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

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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.

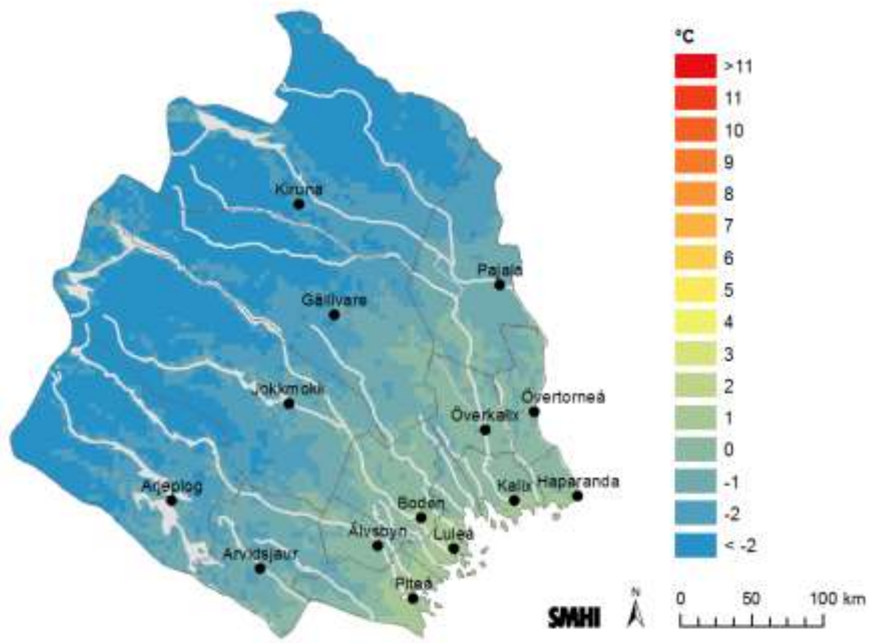
Geography and climate

Pajala is a municipality with about 6000 inhabitants (2018) and an area of 7,917 km2, which is about 2% of Sweden. Pajala is located in Norrbotten County and borders on Finland to the east. 30% of the municipality's population lives in the central town of Pajala, but there are also about 80 official villages, but only Korpilombolo, Tärendö, Junosuando, Sattajärvi, Erkheikki and Kangos haves a population of over 200 people.

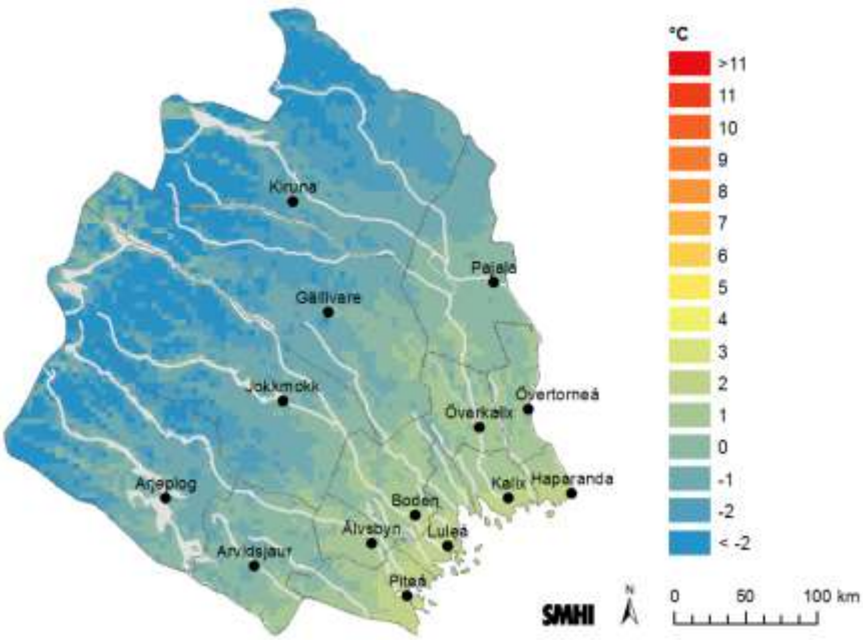
Korpilompolo in Pajala municipality is an active village with about 540 inhabitants. In the village there are a school, a restaurant, petrol station, retirement homes and an ICA store other small- and medium sized companies. The Korpilombolo church is also located in the middle of the village. Since 2005, a cultural festival, the "Night Festival", is held annually on 1-13 December. At Kulturhuset there is a restaurant that is widely used by both residents and visitors.

The annual mean temperature in Pajala has been –1C in the period 1961-1990, but due to climate change, the average temperature is increasing in the last decade and is expected to do so even over the next decades. Maps are showing aannual mean temperature. Together with the annual average precipitation, it is the most widely used index to describe the climate.

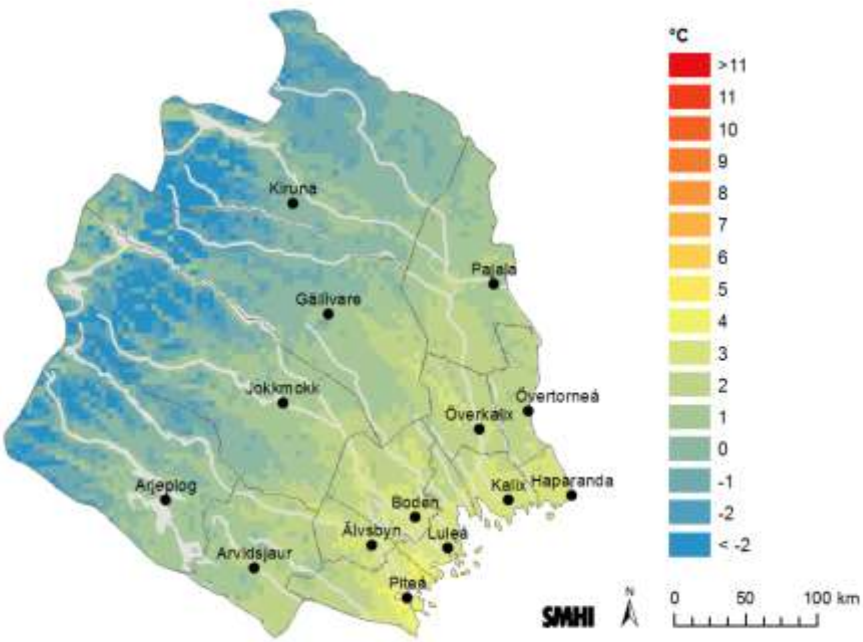
Map 1: Observations 1961-1990, Source SMHI



