Economic efficiency of heat recovery from wastewater

Using the heat contained within wastewater to heat buildings is an innovative, CO_2-saving and economical alternative to conventional heating methods. In times of diminishing energy resources the call for such solutions is becoming louder and louder. In fact, however, the wastewater heat is still a relatively unknown and seldom used energy source in Germany.

The aspect of economy still seems to count more than all arguments for the environment and future markets. Ultimately, new and innovative technology must still be economically justifiable. Utilisation of wastewater heat is in a very good position in this respect in view of the economic efficiency achieved by using low temperatures in the heating circuit of the heat pump. The performance coefficient of a heat pump is referred to as COP. It expresses the effective energy related to electric energy input. This ratio lies normally between 3 and 6. A COP of 4.5, for example, means that one part of 4.5 parts of useful energy is fed with electrical energy by the heat pump compressor and 3.5 parts of the useful energy are extracted from the wastewater. This means approximately 77.8% of the heat energy has its origin in polluted water in sewers.

When using conventional heat sources, such as oil or gas, one kW hour amounts to approx. 5-6 ct. If one kW hour is generated by means of electric power, the costs therefor are stated with approximately the threefold amount. Under the aspect of economy, heat generation by means of electricity would have to be regarded as something that does not make sense. However, the situation is different if the current from the power socket is used to operate a heat pump. The costs for an electrically generated kW hour are still a multiple of the costs for a kW hour generated with oil, but a heat pump needs only approx. 20-25% primary energy to generate approx. 100 kW hours. The costs related to consumption and maintenance are reduced significantly.
The energy consumption of the heat pump is directly connected with the performance coefficient. The performance coefficient is a result of wastewater temperature difference and the flow temperature required in the heating circuit. Simplified, a COP between 4 and 6 [without unit] can be expected with a required flow temperature of approx. 30-50 °C. This results in a current consumption of 16-25% of the useful energy. If factor 3 is taken for the electricity/oil ratio, the resulting financial burden is approx. 50-75% compared to a conventional plant. Consequently, the savings amount to 25-50% of the costs for a gas or oil heating.

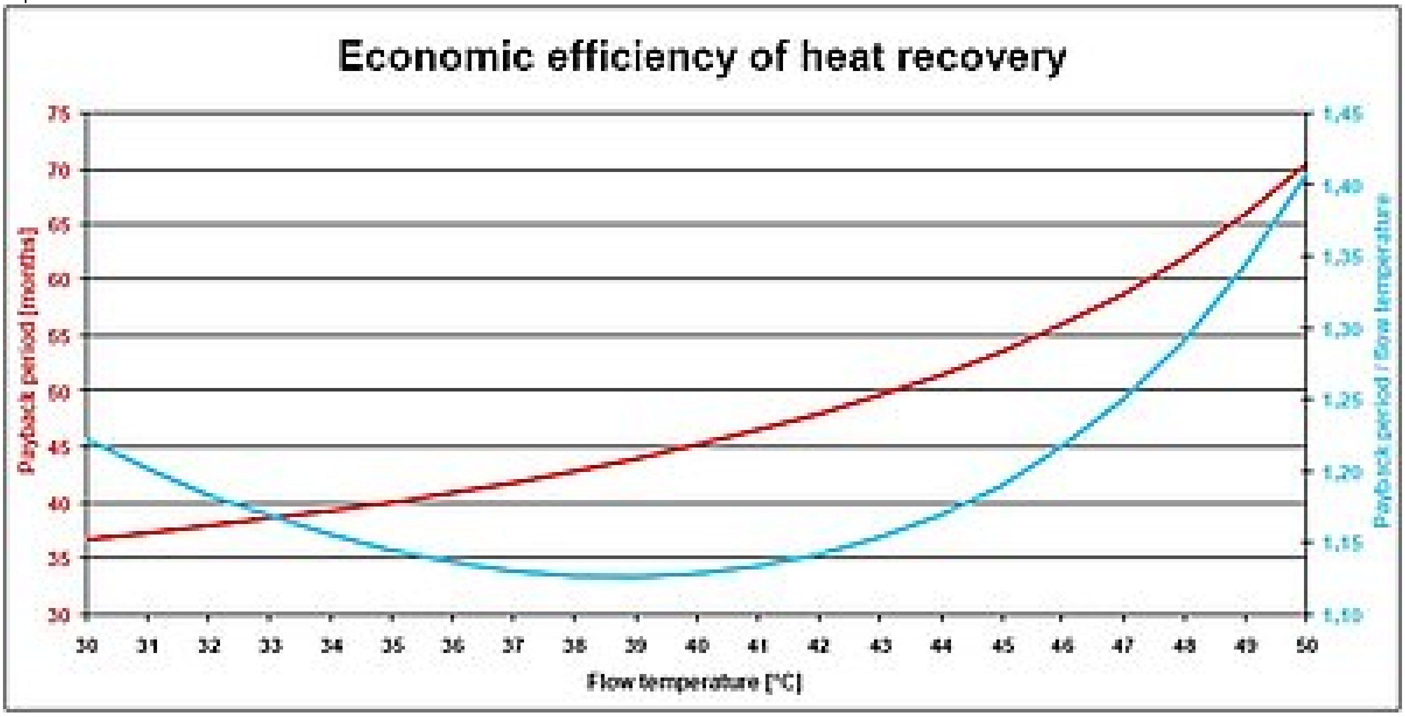
Example calculation:
Energy demand: 250 kW x 24 h/d x 30 d/month -> 180 000 kWh
with 5 ct/kWh (oil): 9,000 Euro/month

