RELaTED

D2.6 – Transition schemes for DH in operation

Date: 2019/10/09

Version: 2.2

Deliverable	D2.6
Name	Low temperature concepts
Website	www.RELaTEDproject.eu
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768567

PROJECT SUMMARY

Project Acronym	RELaTED
Project Title	REnewable Low TEmperature District
Project Coordinator	Roberto Garay. TECNALIA roberto.garay@tecnalia.com
Starting date	2017/11/01
Duration in months	48
Topic	EE-04-2016-2017 New heating and cooling solutions using low grade sources of thermal energy

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DOCUMENT HISTORY

Work Package	WP 2 – System Architectures		
WP Lead	Danish Technological Institute		
Deliverable	D2.6 Transition schemes for DH in operation		
Date	2019/05/29		
Due date	2019/04/30		
Status	Released		
Date	**Version**	**Person/Partner**	**Comments**
2017/12/01	0.1	R. Garay (TECNALIA)	Template
2019/03/12	1.0	M.K. Pedersen (DTI)	List of content
2019/03/12	1.1	L. VLADIC (BeoElek)	First draft
2019/04/24	1.2-1.8	L. VLADIC (BeoElek) M.K. Pedersen (DTI)	Various revisions
2019/05/03	1.9	L. VLADIC (BeoElek) M.K. Pedersen (DTI) C. H. Christiansen (DTI)	Final Draft
2019/05/29	2.0	L. VLADIC (BeoElek) M.K. Pedersen (DTI) C. H. Christiansen (DTI)	Final version
2019/06/11	2.1	L. VLADIC (BeoElek) M.K. Pedersen (DTI) C. H. Christiansen (DTI)	Incomplete sections updated
2019/10/09	2.2	M.K. Pedersen (DTI)	Update after internal review.

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ABOUT RELATED

RELaTED is a joint initiative of 14 industrial companies and research institutes across from various countries in Europe, aimed at pushing forward Low Temperature District Heating networks with increased use of Renewable Energy Sources.

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DE-CARBONISING DISTRICT HEATING SYSTEMS

District heating (DH) systems are one of the most energy efficient heating systems in urban environments, with proven reliability within many decades already. DHs are identified as key systems to achieve the de-carbonization of heating energy in European Cities.

Renewable and waste heat sources are foreseen at the same time as de-carbonized heat sources and the way to guarantee competitive energy costs with limited influence of fossil fuel supply price volatility. To achieve this, a transition is needed in DHs, comprising not only measures to improve overall performance (temperature level reductions, improvement of substations, etc.), but to guarantee system viability as a whole in a context of reduced heat loads with the transition to NZEB (Near Zero Energy Buildings).

RELaTED deploys a decentralized, Ultra-Low Temperature (ULT) DH network concept, which allows for the incorporation of low-grade heat sources with minimal constraints, larger shares of renewable energy sources (RES) and distributed heat sources. ULT DH reduces operational costs due to fewer heat losses, better energy performance of heat generation plants and extensive use of de-carbonized energy sources at low marginal costs.

In the transition towards NZEB and PEH (plus energy houses), RELaTED allows for a prosumer scheme, where positive buildings deliver energy to the grid.

LIMITATIONS OF CURRENT DH NETWORKS

DH systems were designed many decades ago. In most cases, they are designed and operated to distribute heat at about 80 °C to consumers. Their capacity to reduce operational temperatures is related to radiator capacity to deliver sufficient heat to meet comfortable temperatures in buildings and to allow for the safe preparation of domestic hot water (DHW) preparation. DHW limits potential temperature reductions due to the need to avoid legionella-related issues. Depending on specific national regulations, storage temperatures in the range of 55-75 ºC are prescribed.

OVERALL RELATED CONCEPT

RELaTED pursues the development of DH networks with service temperature levels as low as 40-50 ºC. In many alternatives, traditional DHW preparation methods are substituted by "innovative methods". In these concepts, mains water is primarily heated by the DH, and then complemented by electric heaters/boosters up to the required temperature levels. In more advanced alternatives, heat pumps are used for such purposes.

In RELaTED every single building is converted into an energy node, where so-called triple function substations (3FS) allow for bi-directional heat exchange between the building and the network, with the additional functionality of grid injection of excess local solar heat. In fact, adaptations are made to Building Integrated Solar Thermal (BIST) systems to adapt them to Low Temperature (BILTST), with reduced local storage, as the connection to the DH makes it redundant.

Additionally, District-heating connected Reversible Heat Pump systems (DHRHP) allow for recovery of exhaust heat from cooling applications (e.g. air conditioning, ventilation, etc.).

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ULT DH

Even before the consideration of further technological improvements, ULT temperature levels substantially improve the performance of heat production systems. Furthermore, ULT allows for the integration of virtually any waste heat source from industry, sewage, etc.

RELaTED builds atop of the existing trend for integration of large solar thermal plants systems in DH networks, some of them comprising large seasonal storage systems. RELaTED incorporates large ST plants, but also provides the framework for the integration of BIST into the main ULT DH concept.

With lower fluid temperature when compared with regular BILST integration levels, performance levels are expected to rise by 20%, due to lower heat loses. An additional 80% rise is calculated when avoiding local storage due to direct DH connection. The RELaTED ULT network acting as a perfect heat sink avoids storage stagnation situations, thus allowing for larger ST performance levels.

DHRHP systems allow for the de-coupling of temperature levels in DH network and building level HVAC systems. With the DH as heat source, stable temperatures at 35-40 ºC ensure stable COP levels of 6-7 for the DHRHP all-year-round. These units provide an economic way for the preparation of DHW, while at the same time allowing for the connection of buildings with higher temperatures in their HVAC design (i.e. older buildings).

The RELaTED concept, when implemented with a substantial share of RES provides a robust framework to ensure the economic viability of DH networks, in the context of the transition of the building stock to NZEB along the following decades.

