Heat from waste-water

Figure 1: Supply and return lines to the heat-exchanger

The recovery of heat from waste-water is a topic that features energy and waste-water economic dimensions at the same time and can thus entail also a profitable field of activity for network operators. In the past, the IKT examined how the use of heat exchangers in the channel can be technical and economically feasible. The IKT offers possibilities for the collaboration with network operators.

Mode of operation of heat recovery from waste-water

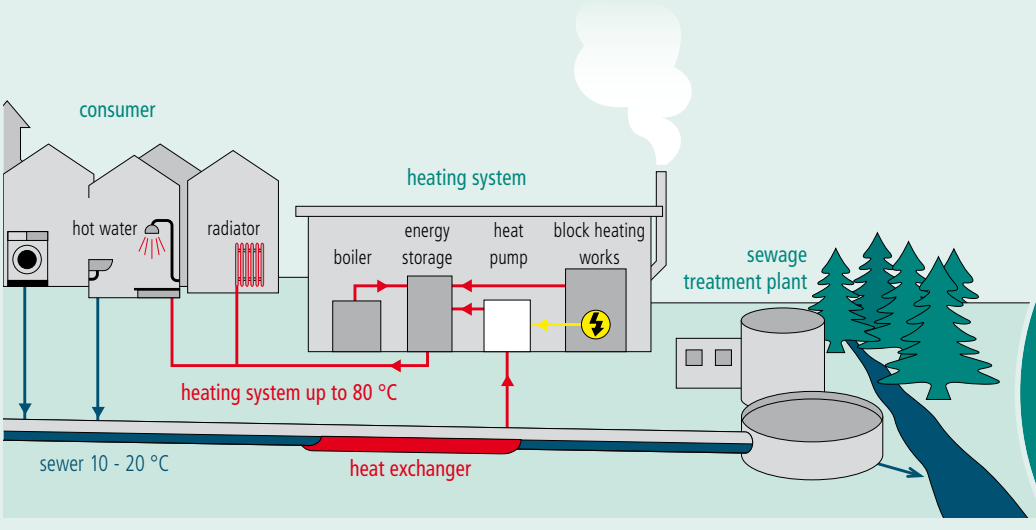
Many uses of drinking water are connected with a heating process, so that waste-water is associated with steady heat dissipation into the sewer system. Depending on the season, waste-water generally features a temperature level between 10 and 20°C. This heat energy can be recovered by means of waste-water heat recovery systems (WHRSs) and can be used for heating real estate as well as for hot water supply. Components of a WHRS are heat exchangers, transmission lines and a heat pump.

The recovery of heat from waste-water takes place in three heat exchange processes: In the heat exchangers above which the waste-water flows, a medium circulates thereby adapting to the temperature of waste-water. The heated medium is fed to a heat pump through transmission lines. There, a second heat exchange takes place through a medium inside the heat pump. This evaporates as result of the heat supply from the channel. In the heat pump, compression of the evaporated medium occurs now by means of which the temperature is raised to a useful level. In a third heat exchange, the heat is fed into the heating circuit.

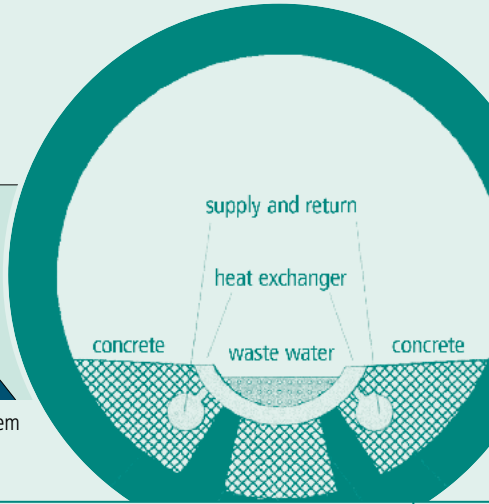
A peculiarity of the heat recovery from waste-water exists in that this is component of a hybrid heating system: The heat pump supplies the base load demand; a conventional boiler is used additionally for peak load demand. A further peculiarity lies in the possibility of using WHRSs for the air-conditioning of rooms. In that case, the heat exchange operates in the reverse direction, i.e. surplus room heat is transferred to waste-water.

