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Feasibility of Local Sustainable Food Production in Longyearbyen through Geothermal Energy Supply

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1 Abstract

With the planned shutdown of coal-based energy production by 2028, Longyearbyen community strives to be a flagship of a sustainable green energy community in the Arctic by the end of the decade. We evaluate the feasibility of providing a local greenhouse with geothermal heat, in addition to district heating and possible electricity production, in order to reduce CO_2 emissions. We found that there is a high geothermal potential around Longyearbyen, measured up to 44 K/km with a heat flow of 80 mW/m^2. It is proposed to use a deep borehole heat exchanger method to extract the geothermal heat, reaching 2500 m depth. Up to 6 boreholes are needed to supply Longyearbyen with district heating. The replacement of food shipments run on fossil fuels with local food production in a 1000 m^2 large greenhouse supplied by geothermal energy will cut CO_2 emissions and food waste and provide healthier and more nutritious food to the local population. It will create a social meeting place in the form of a cafe and a community garden desired by the community thus enhancing life quality. The geothermal greenhouse creates synergies which propagate to the Longyearbyen tourism industry and the job sector. We find that it is possible to supply Longyearbyen with fresh fruit and vegetables from a greenhouse run on geothermal energy and recommend district heating and electricity generation from this energy source, noting that this is not assessed regarding cost effectiveness.

Fig. 1: Draft of greenhouse in upper Sjøområdet for Polar Permaculture, LPO Arkitekter, 2020.

2 Introduction

In the state of changing climate conditions, the Arctic community of Longyearbyen needs to transition into sustainable and renewable energy solutions to contribute to lower global CO_2 emissions. The Longyearbyen coal-fired power plant is the main power component in the town, generating about 40 GWh electricity and 70 GWh heat a year (Ringkjøb et al., 2020). While electricity is mainly consumed by the industrial sector, households and the service sector consume most of the heat. The total CO_2 emission as a result of the energy supply in Longyearbyen is estimated to be 60 000 tons a year (Ringkjøb et al., 2020). For food transportation and supply we estimated about 17323 tons of CO_2 per year.

With the shutdown of the coal production in Longyearbyen within 2028 (Store Norske, 2021), it is essential to find new, but also sustainable energy sources. We will evaluate how district heating by geothermal energy, a renewable energy source derived from the heat within Earth's interior, may contribute to this. Opposed to other renewable energy sources, geothermal energy serves the advantage of an all-year availability and is not weather-dependent (IRENA, 2017). It has very low greenhouse gas emissions compared to other energy sources, but also very low running costs. Additionally, it has the capability of supplying baseload electricity with a higher capacity factor opposed to other renewable sources, which is an essential factor in Longyearbyen (IRENA, 2017).

Presently, Svalbard is dependent on shipping of goods from Norway mainland due to its remote location. The transport by boat and plane ultimately contributes to higher CO_2 emissions, but also a high food waste, estimated to be up to 60 % in Svalbard. We will evaluate how this may be lowered by a local sustainable food production of fruit and vegetables in a greenhouse, powered by geothermal energy.

3 Problem statement

Through the shutdown of coal mining, it is necessary for Longyearbyen to transition to another energy source in the future. In order to showcase a sustainable Arctic community, Longyearbyen wants to ensure generation of district heating and electricity on renewable energy. A high dependency on shipping of fruit and vegetables from Norway mainland must be reduced to decrease CO_2 emissions and food waste.

4 Conclusions

Both geothermal heat supply for district heating in Longyearbyen and a geothermally powered greenhouse are feasible. The area has a high potential for geothermal energy with steep geothermal gradients exceeding 44 K/km and high and steady heat flow of 80 mW/m^2 in the bedrock surrounding the community (Store Norske 2021, Beka et al. 2016). The Dh4 well drilled by Store Norske (2021) has measured >30 °C at 900 m, and temperatures are expected to increase to up to 80°C at 2000 m depth.

We propose a deep borehole heat exchanger system down to 2500 m depth for Longyearbyen district heating, and to supply a greenhouse with heating and optionally also produce electricity. This closed loop pipe system may produce water temperatures of up to 70 °C at the surface. A heat pump can increase the temperature further, which will be necessary in the case of electricity generation and district heating, and to use the existing heating infrastructure of Longyearbyen. Depending on borehole characteristics and actual energy capacity of geothermal heat at depth, about 6 deep geothermal boreholes would be needed to provide the entire Longyearbyen community with reliable heating throughout the year.

