

Calculation for a bigger plant with 80 kWp
This plant is possibly not on a roof but on the ground, would result in a production of about 72 519 kWh per years. However, due to the Swedish subsidy system, a significantly lower income of only 41 711 SEK has been calculated compared to the 13 kWp plant on roof. Under the given parameters, the pay back would be 16 years. Such a project would heavily depend on a lower investment cost, where the plant is situated and how the electricity will be used.

PV plant	80 kW
Energy per year kWh	72 519
Investment cost, 30% subsidy	698 800
Income per year	41 711
Pay back years	16

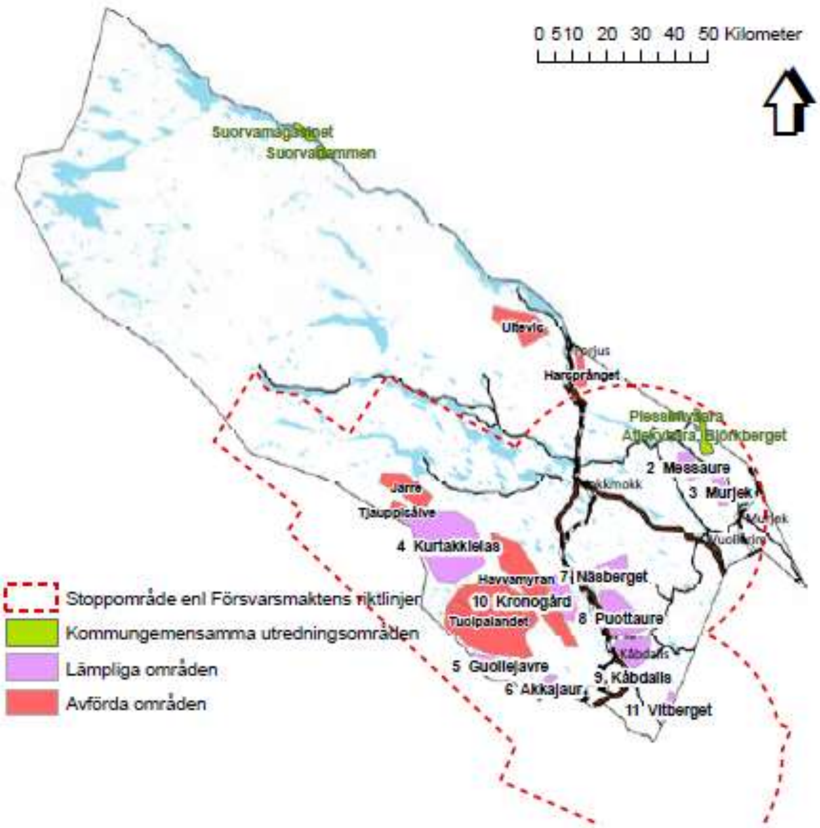
Windpower

Windpower is a very interesting renewable energy source with a well-established market and knowledge base. Jokkmokk municipality land-use planning document from 2011 includes a rough estimation about how many wind power plants theoretically could be built in areas which are suitable from a municipality perspective. This is, areas with no heavy land-use conflicts:

	Storlek kvkm	Antal verk	Effekt GW	Produktion GWh
Harsprånget	26	65	0,325	650
Messaure	36	90	0,45	900
Murjek	33	82,5	0,4125	825
Kurtakkielas	344	860	4,3	8600
Näsberget	63	157,5	0,7875	1575
Kronogård	70	175	0,875	1750
Puottaure	109	272,5	1,3625	2725
Kåbdalis	64	160	0,8	1600
Guollejavre	44	110	0,55	1100
Akkajaur	23	57,5	0,2875	575
Vitberget	18	45	0,225	450
TOTALT	**830**	**2075**	**10,375**	**20750**

Source: Jokkmokk municipality land-use plan 2011

However, due to an airforce base within the borders of Jokkmokk municipality, plans for bigger windpower plants have been stopped so far in any case.



Source: Jokkmokk municipality översiktsplan 2011. The red dotted line marks the airforce area.

However, as a community-owned wind park technically is possible close by Porjus but also in a greater distance in another place within Jokkmokk or the neighbouring municipalities, this feasibility study includes a calculation of a wind park.

Land-based windpark
A 3 MW windpower plant with the average number of 2400 hours of full production per year produce about 7 200 MWh a year[2]. Three different scenarios are shown here:

Kind of project / Number of 3 MW plants	Installed effect MW	Produced MWh per year	Production in 20 years
1	3	7 200	144 000
5	15	36 000	720 000
84	252	604 800	12 096 000

[2] http://vindstat.nu/stat/index.htm

According to Swedish Energy Agency, typical costs for land-based wind power are about 11-30 Mio SEK per MW installed wind power. Cost for production per kWh differ a lot but are calculated to be 0,4 – 0,5 SEK /kWh in the reference case with a total production below 20 TWh. However, Vattenfall reports about an investment of 3,5 billion SEK for 84 windpower plants, which would be a cost of about 4 Mio SEK per plant, which would be very much cheaper[3]. This shows, how difficult it is to calculate for such an investment. How much a wind power plant is producing depends heavily on the specific wind situation at the site. This information is not available currently for the feasibility study. So no investment calculation can be done at this point.

