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Low Temperature District Heating — Critical Literature Review

Abstract
Nowadays, numerous initiatives are being undertaken with the aim to prevent further pollution of air, earth and water. Low temperature district heating (LTDH) offer here an advantage over other heating methods. Implementation of LTDH network into existing buildings have been performed e.g. in Denmark and proved to be feasible without large thermal and in house installation modernisation; however, this must be checked for Polish conditions. The conditions and barriers for such test are discussed here.

Keywords: district heating, low temperature district heating, renewables.

1. Introduction

In a day of an increasing energy crises and poor environmental conditions, being nowadays a fact, numerous initiatives are being undertaken with the aim to prevent further pollution of air, earth and water. There is no doubt that humans have badly influenced the quality of the environment. Bearing in mind the fact that the environment has a huge influence on people, we cannot stay indifferent to its negative changes. One of the important issues in the environmental protection, this article deals with, is a decrease of the temperature of the district heating (DH) medium. This results in the power plant efficiency growth and both, lowering the pipelines heat losses and ability to include renewables as DH heat sources. Therefore, by offering a low temperature district heating (LTDH) from renewables, the residential coal burners might be eliminated, what results in decreasing of the level of the greenhouse gasses emission. Lowering the district heating medium temperature from 90 to 60 Celsius degrees brings also some technical difficulties due to the necessity of the transmission pipelines and buildings thermal modernisation. Moreover the existing in residential building internal heating systems need to be modernised, as lowering the district heating temperature forces the change of subcomponents of the heating system infrastructure.

Even though some Danish pilot cases of implementing the LTDH network into existing buildings have shown that it is possible without large thermal and in house installation modernisation, this must be checked for Polish conditions. The reason is that indoor heating installations in buildings are often improper as they are sometimes obsolete and generally oversized, and their subcomponents are of lower quality.

Additionally, mentioned heating systems are often badly designed from the point of view hydrodynamic and they hardly allow to control the heating medium flow. That is why the working medium heating potential is not being fully utilised. In Poland, from one side there are highly innovative thermal energy distributors, supply networks and substations, and from the other side, there are antiquated heating infrastructure in the building stock. Therefore, the proper cooperation of the thermal energy supplier and consumer in the field of implementing the low temperature district heating is rather difficult from technical and mental point of view.

Some case studies have proven that implementation of the effective LTDH systems faces some difficult technical barriers. The latter concerns thermal modernisation of the existing buildings and proper construction of the new ones. It is an expensive and time consuming solution, however, if the building is of a high thermal energy demand, the low temperature DH may not fulfil its heat demand. In this case, an alternative heating device is necessary. Introducing such solution results, however, in higher costs.

2. Technology issues

Concerning the problem of thermal modernisation, there are now some new solutions being implemented, what brings desired results. The buildings thermal inspection is being carried out using instrumental-and-visual way. Additionally such measurements are now being supported by numerical computations. This way defects of the buildings envelope were being revealed. These non-destructive methods provide most accurate solutions of the existing building thermal performance enhancement (Korniyenko, 2015). The existing building after its thermal modernisation may be supplied with the low temperature heat from the local district heating network.

There are different solutions leading to supply temperature reduction. The simplest way of introducing the LTDH is lowering the outlet temperature from the DH grid. This can be done if the existing district heating network is in a good condition from both, insulation and quality points of view. Thermal comfort of consumers could be reached if the thermal modernisation of the building was carried out. In other case, if the ambient temperature decreases, the additional heating device would be necessary to fulfil demand on heat for the purpose of the hot water preparation. Other possible solution, when the district heating network is in bed condition, is to replace it with new e.g. isolated twin pipes. The twin pipe is a pair of equally-sized media pipes which are embedded in the same insulation and casing pipe. The twin pipe contains the supply and return pipe. The typical media pipes are produced from steel, copper or plastic, from which the latter are being used often in LTDH grid. Worth mentioning is a pair of pipes called double pipe which differs from the twin pipe by one parameter — the pair of pipes differ by the diameter. Aiming to provide the high efficiency of the DH system, it is worth to consider smaller pipe dimensions and larger insulation thickness. The insulation PUR-foam type decrease significantly thermal energy losses (Guidelines, 2014). By implementing the diffusion cell gas barrier at the outer casing, the insulation remains efficient as the gas barrier and disables the contact with its surrounding. Obviously, the shorter the pipe the lower are heat losses which makes that reducing the pipes length strongly recommended.

