Articles

Renovation of a heating system

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General overview of the structure and functioning of a heating system in apartment buildings renovation

Central heating, particularly hot-water heating where the heat emitters used are radiators and convectors, is the most common type of heating system in all places where, during the cold seasons of the year, continuous heating is needed. In Europe alone, it is estimated that there are one billion radiators/convectors in use.

There is a reason for their popularity: Properly designed and properly constructed radiator heating systems work reliably, last a long time, and deliver an excellent thermal comfort. Their reliability is enhanced by decades of user experience of the functioning of both the components and the assembled whole. Indeed, radiator systems have revealed to be one of the least problematic of buildings' different technical systems.

In terms of the structure of their piping, radiator networks are of two basic types: one-pipe systems and two-pipe systems (**Figure 1**). Two-pipe systems are by far the most popular apartment buildings. The use of vertical one-pipe systems in apartment buildings was widespread in Eastern Europe. To some extent, horizontal one-pipe systems are used mainly in small buildings. Because of their deficient in cooling and the resultingly weak energy efficiency, it is advisable to shift from one-pipe systems to the two-pipe option.

This presentation focuses on radiator networks in apartment buildings that are renovated. It is also of key importance to be able to renovate the heating systems while the residents are on site. If it is possible to move the residents to temporary housing for the duration of the renovation, this would offer opportunities for other types of technical solutions.

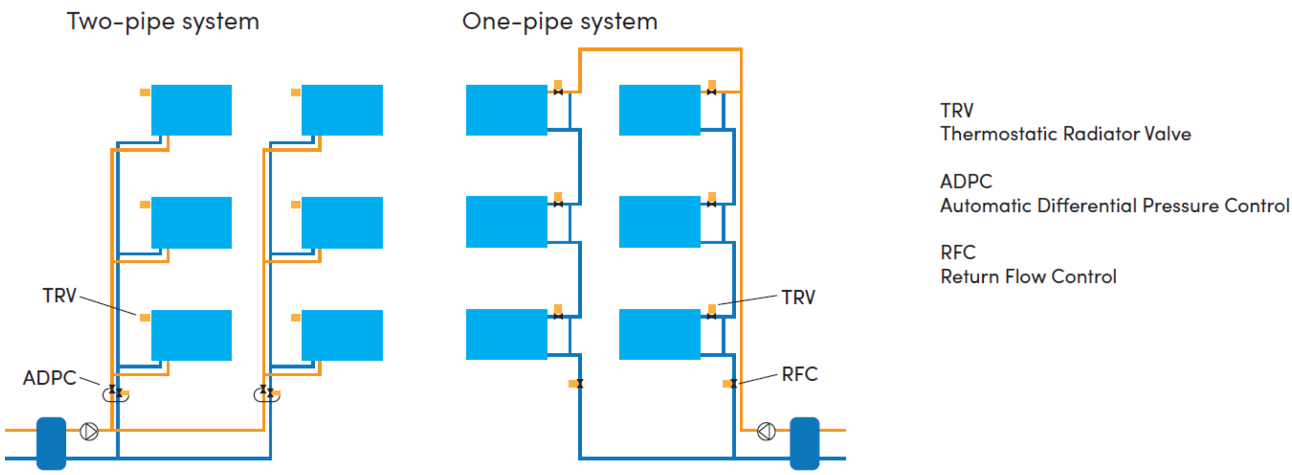

Figure 1. Structure of a radiator network: a two-pipe system (left) and a one-pipe system (right).

Actions to be performed on a heating network during the renovation.

Because renovation of building stock are guided by the statutorily defined objective (EU EPBD requirements) for improving buildings' energy efficiency to the level of a nearly zero-energy building (nZEB), the renovation actions shall ensure that the target energy efficiency is achieved, and that the repairs help to create the conditions for making the buildings carbon neutral.

In old buildings, the key energy renovation focus is to reduce heat losses from the building envelope, such as the replacement of windows and outer doors, and the improvement of the heating insulation. Actions aimed at increasing active energy efficiency include, e.g., shifting to carbon neutral systems for heat generation, installation of heat recovery equipment, reduction of electrical devices' consumption, arrangements to reduce the consumption of tap water (particularly domestic hot water), and implementing measurement of water and energy consumption. Buildings' own electricity generation systems are being installed in ever-increasing numbers. Reduction of cooling needs and the setup of more energy-efficient cooling systems are also an important part of renovation construction.

