District heating systems with low losses

District heating is a system that transfers and distributes heat from one or more heating plants to residential commercial and industrial consumers for space heating, hot water heating and industrial processes. A district heating system consists of heat production units, which could be a combination of heating-only plants, combined heat and power production plants, waste heat recovery plants, peaking and standby heat plants, primary heat distribution network, substations at the consumer connection points, end-users secondary networks and installations for space heating and domestic hot water.

The heat carrier in the heat distribution system can be either hot water or steam. The hot water in the distribution system can be generated in heating-only boiler plants, in combined heat and power production plants, from industrial waste heat recover, refuse incineration plants or sometimes from geothermal sources.

District heating is a natural solution for provision of heat in built-up areas. It helps keep the environment clean and increases housing comfort. District heating also helps conserve energy and the environment. This conservation is best realised in combined heat and power (CHP), which utilises 80–90 per cent of the energy value of fuel. When electricity is generated separately, the utilisation rate of fuel energy is a mere 40–50 per cent. Thanks to the efficiency of CHP, emissions to the environment are about 30 per cent less than in separate generation of electricity and heat (read more about CHP below). Heat is produced using a varied selection of fuels – natural gas, coal, peat, wood and waste wood, or oil – while also paying attention to overall economy and to the impact on the environment. Useable heat from industrial production can also be utilised for district heating

Heat supply

District heat is generated either together with electricity at combined heat and power plants (CHP) or solely as heat at heating plants. The temperature of district heating supply water varies depending on the country standards and weather, being for example 65-115° C. The temperature is at its highest in winter and lowest in summer, when heat is only needed for hot service water.

Heat distribution

District heat is transmitted from production plants to clients as hot water in a closed network consisting of two pipes (flow and return pipes). District heating pipes are laid in the ground, usually at a depth of 0.5 to 1 metre. The pipes have effective thermal insulation. On an average, heat losses in the distribution network account for less than 10 per cent of the energy transmitted in the pipes. Pump energy generally is in the order of x% of the heat transported.

The water circulating in the flow pipes releases its heat to clients via heat exchangers. The return pipe conveys the water back to the production plant for reheating. The temperature of return water from clients to the production plants ranges in best cases between 25 and 50 °C. The district heating water in general does not circulate in the space heating networks of buildings, but also direct connection variants to consumer equipment exist.

End users equipment

Clients receive the district heat in the substation, which includes the heat exchangers for heating and service water and possibly a heat exchanger also for air conditioning, control devices, pumps, expansion and safety equipment, thermometers and manometers and shut-off valves and energy metering. Substations are industrially manufactured units. Clients acquire their district heating equipment and the related installation work from heating contractors or, as comprehensive deliveries, from district heating suppliers. Heat is used in buildings for space heating, for providing hot tap water and for air conditioning. Also cooling of buildings by using district heating supply water in absorption chillers has been introduced lately.

Heat metering

The amount of heat consumed in the building is measured. The components of the heat meter are: a flow sensor, a temperature sensor pair, and a calculator. The flow sensor measures the volume of circulating district heating water. The temperature sensor pair constantly measures the temperatures of water going into the building and coming out of the building. Based on the readings of the flow sensor and the temperature sensor pair, the calculator calculates the thermal energy used for space heating and for hot service water. The calculator automatically takes into account the water density and specific heat corresponding to the temperature. The heat consumed is shown by the calculator as megawatt-hours (MWh).

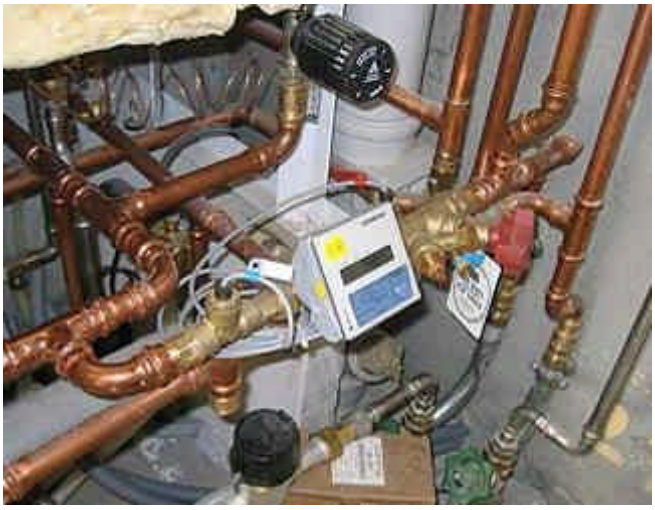

Fig.Metering device.

Reliability

Supply of district heat is very reliable (in Denmark, how about other countries?). On an average, in large DH-systems operation interruptions resulting from damages in the district heat network and the consequent repair work leave the individual client without heat as an average for only one hour a year. Thus, the reliability of supply in district heating is nearly 100%. District heating is also operation and maintenance free for clients – as the maintenance is included in the fee paid by the clients.

Potentials for development of district heating systems

Increased temperature difference/ low temperature systems: At low and medium load times a high temperature difference is desirable because it can save pumping

energy and in many cases can reduce distribution heat losses. Low return temperatures improve also operating conditions and efficiency of CHP.

Heat driven district cooling

In a cold climate there are in summer months plenty of heating capacity available in district heating systems, e.g. for heat-driven cooling. The research issues are how the present one stage water/LiBr absorption process is operated with low temperature district heat. Another problem is the hydraulic restriction of maximum water flow in existing district heating transmission pipelines. The heating demand at wintertime limits the cooling load produced by absorption chillers to about 20% of wintertime maximum load. In warm climate the annual electric power peak occurs in summer, partly due to electric air-conditioning and refrigeration. If a part of the air-conditioning cooling demand would be covered with heat driven cooling machines, the power peak would be shaved off.

Incorporation of solar energy storage

Solar district heating with short-term and seasonal storage have been introduced, mostly in Denmark and Germany. Short-term storage systems are used mainly for the preparation of hot water and able to store heat for one or two days. Therefore the solar fraction of the total heat demand is limited to about 10-20%. The so called week storage system has relatively large collector area per living area (4-10 m^2/m^2) (FK: what do you mean with m^2/m^2?)and projected solar fraction 30-40%. An innovative solar–district heating system called pulse heating has several buffer tanks connected to solar panels and district heating network. The buffer tanks are heated by solar energy with district heating as backup. One tank in turn is filled with hot DH-water as a pulse and other times the DH circuit is closed for reduced pipe losses. The first experiences call for remarkably reduced heat losses and 40-70% annual solar fraction.