Projektinfo **14**/2015

Detailed information on energy research

Efficiently using district heat

Optimised customer systems enable an efficient use of renewable energy sources

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Information Service

In future, it is intended that heating and domestic hot water systems in district heating networks should be increasingly capable of functioning with environmental heat at lower temperatures. However, at the moment the cooling potential is not yet being satisfactorily utilised. This is generally resulting in return temperatures and volume flow rates that are too high. This provides the starting point for the LowEx Systems project: researchers have developed and tested various approaches for reducing the return temperatures from customer installations, including low pressure loss heat distribution systems and cascaded hot water heating with heat storage.

By 2040, Munich is aiming to become the first major German city where the district heating is generated from 100 % renewable energy. To realise this vision, the hydrothermal geothermal energy is being further expanded and the district heating network optimised. However, an efficient integration of renewable energy in the district heating systems is only possible in conjunction with low return temperatures. If the district heating return temperature is lowered from 60 to 40 °C, the geothermal heat output can be increased by up to 70 % (Fig. 1). This therefore means that the lower the temperature level of the heating network, the greater the possible proportion of renewable heat sources. In particular it is the return temperature that decisively affects the performance of systems. In many district heating networks, however, this is considerably too high in summer due to the domestic hot water (DHW) heating. The reason for this is not due to the district heating generation but the district heating customers. Previous research has shown that there is a largely untapped potential for using low exergy systems, particularly for heating buildings and DHW. For conventional heating systems, manufacturers are constantly further

This research project
is funded by the

Federal Ministry for Economic Affairs
and Energy (BMWi)

developing their system components in accordance with own commercial interests. However, development is faltering in regards to transfer stations because of the relatively small quantities. In the LowEx Systems research project, the Stadtwerke München municipal utility company, Munich University of Applied Sciences and the Ebert-Ingenieure building services engineering company have investigated how low-temperature systems can be optimised in buildings. Their premise: If the heat supply can be successfully shifted to lower temperature levels, upstream production systems will work more efficiently.

The trouble with return temperatures

Low return temperatures and a large temperature spread are beneficial not just in district heating systems based on combined heat and power but also in heating systems with biomass, condensing technology and solar backup heating. It is only possible to achieve a highly efficient overall system when there are low return temperatures. With solar backup heating, for example, a low return temperature ensures that the energy yield from the solar collectors increases due to the low operating temperature.

Test rig for district heating transfer stations with DHW and basic evaluation in existing systems

Previous investigations in existing buildings have been less conclusive because, for example, the building size, pipe insulation standard, distribution losses and, in particular, the hot water consumption varied and therefore did not allow comparison. The engineers therefore tried to record the decisive distinguishing features and to typify them by taking measurements in eight apartment buildings with 20 to 290 residential units and a terraced house complex with 16 single-family houses. The ratio of the circulation losses to the net energy demand proved to be informative in regard to the domestic hot water heating.

The extensive measurements in existing buildings established that 10 to 50 times more hot water between 55 and 60 °C is circulated than is heated from 10 to 60 °C and consumed. “One should be aware that standard domestic hot water heating systems are primarily used to reheat circulation water and are only used to a small extent to heat hot water from 10 to 60 °C. That makes it particularly difficult to get low return temperatures from domestic hot water heating systems,” explains Jörg Spannig, director of the LowEx Systems project at Stadtwerke München.

If the daily hot water draw-offs in a building are compiled over 24 hours of the day – known as the daily load duration curve – it can be seen that for more than half of the day no water is drawn off even in large apartment buildings. At the same time, however, for hygiene reasons the circulation must also remain in operation during this period for at least 16 hours a day. During this draw-off-free time, non-storage flow-through systems are only able to provide return temperatures above the minimum required circulation return temperature of 55 ° C for system-based reasons. It is only by using a suitable storage system for temporarily storing the residual heat from the circulation support heating and specifically releasing heat from this storage system to the inflowing cold water is it possible to also achieve return temperatures below 55 °C in this draw-off-free time. The DHW heating