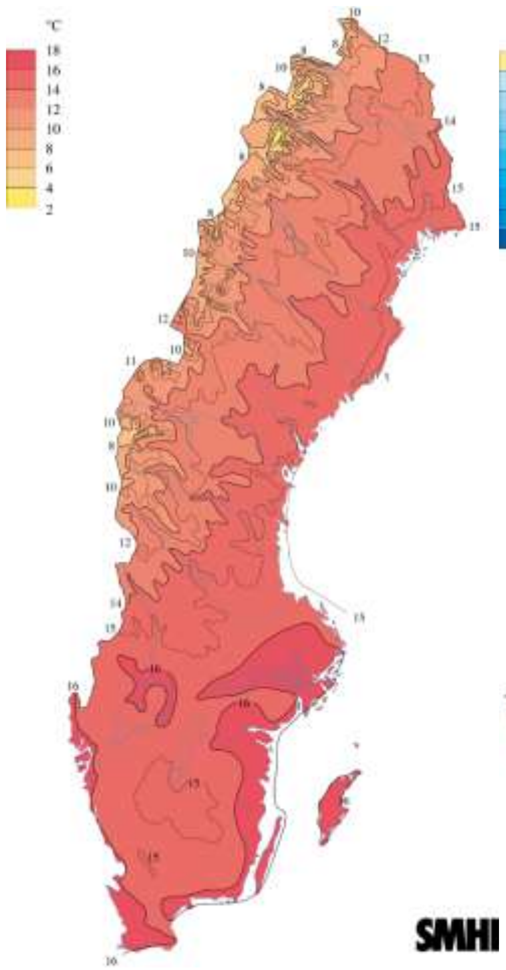
Map 2: Observations 1991-2013, Source SMHI

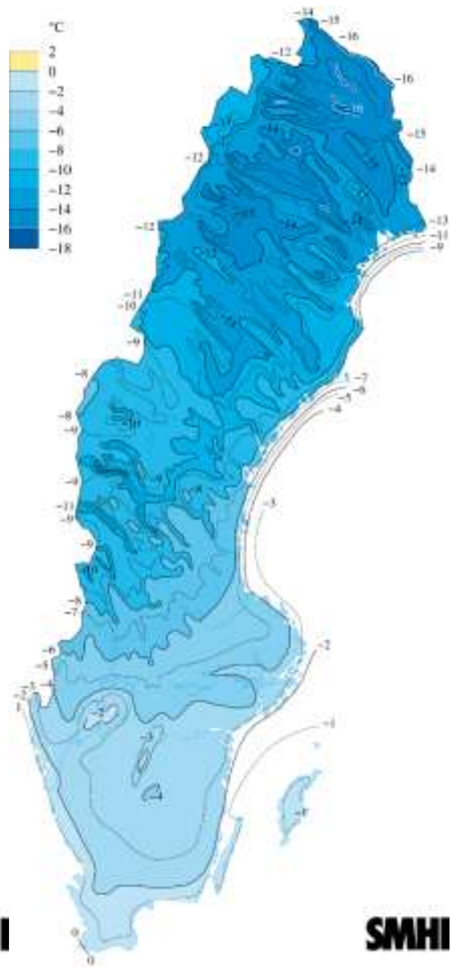


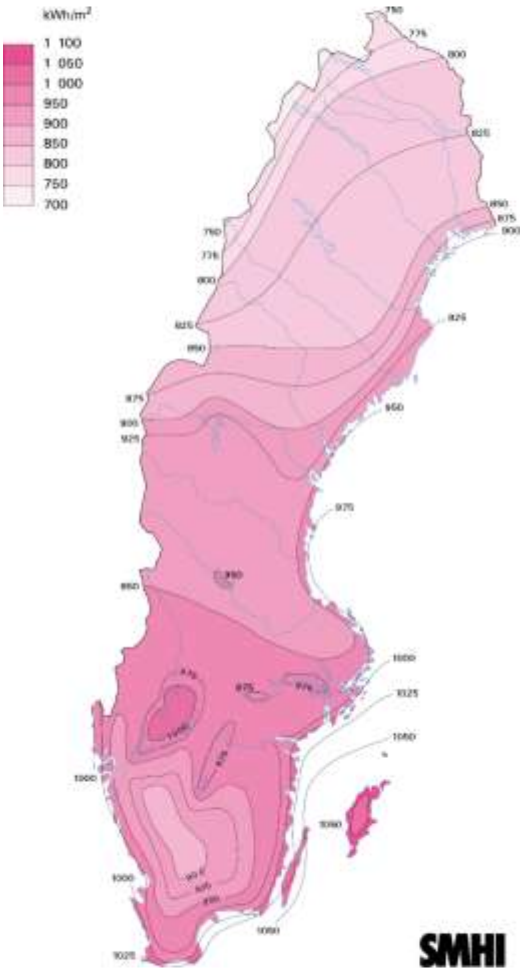
Map 1: Future development according to IPCC scenario scenario RCP 4.5, Source SMHI



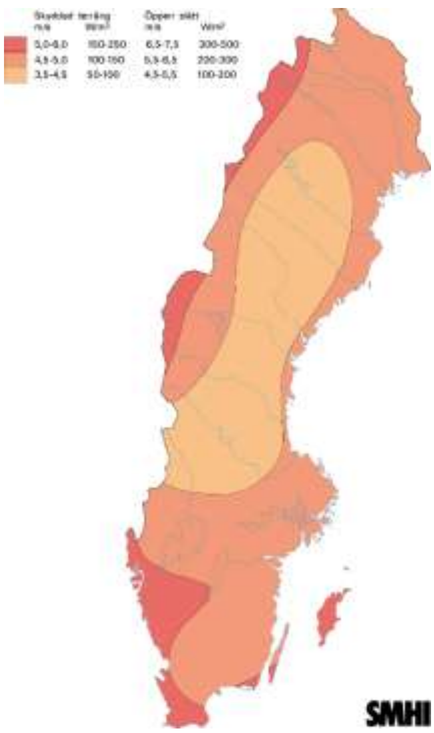
Temperature differs significantly over the year, as the following two maps show:
Map 1: Mean average temperature in July (1961-1990)
Map 2: Mean average temperature in January (1961-1990)