In addition to these measures, one of the most energy-efficient and cost-effective actions that can be taken is the enhancement of radiator networks and turning them into low-temperature heating systems. Heating systems and their functioning are of decisive importance to thermal comfort, energy efficiency and energy costs.

To improve the energy efficiency of heat generation in areas such as heat pumps and district heating, the heating network's temperatures need to be brought to a considerably lower level than before (**Figure 2**). The aim is to improve the efficiency of heat generation and at the same time lower the costs of generating heat energy.

Energy remodeling of a building changes certain building features. The heating needs of the rooms change, as do the ratios of heating needs between the different rooms. This means the heating network needs to be redesigned with dimensions adapted to the new conditions and requirements. Generally, what should be retained from the older system are the heating network's transmission lines and risers. It is practical

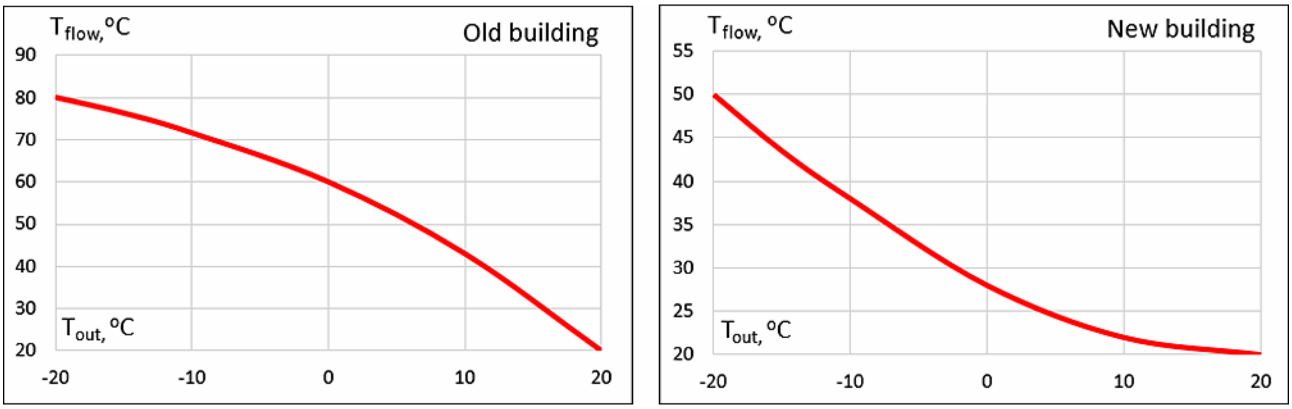

Figure 2. Examples: The old building (left) has high flow water temperatures and a convex heating curve. The new and deep-renovated old buildings (right) have low flow water temperatures due to the low heat demand and a concave heating curve due to the high influence of solar and internal heat gains.

to replace the radiator connection pipes with new ones when possible (**Figure 3**).

New radiators should be dimensioned to the right size for a low-temperature system, while ensuring that their heat-radiating surface is as large as possible, taking into account the space available for installation. Radiator valves should be replaced with precisely preset thermostat valves. The existing risers should be equipped with automatic differential pressure control valves. The heating network should be balanced using calculated values. It is also advisable to update the temperature controller and the water circulation pump.

In an energy-efficient building, up to 60–80% of heating needs during a heating period can be covered by heat gains from residents and electrical devices, and the direct radiation of the sun. The radiator and thermostat, working together, make it possible to utilize free quantities of heat.

In practice, achieving a balanced heating network is straightforward because in the new operating situation, the old supply risers are looser and are no longer a source of friction losses: If one chooses a pressure difference level of, e.g., 10 kPa, this pressure difference will be precisely preserved, even with radiator valves. The settings values of radiator valves can therefore be determined almost entirely on the basis of the design heat demand. A low pressure difference ensures that a radiator valve functions precisely, without making noises, and also ensures good cooling of water.

