Waste water is Gold under our feet

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ABSTRACT

Each winter, we can see the heat, warm air, coming up the sewer shafts in city streets and we should realize the enormous heat potential that is down there and just flows away, untapped and unused. The hidden potential is bigger than the heating potential of wood, solar, geothermal energy and biomass together.
It is very important, that this vast potential is discovered by politicians and made public.
The extraction of heat from waste water has become economical and is funded by states, since we are able and allowed to use the waste water in public sewers to heat and cool buildings, with up to 25% lower cost.
Heat recovered from waste water is economical with a return on investment of 2 to 6 years. It is ecological; saving up to 70% of CO_2 emissions and primary energy, and it is in compliance with public energy policies.

1 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 everything including exhaust air. 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 77 F and in the sewage system an annual mean temperature of 59 F (summer 68 F, winter 50-54 F). 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 149 F, 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.
- Previous obstacles to utilization of untreated water directly in the sewage system have been: (1,2)
  - · possible detriment to the biological purification stage in the water treatment plants, which are designed for a temperature of 46 – 55 F.
  - · lack of a suitable heat exchanger which when installed in the drain channel, cannot lead to blockages and is corrosion and erosion resistant.
    The maximum cooling of the entire waste water on the way to the water treatment plant shall not exceed 0.5 K over a 24 hour day.
  - · In water and waste water, a 3-4 mm thick biofilm is developping on every surface, and lowers the heat transfer by 40%.

2 THE DEVELOPMENT

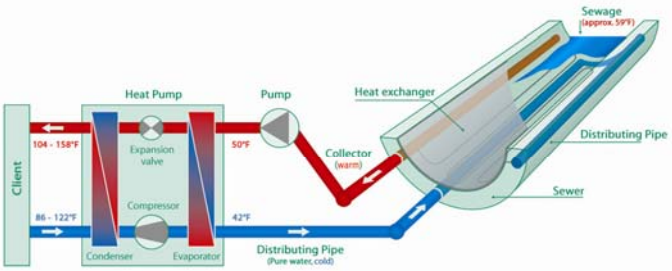
- The expected result of the development process was that the local, decentralized utilization of the continuously available, renewable ambient energy by means of Rabtherm systems is
  - economic and
  - ecological / environmentally friendly.
- The goal was to develop a simple, robust and low-cost system.
  This required special efforts in the following areas:
  - Hydraulics, heat transfer
  - Materials
  - Joining technique, welding
  - Design, installation, cost

• To solve the existing problems, new materials have been developped with good resistance against corrosion and erosion, but also with a good heat transfer coefficient.
To solve the biofilm problem, an anti-fouling system has been very successfully developped and patented. With copper stripes, the fouling can be reduced dramatically.

3 THE PRODUCT AND THE SYSTEM TECHNOLOGY

3.1 Description

The system consists of a stainless steel heat exchanger in the sewer, heat transfer piping to the building and a heat pump, in most of the projects combined with a peak load boiler, which is necessary at temperatures below 0°C (32 F).



• Working principle of the Rabtherm waste heat utilization system

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 a plastic pipe to the heat exchanger at the start of the cycle. The distributor pipe individually feeds each of the 1 to 3m long heat exchangers. The intermediate medium warmed in the heat exchangers is then collected in the collector pipe and returned to the heat pump. (return header system / Tichelmann)
For summer cooling, the heat pump is hydraulically reversed, using the waste water as heat dump.

3.2 Extraction power

The specific extraction power of the heat exchanger is approx. 2-9 kW per square metre of heat exchanger (depending on the sewage flow rate, the flow speed, the slope and the degree of contamination). This rate can increase to 15 kW. with pressure pipes.

3.3 Application criteria

Criteria for the application of Rabtherm systems.
- sewage channel diameter > 400 mm (new sewers)
  > 800 mm (existing sewers)
- sewage flow average rate > 12 l/s (dry weather)
- length of heat exchangers 9m (min.) to 200 m (max.)
- heating or cooling power output min. 80kW
- distance from sewage channel to user max. 150-300 m
- heating temperature max. 70°C

3.4 Construction

• The heat exchanger is cemented into the sewage channel and is designed for a service life of at least 50 years.
• The system can be installed in existing sewers (min. size DN 800) or integrated into new sewers in the concrete or plastic pipe plant. (starting at DN 400)
For pressure pipes, there is a new patented installation technique. Industrial applications with normally high temperature sewage flow 26-40°C (79-104 F) are especially applicable for heat extraction.