Influence of heat exchangers on the sewer system

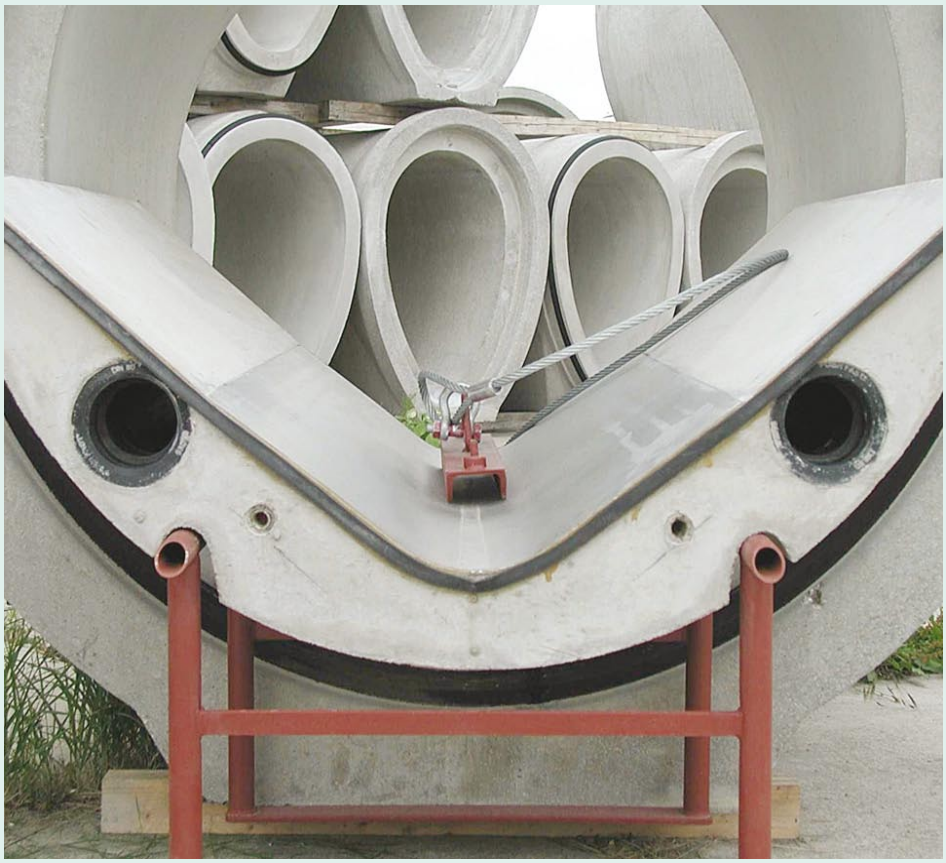
The IKT examined the „Heat recovery from sewer systems" within the scope of the research project, the influence of heat exchangers on the sewer system with respect to working safety, durability, and effect of sewer cleaning. In that case, the IKT researchers oriented themselves towards the heat exchangers, system Rabtherm® installed in Leverkusen/Germany. These heat exchangers consisting of non-rusting stainless steel, with the Material Number 1.4571, are incorporated in a dry-weather sewer and have direct contact with waste-water.



Mode of operation of a waste-water heat recovery system



Right: Heat exchanger in the sewer system



Heat exchanger elements Rabtherm® in a sewer (Figure: Wallstein Ingenieur GmbH)

The investigations yielded that negative effects on leakage tightness or durability are hardly expected just as can restrictions of durability through corrosion be expected. Also sewer cleanings allow no changes to be expected, which have a negative influence on the durability of heat exchanger elements.

With respect to working safety, it could determined to a safe extent that the usual caution necessary, for example, when inspecting brick-built sewers is also appropriate and sufficient when inspecting stainless steel heat exchangers.

Recovery of heat from waste-water

The IKT has worked out the conditions for reasonable use of WHRSs and compiled them in a requirement catalogue. It has become evident that for reasonable utilization of waste-water heat, notable technical and economic restrictions must be observed.

