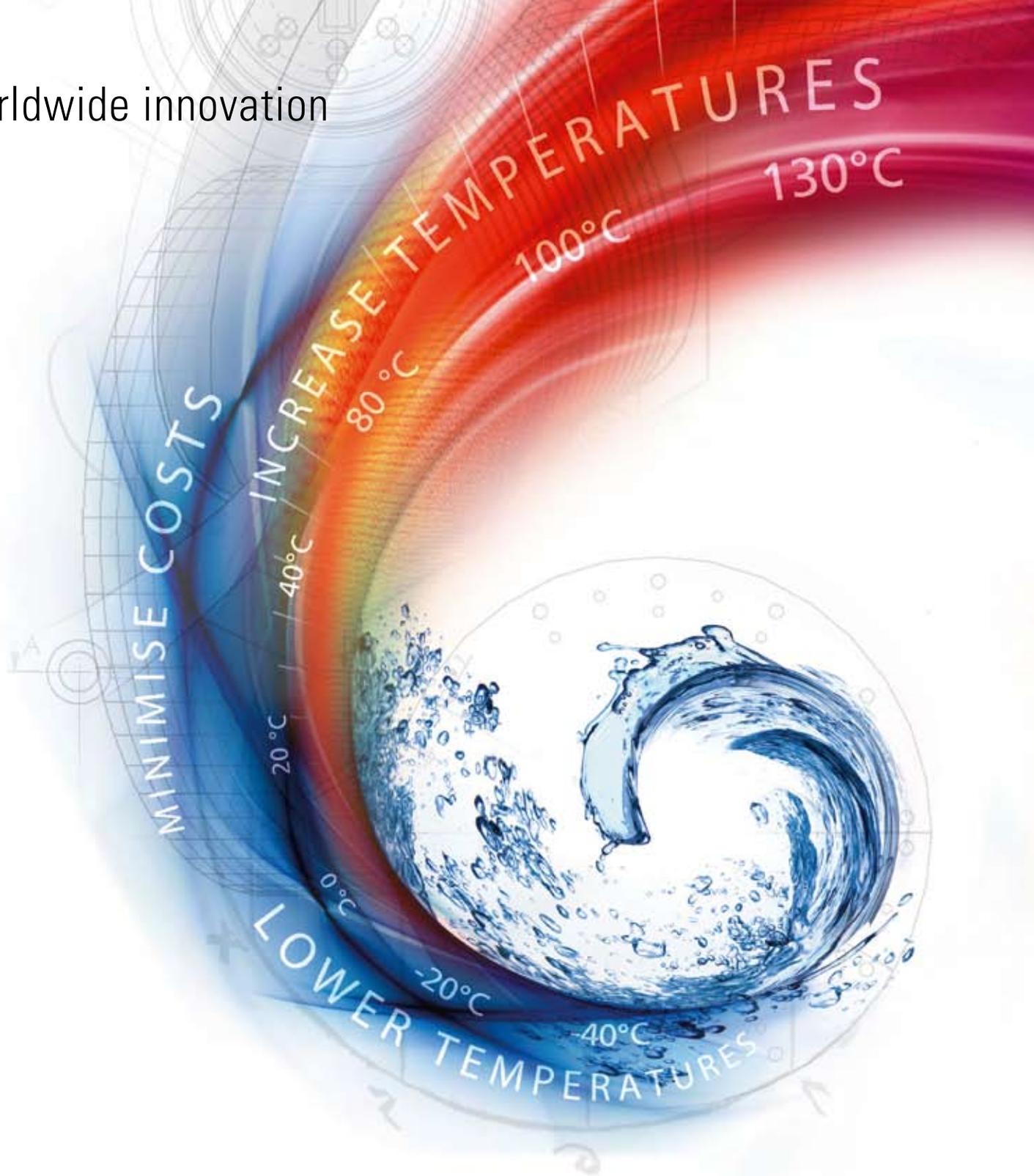


Worldwide innovation



High-temperature heat pumps
and refrigerating machines
for industrial processes

thermea.
Energiesysteme

In co-operation with Robert Bosch GmbH

>>> Use a heat pump to decouple from the energy market



Due to their low supply temperatures, heat pumps have hardly come into consideration thus far for industrial processes. With a new generation of heat pumps that use CO₂ as a working medium, supply temperatures up to 90°C are now possible. These high-performance heat pumps from thermea will essentially broaden the application spectrum for industrial heat supply.

