

Utilization of district heating return water as a potential heat source

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District heating return water offers a practical and cost-effective solution to enhance sustainability and economic efficiency in energy system. However, there is not pricing model available in the market. Depending on the top-up heating system, 10 – 30 % discount makes utilization of return water economical feasible for building owners.

The building sector accounts for approximately 40% of total energy consumption in Europe, contributes around 36% of total greenhouse gas emission [1]. In Finland, space heating alone represents about 27% of total energy use, heavily rely on district heating (DH) [2, 3]. While transitioning to low-temperature district heating (LTDH) is key to reducing emissions and improving efficiency, replacing existing high-temperature DH infrastructure requires major investment [4, 5].

The total length of district heating network is 16 300 km in Finland. A more immediate and practical alternative lies in using return water from existing high-temperature DH networks. This solution harnesses otherwise wasted heat to meet building needs, enhancing energy efficiency and reducing emissions of energy production without the need for major infrastructure changes [6]. This study evaluates the potential for district heating return water utilization in a Finnish apartment building, emphasizing the economic feasibility by attractive pricing models from customers point of view.

Methodology

This research focuses on a newly constructed six-level apartment building located in Järvenpää, Finland. The selected building has a net heating area of 3194 m², comprises 44 apartments and two sauna rooms. Space heating is delivered via radiators connected to a conventional DH network, while wet areas use electric floor heating. Mechanical balanced ventilation with 55% heat recovery efficiency is employed.

In this study, six district heating return water system configurations were evaluated for the demonstration building. These included three types of auxiliary heating systems: using district heating supply water, electric boilers, and return water heat pumps. In addition, two radiator systems with different distribution temperatures were analysed. Details of the system configurations are presented in **Table 1**.

For the demo building, six DH return water systems configurations were investigated in this study. These included three types of auxiliary heating systems: using DH supply water (SW), electric heaters (EB), and a

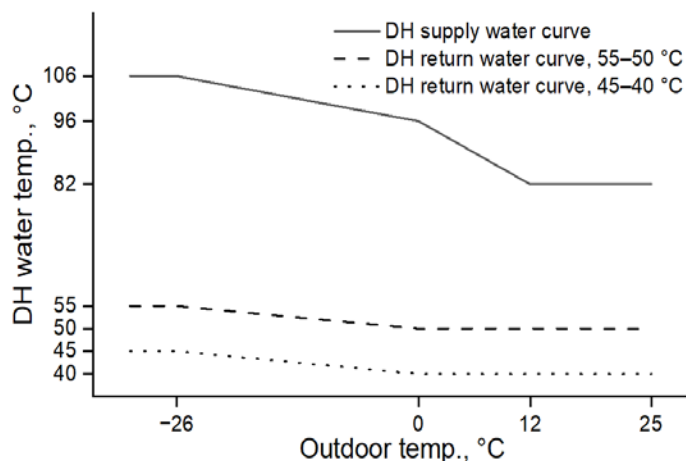
Table 1. Description of studied systems.

Cases	DHRW+SW 60/30	DHRW+SW 45/30	DHRW+EB 60/30	DHRW+EB 45/30	DHRW+HP 60/30	DHRW+HP 45/30
Primary heating	DH return water	DH return water	DH return water	DH return water	DH return water	DH return water
Auxiliary heating	DH supply water	DH supply water	Electric heaters	Electric heaters	Return water heat pump	Return water heat pump
Radiator control curve [°C/°C]	60/30	45/30	60/30	45/30	60/30	45/30

return water heat pump (HP). In addition, two radiator systems with different distribution temperatures were analysed. Details of the system configurations are presented in **Table 1**. Their energy performance was evaluated through detailed energy simulations. The simulations were performed using the IDA ICE software [7], which allows accurate modelling of building energy performance under different scenarios. A typical weather year (TRY) data was selected for the simulations, reflecting average outdoor conditions in southern Finland over past 30 years.

Two DH return water temperature control curves were considered in this study, including a high-temperature profile (55–50°C) based on local network measurements, and a low-temperature profile (45–40°C) for sensitivity analysis. They are presented in **Figure 1**, along with conventional DH temperature control curve utilized in auxiliary heating system.

For economic calculations, a discount is assumed applied in DH return water tariff compared to the

**Figure 1.** Control curve of district heating supply water temperature according to outdoor temperature.

conventional DH tariff to improve its economic attractive for customers. The economic feasibility of investigated DH return water systems was assessed across various discount levels (0%–50%), with a 3% real interest rate and 2% annual energy price escalation [8]. The goal was to identify pricing levels that would deliver a payback period within 10 years.

Investment costs were considered in economic calculations based on market prices and expert advice, including auxiliary heating systems (electric boilers and heat pumps) and necessary renovation for the DH network and electricity connections [6].

