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Article

Trend for heating system renovation in multi - family buildings

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Trend for heating system renovation in multi - family buildings

The activities for building renovation within the rental area in multi - family residential buildings are increasing. This is due to the ageing building masses and the general energy awareness. Decreased energy demands, reduction of operational costs and increased comfort demands are the main drivers behind. This article describes a case story about modernization of a residential building complex initially equipped with a one - pipe system. The buildings are owned by the cooperative housing association SAB in Sonderborg, Denmark.



- Improved building insulation
- Window replacement to meet
- a higher energy efficiency class
- Renovation/replacement of the heating and domestic hot - water system (DHW)
 Renovation of kitchens and bathrooms

To keep future operational costs as low as possible, the special focus was on heating and DHW costs and related distribution losses. To result in an overall good result, it was very important that the correct decision was made in order to address the individual demands of the stakeholders.

Typically the decisions were influenced by:

- Standards and regulations
- Energy suppliers. In this case
- Sonderborg District Heating
- Building owners' wishes and demands
- Residents' wishes and demands

Standards and regulations

Typical standards and regulations are:

- Building regulations with demands for insulation and individual energy metering
- Standards for DHW systems with demands as to capacities and prevention of bacteria growth
- Standards for room heating systems.

Energy supplier

If a district heating system is the energy supplier, typical demands are:

- Type of accepted systems. Among others the use of heat exchangers
- Maximum acceptable system return temperature for room heating as well as DHW system.
- Maximum system ΔP or flow limitation



Building owners' wishes and demands

- Low system cost
- Up to date energy and environmental systems
- Low maintenance cost
- Minimum risk of bacteria growth in the domestic hot water system
- Low operational costs
- Minimum system space demand
- Safety functions
- Long system life time

Residents' wishes and demands

If the residents should have influence on the choice of system, typical demands and requirements could be:

- Simple operation and setting
- Possibility of individual readout of energy consumption, domestic cold water and electricity
- Nice appearance if not hidden away in a locker e.g.
- Safety functions
- Sufficient and comfortable supply of heating and DHW

The existing system in the SAB buildings

The system was initially a one - pipe system for room heating and a central DHW boiler charging system with horizontal and vertical distribution. The system is connected to a district heating system. This kind of system can normally not fulfill the district heating demand concerning a low return temperature.

Despite the fact that the system return line was led to the lower cold part of the DHW boiler, the cooling of the district heating water did not fulfill the required low return temperature.



Alternative system choice

In order to fulfill the requirements given in the district heating regulation concerning low return temperature, the system had to be changed to a two - pipe system. Furthermore, there was a wish of minimizing of the heat loss in the distribution pipes.

Taking this into consideration, following systems were evaluated:

- 1. Central distribution to
- a number of blocks
- 2. Central distribution from a single block
- 3. Central distribution from a staircase
- 4. Flat station system

The systems are listed in different ways to decentralize the DHW systems and heating system, see fig. 2.

In system type 1 – 3, an indirect connected room heating system and a DHW supply system by means of an instantaneous heat exchanger for DHW supply is shown (fig. 3).

An alternative solution to this could be a directly connected system with a weather compensated centrally placed mixing loop. The DHW supply system could be a boiler charging

system as shown in is shown fig. 3.

Central distribution to one or more blocks

Central distribution to one or more blocks often is chosen because of:

- Central flow and temperature control
- Optimization of operation condition
- Optimization of operational costs and system maintenance

Central flow and temperature controlling

In systems with central distribution it is easy to get overview of the system supply conditions and to make some corrections in form of adoptions or limitations, if needed.



FIGURE 1: Existing one-pipe system with central supply of domestic hot water



FIGURE 2: Alternative system types

Optimization of operational condition, costs and system maintenance

In a system with central distribution it is easy to get information about the operational condition, the costs and thereby the need for service.

Among the disadvantages with central distribution are:

- Relative high heat loss from the distribution lines
- Risk of bacteria growth in the domestic hot - water supply system
- Need of flow balancing of the branches in the system both for room heating and domestic water systems
- Limited possibility of individual optimization of conditions in the dwellings
- Unreliable and complicated billing system for calculation of individual costs for consumption in the dwellings

Relative high heat loss from the distribution lines

In a system with central distribution there are 4 supply pipes in which heat loss can occur. The wider the system is distributed, the higher the heat loss will be.

