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Fourth-Generation District Heating and Motivation Tariffs

Future district heating systems and technologies—also known as fourth-generation district heating—have a potentially important role to play in the green transition of societies. The implementation of fourth-generation district heating involves adjustments in the demand side to allow for low temperature supply. In order to facilitate such changes, district heating supply companies have in recent years introduced tariffs with penalties for high return temperatures and benefits for low return temperatures. This paper describes the case of a housing community of 17 buildings in their attempts to adjust to such tariffs as an integrated part of connecting to district heating. Replacing domestic hot water tanks with instantaneous heat exchangers and introducing smart meters resulted in abilities to lower the return temperature from around 40 °C to around 30 °C. However, the current design of the motivation tariffs does not yet fully compensate the consumers because the supply company provides unnecessarily high supply temperatures. Based on such efforts, this paper discusses the fairness and effectiveness of the tariffs and provides recommendations for improving them. [DOI: 10.1115/1.4053420]

Keywords: green transition, decarbonized societies, smart energy systems, fourth-generation district heating, low temperature district heating, motivation tariffs, convective heat transfer, data-driven design, demand response, demand side management, diagnostic feature extraction, energy efficiency, energy management, failure analysis, fault analysis, heat exchangers

Introduction

The transition toward fully decarbonized societies is on the political agenda as a result of the Paris Agreement of 2015 and its aim of restricting the global increase in temperature to less than 2 °C above the pre-industrial level [1], among other reasons.

The concept of Smart Energy Systems [2] and Smart Energy Markets [3] provides a framework for understanding how to design the green transition in a cost-efficient and technically viable way [4]. This is done by exploiting synergies through balancing savings and production [5] as well as the integration of the various energy sectors and infrastructures [6]—such as heating, electricity, transport, and industry—in a holistic concept with a focus on how demand flexibility, storage optimization [7], and production synergies can be used to better exploit the varying energy production from variable renewable energy sources [8].

Having energy efficiency and sector integration as well as thermal storage and grid infrastructures as central elements, the concept of Smart Energy Systems is closely connected with the concept of fourth-generation district heating (4GDH) [9]. The Fourth-Generation District Heating (4GDH) system is defined *as a coherent technological and institutional concept, which by means of smart thermal grids assists the appropriate development of sustainable energy systems. 4GDH systems provide the heat supply of low-energy buildings with low grid losses in a way in which the use of low-temperature heat sources is integrated with the operation of smart energy systems. The concept involves the development of an institutional and organizational framework to facilitate suitable cost and motivation structures*. The 4GDH concept constitutes an essential framework understanding for the design of heating and cooling strategies and solutions, which fits well into a cost-efficient and technically viable implementation of the green transition [10].

In several papers, the transition of district heating and cooling grids to low temperature and the exploitation of synergies through sector integration are central focal points [11]. Volkova et al. [12] evaluate the feasibility of integrating a low-temperature district heating network into an existing district heating network among others by the use of the return heat for supplying low-temperature district heating networks. Revesz et al. [13] introduce a methodology for developing an ultralow temperature smart energy network and apply the method to central London, while Jangsten et al. [14] investigate existing temperatures of a district cooling system in Gothenburg.

Other papers investigate how to improve the design and operation of district energy systems. Wang et al. [15] analyze smart meter data from the largest field trial to determine the residential energy consumption profiles in the United Kingdom, and Melillo et al. [16] present a new model for characterizing buildings' heating demand based on smart meter monitoring data and a simplified physical simulation model.

Leoni et al. [17] use international success stories and stakeholder interviews to develop recommendations for business models for reducing return temperatures in district heating systems. The solutions are described in a generic form. However, one of the recommendations is to initiate customers' engagement in fault detection and in temperature reduction. Dorotić et al. [18] propose a taxing system based on exergy destruction in heat-only boiler units, and Capone et al. [19] propose a global optimization modeling approach with demand-side management for district heating customers. Several other previous papers add to these findings regarding development [20–37], expansion [38–44], and operation improvements [45–50] of smart energy grids.

