COOL DH
COOL DISTRICT HEATING

Cool ways of using low-grade heat sources from cooling and surplus heat for heating of energy efficient buildings with new low-temperature district heating (LTDH) solutions.

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Scope of deliverable

The scope of this deliverable is to present the implementation of the new district heating network applied to the demo case in Høje-Taastrup Municipality, where a new low-temperature network was designed to upgrade the old and obsolete one. In the network, the new plastic pipes developed during COOL DH project was implemented. The design of the network was developed in order to minimize the heat losses, reducing the length of the pipes and minimizing the diameters.

Context of deliverable

In the new generation of district heating networks, the lower supply temperature 53°C (except during peaks) leads to the reduction of the heat losses in the distribution network, reaching a higher efficiency of the system. However, the reduced temperature increases the risk of Legionella if the recommended temperature limits are not reached. In order to reduce the domestic hot water volume to less than 3 litre the domestic hot water is to be produces by new efficient micro heat exchangers – one in each dwelling close to the taps. The expected return temperature is 30°C.

The demo site is in Denmark in the Østerby district of Høje Taastrup, where the existing district heating network is upgraded and converted to low-temperature supply. Part of the heat supply will be supplied by the surplus heat coming from a shopping mall CITY2 located in the same area.

The scope of this deliverable is to present the implementation of the new district heating network applied to the demo case in Høje-Taastrup Municipality.

Perspective of deliverable

The report provides information about the final design and the implementation of the low-temperature district heating network. It can be used as a guideline of the installation process and the challenges found during the installation process and a reference for future similar projects.

Involved partners

Høje Taastrup Fjernvarme a.m.b.a. (UTIL-DK) and COWI A/S (COWI-DK)

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Summary

The transition to low-temperature supply in district heating networks requires new technical solutions to meet the heat requirements of the consumers and guarantee their safety, mainly in connection to the possibility of Legionella contamination through the domestic hot water system. At the same time, the efficiency of the district heating system must be ensured.

The purpose of the deliverable is to present the implementation of the new district heating network applied to the demo case in Høje-Taastrup Municipality, where a new low-temperature network was designed to replace the old and obsolete one. In the network, the new plastic pipes developed during COOL DH project was implemented. The design of the network was developed in order to minimize the heat losses, reducing the length of the pipes and minimizing the diameters.

Contents

1 Introduction

The developments occurred in the district heating (DH) sector in the last two decades are leading the transition from the 3rd to the 4th Generation District Heating. New technologies, new insulation properties, attention to the buildings' features and the stricter requirements in terms of energy consumption and emissions have improved the efficiency of the entire sector, from the production to the consumption. In particular, the improvements achieved at in the building sector are leading to the reduction of the energy demand, which is also reflected on a lower supply temperature required. The standard district heating systems are going to be replaced by low-temperature district heating (LTDH) or ultra-low-temperature district heating (ULTDH) networks, where the supply temperature will be respectively between 50-60°C in LTDH and below 50°C in ULTDH [1]. The mean temperature (flow and return) in the system demonstrated is below 45°C (aiming at 40°C):

The European Union (EU) will play a primary role in the transition towards a more efficient DH sector, financings development and research project. As part of the biggest EU research and innovation programme Horizon 2020, COOL DH project will investigate new technical solutions that can be applied in LTDH networks to ensure the comfort of the occupants and increase the share of renewable energy. The acronym COOL DH stands for "Cool ways of using low-grade heat sources from cooling and surplus heat for heating of energy efficient buildings with new low-temperature district heating (LTDH) solutions".

As result of COOL DH project, two real-scale demo sites will be implemented to show and test the innovative solutions developed throughout the project. The first demonstration site is located in Denmark in the city of Høje-Taastrup, where the existing DH network that was suppling Østerby district was upgraded to a new LTDH network, which will take advantage of the surplus heat coming from the CITY2 shopping mall located in the area. The second demonstration site is in Sweden in the city of Lund. A new district in Brunnshög area is under development, where research facilities, office buildings and residential buildings will be built. This area will be supplied by a new LTDH network, which will use the surplus heat produced by the world's strongest synchrotron microscope (MAX IV) as heat source.

