Recovery of heat from waste-water

The IKT has performed on behalf of the NRW Ministry of the Environment a study into the conditions under which recovery of heat from waste-water might be technically and economically feasible using currently available technology. These conditions then formed the background for an approximate assessment of the energy- and environmental-policy potentials for the state of North Rhine-Westphalia.

The process of heat-recovery from waste-water

More than 1,200 million m^3 of drinking-water (referred to in engineering circles as „potable" water) are consumed every year in the German state of North Rhine-Westphalia. The majority of uses are associated with heating. Waste-water temperatures in the municipal drain and sewer system in NRW, with a total length of 90,000 km, are predominantly between 10° C and 20° C. This waste-water therefore has a thermal potential which might make it interesting for recovery of heat. Waste-water heat recovery systems (WHRSs) are used in order to exploit the heat contained in waste-water for the heating of properties and for provision of hot-water supplies. Heat-exchangers are installed in suitable section of drains and sewers and transmission lines; the overall system is completed by a heat-pump and, where required, a unit-type heat+power cogeneration plant for supply of the energy necessary to drive the heat-pump.

WHRSs are used to supply base-load, and additional heating systems, such as a conventional oil-fired or gas-fired heating boiler, for example, are necessary to cover peak loads. WHRSs can also be used for air-conditioning, however; in this case, the heat-exchange takes place in the reverse direction, i.e., surplus heat from rooms in buildings is transferred to the waste-water.

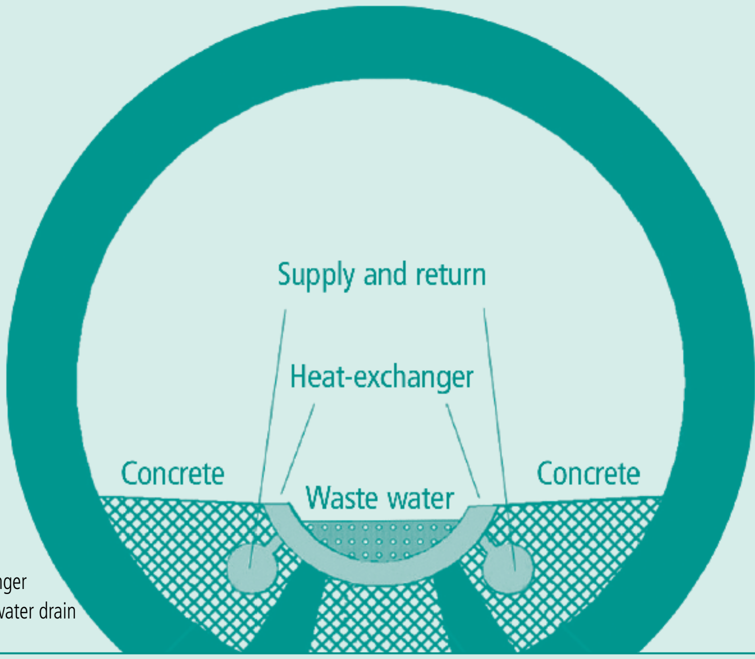
The effects of heat-exchangers on the drain/sewer system

One important precondition for the exploitation of waste-water heat is that waste-water disposal must not be obstructed. For this reason, the IKT has conducted tests on heat-exchanger elements in order to assess their working reliability, durability and effects on conduit cleaning:

Supply and return lines to the heat-exchanger

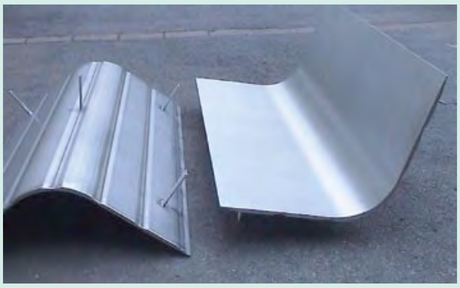
Overview of the IKT test program

	Test	Test criterion/Result
Working reliability	Shearbox	Coefficient of static friction and coefficient of kinetic friction
	In-situ determination of coefficient of kinetic friction	Coefficient of kinetic friction
	Entry	Slipping hazard
Durability	Exposure in accordance with DIN EN 175	Visual inspection and mass losses
	Exposure in accordance with operational loads	Visual inspection
	Darmstadt tipping runner	Abrasion
Conduit cleaning	Abrasion tests with a nozzle-body	Mechanical exposure
	Impact tests	Mechanical exposure
	Hamburg flushing test	Hydrodynamic exposure



Heat-exchanger in a waste-water drain

All the tests were orientated around Rabtherm® system heat-exchangers elements, which the Technische Betriebe Leverkusen (Leverkusen Municipal Engineering Department) has installed in a drain. The heat-exchanger elements consist of stainless steel (Material No. 1.4571), are installed in a dry-weather channel, and are in direct contact with the waste-water.



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

The IKT studies indicated that neither negative effects on tightness and stability, nor any restrictions on durability caused by corrosion processes, need be anticipated. Drain-cleaning operations also cause no negative effects on the durability of heat-exchanger elements.