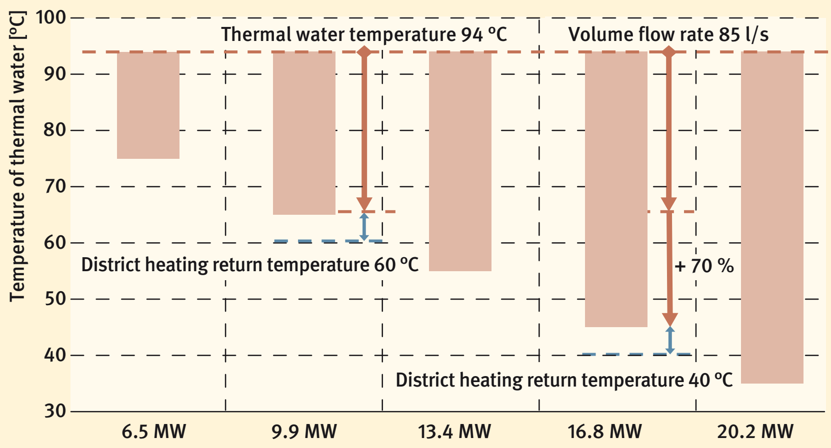

Fig. 1 *The graphic shows the geothermal heat output in accordance with the reinjection temperature of the thermal water.*

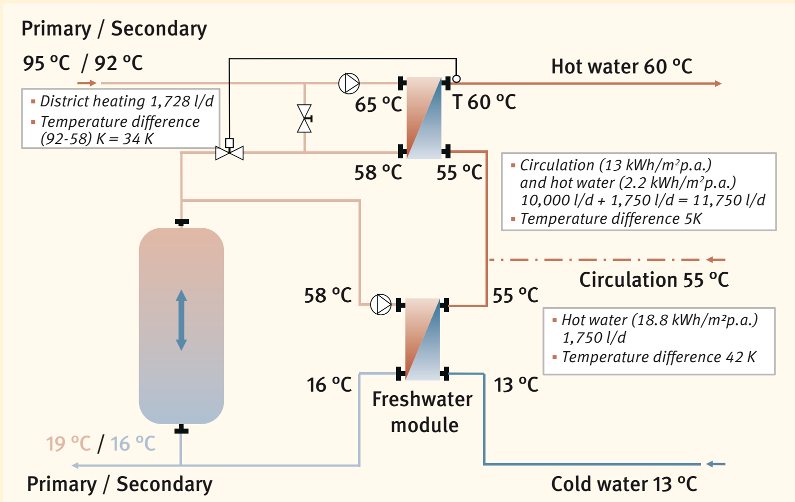

Fig. 2 *Principle behind cascaded domestic hot water heating with an ideally stratified heating buffer storage tank (DHTS 3): In pure circulation operation, the buffer storage tank is charged and then discharged with high hot water consumption. The numerical values correspond to an apartment building with 20 residential units.*

is cascaded, in other words it is heated progressively. In pure circulation operation, a buffer storage system with good temperature stratification is charged and then discharged when there is high hot water consumption (Fig. 2).

On a specially developed test rig (title picture) in a laboratory belonging to Munich University of Applied Sciences, seven district heating transfer stations (DHTS) were tested and optimised with different DHW systems for passive house, new-build and existing building types in summer and winter operation:

- Standard storage tank charging system (DHTS 1)
- Flow-through system with mass-affected preheating level (DHTS 2)
- Heating buffer storage tank with stratified charging devices and freshwater system (DHTS 3)
- Flow-through system with heating connection (DHTS 4)
- Primary charged heating buffer tank and freshwater system (DHTS 5)
- Two-stage storage tank charging system (DHTS 6)
- Flow-through system with three-stage cascade (DHTS 7)

Three DHW systems working according to the basic principle described above achieved volumetrically averaged daily return temperatures below 35 °C on

