Heat Recovery from Sewer System in a Sport Complex

DOMINIKA MACKOVÁ
Slovak University of Technology
Faculty of Civil Engineering
Department of Building Services
d.juhosova@gmail.com

JANA PERÁČKOVÁ
Slovak University of Technology
Faculty of Civil Engineering
Department of Building Services
jana.perackova@stuba.sk

In the paper there are introduced the possibilities of the recovery of waste heat from the sewer system as an answer to the minimalism of the demand of energy needed for the preparation of domestic hot water. The recovery of waste heat from the sewer system is possible using heat exchangers in order to extract heat from wastewater to direct preheating of cold water.

Keywords: heat recovery; heat exchanger; sewage, sewer system, sanitary equipment; wastewater, domestic hot water, sport complex, shower

Nowadays, more and more energy is consumed in buildings for preparing hot water, heating, cooling of the building and thus energy became very valuable. The energy consumption for heating and cooling purposes decreases thanks to the thermal insulation of the building constructions and replacement of old windows for new plastic windows with triple glazing, while the energy consumption for preparing hot water is constantly increasing. How the energy needed to heat the potable water could be reduced? One option is recuperating. We are able to recover waste heat from the sewer system to preheat domestic hot water using heat exchangers. Heat from wastewater can be optimally used for heating, cooling and hot water preparation in low- energy houses.

Recovery of waste heat from the sewer system inside of the building

Buildings with a constant flow rate of wastewater and significant amount of it being drained away are suitable for heat recovery directly inside them. In this case, it is very convenient to use the heat from the sewage for preheating water for immediate consumption. The

This work was supported by Slovak Research and Development Agency and the Ministry of Education, Science, Research and Sport of the Slovak Republic through the grant VEGA 1/0847/18 and KEGA 044 STU-4/2018.

MINISTRY OF EDUCATION, SCIENCE, RESEARCH AND SPORT OF THE SLOVAK REPUBLIC

system is based on heat exchangers, which serve to exchange the heat energy between the waste water and the cold water. There is no contact between the potable water supply and the drain water [1].

Figure 1 shows the fundamental principle of system of recovery of waste heat from sewage inside of building to direct preheating of domestic hot water. Wastewater from shower with a temperature 38°C is drained into the sewerage through the heat exchanger. The cold water with the initial temperature 10°C flows through the heat exchanger, in the opposite flow direction of the drainage water, and is transported into the thermostatic shower mixer tap. Wastewater transfers the heat through the heat exchanger into the cold water in order to preheat it – cold water can reach a temperature of approximately 20°C [1].

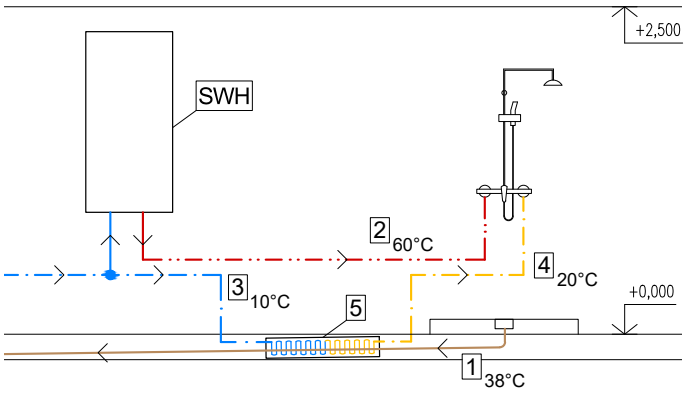


Figure 1. Cold water preheated for immediate consumption through heat exchanger [author]. 1 = waste water drained from the shower (38°C), 2 = hot water supply from the storage water heater (60°C), 3 = cold water supply to the heat exchanger (10°C), 4 = preheated cold water supply to the shower thermostatic mixer tap (20°C), 5 = heat exchanger, ZOV = storage water heater.