This report presents the installation of the new low-temperature district heating network in Østerby district, with the introduction of the new plastic pipes developed during COOL DH project and the optimization of the network design to reduce the heat loss prom the distribution pipes.

1.1 Nomenclature

DH	District Heating
LTDH	Low-Temperature District Heating
ULTDH	Ultra-Low-Temperature District Heating
EU	European Union
DHW	Domestic Hot Water
SH	Space Heating
DHWC	Domestic Hot Water Circulation

2 Background

2.1 European Union's strategy

The building sector is responsible for approximately 40% of the energy consumption and 36% of the CO_2 emission in the EU [2]. In EU households, heating and hot water alone account for 79% of the total final energy use, while cooling is a small share, even though this demand has a rising trend during summer months [3]. In relation to the building stock, about 35% of the EU's buildings are over 50 years and almost 75% are considered as energy inefficient. Among these, only 0.4-1.2% of the buildings are renovated each year. Therefore, a remarkable potential in terms of energy savings and CO_2 emission reduction is identified in the existing buildings. In particular, the energy consumption can be potentially reduced by 5-6%, while the CO_2 emissions can be lowered about 5% [2]. Regarding the energy production, the 84% of the heating and cooling demand is still generated from fossil fuel, while only 16% is generated from renewables. Therefore, to reach the EU's climate and energy goals, the heating and cooling sector must considerably reduce its energy consumption as well as cut the use of fossil fuels [3].

The EU's strategy to the reduce the energy consumption and CO_2 emissions is defined by a plan that establish the terms of reduction and the actions that can be undertaken. It is a long-term plan with intermediates steps in 2020, 2030 and 2050. The aims for 2020 is a 20% cut in greenhouse gasses emissions (from 1990 levels), 20% of the energy in EU should be from renewables and a 20% improvement in energy efficiency must be reached [4]. In 2030, the aims are to cut at least 40% of greenhouse gas emissions, increase the share of renewable energy at least of 27% and improve the energy efficiency at least of 27% [5]. In 2050, the cut in greenhouse gas emissions should reach at least 80%. The action plan will involve all the sectors [6].

3 District heating network renovation project

The transition to low-temperature supply highlights new challenges to fulfil the consumers' requirements and at the same time guarantee a high efficiency of the DH system. Therefore, new technical solutions must be investigated in order to achieve the aim of decreasing the supply (and return) temperature.

In Østerby district, the first attempt to renovate the old existing network was done in 2010, applying a traditional approach, which did not convince the housing associations and the users. Afterwards, between 2017 and 2018, the opportunity of renovating the DH network was encouraged by the possibility of implementing innovative solutions thanks to the funds received by the European Union. In particular, the new solutions implemented aimed to create a new LTDH network, which would have been supplied by renewable sources and would have reduce the heat loss. Figure 1 rapidly shows the timeline from the first attempt to the renovation of the network.

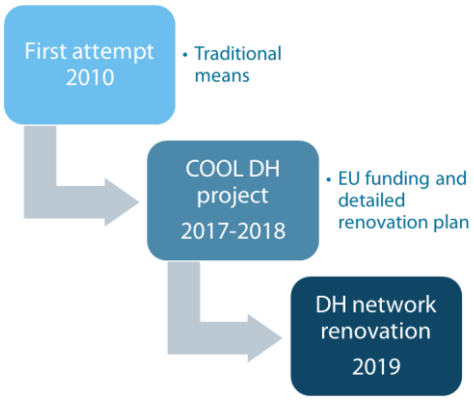

Figure 1. Timeline for the beginning of the project.

Besides the innovations introduced by the project, the key success factors that led to the implementation of the new network were the high focus on the decision triggers combined with the detailed economic and technical feasibility studies. Furthermore, detailed calculations of micro and macro economy were conducted as well as numerous meetings with all the stakeholders. The success of COOL DH project in Østerby is based on a close collaboration between Høje-Taastrup Municipality (MUN-DK), the district heating company Høje Taastrup Fjernvarme a.m.b.a. (UTIL-DK). and the engineering company COWI A/S (COWI-DK).

