Technology Statement

Content

Technology Statement

The main objective of the DemoUkrainaDH funding facility is to introduce and demonstrate modern energy efficient district heating technology and district heating system solutions in combination with the application of international practices for project preparation, design, procurement, implementation and follow-up for more energy efficient and sustainable district heating services. This is intended to be achieved by implementation of demonstration projects in a number of cities in Ukraine. Dissemination of experiences and results of demonstration projects could accelerate the adoption of state of the art district heating technology and design principles adapted to the Ukrainian context.

These technology and design principles are based on proven technology and applied already for more than 20 years in the Nordic countries and in Europe as a whole. The economic benefits of applying these principles are evident. Both investment and operation costs can be decreased substantially and energy efficiency can be increased significantly.

Below are guiding principles to be applied when selecting projects defined. These principles should be applied also during design and preparation of technical specifications, procurement and project implementation.

1 Heat Metering and Temperature Control

In order to improve quality of DH services, building-level heat meters should be installed with temperature controls in Individual Heating Substations (IHS). Temperature controls would allow DH utilities to better match heat supply to actual heat demand, thus improving efficiency of heat supply as well as production.

Temperature controls could also be at group substations, or centralised heat substations (CTPs), which control temperature for a group of buildings. In this case, the supply of heat to each building would depend on the average demand of the buildings connected to a CTP. The efficiency gains of this option would be more modest than for IHS'.

1.1 Individual Heating Substations

1.1.1 Technology

Only single stage substations should be used, preferably with brazed heat exchangers. Direct connection cannot be accepted, except at particular occasions for very small DH-systems.

Heat meters should be in accordance with EN1434. Connection possibilities to future SCADA systems are recommended.

Expansion vessels shall be of the closed type.

The energy efficiency index for pumps according the ErP directive must not exceed 0,23. Reserve pumps are normally not needed and should be avoided in general.

Fast acting control valves for Domestic Hot Water (DHW) should be used in case the hardness of the water is high. Differential pressure regulators should be avoided.

Manometers shall be of accuracy class 1.0. For accuracy reasons only one manometer should be used for as many measuring points as possible. Separate manometer for each measuring point should be avoided.

Automatic filling of feedwater should be avoided. In case feedwater is supplied with district heating water from the primary side to the building heating system a flow meter should be installed in the supply pipeline.

1.1.2 Design

The scheme of Individual Heating Substations should be as simple as possible. Additional shutoff valves etc. should be avoided.

Design and sizing of heat exchangers, control valves, pipelines etc. for space heating systems should be based on the current space heating load.

Design and sizing of heat exchangers, control valves etc. for DHW systems is recommended to be based on the formula presented in the **Euroheat Guidelines for District Heating Substations / Design of Individual Heating Systems** (see extract below), with addition of 10 % as safety margin.

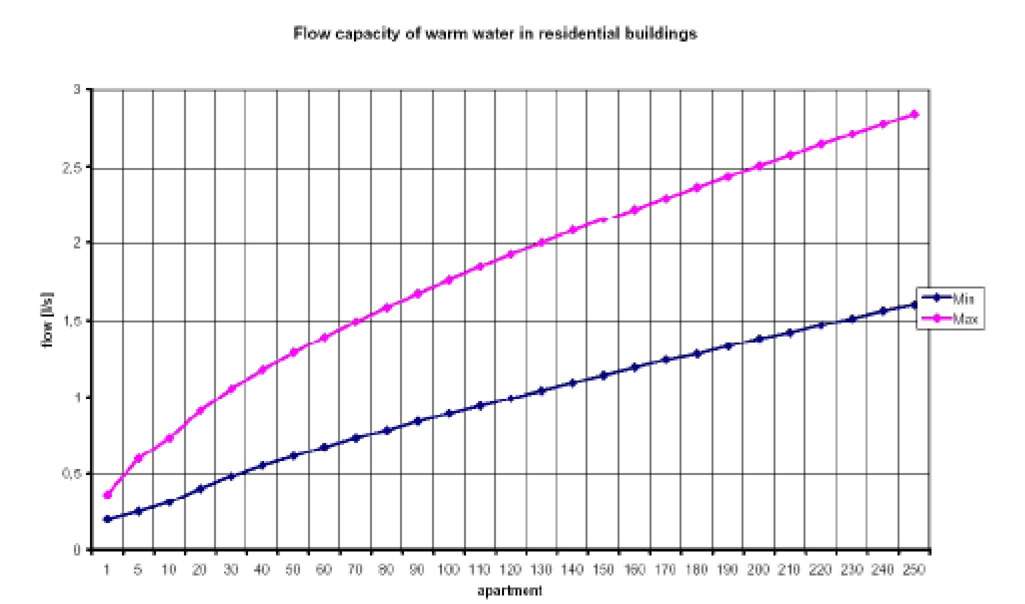
Neither current DHW load nor DHW load as defined in the old SniP or current DBN/DSTU-norms should be used as basis for design of new equipment.