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Acronyms

3FS	Triple-function substation
BILTST	Building Integrated Low-Temperature Solar Thermal System
CHP	Combined Heat and Power
DCS	District Cooling System 10/15 °C
DER	Distributed Energy Resources
DH	District heating
DHRHP	District Heating Reversible Heat Pump
DHW	Domestic Hot Water
EC	European Commission
H2020	Horizon 2020 EU Research and Innovation programme
HT	DH High Temperature 100/50 °C
LT	DH Low Temperature 80/40 °C
NZEB	Nearly Zero Energy Buildings
PM	Project manager
RELaTED	Renewable Low Temperature District
RES	Renewable Energy Sources
TL	Task Leader
ULT	DH Ultra Low Temperature 45/30 °C
VLT	DH Very Low Temperature 60/30 °C
WP	Work Package
WPL	Work Package Leader

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1. Executive summary

In RELaTED Task 2.6 a set of guidelines were developed for how the low temperature concepts can be applied for operational high temperature district heating networks. This report (D2.6) is one of various RELaTED reports describing low temperature concepts from different perspectives. The report refers to other RELaTED reports when relevant.

The guidelines of this report are in general terms, based on best practice as most DH networks are different in relation to visions, DH network topology, temperature levels, building installations, tariff structure, management etc. In Annex 1 an example from Belgrade is used to illustrate and detail some of the paragraphs of the report.

The guidelines are concerning the following topics:

Strategic and integrated energy planning covers the vision for the transition process and the strategy of how to implement it. It also covers the integration in the existing system.

For the DH supplier the economy focus is on investments, operation expenses and how this compares to the possible income from heat sales. From the customers point of view the focus might be related to the total energy cost and how it affects the customers economy after the transition compared to before.

Different types of temperature reduction measures at network sectioning's are described based on a centralized DH network topology.

The scenarios for how the transition will roll out over a longer period of time including change in energy demand and potential new energy resources are studied. Pros and cons regarding temperature levels of the network in transition and how it affects the changes of building installations and heat loss in the network are discussed.

The implementing measures involves how the delivery conditions as well as the technical building systems specifications are defined and how building renovation regulation can influence on this process.

Operation and management cover how the operation and the management of the system is handled in the transition process and afterwards.

The guidelines will be used in the succeeding work packages of RELaTED to investigate further the architecture of the ULT concept (WP2), design and

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adaption of subsystems to facilitate the use of distributed energy resources (WP3), analyse the economic feasibility and business case (WP4) and prepare and conduct demonstrations (WP5), of the RELaTED project.

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2. Introduction

This deliverable will report on the activity carried out under RELaTED Task 2.5. It will define the RELaTED Development Schemes for new DH developments in new urban environments. This report is part of a set of reports that define the system architecture of the RELaTED concept. The reports are:

- D.2.1 Low temperature concepts
- D.2.2 Interconnection schemes for consumer installations
- D.2.3 Interconnection schemes for producer installations
- D.2.4 Energy flexibility and district heating control
- D.2.5 Development schemes for new DH developments
- **D.2.6 Transition schemes for district heating in operation**

2.1. Objective

The objective of task 2.6 is to develop a set of guidelines for transition to low temperature district heating for DH in operation. The Guidelines will focus on energy planning and economy, Network topology, Scenarios for timeline and energy sources, necessary measures for implementation, project developments and operation and management.

2.2. Methodology

To carry out task 2.6 the available information about the transition process done in various existing DH networks was studied and used as background knowledge for the subjects covered in this report. A case from the DH supplier BEOELEK in Belgrade was used as an example for some of the topics covered in the report

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2.3. Report content

The content of this report is sectioned as follow:

1. Executive summary: Contains a summary of the report.

2. Introduction: Introduces the report, the objective and the methodology

3. Development schemes for transition to low temperature district heating for DH in operation: Guidelines regarding Strategic and integrated energy planning, Economy, Topology, Scenarios, implementing measures, project developments and operation and management.

Some of the contents in this report relies information already outlined in the reports: D.2.1 Low temperature concepts, D.2.2 Interconnection schemes for consumer installations and D.2.3 Interconnection schemes for producer installations. In these cases, the subject is briefly described in this report and referenced to the relevant report for more information.

Annex 1 presents the practical implementation of the transition schemes in the DH network in Belgrade.

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3. Development schemes for new district heating development areas

3.1. Strategic and integrated energy planning

3.1.1. Vision

Transition of an older system to an ULT system will typically be based on or linked to a vision. Such a vision could be on global, national, regional or local level. On local level ULT DH can support visions on for instance sustainable living, use of local heat sources and clean air. In the wider scope, ULT DH can support visions on reducing CO_2-emissions, phasing out fossil fuels and other climate related visions including the European Commission's long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050 – A Clean Planet for All. Source: A Clean planet for all, 2018 [1].

3.1.2. Strategy

The realization of a vision needs a strategy. Strategic energy planning is used on municipality, regional or national level to plan the most viable way to supply and use energy over a longer time horizon. Source: Strategic energy planning at municipal and regional level, 2015 [2], Regulation and planning of district heating in Denmark, 2017 [3], Varmeplan Danmark [4].

In a district heating transition scheme, the focus will typically be on long term planning and optimisation of:

- Heat supply and production
- Operational supply temperature
- Transmission and distribution networks
- Building substation designs

The planning could also include electricity, transport and cooling. Taking this holistic approach different synergies and scenarios can be identified and analysed across traditional boundaries paving the way for the optimal solution for the society. ULT DH can in this respect provide energy efficient solutions for integrating surplus heat and renewables in the energy system including provide

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flexibility through thermal storage. An important part of the strategic plan will be to identify potential surplus heat and renewable energy sources.