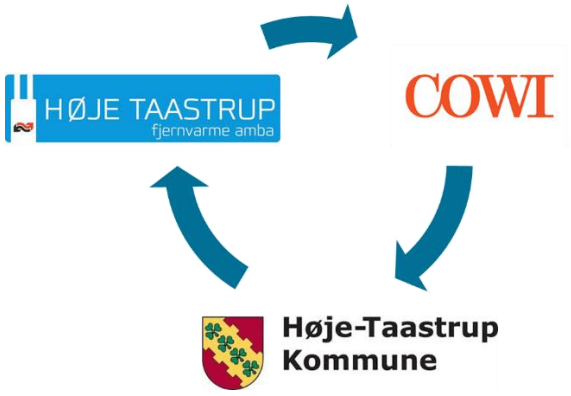

Figure 2. Main actors involved in the renovation of Østerby district

Figure 3 gives an overview of the Østerby district, which is divided in social housing, housing associations and a kindergarten. It is composed in total by 413 users distributed in different type of dwellings. In the first part of the optimisation process of the new LTDH network, all the buildings were supposed to be supplied by the new network. However, during the negotiation process, part of the housing associations decided not to continue with the replacement process (yellow area in Figure 3). Therefore, the users that are going to be supplied from the new network are 159 for a total area of 12,692 m², while the remaining 254 users are not going to be connected to the new LTDH network in the first phase.

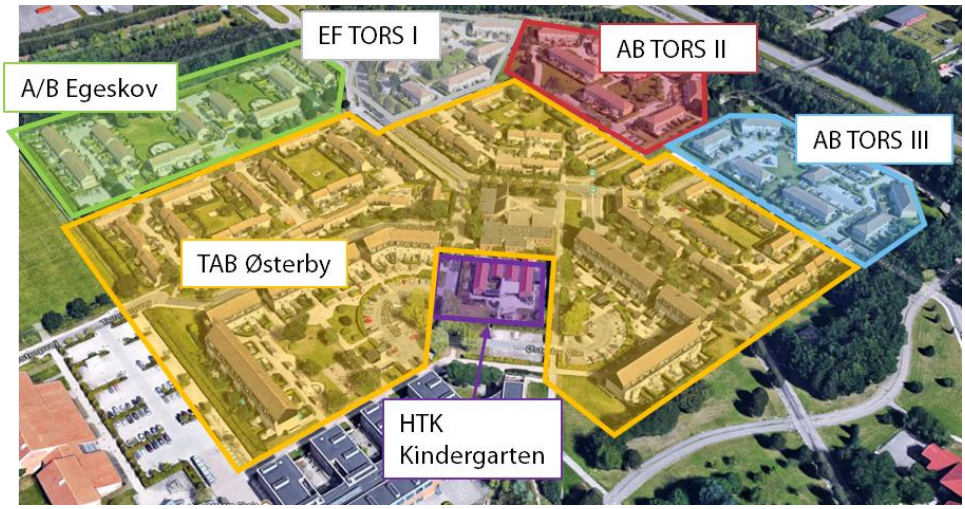

Figure 3. Overview of the housing associations and the kindergarten in Østerby district.

The LTDH network will take advantage of the surplus heat from the cooling system that operates in the nearby shopping mall called "CITY2". On CITY2 a 16,300 m² PV plant has been installed. The network will be designed to ensure a temperature of 55°C on the supply side and 30°C on the return side. In Østerby network, it is expected that the furthest user will be supplied with 53°C and a flow of 1000 l/h.

4 Østerby

Figure 4 shows the configuration of the network before and after the renovation process. On the left part, the old network is represented. Østerby district was supplied by a centralized heat exchanger located at the end of the main distribution network (red line) in the middle of the figure. From this point, an internal DH network guaranteed the direct connection of the SH system for all the consumers, with different types of units implemented in each building for the DHW production. The distribution pipes of the existing DH network were placed under the buildings.