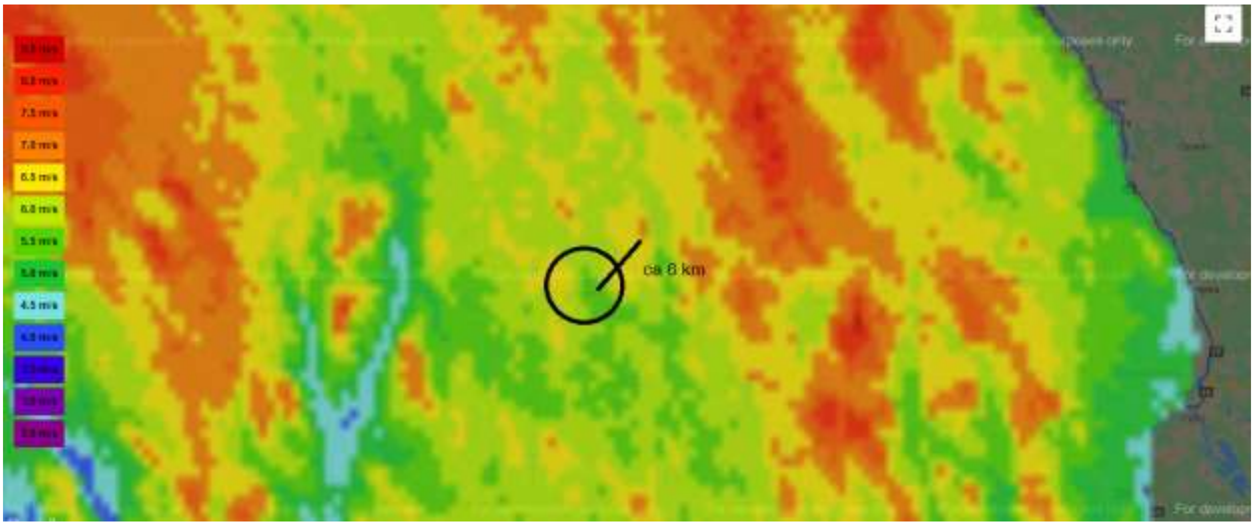


Mean global radiation in Pajala municipality is around 800 – 825 kWh/m2 with a slightly higher value in the areas closer to the coast and lower in the mountain regions (Source: SMHI).



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.

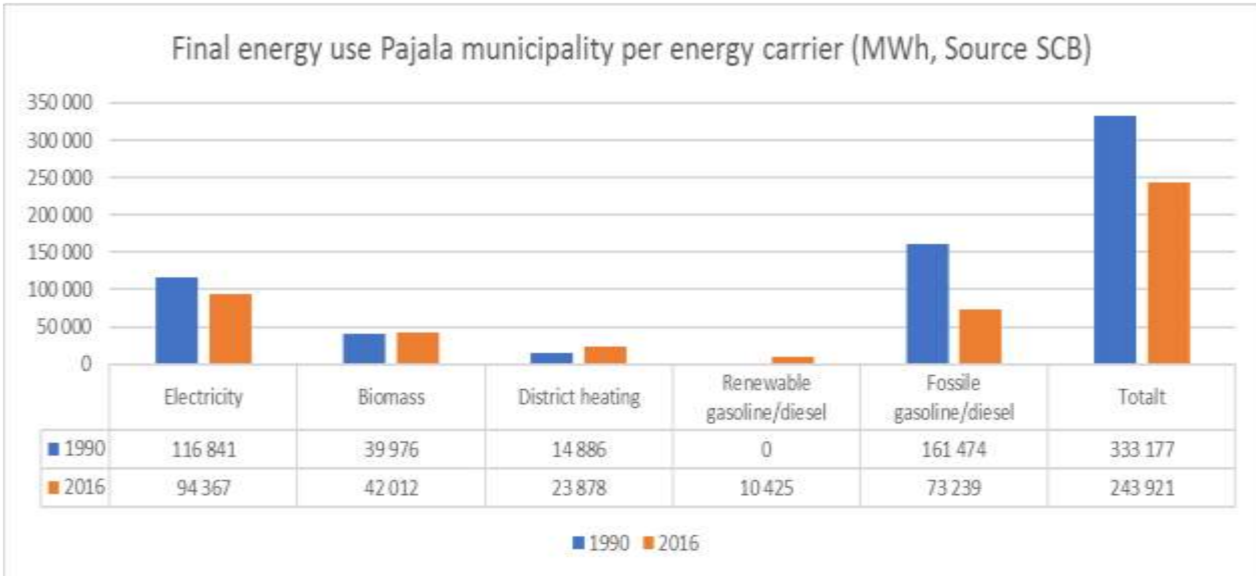
Even the more detailed map of windmap.se shows similar results with respect to wind measurements for Pajala/Korpilombolo area:



Source: windmap.se

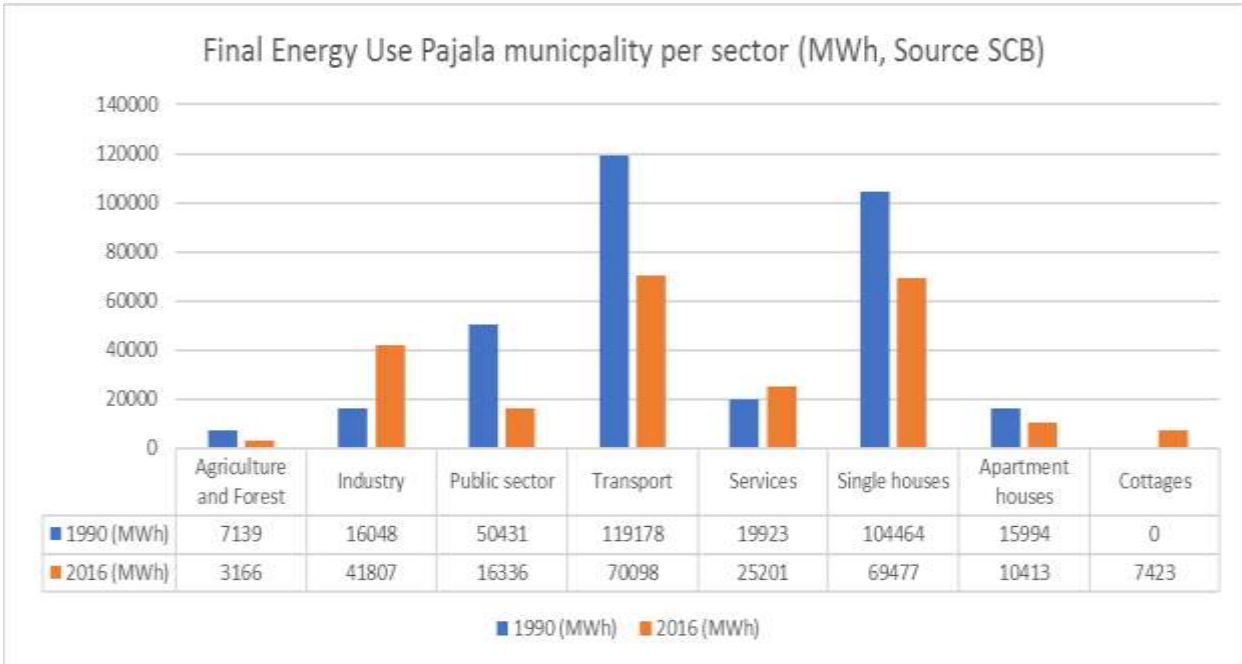
Final energy use baseline inventory

As a first step in the feasibility study a final energy baseline inventory has been done for both Pajala municipality and for Korpilombolo community more specific. Sweden Statistics is providing data on a municipal level, that means for Pajala municipality. The total final energy demand was 243 921MWh in 2016. The main energy sources are electricity followed by fossil petrol and diesel. A calculation with average energy prices shows that energy costs for the whole municipality is about 295 000 000 SEK (2016).



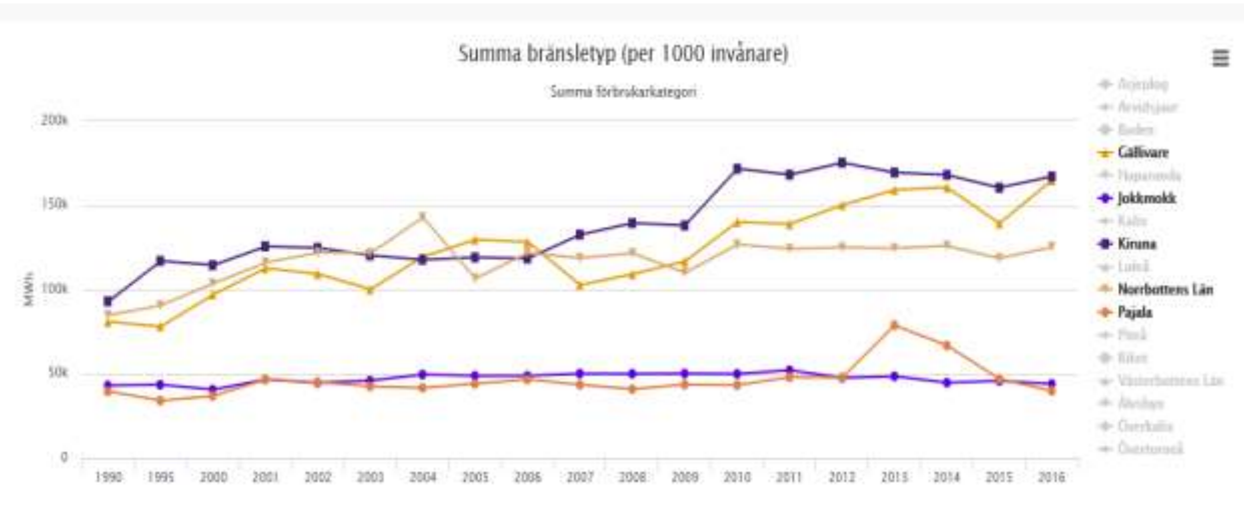
	Electricity	Biomass	District heating	Renewable gasoline/diesel	Fossile gasoline/diesel	Totalt
1990	116 841	39 976	14 886	0	161 474	333 177
2016	94 367	42 012	23 878	10 425	73 239	243 921

An analysis about the final energy demand per sector shows a high energy demand in the transport sector, but also for single family houses. The total energy demand has decreased between 1990 and 2016, which is partly due to the decrease in population.



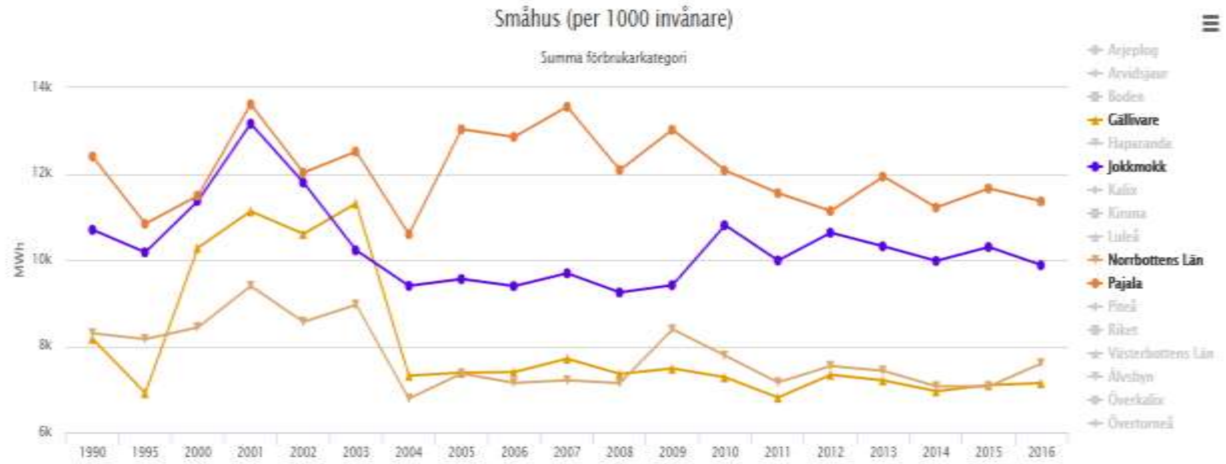
Source: SCB data, own graphic

The energy use per 1000 inhabitants in Pajala municipality lies under the average of Norrbotten county, which is related to the fact that big industries in mining and steel production in Kiruna, Gällivare and the county capital Luleå give Norrbotten a very high energy demand per capita in total. Compared to similar municipalities, Pajala is on average.