Extract from Guidelines for District Heating Substations, Euroheat & Power October 2008

2.7.1. Determining flow capacities for domestic warm water

The formula below is recommended for nearly all existing residential buildings in Europe. The choice of flow is recommended in accordance with the dimension slopes below. There are a number of advantages in choosing adequate sized heat exchangers and the smallest possible valves.

Figure 4 Flow capacity for Domestic Warm Water for residential buildings



The two slopes represent the upper and lower flows that are currently used in Western and Northern Europe for dimensioning of flow demand in residential buildings. By striving to make dimensions closer to the lower line in Figure 4 above, one can obtain better economical and maintenance results for both substations, network and production. See chapter 2.7.2.

The different flows are originally calculated by the following formula:

$$q = q_m + O(n * Q_m - q_m) + A\sqrt{O * q_m}\sqrt{n * Q_m - q_m}$$

q = design flow rate [l/s] for n apartments

n = number of apartments

q_m = 0,15 = aggregated flow per apartment to determine heat exchanger data

Q_m = 0,20 = total maximum flow per apartment; may be increased if needed

O = 0,015 = probability of exceeding q_m

A = 2,1 = probability of exceeding q

The figures entered refer to the lower slope in the graph.

Capacities of heat exchangers in residential buildings should be calculated and determined on the basis of the following conditions:

Table 4

Number of apartments	Domestic warm water, l/s	Number of apartments	Domestic warm water, l/s	Number of apartments	Domestic warm water, l/s
1	0,20 - 0,36	80	0,78 - 1,58	170	1,24 - 2,30
5	0,25 - 0,60	90	0,84 - 1,67	180	1,28 - 2,37
10	0,31 - 0,73	100	0,89 - 1,76	190	1,33 - 2,44
20	0,40 - 0,91	110	0,94 - 1,84	200	1,38 - 2,51
30	0,48 - 1,05	120	0,99 - 1,92	210	1,42 - 2,57
40	0,55 - 1,18	130	1,04 - 2,00	220	1,47 - 2,64
50	0,61 - 1,29	140	1,09 - 2,08	230	1,51 - 2,71
60	0,67 - 1,39	150	1,14 - 2,15	240	1,56 - 2,77
70	0,73 - 1,49	160	1,19 - 2,22	250	1,60 - 2,84

Several conditions must occur or be present simultaneously before a shortage is likely to arise:

- a district heating supply temperature of less than the normal minimum °C;
- differential pressure lower than the design minimum differential pressure;
- a cold water temperature lower than 10°C;
- a temperature drop of more than 5°C between the heat exchanger and the tap;
- a warm water flow rate exceeding q (l/s) as used in the above calculation.

In addition, the domestic warm water and circulation piping has a smoothing effect on the domestic warm water temperature.

The required performance parameters for buildings with a recognised higher domestic warm water demand, such as non-residential buildings, can be different, and should be specified. High flow-rate tap water systems may be encountered in older buildings and allowance should be made for them when deciding on the necessary flow-rate capacity of the heat exchanger.
If the system supplies more than 250 apartments, the requirements should be checked using the formula above. In addition, it should be acknowledged that it is the heat exchanger for which this formula intends to provide design data: rules for determining design capacities of the domestic warm water system piping in the building(s) are set out in prEN 806-3; Requirements for Systems and Components Inside Buildings Conveying Water for Human Consumption - Part 3: Determining the Sizes of Tap Water Pipes.

The flows are valid for apartment buildings with more than five apartments. The 'single' apartment shown in Table 4 represents a detached house or an individual apartment district heating substation unit. In many places in Europe there are extensive residential areas with very big apartment buildings, some containing more than 500 apartments per building. In some cases there is no good domestic warm water circulation and this, and possible other circumstances, could demand higher flows than calculated.

Control valves should be selected based on the available pressure difference in the substation. The DH utility has to guarantee a pressure difference of at least 1 bar at the pipeline entrance to each building.

1.1.3 Eligible investments

Any investment that contributes to reduced heat consumption is eligible.

