# Waste Heat Recovery at the Steel and Rolling Mill "Marienhütte", Graz (Austria)

**Alexander Arnitz, René Rieberer, Institute of Thermal Engineering, Graz University of Technology**
**Veronika Wilk, Austrian Institute of Technology GmbH**
**Helmut Unger, Peter Schlemmer, Energie Graz GmbH & Co KG**
**Austria**

**A long-standing cooperation between two companies, the energy service provider and district heating network operator Energie Graz GmbH & Co KG and the steel and rolling mill Marienhütte GmbH, has resulted in a project that is economically viable for both partners and ecologically valuable for the Graz region (Austria). Due to the installation of two highly efficient large heat pumps, waste heat from the steel and rolling mill Marienhütte GmbH can be used to deliver environmentally friendly heat to the existing district heating network in Graz.**

## Introduction

A long-standing cooperation between the two companies, the energy service provider and district heating network operator Energie Graz GmbH & Co KG and the steel and rolling mill Marienhütte GmbH, has resulted in a project that is economically viable for both partners and ecologically valuable for the Graz region. The core of this cooperation is the use of waste heat from the steel and rolling mill "Marienhütte" for district heating purposes. This cooperation began in 1992 with the direct use of waste heat at a temperature of up to 100 °C and has since then been continuously expanded. Due to the construction of a buffer storage facility, the direct delivery of waste heat to the district heating network was increased to about 60 GWh/year in 2011 (this is about 5% of the heat supplied by the district heating network in 2017).

A further expansion of this cooperation was inspired by Energie Graz through the construction of a central energy station at the company site of Marienhütte in 2015, and the commissioning of two heat pumps with a total heating capacity of up to 11.5 MW at this location in May 2016. These heat pumps use waste heat at a temperature of about 30 to 35 °C as heat source, waste heat which otherwise cannot be used for district heating purposes. Since the commissioning of these heat pumps, heat is delivered to the existing district heating network.

In 2017, the construction of the new low-temperature district heating network in the Reininghaus district of Graz was started and the first part of a modular and expandable thermal water storage tank was constructed, including the hydraulic connection to the heat pumps. According to [1], a district heating input of about 40,000 MWh/a into the existing heating network or about 46,000 MWh/a into the new low-temperature district heating network is expected. The heat pumps are supplied with electricity from renewable sources by a subsidiary of the Energie Graz, thus all the heat provided by the heat pumps is regarded as renewable. For this reason, $CO_2$ annual savings of up to 11.7 million kg can be reached, compared to the heat supply with a natural gas boiler (see figure 1).

## System description

Energie Graz GmbH & Co KG ("Energie Graz") operates the district heating network in Graz and supplied around 70,000 households with a heating demand of about 1,200 GWh and a maximum heating capacity of 455 MW during 2017. The existing district heating network has a pipe length of more than 800 km and is operated with a supply temperature in the range 75 to 120 °C, depending on the outdoor temperature. The return temperature fluctuates between 55 °C (during winter) and 65 °C (during summer), with an additional temperature fluctuation of up to 3 K during a day.

Furthermore, the apartments, which will be built in the next years for about 12,000 inhabitants as part of the "Reininghaus" district development project, will be supplied with heat from a new district heating network. This new district heating network will be operated with a supply temperature of about 70 °C, which is required for hot water preparation all year round, and a return temperature of about 43 °C and will be "physically" decoupled from the existing district heating network. The required heat for this new district heating network will be provided mainly by the heat pumps commissioned at the central energy station in 2016. The modular, expandable thermal water storage tanks are used to bridge downtimes of the steel and rolling mill production. Furthermore, a heat exchanger is installed as a backup system to transfer heat from the existing district heating network to the new district heating network.

The **steel and rolling mill Marienhütte GmbH** ("Marienhütte") is the only manufacturer of ribbed structural steel in the form of bars or rings in Austria. Further products are plain bar steel and metallurgical ballast. In total about 400,000 tons of steel are produced per year. Electricity and natural gas are used as energy sources for the steel production. The high temperature needed for steel production requires active cooling to avoid overheating. For this purpose, three closed cooling circuits at high temperature (up to 100 °C), which are used to supply heat to the existing district heating network, and two open cooling circuits at low temperature (about 30 °C) are used. One open cooling circuit, the