Following the inputs provided by the investigation presented in the deliverable "D2.7 New design concepts for LTDH ", the district heating network was designed and optimized to ensure the heat supply in the entire district and minimize the heat losses. During the design process different optimization aspects were considered. Higher insulation level and twin pipes were used to limit the heat losses; furthermore, the network was optimised from the length and the hydraulic point of view. On the right part of Figure 4, it is possible to see the network optimization, using the simulation software Termis, for the dwellings that are going to be connected.

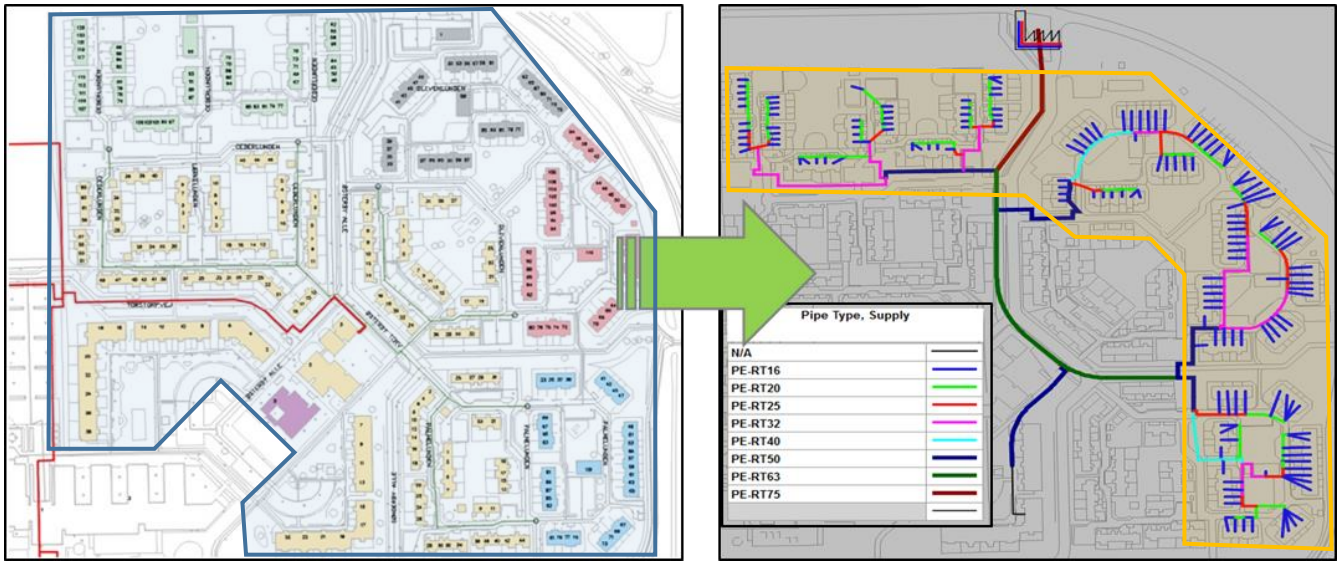

Figure 4. Old configuration of the DH network (left) and new low-temperature DH network (right)

As it was mentioned before, the heat supply of Østerby district is ensured by nearby shopping mall CITY2. Figure 5 gives an overview of the area, highlighting the shopping mall and Østerby district. The red highlighted area represents the part of the district that will be supplied by the new low-temperature district heating network. Inside this area, the blue part shows the part of the network entirely supplied by the new plastic pipes, while the remaining area is composed by a mix of plastic pipes and steel pipes.

Figure 5. Østerby district and CITY2 shopping mall

5 New district heating network

The installation operations of the main pipes of the new LTDH network in Østerby district took place in the period spring-summer 2019 and continued throughout the rest of the year with the installation of the service pipes and the connection of the users. Figure 6 shows the final configuration of the network that was implemented in Østerby district. The network resulted different from the simulation made with Termis, since it must be optimized also in relation to the existing installation that are already buried in the area.

