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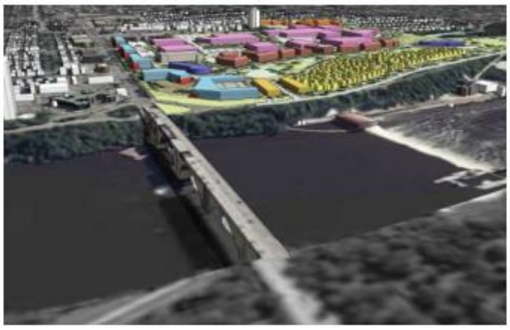
DISTRICT ENERGY FOR DEVELOPERS
INTRODUCTION



RAMBOLL

DISTRICT ENERGY FOR DEVELOPERS INTRODUCTION

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1. INTRODUCTION

This document is intended to serve as an introduction to district energy systems for property developers.

The document outlines the characteristics of a district energy system as well as the typical setup. The document deals with both district heating and district cooling, with focus on the connection of buildings (consumers).
The document does not in detail deal with the production of heating and cooling.
The buildings internal systems and their requirements related to district heating and cooling systems are briefly outlined.

The document is not intended to elaborate on all details of building a district energy system, but the focus is to give developers an introduction and idea of the critical factors when choosing a district energy solution and the resulting impact on building installations and operation.

2. WHAT IS DISTRICT ENERGY

District energy (DE) is a system that provides heating and sometimes also cooling from central production plants to a number of consumers to meet the consumers need for space heating and domestic hot water and cooling. The heating and cooling is distributed by means of a piped distribution network using hot or chilled water.

The network consists of supply pipes and return pipes and the proposed network in St Paul for the Ford Site can be split into two levels: The branches and connections to supply the buildings and the distribution heating and cooling networks themselves. The distribution network connects the supply from the Energy Centre's central plant, where the heating and/or cooling is produced to the buildings via the branches and connections.

Modern DE systems combine district heating, district cooling with combined heat and power (CHP) also known as co-generation, thermal storage, heat pumps and/or decentralised energy.

DE is characterised by a high degree of fuel flexibility as a wide range of fuels can be used as heating and /or cooling source. DE can be produced from fossil fuel sources such as natural gas, oil or by renewable energy (e.g. biomass, solar thermal, geothermal or heat pump solutions) or waste heat from industrial processes. The fuel is burned directly in boilers or through CHP. The heat to a heat network can also be produced by solar thermal panels or large scale heat pumps connected to the network.

The high degree of fuel flexibility often helps securing low and stable heat prices. By CHP the surplus heat from electricity production is utilised to supply heating and/or cooling to the networks.

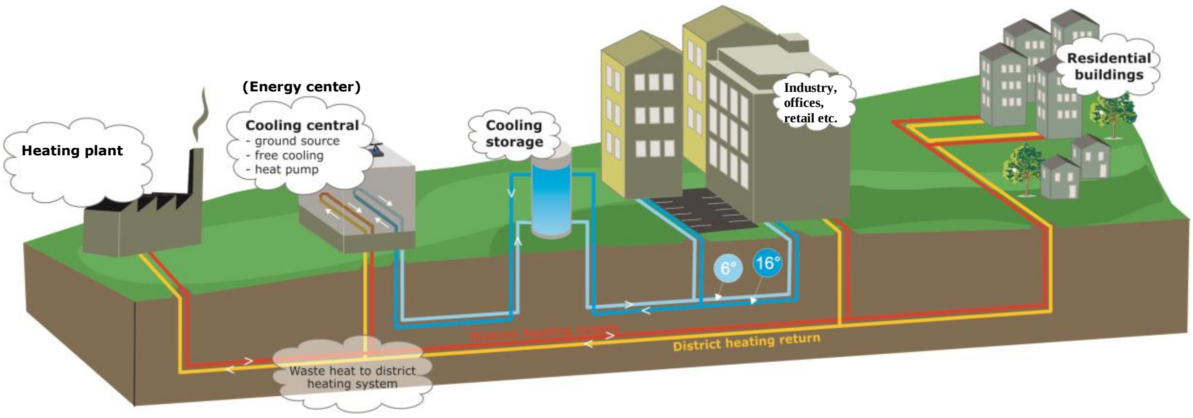

Figure 2-1 Supply concept for district heating and cooling.

