Heat Pumps in district heating: pre- study for Arvidsjaur and Jokkmokk

Increasing fuel prices have made Swedish district heating companies interested in reviewing their heat supply mix. A pre-study financed by the European Investment Bank has examined how district heating in two smaller localities in Norrbotten, Sweden, can integrate heat pumps. The results differ.

IBF EXPERTISE and Energy Modelling Lab, on behalf of Energikontor Norr and Region Norrbotten in collaboration with EIB Advisory

Written by Kristina Lygnerud engaged by Energy Modelling Lab

Background

District heating companies in Europe have been challenged the past years. The costs for both gas and biomass increased because of Russia's invasion of Ukraine. One consequence of the increased price level is that Swedish district heating companies have started to review their heat supply mix.

In a project funded by the European Investment Bank a pre-study was made to understand how the district heating companies in two smaller localities in Norrbotten, Arvidsjaur and Jokkmokk, could integrate heat pumps in the heat supply mix. The study was made by IBF EXPERTISE and Energy Modelling Lab on behalf of Energikontor Norr and Region Norrbotten in collaboration with EIB Advisory.

The method applied has been energy systems modeling developed specifically for district heating activities. With the model as point of departure the inclusion of heat pumps, thermal storage and reinvestments in new heat boilers on different fuels in the system were assessed from both economic and environmental perspectives.

Two localities with different circumstances

In both Jokkmokk and Arvidsjaur the district heating activities are currently based on combustion of biomass.

In one locality, a first diversification step has been to install ORC technology to ensure that electricity can be provided locally and reduce the cost of electricity for operations. The other locality is installing the same technology in combination with a battery storage allowing a maintained operation in the case of power outage.

The circumstances regarding the installation of heat pumps differ between the two municipalities. In Arvidsjaur, an air-source heat pump is seen as a way of avoiding to keep the combustion plant running during the summer months. This can be seen as an advantage as it allows biomass to be utilised during the colder months of the year, resulting in better utilisation of the fuel with higher overall efficiency, rather than operating the boiler inefficiently. In Jokkmokk, plans are in place for a data centre that can provide more residual heat than the town requires, making the heat pump a highly advantageous option.

In both cases, alternative heat extraction points via heat pumps were also quantified, such as waste heat from industry, wastewater, watercourses and lakes, as well as other heat sources such as available biomass, solar heat and alternative technologies for weekly and seasonal storage.

Results

The final analysis concluded that an 8 MW heat pump for waste heat recovery from a data centre would be cost-effective in Jokkmokk. Together with a 100 MWh storage tank and a 3 MW electric boiler, peaks in production are covered. Existing oil-fired boilers will be retained as a backup (11 MW).

In Arvidsjaur, the modelling showed that the inclusion of an air-source heat pump was only effective when operated during the summer months, with an output of 2.5 MW. It was combined with a new 10.5 MW wood chip boiler. Together with a 100 MWh storage tank and the existing 5.4 MW pellet boiler, this setup handles peaks in production. Existing oil-fired boilers are retained as a backup (5 MW).

The annual average coefficient of performance (COP) for the heat pumps is estimated to be 12.6 in Jokkmokk and 1.96 in Arvidsjaur. Figures 1 and 2 show how capacity and output are projected to develop up to 2050, whilst Figures 3 and 4 illustrate how the heat

pumps will be integrated into hourly operation for each case study.