We also propose a greenhouse with a footprint area of 1000 m^2 which can host a food cultivation area of 3000 - 4000 m^2 and produce around 30 tons of vegetables per year, equivalent to 19 % of the required vegetables to provide Longyearbyen. 6 greenhouses could replace the import of vegetables to Svalbard from mainland Norway altogether. The greenhouse can entirely be supplied with heat and electricity from the geothermal well.
Local food production reduces food waste through shorter transportation ways and increased product attachment and identification by the consumer. We expect health benefits and increased life quality of the local population through fresher and more nutritious food and through creation of new meeting spaces.

5 Results

5.1 Carbon footprint of current food supply and district heating in Longyearbyen

Currently, the heating of the houses in Longyearbyen is provided by district heating. The power plant produces 40 GWh of electricity and 70 GWh of heat per year, creating CO_2 emissions of 60 000 tons (Ringkjøb et al., 2020). Due to a lack of data, it was not possible to calculate the fraction of CO_2 emitted by the power plant that accounts for the heating. Parts of the heat are produced as a byproduct of the electricity production but especially during the winter coal needs to be burned additionally to compensate for the increased heat demand (Antonsen, 2021). A change in the district heating supply from coal to geothermal energy, would reduce the amount of coal burnt in the power plant significantly especially during winter and would thus also reduce the CO_2 emissions. Furthermore, is the coal mine and therefore also the coal power plant scheduled to shut down in 2028 and a new heat and energy source needed (Multiconsult, 2018). In contrast, a heating system powered by geothermal energy would emit only 6-80 g $CO_{2,\ eq}$ per kWh (IPCC, 2011) and would provide a constant heat supply all year round.

Today, food is transported from Norway mainland to Svalbard by boat and plane. The greatest fraction of food is transported by the freight boat Norbjørn which delivers food and other goods every 10 days from Tromsø. Norbjørn uses around 25 tons of fuel per day (Muilwijk, 2019); a journey to Svalbard takes around 2.5 days. For one delivery and return trip, this results in a fuel consumption of 147058 l and 391 tons CO_2 emissions. For a full year, this sums up to 14000 tons of CO_2. We did not get information from 'Bring' about the amount of freight brought to Svalbard on each delivery. Every shipment contains 8 to 9 tons of fruit and vegetables (Coop, 2021). Additional 140 kg of fresh fruits and vegetables are brought with the mail deliveries by the mail plane, a Bombardier CRJ200 model, on 4 days a week (Coop, 2021). During one year the mail plane deliveries are responsible for the emission of 3421 tons CO_2. It was not possible to get any information about the total freight delivered by the mail plane from Posten or Bring, so we could not calculate the fraction of CO_2 accounting for the transport of vegetables and fruit by plane. During the summer months most of the vegetables are produced in Norway, whereas during the winter months most of the food is delivered from southern Europe to Norway (Coop, 2021). These extra transportation ways must be taken into account when looking at the total CO_2 footprint of the food but were not included in this study.

Local food production would reduce the amount of fresh vegetables and fruit that have to be transported from Norway mainland or continental Europe and further cut the CO_2 footprint of the food by enabling less frequent shipping deliveries. With no delicate vegetables or fruit on board to constantly supply Longyearbyen with fresh food, the boat could run less often. A cut of 10% of boat deliveries could already save 1400 tons CO_2 per year. As the mail plane is a crucial part of the local infrastructure, local food production is unlikely to cut the number of flights each year. But it can be expected that less freight would result in a lower fuel consumption and lower CO_2 emission. Also, remaining vegetables and fruit that need to be shipped could be transported by plane instead, reducing the number of shipments even further.

5.2 Geothermal energy potential in Svalbard and Longyearbyen area

Various studies have shown good potential for geothermal energy in Svalbard, significantly higher than on mainland Norway (Midttømme et al., 2015, Store Norske, 2021). A borehole of 972 m depth in Adventdalen (UNIS CO_2 lab well park area, named Dh4 well) has indicated a geothermal gradient up to 44 K/km under the permafrost. Store Norske (2021) has measured steep gradients around 30 - 40 K/km in south and central Spitsbergen, while the northwestern part has shallow gradients of 25 K/km. A steady borehole heat flow rate in the area of Sysselmann Breen of central Spitsbergen is estimated to be 80 mW/m^2, which is considerably larger than commonly found in northern Europe (Beka et al., 2016).

Subsurface lithology has a large impact on the corresponding thermal conductivity (e.g. ability to transfer heat) and temperature gradient. The Longyearbyen area is dominated by siltstone and shale in the uppermost layers, which have a low apparent thermal conductivity (Midttømme et al., 2015). In turn, this gives a high geothermal gradient in these areas.