Results

Energy and power coverage

Figure 2 shows the annual purchased energy consumption, peak energy power demand results and corresponding DH return water coverage for simulation cases utilizing high-temperature (55–50°C) DH return water. The energy simulation results indicated that DH return water can fulfill a major portion of heating requirements, covering 77% of the annual heating energy demand and 91% of peak power demand, regardless of the radiator system and backup heater.

Sensitivity analysis results provided insights into the effect of decreased DH return water temperature (45–40°C) on system energy performance (**Figure 3**). Lower return water temperature reduced the energy coverage from 77% to 67% and decrease the peak power coverage to 72%–82%. Additionally, results highlight the significant impact of radiator distribution temperatures on return water peak power coverage, when utilizing low-temperature (45–40°C) DH return water. A 10% higher return water peak power coverage can be achieved by integrating radiators of lower distribution temperature (45/30°C).

What is the required discount of return water?

Table 2 presents the economic evaluation results of simulation cases under different DH return water pricing scenarios, with discounts range 0% – 50%. Highlighted cells refer to economically infeasible scenarios with discounted payback periods of over 10 years. For simulation cases employing electric heaters or direct DH supply water connections, a moderate discount of approximately 10% on DH return water is sufficient to achieve 10-year payback period, which strengthen the economic attractive for customers. In contrast, heat pump cases require a significantly higher discount, around 30%, to achieve economic feasibility, mainly due to the high initial investment.

Table 3 shows the economic evaluation results when DH return water temperature is reduced by 10°C. When using the lower DH return water temperature (45–40°C), the differences in radiators distribution temperature are highlighted. For simulation cases with a heat pump or direct DH supply water connections, the utilization of lower-temperature (45/30°C) radiators expands the discounted payback periods, as it leads to a higher return water peak power coverage (**Figure 2**), consequently, a higher DH return water power fee. An exception occurs in electric heater systems, where the need for a smaller electricity connection, less heaters, and decreased electricity use

makes the low-temperature radiator option more cost-effective than the high-temperature one.

In comparison to results with high-temperature DH return water (**Table 2**), heat pump cases achieve a shorter payback period under low return water temperature conditions. In this case, a 25% discount is enough for the investment to be recovered within 10 years. However, electric heater systems became less attractive, needing a 5% higher discount to offset the increased electricity use (**Figure 3**).

Conclusion

District heating (DH) return water, combined with well-selected auxiliary heating systems, presents a highly viable solution for cost-effective and environmentally sustainable heating in Nordic apartment buildings. This study confirms district heating return water ability to cover up to 77% of heating demand and over 90% of peak power needs in a Finnish new apartment building. Additionally, to attract consumers, moderate pricing incentives are needed. A 10% discount suffices for configurations supported by electric heater or DH supply, while heat pump systems need around 30%.

Sensitivity analysis shows that return water temperature and radiator design significantly affect required discounts. For instance, with low return water and high radiator (60/30 °C) temperature, systems using DH

Table 2. Payback periods for the alternative district heating systems with varying discount rates and return water temperature range 55-50°C.

Discount	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
DHR+SW 60/30	-	15	8	6	5	4	3	3	2	2	2
DHR+SW 45/30	-	15	8	6	5	4	3	3	2	2	2
DHRW+EB 60/30	-	-	9	4	3	2	2	1	1	1	1
DHRW+EB 45/30	-	-	6	3	2	1	1	1	1	1	1
DHRW+HP 60/30	-	-	18	15	13	11	10	9	8	8	7
DHRW+HP 45/30	-	-	18	15	13	11	10	9	8	8	7

Table 3. Payback periods for the alternative district heating systems with varying discount rates and return water temperature range 45-40°C.

Discount	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
DHR+SW 60/30	16	10	7	5	4	4	3	3	2	2	2
DHR+SW 45/30	-	12	8	6	5	4	3	3	2	2	2
DHRW+EB 60/30	-	-	16	7	5	3	3	2	2	2	1
DHRW+EB 45/30	-	-	-	6	3	2	2	1	1	1	1
DHRW+HP 60/30	14	13	11	10	9	9	8	7	7	7	6
DHRW+HP 45/30	18	15	13	12	11	10	9	8	8	7	7