3.1.3. Integration

The idea of integrated energy planning is that energy supply, energy infrastructure and final use of energy are prioritised in the overall planning process of a city or existing district area along with other infrastructure and objectives. In planning ULT DH transition it is very important that energy is integrated from the beginning of the planning to make sure the special requirements according to the low temperatures are taking into considerations. Also, area reservations for renewable energy sources as for instance solar thermal panels, geothermal heat or heat pumps must be included. In this respect, the transition of an older system to ULT does not differ significantly from that of a new development area.

Integration of lower temperature levels might be done only for a part of an existing DH network (subnetwork) where user installations are estimated to work with these temperature levels, while the rest of the network will keep the existing temperature levels to ensure proper operation.

In the subnetwork the temperature levels can then be lowered to the point where the user installations capacity will be just sufficient. This can include gradual lowering of the temperature over a longer time period to gain experience that can be used for other subnetworks.

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3.2. Economy

The economy of transition to ULT DH in an existing network must be economical attractive for the company operating the scheme and for the customers.

3.2.1. Company

the ULT scheme for a transition area must be studied thoroughly to identify the investment costs, operating expenses and income from heat sales. How is the Internal return on investment for the company in relation to make the necessary investments, changes in operation costs and perhaps lowered income from heat sales because of substitutions with electric boosting of the temperature levels for DHW production at the consumers etc. Lowering of the temperature levels should still be a feasible business for the DH operator.

3.2.2. Customer

For the customer the transition must be economical beneficial especially if the customers heating and DHW installation has to be changed in order to adapt to a lower supply temperature. If an energy boost is needed to heat the DHW the customer might expect to be compensated for the use of electricity for this. From the customers point of view the price for DH should be reflected in the higher investment in equipment and the use of electricity for DHW boosting.

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3.3. DH network topology

The topology for an existing DH network will in most cases be centralized. Lowering the temperature might be done for smaller parts of the network by dividing it into a subnetwork in order to ensure the operation of user installations in other parts of the network and concentrate on the chosen subentwork. In order to lower the temperature in the subnetwork, some sort of sectioning of the chosen subnets with a mixing loop or a temperature optimisation unit is needed.

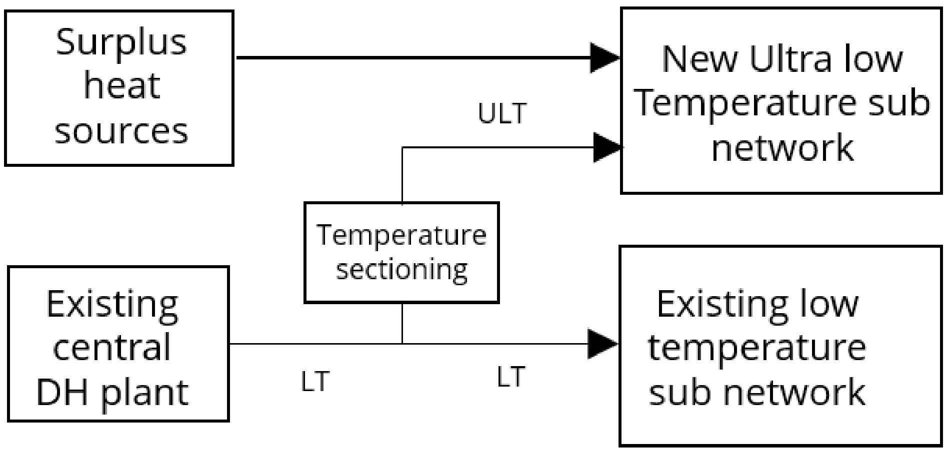

Figure 1 Temperature sectioning for a new ultra-low temperature subnetwork in an existing low temperature network

The sectioning can be done in many ways. Three possible solutions for temperature sectioning of subnets are sketched in figure 2 below.

1. Classic mixing loop. The solution makes the subnetwork pressure independent by having a dedicated pump for the subnetwork, and at the same time it is possible to limit the pressure from the main network with the control valve.

2. Free flow solution. The solution makes the subnetwork pressure independent by having a dedicated pump for the subnetwork and has no pressure loss in control valves because of the use of a shunt pump..

3. Shunt solution. This solutions is dependent on the pressure in the upstream network as there is no dedicated pump for the subnetwork. This also means there is now way of adjusting the

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pressure in the subnetwork. Because the solution only has a shunt pump it is the most cost-efficient solution

Source: Optimize your network with low temperature zones in district heating, 2018 [5]

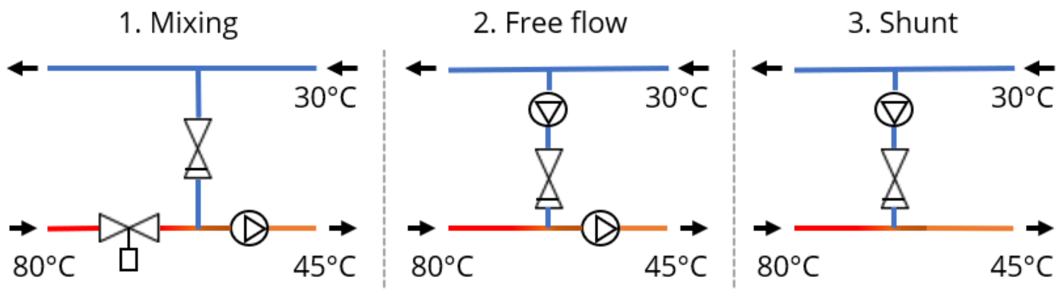

Figure 2 Principle of three possible solutions for temperature sectioning

Another possibility is to use the return water from the main network with a higher operation temperature than the subnetwork. If the return temperature from the main network is not sufficient it can be mixed with supply water by use of a threeway valve to adjust the supply temperature in the subnetwork. In figure 3 the principle of such a solution for using return water with the possibility to mix with supply water is sketched

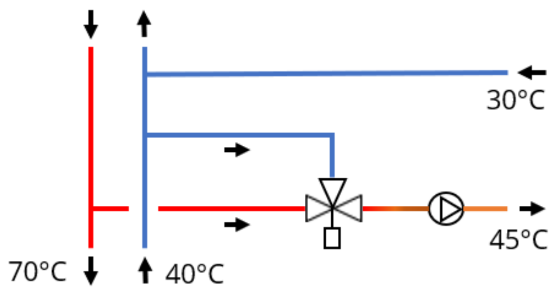

Figure 3 principle for use of return water

Connection of decentralized surplus heat sources might call for some measures in the network to adapt to this. With the use of a mixing loop pictured in figure 2 backflow in the supply line can be prevented with the control valve if the system temperature is sufficient. Another way to prevent backflow is to have pump system for injection with pressure control in relation to the actual system pressure.