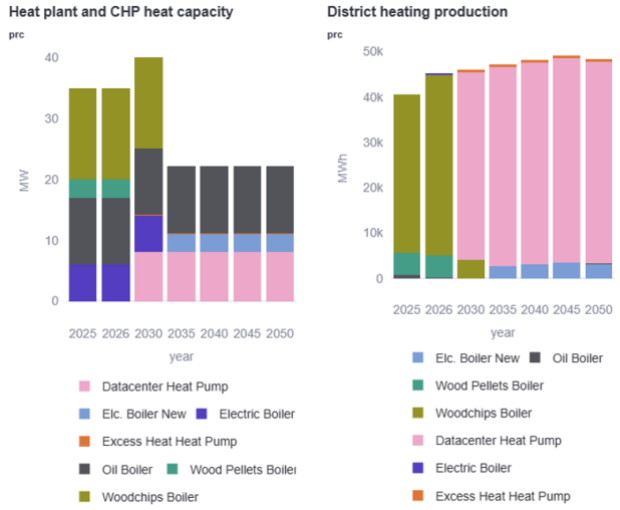


Figure 1. Jokkmokk. Installed heat generation capacity (MW, left) and district heating production by technology (MWh, right), 2025 to 2050.

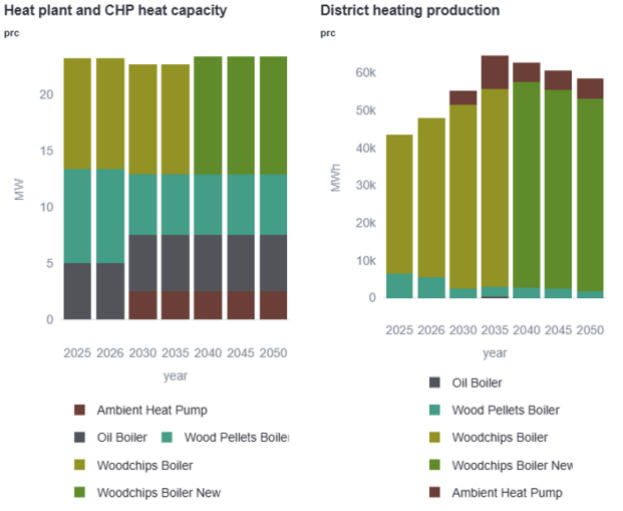


Figure 2. Arvidsjaur. Installed heat generation capacity (MW, left) and district heating production by technology (MWh, right), 2025 to 2050.

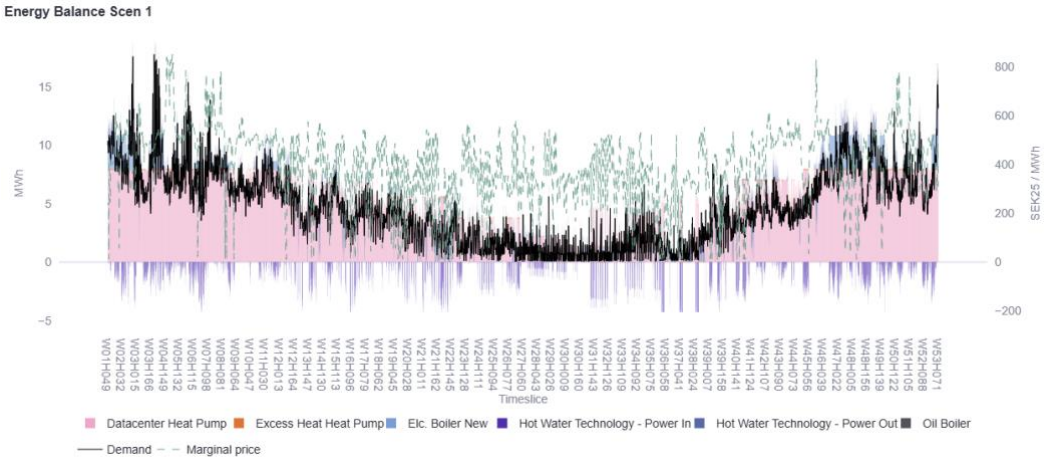


Figure 3. Jokkmokk. Energy balance by time step over one year (scenario 1): heat production by technology (MWh), heat demand and marginal cost of heat (SEK/MWh, right-hand axis).