-New Sewers

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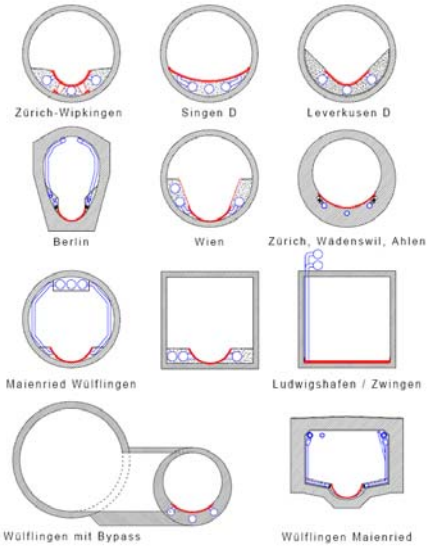
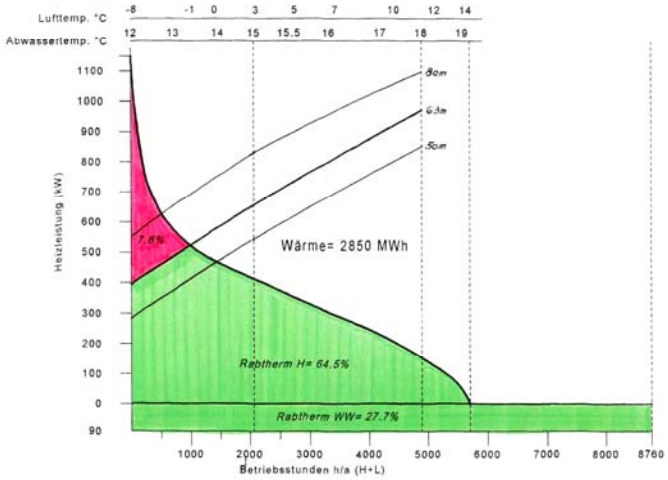
- Existing sewers with antifouling system

• Installation possibilities



• Bivalent system with boiler or district heating for peak load.

The performance diagram shows, that with a heat pump designed for 30 to 40% of the heating demand, the yearly energy demand can be covered between 70 and 90 % by the heat pump.



3.5 Maintenance

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.

3.6 Sequence in planning (3,4,5)

• Checklist basic data
• Site analysis
• Meeting with the sewage and water treatment department
• Feasibility study
• City potential study
• Control measurements of waste water flow and temperature
• User contract with city
• Request for state or government funding
• Economical calculations, roi
• Project
• Tender with contractor

4 INVESTMENT COST

Heat exchanger with installed piping
CHF 2300 – 3300 /m^2 heat exchanger surface
EUR 1550 – 2200 /m^2 heat exchanger surface
USD 2000 – 2900 /m^2 heat exchanger surface

Complete heating energy system
CHF 1300 – 2100 / kW connected heating power
EUR 850 – 1500 / kW connected heating power
USD 1150 – 1850 / kW connected heating power

Price range of complete system
EUR 100’000 – 2’000’000 / USD 130’000 – 2’650’000

Average cost of complete system
EUR 230'000 / USD 310’000

5 THE ECONOMY

Investment cost

Heat exchanger	33%
Waste water piping / sewer	24%
Heating plant (heat pump, peak boiler)	28%
Engineering	15%

Total cost per year

Capital cost	30%
Energy cost	66%
Maintenance cost	4%

ROI (return on investment)
housing, public buildings 3 to 7 years

office	2 to 5 years
industry	1 to 2 years

6 ECOLOGY

Energy	g/kWh	
	CO_2	Fine dust
Oil	205	36
Gas	198	21
Wood / Pellets	neutral	421
Geothermal	0	0
Waste water heat pump	0	0

Emission rating

- Rabtherm installations reduce the CO_2 emissions over those from conventional plant by 50 – 80% (ecological benefit) Rabtherm installations reduce also the amount of primary / conventional energy.
- CO_2-output with 17 running plants is reduced by 6000 tons.
- Rabtherm systems produce no fine dust like diesel engines and wood burning plants.

7 THE MARKET

7.1 Market potential

- Towns and cities
  over 500'000 inhabitants 60 to 120 plants
  200-500'000 inhabitants 27-60, equal to approx. 12'000 apartments
  100-200'000 inhabitants 20-27 plants
  40-100'000 inhabitants 12-20 plants
  15-40'000 inhabitants 5-12 plants
  5-15'000 inhabitants 1-5 plants
- World

Switzerland	3'000 plants
Germany	30'000 plants
Europe	170'000 plants
Asia (CHI,JAP,SK)	150'000 plants
USA / Canada	180'000 plants
South America (CHI/ARG)	25'000 plants

7.2 Projects

Present Mega-projects
- Harvard university in Boston (USA)
- 2 MW-project in Vancouver (CA)
- 4 MW-project in Seattle (USA)
- 5 MW-project in Seoul (South Korea)
- 6 MW-project in Shanghai (China)
- 3 MW-project in Milano (Italy)

Standard and small projects
- German ministry of environment in Berlin (D)
- condos, offices, hospitals, sport arenas, fire station, school, nursery in cities with a population between 5000 and 10000.

Industry
- Automobile industry in Germany with process cooling water 104 F / Breweries / Water treatment plants

8 MARKETING CONCEPT

8.1 Licensees and Partners

- Today, Rabtherm has licensees and know-how partners in 12 countries, in addition 5 licensed manufacturing plants.
- Licensees
  - Consulting engineers for acquisition, study and planning of installations.
  - Contractors for the installation, maintenance and operation of installations.
    · Electrical utilities
    · Municipal works
    · Industrial enterprises
  - Heat exchanger manufacturers

- Partners
  - Manufacturers of sewer pipes
    · concrete, cast iron, plastic
  - Manufacturers of heat pumps
  - Cities with energy plans

8.2 Situation

Rabtherm has Licensees and partners in the following countries

• Europe:	Germany, France, Netherlands, Ukraine (In France our system is distributed by Lyonnaise des eaux under the name Degres bleus)
• America:	United States, Canada, Chile
• Asia:	Korea, China, Japan (In Korea our system is distributed by Hudigm under the name HSE)

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