Small-scale windpower

In Sweden, the following rules apply for small-scale windpower:

The maximum height to set up a wind turbine without a building permit is 20 meters, the rotor diameter must be no more than 3 meters, and it must be accommodated lying lengthwise within its own plot boundary. In order to avoid building permits, the wind power plant must not be mounted on a building. It is also important to consider the rules for the maximum permissible sound level in relation to neighbors

A so-called farm wind power plant is defined as a wind turbine with a total height of 20-50 m or a plant whose rotor diameter exceeds 3 m. In order to build such a wind turbine, building permits are required according to the Planning and Building Act and the associated regulations. Building permits are handled by the municipality's building committee.

The Swedish network for wind power publishes each year a market study for small scale windpower, which includes plants up to 100 kW. In 2017, 9 different types of plants are included in the report, but the number of installed plants in Sweden is small, often not more than 20 and max. 100 for one type of plant.

The key problem for small-scale wind power is the low wind speed which often does not exceed 4-5 m / s. The production is pretty low, while the investment costs are comparatively high. This might also be a result of low numbers of plants built, so possibly the investment cost can go down as they did for PV if a mass production would start. Other barriers to overcome are the lack of experience in the region, no good or best practice examples and probably even the fact that service – if something goes wrong – is far. A calculation with one of the most installed types of wind power shows, that it is difficult to make this investment profitable under today's framework conditions.

[3] https://www.svt.se/nyheter/lokalt/norrbotten/vattenfall-planerar-for-ny-vindkraftspark-i-norrbotten

Windstar 3000, 3 m Rotor	3 kW vid 12 m/s
4 m/s årsmedelvind produktion kWh	3 680
Investering	75 500
Pris El	1,5
Inkomst per år	5 520
Livstid	15
Återbetalning	14
Total vinst	7 300

Small scale co-generation

Combined Heat and Power (CHP) technologies based on biomass combustion have great potential to reduce CO2 emissions because they use renewable energy sources, such as wood fuels or sawdust. In order for CHP plants to operate in a way that is economically and ecologically beneficial, both the electricity and the heat produced must be used.
CHP technology is already available on Swedish and European markets. Due to the high installation costs, and a lack of information about its efficiency, the technology is, however, currently not widely used in small-scale plants. Extensive research has been undertaken to illustrate the vast environmental potential of CHP technology but a larger initiative that looks at increasing market application is still needed.
A pilot co-generation plant in Porjus would be of high value for the development of the market, but it is not possible in this stage to give any details about technology or economics.

Transport sector

The energy baseline inventory shows clearly that the energy need for transport in Jokkmokks is high. However, this is also an area which is difficult to tackle. Long distances and a sparsely populated area make public transport difficult and non-economic in many cases to serve the needs of the inhabitants. On the other hand, are gas and diesel prices very likely to increase, also due to Swedish government tax and environmental policies, so to reduce the need for transport and replacing fossil fuels by using locally produced renewable energy would be of high interest. Electric cars have proven to be usable even in cold climate and by longer distances[4]. According to the national emission database RUS[5] used every inhabitant in Jokkmokk 261 liter of diesel and 320 liter of gasolines in 2016. For Porjus (684 inhabitants), this means a total of 397 415 liter of fossil fuel to a cost of approximately 6 Mio SEK a year and an energy need of 3646 MWh of energy for transport.

Diesel	Gas	
178 851	218 564	l
10	9	kWh/l
1 751	1 895	MWh

[4] CELLER-i project https://www.alvsbyn.se/naringsliv/eu-internationellt/aktuella-eu-projekt/celler-i/
[5] http://extra.lansstyrelsen.se/rus/Sv/statistik-och-data/korstrackor-och-bransleforbrukning/Pages/default.aspx

A first step to more sustainable transport modes could be a community owned cooperative electric car-pool, which also includes electric bicycles. As the total impact on the energy need for transport is difficult and likely to be small in the beginning and investment and operational cost can vary a lot, no further calculations are done at this point.

Scenario for sustainable energy in Porjus

Energy efficiency

The technical energy efficiency potential for buildings in Porjus is assessed to be high. This is due to the high average age of building in Porjus with almost no new builts. However, the economic potential has to be assessed significantly lower, as houses are cheap in Porjus . High investment costs are difficult to justify. However, experience show that change of behaviour and small investments can lead to savings of about 10 percent in private homes. In companies and public buildings, up to 20% are possible by measures with a pay-back less than 5 years (and 30 or even up to 50% with more comprehensive measures which are not taken into account in the case of Porjus).