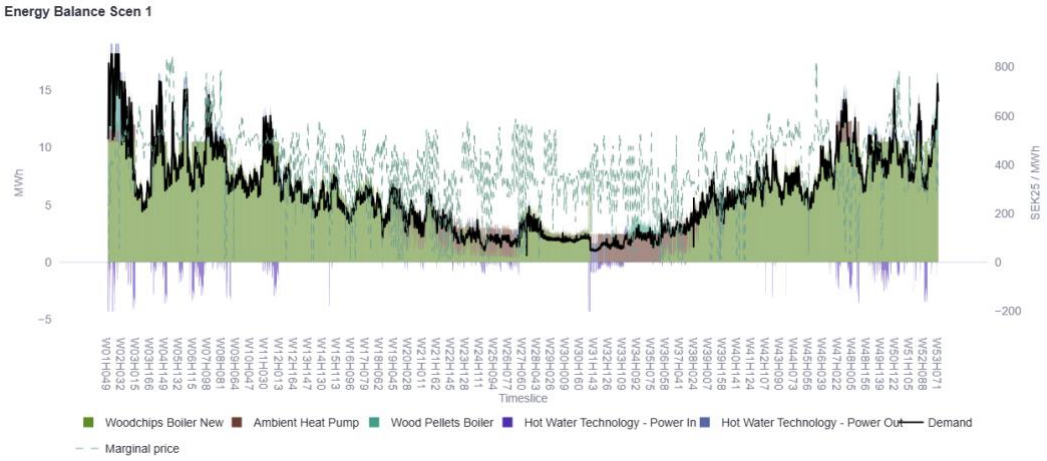


Figure 4. Arvidsjaur. Energy balance by time step over one year (scenario 1): heat production by technology (MWh), heat demand and marginal cost of heat (SEK/MWh, right-hand axis).

Costs and payback period

Regarding costs, an analysis has been carried out of the investments required and the expected payback period, taking into account various payback requirements. In Arvidsjaur, the payback period is over 15 years, whilst in Jokkmokk it is 7 years (including the costs of laying pipes). As regards the impact on production costs, these will fall in both cases between 2025 and 2050. The reduction is greater in Jokkmokk than in Arvidsjaur.

Stakeholders' views

The project has gathered views from various stakeholders, and the utilisation of waste heat is desirable; however, it also creates a vulnerability to which the system has not previously been exposed, as dependencies are established on operators whose main business is not the generation of waste heat.

In Jokkmokk, the situation may arise where residual heat becomes the new dominant heat source; however, it is highly likely that a biofuel backup will be required to manage situations where residual heat is unavailable or insufficient. For effective implementation going forward, it is critical that the contractual arrangement is efficient and that the planning of the technical installation is carried out correctly and efficiently.

Concluding reflections

In summary, the preliminary study indicates that diversifying the fuel mix may be effective in small systems with cold winters. One advantage is that fuel price volatility becomes less significant. However, the extent to which this is cost-effective depends on the heat sources available and their costs.

In the case of Jokkmokk, there is potential for a cost-effective solution provided that both parties can agree on the value of the residual heat. In the case of Arvidsjaur, a trade-off needs to be made between the benefits of a longer summer shutdown of combustion and reduced exposure to biomass price fluctuations, compared with the investment cost of a heat pump.

Voices from the project

Jokkmokks Energi

For us at Jokkmokks Energi, it is incredibly inspiring to be able to collaborate with organisations at the cutting edge of technology and to be part of a project that has the potential to transform Jokkmokk's entire future energy supply. Being able to heat our community by utilising energy that would otherwise go to waste is a fantastic example of how industrial development and the climate transition can go hand in hand.

The fact that this opportunity now exists is also the result of local entrepreneurship. Thanks to Ållojaure Site's commitment and development work, together with the municipality's detailed planning work, the conditions have been created for a new development that could prove of great significance to Jokkmokk.