The Dh4 borehole drilled by Store Norske (2021) up to 970 m has given the result of a geothermal gradient exceeding 30 °C at 900 m. Further, it is expected to be up to 55 °C at 1500 m, and up to 80 °C at 2000 m (see Fig. 2).

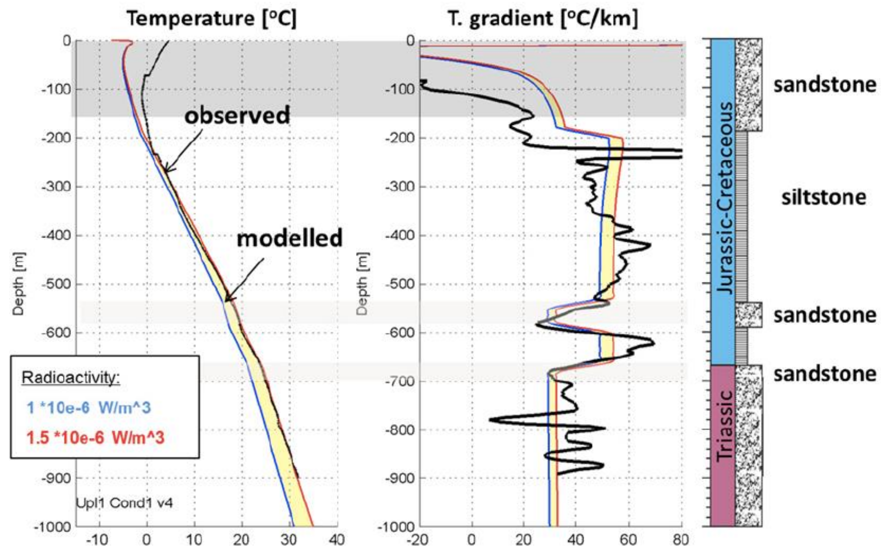

Fig. 2: Observed and modelled temperature and temperature gradient along the well dh4 to a depth of 1000m. Displayed with the lithology observed in the well. (Store Norske, 2021)

Due to highly changing weather conditions in Svalbard, along with periods of complete darkness, geothermal energy may be a particularly useful energy source in Longyearbyen. As already mentioned, it has a greater capacity opposed to other energy sources, along an all-year-round availability. How this may be supplied to a greenhouse and for district heating of houses in Longyearbyen will be further discussed in the following sub-chapter.

5.3 Geothermal energy generation for greenhouse and district heating in Longyearbyen

An ongoing Folkehøyskole project in Longyearbyen by Store Norske (2021) will use a 1000 - 2000 m deep borehole heat exchanger method. It is a closed loop system that is not dependent upon the surrounding rock type and is considered the system of lowest risk (Store Norske, 2021). As illustrated in Fig. 3, it consists of two pipes, an outer and a centre pipe. The water circulates into the well along the outer pipe, is heated by the rock, then transported back to the surface through the centre pipe. This is accomplished by a pump. The geothermal energy is generated from steam or heated water that carries the energy to the surface (IRENA, 2017). Around the borehole casing there will be a mantle of conductive cement enhancing the heat transfer between the bedrock and the circulated water. Still, the heat transfer is not as effective as in an open system geothermal borehole, where water is directly pumped through bedrock and aquifers. In the closed loop system, if the bedrock is 100 °C, the water coming back to the surface may reach only 60 °C. Thus, it will be necessary to implement an additional heat pump to increase the temperature at the surface for electricity generation and district heating, and if the existing infrastructure of Longyearbyen district heating system is to be used. District heating and electricity of the community is estimated to require 5 - 6 boreholes to supply adequate energy (Jochmann 2021, pers. comm.). Energy generation and capacity from boreholes are dependent upon many factors, such as borehole characteristics, pump speed, thermal conductivity of surrounding rocks, temperature variations etc. Due to lack of this data, this is not estimated and should be further studied to provide precise results.

We propose a borehole of about 2000 to 2500 m depth to supply the greenhouse with heating and to optionally produce electricity, but also the same system for district heating in Longyearbyen. At this depth, temperatures in the bedrock of the Adventdalen area are expected to reach between 80 to 105 °C. The water that is pumped to the surface will have around 60 to 70 °C. There it enters first a heat exchanger where heat is transferred from the pumped-up water to the district heating water cycle and/or to another chemical fluid with a lower boiling point for electricity production. Secondly, a heat pump increases the temperature of the chemical fluid above boiling point, thereafter electricity is generated with a turbine. If a chemical fluid is chosen to be in the closed loop system of the borehole, electricity could be produced with an Organic Rankine Cycle (Beka et al. 2015) directly from the closed loop borehole.