Exchange of cold water pipelines to larger dimensions when individual heating substations are introduced is as a rule not needed and consequently not eligible.

1.1.4 Procurement

Goods contracts are preferably used for procurement of individual heating substations, to attract the most qualified suppliers. The Supplier will carry responsibility for the proper function of the substation and execute commissioning. Installation and design work is preferably procured locally.

1.2 Central Heating Substations and 4-pipe systems

1.2.1 Technology

Central Heating Substations (CHS) and 4-pipe system are commonly used in Ukraine. Reconstruction and modernisation efforts should only be done for such systems when they are proven to be the least cost heating solution. This is normally only the case in cities with warmer climate, e.g. shorter heating seasons, typically areas in Southern Ukraine close to the Black Sea.

In case a CHS and 4-pipe system is not proven to be the significant least cost heating solution, conversion to individual substations should be implemented. For technology of the substation, see section 1.1.1. For pipelines, first consider using the existing pipeline for the space heating circuit. The current dimensions are in most cases sufficient or even some sizes too large.

In case CHS is proven to be the least cost heating solution, investments may include installation of:

1 Control valves in each connected building

2 Heat meters

3 Circulation pumps, including variable speed control.

4 Pipeline replacement, in particular the DHW pipelines

5 Modern heat exchangers

1.2.2 Design

For design and sizing of components, see section 1.1.2.

1.2.3 Eligible investments

Usually when the domestic hot water load is transferred to be supplied via the heating pipeline the existing branch pipelines are sufficient for the combined load. To make any replacement of existing district heating pipelines with larger dimensions eligible it has to be proven that the capacity of the existing pipeline is not sufficient, applying heat and DHW loads as indicated in section 1.1.2.

In case the domestic hot water will be prepared locally, the demand for cold water will increase.

Exchange of cold water pipelines to larger dimensions when individual heating substations are introduced is as a rule not needed and consequently not eligible.

1.2.4 Procurement

The same procurement principles should be applied for modernisation of central heating substations as for individual heating substations. For procurement of individual heat substations, see section 1.1.4.

2 District Heating Pipelines

The ability to meet the actual demand of each building coupled with rehabilitation of the distribution network may reduce building-level heat consumption by 15-25 %.

Installing IHS' may require replacing part of the distribution network, which in turn leads to reduced distribution losses. The cost of maintaining new distribution pipelines will be significantly lower than the cost of maintaining deteriorated pipelines.

2.1 Technology

For replacement of pipelines laid in the ground, **prefabricated bonded pipelines** fulfilling the requirements in the European standard EN253 should be used.

Prefabricated bonded pipelines

The bonded DH pipeline system means that the carrier steel pipe, the polyurethane foam insulation and the plastic casing pipe are bonded together.

The outer surface of the carrier pipe and the inner surface of the casing pipe are pretreated to ensure that the foam insulation adheres to the pipes, and that stresses can be transmitted through the insulation.
The elements of the bonded pipes expand and move together. The movements are restricted by the friction between surrounding soil and the casing pipe.

The mode of operation depends on the pipe laying method applied. For DemoUkrainaDH projects the heat pre- stressed pipe laying method is preferred from demonstration purposes.

The pipeline installations should preferably be designed as **heat-prestressed systems** in accordance with EN 13941 or using **cold laying** for small and medium sized pipes.

Heat-prestressed District Heating system

Since the introduction of District Heating (DH) there has been a development in the distribution technology. The development can be divided into three generations:

1st generation: Steam pipes in ducts

2nd generation: Water pipes in ducts

3rd generation: Directly buried pre-isolated pipes

The 3rd generation DH-network consists of a steel carrier pipe, thermal insulation (polyurethane) and a plastic jacket pipe. The pipes are all bonded, which means that the isolation is bonded (connected) both to the carrier pipe and to the jacket pipe. The elements of the bonded pipes expand and move together. The movements are restricted by the friction between soil and jacket pipe. A district heating network using all bonded pre-insulated steel pipes the network can be built without compensators and fix point arrangements and no chambers for valves are needed.

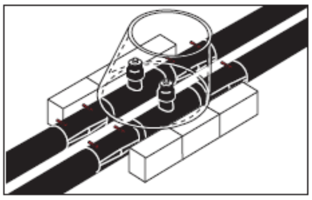
In a modern DH system all components, including valves, are directly buried in the ground.

