Industrial heat pump applications in Switzerland – Heat pump integration case studies

WS-4 – Workshop: Successful Applications of Industrial Heat Pumps

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NTB Buchs

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ICR 2019, The 25th IIR International Congress of Refrigeration
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Content

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- **Introduction to Industrial Heat Pumps in Switzerland**
- **Application examples in the food industry**
- **Conclusions**

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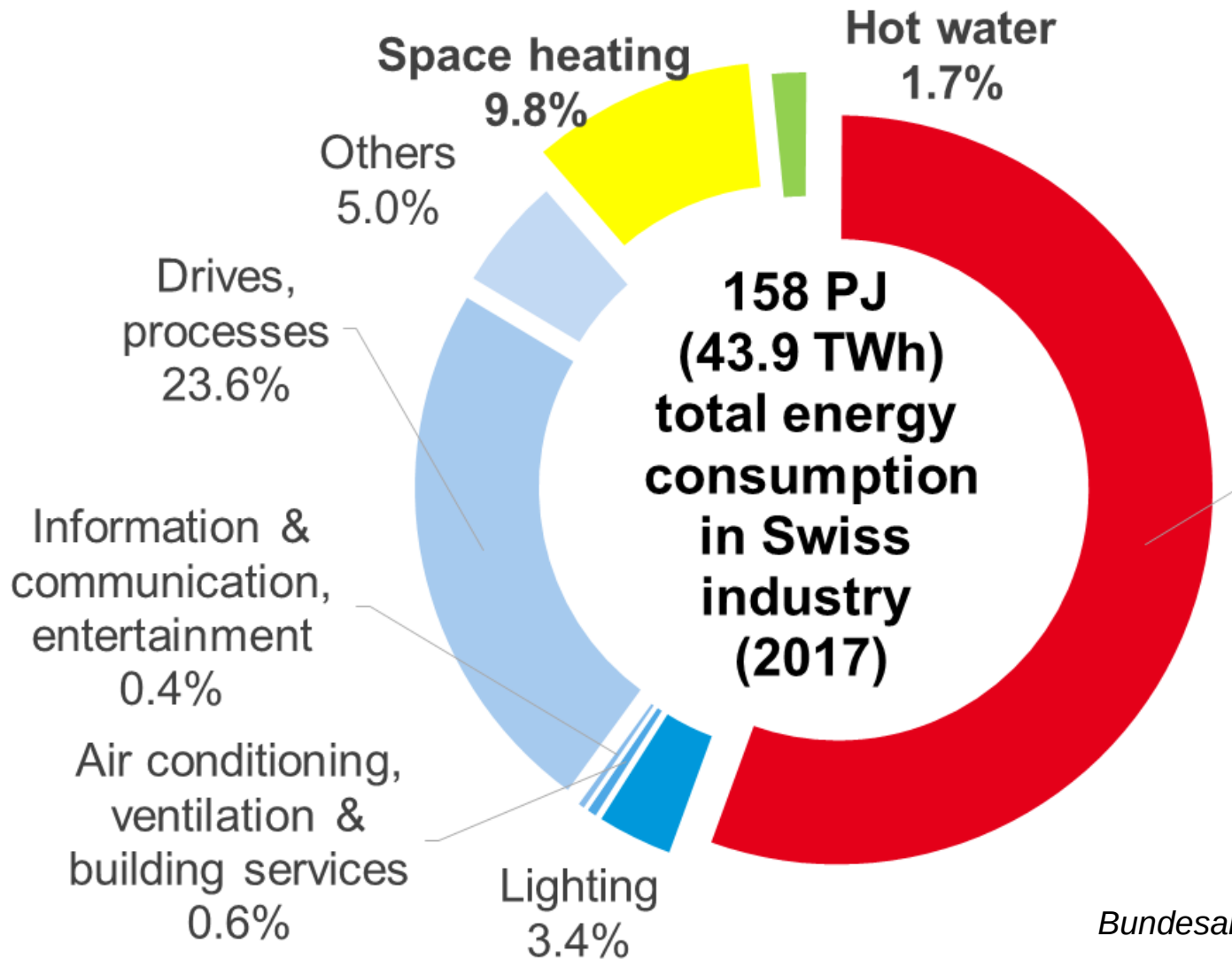
Process heat demand in Switzerland



This corresponds to:

= 6.6 x *the* ***total heat production*** *of all* ***30 waste incineration plants*** *in Switzerland (3.7 TWh in 2018) (www.vbsa.ch)*