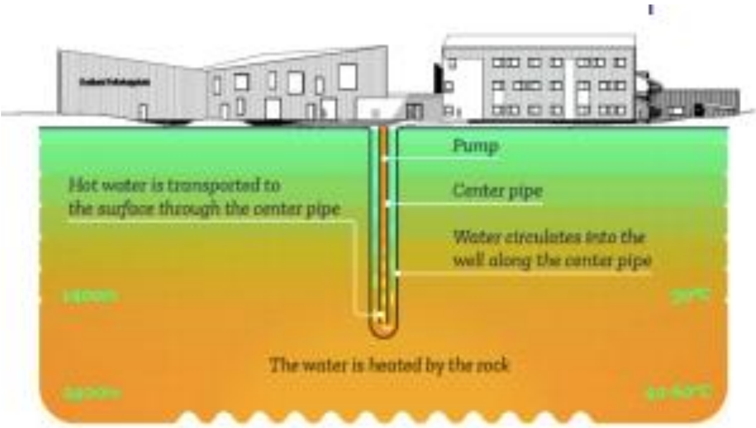

Figure 3: Illustration of a Borehole heat exchanger system. Source: Store Norske (2021).

Extracted geothermal energy through heated water and steam in pipes may thaw the surrounding permafrost. This might cause borehole instability and mobilization of mud and gas and should be managed by actively cooling the upper 30 m of the borehole. This is achieved through extra cooling boreholes around the main geothermal borehole (A) or/and extra insulating casing around the borehole (B) as described in fig. 4. If the borehole is located in a surface bedrock outcrop area, this could be insignificant.

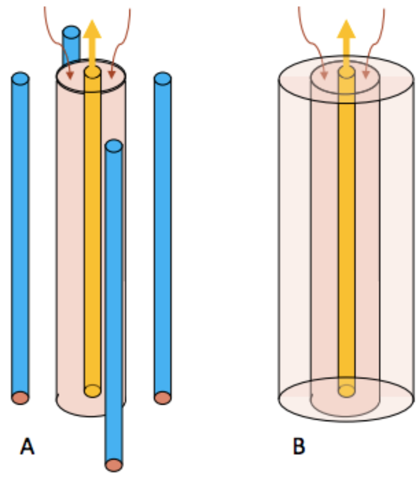

Fig. 4: Borehole cooling system in the uppermost 30 m of a geothermal heat borehole. A: main geothermal borehole in the middle (yellow and orange) and smaller cooling boreholes distributed around. B: geothermal borehole with extra insulating casing in upper part, without cooling boreholes around. Extracted from: Store Norske (2021)

4.4 Greenhouse considerations and calculations

The prospective greenhouse will have the design of a Rubb Hall - a storage tent with a steel frame and transparent double walled covering (Fig. 5). These storage tents have been established in Longyearbyen for some decades and have proven to be stable and robust enough for general climate and, specifically, wind conditions in Longyearbyen.