The DE concept takes advantage of the effectiveness of central and large scale production, or even surplus energy from other processes, to produce energy more efficiently than individual small scale energy conversions such as gas boilers. These advantages outweigh the downsides of any heat losses in the distribution networks, which with the right design are relatively small.

Having both a district heating and a district cooling system brings a number of synergies, which is beneficial for both the DE utility company and the consumers. Most important to mention, is that surplus heat from the cooling system can be used in the district heating system by means of large heat pumps. Utilizing this heat can potentially give lower heat and cooling prices for the consumers.

It is recommended that modern district energy systems are designed according to the principle of low temperature district heating and high temperature district cooling to provide the most efficient and cost effective systems.

3. DOMESTIC HEATING INSTALLATIONS

3.1 Connecting buildings to district heating

The individual apartment, condo, house or building's heating system can be either directly or indirectly connected to a district heating (DH) network.

Two service pipes connect an apartment, condo, house or building ("the building") to the district heating network. One brings the hot water to "the building" and the other returns the "cooled" water to bring it back to be reheated at the energy center or plant building.

The domestic hot water (DHW) can either be supplied through a hot water cylinder or instantaneously.

"The building" can be heated either by radiators, floor heating or by a combination of radiators and floor heating. Hot air can also be used, however, radiators and floor heating give a better thermal comfort than air heating.

3.2 Typical setup – indirect connections

The most typical setup connecting the domestic heating system with the DH network is through substations. The hot water coming from the DH system is run through a plate heat exchanger to heat the water of the domestic heating system. Which effectively is two closed loop systems transferring energy.

Domestic hot water is produced in the same way, although this is not a closed loop.
A hot water tank can be added depending on the setup, as well as an expansion body for safety reasons in case of changes in pressure in the main system. Substations create a minor temperature loss, as the temperature on the domestic system can never be as high as in the distribution system, but they also provide a separation of the systems that many operators prefer.

For high-rise buildings, multi-dwelling houses and one family houses separate substations, with meters, can be applied for each end-user.

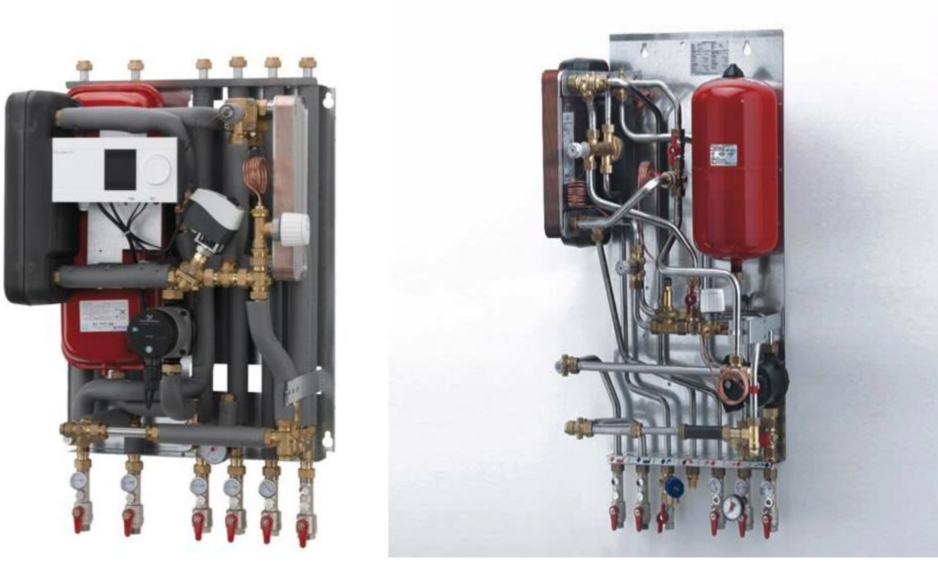

Figure 3-1 Examples of a wall mounted consumer substation for an individual residence. The substations are illustrated without casing. The substation to the right is shown without any insulation (Photo: Danfoss)

You can find DH substations with integrated floor heating systems like the below examples.