In addition to the operation temperature and source origin of district heating grids, the energy efficiency of buildings is central to the concept of 4GDH, since energy efficiency in buildings is often the basis for the ability to heat the buildings with low-temperature district heating. Blumberga et al. [51] explore the possibilities of using waste heat regeneration and find that very ambitious energy efficiency improvements are required to achieve positive energy building blocks. Best et al. [52] develop a methodology for determining the heat demand of new residential developments using plot ratio and buildings' energy efficiency standard

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only, and Christensen et al. find that the peak-hour energy consumption of an apartment block can be reduced by 85% on average by controlling the individual room temperature of each room in the apartment block [53]. Benakopoulos et al. [54] develop a strategy for low-temperature operation of radiator systems using data from existing digital heat cost allocators, and Ziemele et al. [55] have described a methodology for connecting low heat density consumers to a district heating system. Licklederer et al. [56] as well as Gross et al. [57] investigate the options of integrating buildings as prosumers into the heating grids and Gorrono-Albizu and Godoy address the issue of fairness in the transition [58]. Several other previous papers add to these findings regarding energy consumption modeling [59–62] and energy renewability improvements [63–70] for buildings. The newly developed methodologies for determining the heat demand create the possibility of better matching the production with the consumption, thereby creating a more energy-efficient system. Together with reducing the overall emissions of buildings by considering origin sources of the energy used, this brings a better knowledge as to how the future heating of buildings can be improved toward carbon neutrality.

In the definition and discussion of the 4GDH concept, five abilities have been emphasized in order for the 4GDH to fit into the green transition. The transition to low-temperature—or even ultralow-temperature [71]—district heating grids is an essential element to fulfill these five criteria. One of the five criteria is the ability "*…to ensure suitable planning, cost and incentive structures in relation to the operation as well as to strategic investments related to the transformation into future sustainable energy systems*" [72].

In order to facilitate such changes, district heating supply companies have in recent years introduced tariffs with penalties for high return temperatures and benefits for low return temperatures. This paper describes the case of a housing community of 17 buildings in their attempts to adjust to such tariffs as an integrated part of connecting to district heating. Based on such efforts, this paper discusses the fairness and effectiveness of the tariffs and provides recommendations for improving them.

The Fourth-Generation District Heating Context and the Vaarst Vestervang Case

Aalborg municipality is located in the northern part of Denmark. For many years, the heating of the city of Aalborg as well as its surrounding areas has been based on comprehensive district heating supply. The main heating sources have been excess heat from the coal-fired power station (60%) in combination with excess heat from the local cement industry (20%) and the local waste incineration plant (20%). However, as part of the green transition, the coal-fired power station will be decommissioned in a few years, and thus, Aalborg municipality is planning to change the heat supply as a coordinated action in terms of a green transition for the entire energy supply [73]. The overall strategy is based on creating a suitable geographical expansion of the district heating supply as well as achieving a suitable balance between savings and supply [74]. The basic principle of the Aalborg green transition is based on the smart energy systems concept including the transformation to future low-temperature fourth-generation district heating solutions. One of the key drivers for

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Energiafregning med motivationstarif 01.10.2017

Retur i °C / Fremløb i °C	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
20	-25%	-25%	-25%	-25%	-25%	-25%	-25%	-24%	-24%	-24%	-22%	-22%	-22%	-20%	-20%	-20%
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31	-8%	-6%	-6%	-6%	-4%	-4%	-4%	-2%	-2%	-2%	0	0	0	0	0	0
32	-6%	-4%	-4%	-4%	-2%	-2%	-2%	0	0	0	0	0	0	0	0	0
33	-4%	-2%	-2%	-2%	0	0	0	0	0	0	0	0	0	0	0	0
34	-2%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	+2%	+2%	+2%
36	0	0	0	0	0	0	0	0	0	0	+2%	+2%	+2%	+4%	+4%	+4%
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55	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%

Fig. 1 Motivation tariff for Aalborg district heating supply. Using smart meters, supply and return temperatures are measured on an ongoing basis at the consumer. Consumption-weighted mean temperatures are calculated and used as the basis for the accounting. If the consumers supply a low return temperature (the green area), a discount of up to 25% of the variable price is granted, while in the case of a high return temperature (the red area), a penalty of up to 25% is added to the price. The requirement for a neutral return (the orange area) is subject to the supply temperature assuming that it is usually easier to achieve a low return temperature if the supply temperature is high.