Besides, the need for grid modernization, a big problem of Polish DH is in-door installations being strongly oversized. In the previous decades, heating installations designers intended to oversize the radiators and other network subcomponents by 20% to reduce the danger of underestimation of heat demand. There oversized were radiators, piping and pumps. This resulted in the overall installations being oversized by several dozen percent, approximately, so the flow regulation is more difficult. Additionally, thermal modernisation of the buildings increased the problem with heat supply infrastructure being oversized.

This finally resulted in temperature of return flow being too high — main problem for heat suppliers. These can be partly solved by proper regulation of flows in radiators. In properly designed and regulated radiator, only one third of its area is heating, exceed the room temperature.

Concerning the economics and energy efficiency of the LTDH system, two main related parameters which determine the district heating network profitability are heat demand and linear heat-flux density. The linear heat-flux density tends to decrease with the thermal modernisation of the buildings and climate change. In the existing district heating network, connections of the newly built energy efficient building stock may not be sufficient from both efficiency and profitability point of view if the conventional DH technology is being applied (Castro, 2017). The costs of DH network building and operation are strongly related to the nominal and operating (supply/return) temperatures.

On the one side there are thermal energy distributing units which set the supply temperature of the DH network to optimise the overall operation and costs. On the other side, there are consumer substations which should comply the minimum operating parameters and design. Unfortunately, the substations malfunctioning is commonly encountered. Concluding, an improvement of the operation conditions and settings of the consumer substations leads to lower return temperatures and consequently, to increase of the DH-system operation-efficiency. Lower return temperatures allow higher electricity production in the CHP system, what increases system overall economy. Besides, the use of efficient heat pumps, industrial waste heat and renewables increase system efficiency.

Likewise, the supply/return temperature difference increases the heat capacity of the DH network and consequently decreases the mass flow rate of the heating medium (see eq. 1).

$$\frac{\dot{Q}}{\dot{m} \cdot c_p} = \Delta t \tag{1}$$

Resulting from the equation (1), decreased mass flow rate causes lower pressure drops in the network. Concluding, supplying the same amount of thermal energy by increasing the temperature difference lead to lower operation costs, as pressure drops decrease and circulating pumps use less energy.

Aiming at providing thermal comfort for consumers, simultaneously with the return temperature reduction and energy saving, the hydronic-system heating-loop ought to be of a proper design and operation. When implementing LTDH, the radiator space heating control (RSHC) differs from the RSHC being used in a conventional

DH. It is very important to achieve a proper heating medium mass flow rate control in a way which provides the limitation of the maximum mass flow, resulting in achieving lower supply temperature.

In the previous decades, the hydraulic balance was reached by introducing the orifice at the radiators inlet. Nowadays, thermostatic radiator valves (TRV) with the pre-setting function, which is the orifice function, are being used to reduce the risk of the radiator overflow. The pre-setting function is limiting the maximum mass flow rate of the heating medium to designed demand. Hydraulic balance may be achieved through the properly set of the pre-set function. There are two main flow parameters which need to be controlled, the temperature and the pressure of the fluid. That is why, to control the operation of the TRV, a differential pressure controller needs to be installed, which will ensure the stable operation conditions for the TRV by providing a suitable differential pressure in the heating system loop. Additionally, the return temperature controller may be used at the radiators outlet. It will ensure a proper outlet temperature as it will close when the outlet temperature will be higher than a set point. During the cold days, higher radiator outlet temperature is recommended and should be accepted, even though normally, the radiator outlet temperature may be approximately 25 Celsius degrees. Therefore, it is proposed to develop an innovative smart TRV which would have an additional temperature sensor and could provide a low return temperature even if the TRV wouldn't operate in an optimal mode.

3. Conclusions

This paper reveals the problem of the DH network. Main conclusion is that even though there are some pilot LTDH cases having been carried out in Sweden and Denmark, Polish systems need to be refurbished and prepared as the problem of the LTDH implementations lays mostly at the indoor heating infrastructure. Heat suppliers and district heating pipelines in Pomeranian region (Gdynia, Wejherowo, and Rumia) are well prepared to work on lower heating medium supply temperature.

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