Zukunft Bau

SUMMARY

Title

In-house heat recovery of domestic waste water

Occasion

About 5 % of the total final energy consumption in Germany is used for water heating. Referring to buildings the percentage of the final energy consumption for domestic hot water is about 11 %. This tremendous amount of energy contained in the waste water is mostly unused discharged in the sewage system.

Content

The research project „In-house heat recovery of domestic waste water" aims at using the heat of waste water flows in-house before entering the sewage system. Due to the high source-temperatures of the waste water inside the building - of 23 to 26 °C on average - the efficiency and profitability of a heat pump system can be increased extensively. It is appropriate to use the heat pump for domestic hot water heating in the building to create a heat cycle wherein the supply and the demand of energy are comparable.

In the research project an extensive potential analysis for in-house waste water heat recovery based on long term measurement data is conducted. For this purpose, the amounts of drinking water as well as the temperatures of the waste water flows are measured (cp. fig. 1) in two student residences (246 and 209 inhabitants), a hotel (150 rooms) and a hospital (348 beds). The estimated amount of waste water is based on the measured amount of drinking water. The aim of this monitoring concept is to determine representative time-variation curves of simultaneously waste water temperatures and flows in different types of buildings in order to identify the energetic potential of waste water flows. To derive time-variation curves for single days of the week the measurement raw data (in five second intervals) have to be transformed in hourly data and also statistically evaluated.

In conclusion, all time-variation curves (cp. fig. 2 to 5) show a well distinct drinking water peak during the morning hours. Additionally there is a second, less distinct consumption peak in the evenings in buildings with residential or hotel function. While in residential buildings the daily average amount of consumed drinking water in the Federal Republic of Germany (FRG) of 122 liter per person is reached, consumption levels in hotels and hospitals are higher. The average waste water temperatures of 23 to 26 °C show the comparatively high source-temperature level. Consequently waste water represents an ideal heat source for heat pumps.

In this context an analytical concept is developed to enable an energetic evaluation of waste water heat recovery (system concept cp. fig. 6). The results of different scenarios indicate high performance levels of heat pumps that – projected at a whole year of operation – lead to seasonal performance factors of 3,0 to 4,7. Heat pump systems that

provides a preheating of the domestic hot water to 45 °C, reach seasonal performance factors of approx. 4,5. This concept contains a second boiler (reheater), for example a gas boiler, that provides the temperature raise to the hot-water temperature of 60 °C in order to ensure a hygienic uncritical supply system concerning legionella growth. The systems that generate the entire domestic hot water heating on the temperature level of 60 °C achieve seasonal performance factors of approx. 3,0.
As a result of the eutrophy of waste water, the formation of biofilm on the sewage-sided heat exchanger can be expected, which significantly constrains the heat transmission. The reduction of biofilm formation with the help of automatic cleaning processes for instance is essential for the system efficiency. The cooling down of the waste water by the use of the heat pump to 15 °C on average is rather moderate. Consequently it can be assumed that there will be no decisive interferences on downstream waste water treatment processes.

Conclusion

The determined time-variation curves of waste water temperatures and flows show the high energetic potential of the heat source waste water, that can be used efficiently in-house with heat pump technology for domestic hot water heating.
Based on a daily domestic hot water demand of 40 liter per person with a hot-water temperature of 60 °C, the installation of a waste water heat pump system, compared to conventional generation with gas or oil boiler respectively electrical direct heating, leads with regards to further assumptions to feasible savings of carbon dioxide emissions from 25 to 73 % as well as cost savings from 32 to 77 %.