	MWh (2016)	Scenario 2025 in MWh
Public buildings	9511	7609
Private homes	2 006	1 806
Private companies	1500	1200
Sum	13017	10614

Solar energy

To assess the total potential for solar energy in Porjus, it is assessed that 30% of the private homes have roofs oriented to south-west, south or south-east and will use both solar heat and PV. For apparment houses, only PV is calculated. In addition, a bigger plant of 80 kWp is calculated. The total installed PV capacity is assessed to 750 kWp.

What	MWh/year
27 private homes, solar heating + 5 kW PV	160
10 bigger buildings, 13 kW PV	111
Bigger PV plant, 80 kW:	72
Sum	343

Heat pump
For heat pumps, it is assesses that 20 private homes will invest in an air-to-air heat pump, and another 5 in ground or geothermal heat pump.

What	MWh/year
20 Air to air heat pump	80
5 Ground heat pump	177
Sum	257

Bioenergy
For bioenergy, it is assumed that 10 private homes invest in wood or pellets stove as a complement to direct electric heating.
In addition, it is assumed that there is an economic potential for a small scale cogeneration plant. The calculation is done for a Spanner Re2 HKA 10 with 9 kW electricity and 22 kW heating and 6000 working hours per year.

What	MWh/year
10 Wood or pellets stove	90
Small-scale cogeneration electricity	45
Small-scale cogeneration heat	132
Sum	627

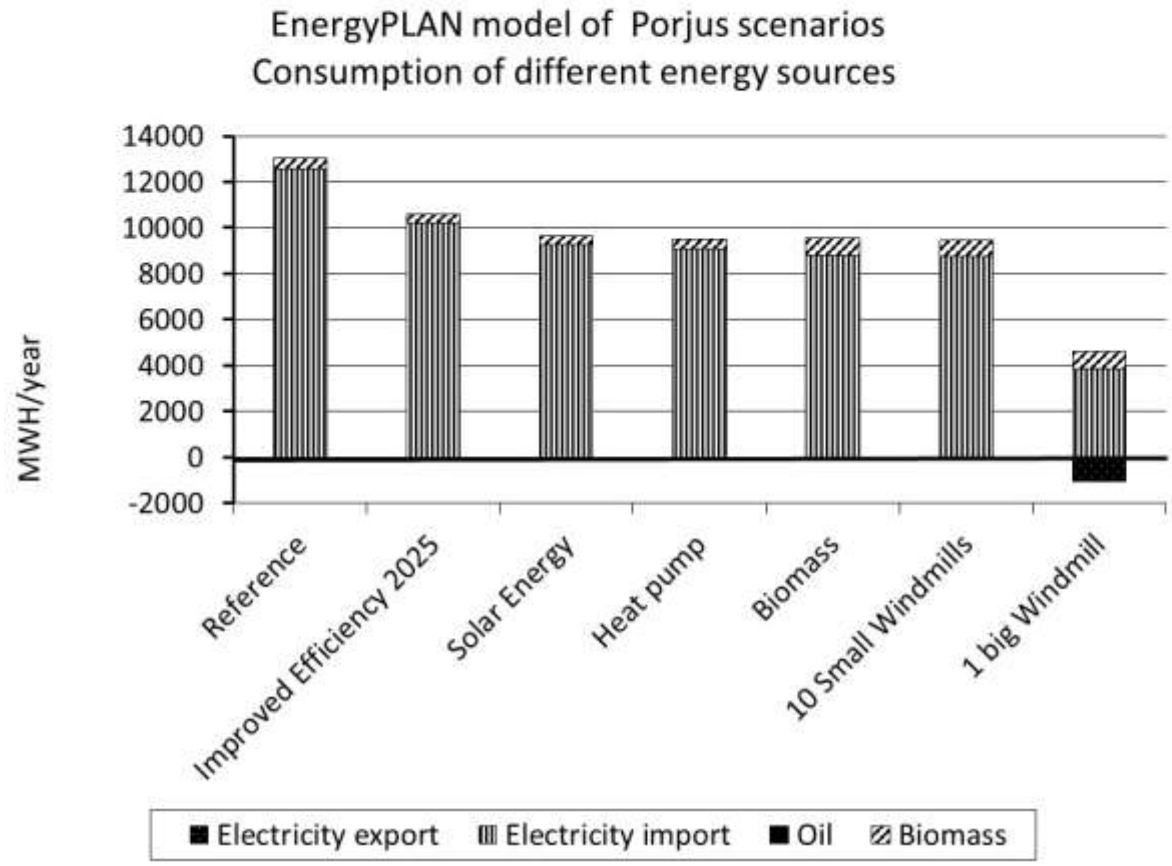
Wind Power
For wind power, different energy production scenarios have been calculated, however, now wind measuring has been done and no economic calculation is possible at this point.