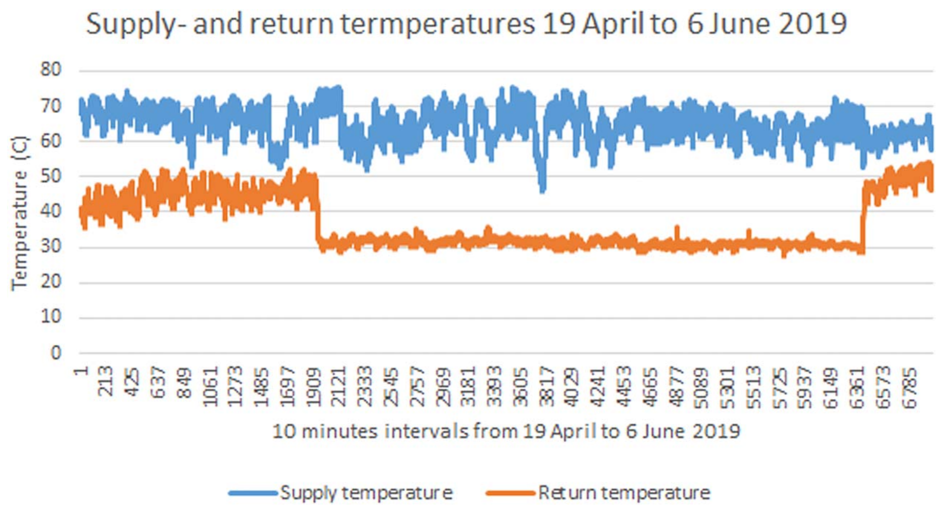

Fig. 2 Measurements of Vaarst Vestervang district heating supply and return temperatures during the period April 19 to June 6, 2019. During one month of this period, all domestic hot water tanks were disconnected from the system, and the return temperature decreased from 40–50 °C to 30 °C. When the domestic hot water tanks were connected again, the return temperature rose to 40–50 °C again.

such a change is the potential benefits of increased efficiencies of the future sources to replace the heat from the coal-fired power station [10].

In order to implement the green transition in Aalborg, tariffs have been discussed [75], and Aalborg District Heating Supply (Aalborg Forsyning) has introduced a tariff to motivate better cooling on the demand side in order to pave the way and facilitate the implementation of low-temperature solutions (Fig. 1).

Vaarst Vestervang is a community of 16 detached houses and a common house located in the Aalborg district heating supply area. Vaarst Vestervang was constructed in 1991 as low-energy houses, which means that the heat consumption is calculated to be at least 50% lower than consumption in a house that meets the energy envelope of the legal building codes at the time of construction. Low heating consumption was achieved by choosing thicker insulation in the floor, roofs, and walls; room ventilation with the recovery of heat, and by installing all windows with Kappa energy panes (two-layered sealed units with a coating that prevents radiation and argon between the panes). From the beginning, the houses were heated by low-temperature district heating from central heating in the common house. During winter, the heat was produced by two boilers fueled with wood pellets made from waste material from wood processing. In the summer, the heat came from two solar heat panels integrated into the roof of the common house [76].

In 2019, Vaarst Vestervang decided to connect to the local district heating supply operated by Aalborg Forsyning and thus made subject to the motivation tariff.

Analysis: The Problem and the Solution

When the decision of connecting to the central district heating was considered, the local district heating system at Vaarst Vestervang was operating with a supply temperature of 60–70 °C and a return of 40–50 °C. With such a return temperature, Vaarst Vestevang would be subject to penalties in accordance with the motivation tariff. Thus, it became essential to identify the cause for such high return and investigate potential changes in the system.