Survey

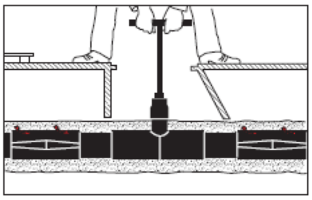
Isolation valves are installed as a part of the pipe system at any required point on the pipe run.
Consequently, expensive, special concrete chambers are not necessary.

Installation

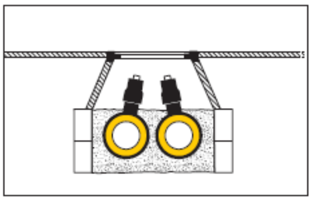
The simplest way to make access chamber to the valves is to place a concrete chamber on two rows of foundation bricks.



This ensures the free expansion of the pipes and the spindle tops are kept free of sand.



The method shown can also be used for major dimensions, provided that the spindles are tilted to enable operation from the chamber opening.



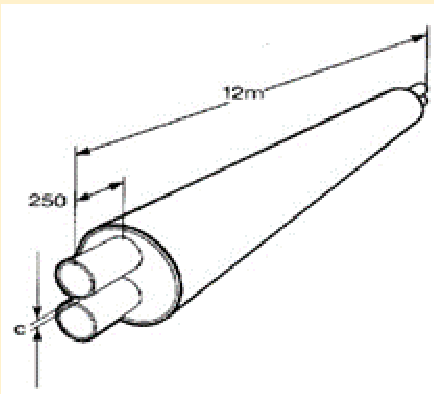
Example of pre-insulated valves buried directly in the ground with access from street level.

When constructing a heat-prestressed DH-network the pipes are pre-heated to a temperature (preheating temperature) between the installation temperature and the normal operating temperature in open ducts before filling. By this procedure the pipeline is expanded before filling and the pipeline will be fixed by friction forces caused by the soil. Further thermal expansion and contraction of the DH pipes will only take place in bends without unacceptable stress achieved.

The regulation of design and installation of preinsulated bonded pipe systems for district heating is described in the European standard EN 13941:2009.

For smaller pipe dimensions, **twin pipes** are recommended, fulfilling the requirements of the European standard EN 15698.

Twin Pipes



The twin pipe system means that two carrier pipes are placed in one casing pipe with polyurethane foam insulation. The two carrier pipes are fixed together with fix plates and move as a whole. All pipe section ends are provided with fix plates designed for temperature variations between the two carrier pipes of typically maximum 90 °C.

The heat loss from a twin pipe is typically 30 % lower than from a pair of pipes of same dimensions. In a twin pipe system the two carrier pipes are placed over one another, the upper being the return pipe.

A twin pipe does not require the same trench width as a pair of pipes, and only half as many joint installations, resulting in considerable savings in construction costs.

The heat pre-stressed laying method is with advantage used for twin pipes.

Flexible piping systems can preferably be used, e.g. in 4-pipe systems. Flexible pipelines should fulfil the demands of EN 15632.

Flexible Piping systems

Flexible pipe systems can be used for complete minor distribution networks and as branch pipelines in bigger systems. Flexible pipe systems are available with carrier pipes in different materials depending on purpose. Steel flexible systems are used for district heating systems up to 130 °C, plastic (PEX – Cross-linked polyethylene) flexible systems are used for low temperature district heating systems and for domestic hot water, copper flexible systems can be used for domestic hot water.

Steel flexible systems for district heating offers a wide range of advantages enabling significant savings during installation. The pipes are available in long coils, which means only a few joints are necessary and installation time is short. The pipes can be placed on top of one another, which mean that only a narrow trench is required. Rapid laying and installation of the pipes, combined with continuous subsequent covering of the trench allow quick reinstatement and a minimum of inconvenience.

Steel flexible systems can be laid as a non-compensated system without being stress overloaded regardless of the length. However, it may be proven necessary to reduce the stresses at the connection to main pipelines if the flexible pipe is welded directly to the main pipe. It is possible to reduce the stresses by curves and bends in order to absorb the expansion.

2.2 Design

Pipelines shall not be replaced using the same dimensions without performing a supporting pressure drop calculation. Normally, a pressure drop of 1 mbar/m is suitable for all pipelines except branches, where higher pressure drops can be accepted. The same principle for heat loads as presented for district heating substations according to chapter 1 must be used, including considerations of coincidence factors.

Insulations thickness shall be selected using **Life Cycle Cost calculations**, taking current and future fuel prices into account. Normally, this means that **insulation thickness according to Series 2 or Series 3** should be used.