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For more info about connection of surplus heat sources see RELaTED report D2.3 section 6

3.4. Scenarios

3.4.1. Time period

An important part of the planning process is the time period for how long it will take to lower the temperature in the area. User installations not suited for the lower temperature levels has to be identified and a plan for how to ensure operation of these installations has to be made. When the temperature actually is lowered some heating installations might not be still be problematic because of control issues or other unforeseen factors. Therefore, it will not be wise to lower the temperature at once but rather do it in small steps to avoid a lot of complaints that might lead to raise the temperature again. Because of that, the plan of ULT DH transition must be flexible and robust to take into account that the planned savings might take long time to reach.

3.4.2. Energy demand

The energy demand might be lowered due to the reduction in heat loss from the network and the reduced use of energy for DHW production due to the use of electricity for boosting. The energy reduction in relation to DHW production will mostly affect the peak load. Reduction of the energy demand for heating of buildings may happen over time due to renovation of buildings but cannot be forced as it depends on the building owners.

3.4.3. Mapping of energy resources

Lowering the temperature levels may open for use of local energy source(s) for example surplus heat from local industry or local BILST systems. For buildings with combined consumption and production of heat the connection to the DH network could be via an 3FS substation. Info regarding conditions for heat delivery to a DH network see section 3.5. For more info regarding Energy resources and connection to the DH network see RELaTED D2.1 report section 4.5 and 4.6 and RELaTED D2.3 report section 3.

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3.4.4. Operational temperatures

A decision about which operational temperatures the new network should operate at have to be taken. It could be low temperature 60-30 °C or ultra-low temperature (ULT) 45-30 °C or another temperature regime suited the area. Where 60-30 °C will typically work without temperature boosting of the DHW, 45-30 °C will need the boosting but have a smaller heat loss in the network.

Some of these consequences of the choices are discussed in the following paragraphs.

For more info about operation temperature definitions see the RELaTED D2.1 report section 3.1 and for analyses of different temperature schemes see RELaTED D2.1section 5.6

3.4.5. Design of building installations

The design of the existing user installations should be considered in relation to the choice of operational temperatures. If ULT is chosen, the end user installation might will have to be updated in order to boost the supply temperature for DHW production facility and heat emitters dependent on the type.

If the supply temperature is lowered to ULT levels most DHW installations will not have the necessary capacity to deliver sufficient DHW temperatures. At higher temperature levels like LT a calculation of the existing DHW equipment could be made, if the specifications are available, to check if it could be used at these temperature levels or if other measures have to be taken. It will typically be the sizes of heat exchangers, control valves and pumps that has to be examined.

Of course, if to many parts of the substation has to be retrofitted and automatic systems has to be rewired it might be more economical beneficial to exchange the whole substation with a new one.

Some of the possible options for upgrading existing DHW installations with boosting in single dwellings could be:

1. DH for space heating. DH for preheating of DHW supplied with instantaneous electric heating for heating the DHW to a sufficient temperature, see RELaTED D2.1 and D2.2 reports
2. DH for space heating. DH for preheating of DHW storage tank and direct electric booster in the DHW storage tank

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3. DH for space heating. DH for preheating of DHW supplied with a microbooster for heating the DHW to a sufficient temperature. The microbooster concept is described in the RELaTED D2.1 and D2.2 reports.

4. DH for space heating. Heat pump in a ventilation unit with storage tank for heating of DHW with or without DH supplement.

Where solution 1, 2 and 3 and for some parts solution 4 will result in some DH sales in the summer period, solution 4 without DH supplement will not as all DHW is produced only by electricity. This should be considered in relation to how the operation of the DH system will be in the summer months. Solution 2 will result in the highest DH sale in the summer because of the Microboosters use of DH as a heat source for the integrated heat pump. If solution 4 without DH supplement is chosen for the whole transition area, it could be possible to shut down the DH network in this area in the summer. Of course, this will result in no heat sales in this period plus the incitement for use of surplus heat sources will be lower especially solar heating.

For buildings where the heat emitters are floor heating the transition should for most parts not be a problem since these systems already operates at temperatures at around 30-40 °C.

For radiator systems sometimes there might be enough capacity to reuse them in an LT or even an ULT systems, but that might depend type and whether they are oversized. Calculations or testing of the heat capacity at these temperature levels might show whether or not this could be a possibility.

For larger installations in apartment buildings where neither the heat emitters nor the DHW production can operate at ULT temperatures an option could be to integrate an DHRHP HEAT pump for general temperature boosting. This way all connected systems in the building can work at for example LT temperatures or higher like before the transition while the network operates at ULT temperatures.