Vaarst Vestervang identified existing domestic hot water tanks to be the main cause of the high return temperature. As illustrated in Fig. 2, during one month of decoupling, the hot water tanks from

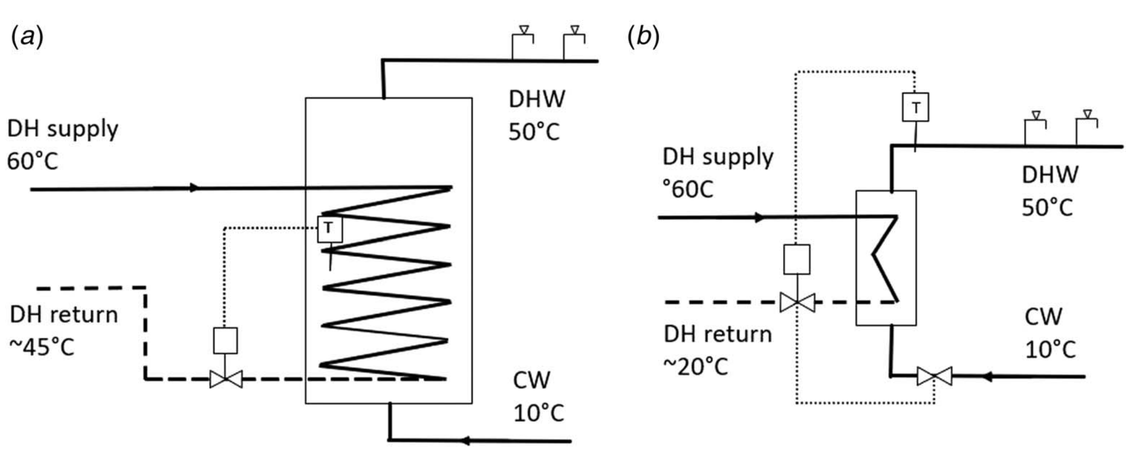

Fig. 3 Schematic of (*a*) domestic hot water tank and (*b*) instantaneous heat exchanger for domestic hot water. For the storage tank, the heat is transferred via an internal coil and controlled by a simple thermostat, whereas for the instantaneous heat exchanger, the control is made by a thermostat with a tapping flow feed-forward function.

Fig. 4 Temperatures in one of the houses before and after replacing the hot water tanks with instantaneous heat exchangers. The upper diagram shows measurements on August 16–17 in house 3 before the replacement. As seen, the return temperature is in general as high as 40 °C (green curve), and when hot water is consumed the return rises to 50 °C. The lower diagram shows measurements of the same house on November 8–9 after the replacement (magenta curve). As seen, the return is now below 30 °C and when domestic hot water is tapped it is even close to 20 °C.

the district heating supply and running domestic hot water on electric heating (in the domestic hot water tanks), the return temperature was lowered to approx. 30 °C.

As a consequence, the domestic hot water tanks were replaced by instantaneous heat exchangers. This was initially done as a test in two houses and afterward in the whole community of the 17 houses. One of the benefits of choosing an instantaneous heat exchanger is that any potential problems with legionella are highly reduced, and thus, precautions and extra costs are avoided [77]. Figure 3 shows a principle comparison between the two applications. The indicated district heating return temperatures are representing the tapping situation shown in Fig. 4. Also, other return temperatures from the service of domestic hot water can occur, as can be seen as well from Fig. 4. For the storage tank (Fig. 3(*a*)), a simple thermostat is applied whereas for the instantaneous heat exchanger (Fig. 3(*b*)), a thermostat with a tapping flow feed-forward function is applied. In case there is no tapping, the district heating flow is stopped. There is no need of keeping the heat exchanger warm during no tapping periods.