Prof. Dr.-Ing. Uwe Franzke

Institut für Luft- und Kältetechnik gGmbH
Hauptbereich Luft- und Klimatechnik

Distinct cost advantage

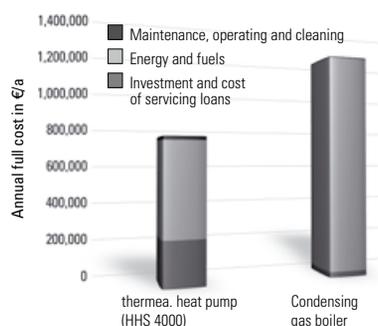
> A change from conventional low-temperature or condensing boilers to a new thermea. heat pump can pay off already after just 3 years.

> You can lower your annual full cost by 35% compared to that of a condensing gas boiler.

> Secure your competitiveness by an unrivalled efficient energy supply.

Tremendous potential for savings – paying off in a very short time

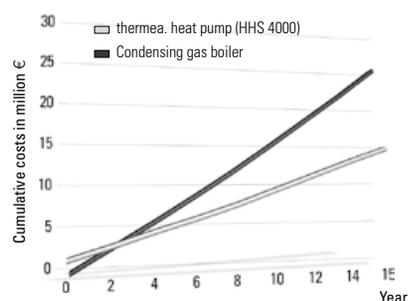
Full cost comparison between a heat pump and condensing gas boiler system



The annual costs of the thermea. heat pump are only 65% of that for a condensing gas boiler.

Marginal conditions (left and right charts)
COP = 3.5 at 5000 h/a
Q_h = 4.0 MW
Price-increase rate (maintenance, operating, energy): 2%/a
Net electricity price (AP) incl. network use and surcharges for KWK/EEG: 120 €/MWh
Full cost heat price (net kilowatt-hour rate) for gas heating: 60 €/MWh
Avoided recooling cost (energy cost): 15 €/MWh_{cooling}
Annuity method acc. to VDI 2067

Efficiency comparison



By the example of a thermea. HHS 4000 high-temperature heat pump, it can be clearly demonstrated that in spite of a higher investment cost, short payback periods as well as considerable cost savings are possible compared to conventional heating systems.

and remain competitive in future as well <<<



Advantages of waste heat recovery

The application of thermea high-temperature heat pumps can considerably lower the cost of ownership of recooling plants and cooling circuits by the recovery of heat from low-temperature heat flows. Use of waste heat for heat pump heating allows for a particularly efficient and resource-saving plant operation. Compared to groundwater use, the evaporation temperature can be increased from 4°C (typical for groundwater) to 20°C (typical for low-temperature heat use). This essentially improves the heat pump's coefficient of performance (COP) so that its demand of electricity for driving is thereby reduced.

Example: Providing 4 MW heating capacity

$$P_{el} = 1136 \text{ kW} \quad (t_0 = 4 \text{ }^\circ\text{C, groundwater, for example})$$

$$P_{el} = 718 \text{ kW} \quad (t_0 = 20 \text{ }^\circ\text{C, industrial waste heat, for example})$$

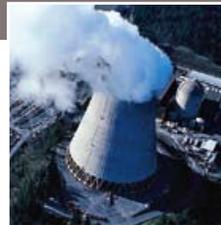
$$\Delta P_{el} = 418 \text{ kW} \quad (\text{saving})$$

At 5000 h/a, this means a reduction of electricity consumption of 2090 MWh/a. Assuming an electricity price of 120 €/MWh, the use of waste heat results in a cost advantage of 250,000 €/a compared to a natural heat source.