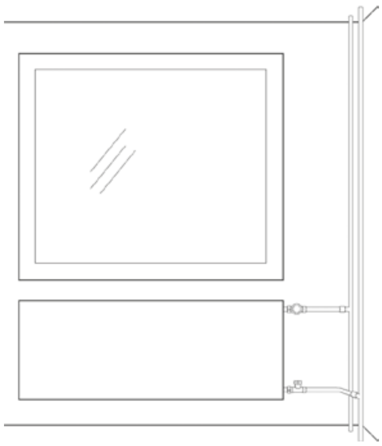

Figure 3. A properly dimensioned radiator will have a large heat-radiating surface. A new radiator and its valves are easiest to install when the radiator connection pipes from risers to radiator valves are replaced.

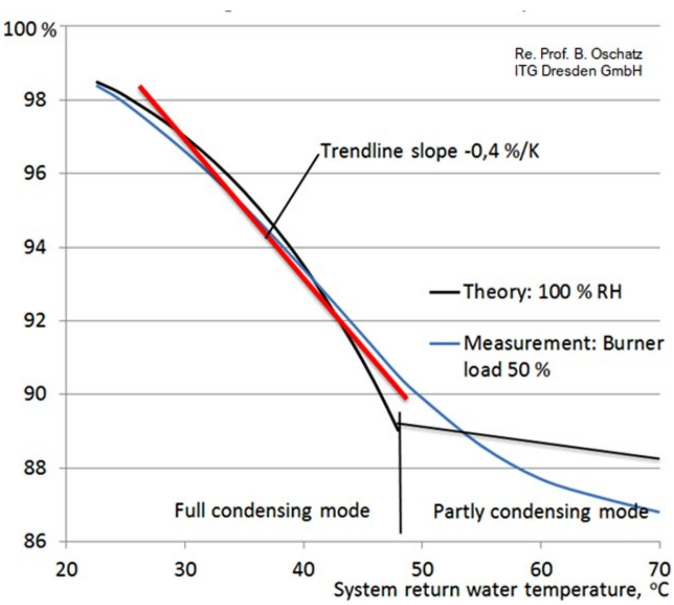

Figure 4. The condensation of output gases is significantly enhanced when the temperature of the return water falls to under 50°C, in which case boiler efficiency can improve by up to 10%.

Dimensioning and energy efficiency of radiators at district heating and heat pump sites

District heating

With a district heating connection, a functional level for the dimensioning temperature is 60/30/21°C (flow temperature/return temp/room temp). Heavy cooling, i.e., low temperature of return water – improves the energy efficiency of district heating: The network's ground losses are smaller, lower levels of flow and pumping power are made possible, the boiler operating efficiency improves when the temperatures of flue gasses decrease, and increased condensation enhances the functioning of the flue gas scrubbers reducing the particle emissions (**Figure 4**). Thanks to these benefits, many district heating providers have also been able to reduce consumer tariffs. In energy prices, it is typical to have a €2/MWh deduction for each degree the temperature of the return water is reduced; for example, the monthly average of return water temperature compared to a reference temperature of 50°C. Some district heating providers also issue fines when the temperature of return water exceeds the reference temperature.

Efficient condensation of flue gases, and the boiler efficiency that such condensation affords, pertains to all types of heating boilers, such as bio-mass, gas and oil boilers.

Heat pump system

It is important to a heat pump's efficiency to keep the heating system's temperatures low. When the heating need is low, radiators can also be dimensioned for very low temperatures.

The operating efficiency of a heat pump is described with the coefficient of performance (COP), which is the ratio of the heat generated by the heat pump system (Q) to the work done by the electrical energy of the compressor (W).

$$COP = \frac{Q}{W}$$

where

- Q is the useful heat supplied or removed by the considered system
- W is the work required by the considered system

The expression COPa is also used for the annual coefficient of performance.

In practice, the temperature of the supply water is of decisive importance because a heat pump's coefficient of performance (COP) is about 2/3 dependent on the supply water's temperature, and 1/3 on the temperature of the return water (**Figure 5**). For this reason, in the dimensioning of a heat pump, a temperature of, e.g., 50/40°C (flow/return temperature) is better than 60/30°C, the latter of which is suitable for district heating. For a guideline value, one can assume that a decrease of 10°C degrees in supply water temperature will improve COP by about 30%, which, at an annual level, means that the heat coefficient COPa rises by 12-15%, with focus on the space heating.