Preheated water is supplied into the thermostatic shower mixer tap. Adding the preheated water into the thermostatic mixer instead of cold water, a smaller portion of hot water is mixed with a larger portion of preheated cold water thus reducing the hot water flow. This serves to reduce the hot water consumption and energy needed for water heating [2]. The recovery of waste heat to direct preheat of hot water is recommended for sanitary appliances where the need for hot water exceeds the need for cold water – the best example are showers and wash basins.

Heat exchangers could be installed in a several ways. Heat exchangers should always be installed as close to the sanitary appliance as possible. Methods of installation are as follows [1]:

a) direct connection of one heat exchanger to one sanitary appliance (shower)

The waste water from one sanitary appliance (e.g. one shower) flows through the heat exchanger into the sewerage. The cold water flows in the opposite direction of the sewage water and is supplied into the mixer tap as the preheated water in order to reduce the hot water flow.

b) direct connection of one heat exchanger to several sanitary appliances (shower and wash basins)

The waste water drained from the shower and washbasins flows through one common heat exchanger into the sewerage. The preheated water is supplied into the thermostatic mixer tap of the shower and also into the mixer taps of washbasins.

c) combined connection of the heat exchanger with a storage water heater

In this case, the preheated cold water is not only supplied into the thermostatic mixture tap, but it is also transported into the local storage water heater which serves to save energy needed for hot water preparation. This type of installation is the most effective one in terms of energy savings.

d) parallel connection of the heat exchanger to several sanitary appliances

Sewage from many showers flows into the sewerage through one common sewer pipe into many heat exchangers. With this type of installation, as many heat exchangers are installed as many sanitary appliances there are - heat transfer is more efficient.

Types of heat exchangers for recuperation of waste heat from

Several types of heat exchangers for recuperation from the internal sewerage systems are known - heat exchanger in combination with a shower with floor drain system [4] (see point A), special shower trays with integrated heat exchanger [5] (see point B), heat exchanger in the form of regenerative panel placed under the shower tray [6] (see point C), regenerative panels with stainless steel heat exchanger [3] (see point D), etc. In the rest of this article, alternative solutions of the recovery of waste heat in the object of a sport facility are applied.

A. Heat exchanger in combination with a shower with floor drain system

Application: This alternative is suitable for sanitary equipment with showers, where a shower with a floor drain system is designed (**Figure 2a**). The heat exchanger is in a form of a double walled stainless-steel heat exchanger. The energy efficiency depends on the hot water flow [4].

Principle: **Figure 2b** shows a floor plan of the sanitary equipment with showers with a floor drain system where the recuperation is provided by a compact heat exchanger. The sewage water from the shower (38°C) flows into the sewerage through a heat exchanger by a connecting pipe in the floor. The cold water (10°C) is preheated (20°C) and supplied directly into the thermostatic shower mixer. Hot water is prepared locally. Pipes for cold water and drain of wastewater are laid in the floor.

B. Shower tray with integrated heat exchanger

The second recuperation system consists of a special shower tray with the heat exchanger integrated underneath the shower tray (**Figure 3**).

Application: If in the object is a shower designed with a shower trays, the option is recuperation using this special shower tray with an integrated circular heat exchanger in the form of spiral of copper pipes (**Figure 3a**). The heat exchanger is placed under the shower tray, but the normal height of shower tray is maintained. The efficiency depends on the hot water flow and is around 41% [5].

Principle: **Figure 3b** shows a floor plan of the sanitary equipment where the heat recovery is solved using a shower tray with an integrated circular heat exchanger through which the wastewater flows. The cold water (10°C) is supplied into the shower tray from the bottom of the heat exchanger.