Source: SCB, graph: http://energiluppen.se/

However, the high average age of private homes leads to a comparatively high energy demand in this sector compared to the Counties ‘average:



Source: SCB, graph: http://energiluppen.se/

Pilot community Korpilombolo 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.

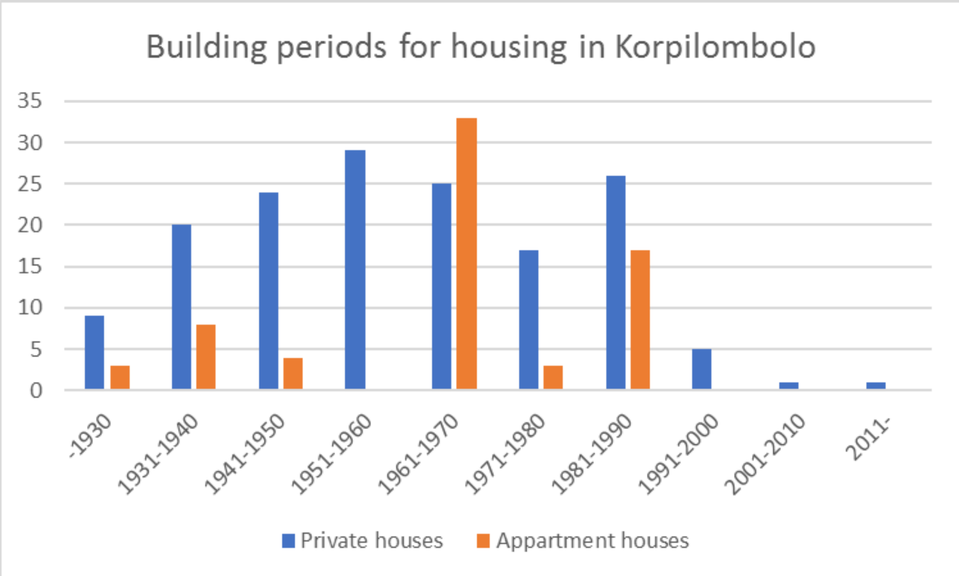
Public buildings and facilities:

Pajala municipality owns a range of facilities in Korpilombolo which use both electricity and wood pellets. The total energy demand is 1 878 750 kWh (2018)

Facility/Building	Electricity (kWh)	Wood pellets (kWh)	Total kWh
Bus stop	54000		54000
Apartment house	18000		18000
School	42000	514250	556250
Retirement home	140000	1028500	1168500
Fire station	82000		82000
Sum			**1 878 750**

Source: Pajala municipality

Private houses and apartment houses:
Most private homes in Korpilombolo are older than 40 years. Over the last years, the number of inhabitants has decreased and new-builds are rare.



Source: SCB, own graphic

LTU has done a calculation about average energy use in buildings for heating based on the building year and an average heating demand per m2:

Heating demand for housing in Korpilombolo in MWh/year (Source: SCB/LTU)			
m2	Other	Private homes	Apartment houses
31-40	0	4	32
41-50	0	0	135
51-60	0	13	17
61-70	0	46	254
71-80	10	97	56
81-90	12	140	38
91-100	0	325	57
101-110	0	260	0
111-120	0	230	17
121-130	0	221	0
131-140	0	207	20
141-150	0	239	0
151-160	0	73	0
161-170	0	78	0
171-180	0	21	0
181-190	0	22	0
191-200	0	46	0
> 200	0	118	0
SUM	22	2 140	627

The total energy demand for heating is calculated to about 2790 MWh per year. An average electricity use for private homes in Sweden excluding heating is about 5000 kWh[1]. The total energy use for private housing in Korpilombolo is therefore estimated to be about ~~3 585~~ 3935[CG1]
MWh

Private companies:
There is a range of private companies in Korpilombolo , but no statistic data on energy use are available. However, some of the companies which have shown interest in becoming an active part of the LECO project have provided data and an average energy use for companies is estimated to 150 000 kWh a year. These will serve as basis for calculation on case studies for sustainable energy in a later chapter.

Compilation of estimated total final energy use in Korpilombolo :

	MWh (2016)
Public buildings	1 878
Private homes & Apartment houses	3935[CG2]
Private companies	2 250
Sum	8 063

Pilot community Korpilombolo Renewable Energy Potential

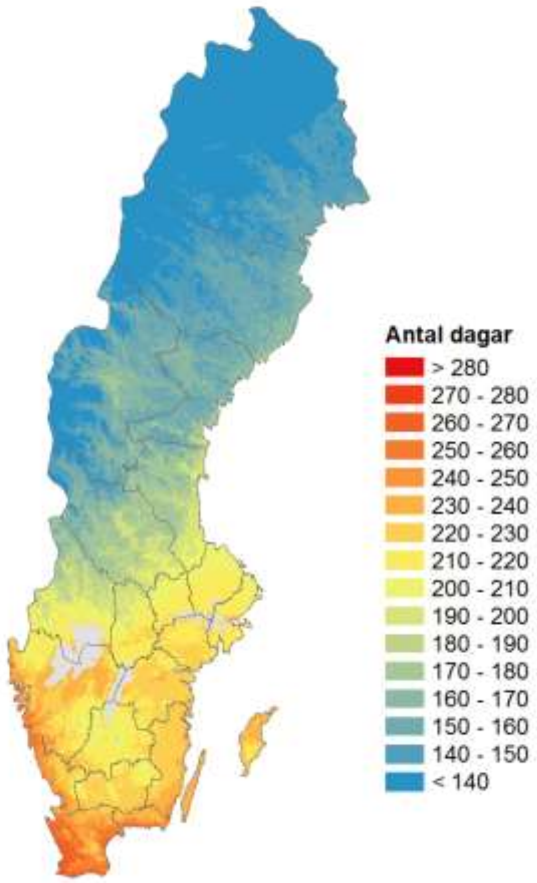
An analysis on the renewable energy potential for Pajala municipality has been done by the regional energy agency Energikontor Norr and LTU in 2010. The results are listed below:

	Today	Technical potential
Hydropower	1700 MWh/ year	+200 MWh/year
Forest biomass	400 000 MWh/year	800 000 MWh/year
Wind power	480 000 MWh/year	+2 500 000 MWh/year
Agricultural biomass	0	+20 000 MWh/year
Solar (PV and heating)	Small	Big
Heat pump	Unknown	Big
Waste heat	5 700	Relevant, potential in mining

[1] Source: https://www.energimarknadsbyran.se/el/dina-avtal-och-kostnader/elkostnader/elforbrukning/normal-elforbrukning-och-elkostnad-for-villa/

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 and economic perspective as well. It is also important to consider conflicts with other interests like biodiversity and cultural heritage when planning for new renewable energy. 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.

