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Developing smarter district heating in Kuusamo

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Combined heat and power production (CHP) has been an energy efficient and environmentally friendly way to produce district heating in Finland for decades. However, as the renewable energy production, especially wind power, has affected the power markets and decreased electricity prices, also the profitability of CHP production has worsened. The SMARTrenew project introduces and pilots a thermal energy storage in district heating system as partial solution.

Finland is seen as forerunner in district heating (DH) production. DH is the most common way of heating in Finland and its market share in heating buildings is almost half. In cities and densely populated municipalities the market share is over 90 % as in densely populated areas district heating is naturally more cost-effective due to greater number of customers and lower quantity and expenditures of pipelines. Total length of district heating network in Finland is over 15 000 kilometers. [1]

District heating can be produced as a part of combined heat and power production in CHP plants or by heat only boilers producing only thermal energy. CHP plants are much more energy-efficient than separate production of heat and electricity. In cogeneration of heat and power the fuel is recovered the most energy efficient way. Compared to separate production, combined heat and power district heating saves one third of the fuel to produce the same amount of energy which is due to the proportion of electricity production. [2]

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District heating is also considered as an environmentally friendly way to produce energy compared to individual heating. This is due to district heating and in general bigger sized plant`s more advanced pollution control equipment and more controlled burning conditions which both reduces emissions of hazardous compounds. Carbon dioxide emissions of district heating depends on the fuels used. Fuels used for DH are typically wood, peat, waste, oil, coal or natural gas. Also industry produces DH as actually generated and as residual heat from processes. Biomass covers overall about one third of fuels used in DH in Finland [3]. In Northern Finland due to rich biomass resources the proportion is bigger and fossil fuels are typically used as reserve capacity. Peat is situated somewhere in the middle ground of this, its use is declining, and it is being often used as a mixed fuel for co-firing to aid in the utilization of more problematic biofuels [4]. Biomass being the main energy source and fossil fuels the auxiliary option is also the case in Kuusamo for the local water and energy co-operative EVO.

District heating and heat storage pilot in Kuusamo

EVO is the water and energy co-operative that is responsible for district heating, water treatment and clean water distribution in Kuusamo (picture 1). Kuusamo is an over 15 000 resident city in northeastern Finland, in northern Ostrobothnia. Ruka, the second biggest ski centre in Finland, is situated in Kuusamo creating its own share of heating demand. In the downtown area the district heating is produced at the Toranki CHP plant and in the Ruka area at the Ruka biopower plant. In 2018, a total of 123 gigawatt hours of district heat were

generated. The main fuel for district heating in Kuusamo consists of the by-products of nearby sawmills, such as sawdust, bark and wood chips. [5]

PICTURE 1. Beautifull day at the office. District heating network under progress in Kuusamo (Picture by Kuusamon EVO)

When the CHP and biopower plants cannot generate enough heat to cover the needs of the entire customer base, EVO needs to use its oil burning auxiliary heat only boilers to generate the needed additional heat. Now EVO, in cooperation with Oulu University of Applied Sciences (Oamk), is starting piloting of a heat storage to be connected to the district heating network. Utilizing the heat storage EVO could reduce its need to use oil for additional heating.

The heat storage pilot is a part of the international, Interreg NPA-funded SMARTrenew project which aims to increase energy security in northern periphery and rural areas through sharing knowledge and piloting different solutions for smart and renewable energy and energy storage.

During the summer of 2020 EVO will install a 500 m^3 heat storage tank to its district heating network. The heat storage is an unpressurized water tank, and the charging temperature of the storage is estimated to reach 92–95 °C. The storage has its own closed loop cycle and is connected to the district heating network through a heat exchanger. The stored heat can be discharged to either the district heating outlet or inlet pipe. Discharging the heat to the outlet pipe is the primary objective. When the demand for the output heat exceeds the charge in the heat storage but there is still charge compared to the inlet pipe, then the storage can be used to preheat the returning district heating water. [6]

Challenges in combined heat and power production

One third of Finland`s electricity has been obtained from CHP generation. Number is the highest in Europe and hence Finland is ranked as forerunner. CHP plants are also favorable in cold Nordic circumstances as electricity is needed when heat is needed the most and plant can be run at full capacity. However, the rising share of renewable energy production, especially wind power and subsidies has affected the Nordic electricity markets which Finland is also part of. As electricity prices have lowered, the profitability of co-generation of heat and power has worsened. [2]