For us, the transition is also about reducing our dependence on biomass. Competition for forest raw materials is increasing, whilst EU regulations and ambitions regarding the use of forests are changing the conditions for biofuels. Whatever one's views on this development, it is a reality that we, as an energy company, must address. By diversifying our heat production, we can reduce our vulnerability, strengthen security of supply and create the conditions for long-term competitive district heating prices.

The work on the feasibility study has been very rewarding, and I would particularly like to thank all the dedicated consultants and Energikontor Norr for their valuable contributions. For a small municipal energy company, this collaboration means a great deal, both in terms of our professional development and the opportunity to offer a stimulating and forward-looking workplace.

The next step will be to seek further funding and turn the feasibility study into a viable project. Our hope is to realise a solution that will be of great significance to Jokkmokk and our future energy supply, whilst also creating clear added value for Fossefall's establishment of an AI data centre.

It is precisely these kinds of long-term partnerships that we want to help develop – where industrial development and a sustainable energy supply reinforce one another.

Erik Fagerström
CEO, Jokkmokks Energi AB

Arvidsjaurs Energi

Arvidsjaurs Energi is at a stage where we need to plan for new investments to keep pace with developments in Arvidsjaur. The feasibility study therefore came at just the right time and has provided us with a valuable basis for assessing which technologies and energy sources could form future additions to our district heating system. Although the modelling shows that a heat pump is not economically viable under current conditions, the study provides greater insight into both the opportunities and limitations. This strengthens our basis for decision-making regarding future investments and helps us to continue developing robust, resource-

efficient and long-term sustainable district heating production.

As Erik Fagerström of Jokkmokks Energi explains, competition for biofuel has increased, whilst prices have fluctuated significantly. This creates a degree of uncertainty that we need to consider in our long-term planning. By exploring alternative heat sources and complementary technologies, we can reduce our dependence on a single fuel, strengthen security of supply and create better conditions for stable and competitive district heating prices. The feasibility study is therefore an important step in the process of identifying which solutions are technically, economically and environmentally sustainable for Arvidsjaur in the longer term.

William Nyman
CEO, Arvidsjaurs Energi AB

Energikontor Norr

For Energikontor Norr, the feasibility study is a clear example of what we aim to achieve in the region: to give smaller municipal energy companies access to expert support and funding that would otherwise be difficult to obtain. Through their collaboration with the European Investment Bank Advisory, Arvidsjaurs Energi and Jokkmokks Energi have been able to produce a decision-making basis of a quality rarely available to companies of their size, and this has been done in close dialogue with those who know the systems best.

The results also show that there is no one-size-fits-all solution. In Jokkmokk, the establishment of a data centre creates the conditions for a heat pump that is both cost-effective and strategically important. In Arvidsjaur, the modelling shows that the current conditions are not sufficient, and that finding is at least as valuable. A well-founded conclusion about what is not viable helps the company to avoid misguided investments and to direct its resources where they will be of greatest benefit; in Arvidsjaur's case, it also serves as confirmation that they are on the right track.

District heating in Norrbotten's smaller towns faces similar challenges: increased competition for biofuel, fluctuating prices and new requirements under EU regulations. At the same time, interest in data centres and other electricity-intensive industries is growing in the region. Jokkmokk demonstrates how such developments can become a resource for the local community rather than merely a new electricity consumer. The feasibility study also highlights what is needed to succeed: clear agreements that address dependence on an external supplier of residual heat, reliable reserve capacity, and efficient licensing and regulatory processes for technologies that are not yet established.

We would like to thank Arvidsjaurs Energi, Jokkmokks Energi, Region Norrbotten, the consultants and EIB Advisory for their excellent cooperation. Energikontor Norr will continue to support the companies in the next stage, including in their efforts to secure funding, and will continue to share these experiences with more local authorities and energy companies in Norrbotten. The knowledge gained from Arvidsjaur and Jokkmokk makes an important contribution to a robust, resource-efficient and fossil-free energy supply throughout the region.

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