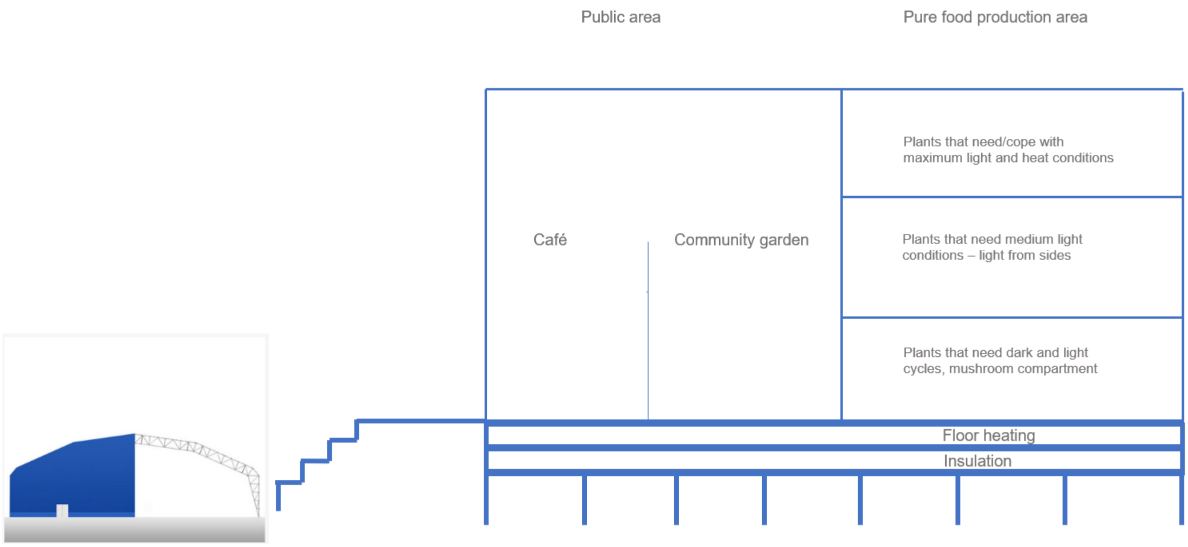

Fig. 5: Left: cross section of the greenhouse; Right: schematic side view of greenhouse with pure food production area and a public area with café and community garden.

The dimensions will be roughly 20 to 30 m in width, 50 to 70 m in depth and 4 to 6 m in height. Within the greenhouse tent there will be three levels in the pure food production area, the lowermost level being able to provide dark conditions during polar day for day-cycle sensitive crops. The second level accommodates crops that need medium light conditions and the uppermost level accommodates plants that need highest temperatures and full light conditions or do survive in full light conditions. This produces a footprint area of around 1000 to 2100 m^2, plus an additional 1000 to 2100 m^2 if two extra stories of the food production area are added. The air volume in the hall that would have to be heated to around 18 °C is approximately 1350 to 4000 m^3. The structure would stand on pillars to insulate it from the ground and to prevent permafrost ground from thaw and deformation. Additionally, a thick insulation layer in the floor is applied where on top of that heating cables with water from geothermal heat supply run through the floor.

In collaboration with LPO Arkitekter Svalbard and UNIS/SNSK Geologist Malte Jochmann, we identified 4 locations in the wider Longyearbyen area which are favourable as locations for the planned geothermal greenhouse (see Fig. 6). In the town center area we identified two spaces along upper Sjøområdet in an area with existing storage tents and halls. These are favourable as the greenhouse would be more accessible for the public and easy to reach without polar bear protection measures. In these areas are also several objects favoured for reuse and repurposing, like the old Avfallstasjon. Jochmann suggested locations around Hotellneset and close to Småbåthavna for larger food production greenhouses without social components or smaller community gardens. These locations are favourable because we find bedrock outcrops here which provide good fundamentals and because it is close to the airport and harbour for optional export of 'Arctic' fruit and vegetables.

Fig. 6: Possible locations of greenhouses in the Longyearbyen area. Left: downtown area of Longyearbyen; Right: Hotellneset and airport area.

Energy demand

The heat demand of a greenhouse of the dimensions 20x50x6 m and with a 150 mm thick insulation layer as suggested by the manufacturer (Rubb, 2021) is 18 kW, resulting in an energy of 158 MWh/year. If the greenhouse is not equipped with a built-in ventilation system, a dehumidifier is needed with an approximate electricity consumption of 4.8 kW (DryGair, 2021). Growing lights for day-cycle sensitive plants need 56-79 W per lamp (Philips, 2021). With one lamp for 2 m^2 of plants in a 1000 m^2 production area, the lighting needs 28 kW. With 10 hours of lighting during the dark season for the whole food production area and 10 hours of light for day-cycle sensitive plants during the full year 76 MWh/year of electricity. Ventilation and lighting thus require 497 MWh/year of electricity if the ventilation system runs constantly. The electricity required could be provided either by an ORC turbine producing electricity from excess geothermal energy or by the local electricity grid.

Plant choices & Food production per area

To maximise the cultivation area and thus amount of possible produced food, we propose shelves with 4 stories within each level. As for plant choices, it is possible to grow all types of vegetables or fruits, as it is possible to adjust the greenhouse to the conditions needed by the plants. For simplicity, we suggest a choice of plants that are content with similar growing conditions, such as temperature and humidity and also those plants that need little space and soil compared to their yield. Also, we propose to start with growing vegetables or fruits that grow fast and are delicate and difficult to transport to improve food quality and reduce the demand for frequent transport of fresh fruits and vegetables to Svalbard. This would namely be salad, tomatoes, cucumbers, chillies, microgreens, several types of herbs, and berries growing on bushes like raspberries. Vegetables that need more soil or space, such as pumpkin or squash, could be grown either on the ground level underneath the shelves or vertically.