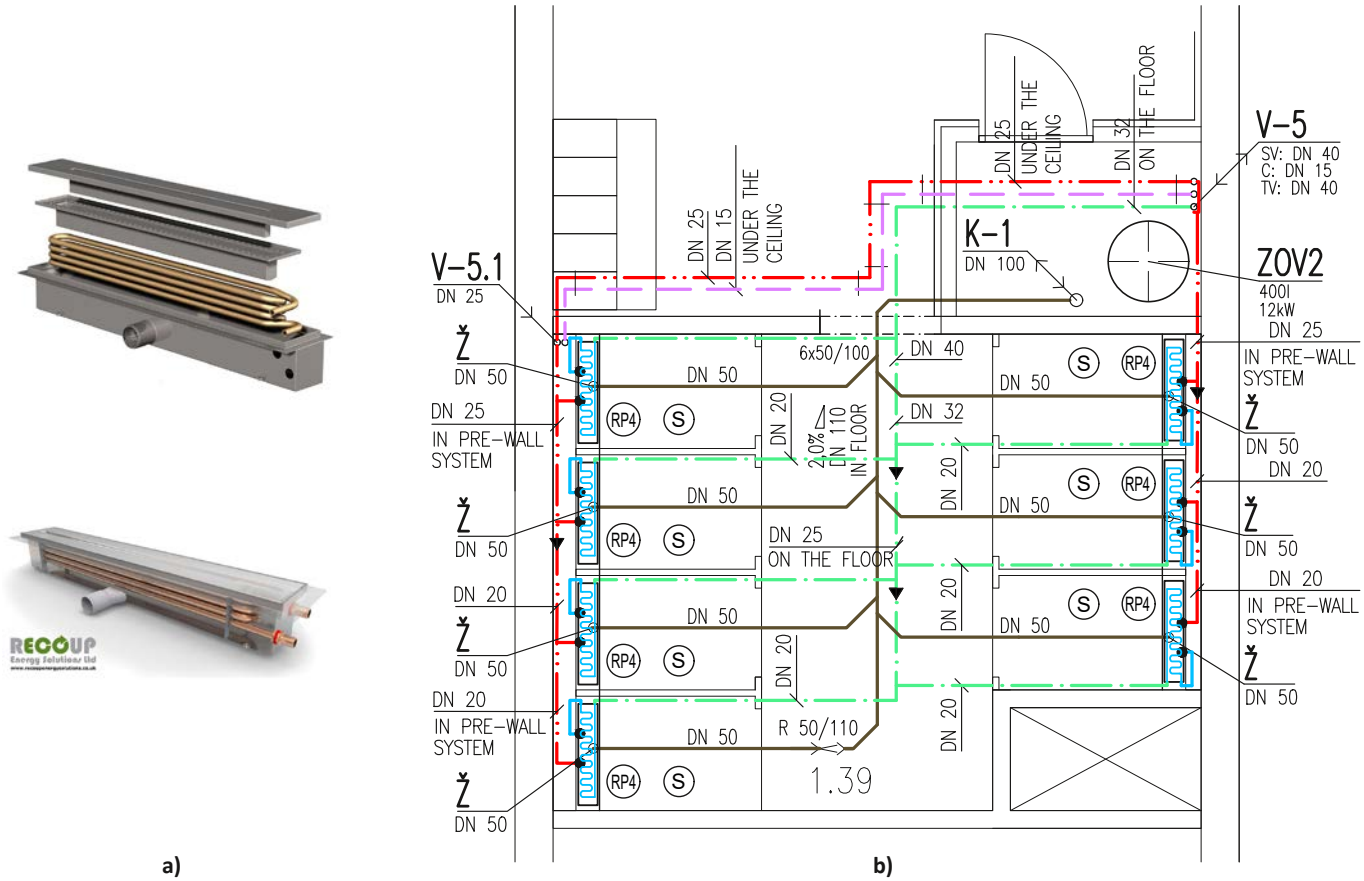


Figure 2. Recovery of waste heat using a heat exchanger in combination with a shower with floor drain system. a) view to the heat exchanger [4], b) floor plan with an application of this heat exchanger. V = rising pipe of cold water, hot water and circulation of hot water, K = foul water stack, ZOV = water heater, Ž = shower with a floor drain system, RP4 = heat exchanger in a combination with floor drain system, S = thermostatic shower mixture tap. [author]

C. *Heat exchanger in the form of regenerative panel placed under the shower tray*

Application: If in the object is a shower designed with a shower tray, another option is using this regenerative panel with plastic casing and heat exchanger made of a copper pipe [6] (**Figure 4a**).