Key data

In-house heat recovery of domestic waste water

Research group / project manager:

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Total costs: 189.050,00 €

Quota state grant: 115.500,00 €

Project duration: till 31.10.2011

Figures:

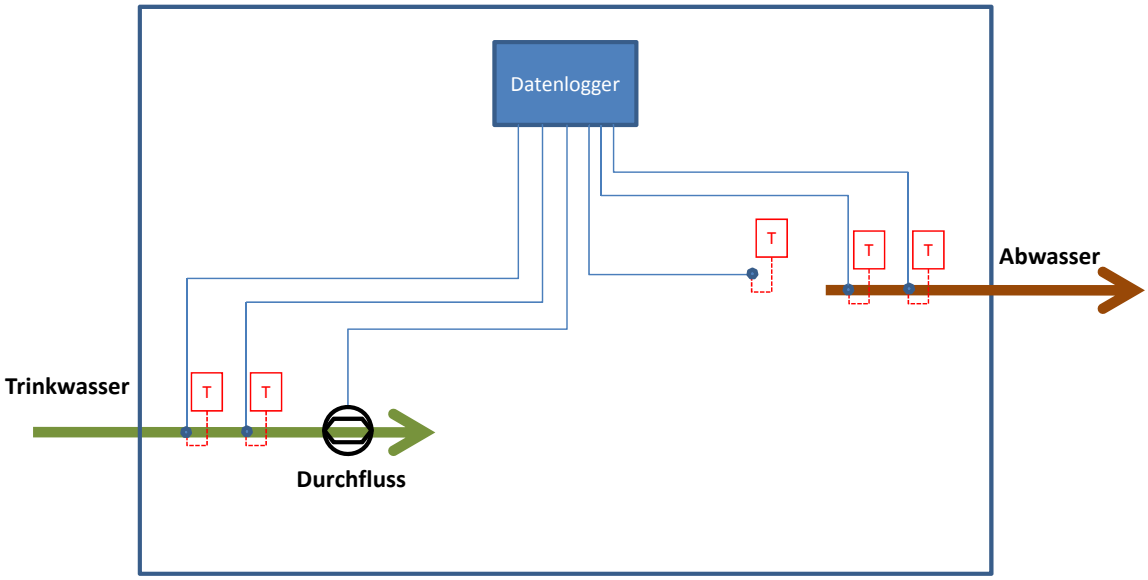

Figure 1: Monitoring concept

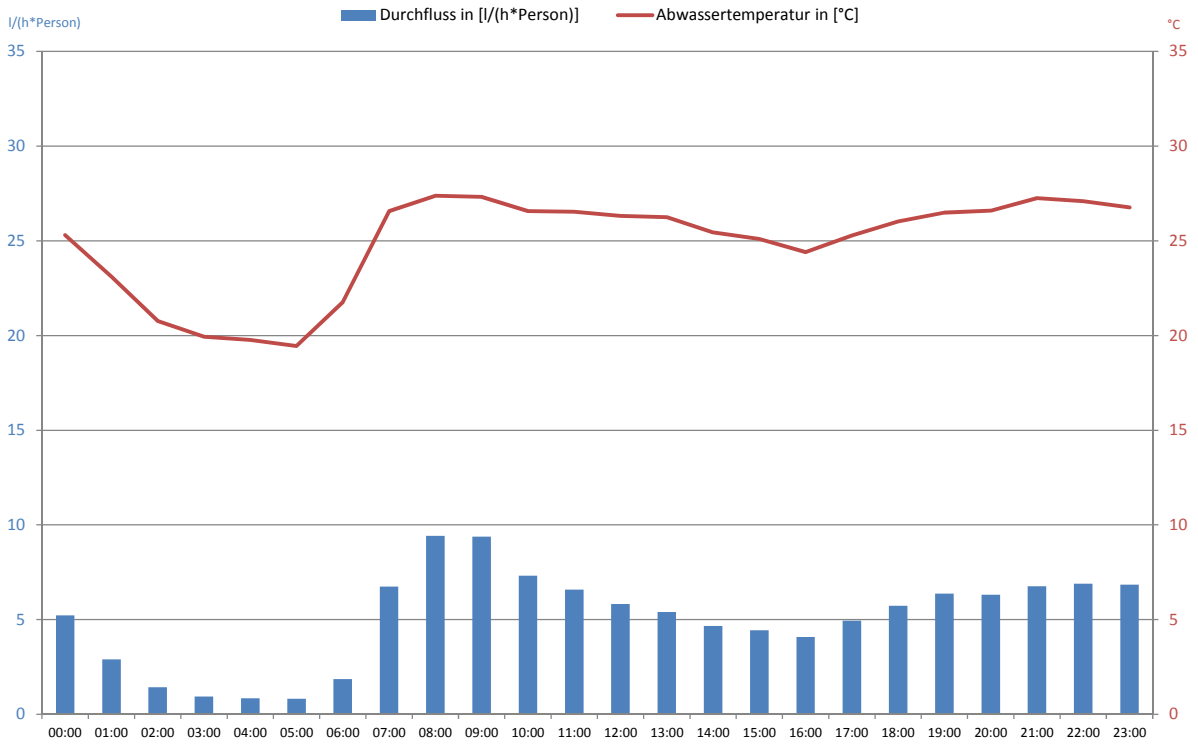

Figure 2: Theodore von Kármán Haus, time-variation curve, workdays

