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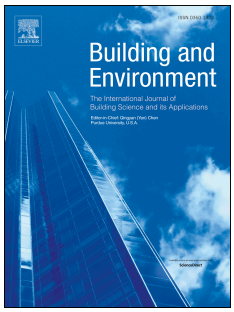

Utilization potential of low temperature hydronic space heating systems: A comparative review

Petr Ovchinnikov, Anatolijs Borodiņecs, Ksenia Strelets

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Utilization potential of low temperature hydronic space heating systems: A comparative review

Petr Ovchinnikov[1], Anatolijs Borodiņecs[2], Ksenia Strelets[1]

[1]Peter the Great St.Petersburg Polytechnical University, Polytechnycheskaya str., h. 29, St. Petersburg, 195251, Russia
[2]Riga Technical University, Kipsalas str., h. 1, Riga, LV-1658, Latvia

Abstract. Recently, there has been a rising concern for hydronic space heating systems of various configurations for low temperature water heating applications due to constantly tightening energy codes and regulations. Current tendencies in Russian legislation system aim to transfer local building sector for low-exergy systems. The current work aims at reviewing the recent researches conducted on the low-temperature hydronic space heating systems and heat emitters with a view of evaluating their practical application in Russian building sector. The review is based on the comparison of various key performance data for systematic representation of studied concepts. It was stated that having a wide range of different approaches and performance criteria increases the difficulty of examining a specific system and comparing it with the others. Studies and practicies, analyzed in similar to Russia weather conditions, indicate distinct prospects of utilization of low-temperature hydronic heating systems. An optimum hydronic space-heating configuration can be identified for the specific case but it is strongly dependent on initial boundary conditions.

Keywords: Low-temperature heating systems; Low-temperature district heating; Energy efficiency; Energy performance; Thermal comfort.

1. Introduction

Previously, high-energy consumption that was attributed to the building stock has raised the need for studying low exergy systems. For instance, as it was estimated in European buildings, the total energy consumption reaches approximately 40% of primary energy usage [1], and a part of consumption, that is demanded for heating, accounts for more than 70% [2]. Nonetheless, there is a large potential in the building segment in terms of saving energy, i.e. by applying materials with low heat transfer coefficient (U-value), increasing of envelope's air-tightness, relying on renewable energy resources, using modern high-effective equipment for heating. Fulfilling these steps can substantially reduce the length of a heating season and the total heating demand. Ultimately, this measures aim to transform the existing buildings and to design the new ones according to net zero energy/emissions buildings concept [3].

House space heating (SH) and domestic hot water (DHW) in urban areas are predominantly provided by combined heat and power plants (CHP) using 3rd generation district heating system (3GDH). As an example, in Russia, 3GDH has supply/return temperature at level 95/70 °C and up to 150/70 °C. Previously, higher temperatures, such as 90/70 and 80/60 °C have been used in Sweden (i.e. Denmark – 80/40 °C, Finland – 70/40 °C), partly because there were no incentives for low temperatures in systems with boilers, but also because smaller radiators could be employed. The advantages of low temperatures have led to lower temperatures being used today, e.g. 60/45, 60/40 or 55/45 °C. Since 1982, temperatures higher than 55 °C are not allowed in new heating systems, which should promote the use of low-temperature heating systems [4].

Current tendencies in Russian legislation system aim to transfer local building sector for low-exergy systems. EU main energy efficiency targets can be easily implemented on Russian market. However, main barriers such as high final energy consumption and low inhabitants energy awareness should be removed. Tendencies for building sustainable environment are legally established by the Federal Law №261 only in 2009 [5]. While Russian regulations are being constantly actualized, practices of using low-exergy systems are still being obstructed by obsolete 3rd generation district heating (3GDH), inherited from soviet times, and currently there is no real evidence of transition from high temperature to low temperature district heating. As of 2007, the district heating (DH) and combined heat and power (CHP) plants in Russia included around 500 CHP plants and 65 000 boiler houses connected to the end-users by means of 200 000 km of DH networks. In Russia, these systems operate at sufficiently low level of energy efficiency compare to the most technologies used internationally [6]. The new Energy Efficiency Strategy of Russia to 2030, supported by the Russian Federation Government (Decree №1715-r [7]), sets the strategic goals of increasing DH/CHP- and end-user energy efficiency. For that reason, studying experience from recent researches and practices seems exceptionally important prior actual application of modern systems.

As an example, a well-designed heating system that allows room air temperature to be lowered by 1 °C may lead to approximately 7% of annual energy savings [8]. Current studies show that it is possible at least to reduce the total energy use for SH of new buildings to a level equivalent to the energy use for DHW (50-55 °C) [9]. The change in temperature demand may be further improved by introducing heating systems that can use supply temperatures of 40 °C and cool down the district heating water to near room temperature (20-22 °C).