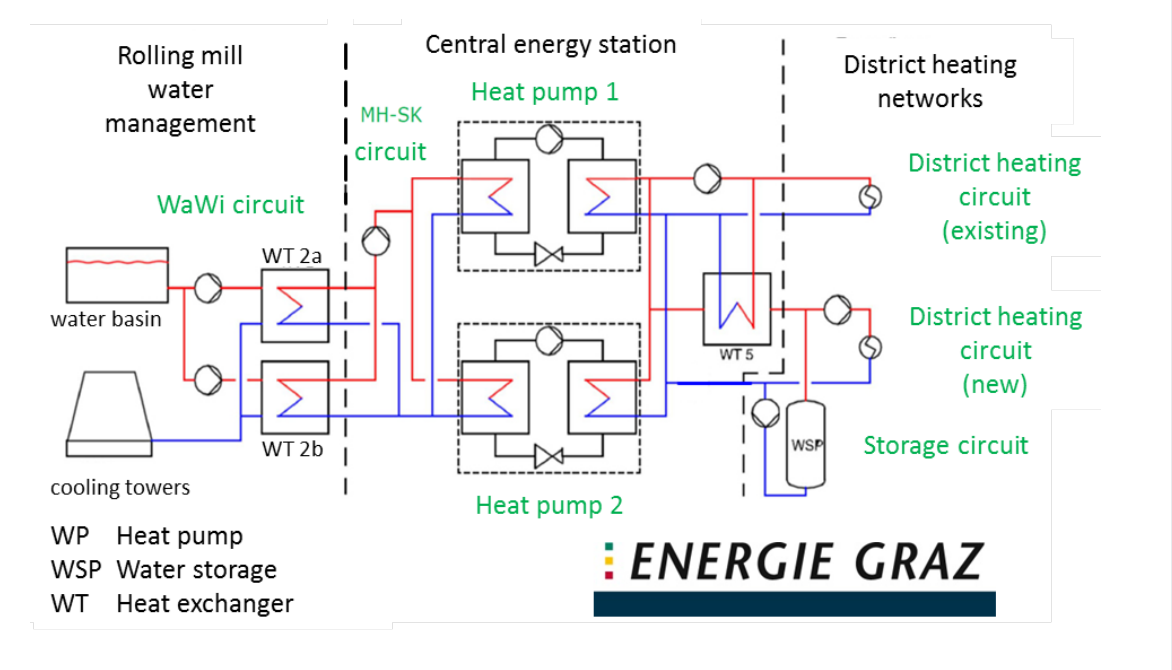


*Fig. 1: Hydraulic connection of the heat pumps to the WaWi cooling circuit of the steel and rolling mill and the connection to the existing and the new district heating network (simplified illustration)*

so-called water management circuit (WaWi), is used as heat source for the heat pumps

**The hydraulic connection of the heat pumps**

Figure 1 shows a simplified scheme of the hydraulic connection of the heat pumps to the heat source and sink. The heat pumps use waste heat from the rolling mill water management (WaWi) circuit as a heat source. The connection to the evaporators of the heat pumps is realized using an additional circuit (MH-SK circuit) which is separated from the WaWi circuit with two heat exchangers (WT2a and WT2b). The evaporator inlet temperatures are between 32 and 35 °C and the evaporator outlet temperatures are between 25 and 29 °C. The circulation pumps and a mixing valve can be used to control the temperature in the evaporator circuit (MH-SK circuit).

The separation of the evaporator circuit from the WaWi circuit of the "Marienhütte" ensures an independent operation of the internal cooling circuits when the heat pumps are not in operation (e.g., in case of no heat demand, service of the heat pumps, etc.). In this case the heat transfer to the district heating network is interrupted and the waste heat is dissipated to the environment using the existing cooling towers. With this integration concept the costs for the necessary heat removal from the "Marienhütte" are minimized while the heat pumps are in operation without any risk for the production waste.

The water of the existing district heating network or the water of the new low-temperature district heating network flows directly through the condensers of the heat pumps. In addition, in Fig. 1 the storage circuit and the heat exchanger for the transfer of heat from the existing district heating network to the new low-temperature district heating network (WT5) are shown.

**The heat pumps**

The installed R1234ze heat pumps are two large heat pumps of the type Unitop produced by the company Friotherm (see figure 2). The dimensions of one heat pump are 8.2/3.7/3.3 m (L/W/H) with a weight of about 30 000 kg. In each heat pump, two turbo compressors are installed which can be operated in parallel or serially. The maximum useful water temperature at the condenser outlet is 95 °C, which can be reached in serial operation of the turbo compressors. In serial operation of the turbo compressors and temperatures at the condenser inlet/outlet of 63/90 °C, a heating capacity of about 3.42 MW per heat pump can be reached. In parallel operation of the turbo compressors and temperatures at the condenser inlet/outlet of 43/69 °C, the maximum heating capacity increases to about 5.64 MW per heat pump. The design temperatures at the evaporator inlet/outlet are 33.8/29 °C in serial operation and 33/25.8 °C in parallel operation. Further information can be found in table 1.

Until the completion of the new low-temperature district heating network, heat will be supplied to the existing district heating network. When the construction of the low temperature district heating network is completed and the first buildings require a heat supply via the network, the heat supply may be provided by one heat pump depending on the heat requirement. In this case the second heat pump can still supply heat into the existing district heating network. The lower supply temperature of 70 °C in the new low-temperature district heating network, compared to the supply temperature of about 95 °C in the existing district heating network, leads to an improvement of the COP from 3.3 to 4.5, which is an improvement of 36%.