The technical requirements are in the first place directed to features of the sewer system. For the heat recovery from waste-water, there are suitable sewer system sections if the following criteria are fulfilled:

- Minimum cross-section> ND 800 (accessible channel)
- Middle dry-weather drainage> 12 to 15 l/s
- Minimum gradient
- Material and condition of the channel
- no restrictions of the required hydraulic reserves
- sewers that are as straight as possible, with a length of up to 200 m
- Accessibility for building phase and operation
- Exclusion of falling short of the minimum operating temperature for waste-water treatment systems

Altogether, the technical requirements are already manifold. Based on the size of the sewer system networks, sewer system sections can be found, which fulfil technical restrictions and are thus fundamentally available for the heat recovery from waste-water.

Marketing of heat from waste-water

Beyond the recovery, the marketing of the heat energy plays a central role. Therefore, also economic restrictions for the use of WHRSs are to be observed. Suitable locations for the marketing of heat from WHRSs are characterised in that

- in maximum distance of 200 m from the place of heat recovery a heat consumption demand of minimum 150 kW can be served,
- the WHRS is possibly continuously used at full capacity (sale of heat energy in winter and air-conditioning energy in summer) and
- the timeline for investments in new channel construction or restoration, energy supply and heating system coincide.

If these prerequisites are fulfilled, the economic advantages of an WHRS can come to effect. However, a further step is required up to the realisation of a WHRS: The involved participants must undergo a voluntary and durable cooperative relationship. Involved participants are channel network operators and energy providers on the supply side and real estate owners on the demand side. In this constellation, cooperation can come into being if all expense (investment and overhead) can be covered and furthermore a profit can be collect from the yields of marketing the heat energy. In that case, the heat energy must be offered at competitive prices so that heat from waste-water also becomes interesting for the demand side.

The profitability is the economic key criterion in the marketing of waste-water heat. A profitable WHRS exists if heat energy is offered at competitive prices and from the proceeds all occurring investment and overhead as well as the profit claims of the supplier (channel network operator, energy provider) are served.

Potential of heat recovery from waste-water in NRW

With the help of heat exchangers, 1.5 kWh per Kelvin temperature difference can be recovered from 1,000 litres of waste-water. The output capacity per metre of heat exchanger is about 2.5 kW. Thus, a system with a maximum of 200 m long heat exchanger features output capacity of approximately 500 kW.

Whilst considering technical and economic restrictions, the IKT has the roughly calculated the potential for the recovery and marketing of heat from waste-water for the State of NRW. According to the IKT's estimation by considering the criteria cited above, an annual potential exists for about 50 WHRSs with an entire output capacity of 25 megawatts within the approximately 87,000 km of long sewer system in NRW (German state North Rhine Westphalia).

Altogether only a niche potential for heat recovery from waste-water exists today, which will not be exhausted for along. In that case, some aspects are to be emphasized especially supplementarily: Because the potential of 50 WHRS involves an annual value, the energy economic and environmental effects (reduction of primary energy use and CO_2 emission) would cumulate over the time axis.

Moreover, an increased competitiveness of WHRS is to be expected with the increase of crude oil prices because in WHRSs primary energy is required only to comparatively small scope. In the end, also learning effects can find positive expression in the economics during erection and operation of WHRSs.

Systematic development of waste-water as heat source

In order to be able to use heat from waste-water, first of all a careful selection of suitable locations must occur based on the criteria illustrated above. For the selected locations, the profitability to be expected must be determined based on economic calculations in an individual case. In case of a positive result, the basic prerequisites are fulfilled for the cooperation of involved participants.

The development of the waste-water heat source according to the opinion of the IKT are contrary to a combination of lack of information and different knowledge distribution (information asymmetries): Suitable locations are fundamentally available, however, they are known to neither the channel network operators nor to the energy providers. Moreover, information asymmetries exist indicating that energy providers know little about the waste-water and energy quantities at disposal in the sewer system. Also, it is not well known to the energy providers when channel sections are restored and where the channel sections are, which generally fulfil the technical prerequisites for the heat recovery from waste-water. A comparison with the demand for heat energy can therefore not take place. On the side of the network operators, the knowledge about suitable sewer system sections is available, on the other hand not the knowledge about the chances and risks of marketing of energy.