Risk of bacteria growth in the DHW system

In domestic hot - water supply systems, the legionella bacteria is the mostly discussed bacteria threat. The experience is that the hot-water temperature has to be >55 °C in order to avoid legionella bacteria growth.

Risk of legionella growth often exists in still water and in pipes with low rate of replacement. Growth of legionella bacteria can be reduced by selecting instantaneous heat exchanger systems instead of boiler systems for DHW supply systems. Also the correct use of balancing valves in the circulation lines in the DHW system will avoid still water in the system and reduce the risk of bacteria growth.

DVGW in Germany has a technical rule (W551 chapter 5.2.1) stating that the hot - water temperature has to be min. 60 °C in central supply systems with a water volume in the secondary pipe system of >3 liter. However, in systems where the secondary pipe volume is <3 liter, there is no specific temperature demand stated. For your information the water volume in a pipe with an internal diameter of 12 mm corresponds to a length of about 26 m).

Flow balancing of branches and risers in room heating and DHW systems

Systems with central distribution need a carefully hydraulic balancing of the circulated water in the total system. Balancing of the water flow provides a uniform temperature and flow in the total system. Unless automatic balancing valves are installed, a carefully balancing out of the total system is a costly operation.

Limited possibility of individual optimization of condition in the dwellings

With a central distribution system, the optimizations of the operating conditions in the individual dwellings are limited. A low cooling off from a radiator in the dwelling can result in that the stated demands cannot be fulfilled due to unbalance.

Billing system for calculation of individual consumption costs in the dwellings

According to standards in some countries, the consumption of heat, domestic water and electricity has to be registered on an individual consumer level. If meters are not installed decentralized in the dwellings, the registration and calculation of the individual cost allocation for the consumption becomes complicated. One way to do this is to calculate consumption based on readout from evaporation meters placed on the individual radiators and a water meter on the supply pipes to the dwellings. Also registration based on area of the dwelling or inhabitants in the dwelling are used. This is not a secure way to calculate consumption, and this way of registration does not inspire the residents to save energy as much as the individual energy cost allocation would.

With a central distribution in the staircases the control equipment costs are increased, however, some of the mentioned drawbacks are reduced.

Among others are:

- Heat loss in the horizontal distribution lines
- The hydraulic balancing procedure at commissioning is significantly reduced

The flat station systems

Typical of a flat station system is that it is a low condition central unit for controlling the room heating system, typically up to PN10, and the DHW service system in placed individually in each dwelling. The room heating system can be a normal radiator system, a floor heating system or a





FIGURE 3: Two-pipe room heating system with alternative central system types



FIGURE 4: Alternative supply systems



FIGURE 5: Cost comaparison for the Århus case, a traditional system compared to flat station system



FIGURE 6: The selected system, a flat station system

2002	2003-2005	2005	2009-2010	2010
Ordinary building	Building renovation	Building renovation finished	Installation of new HE and DHW system	Total renovation finished
One-pipe system			Mixed one- and two-pipe system	Two-pipe system

FIGURE 7: Plan for carrying out the renovation



FIGURE 8: The energy consumption is measured for 5 blocks in meter M2

combination of both with or without weather compensated control system. The DHW service system normally is an instantaneous heat exchanger system.

The centrally placed supply system for a flat station system can be a high and low conditioned district heating system or it can be a boiler system. Typically, the station is supplied with a meter for registration of heat and a meter for registration of cold water consumption.

By choosing a flat station system, the following advantages will be obtained:

- Low heat loss from the installation in the building based on the reduced number of distribution pipes
- The distance from the DHW service system to the tap location is normally very short, meaning a DHW circulation system is not necessary
- Exact readout of the consumption. This is influencing the aim of saving energy and water consumption
- Possibility of setting individual DHW temperatures
- Possibility of establishing a simple night setback function by means of a zone valve and a clock switch
- Depending on system application, no additional hydraulic system

balancing is necessary. The system is equipped with a ΔP controller or a combined flow and ΔP controller in the room heating system. In

many cases, a DHW controller with built - in ΔP controller is selected.