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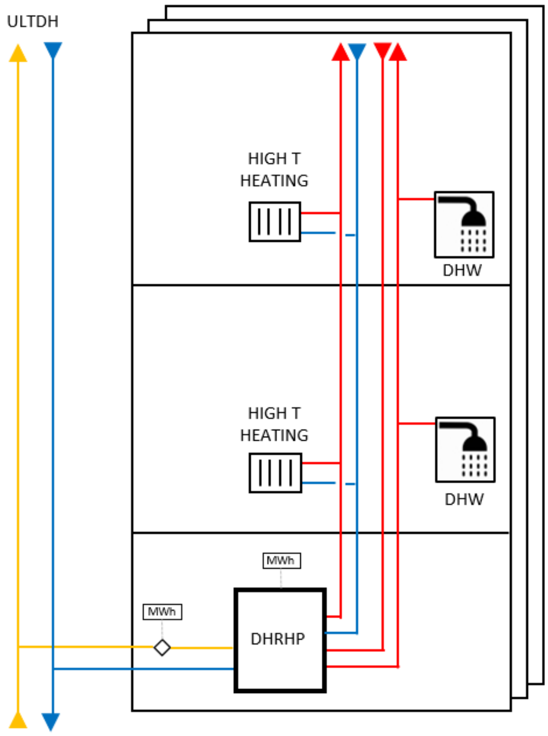

Figure 4 example of use of DHRHP heat pump for general temperature boosting in apartment building

There has to be some rules about which possible solution can be chosen in order to prevent an inefficient system with a lot of heat wasted on heat loss for only supplying few consumers in the summer month.. In case the solutions are mixed, the full advantage of the different systems cannot be achieved.

For more information about the possible designs of user installations see RELaTED D2.2 report section 6.

3.4.6. Heat loss

In relation to the above paragraphs regarding operational temperatures and design it's worth noticing that the heat loss of the DH network will lower because of the lowered temperature, but the heat loss share of the total energy consumption might be higher in the summer months due to the lower energy consumption for DHW production because of electric boosting.

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3.4.7. Overall evaluation

An overall evaluation of different scenarios including the above paragraphs regarding, time, energy demand, energy resources, operational temperatures, design, and heat loss could give the necessary input to choose the solution for the area in relation to economy and energy. As part of this evaluation the economy for company and customer should be calculated for the scenarios, see section 3.2.

3.5. Implementing measures

Implementing measures are specifications and requirements that must be met to get a well-functioning and fair ULT DH system. The DH supplier should specify and make the delivery conditions and technical building system specifications public available for the customers as well as conditions for heat sales to the DH network. A change in tariff structure must be in place before the transition begins.

3.5.1. Delivery conditions for consumers

Changes in delivery conditions due to lowered temperatures might be necessary to make years in advance to ensure that renovation of existing installations is ready for when the temperature is lowered. The Delivery conditions must as minimum specify the boundaries between the supplier and the customer, the supply temperature and pressure difference the customer can expect and specifics for meters (placement, power supply etc.)

3.5.2. Technical building systems specifications

The technical building systems specifications must specify more specific requirements for the installed building systems i.e. substation unit DHW production equipment and heat emitters. This could be requirements for how much the return water must be cooled down in the DHW production and the heat emitters respectively. For DHW production the requirements for the supply temperature could be lower than the general temperature in order to ensure proper operation in the summer where the flow in the network is very low and it's harder to keep a sufficient supply temperature at the customer.

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3.5.3. Building regulation integration

For every new building, the energy performance must be calculated as a result of the EPBD and meet a certain level of performance. When ULT DH or DH in general are proposed transition areas it should be investigated how these concepts are accounted for in the EPBD calculations. Experience have shown that the definition of primary energy factors for DH and electricity can have a large impact on the result.

3.5.4. Conditions for heat purchases

Conditions for heat sales may consist of a pricing model that might be based on several factors like temperatures, quality (temperature variations), demand, time of the year etc. For more info regarding pricing models for heat sales see RELaTED report D2.3 section 4.2.

If the heat purchases will be based on smart metering the conditions have to state under which circumstances heat purchases can be expected.

Other that there might be requirements for a minimum temperature for heat injected into the supply line and/or a maximum temperature for heat injected into the return line. For networks based on power plants with flue gas condensation injection to the return line might be problematic due to low temperature requirements for the flue gas condensation to work efficiently. Injection of heat into either the supply might require some local pump capacity to overcome the pressure in the DH network. The conditions must state requirements pressure control in order to ensure proper operation of the network.

For more info regarding barriers and solution related to heat purchases see RELaTED report D2.3 section 4 and 5.

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3.5.5. Infrastructure investment model

The infrastructure investment model of the transition from traditional DH to ULT DH will in most cases be different from the approaches taking in a new development area.

Investments in heat supply and production as well as distribution and transmission network can be seen as part of the general and running investments in the existing scheme.

Though, for renewal of piping systems costs linked directly to lowering of the temperature may be considered. Such costs can relate to increased capacity or insulation requirements of the piping system. In case of ULT DH, pipes in other materials (plastics) and with less insulation may be options that reduce investments. Source: Demonstration in Soenderby, EUDP 2010-II, 2014 [7] Distribution heat losses for ULT DH and less insulation can be on par with traditional temperature DH and better insultation, resulting in comparable operating expenses but less investments. Investment in better insulation, on the other hand, reduces the operating expenses. Case-by-case calculations should be performed. The investment in additional capacity, is normally taking into consideration in the design phase of renewal of piping systems. Additional capacity investment may be considered when future expansion of the district is planned or in case of reduced temperature will result in higher flows and pressure losses. For existing piping systems with remaining lifetime, additional capacity may already be available due to over-dimensioning, as-built originally or due to already realized refurbishment of buildings resulting in lower heat demand. In these cases, no additional investments in piping systems are required.

Equipment for temperature sectioning might be a requisite for lowering of the temperature in a part of a DH network. The investment in this equipment might also be seen as a running cost but could also be financed through the heat loss savings.