If now the waste-water heat source is supposed to be developed systematically, then the information asymmetries must be dismantled. This can occur in the following idealised steps:

- The network operators disclose those locations for which the technical requirements are fulfilled for the heat recovery from waste-water.
- The energy providers undertake an assessment of the locations with regard to the marketing chances.
- For potentially suitable locations, an economic viability calculation is performed.
- Sewer network operators and energy providers agree on a binding regulation about the distribution of the profit as well as of the tasks and obligations for the erection and operation of the WHRSs.

Benefit for sewer network operators

The recovery of heat from waste-water can be advantageous for sewer network operators because revenue is earned from the provision of the sewer system for the heat recovery. In that case, at minimum, the costs incurred by the utilization the waste-water heat must be compensated including the additional overheads (for example, increased inspection and cleaning expenses). In order to give network operators an incentive for commitment to the heat recovery from waste-water, they must additionally participate in the profits from marketed waste-water heat. As far as the financial freedom of action for mastering of the draining task can be improved in this manner, indirect benefit also emerges for to the benefit of the water conservation.

A further interesting aspect exists, in that, the sewer system gains importance for energy supply system, not often perceived by the public, beyond the function of the waste-water disposal. Energy economic topics enjoy much attention in the public, above all if environmentally friendly energy sources play a role. If the services around the sewer system come into the consciousness of citizens more strongly through the heat recovery from waste-water, then advertisements for positive attitude to the activities by channel network operators can be made in this manner. Good relations between channel network operators and citizens can pay off at some point in time if channel network operators must approach the citizens with less popular tasks, for example, with regard to the drainage of real estate.

Heat exchanger elements Rabtherm®
(Figure: Wallstein Ingenieur GmbH)

Rabtherm® heat-exchanger elements not yet installed
(Figure: Wallstein Ingenieur GmbH)

What the IKT can do for you

The IKT has the know-how for the identification of sewer system sections suitable for the heat recovery from waste-water. With the application

Heat exchange

of this knowledge, from neutral and independent side, to the existing sewer system of your community, the cornerstone can be laid for a systematic development of waste-water heat source. The IKT offers following services:

Feasibility study

- Report on the conditions and possibilities of heat recovery in your community
- Process design for further development of waste-water heat source
- Designation of the participants to be involved

Potential analysis

- detailed investigation to identify potentially suitable locations
- energy and environmental potential of the heat recovery from waste-water

Contact development and presentation

- Dialogue with the participants to be involved at municipal level
- Development of networks at superregional level
- Experience exchange
- Standardisation of procedures

Your advantages: High economic viability, decision certainty, image effects

Point of contact in the IKT

If you would like to know, which potential your sewer system network offers to the heat recovery from waste-water, please get in touch with. We will be grateful to discuss with you in a personal meeting about the possibilities of support by the IKT.

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neutral
independent
non-profit institute

IKT - Institute for Underground Infrastructure

ABOUT IKT

IKT - Institute for Underground Infrastructure is a research, consultancy and testing institute specialized in the field of sewers. It is neutral and independent and operates on a non-profit basis. It is oriented towards practical applications and works on issues surrounding underground pipe construction. Its key focus is centred on sewage systems. IKT provides scientifically backed analysis and advice.

IKT has been established in 1994 as a spin-off from Bochum University, Germany.

The initial funding for setting up the institute has been provided by the Ministry for the Environment of the State of North-Rhine Westphalia, Germany's largest federal state.

However, IKT is not owned by the Government. Its owners are two associations which are again non-profit organizations of their own:

a) IKT-Association of Network Operators:
Members are more than 120 cities, among them Berlin, Hamburg, Cologne and London (Thames Water). They hold together 66.6% of IKT.

b) IKT-Association of Industry and Service:
Members are more than 60 companies. They hold together 33.3% of IKT.

You can find information on projects and services at:
www.ikt.de

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