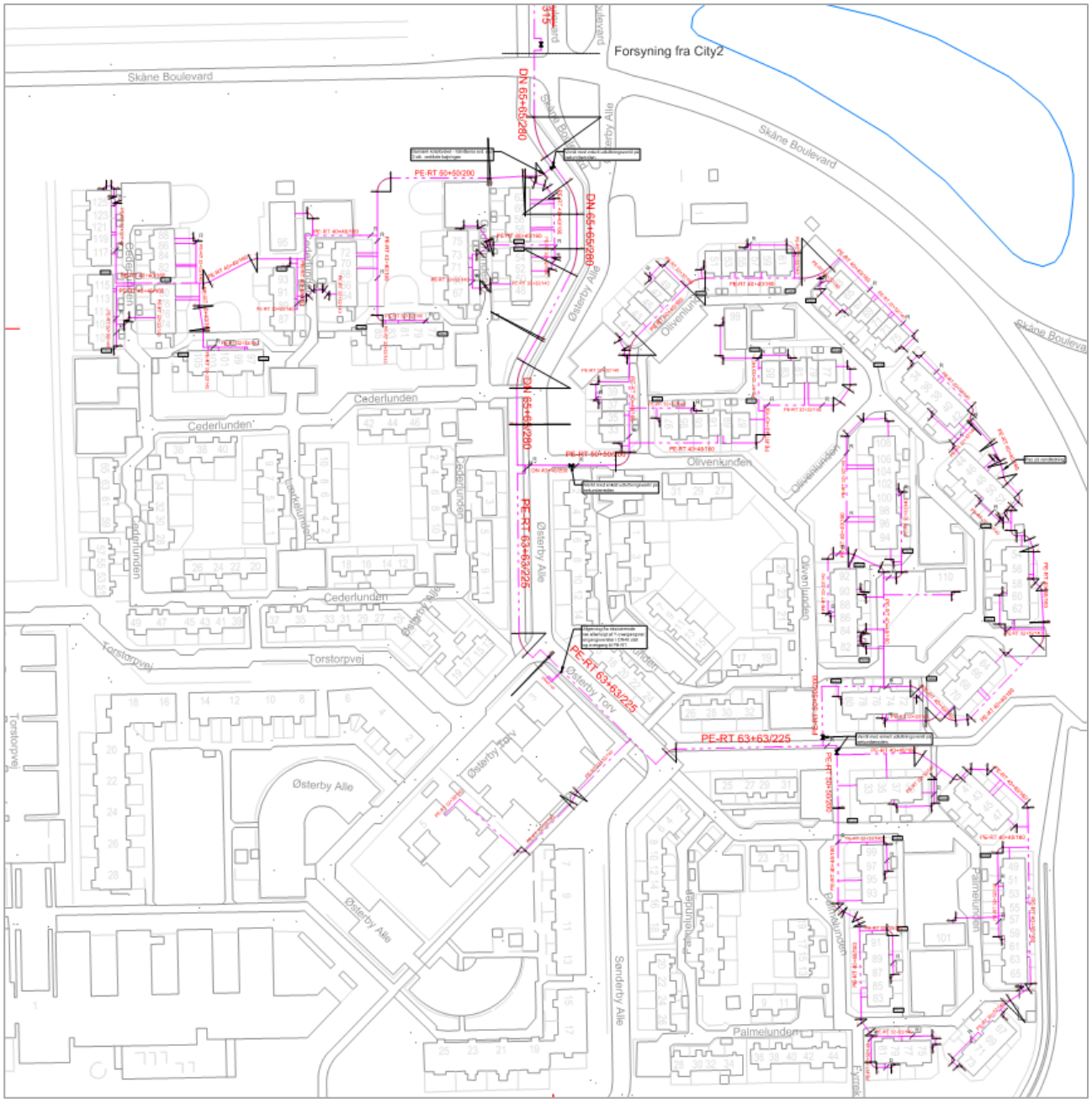

Figure 6. New LTDH network in Østerby district

The differences in terms of DH pipes between the simulations and the final design of the network can be seen from the Table 1.