Principle: **Figure 4b** shows the sanitary equipment floor plan where the heat recovery is solved using a regenerative panel placed under the shower tray. The wastewater (38°C) is drained through the panel placed under the shower tray, on the floor. Cold water is supplied through the heat exchanger in order to preheat it, preheated water is supplied to the shower mixer.

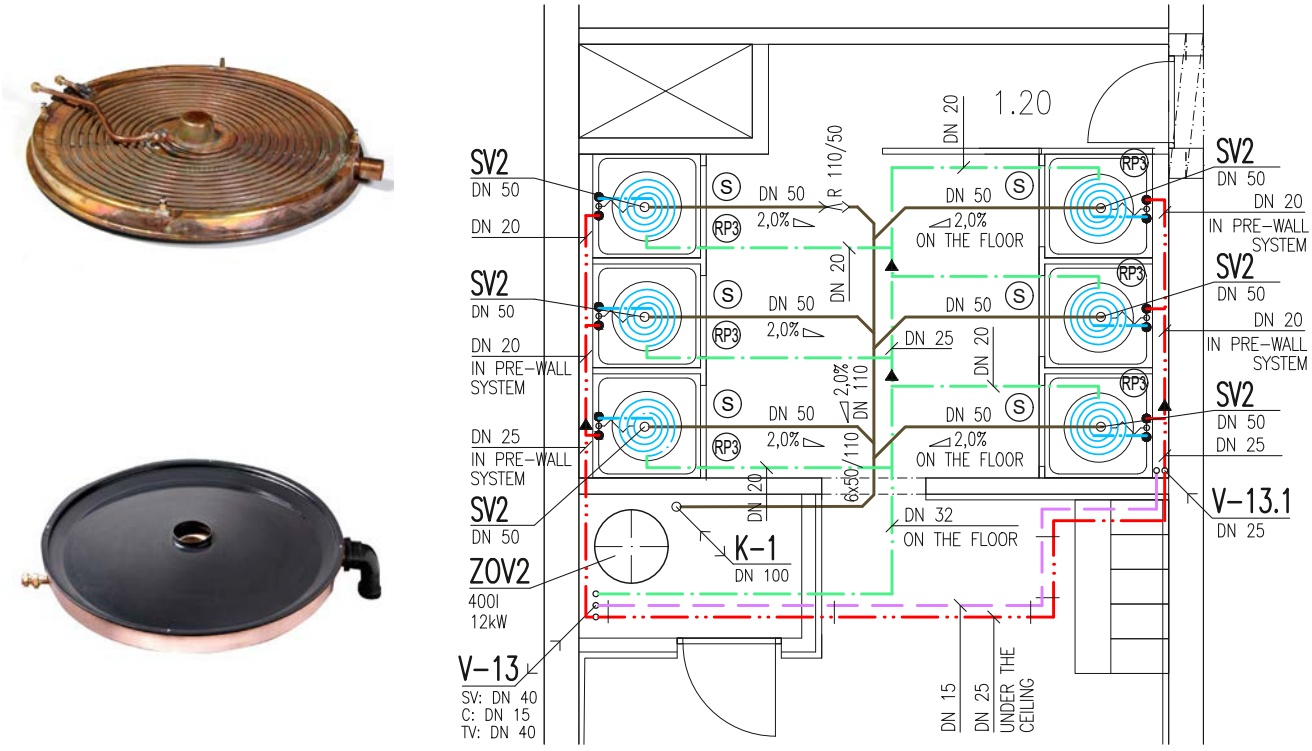
D. *Regenerative panels with stainless steel heat exchanger*

This recuperation system consists of a heat exchanger in the form of regenerative panel [3].