Agricultural biomass



Due to its Arctic climate, the growing season is relatively short, as the map shows (around 150 days, Source: SMHI), 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, as there is no active farming in Korpilombolo by now and the community does not own significant areas of agricultural areas, this option seems not to be relevant at present for Korpilombolo .

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.[2]

Even in Pajala 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 must be announced and approved by the municipality, but it is unclear whether this has happened in any case. 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 Korpilombolo shows that both investments are profitable with a pay-back of 4 years for air-to-air and 8 years for geothermal heat pump with the given parameters.

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

[2] 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

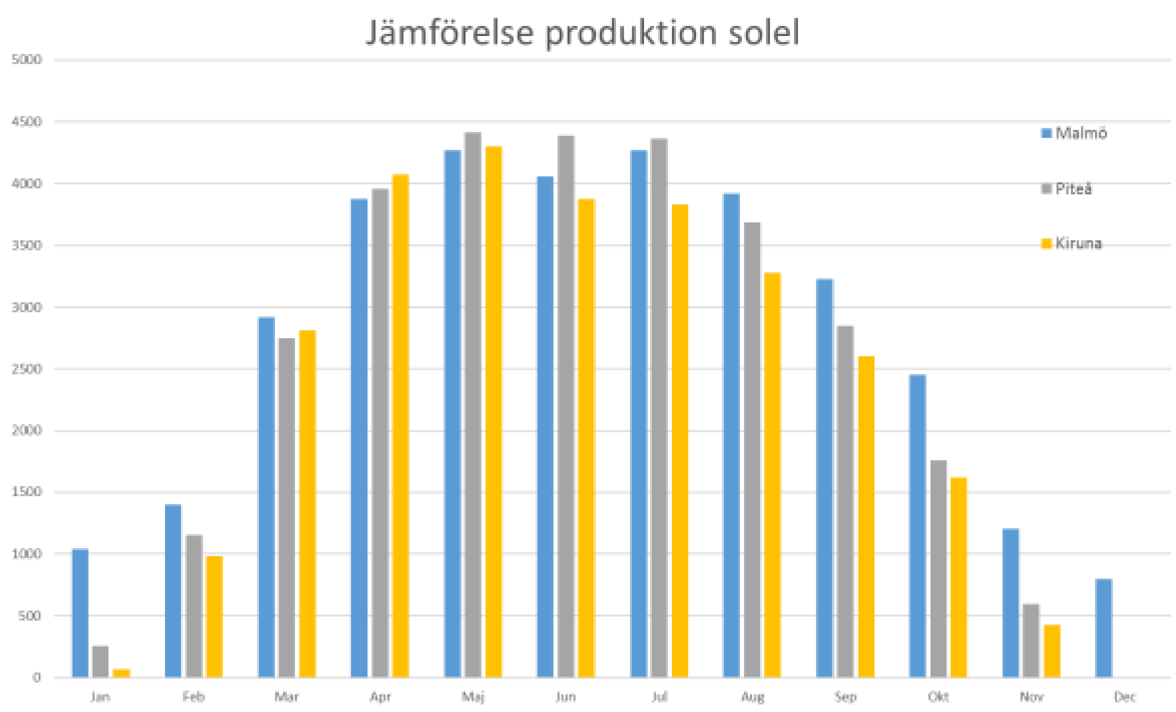
Pellet or wood stove

As mentioned above, private homes in Korpilombolo might not have central heating, but direct electric heating. However, several houses hava 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 if 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.



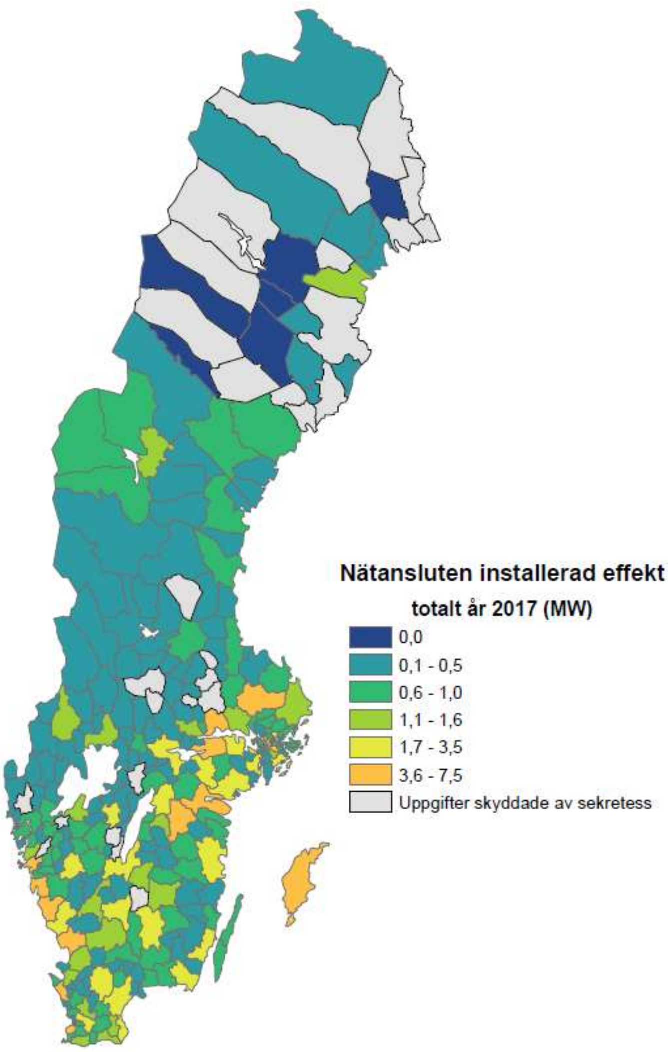
Source: Piteå Energi

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 Korpilombolo

A calculation for a PV plant for private homes in Korpilombolo 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 considered.

