

## **Heat recovery from raw sewage - An alternative for thermal energy supply in cities**

Urs Studer

Rabtherm AG, Switzerland

*Corresponding email: info@rabtherm.com*

### **THE IDEA**

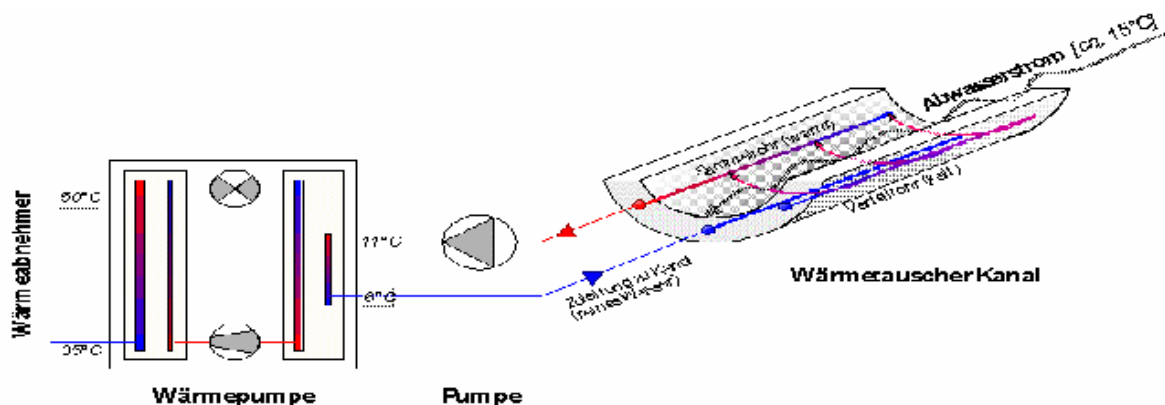
- It is high time that we start recovering and re-using waste heat from industry and households. On a comprehensive view, waste heat could cover at least 30 % of our heating and cooling energy requirements. Today heat is being recovered from exhaust air and used on a very large scale. In many countries this is even governed by regulations. But what happens to waste water? Out of sight, out of mind.
- This was the starting point of the idea to utilize these resources, an idea resulting in the Rabtherm® Energy System. RABTHERM stands for heat recovery and utilization from untreated waste water. On leaving a house, the sewage has an average temperature of over 25°C and in the sewage system an annual mean of 15°C (summer 20°C, winter 10-12°C). Sewage is a continuously renewed source on a relatively high temperature level. With modern heat pumps one can transform this to a useful temperature of 65°C, high enough for hot water production and for the heating of newly constructed houses → heat pump COP's between 3.1 and 5.2, in special cases up to 6.2.
- The heat present in the waste water from residential buildings, trade and industry should therefore be utilized decentrally, i.e. locally, where it is generated, with a heat exchanger in the sewers and a heat pump. The temperature level is higher than that of most of the other natural renewable energy sources. The system can be used for heating and hot water in winter, and for cooling (air conditioning) and hot water in summer.
- The idea is not new but so far heat has been extracted practically only from purified waste water downstream of sewage works. However, since many sewage works lie at the periphery or outside residential areas, with large distances to the heat consumers, this strategy is uneconomic.
- Previous obstacles to the utilization of untreated water directly in the sewage system have been:
  - possible detriment to the biological purification stage in the sewage works, which are designed for a temperature of 8-13°C.
  - lack of suitable heat exchangers which when installed in the drain channel, cannot lead to blockages.→ Today, these problems have been technically and economically solved, and the system is accepted by the authorities, i.e. Rabtherm® can now be marketed. The maximum cooling of the entire waste water on the way to the sewage works will in no case exceed 0.5 K.
- Contamination of the sewage channel and therefore the heat exchanger leads to a decrease in heat exchanger efficiency of up to 40%. (soiling with biomass film) Patented systems to solve this problem.

## THE DEVELOPMENT

- The idea now had to be developed and brought to market in an economic manner.
- For this purpose, a trend analysis was required, e.g.
  - what is demanded by the energy market?  
→ economical and/or ecological products
  - how are other technologies developing?
  - how fast is the political situation changing? (climatic changes, CO<sub>2</sub>, fine dust)
 The trends were quite clear .
  - Electricity prices will drop .
  - Oil and gas prices have a tendency to rise .
  - Energy price surcharges or eco-taxes cannot be avoided sooner or later
- The expected result of the development process was that the local, decentralized utilization of the continuously available, renewable ambient energy by means of Rabtherm systems is
  - economic and
  - ecological / environmentally friendly.
- The goal was to develop a simple, robust and low-cost system. This required special efforts in the following areas:
  - Hydraulics, heat transfer
  - Materials
  - Joining technique
  - Design, installation
 The above objective has been achieved and led to patents. The know-how gained during this process represents a decisive lead over any competition.