CHP production has been balancing the seasonal demand of electricity and the intermittent production of renewable energy production. Three quarters of district heating in Finland is covered by CHP production. The replacement of CHP plants with simple heating plants causes problems in balancing electricity production not to mention the impacts on Finland`s energy self-sufficiency nor national economies. Hence it is crucial to enhance the performance of CHP district heating and make needed improvements for better profitability of CHP production. [2] One application to enhance both the performance and profitability of CHP production is a heat storage.

Thermal energy storage as part of CHP district heating enables the production of heat and electricity uncoupled for a period. Uncoupling heat and power is cost-effective as electricity can be produced during the hours when it pays best and to balance the energy system, while heat can be stored if not needed. Heat storage can be discharged during low-price electricity or to cover peak loads of heat. Traditionally peak loads are covered by fossil fuels and hence a heat storage also reduces carbon dioxide emissions.

In Kuusamo the heat storage pilot will address all the above-mentioned issues. Oamk will work with EVO (picture 2) to optimize the storage use to maximize the gain from charging the storage when electricity prices are high and discharging it to cover peaks in heating demand, thus decreasing oil use and CO2 emissions and increasing income from the additional electricity production. Oamk energy technology students have planned metering instrumentation for the heat storage and Oamk will collect and analyze data from the storage to use for the optimization.

PICTURE 2. In connection to the SMARTrenew project Oamk staff visited Kuusamo and EVO's heating plant. Behind Oamk's senior lecturer J. Ylikunnari is one of the oil burners that will see less use once the heat storage is operational (Picture by Veli-Matti Mäkelä)

In July 2019, the CHP plant in Kuusamo produced 365 MWh heat energy with oil-based fuel, of which 222 MWh could have been covered with the use of the planned heat storage. If one MWh of oil costs approximitely 85 euros and renewable fuels used in CHP plant cost approximitely 22 euros per MWh the heat storage could have saved EVO almost 14 000 euros in July alone. [6] The heat storage option's effect on oil consumption from monetary perspective is illustrated in figure 1.