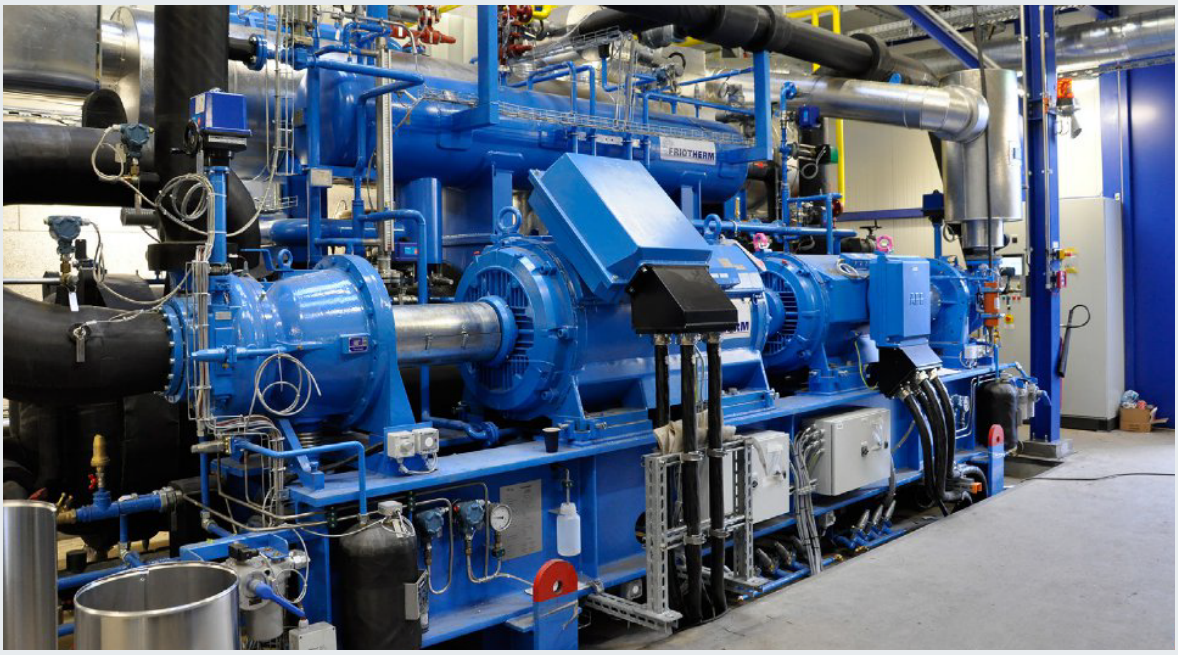

*Fig. 2: One heat pump at the location of the "Marienhütte" [1]*

*Table 1: Information about the heat pumps*

| | | | | |
|---|---|---|---|---|
| Heat pump manufacturer | Friotherm | | | |
| Heat pump type | Two Unitop 28CX-71210U | | | |
| Compressor | Turbo-Compressor | | | |
| Refrigerant | R1234ze | | | |
| Heat source temperature in °C (in/out) | 34/29 | 34/29 | 34/29 | 33/26 |
| Heat sink temperature in °C (in/out) | 90/63 | 95/57 | 83/65 | 69/43 |
| $COP_H$ | 3.41 | 3.28 | 3.71 | 4.54 |
| Condenser capacity of two heat pumps in MW | 6.84 | 6.76 | 6.54 | 11.27 |
| Evaporator capacity of two heat pumps in MW | 4.83 | 4.70 | 4.78 | 8.79 |

## Conclusions

Two large heat pumps are installed by "Energie Graz" for district heating purposes at the company site of the steel and rolling mill "Marienhütte" in Graz (Austria). The heat pumps can be used to supply heat to the existing district heating network as well as to a new low-temperature district heating network. The heat pumps are able to supply heat at a temperature up to 95 °C. They use waste heat from the steel and rolling mill at a temperature of about 30 to 35 °C as heat source that would otherwise be dissipated to the environment. The efficiency of the heat pumps achieved during operation is satisfactory.

## References

[1] Götzhaber, W., Meißner, E., Moravi, G., Prutsch, W., Schlemmer, P., Schmied, R., Slivniker, E., Zimmel, M., 2017, Wärmeversorgung Graz 2020/2030 – Wärmebereitstellung für die fernwärmeversorgten Objekte im Großraum Graz – Status Report 2017, Grazer Energieagentur Ges.m.b.H.

[2] Unger, H., 2018, Energiemodell Reininghaus – Abwärmeauskopplung Marienhütte durch Energie Graz, Technical report

**RENÉ RIEBERER**
**INSTITUTE OF THERMAL ENGINEERING, GRAZ UNIVERSITY OF TECHNOLOGY**
Austria
rene.rieberer@tugraz.at
https://doi.org/10.23697/hh8p-e074

**HELMUT UNGER**
**ENERGIE GRAZ GMBH & CO KG**
Austria
h.unger@energie-graz.at
https://doi.org/10.23697/hh8p-e074