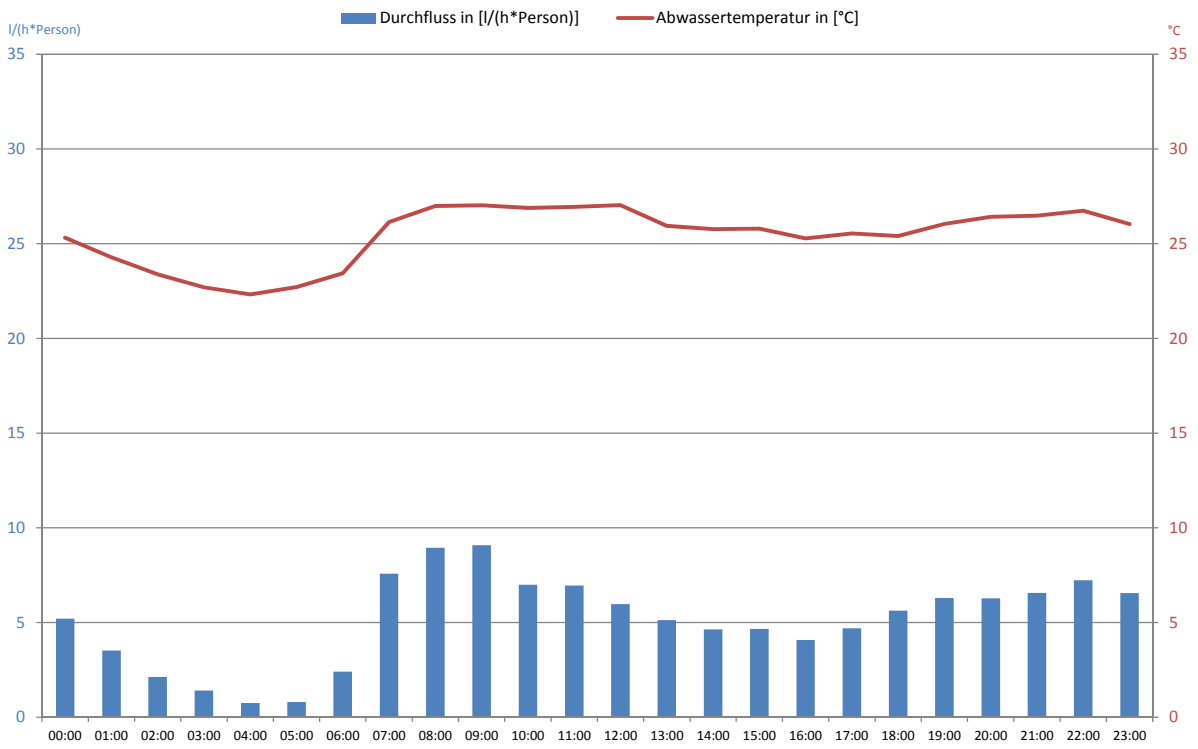

Figure 3: Otto Petersen Haus, time-variation curve, workdays

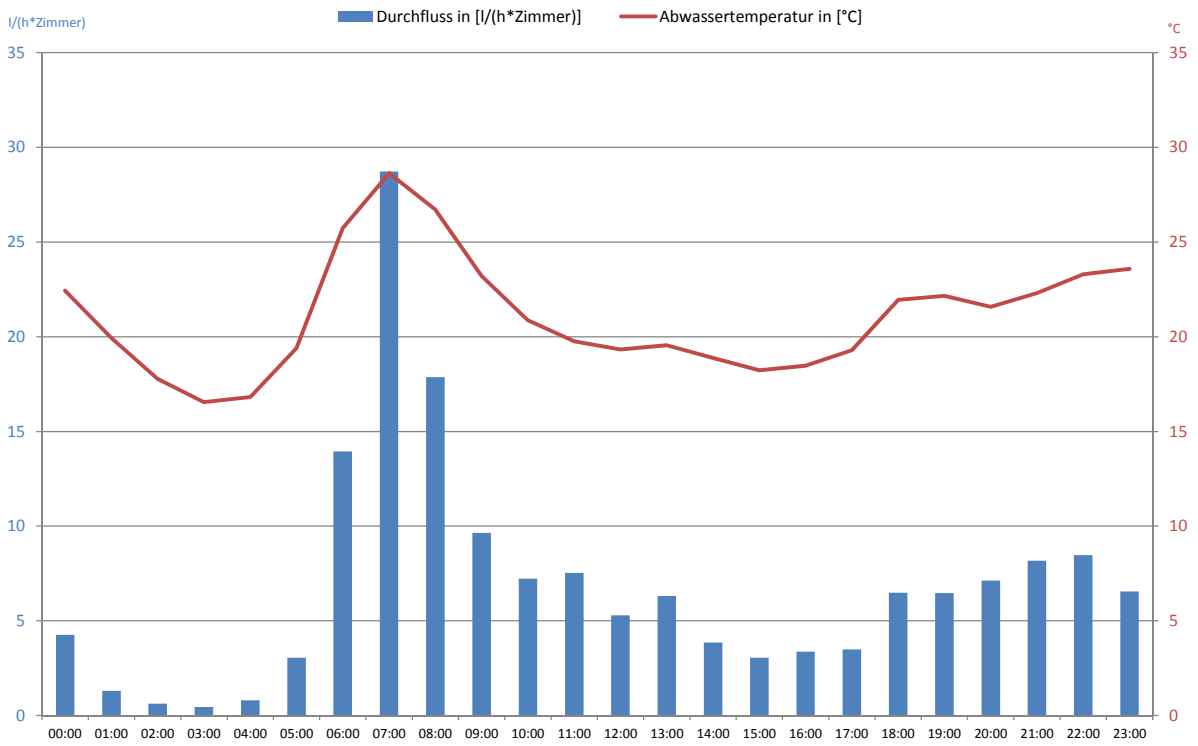

Figure 4: Business Hotel Aachen City, time-variation curve, Tuesday – Friday