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

ETC PV plant in Kurkkio / Pajala
That ground-based PV plants are possible and economic shows one example: The company ETC has built a PV plant on the ground in Kurkkio/Pajala which has been financed by crowdfunding. The plant has a capacity of 100 kWp with 2 percent interest rate.

Source: https://etcel.se/pajala

Windpower

Windpower is a very interesting renewable energy source with a well-established market and knowledge base. Pajala area has good conditions for wind power and wind power companies are still established and new plans are under way.

Company OX2[3] is producing wind power in the Lehtirova wind farm which is located on the border between Gällivare and Pajala municipalities in Norrbotten County. The facility is divided into three sub-areas and is located in the area between the villages of Ullatti and Kompelusvaara. The distances to these villages are approximately 7 and 4 km respectively. The land in the area is mainly owned by private property owners. The facility comprises 41 wind turbines with a total height at a maximum of 184 m. Electricity production from the plant is estimated at approximately 490 GWh per year. Construction began in October 2016 with logging of forests, adjustment of existing roads and construction of supplementary new roads to the project site. June 2017, the foundation was cast and turbines were delivered in June 2018, and installation of the wind turbines began. The wind farm was ready in December 2018.

Vattenfall is investigating the possibility of constructing a wind farm in the area on and near the Käymävaara mountain near Käymäjärvi village in Pajala municipality. Parts of the area at Käymävaara are mentioned as suitable for wind farms in the municipality's land use plan and wind measurements show that it is blowing really well in place. The current project area has a potential of up to about 60 wind turbines and could annually provide more than 100,000 homes with renewable household electricity if implemented. Plans are to apply to build up wind turbines with a total height of up to 250 meters [4] A dialogue including the military is needed as concerns are that a wind power plant will interfere with military air force needs.

In this feasibility study, focus lies on a community-owned 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[5]. 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

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

[3] https://www.ox2.com/projekt/lehtirova/

[4] https://corporate.vattenfall.se/om-oss/var-verksamhet/var-elproduktion/vindkraft/pagaende-vindkraftprojekt/vindkraftprojekt-pa-land/kaymavaara-vindkraftpark/

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

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[6]. 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.

However, as Korpilombolo community has shown interest in this type of technology – and so have others – it is worth to try to get some pilot projects under way for testing and learning about how actually small-scale windpower works and how it could be improved. If the electricity is mainly used in the own building or for charging an electric car and the income per kWh is 1,5 SEK the results could be as calculated below:

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

Windstar 3000, 3 m Rotor	3 kW at 12 m/s
Production kWh/year (4 m/s average)	3 680
Investment	75 500
Income per kWh	1,5
Income per year	5 520
Lifetime (years)	15
Pay-back (years)	14
Total Profit (SEK)	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. CHP plants are usually economically and ecologically beneficial, if both the electricity and the heat produced can 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 currently not widely used in small-scale plants in Sweden. 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 Korpilombolo 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 Pajala and probably also Korpilombolo 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[7]. According to the national emission database RUS[8] used every inhabitant in Pajala 302 liter of diesel and 292 liter of gasolines in 2016. For Korpilombolo (539 inhabitants), this means a total of 320 348 liter of fossil fuel to a cost of approximately 4,5 Mio SEK a year and an energy need of 2883 MWh of energy for transport.

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.

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[7] CELLER-i project https://www.alvsbyn.se/naringsliv/eu-internationellt/aktuella-eu-projekt/celler-i/

[8] http://extra.lansstyrelsen.se/rus/Sv/statistik-och-data/korstrackor-och-bransleforbrukning/Pages/default.aspx

Scenario for sustainable energy in Korpilombolo

Energy efficiency

The technical energy efficiency potential for buildings in Korpilombolo is assessed to be high. This is due to the high average age of building in Korpilombolo with almost no new builts. However, the economic potential has to be assessed significantly lower, as houses are cheap in Korpilombolo. High investment costs are difficult to justify. However, experience show that change of behaviour and small investments can lead to savings of about 10-15 percent. In companies and similar facilities, up to 20% are possible by simple and cheap measures, and 30 and up to 50% with more comprehensive measures.

	MWh (2016)	Scenario 2025 in MWh
Public buildings	1 878	1 596
Private homes & Apartment houses	3 935	3 541
Private companies	2 250	1 575
Sum	8 063	6 515

Solar energy

To assess the total potential for solar energy in Korpilombolo, 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 apartment houses, only PV is calculated. In addition, a bigger plant of 80 kWp is calculated.

What	MWh/year
50 private homes, solar heating + 5 kW PV	293
10 bigger buildings, 13 kW PV	56
Bigger PV plant, 80 kW:	72
Sum	421

Heat pump

For heat pumps, it is assessed that 25 private homes will invest in an air-to-air heat pump, and another 12 in ground or geothermal heat pump.

What	MWh/year
Air to air heat pump	100
Ground heat pump	220
Sum	320

Bioenergy
For bioenergy, it is assumed that 25 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.