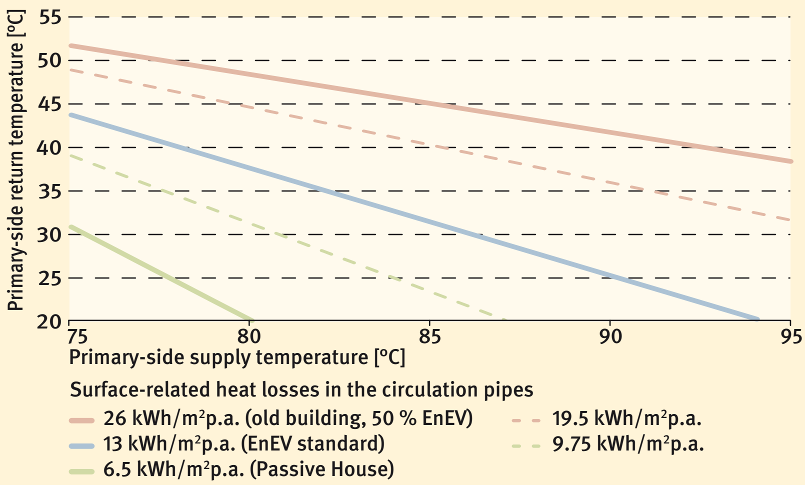

Fig. 3 *Possible primary-side return temperatures at a district heating transfer station (DHTS 3) with indirect connection in summer mode (without heating) in accordance with the primary-side supply temperature and the area-related heat losses in the circulation pipes*

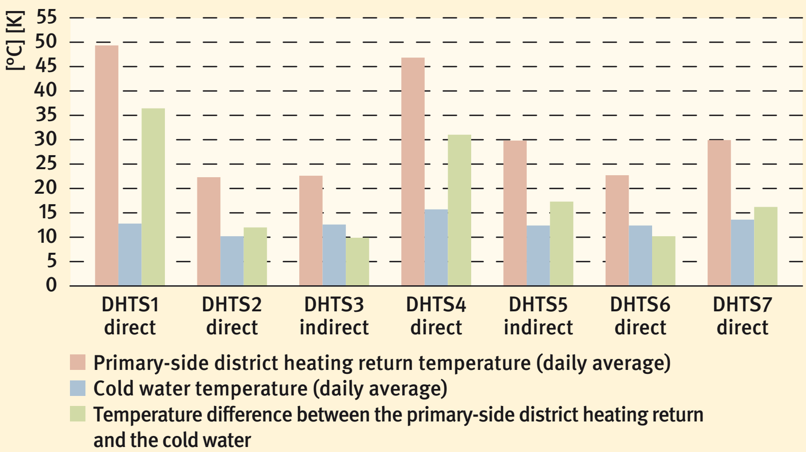

Fig. 4 *Daily averages of the primary-side return temperatures for the investigated district heating transfer stations in summer mode (without heating) with well-insulated circulation pipes (to EnEV standard) and a primary-side supply temperature of 95 °C*

the test rig; under favourable conditions – namely low circulation losses and a high hot water supply temperature – they even achieved temperatures below 25 °C. These systems comprised the flow-through system with a mass-affected preheating level (DHTS 2), the heating buffer storage tank with a freshwater system (DHTS 3) and the two-stage storage tank charging system (DHTS 6) (Fig. 4). In the tested district heating transfer stations, five plants directly connect the district heating to the domestic hot water heating system and are therefore suitable in accordance with DIN EN 1717 for providing Category 3 district heating water. DHTS 3 and DHTS 5 are indirectly connected to the DHW system and can be used for district heating water with hazardous additives (Category 4).

"Protecting drinking water from contamination has top priority and in district heating networks requires Category 4 indirect connections. The test results and pilot systems show, however, that very low return temperatures can also be achieved even with indirect connections," explains Professor Franz Josef Ziegler, Head of the Laboratory for Heating Engineering at Munich University of Applied Sciences. The measurements on the test rig and pilot systems show that the achievable primary-side return temperature is mainly dependent on two factors: the primary-side supply temperature and the circulation losses in relation to the net energy demand for DHW heating (Fig. 3).

What is exergy?

Exergy is a thermodynamic quantity and describes the proportion of an energy flow that can be converted into mechanical work. Anergy is the proportion that cannot be converted into mechanical work. With renewable heat generation or waste heat recovery, only low temperatures are usually available and the exergy proportion is low. These heat sources can be used in buildings with low-exergy (LowEx) systems for space and domestic hot water heating.