Kind of project / Number of 3 MW plants	Installed effect MW	Produced MWh per year	Production in 20 years
1	3	7 200	144 000
5	15	36 000	720 000
84	252	604 800	12 096 000

Smal-scale windpower:
If, despite the economic limitations, a pilot wind park for small-scale windpower will be erected, it might be possible to produce up to 50 MWh per year with about 10 smaller wind power plants.

Import and export

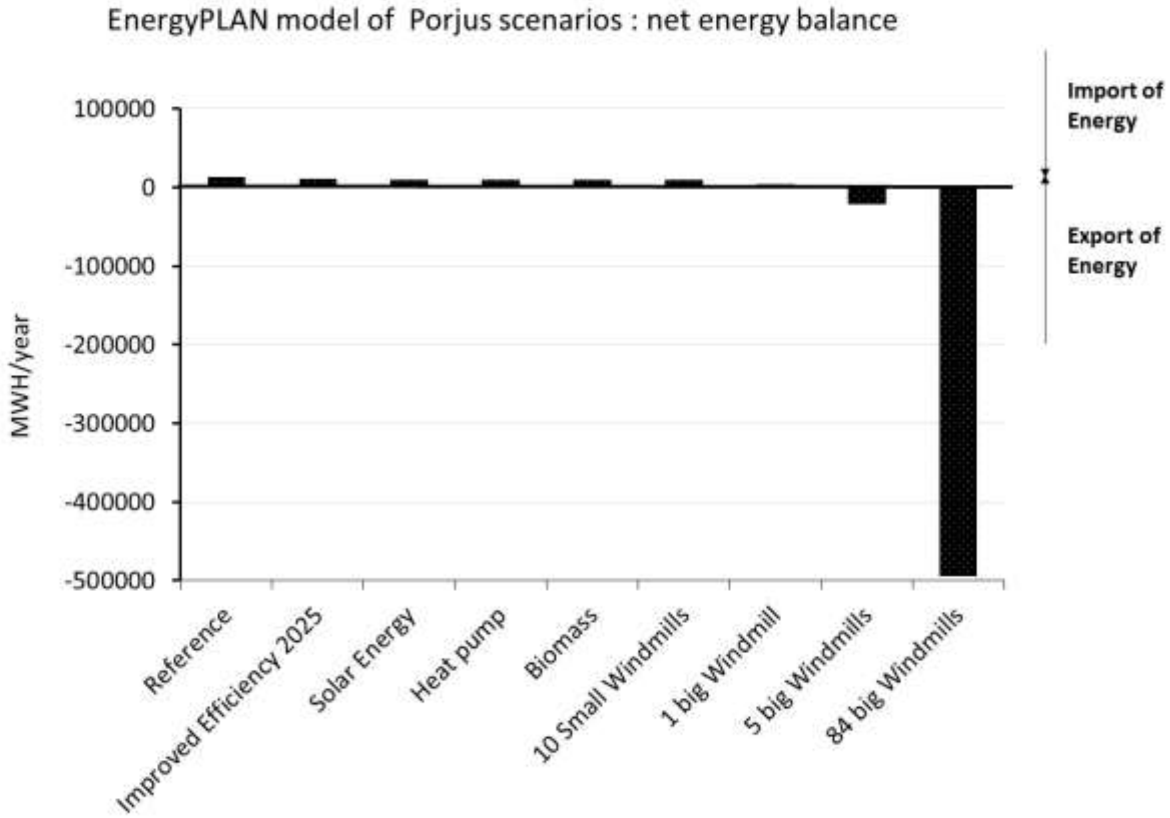
LTU did a calculation for different scenarios with the global energy planning tool EnergyPlan. The figure below shows how the consumption of different energy sources is influenced with gradual improvements according to the scenario description (see above)



Wind power is only shown with up to 1 big windmill (Otherwise the scale would make it difficult to read the differences up to the installation of windmills). We see that the effect of the big windmill is a combination of less consumption from and export to the net. The electricity dominates in all cases because of the consumption in the data center.

The EnergyPLAN model for wind power uses a correction factor to compensate for the non-linear behaviour of the Windspeed vs power curve. This can be calculated e.g. by comparing effect and yearly output for real windmills in the area. We lacked other data, so the table on possible locations on page 19 was used. For each case the values on effect and yearly production were used to find the value of the correction factor that cave best agreement. The mean value of these factors was calculated as 0,4927 and used in the modeling of the wind power cases.

Next picture shows the net effect (Import minus export of Energy) for all scenarios.



We see that Porjus becomes a net exporter of energy with 5 large windmills or more