Investments in renewal of building installations e.g. substations and space heating systems will typically be the building owner's responsibility. The technical building system requirements from the DH supplier and the local building regulation rules ensures that new equipment should be ready for a lowered temperature in the system. In most cases however renewal of building installations will not be done before the equipment has reached end of life or is defunct. A temperature level transition process will therefore depend on a critical mass of building installations being renewed before the transition process start

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or might require economic incentives for the building owners to renew their installations. These economic incentives could for example be an energy efficiency subsidy scheme or similar program. A lowered cost for the energy due to the lower temperatures will often not be enough for the building owners to make the necessary renewal of building installations.

Considering distributed energy sources, the investment model can include investments taking solely by the DH company, solely by the independent producer or a combination.

For the independent producer the investment should make a yield to pay for the necessary investments in equipment before the equipment needs to be renewed and at the same time make profit for the producer. For the DH company the investment might be seen as a running cost in heat sources as mentioned before and might not necessarily have to be profitable.

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3.5.6. Tariff structure

The tariff structure must reflect the benefits of the ULT transition depending on whether or not existing capacity of the whole system can be expanded due to lower heat loss and lower use of DH for DHW heating as it is substituted with electricity for boosting. It should be considered if the electricity used for boosting the DHW temperature should be included in the tariff or if the building owners should have some compensation in the DH price to reflect the energy level.

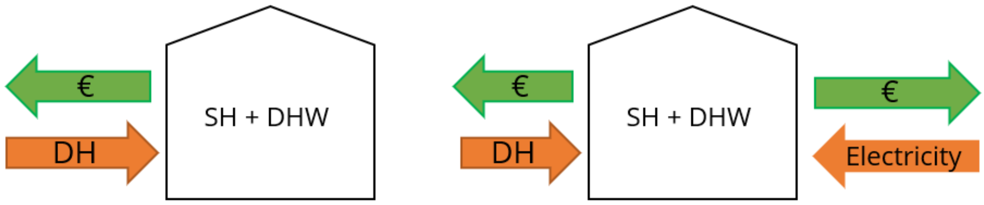

Figure 5 Illustration of tariff structure for conventional DH (Right) and for ULT with electricity supplement (Left)

Because of the changes to the building installations that may lead to lower heat sales the price structure may have to be changed so a larger part of the tariff is fixed to cover the base expenses of operation than before the transition.

For the customer this change can be complicated to understand and if the electricity used for boosting of the DH production is not included in the DH tariff even more so.

Therefor the tariff structure has to be transparent and easy to understand

For more information about tariff structure se RELaTED report D2.2 section 5.2.

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3.6. Project development

3.6.1. Responsibilities

In general, the DH supplier has the overall responsibility of the transition from traditional DH to ULT DH. In comparison to a new development area, the transition scheme will already include an existing distribution and transmission network and an existing cooperation channels with municipalities and other stakeholders. The DH supplier would typically be responsible for the planning and implementation of the proposed changes of the network, enforcement of the delivery conditions, whereas the building owners have the responsibility for the house installations.

3.6.2. Information

Information to all involved parties especially the customers is a very important part of the transition process in order to make sure that all the prerequisites for lowering the temperature is maintained throughout the entire development. An example of important information could be when to expect outages due to renovation of substations, and when to expect performance related issues due to the lowering of the temperature level and what to do if this occurs.

It is important to clarify who will take care of the information or if it is split between the involved parties i.e. the DH supplier, sub-contractors and/or the municipality. For most part in a transition progress the DH supplier might be the main source of information.

3.6.3. Support

When a transition progress is starting the DH supplier should have the organisation ready for an increased level of support for the individual building installations in order to ensure that temperature levels are not lowered to much and to avoid escalation of problems that could lead to inefficient operation of the whole network.

For an existing DH supplier with a solid organization this shouldn't be a problem to handle. For smaller suppliers it might be necessary to introduce extra workforce to handle the support in the transition period.

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3.6.4. Follow up

Follow up on operation of building installations after the transition in order to ensure proper operation of the system might be a good idea. The follow up can an inspection of the installation in relation to the requirements set in the technical building system specifications.

If the installation is not up to the required standard and is causing problems for the operation a notice must be made and another follow up may be necessary when the error is corrected.

3.7. Operation and management

In case of transition of existing DH networks to ULT the DH supplier will probably already have the organization for operation and management in place and might not need changes in that regard.

However, a few areas require extra focus:

- The transition project will typically have a long time-horizon (typically more than a decade) and the organization must be able to handle the time aspect in a consistent way to succeed.
- Increasing complexity of the system e.g. more temperature sectioning units and/or sensors in a DH network, more distributed energy sources and the necessary focus on optimizing building installations may require a centralized system to monitor the operation. Consequently, this might call for new staff competences.
- Communicating the advantages of the transition to the community ie. energy savings, green energy, CO_2 reductions etc.

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Annex 1 – Optimizing Belgrade DH network

About Belgrade and BEOELEKTRANE

Belgrade is the capital of Serbia with about 2.000.000 inhabitants. It has a moderate continental climate. For the heating of more than 50% of apartments, PUC "Beogradske elektrane" is in charge, a district heating company founded in 1965. The heating season lasts for maximum 7 months. With the installed power of 3GW in 40 heat sources, the annual production of heat energy of 3600 GWh, district heating network of 750 km long and 9000 substations are one of the largest heating systems in the region. The heating system is divided into 5 DH networks: Novi Beograd, Dunav, Konjarnik, Cerak and Vozdovac.

Figure 6 Belgrade District heating network area

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Strategic and integrated energy planning

The existing DH system in Belgrade is based on natural gas as the main fuel. The vision is to reduce CO_2-emissions by phasing out the fossil fuels. A more detailed overview of the vision for the development of new sources for heating purposes in Belgrade is given in RELaTED report D.2.1. Chapter 7.3

The Strategy for the Development of Belgrade District Heating envisages a reduction of natural gas from 90% to 26%, which will be enabled primarily by the use of waste energy from the Obrenovac Thermal Power Plant (with a share of 55%), and then from the energy from the waste incinerator and renewable sources (with a share of 9 %).