A conventional soil-based cultivation area of 1000 m^2 would produce either 1.8 tons of salad, 12.1 tons of cucumbers, 18.4 tons of tomatoes or 9.2 tons of bell pepper each year (destatis, 2021). Assuming a maximised cultivation area of 3000 - 4000 m^2 by using multi-story shelves and two levels within a 1000 m^2 base area greenhouse, this could lead to an annual food production of 32 to 41 tons. This is equivalent to the amount of food annually transported to Svalbard by plane or 10 % of the total amount of vegetables delivered to Svalbard (Coop, 2021).

On average 40 % of fresh vegetables and fruits are thrown away in Norway (Stensgård, 2020). For Svalbard we assume this fraction to be higher, around 60 %, due to long transportation distances. We assume that a local food production with very short transportation ways and a broad support and awareness within the Longyearbyen community would cut the food waste down to 20 %. This would mean that instead of 335 tons of vegetables that are currently transported to Svalbard only 160 tons of vegetables would be needed. In this case, the food production in a 1000 m^2 greenhouse with a 3000 m^2 cultivation area could replace 19 % of the local need for fresh vegetables. To replace the entire amount of shipped vegetables by locally grown ones, assuming a lower amount of food waste, 6 of such greenhouses would be sufficient.

Hydroponics or normal soil system, what is better?

For the conventional growth of plants, the soil needs to be transported to Svalbard. For a 1000 m^2 cultivation area, this would mean a need of around 16 tons of soil. Water could be taken from the local fresh water supply. An alternative could be a hydroponic system in which the plants are grown directly in water without any soil needed. On the one hand, this system would make sense considering the large amount of soil that is required for conventional plant growth; it also would need less fresh water and fertilizer than conventional soil growth; on the other hand, these systems are very expensive, thus needing a longer time to pay off (Zhang, 2018). Exact numbers on the costs for a hydroponic system could not be found.

Reuse/Recycling of materials in Arctic Sustainable Architecture

The material used to set up the greenhouse will be partly recycled from the dismantling project in Svea and from the Longyearbyen area and partly imported from the UK (tent frame) and Norway (soil). We also suggest a new waste management system that composts within the greenhouse unit and produces soil and fertilizer for the greenhouse. This can be further enhanced with incorporation of chickens in the composting area, because they speed up the decomposition and soil formation process.

Multiple dedicated use

There are different partitions planned within the greenhouse which can be dedicated to different uses by the local population. Both the community garden area and café area in the front part of the building provide spaces to meet up and organize events in a green and bright space with a comfortable level of air humidity. Additionally, the school is invited to use the gardening facilities for teaching purposes.
More meeting spaces in the city area were one of the main requests by the local population following a community dialogue that started in 2019, conducted by the Svalbard Social Science Initiative (SSSI, 2019). The greenhouse will also have a large, wooded terrace around the public entrance area, which is oriented South-Southeast, so that sitting outside in good weather is always an option.

5.5 Estimated costs & Cost effectiveness

Estimated costs for geothermal energy

There is an uncertainty attached to geothermal energy production, both in terms of costs of investment as well as the actual resource potential (Beka et al., 2015). IRENA (2017) has estimated the global total installed costs to vary between USD 1 870 to USD 5 050 per kW for geothermal power plants. Already established fields, where only additional capacity is needed, will have a lower cost, while new, more challenging site conditions will have the highest costs. Opposed to initial costs, operating costs are very low and predictable. Levelized costs of electricity for geothermal power plants are estimated to vary between 0.04 and 0.14 USD per kWh (IRENA, 2017). In this assumption, maintenance costs of USD 110 per kW per year is taken into account, as well as a 25-year economic life.

The estimated cost of a borehole heat exchanger system would be 200 - 500 million NOK (Jochmann 2021, pers. comm.), for a borehole of maximum 2500 m depth. However, this is only an estimation, and the final costs would depend upon many factors, such as the actual lithology in deeper layers, unknown aquifers and unexpected engineering problems or legal setbacks. Additionally, it is hard to estimate the full life cycle of a geothermal borehole. Here we estimate a life span of 40 years (Jochmann 2021, pers. comm.).

The ongoing geothermally powered Folkehøyskole project of Store Norske (2021) will lower the unpredictable factors regarding the expected costs and geothermal potential of the area, and thus make it possible to establish more precise predictions of the total costs.

Estimated costs of the greenhouse

We estimate the cost of a recycled/reused greenhouse construction to be around 20 000 NOK/m2, which amounts to 20 million NOK and 42 million NOK for the small and large version of the greenhouse, respectively. The relatively low costs result from the reuse of existing facilities, recycling of materials which are already in Svalbard and because the building materials are few. The most cost intensive part will be the foundation drilling for the pillars and the ETFE foil purchase. In case of an entirely new building the costs would be 35 to 73 million NOK.