The heat exchanger performance in terms of thermal length, also known as the number of transfer units (NTU), is of relevance when dimensioning a heat exchanger for low-temperature operation. A higher NTU means that the heat exchanger is able to operate at a lower temperature difference between the primary, in this case, the district heating side, and secondary, in this case, the domestic hot water side. As an example, keeping the secondary temperatures constant, e.g., the cold water inlet temperature of typically 10 °C and the domestic hot water outlet temperature of typically 50 °C, a doubling of the NTU from 3.2 to 6.5 reduces the district heating return temperature from 23.1 °C to 14.7 °C at a district heating supply temperature of 60 °C.

For the same media pressure drop, a higher NTU requires more heat transfer area, and it will thus consist of more or bigger heat transfer plates. Based on the study [78], an increase of the typically applied NTU for the heating system heat exchanger by a factor of 1.7 to 2.5 is recommendable, based on the assumption that the added costs for the heat transfer area are covered by 12 years of energy savings due to reduced distribution losses by operation at the lower temperatures.

Comparing the NTU of the coil inside a hot water tank and the NTU of an instantaneous heat exchanger, the latter has typically higher convective heat transfer numbers due to high media speed on both sides of the heat exchanger and a larger area, which leads to higher NTU, and thus a lower return temperature. Furthermore, the control principle of the hot water tank can influence the return temperature; e.g., if the primary valve opens excessively or if the temperature of the water increases at the bottom of the tank, the return temperature will increase.

As illustrated in Fig. 4, the replacement of hot water tanks with instantaneous heat exchangers solved the problem of the return temperature.

As a next step, smart meters were installed and used in the further identification of individual problems in the floor-heating systems of the houses. Figure 5 illustrates a measurement in which a fault in the

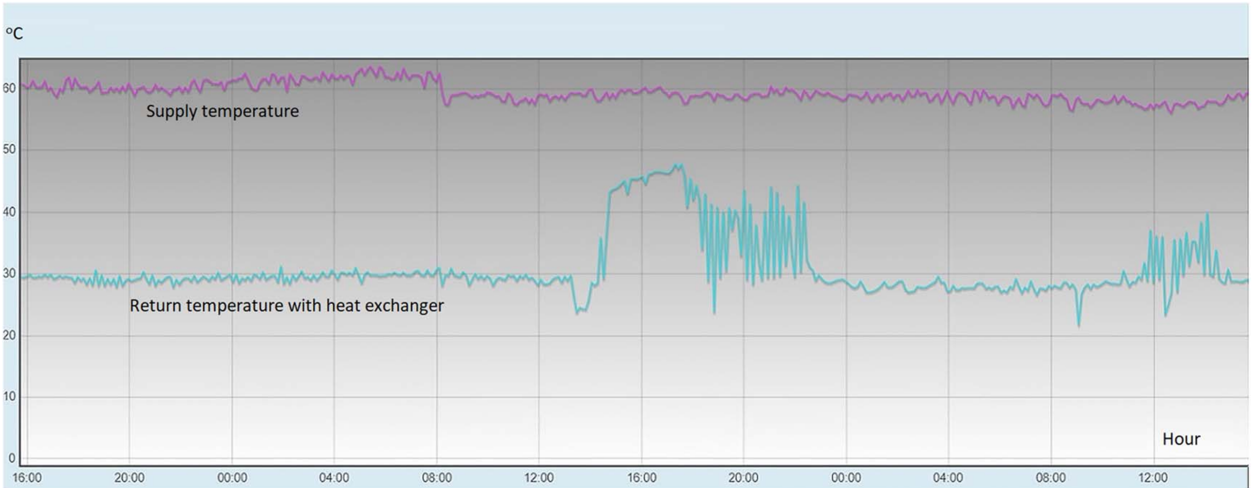

Fig. 5 Detection of a fault on a floor heat thermostat in house 3 in November 2019

floor heating shunt thermostat was discovered by oscillations in one of the houses, which then has to be replaced.