Using these new energy sources requires interconnection of the existing DH networks into a common system with an interconnection ring transmission line and efficient energy management. In order to reduce the outgoing temperature in the DH system and reduce the required energy for heating, it is necessary to simultaneously perform energy retrofit of building installations in accordance with the applicable regulations

For newer buildings grouped in the one subnetwork the long-term plan is to install BILST and lower the temperature in that part of the network by construction of mixing shunts.

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Economy

Previous renovation of the substations in Belgrade performed in 2008-2012 has been financed by credit from EBRD, and also financed by local contributions.

In the RELaTED project two substations in will be renovated financed by EU commission. For future renovations in order to decrease the temperature and use renewable energy sources options investments could be local contribution and credit financed such as EBRD or KfW

For the end users the lower temperature concept in the existing network is expected to result in a lower price for heating energy.

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DH network topology

The current 5 networks are constructed as centralized solutions with a larger plant in each network that covers the whole area. Their average age is about 20-25 years. The temperature regime is the same in all of the network and there are no subnetworks or sectioning with different temperature regimes, so lowering the temperature will be done for the whole network.

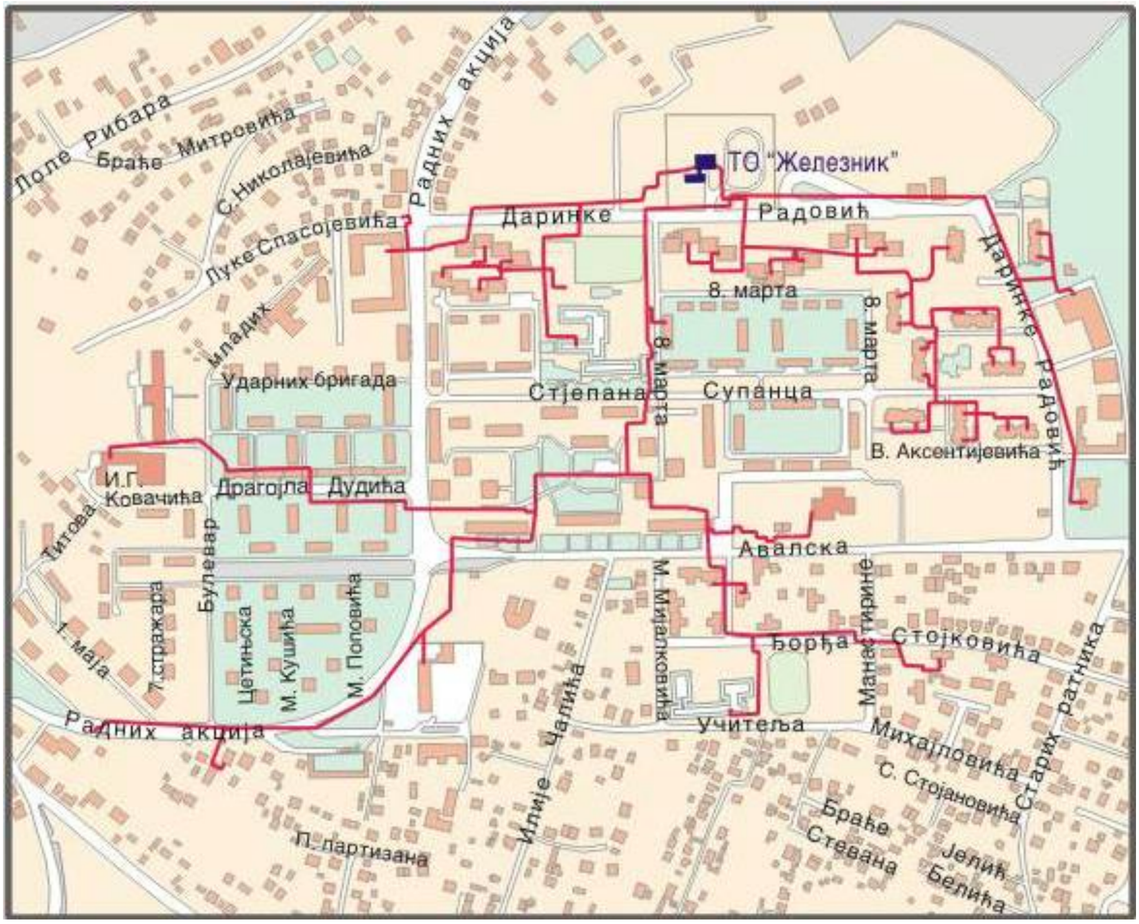

Figure 7 One smaller generation plant with main network and subnetwork

Implementation of the network interconnection of the different DH networks in Belgrade will be done according to results of feasibility studies which is under procedure. The interconnection between the networks is planned as a transmission line with lower temperature. The temperature will be boosted in the existing gas boilers in the networks.

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Scenarios

Most of the substations in the networks are already renovated in 2000-2012. and the temperature is lowered considerably, from 150°C to 120 °C. In the same period the design temperature has been changed from -15 °C to -12 °C.

Decreasing of the temperature will first be done in the several subnetworks. When all other substations are reconstructed with BILST temperature in whole network will be reduced centrally in the generation plant

Installing of BILST in newer buildings grouped in one subnetwork is a short-term plan, that will enable lower temperature regime in that subnetwork down to 60 ^{o}C

After implementation of the RELaTED demo project and testing results within the next year it is realistic to make engineering calculations of BILST for selected newer buildings.

In order to obtain LT concept, the main task for now is to renovate older buildings in order to lower the energy demand. Mostly buildings in Belgrade are uninsulated or have unsatisfactory level of insulation. This renovation will probably take many years and it will depend on decision and financing from building owners or the City of Belgrade. After that process it is expected that the current annual heating demand of 140KWh/m^2 for existing buildings will be reduced by at least 30% when renovated and make conditions for further temperature decreasing.