Application: This alternative could be used in sanitary equipment where showers without shower trays are designed. This panel consists of a plastic waterproof case and a stainless-steel heat exchanger (**Figure 5a**). The heat exchanger is placed on the floor, as close to sanitary equipment as possible. The regenerative panel is available in two versions: *630 mm long version and 1320 mm long version.*

Principle: The wastewater from the shower (38°C) flows through the heat exchanger placed in the thermal insulation layer of the floor. **Figure 5b** shows a floor plan with an alternative solution of heat recovery when the cold water is supplied into the thermostatic shower mixer tap through the heat exchanger and heat from wastewater is extracted and transferred into the cold water (10°C) in order to preheat it (20°C). *I suggest using a 630 mm long recuperation panel for one shower and one longer recuperation panel with a 1320 mm length for recuperation of sewage water from two showers.*

Figure 5c shows a floor plan with an alternative solution of heat recovery by using heat exchangers with their **parallel installation**. For three showers I suggest the parallel connection of three heat exchangers through which the water will be preheated for three shower ther-



a) b)

Figure 3. Floor plan with alternative solution using a shower tray with integrated heat exchanger. a) view to the heat exchanger [5], b) floor plan with an application of this heat exchanger. V = rising pipe of cold water, hot water and circulation of hot water, K = foul water stack, ZOV = water heater, SV2 = squared shower tray with drain in the middle, RP3 = shower tray with integrated heat exchanger, S = wall-mounted thermostatic shower mixer. [author]