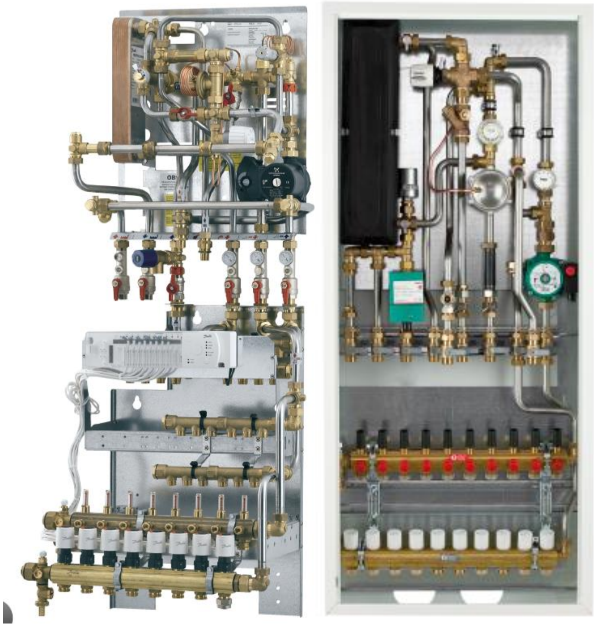

Figure 3-2 Examples of consumer substations for an individual residence with integrated heating manifolds. The installations are shown without casing / insulation (Photo: Danfoss and PEWO)

In the larger apartment buildings there can be a central substation with a heat exchanger at the ground floor supplying every flat with direct heating (no heat-exchanger) to radiators and/or through a mixing circuit (loop) for the floor heating system as well as for the domestic hot water via a small heat exchanger.

A typical example of a larger central floor mounted substation is seen below and it will be supplying into larger or high rise buildings via a heat exchanger. Such a large substation solution could also be used for commercial, retail and offices buildings. These substations are shown without large domestic hot water tanks, which could also be an option.

Figure 3-3 Examples of floor mounted substations with heat exchanger for blocks or large commercial, retail or office connections. The components are illustrated without insulation /casing (Photo: Danfoss)

3.3 Apartment block / high rise building: 3-pipe vs. 5-pipe riser system

Instead of having a large central substation in the basement of an apartment block / high rise building, which require a 5-pipe system for heating and domestic water supply (incl. circulation) another concept can be to have a system with individual sub-stations or Hydraulic interface units (HIU). Such a system will only require a 3-pipe distribution system in the building and installation of a small individual consumer substation in each living unit.

The concept is shown in the figures below.