Life Cycle Cost calculations

LCC is a valuable financial approach for evaluating and comparing different pipe designs in terms of initial cost increases against operational cost benefits with a long-term perspective. The key incentive for applying an LCC analysis is to increase the possibility of cost reductions for the operational phase, even if an additional increase in the initial investment is necessary. LCC is defined as "a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors, both in terms of initial costs and future operational costs" (Standardised Method of Life Cycle Costing for Construction Procurement ISO15686, 2008). The initial additional investment for a higher insulation thickness should be compared with the benefit streams from lower heat losses during the life expectancy of the pipe network, 30-50 years life expectancy is recommended to use. The heat losses are valued with the marginal energy generation cost for each part of the year, e.g. if a biomass boiler is used as base load, the variable generation cost for biomass during the part of year when only this boiler is operated. For the rest of the year the variable cost of e.g. the gas boiler used for peak load purposes should be used.

Insulation thickness according to Series 2 or Series 3

The EN pipe standard does not specify insulation thickness. Instead it is the dimensions of the jacket pipe that is standardised. Series 2 and Series 3 are trade marks of different pipe manufacturers. If a pipe with the nominal diameter of 100 is chosen, the Ukrainian DSTU standard prescribes a jacket pipe with diameter 200. A Series 2 pipe has instead diameter 225 and Series 3 has diameter 250.

In case the domestic hot water will be prepared locally, the demand for cold water will increase. Exchange of cold water pipelines to larger dimensions when individual heating substations are introduced is as a rule not needed and consequently not eligible.

For branch pipelines, higher relative pressure losses are accepted, up to 8 mbar/m in order to avoid cooling of water in pipelines when there is no heat and/or DHW load. Thus faster delivery of DHW can be ensured, without extensively draining the taps.

2.3 Eligible investments

Pre-insulated preheated district heating pipelines are installed without ducts or chambers. Anchors or compensators could be allowed only in extraordinary cases.

The use of sectioning valves should be minimised, so also the number of bends.

2.4 Procurement

Procurement of district heating pipelines is recommended to be performed as Goods contracts including design review and supervision as additional services.

Installation and civil works are advantageously either procured locally or performed in-house by the DH utility.

3 Boilers and Boiler Plant Rehabilitation

Rehabilitation of boiler plants should be considered only when it can be proven that the boiler plant is part of medium/long term least cost heating solution for the DH utility.

3.1 Technology

Typical investments to include:

1. Burner replacement
2. Economiser installation
3. Boiler replacement
4. Pump replacement and/or installation of Variable-Frequency Drive (VFD)
5. Water treatment improvements

New boilers shall fulfil the Best Available Technology (BAT) requirements.

Conversion from gas, oil or coal to renewable fuels is a preferred investment. Suitable renewable fuels can be wood residues, agricultural residues or different kinds of fuel pellets. Alternative investments in boilers and other equipment for renewable fuels have to be carefully considered and deemed not to be feasible, to allow for investments in equipment for use of fossil fuels.

Emission demands should at least apply to Ukrainian environmental norms and regulations.

3.2 Design

The heat generation capacity of new boilers should be adapted to the connected heat load after implementation of demand side measures, including heat metering and temperature control.

The heat generation capacity from biomass boilers should be selected for best profitability considering the fuel supply options. Generally this means a boiler capacity of 40-50% of the maximum connected heat load, corresponding to approx. 85% of the annual heating energy supply.

Investments in fossil fuel equipment shall be designed, where reasonable from a technical and cost perspective, to be able to be converted for future use of renewable fuels, so as to avoid lock-in effects.

3.3 Eligible investments

Investments in biomass boilers may include a gas fired boiler for peak load operation.

3.4 Procurement

Only Supply and Install contracts should be used for procurement of boilers.

4 Installations for Combined Heat and Power (CHP) production units

Installation of combined heat and power units could increase the efficiency of heat production in certain applications.

4.1 Technology

Typically, two types of CHP plants can be of interest for the actual size of district heating networks:

Gas engines

Small scale biomass CHP, possibly based on Organic Rankine Cycle (ORC) technology

Equipment for renewable fuels have to be carefully considered and deemed not to be feasible, to allow for investments in equipment for use of fossil fuels.

4.2 Design

Sizing of CHP plants have to be considered individually for each project.

Investments in fossil fuel equipment shall be designed, where reasonable from a technological and cost perspective, to be able to be converted for future use of renewable fuels, so as to avoid lock-in effects

4.3 Eligible investments

Connections to electricity grid may be included.

4.4 Procurement

Only Supply and Install contracts should be used for procurement of CHP installations.