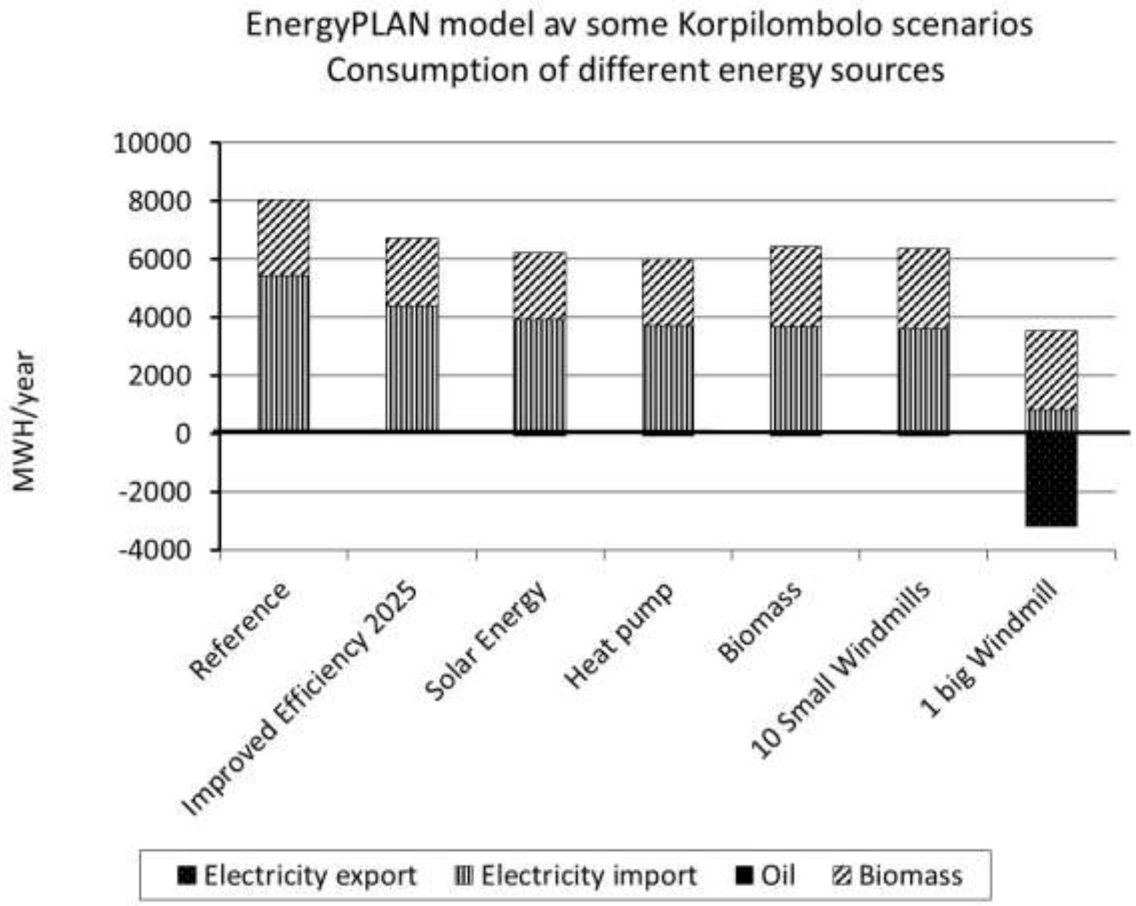
What	MWh/year
25 Wood or pellets stove	225
Small-scale cogeneration electricity	45
Small-scale cogeneration heat	130
Sum	400

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.

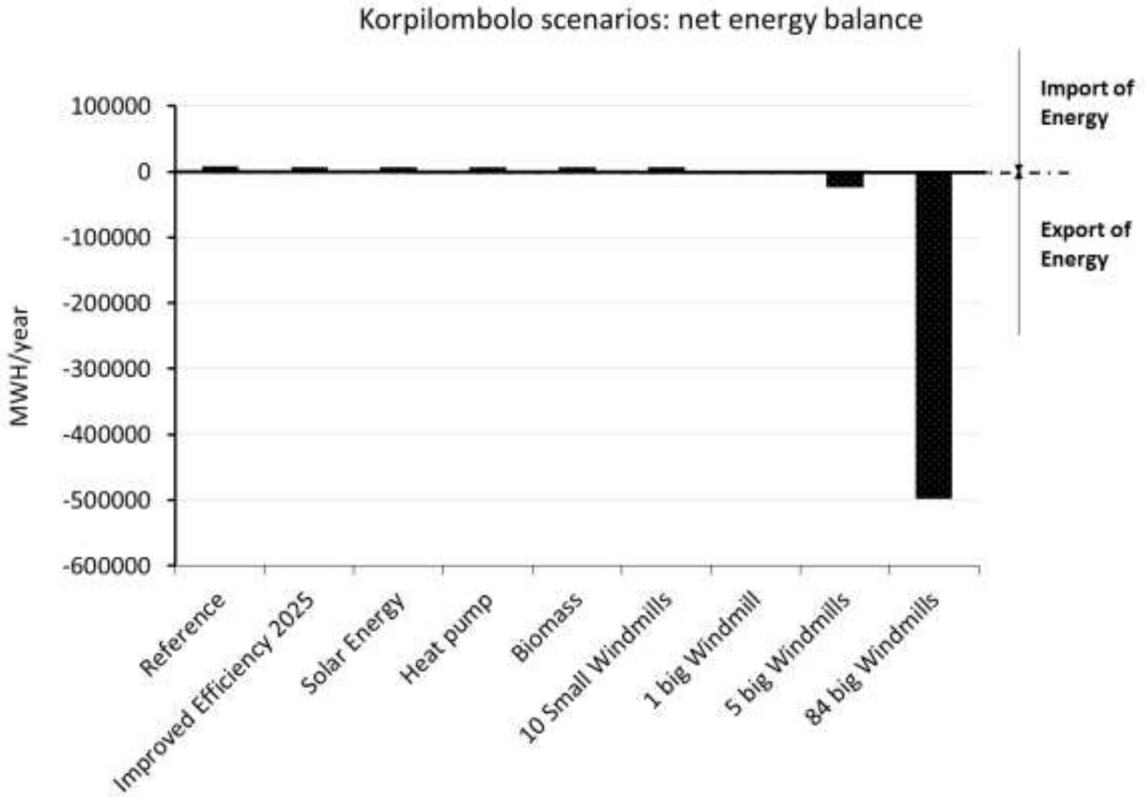
Import and export
LTU did a calculation for different scenarios with the global energy planning tool EnergyPlan. The figure below shows how the consumption of different energy sources is influenced with gradual improvements according to the scenario description (see above)



Wind power is only shown for up to one big windmill in this diagram. (Otherwise the scale would make it difficult to read the differences caused by other improvements.). We see that the effect of the big windmill is a combination of less consumption from and export to the net.

The EnergyPLAN model for wind power uses a correction factor to compensate for the nonlinear 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. The same factor as the one used in Vuollerim and Porjus was used: 0,4927.

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



The diagram indicates that Korpilombolo becomes self-sufficient in Energy with five or more big windmills