Furthermore, the smart metering system was used to identify adjustments in the supply temperature measurements and individual problems in the return temperature as illustrated in Fig. 5 and explained further in the following. The district heating system of Vaarst Vestervang has pipes going directly from house to house starting in house no. 1, the common house which holds the central connection to the public district heating grid. From this point, the heating is distributed in two parallel circles, one for the western part and one for the eastern part of the community. As shown in Fig. 6, the outlet temperature from the central point in house 1 is 64.92 °C. The temperature is reduced gradually due to grid losses down to approx. 57 °C in the two houses furthest from the outlet point, i.e., houses 9 and 10, respectively. Figure 6 also shows the return temperature of each of the houses, in this case being reduced to 26.75 when reaching the central point in house 1 again.

The smart metering management system has been used for several purposes including:

- Identification of wrong temperature measurements in the meters due to differences in how temperature sensors were actually installed and the fact that the temperature sensors were not adjusted in this case to measure absolute temperature (for energy metering the delta t and not the absolute temperatures is important). This can easily cause 0.5–1 °C difference. As illustrated in the figure, the supply temperature actually increases from one house to another; e.g., it increases from 59.58 °C in house 15 to 61.01 °C in house 14. This is not possible since there is no heating source involved, and thus, it reveals a wrong temperature measurement in house 15.
- Identification of houses with a relatively high return temperature. In such situations, a detailed investigation of causes, etc., has been carried out, leading to changes in the use of thermostats, etc.

In the case of Vaarst Vestervang, it was easy to identify wrong supply temperature measurements in the meters since the district heating supply pipes were connected directly between the houses, without connection pipes from the street. In most other systems, this principle of connection is not applied. Normally, the distribution pipes are in the street, then being connected via supply, and return connection pipes to each dwelling. In both cases, volume-weighted supply and return temperatures would normally be used

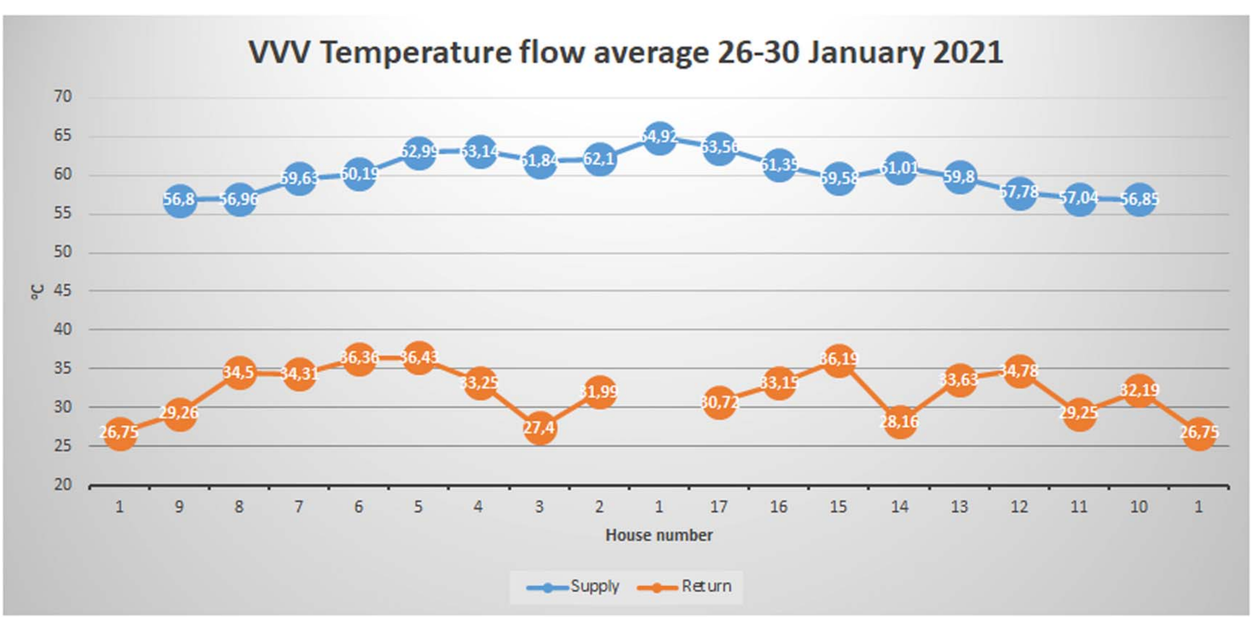

Fig. 6 Detection of faults in measurements of supply temperatures in some of the Vaarst Vestervang (VVV) houses