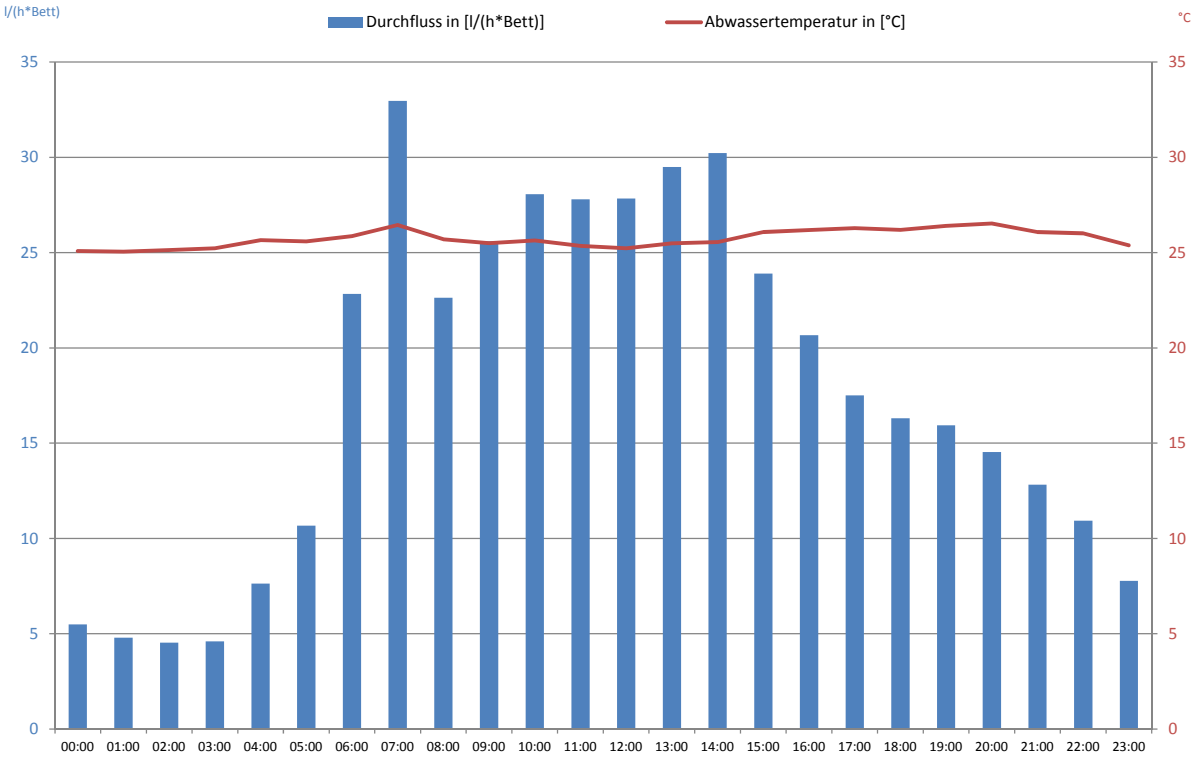

Figure 5: Luisenhospital, time-variation curve, workdays

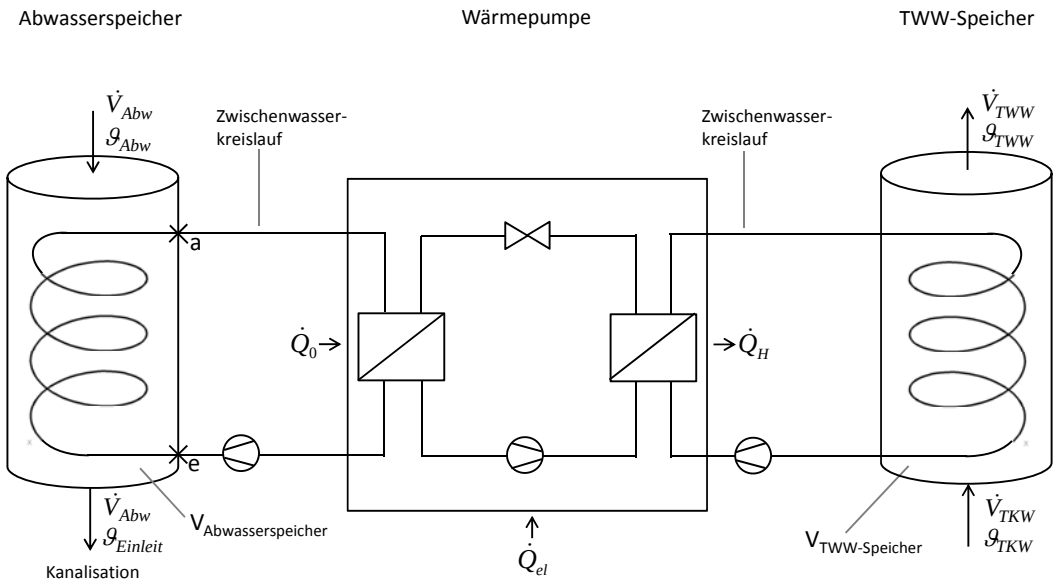

Figure 6: In-house waste water heat pump system