Currently the heat source in Belgrade is a gas boilers with 90-92% efficiency.

In order to reduce consumption of gas as priority heat power in near future the plan is to use waste and renewable energy according following plans:

- Connection of heat recovery from waste incineration plant. Estimated power: 56,5 MW. Action in progress.
- Planning and tendering for the conversion for heat recovery and connection of a 1500MW electric power plant with an estimated heat output of 600MWt. Action in progress.
- Connection of a large solar heat production plant. Estimated heat production of 60GWh/year.
- Connection of several reject heat producers from cooling applications.

The plan is to lower the supply temperature in the winter from around 100 °C to around 90 °C, and in the summer months to around 70 °C.

The existing radiator systems are designed for a temperature set of 90-70°C but are in practice used at a temperature set of 80-60°C. Lowering the supply temperature in the DH network to 90 °C in the winter from should not cause

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problems as the temperature is mixed down to a lower system temperature in the buildings. Lowering the network temperature in spring and autumn months will be done with a little more consideration to ensure high enough service temperature on cold days

Existing substations are located in building basements and covers one on more buildings with heating depending on their capacity. Average substation capacity is 350 KW. Mostly of them are indirect type with plate heat exchanger for SH.

SH and DHW are distributed in separate pipes to the buildings where it is consumed. For more info about existing installation see the RELaTED D2.2 report section 6.3.2.

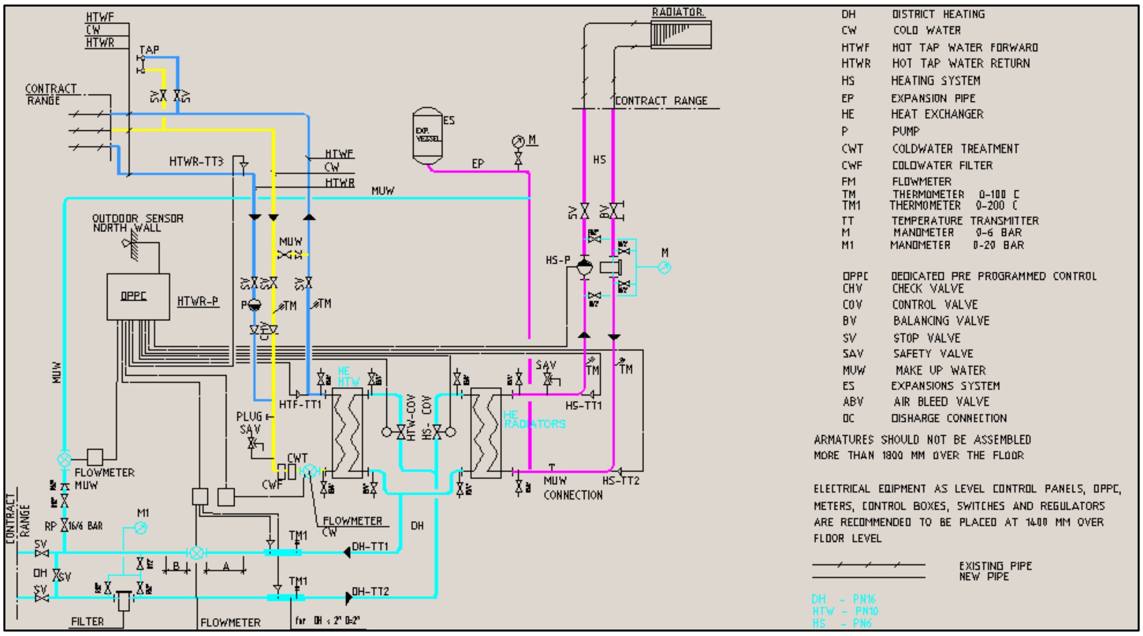

Figure 8 Typical scheme of SS for Heating and DHW

In the previous decade PUC Beogradske elektrane have already renovated primary and secondary side of the substations. All substations are modernised with heat meters, regulating valve and controller in order to maintain quality-quantity regulation of flow and temperature in relation to the outside temperature. On the secondary side tube heat exchangers are replaced with plate heat exchangers and old circulation pumps are replaced with new ones (mostly frequently regulated) and branches has balancing valves mounted.

Not so many exceptions are possibly in network without actually compromising the overall system. For old buildings that have not be renovated (for example historically protected buildings) it is possible to increase the flow rate when the

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whole network is converted to LT. This increase of flow is limited, and it need additional engineering calculations to prove the concept.

There hasn't been done any calculations of the building installations beforehand. The temperature lowering has been done without because the building installations was already made for much lower temperature levels than the network temperature.

In relation to reducing the temperature, it is also expected that the heat losses in the network will be reduced. There hasn't been done any calculations for this. The effect of the reduction can potentially be greater if additional repair of worn out pipes or worn insulation on pipes is done. The plan is that in future interventions pipelines will be changed from pipes in channel to preinsulated pipes. There are no plans for this renovation process as of now because the financing is not in place, so this could probably take many years

Implementing measures

With the reconstruction of substations (done in 2000-2012) the temperature in the networks is already lowered from 150°C to 120°C without changes to the delivery conditions and technical building specifications.

According to the local building regulative all new buildings shall have thermostatic valves and allocators on radiators. A large investment in the future is installation of thermostatic valves and allocators on radiators in existing buildings. It will probably take many years for this to happen and there is no plan for it as of now. These investments will be financed either by building owners or the City of Belgrade.

If the energy systems is retrofit in existing buildings the local Building regulation must be followed.

The tariff structure will not be changed due to the temperature decrease, but the energy price will be lowered.

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Project development

Beogradske elektrane and City as local investor founder, will be in charge of all parts of the future project development regarding optimization of the DH network.

Operation and management

As BEOELEK already have an existing organization they can take care of operation and mangement relatede to the changes in the network without any changes in the organization for that.

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