## THE PRODUCT (TECHNOLOGY)

- Working principle of the Rabtherm waste heat utilization system



Wärmeabnehmer .....	user
Wärmepumpe .....	heat pump
Pumpe .....	circulation pump
Wärmetauscher Kanal .....	heat exchanger sewage channel
Zuleitung zu Kanal (reines Wasser) .....	connecting pipes (tap water)
Verteilrohr (kalt) .....	distribution pipe (cold)
Sammelrohr (warm) .....	collection pipe (hot)
Abwasserstrom [ca. 15°C] .....	sewage

In the heat exchanger heat is extracted from the waste water and fed to the heat pump via the intermediate medium. The latter (pure water), circulating between heat pump (heat generation) and heat exchanger (heat utilization, heat extraction), is fed through the plastic pipe to the heat exchanger at the start of the cycle. The distributor pipe individually feeds each of the 1 to 3 m long heat exchangers. The intermediate medium warmed in the heat exchangers is then collected in the collector pipe and returned to the heat pump.

For summer cooling, the heat pump is hydraulically reversed, using the waste water as heat dump.



preassembled Rabtherm® - heat exchanger elements

- The specific extraction power of the heat exchanger is approx. 2-9 kW per metre heat exchanger (depending on the sewage flow rate, the flow speed or gradient and the degree of contamination). This rate can increase to 15 kW with pressure pipes. From 1 m<sup>3</sup> of waste water (the contents of 5 bathtubs), the heat exchanger can extract 2-3 kWh of energy.
- Criteria for the application of Rabtherm systems.
  - sewage channel diameter > 400 to 500 mm
  - sewage flow average rate > 12 l/s
  - length of heat exchangers 9 m (min.) to 200 m (max.)
  - heating or cooling power output min. 80 kW
  - distance from sewage channel to user max. 150-300 m
  - heating temperature max. 70°C
- The heat exchanger is cemented into the sewage channel and is designed for a service life of at least 50 years.  
Corrosion, erosion / wear, leak tightness, channel maintenance and cleaning are some of the factors that because of the strict quality assurance criteria, had a decisive influence on choice of material, design, product (welding) and assembly / installation. Parallel to quality assurance, all possible damage repair scenarios have been established following the principles of "analysis-find-repair".
- The maintenance of the sewage channels with the integral heat exchanger requires no special effort. Blockage of the channels is impossible and they are cleaned with conventional equipment. The heat exchanger is dimensioned to withstand this treatment



Rabtherm Wülflingen (CH).



Trockenwetterrinnen Rabtherm Leverkusen (D) Dry weather channels.

## THE MARKET

- After it had been recognized and proved that the system
  - makes good sense energetically, inasmuch as it has already been included in many urban energy plans
  - is economically feasible, in contrast to many other forms of alternative energy
  - brings ecological benefits with comparable or lower energy production costs than with energy from fossil fuels the question of markets and customers was considered.
- Who is interested in Rabtherm?
  - The heat consumer (user)
    - . Rabtherm replaces the conventional heat energy supply with gas or oil by an environmental superior technology utilizing the waste heat from households that generates heat at economically comparable prices
    - . The customer gets the same benefits (heat) at a comparable or better price, but in an ecological manner.
  - Who are the consumers?
    - . Towns and cities with roughly 5'000 inhabitants upwards.
    - . Communal co-operatives and consortia
    - . Industrial enterprises with a significant fraction of consumption for space heating
    - . Private building owners
    - . The public sector
      - . Rabtherm helps the public sector to
        - . improve ecobalances
        - . achieve energy policy goals
        - . guarantee security of energy supply.
      - To supply 100 apartments with heat from waste water, the effluent from 300 apartments plus trade and infrastructure is required. To generate one kWh of heat, about 420 litres of waste water are needed.
      - . Employment.
        - . Rabtherm can generate around 30'000 man-years of work (up to 3'000 jobs).
- Who are our partners in the market?
  - Consulting engineers for the acquisition, study and planning of installations

- Contractors for the installation, maintenance and operation of installations.  
Contractors are e.g.
  - . Electricity utilities .
  - . Municipal works .
  - . Industrial enterprises

Contractors finance the construction of the installations and sell the energy generated. Electricity utilities and municipal works are highly interested in this lucrative second or additional source of income.