Table 1. Comparison of district heating network pipes resulting from TERMIS simulations and Final Design

TERMIS simulation		**Final Design**	
Pipe type	**Length [m]**	**Pipe type**	**Length [m]**
PE-RT75	107	DN65 (steel)	170
PE-RT63	223	DN40 (steel)	27
PE-RT50	246	PE-RT 63	207
PE-RT40	122	PE-RT 50	211
PE-RT32	390	PE-RT 40	979
PE-RT25	241	PE-RT 32	683
PE-RT20	446	PE-RT 25	902
PE-RT16	967		
SUM	**2741**	**SUM**	**3179**

The differences in terms of DH pipes used in the final design of the network are due to the real application of the network, which had to be adapted to the district and the existing installation that were already in the area. Furthermore, as it is possible to see from Table 1, less pipe diameters were used in the final design, since the production of many different diameters leads to higher production costs.

The new plastic pipes developed during COOL DH project considered Figure 7 shows the connection of two pipe segments with press coupling connection. Figure 8 shows a closer view of the press coupling connection.

Figure 7. Installation operations of the press coupling connection

Figure 8. Press coupling connection

Figure 9 shows a branch of the DH network in Østerby district before laying it in the trench.

Figure 9. District heating pipe in Østerby district

Figure 10 shows the installation of the service pipes in close to the users' buildings in order to reduce the length of the network and consequently the heat losses.

Figure 10. Installation of the service pipes in Østerby district

As it was mentioned, 159 users are going to be connected to the network. They are going to be supplied through single-family DH units that are installed in every dwelling. The challenging part of the installation of the new DH network was partly represented by the digging work that was performed in the final users' garden. The service pipes were then connected to the buildings, as it is shown in Figure 11. In details, it is possible to see that the service pipe showed in the picture supplies two dwellings.

Figure 11. Final installation of a district heating unit (flat station) at a customer's dwelling in Østerby

The network is owned by Høje Taastrup Fjernvarme a.m.b.a. which is responsible of its the operation and maintenance. Table 2 shows an overview of the main costs for the implementation of the new LTDH

Table 2. Overview of the main costs for the implementation of the LTDH network in Østerby (exchange rate: 1 EUR = 7.4532 DKK)

Digging work	6.715.883,10 DKK	901.073,78 EUR
Pipe installation	1.698.855,68 DKK	227.936,41 EUR
Material	3.820.039,01 DKK	512.536,76 EUR
Meters	514.795,82 DKK	69.070,44 EUR
Other costs	316.762,28 DKK	42.500,17 EUR
Engineering/Design work	458.208,15 DKK	61.478,04 EUR
Commissioning	1.352.454,40 DKK	181.459,56 EUR
TOTAL	**14.876.998,44 DKK**	**1.996.055,17 EUR**

Table 3 show the main actors involved in the design and implementation of the network.

Table 3. Main actors involved in the implementation of the Østerby's district heating network

	Name	**Telephone & e-mail**
Plant owner	Høje Taastrup Fjernvarme a.m.b.a	43 55 30 10 htf@htf.dk
Installer/contractor	Brøndum A/S	86 62 36 66 brondum@brondum.dk
Supplier	Logstor A/S	99 66 10 00 logstor@logstor.com
Design engineer	COWI A/S	56 40 00 00 cowi@cowi.com

6 Output and experience acquired during the implementation process

The implementation of the new LTDH network gave some insights about the practical issues related to the installation of the new pipes.

Twin pipes result quite rigid to work with during winter, when the outside temperatures are low and especially when the large casing are used. On the other hand, during the summer, shrink-fitting presents some challenges as the material in the connection is softer.

During the connection of the twin pipes, two people are required to move the two endpoints and keep them together for the connection, especially in the case of larger diameters. In this way, a larger work force is required with prefabricated branches, with a consequent increase of the installation costs. In case of single pipes, the installation process resulted easier.

Other issues were found in relation to the development of the new plastic pipes. The development of such new technology requires a period that is relatively long in comparison to the length of the project. The new plastic pipes need to be tested, usually requiring a long process. This can affect the installation and implementation of the DH network, which in some cases had to be postponed or changed with steel pipes. Fortunately, even though it was needed to implement steel pipes in some cases, it was still possible to use the new developed insulation foam that ensures lower heat losses from the network. Overall, there is a need for further development of connection methods, for example electro-welding sockets such as those used in water supply systems. However, this method must be tested and approved for district heating temperature.

7 References

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