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Retur i °C

Fremløb i °C	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
20	-25%	-25%	-25%	-25%	-25%	-25%	-25%	-24%	-24%	-24%	-22%	-22%	-22%	-20%	-20%	-20%
21	-25%	-25%	-25%	-25%	-24%	-24%	-24%	-22%	-22%	-22%	-20%	-20%	-20%	-18%	-18%	-18%
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28	-14%	-12%	-12%	-12%	-10%	-10%	-10%	-8%	-8%	-8%	-6%	-6%	-6%	-4%	-4%	-4%
29	-12%	-10%	[illegible]	[illegible]	[illegible]	-8%	-8%	-6%	-6%	-6%	-4%	-4%	-4%	[illegible]	-2%	[illegible]
30	-10%	-8%	-8%	[illegible]	[illegible]	-6%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-2%	0	0	0
31	-8%	-6%	[illegible]	[illegible]	[illegible]	-4%	-4%	-2%	-2%	-2%	0	0	0	[illegible]	0	[illegible]
32	-6%	-4%	-4%	[illegible]	-2%	-2%	-2%	0	0	0	0	0	0	0	0	0
33	-4%	-2%	-2%	-2%	0	0	0	0	0	0	0	0	0	0	[illegible]	0
34	-2%	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	+2%	[illegible]	+2%
36	0	0	0	0	0	0	0	0	0	0	+2%	+2%	+2%	+4%	[illegible]	+4%
37	0	0	0	0	0	0	0	+2%	+2%	+2%	+4%	+4%	+4%	+6%	[illegible]	+6%
38	0	0	0	0	+2%	+2%	+2%	+4%	+4%	+4%	+6%	+6%	+6%	+8%	+8%	[illegible]
39	0	+2%	+2%	+2%	+4%	+4%	+4%	+6%	+6%	+6%	+8%	+8%	+8%	+10%	+10%	+10%
40	+2%	+4%	+4%	+4%	+6%	+6%	+6%	+8%	+8%	+8%	+10%	+10%	+10%	[illegible]	[illegible]	[illegible]
41	+4%	+6%	+6%	+6%	+8%	+8%	+8%	+10%	+10%	+10%	+12%	+12%	+12%	+14%	+14%	+14%
42	+6%	+8%	+8%	+8%	+10%	+10%	+10%	+12%	+12%	+12%	+14%	+14%	+14%	+16%	+16%	+16%
43	+8%	+10%	+10%	+10%	+12%	+12%	+12%	+14%	+14%	+14%	+16%	+16%	+16%	+18%	+18%	+18%
44	+10%	+12%	+12%	+12%	+14%	+14%	+14%	+16%	+16%	+16%	+18%	+18%	+18%	+20%	+20%	+20%
45	+12%	+14%	+14%	+14%	+16%	+16%	+16%	+18%	+18%	+18%	+20%	+20%	+20%	+22%	+22%	+22%
46	+14%	+16%	+16%	+16%	+18%	+18%	+18%	+20%	+20%	+20%	+22%	+22%	+22%	+24%	+24%	+24%
47	+16%	+18%	+18%	+18%	+20%	+20%	+20%	+22%	+22%	+22%	+24%	+24%	+24%	+25%	+25%	+25%
48	+18%	+20%	+20%	+20%	+22%	+22%	+22%	+24%	+24%	+24%	+25%	+25%	+25%	+25%	+25%	+25%
49	+20%	+22%	+22%	+22%	+24%	+24%	+24%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%
50	+22%	+24%	+24%	+24%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%
51	+24%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%
52	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%
53	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%
54	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%
55	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%	+25%

Fig. 7 Indication of the areas in the motivation tariff depending on the supply temperature provided by the district heating supply company as well as the return temperature obtained by the consumer

(calculated in the smart meter), which would provide the average temperatures when the heat installation is in use and take the volume flow history into account. If only the actual temperatures are used, not volume-weighted, these can easily vary 10–15 °C depending on the flow to the building.