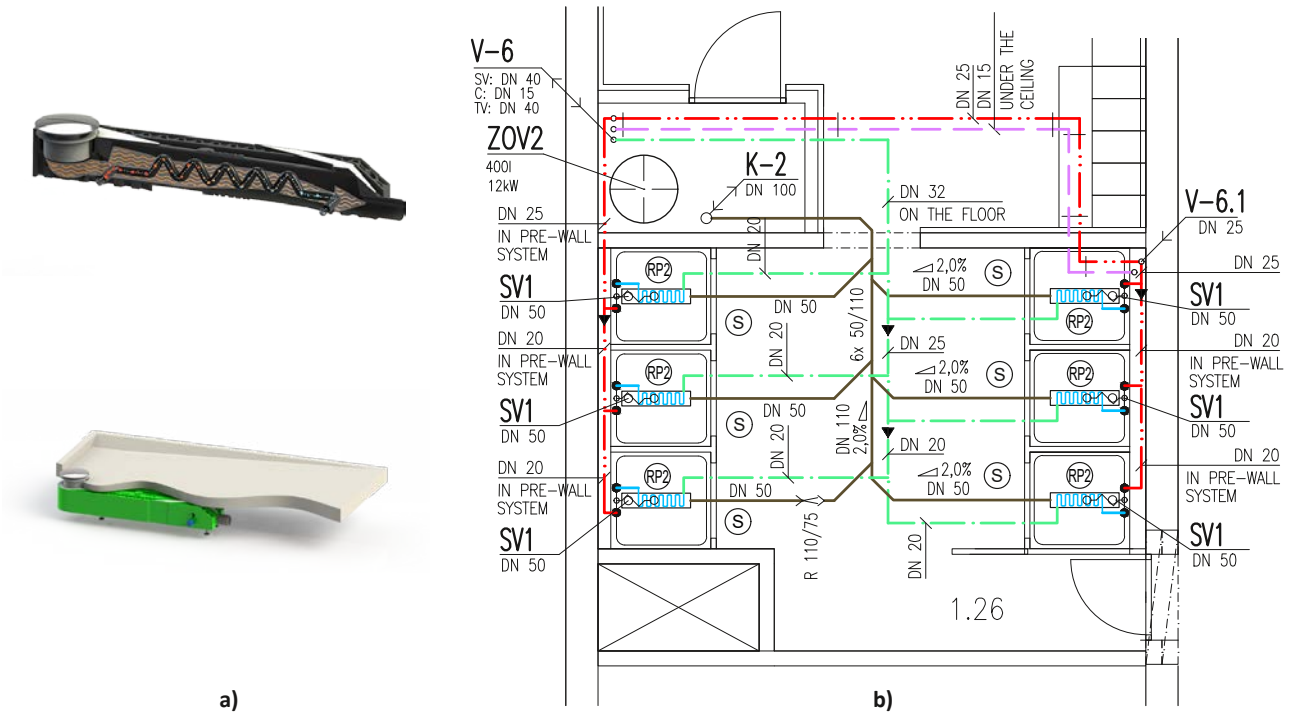


Figure 4. Alternative solution of recovery of waste heat using a heat exchanger placed under the shower tray. SV1 = squared shower tray with drain, in the middle, RP2 = heat exchanger - regenerative panel placed under the shower tray, S = wall-mounted thermostatic shower mixer.

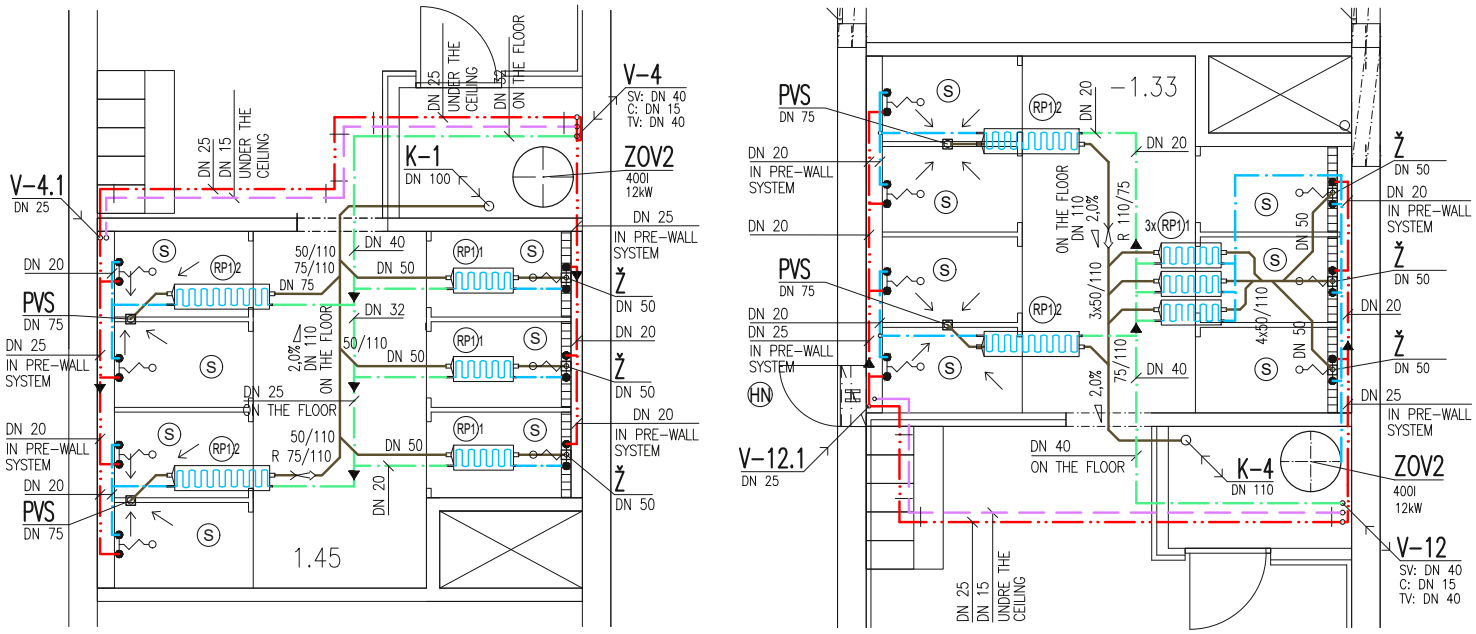


Figure 5. Alternative solution of recovery of waste heat using a panel with stainless steel heat exchanger. a) view to the heat exchanger [3], b) direct installation, c) parallel installation of heat exchangers. V = rising pipe of cold water, hot water and circulation of hot water, K = foul water stack, ZOV = water heater, PVS = shower floor drain, RP1 = regenerative panel with stainless steel heat exchanger placed in the floor: RP1.1 = length of panel 630 mm, RP1.2 = length of panel 1320 mm. [author]

mostatic mixer taps. In this alternative solution I also suggest supplying the preheated water (20°C) **into the storage water heater**.