- What does Rabtherm cost?
  - Installations
    - . CHF 1'800.00 - 2'500.00 per connected residential unit (€1170-1620)
    - . CHF 500.00 -700.00 per kW of connected useful power (€325-455)
  - Heat exchangers
    - . CHF 1'600.00 - 2'100.00 per m of heat exchanger (€1070-1360) .
    - . The heat exchanger as an element, uninstalled, costs approx. 6-10% of the overall installation.
  - A sensitivity analysis predicts with high probability an improvement of profitability by over
  - 20%, influenced by
    - . the price of electricity
    - . the price of oil
    - . investment costs
    - . technological improvements (heat pump)
- How and where will Rabtherm® be employed?
  - The Rabtherm technology should be examined in the case of
    - . renovation of large sewage channels .
    - . renovation of large central heating or cooling works .
    - . new sewage channels .
    - . larger central heating or/and cooling works in the vicinity of larger sewage channels
- Market potential
  - Towns and cities
  - over 500'000 inhabitants 60 to 120
  - 200-500'000 inhabitants 27-60, equal to approx. 12'000 apartments
  - 100-200'000 inhabitants 20-27
  - 40-100'000 inhabitants 12-20
  - 15-40'000 inhabitants 5-12
  - 5-15'000 inhabitants 1- 5
    - . Switzerland 2500
    - . Germany 25000
    - . Europe 120000
    - . world 400000
- Existing and running installations 17 in Switzerland, Germany, Austria
- Installations in building or planning stadium over 100 in Switzerland, Germany, Austria, France, Ukraine, USA

## **ECOLOGY**

- Rabtherm installations reduce the CO<sub>2</sub> emissions over those from conventional plant by 50-80% (ecological benefit) Rabtherm installations reduce also the amount of primary / conventional energy.
- CO<sub>2</sub>-output with the 17 running plants is reduced by 6000 tons.
- Rabtherm systems produce no fine dust like diesel engines and wood burning plants.

## **WHAT IS THE PRACTICAL SEQUENCE OF EVENTS IN THE PLANNING OF A HEAT UTILIZATION SYSTEM FROM UNTREATED SEWAGE?**

- By means of a check list, a site can be roughly assessed for acceptance or rejection.
- Next the following procedure is scheduled .
  - Fundamental decision by the
    - . sewage channel operator
    - . sewage works operator
    - . community
  - Analysis, site or feasibility study with data on the drainage system and heating furnaces. The studies contain the results of the local examination of sewage channel data (incl. condition) and furnace data, calculations of heating power and profitability, and cost estimates for the investments.
  - Clarification with the users or those to be connected .
  - Project with consulting engineers and contractor .
  - Execution and operation by contractors under long-term heat supply contracts.

Even with generally sinking heat demand, the Rabtherm technology, used in the district heating networks of city agglomerations, has an excellent chance of success, also in towns with an existing remote heating network.

## **ASSESSMENT / CONCLUSIONS**

- The success of waste heat utilization from the public sewer system is based upon the following corner-stones

- |                    |
|--------------------|
| 1. Profitability   |
| 2. Financing       |
| 3. Public interest |
| 4. Ecology         |

- Profitability .
  - The heat production costs with a Rabtherm system are 5-20% lower than for conventionally generated heat.
  - The profitability increases when the installations are used in summer for cooling
  - Financing . by contracting
  - Public interest

- Compliance with goals of energy and environmental policies
- Creation of jobs
- Rabtherm Systems have an excellent outlook Future R&D can bring another 30% of improvement in quality, price and economy

### **RABTHERM PARTNERS**

- engineers
- manufacturing companies
- concrete works
- contractors

have access to all the data, software and the latest research results.

**GO WITH RABTHERM IN THE FUTURE  
GOLD FLOWS CONSISTENTLY AND EVERYWHERE UNDER OUR FEET**

Rabtherm AG (CH)  
Dennlerstrasse 41  
CH - 8047 Zürich  
Tel. ++41 / 44 400 21 21  
Fax ++41 / 44 401 07 27  
e-mail: [info@rabtherm.com](mailto:info@rabtherm.com)  
[www.rabtherm.com](http://www.rabtherm.com)