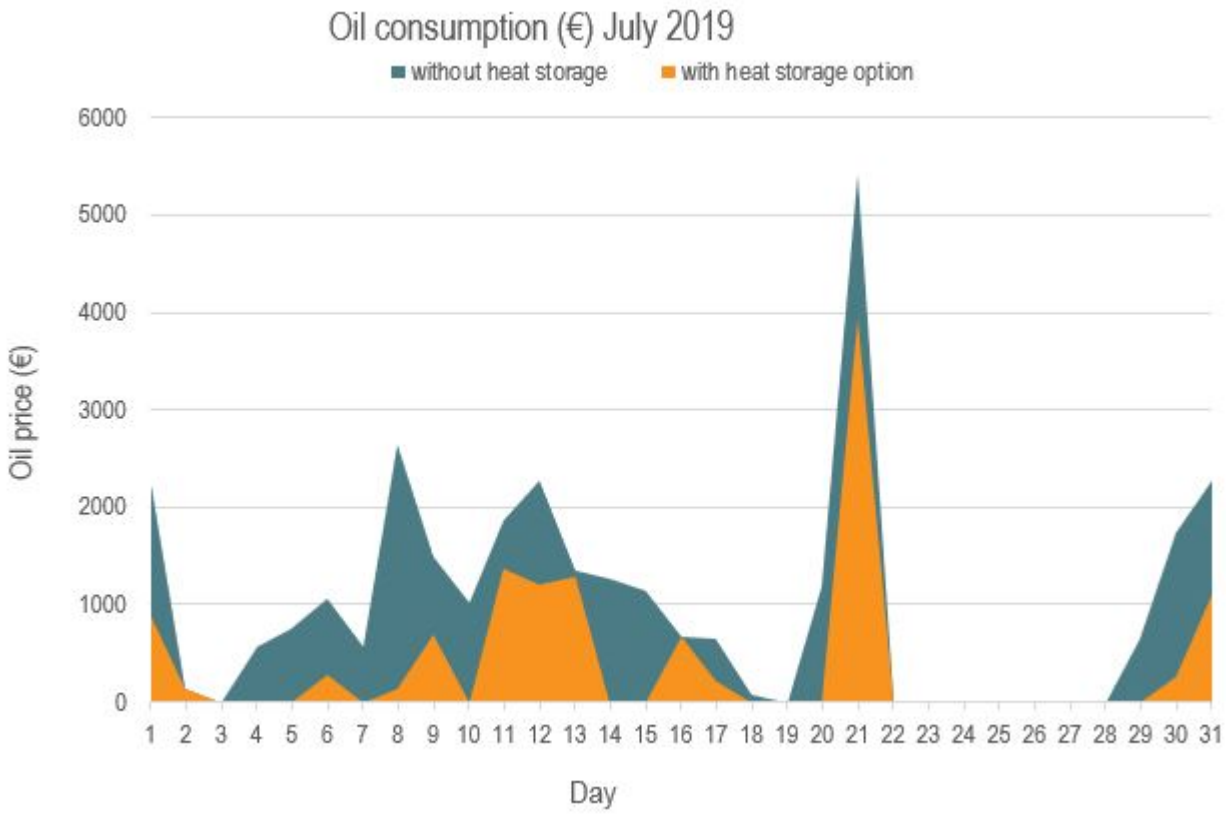

FIGURE 1. Heat storage use can bring economic benefits in addition to the ecological ones by reducing oil use [1]

The figure 1 illustrates on green the monetary expense when oil burning auxiliary power is used without the heat storage option and on orange the situation, where the heat storage capacity is utilized fully. In addition to its positive ecological effect in reducing oil use and CO_2 emissions, the heating storage system can also bring significant financial benefits. The storage is to be installed in the summer 2020, data and experiences collected throughout the rest of the year, analyzing the data and final reporting on the pilot's success is planned to be delivered during the spring 2021.

Conclusions

In the last years, the profitability of CHP plants has decreased due to lowered electricity prices. A partial solution to enhance the cost-effectiveness of CHP district heating is a thermal energy storage. Oulu University of Applied Sciences in cooperation with EVO, the energy and water co-operative of Kuusamo, is building and piloting a heat storage for district heating in Kuusamo area in Northern Finland. The intention is to produce electricity during its high price hours while heat can be stored if not needed. Heat storage can be discharged during low-price electricity or to cover peak loads of heat.

The storage is to be installed in the summer 2020, data and experiences collected throughout the rest of the year, analyzing the data and final reporting on the pilot's success are to be done in the spring of 2021.

Oulu University of Applied Sciences (Oamk) is developing renewable and intelligent energy solutions in SMARTrenew project during 1st of Oct 2018 until 30th of Sep 2021. SMARTrenew is funded under Northern Periphery and Arctic Programme (NPA) in addition to Finnish national funding by the Ministry of Economic Affairs and Employment. Total budget of the project is 1,6 million euros.

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Picture References

1. ^FIGURE 1. Heat storage use can bring economic benefits in addition to the ecological ones by reducing oil use. In Nukarinen, S., Pelkonen, L., Rahkola, T. & Tolppi, S. 2020. Kaukolämpöakun mittaroinnin suunnittelu. Project report. Oulu University of Applied Sciences. Oulu.

Metatiedot

Nimeke: Developing smarter district heating in Kuusamo

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Aihe, asiasanat: energiantuotanto, kaukolämmitys, district heating, energy production

Tiivistelmä: Combined heat and power production (CHP) has been the most popular way to produce district heating in Finland for decades, especially in population centers. In the last years, the profitability of CHP plants has however decreased due to lowered electricity prices.

A partial solution to enhance the profitability of CHP district heating is a thermal energy storage. Oulu University of Applied Sciences in cooperation with EVO, the energy and water co-operative in Kuusamo, are building and piloting a heat storage for district heating in Kuusamo area in Northern Finland.

The pilot aims to increase electricity production during its high price hours and reduce oil use in covering peak loads of heat. Heat storage can be discharged during low-price electricity or to cover peak loads of heat. The storage use will be analyzed and optimized during 2020 and 2021 to reach the maximum profit and minimum amount of CO2 emissions.

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