The contribution describes four types of heat exchangers applied in the sanitary equipment of a sport complex. The energy efficiency always depends on the flow rate of hot water and the efficiency could decrease as a result of dirt accumulating on the inside of the heat exchanger – *every heat exchanger must be maintained sufficiently,* as follows:

- every heat exchanger must be installed with a shower drain filter and trap to prevent the passage of debris. Like any other drain pipe, is strongly recommended a periodically cleaning;
- if it is necessary, the shower drain filter should be cleaned or replaced for a new one;
- the surface of the heat exchanger can become slightly fouled, it only takes a couple of minutes, once or twice a year to clean the surface using some detergent and brush.

The maintenance required for the heat exchanger is very minimal, however, it is recommended to clean the unit periodically to avoid any reduction in efficiency. This cleaning will remove any build-up of soap and dirt residue on the inside of the copper pipe where the wastewater passes [3].

Conclusion

The aim of article was to introduce different possibilities of using heat from internal sewerage systems and answer to the question about reducing the need for preparation of hot water. Heat recovery from sewerage systems inside of the buildings could be applied in dwelling houses and apartment flats, in sports facilities, swimming pools or factories and the advantage of these systems is that, in addition to their simplicity and price, there is no need for electricity to operate them.

In the article there are presented alternative solutions using recuperation. The options of recovery of waste heat from sewerage systems are many and these systems can also be applied in our conditions. Sewage water is full of unused energy and presents a low-potential renewable source of energy that can be used to prepare hot water or heating and cooling the building. ■

References

[1] Buzás, V. (2019): *Heat recovery from sewage systems*, Dissertation thesis, Faculty of Civil Engineering, Slovak Technical University of Technology in Bratislava. Bratislava, Slovakia (in Slovak).

[2] J. Peráčková, V. Podobeková (2013): *Utilization of heat from sewage*, In Budownictwo o zoptymalizowanym potencjale energetycznym, pp. 79 - 86., ISSN 2299-8535.

[3] Innova renewing energies. Bee the heat recovery system for hydro- sanitary systems. Available from: https://www.innovaenergie.com (online).

[4] RECOUP, Recoup drain+, Drain+Compact Heat Exchanger, Available from: https://recoupwwhrs.co.uk/products (online).

[5] HEI-TECH, Shower trays - The Recoh tray heat exchanger, Available from: https://www.specifiedby.com/hei-tech/the-recoh-tray (online)

[6] ZYPHO Drain water heat recovery system, Available from: https://www.zypho.eu/products/zypho-standard (online)

[7] SHENOY V.U.: *Heat exchanger network synthesis*. Proces optimization by energy and resource analysis. Houston: Gulf Publishing Company, 1995. ISBN0-88145-319-6.

[8] Buri, R., Kobel, B. (2005): Leitfaden für Ingenieure und Planer," Institut Energie in Infrastrukturanlagen Zürich, ECO.S Energieconsulting Stodmeister, Berlin

[9] Muller E.A., Sschmid F., Kobel B. (2005): *Heizen und Kühlen mit Abwasser*, Institut Energie In Infrastrukturanlagen Bundesverband Wärmepumpe (BWP), München

[10] Brunk M.F., Seybold C.: *Dezentrale Wärmerückgewinnung aus häuslichem Abwasser, Endbericht der RWTH Aachen, Lehrstuhl für Baubetrieb und Gebäudetechnik* im Forschungsprogramm Forschungsinitiative Zukunft Bau des Bundesministeriums für Verkehr, Bau und Stadtentwicklung, Aktenzeichen" SF-10.08.18.7-10.4.