Production of domestic hot water (above 55°C) solely with geothermal heat pumps and outdoor air heat pumps is often not economic. For most heat pumps, 50°C can be regarded as a reasonable temperature lift. The larger the temperature lift, the lower the COP becomes (**Figure 6**). The optimal temperature increase level depends on the COP corresponding to the threshold temperature level in question, and the prevailing price ratio between electricity and other forms of energy.

For their heat source, exhaust air heat pumps use ventilation exhaust air, which has a high temperature (in the range of 22°C year-round). With a high initial temperature, an exhaust air heat pump can produce warm supply water and domestic hot water energy efficiently. But be aware that given the limited extract airflow of a mechanical ventilation system the capacity of heat pumps using the exhaust air as their heat source is limited.

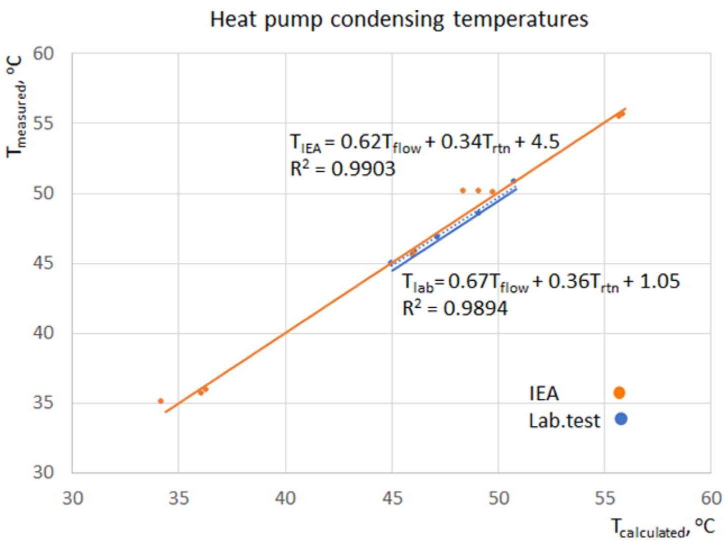

Figure 5. A heating network's supply water temperature has about a 2/3 impact on a heat pump's COP, and return water has an impact of about 1/3 – compare the coefficients of the regression equations.

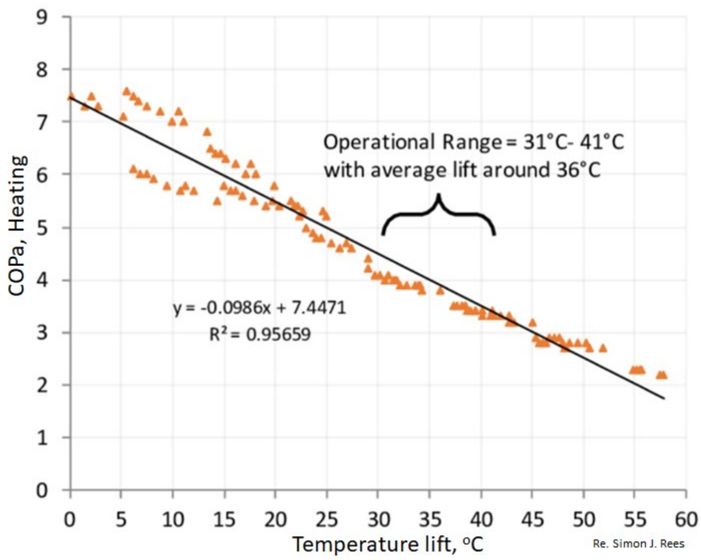

Figure 6. Typical COPa values gathered from different sources.

Generally speaking, it is recommended to use a heat pump in parallel with district heating or a heating boiler if the capacity of the heat pump is insufficient on its own to achieve economic heating of domestic hot water or peak efficiency of the heating system.

However, one should remember that such hybrid systems always require high-quality control and connection systems to ensure optimal functioning. ■