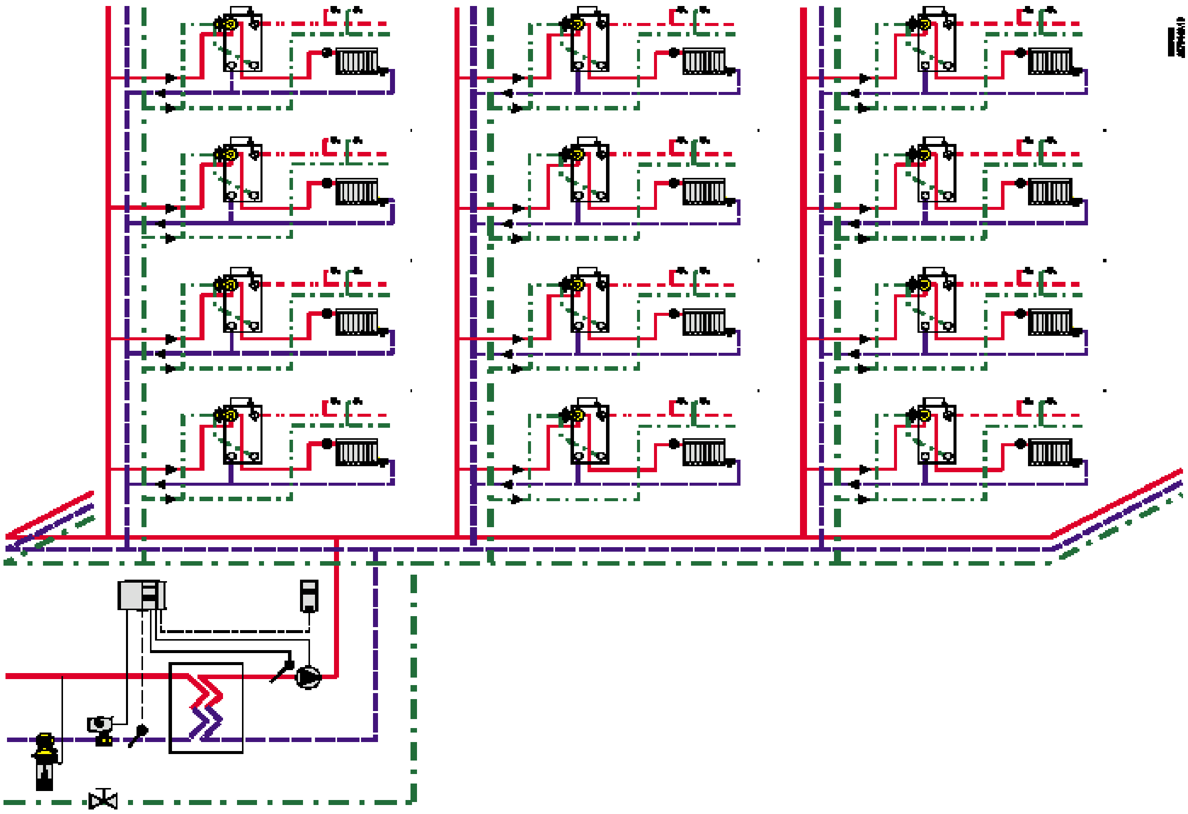

Figure 3-4 Example of district heating system connection in a high rise building (Illustration: Danfoss).

Here it is shown with radiator panels, but it could also be with floor heating or hot air units.

This type of design is considered to be a more modern heat supply concept and should be considered for new buildings, including hotels and domestic sector. Main advantages of the individual sub-station system compared to the central production of domestic hot water are:

- Possible to supply with a lower DH temperature (and the design can be suitable / prepared for low-temperature DH).
- Reduced distribution heat loss
- Individual metering of heating and domestic hot water energy consumption with only one meter
- Low volume of domestic hot water resulting in reduced risk of bacterial growth.

3.4 Temperature requirements from the DH supply

The temperature supplied from the DH system can vary depending on a number of factors. Generally it should be noted that there has been a move from steam systems with super-heated water towards lower temperatures, in some cases down to 140°F (60°C) supply temperature.
One reason is that hot water at lower temperatures is “cheaper” to produce; it allows for more renewable energy, and it results in lower heat losses in the distribution networks.

The temperature of the water in the return aspect of the system, and more importantly the temperature difference between supply and return water (delta-T), is of paramount importance for the system effectiveness. Generally the delta-T is between 35-80°F (20-45°C) and illustrates how much energy is utilized in the buildings. The greater the delta-T, the more efficient use of the energy, although systems with lower supply temperature will naturally have a smaller delta-T.