Cost effectiveness

In this study, the cost effectiveness of the geothermal energy supply to district heating in Longyearbyen is not assessed. Due to the lack of an existing borehole in a comparable environment, we could not estimate the geothermal capacity which is necessary to evaluate the costs and energy output of the project. We suggest a re-evaluation of the costs after the borehole for the Folkehøyskole is drilled and the geothermal capacity has been measured. We have several options to increase the economic feasibility: The greenhouse can be linked to the local tourism industry not only as a cafe but also as a main sustainable attraction in town. Once the geothermal heating system is established, large-scale food production on cheap geothermal energy can be economically feasible which opens the opportunity for export of the grown food and the creation of new jobs.

6 Challenges

There are several challenges that need to be considered when implementing a geothermal borehole and geothermally powered greenhouse. In the Adventdalen area there are technical considerations for drilling in ground with the risk of gas leakage, different subsurface pressure conditions and fault zones, which should be evaluated by experienced professionals in relevant fields (Store Norske, 2021). We might also face challenges connected to strict plant and livestock import regulations and complicated building restrictions in Longyearbyen. Maintaining plant light cycles are also a challenge in Svalbard, where the light conditions change from 24 hours of daylight to 24 hours darkness. Some plants require a partly darkened day cycle in order to create fruit. This can be managed by greenhouse compartments which can be fully shaded during bright season and growing lights in the dark season to regulate and optimise hours of light exposure for the plants. High amounts of soil are needed if a conventional greenhouse approach is implemented. A solution to that would be to establish a hydroponic greenhouse system.

Finally, we point out that social acceptance has not been assessed for greenhouse or geothermal borehole plans and could present a challenge. We however expect a positive response of the local and tourist population towards the sustainably heated greenhouse, not least because of new employment opportunities in servicing the greenhouse and geothermal heat system.

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Appendix

a. Greenhouse: small version

Dimensions: 20x50x4m

Heat demand: Φ=Ucs* Ab*F*ΔT

Base area	Ab	1000 m^2
Envelope area factor	F	1.64
Temperature difference	ΔT	18-(-24)
Heat demand/consumption coefficient	Ucs	0.25 W/m^2K
Heat demand (W)	Φ	18040
Energy per year (MWh/year)		158

b. Vegetable yield in tons per m2 of conventional greenhouses in Germany (destatis, 2021):

Salad: 0.001
Cucumbers: 0.012
Tomatoes: 0.018
Paprika: 0.0092

Soil: based on estimates for soil need of basil plant

ca. 300g soil per basil plant (Bauhaus.info)
53 basil plants per 1m
soil need: $16kg/m^2$

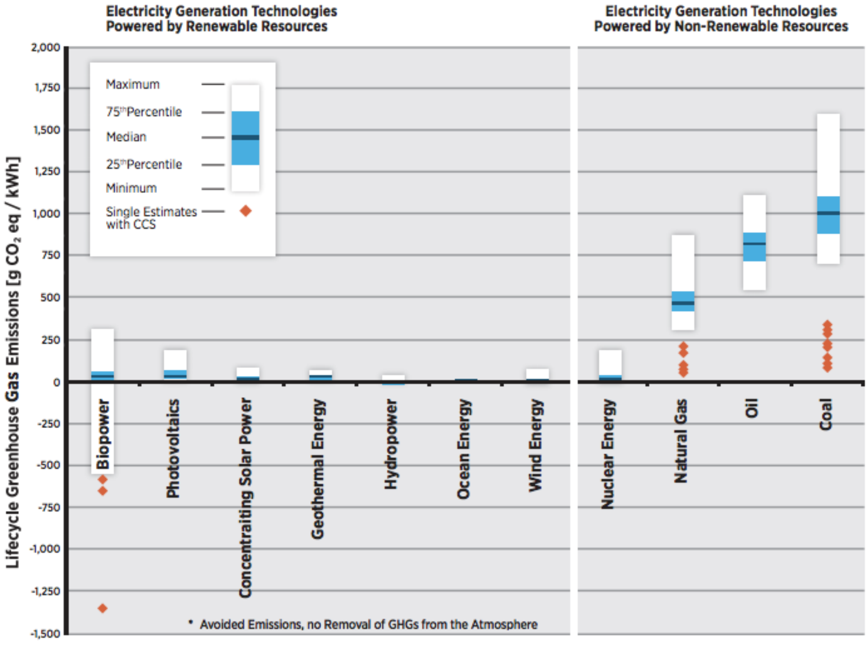
c. CO_2 emissions by boat:

Emissions (Kg CO_2) = 2.66 (kgCO_2/l)*diesel (l)

d. Emissions by mail plane (Bombardier CRJ200):

Fuel consumption per km (liters) = 3.24 (FlyRadius, 2015
return trip Tromso-Longyearbyen = 1900k
total fuel for journey (liters) = fuel consumption per km (liters) * distance (km) = 6161.4 liters = 4.9 ton
CO_2 emission for 1 ton of kerosin (tons) = 3.16 (atmosfair, 2016
CO_2 emissions for journey (tons) = 3.16 * total fuel for journey (tons) = 15.6 tons

e. Estimation of greenhouse gas emissions according to power generation source



Count of Estimates	222(+4)	124	42	8	28	10	126	125	83(+7)	24	169(+12)
Count of References	52(+0)	26	13	6	11	5	49	32	36(+4)	10	50(+10)

Fig. 1:
Estimation of greenhouse gas emissions according to power generation source. (IPCC, 2011).

f. Additional geothermal heat data

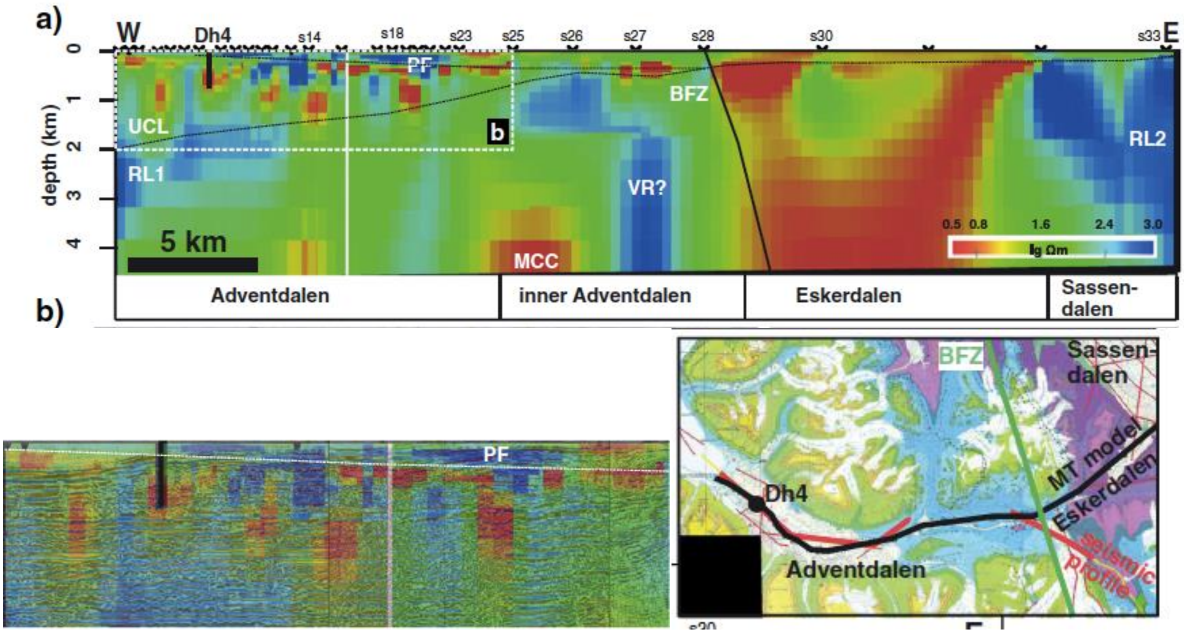


Figure 3: Images are extracted from the study of Beka et al. (2016). Image a) displays the resistivity measurements of the whole study area. Image b) is an up-close image of the resistivity measurements in Adventdalen, displaying a high heterogeneity and patchiness. Well Dh4 is present as a black line. Image c) is an overview of the study area.

A study by Beka et al. (2016) uses a magnetotelluric (MT) study to estimate the resistivity of the subsurface geology around Longyearbyen. This geophysical method is highly sensitive to anomalies related to conductive geothermal fluids, their flow mechanism and temperature. It therefore serves as an indicator of accessible geothermal systems that are present in the subsurface. The study of Beka et al. (2016) suggests that the mid-crust conductor (MCC) anomaly, as well as a deep conductive zone beneath the Billefjorden Fault Zone (BFZ), are possible candidates of geothermal sites.