Heat recovery

thermea high-temperature heat pumps are designed for heat recovery from low-temperature waste heat flows. Particularly suitable heat sources include:

- > Waste heat from cooling circuits from energy generation or production plants
- > Waste heat from air conditioning, cold or ice-cold water networks with direct heat and cold generation
- > Water or wastewater with temperatures between 8°C and 35°C
- > Waste heat from the recooling plants of existing refrigeration systems



Capacities up to 4000 kW and the highest temperatures >>>



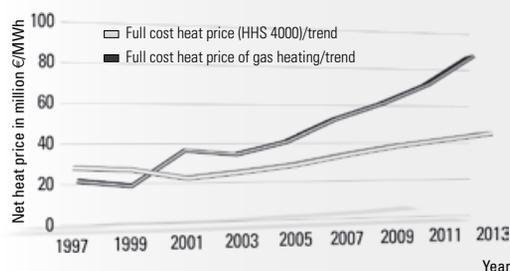
thermea.HHR

thermea.HHS

Principle	Reciprocating Compressor	Screw Compressor
Rated heating capacity	20 ... 300 kW	750 ... 4000 kW
Rated refrigerating capacity	15 ... 215 kW	540 ... 2850 kW
Heating water supply temperature	Up to approx. 90 °C	Up to approx. 90 °C
Cold water supply or brine temperature	Approx. -10 ... +20 °C	Approx. -10 ... +20 °C
COP heating	max. 5.5	max. 5.5
COP heat and cold cogeneration	max. 9.0	max. 9.0
Dimension range in mm (L x W x H)	From 1200 x 800 x 1300 to 4000 x 800 x 1300	From 5000 x 1500 x 2500 to 5000 x 4500 x 2500
Applications	<ul style="list-style-type: none"> > Process heat generation by heat recovery from low-temperature waste heat flows, in particular the heating up of material flows (gases or liquids) > Air conditioning refrigeration, cold and ice-cold water generation with high-temperature heat decoupling for the simultaneous heating up of material flows (gases or liquids) as high-temperature heat and cold cogeneration > Drying of material flows 	
Features	Customised configuration and optimisation upon request	

A constant price for heat - nearly independent of gas and oil

Full cost heat price trends based on the energy sources used

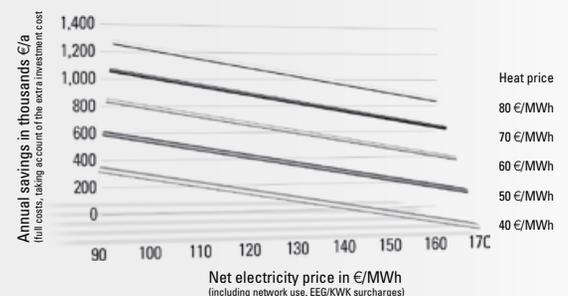


The long-term stability of the heat price is of special interest as the variations of the electricity price have only little effect on the heat price.

Marginal conditions

Price basis 2008:
 Electricity price: 120 €/MWh
 Heat price: 60 €/MWh
 COP = 3.5; $\eta_{th} = 0.95$
 Indices acc. to Federal Office of Statistics