Many DH suppliers will reward customers for helping them maintain a high delta-T.

3.5 Domestic hot water

The requirements in the building code of the state should be fulfilled. The temperature requirement for showers and wash sinks could be about 104°F (40°C) and for kitchen sinks 113°F (45°C). Note that in (larger) internal domestic hot water systems with circulation the temperature in the system must not drop below e.g. 131°F (55°C) anywhere in the system in order to avoid bacterial (legionella) risk.

In systems with individual sub-substations and with an instantaneous heat exchanger and no domestic hot water storage, the risk of bacterial growth is prevented by having no water storage and the water content in each DHW supply line, including the volume in the secondary side of the DHW heat exchanger kept to a minimum (below 3 liters). This is the allowable water content for the instantaneous DHW preparation systems that is considered to assure safety in relation to the Legionella risk, even without any treatments. This needs to be checked with local guidelines.

3.6 Internal heating system

To enhance a high delta-T in the DH network an efficient internal heating system within the buildings are required. Most commonly a two-string water based heating system with radiant heat through radiators, wall or underfloor-heating in each room is preferred, as it provides thermal comfort. In general, a setup with large heated surfaces such as underfloor heating allows for a greater heat transfer and, as such, optimal for enhancing a higher delta-T and/or use lower supply temperature. Larger radiator surfaces are also a solution.

Traditional building design with very small radiators should be avoided, since it requires high temperatures and result in a very low delta T.

The requirements in the building code of the state or as set by the City of St Paul for the Ford development should be fulfilled. Optimal indoor temperatures could be e.g. 70-71.5°F (21-22°C) in living rooms and 71.5-75°F (22-24°C) in bath rooms.

3.7 Examples of other district heating utilization possibilities

Briefly examples of other utilization possibilities for district heating (than room heating and normal domestic hot water heating) are described below.

3.7.1 Snow-melting and freeze protection

A practical solution – not an energy saving solution – is to utilize district heating to heat up exterior / outdoor construction surfaces in order to remove snow and ice.

Snowmelt technology can reduce or eliminate conventional snow removal, reduce wear and tear on walking and driving surfaces, and provide clean, safe, ice-free traffic areas. Walkways that are snow, ice, and salt-free will increase the comfort and confidence of users and building owners. Snowmelt systems can be designed into new or existing district systems. Buildings already connected to a district system can be readily connected to a supply or return line to heat and clear sidewalks, driveways, parking lots or ramps, and other major pedestrian or automotive traffic areas. These snowmelt applications reduce maintenance efforts for snow clearing and improve the safety of these areas.

Snowmelt systems utilize low water temperatures (for example at 95-120°F (35-50°C)) to circulate through the snowmelt tubing. Utilizing the lower temperature hot water allows for the incorporation of a wide variety of low-grade energy sources such as waste heat, condensate return, or district heating return lines. If the district heating is produced by a CHP plant, a lower return temperature to the plant will lead to higher energy efficiency of the plant.

Selection of piping for these installations is an important consideration for effective operations. Polyethylene (PEX) pipes are an attractive option because they are corrosion-free, manufactured in long sections with fewer joints, easy to handle, and require reduced installation time. Glycol selection is important in order to secure freeze protection, corrosion resistance, and low viscosity impacts for the circulating loop. Glycol selection should also consider design intent, pumping resistance, tubing spacing, r-value, freezing points, and load design.

3.7.2 Domestic appliances with hot water connection

Another idea to increase the potential for district heating is for households to install domestic appliances with hot water connection. Instead of using electrical power for heating up water, the appliances use hot water heated up by district heating. For households this will convert power consumption into an increased district heating consumption.

The economic benefit of this technology depends on the local prices of electricity and district heating, while the environmental benefit depends on the actual carbon emissions for electricity and district heating. District heating systems with a large share of surplus heat, solar heating etc. will particularly benefit from the technology, because it will increase the potential heat consumption during summer time.