COP = 5 [without unit] 1/5 x 250 kW = 50 kW (electric)
Energy demand: 50 kW x 24 h/d x 30 d/mon -> 36 .000 kWh
with 15 ct/kWh (current): 5,400 Euro/month

The resulting saving is 3,600 Euro per month.

The payback period for an investment of approx. 160,000 Euro is approx. 45 months. Assuming approx. 7.5 heating months per year, the calculated payback period is approx. six years.

The below diagram shows the dependence of payback period on flow temperature. As the flow temperature has a direct effect on the COP of the heat pump, a higher electric energy is required with a higher temperature difference between heat source and heat distribution. Since the current cost will rise then and savings decrease, the payback period will be longer, as shown by the red curve in the diagram.



The blue curve describes the payback period / flow temperature ratio. The optimal operating point is achieved with a low payback period and high temperature within the heating circuit. The quotient of both values has therefore its lowest value at the optimal operating point. The diagram shows this value at approx. 39°C. The optimal temperature for a heating plant with heat pump lies between 35° and 45°. This fact is underlined by the figures provided by the diagram.

An explanation for this is high consumption of electric energy if a higher flow temperature is needed. The paradox that the payback period / flow temperature ratio is getting worse at an effective temperature of below 39 °C can be explained with the fact that a certain basis of hardware is even necessary to provide only low temperatures. The energy yield with this investment is however lower due to the lower temperature level.
The whole plant can be used for cooling purposes during summer without the need for any significant plant modification or extension. This allows for an even shorter payback period. All these facts together make heat recovery from wastewater an economically efficient system that without doubt represents a welcome alternative to conventional heating systems in times of ever diminishing energy resources.

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HUBER Technology srl
P.IVA e C.F. 01689490215
Cap. Soc. Euro 600.000,00 int. ver.
Iscr. al Registro delle Imprese
di Bolzano n. 01689490215

Sede amministrativa:
Zona Produttiva Vurza, 22
39055 Pineta di Laives (BZ)
Tel. 0471.590107
Fax 0471.594280

Sede commerciale:
Via A. Meucci, 35
27055 Rivanazzano (PV)
Tel. 0383.934023
Fax 0383.944453

Internet:
www.huber.de
www.hubertec.it
info@hubertec.it