Low pressure loss distribution system and building monitoring

When refurbishing existing building stock, measures are often only implemented on the building envelope to reduce the heating requirement. Because a structural restoration with the additional replacement of pipes and heating surfaces is not carried out, over-sized heating surfaces often remain after such refurbishments. The low pressure loss distribution system developed in the project takes advantage of this circumstance: if the supply temperature is raised and the pump delivery head is accordingly adjusted, the required volume flow rate reduces and, with it, the pressure loss and the resulting return temperature. When designing heating systems, this strategy should be particularly used to achieve a maximum temperature spread.

Using simple and reasonable measuring methods available to all district heating network operators, building monitoring is used to locate district heating customers with excessive return temperatures and to identify the respective causes of the defective return cooling. Modern heat meters are usually adequate for finding increased return temperatures. The researchers compiled the typical planning and execution errors revealed by these measurements in a LowEx user guide. In particular, hot water overflow from the supply to the return system must be consistently avoided. This therefore means that hydraulic separators must be dispensed with. It is also recommended that the heating and hot water distribution system should be precisely balanced in a hydraulic way. However, the user manual also recommends simple, cost-effective measures such as avoiding multiple thermostatic valves within a room or simply reducing the speed with heating circulation pumps.

Network operators are benefitting from the findings

"If the advice from the user manual is consistently complied with, the typical errors that occur when building a low-exergy heat distribution system can already be identified in advance and avoided during execution," says Jörg Spannig and adds: "The underlying economic and environmental prerequisites for district heating networks can be significantly improved through the widespread use of LowEx technologies."

The manufacturers are already using the project findings and are offering such LowEx systems. District heating supply companies can contractually agree highly efficient transfer stations with their customers that are also suitable for the integration of renewable energies. This is a sensible decision in view of the roughly 30-year service life.

Achieving exergetic efficiency

With the help of research projects from the EnEff:Wärme funding initiative, the aim is to improve the heating supply in energy efficiency, economic and ecological terms. In addition to developing and optimising low-temperature systems in buildings – such as with the LowEx Systems project in Munich, it is also aimed to increase the exergetic efficiency of the district heating systems used for entire cities or urban districts.
For example, about 50 % of the total heating requirement for the city of Ulm, which has around 120,000 inhabitants, is met by district heating. In order to optimise the municipal district heating in Ulm in exergetic terms, researchers investigated the impact of reducing the network return temperature during the course of the local steam network's conversion to hot water operation. Here they changed, for example, the technical requirements for space and domestic hot water heating systems. With the EnEff:Wärme project entitled "Exergetic optimisation of the district heating supply in Ulm", the scientists, designers and network operators want to support the dynamic development of the district heating that has taken place in Ulm in recent years. New requirements from customers, including major housing associations, shall also be taken into account. Lowering the return temperature is also generally an effective way to lower the network supply temperature in the long term. However, the return feed connections from heating customers are subject to technical limitations. For example, at a certain limit to the return feed output, less densely populated areas need to be adapted to the return temperature since further individual connections no longer make sense.

Converting the steam network for exergetically-optimised district heating

With the concept for converting the inner-city steam network to hot water operation, a cornerstone has been laid for the structural redesign of the district heating: The significantly lower supply temperatures and the associated increase in the electrical generating efficiency enable the centrally generated energy to be used with greater exergetic efficiency. In addition, the researchers are looking for other ways to reduce the supply and return temperatures without compromising the supply quality for the customers.
The Ulmer Wohnungs- und Siedlungsgesellschaft housing association is currently constructing an apartment building with 70 residential units and a thermal connected load of 160 kW. A flow-though freshwater system provides domestic hot water heating. Once the district heating house station has been installed, a measurement programme will monitor the trial operation of the house station and the first year of operation.

Project participants

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Links

- Project summary and final report on "LowEx systems – Widespread application of low-temperature systems as guarantors of sustainable heating provision" at EnEff:Stadt: http://www.eneff-stadt.info/en/new-technologies/

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Imprint

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Federal Ministry for Economic Affairs and Energy (BMWi)
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Germany

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Project number
03ET1005A

ISSN
0937-8367

Publisher
FIZ Karlsruhe · Leibniz Institute for Information Infrastructure GmbH
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Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Concept and design: iserundschmidt GmbH, Bonn – Berlin, Germany · Layout: KERSTIN CONRADI · Mediengestaltung, Berlin, Germany