Appliances on the market in Europe suitable for hot water supply:

Appliances with a heat exchanger – district heating can be connected directly HWC-machines (Heating Water Circuit):	Appliances with a direct domestic hot water intake / connection:
• Dishwasher • Washing machine (laundry) • Tumble dryer (laundry)	• Dishwasher • Washing machine (laundry)

Test studies of household appliances with built-in heat exchangers and/or washing machines with separate cold-and hot-water intake have been made in Denmark and Sweden. Results show that under ideal conditions, tumble dryers, washing machines and dishwashers with built-in heat exchangers can replace more than 80% of electricity consumption with district heating. For washing machines that use hot water, over 70% of electricity demand can be replaced by district heating.

Washing machines with cold and hot water intake have been on the market in Europe for the professional segment e.g. for common laundries, institutions, etc. for a number of years. In the market for household appliances there have also been various attempts from the manufacturers. At the moment about 3 washing machines are being sold on the Danish market. In addition, many dishwashers on the market are designed in such a way that hot water can be connected directly –it is usually indicated in the user manual, if it is possible.

Studies from Denmark show that, the hot water usage increases in the range of 5-15 % with hot water connection of washer and dish washer machines, which in particular, will have a positive impact on district heating network's operation in the summer months. In addition, it is assessed that the introduction of hot water connected machines will not affect the design conditions of the layout design of the district heating network.

Increased district heating consumption during summer in particular will be an advantage for the pipe network heat loss, because it will be relatively smaller.

4. DOMESTIC COOLING INSTALLATIONS

The overall principles of district cooling are very similar to district heating.

4.1 Connecting buildings to district cooling

Two service pipes connect a building to the district cooling network. One brings the cold water to the building and the other returns the “heated” water to bring it back to be re-cooled at the energy center or plant building.
The district cooling connection has a small space requirement for one or more heat exchanger and other equipment. The figures below show an example of how the district cooling can be connected to internal cooling distribution system in a building.