In the case of working safety, the normal care and normal precautions taken for entry to masonry conduits are, to be on the safe side, appropriate, but also adequate, for entry to stainless-steel heat-exchangers.

Suitability of drain sections for installation of heat-exchangers

There are specific technical requirements which determine the suitability of sections of drain conduit for the installation of heat-exchangers:

- Minimum cross-section > DN 800 (walk-in conduit)
- Average dry-weather flow > 12 to 15 l/s
- Minimum gradient
- Conduit material and condition (in case of retro-installation)
- No restriction on necessary hydraulic reserves (in case of retro-installation)
- Conduits with straightest possible course, with a straight length of up to 200 m
- Accessibility during both construction phase and operation
- Constant minimum temperature for treatment-plant operation

Rabtherm® heat-exchanger elements in a drain (photo: Wallstein Ingenieur GmbH)

The technical requirements are, it is true, on the whole rather numerous and diverse, but it is nonetheless perfectly possible to find locations that fulfill all of these criteria.

Profitability the key economic criterion

Marketing of thermal energy recovered from waste-water will be possible only provided the participating bodies, i.e., the energy-supply utilities, the system operators and property owners, are prepared to enter into a long-term cooperation which will bring economic benefits for all concerned. The time-horizon involved extends to fifty years or more.

System operators (SOs) will have incentives to utilize waste-water heat provided installation and operating costs are completely covered and, in addition, it is possible to achieve a profit.

From the point of view of property owners (POs), the kWh-prices for thermal energy from waste-water must, depending on location and preference, not be greater than market prices for thermal energy from conventional and from renewable heat-supply systems.

Energy-supply utilities (ESUs) which market thermal-energy recovered from waste-water will, ultimately, expect to achieve a net surplus which must meet their profitability criteria. The central economic requirement for recovery of heat from waste-water is located in the profitability of the WHRS: only WHRSs which operate profitably will, ultimately, make it possible to satisfy the requirements of system operators and the ESUs' profit criteria and to supply property owners with thermal energy at competitive prices.

Recovery of heat from waste-water not profitable at present

The purchase and installation of an WHRS and, where necessary, a unit-type cogeneration plant, involve high levels of investment and therefore tie down a large amount of capital. Significant internal costs borne by the system operator must also be added to this calculation. The total investments for an WHRS can easily amount to 500,000 Euro.

System operators' internal costs

Phase	Costs	Relevance
Preparatory	Information costs	high
	Planning costs	high
	Negotiation costs	high
Construction	Material selection	medium
	Installation organization	medium
	Quality Assurance	high
Operational	Capital costs	very high
	Inspection/cleaning, miscellaneous	low
	Success checking	low
Decommissioning/Disposal	Dismantling/disposal	low
	Refurbishing	low

In addition, continuous running costs, consisting essentially of operating costs (energy, servicing and maintenance, premises costs, insurance costs, etc.), depreciation and interest, must also be taken into account.

On an overall view, the recovery of heat from waste-water does not, at present, exhibit the profitability which would be necessary to permit it to assume a relevant position on the market. It must also be noted that potential sales-related (market) risks across the installation's productive life of some fifty years would need to be borne by the WHRS operators and, possibly, also by the participating drain-system operators.

Orientational points for optimization of profitability

Profitability can, in principle, be increased by reducing the amount of capital tied down, by reducing costs and/or by increasing the income generated. Investment levels and continuous costs (depreciation) are lower if WHRSs are installed in the context of the construction of new drain systems or of rehabilitation projects.

Proceeds from operation can be increased if WHRSs are also used for air-conditioning of properties. Since costs per kWh decrease as the size of the WHRS rises, only properties with large requirements for heat should be supplied using WHRSs.

The politicians will decide

The system for recovery of heat in waste-water drain/sewer systems studied by the IKT is entirely operable from a technical viewpoint. Heat-recovery from waste-water is undoubtedly feasible under the preconditions discussed above (minimum cross-section, dry-weather flow, etc.).

It is, however, nonetheless necessary to view the economic rationality of recovery of heat from waste-water with great skepticism. WHRSs cannot be operated profitably at present, and voluntary cooperation projects between the necessary participants are not likely. Entry to the market is possible at the present time only with state subsidies.

The example of the Leverkusen WHRS illustrates that the facility, despite favourable boundary conditions (construction of a new drain system and new properties, proximity to energy purchasers), would not have been constructed without state financial support. And, despite far-reaching state subsidization, Technische Betriebe Leverkusen ultimately decided against construction of the system. Only with the support of Dortmund's HEC energy-supplier was the installation finally approved and built. The conclusion to be drawn is that, ultimately, it is the politicians who can set the path for or against the use of this technology, with their decisions concerning subsidies.

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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 about 100 cities, among them Berlin, Hamburg, Cologne and London (Thames Water). They hold together 66.6% of IKT.

b) IKT-Association of Industry and Service Providers: Members are about 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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