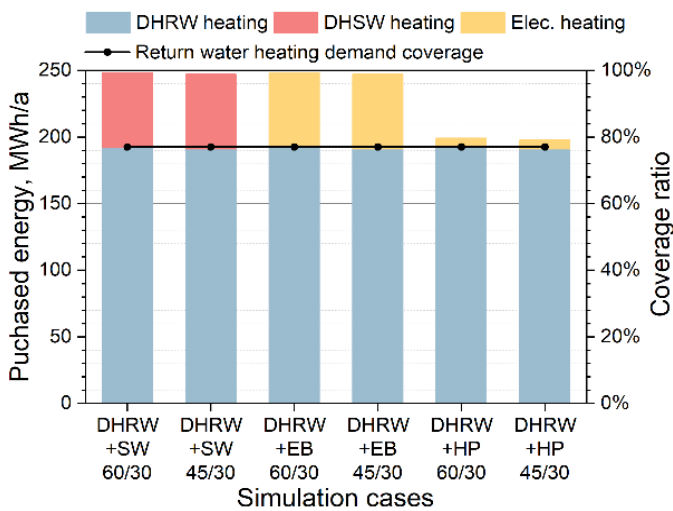
supply or a heat pump can achieve a 10-year payback period with only a 5% and 15% discount, respectively. In contrast, electric heater systems require at least a 15% discount under low return water temperature, regardless of the radiator temperature.

Acknowledgements

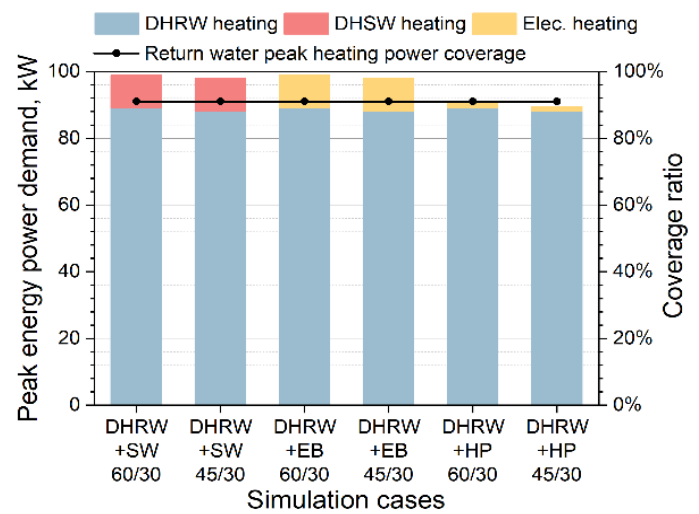
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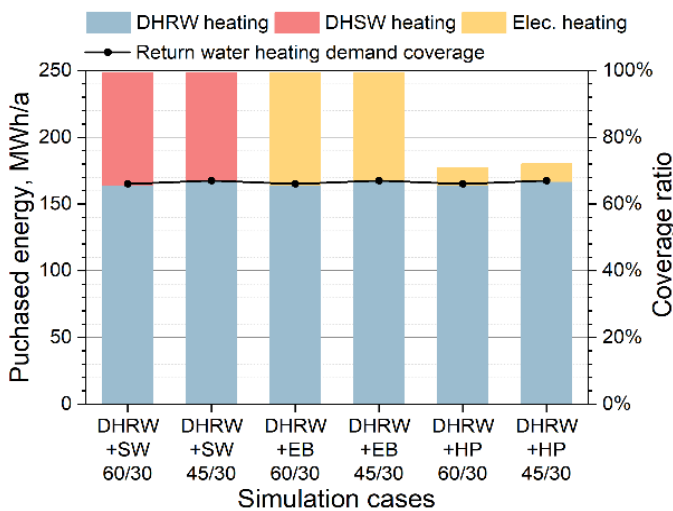


(a) Purchased energy consumption

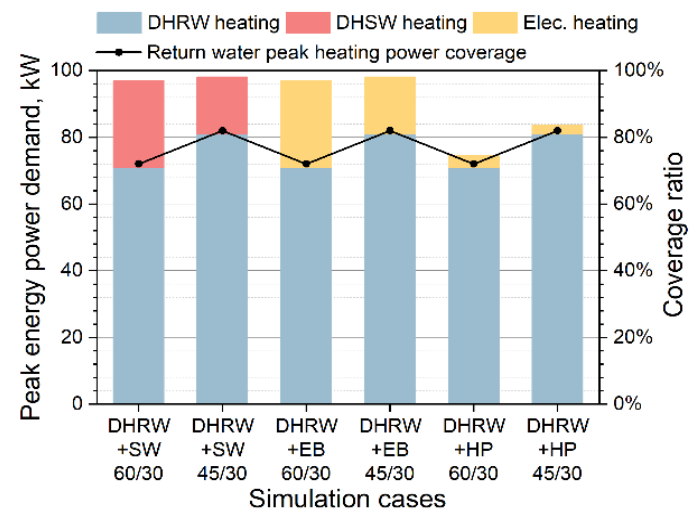


(b) Peak energy power demand

Figure 2. Energy and peak power coverage ratio with high-temperature (55–50°C) DH return water.



(a) District heating return water of 55–50°C



(b) District heating return water of 45–40°C

Figure 3. Energy and peak power coverage ratio with low-temperature (45–40°C) DH return water.