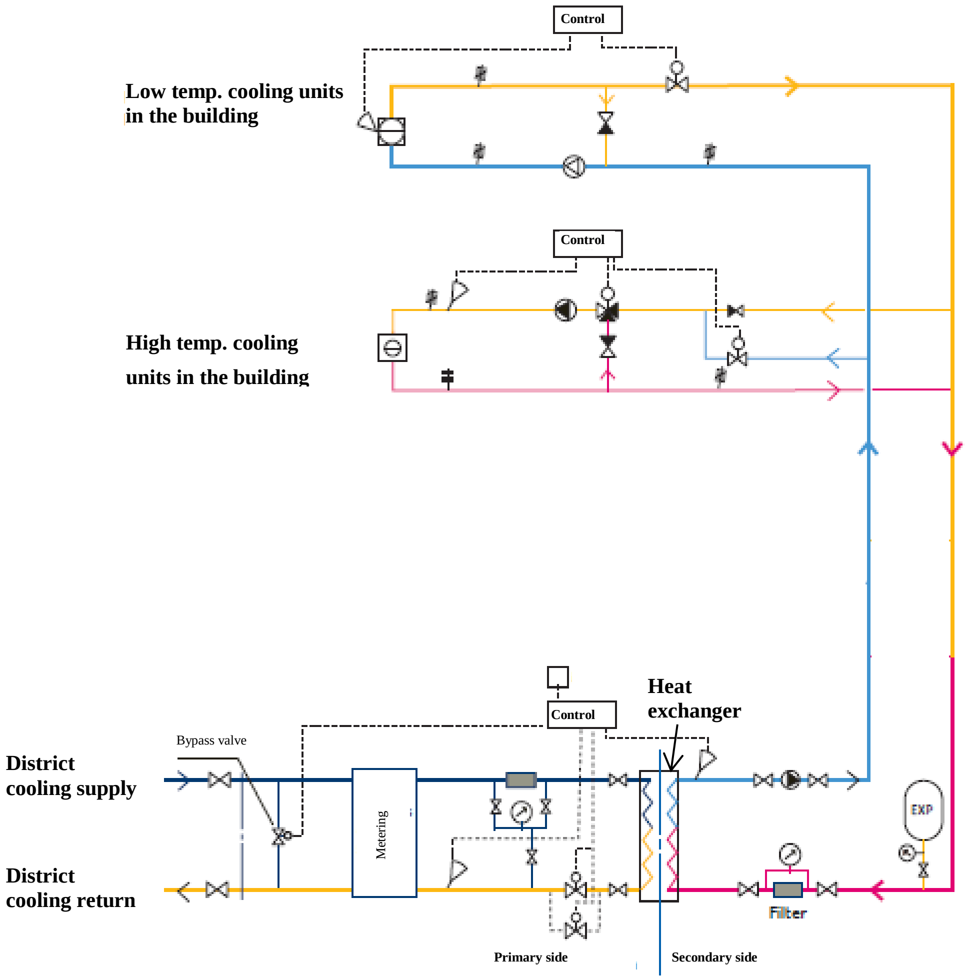

Figure 4-1 Example of a district cooling connection of a building

4.2 Temperaures in DC systems

Typical temperatures in a district cooling distribution network could be:

- Primary supply: 43°F (6°C)
- Primary return: 61°F (16°C)

Some buildings can have special cooling demands. Very low temperatures could be required. Buildings like supermarkets or other buildings with food storages etc. could need a lower supply temperature. For example if an air temperature of 35.5°F (2°C) is needed, it could be necessary to have a supply temperature of 23°F (-5°C) in order to provide that. In such cases the base cooling load could be delivered by the district network with 6°C in supply and then by small-scale units locally at the consumer level for be cooling further to the exact demand.

5. OPERATION, MAINTENANCE AND METERING

A DE scheme is a high cost capital asset and the investment is generally to be justified over a long operating period and it is important to look after the investment.
It is also essential that everybody involved have confidence in the system and that the asset can be and is maintained in operation without undue maintenance costs.

A high quality maintenance regime for the central plant will improve energy efficiency, provide a more reliable service, maximize environmental benefits and prolong the life of the plant and the network.

There are a number of established standards and industry guidance available including specific guidance for each type of heat source that might be used.

The substation and internal heating system requires very little attention in general. Modern substations automatically switch on and off when needed, and only need a general service check once a year or every other year to ensure that everything is in order.

Generally the district energy utility supplier will deal with all maintenance requirements up to and sometimes including the customer heat exchanger and/or the individual sub-station.

These days the utility meters are not only used for the settlement of the customer's energy consumption. The meter is also a natural tool for a constructive dialogue between the supplier and the customer. The possibilities of the meter are such that it can help the customers to ensure that their needs are covered at the lowest possible costs.

Modern meters and control systems also enable the DE operator to monitor and read all units remotely and smooth debugging and billing.

It is preferable that each consumer has installed a heat or chilled water meter as well as maybe domestic hot and cold water meters.

Heating or cooling meters are normally installed in the return pipe and typically it is mounted in the substation at a pre-defined place. Remote monitored heat meters can be used to detect malfunctions in the building heating system or at the consumer installation. For the district energy utility it is very useful to be able to detect possible operational errors in the district heating and cooling network in order to optimize the overall operation. The figure below shows example meters.

Figure 5-1 Example of energy meters for heating / cooling (left). Example of meters for hot and cold water (right) (Photo: Kamstrup).

6. DESIGN COORDINATION AND ADVISE

It is important that the internal heating and/or cooling systems in the buildings are designed to fit to the design of the DE network. Therefore, it is of great importance that the recommendations given in this folder are followed. This will help secure the lowest operational costs for the system as a whole and thereby the lowest price for the consumers.

For further information and advice on the Ford DE scheme and design of internal heating systems in the buildings please contact:

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