Annual full cost savings as a function of energy purchase prices



are possible by the use of CO₂ >>>



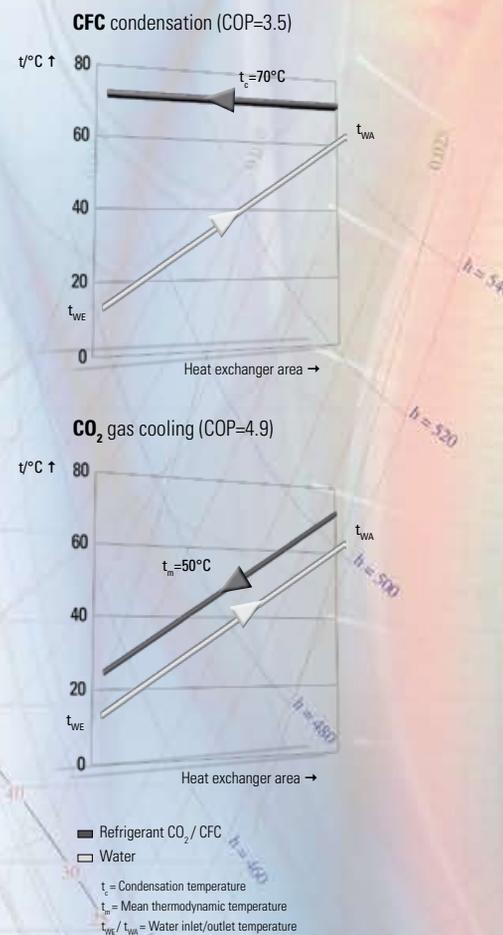
Carbon dioxide as a working substance

- > For high-temperature heat pumps, the working substance CO₂ (R744) is the first choice whenever high temperature differences have to be overcome on the hot side of the heat pump.
- > Under the above described application conditions, the thermodynamic advantages of CO₂ take full effect and result in high coefficients of performance.
- > Compared to conventional heat pumps, the thermodynamic advantages of CO₂ for trans-critical heat decoupling are distinctively higher coefficients of performance and higher useful temperatures.

Eco-friendliness

- > As a natural working substance, CO₂ does not additionally contribute to the greenhouse effect or to the destruction of the ozone layer.
- > Unlike other working substances or refrigerants, carbon dioxide is not subject to restrictions or even prohibitions.
- > With thermea. high-temperature heat pumps, CO₂ emissions can be reduced by approximately 40% compared to conventional heating systems.
- > An emission-free heat generation is possible when thermea. high-temperature heat pumps are operated with electricity that is 100% generated from renewable energies.

Heat output comparison



Application examples

User	Woodworking industry	Food industry	Public buildings
	Process air heating of 325,000 m ³ /h to 80°C using a HHS 4000	Heat and cold cogeneration for cooling products while heating the inlet air for a spray dryer (44,000 m ³ /h) up to 80°C	Heat and cold cogeneration for hot potable water supply while providing refrigeration for the cooling of technical equipment
Heat source	Low-temperature process waste heat in the form of cooling water at 30°C	Cold water network for product cooling at 10°C	Air-conditioning cold water network at 12°C
Heating capacity	4050 kW	800 kW	190 kW
Refrigerating capacity	3110 kW	540 kW	130 kW
Operating hours	7000 h/a	8000 h/a	5900 h/a
Heat price	37 €/MWh	51.5 €/MWh	56.5 €/MWh
Recooling/ refrigeration price	14.6 €/MWh	39.7 €/MWh	42.1 €/MWh
Electricity price	65 €/MWh	100 €/MWh	111 €/MWh
Internal interest rate	6 %	8 %	7 %
Savings per year (incl. the servicing of loans)	1,000,000 €	Approx. 130,000 €	70,000 €



thermea. energy systems

- > Recovery of industrial waste heat
- > High-temperature heat and refrigerating technology using the natural refrigerants carbon dioxide and ammonia
- > Steam generation using patented heat pump technology
- > Steam saving systems for the use of desorbate heat

Heat contracting

As a partner and competence centre of SÜDWÄRME AG we offer tailored energy service and financing models:

- > We undertake your complete heat supply.
- > You obtain high-quality equipment without own capital investment.
- > The achievable cost cutting potentials surpass the financial charges and service costs and provide for additional liquidity.

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We are partner of SÜDWÄRME Gesellschaft für Energielieferung AG. For further information, see www.suedwaerme.de.



We are a member of an Internet platform for the natural working substance carbon dioxide. For further information, see www.r744.com.

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