In a district heating setup with connection pipes from the street, temperature sensor outliers can also be detected by using data from all smart meters and information about the pipe layout to estimate (via digital twins) the temperature in the street. This temperature can then be compared with the volume-weighted average temperatures measured in the dwelling. For example, if the contact between the temperature sensor and the water flow is insufficient, it can measure temperatures that are different and too low.

Motivation Tariffs, Effectiveness, and Fairness

As described earlier, the purpose of the motivation tariff is to motivate consumers to lower their return temperature as part of transforming the Aalborg district heating supply into a future fourth-generation low-temperature grid for the mutual benefits of the supply company and the consumers.

In the case of Vaarst Vestervang, the tariff has proven quite effective since it has motivated the necessary investments and changes in operation in order to lower the return temperature from previously 40–50 °C to currently approx. 30 °C. However, one could ask if it is fair from the consumers' point of view.

In Fig. 7, the starting point *previous to the changes* in Vaarst Vestervang is shown as area 1. Aalborg district heating company supplies the heat at a temperature of close to 75 °C, and Vaarst Vestervang provides a return of 40+°C and would thus have a penalty of around 10%. *After the changes*, with a return of approx 30 °C, Vaarst Vestervang comes into the neutral area, shown as area 2 in the figure.

However, Vaarst Vestervang can easily be operated with a supply temperature of 60–65 °C. This is what actually happens since Vaarst Vestervang lowers the supply temperature before it is supplied into the Vaarst Vestervang distribution grid.

Area 3 in the figure illustrates where in the diagram Vaarst Vestervang would have been located if the central supply temperature had been 60–65 °C. In such case, there would have been a discount of 10% or the similar. This means going from operating area 1 to 3 would lead to savings of approx. 20%.

Thus, the motivation tariffs do not yet fully compensate the consumers because the supply company provided unnecessarily high supply temperatures. Therefore, from the consumers' perspective, the tariff is not fair.

Conclusion

Motivation tariffs were introduced to motivate district heating consumers to align with future low-temperature fourth-generation district heating. This paper describes the case of a housing community of 17 buildings in their attempt to adjust to such tariffs as an integrated part of connecting to district heating. Replacing domestic hot water tanks with instantaneous heat exchangers with high NTU and introducing smart meters resulted in the ability to lower the return temperature from around 40 °C to around 30 °C.

The conclusion is as follows:

- The use of *instantaneous heat exchangers for domestic hot water production with high NTU and smart meters* has successfully decreased the return temperature to 30 °C and maintained the decrease also when reducing the supply temperature from 70–75 °C to 60–65 °C.
- The case has proven that *fourth-generation district heating is possible* with 60–65 °C supply and 30 °C return temperatures

- *Motivation tariffs have been effective*: Return temperature has decreased from 40–50 °C to approx. 30 °C
- *Seen from the consumers' point of view, the motivation tariff in its current form is not fair*: Either the supply company should also adopt the supply temperature to fourth-generation district heating or the design of the tariff should not depend on the supply temperature.
- *The district heating utilities should prescribe consumer installations able to handle fourth-generation district heating temperature levels*: both for new installations, but also in the case of replacement due to maintenance of existing systems.

Based on these conclusions, district heating supply companies are recommended to consider adjusting the motivation tariffs. For example, one could remove the dependency on the supply temperature or offer consumers with lower temperature requirements a tariff accordingly.

It should be mentioned that neither lower return temperatures nor lower supply temperatures have any disadvantages for the overall district heating system. On the contrary, any decrease in any of the temperatures will generate benefits in terms of lower grid losses, and more importantly, it will typically increase efficiencies in most future district heating sources no matter whether it concerns heat pumps, industrial excess heat, solar thermal or geothermal heat.

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Conflict of Interest

There are no conflicts of interest. This article does not include research in which human participants were involved. Informed consent is not applicable.

Data Availability Statement

The authors attest that all data for this study are included in the paper.

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