Cost calculation from a system in Århus Denmark, see fig. 5, shows that the investment for a flat station system is at the same level as a traditional system. By traditional system is meant centrally produced DHW with circulation.

Selection of system

For the system concerned it was decided to replace the one - pipe system with a two - pipe flat station system.

The main arguments for choosing this solution were:

- Lower system heat losses
- Simple and safe allocation of individual consumption.
- High rate of hydraulic balance in the total system
- User friendly system due to the individual possibilities
- Low risk of legionella bacteria growth

Measuring data from the SAB case

In the system concerned, the total renovation is finished. For the energy evaluation, 5 apartment blocks have been chosen, as they have been finalized for a longer period. Based on this, measuring and comparison of the impact of energy consumption can be evaluated. The energy consumption data used for the comparison are based on the registered data of the district heating company meters over the years 2005 - 2010. The energy consumption over a year was degree - day corrected so that it represents a normal Danish climate reference year. The building renovation took place according to fig. 7.

According to this, the building renovation was finalized in the year 2005. The heating and DHW system was renovated and replaced from beginning 2009 and finalized up to 2010. The energy consumption impact for the renovation of the heating and DHW system is compared for the years 2005 - 2008 and 2010.

From figure 9 it can be seen that the return temperature dropped from approx. 65 °C down to approx. 35 °C after the system renovation. This was due to the change from a one - pipe system to a two - pipe system with flat stations.

Energy saving

After the system renovation, energy savings of approx. 30 % over a year could be achieved. Focusing on the summer time only, the seasonal energy saving was approx. 40 %. See fig. 10.







FIGURE 10: Energy consumption and saving

Conclusion

The main problem with the supply system at SAB was:

1. The heating system had to fulfill the demand from the district heating supplier concerning low return temperature

2. The horizontal distribution pipes together with the central supply system was placed in the basement and it led to a much to high room temperature there and a far too high energy loss

3. The existing billing system was complicated and not very reliable To fulfill the objective 1 the renovated system had to be replaced by a two-pipe room heating system.

The next discussion point was selection between a flat station system and a staircase system. Seen from a billing system and a energy saving point of view, a flat station system was selected. With a flat station system, the best billing system could be achieved and at the same time the residents had more influence on their consumption by means of their behavior.

Measurements revealed a yearly energy saving of 30 % based on:

- Replacement of the one pipe system with a two pipe system
- Removing of the centrally placed substation and water treatment system in the basement
- Removing of the DHW distribution system in the basement and part of the vertical pipes in the staircases.
- Elimination of the central DHW boiler system and the water treatment system, significantly reduced the maintenance cost

The energy savings of 30 % in total obtained by SAB is based on:

- 8 % from the reduced number of distribution pipes
- 10 % from the eliminated central station heat loss
- 12 % from the increased consumer energy awareness and related behavior

The residents' reaction on implementing this system was they appreciated the influence they got on their own consumption and consequently adapted their behavior. Also the reduction in costs of consumption was highly appreciated.

Summary

The flat station concept is addressing the future demands for high energy efficient building installations. The SAB case in Sonderborg clearly proves this.





More articles

1] Differential pressure controllers as a tool for optimization of heating systems by Herman Boysen

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- [2] *Hydraulic balance in a district heating system* by Herman Boysen and Jan Eric Thorsen
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- [4] Selection of district heating house stations by Herman Boysen
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- [6] Dynamic simulation of DH House Stations by Jan Eric Thorsen
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- [9] Distribution systems in apartment buildings by Halldor Kristjansson
- [10] Cost considerations on storage tank versus heat exchanger for hot water preparation by Jan Eric Thorsen and Halldor Kristjansson
- [11] Optimum control of heat exchangers by Atli Benonysson and Herman Boysen
- [12] Valve characteristics for motorized valves in district heating substations by Atli Benonysson and Herman Boysen
- [13] Analysis on flat station concept (Preparing DHW decentralised in flats) by Jan Eric Thorsen

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