Data source:
Bundesamt für Energie BFE (2018)

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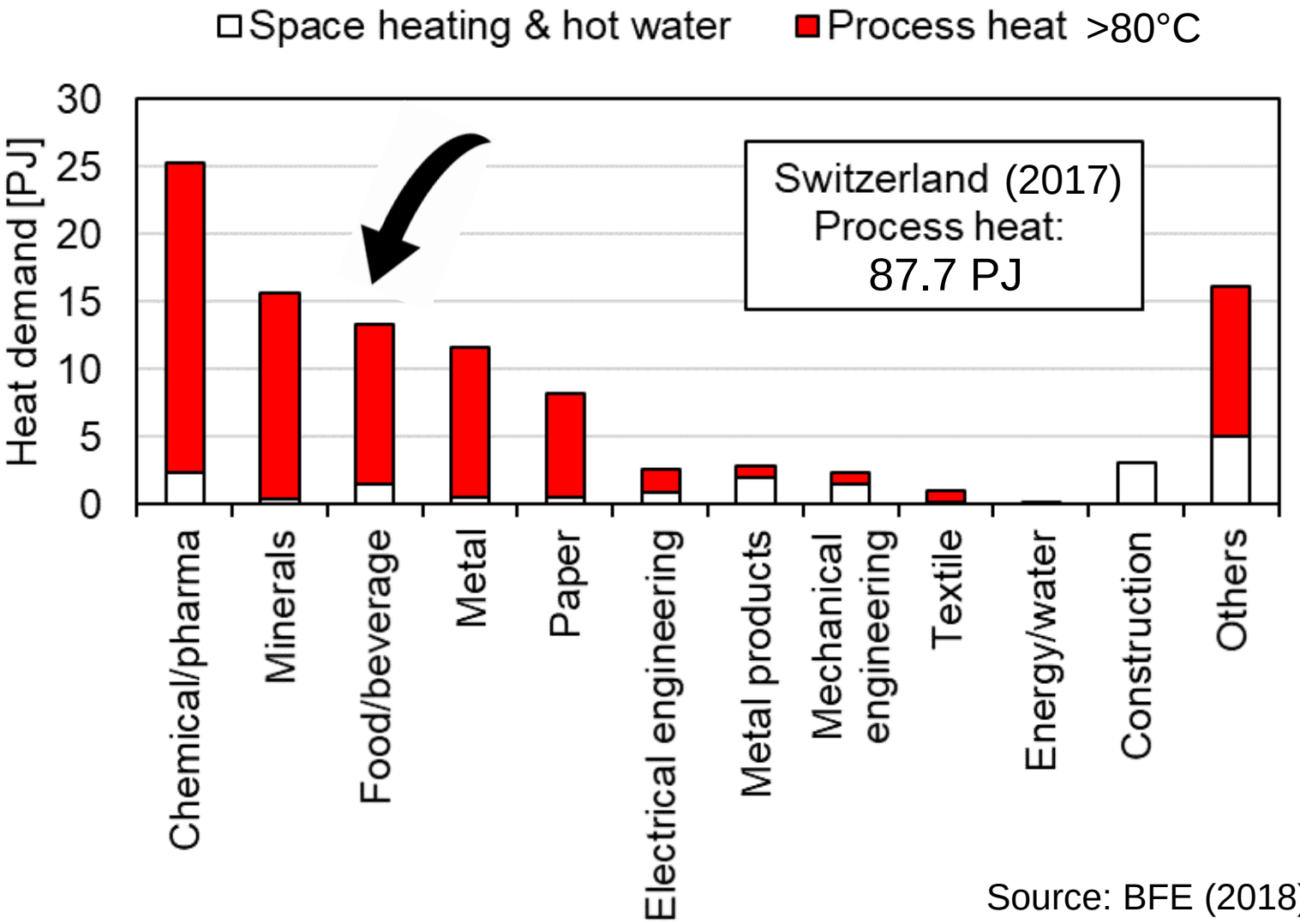
Potential for industrial heat pumps in Switzerland



Source: BFE (2018)

Growing importance of heat pumps in Swiss industry
(expert survey)

- **Priority 1: Food**
- Priority 2: Chemistry, Pharmaceuticals, Paper, Mechanical Engineering & Textiles
- Priority 3: Metal products, metals, minerals

Source: Wolf et al. (2017)

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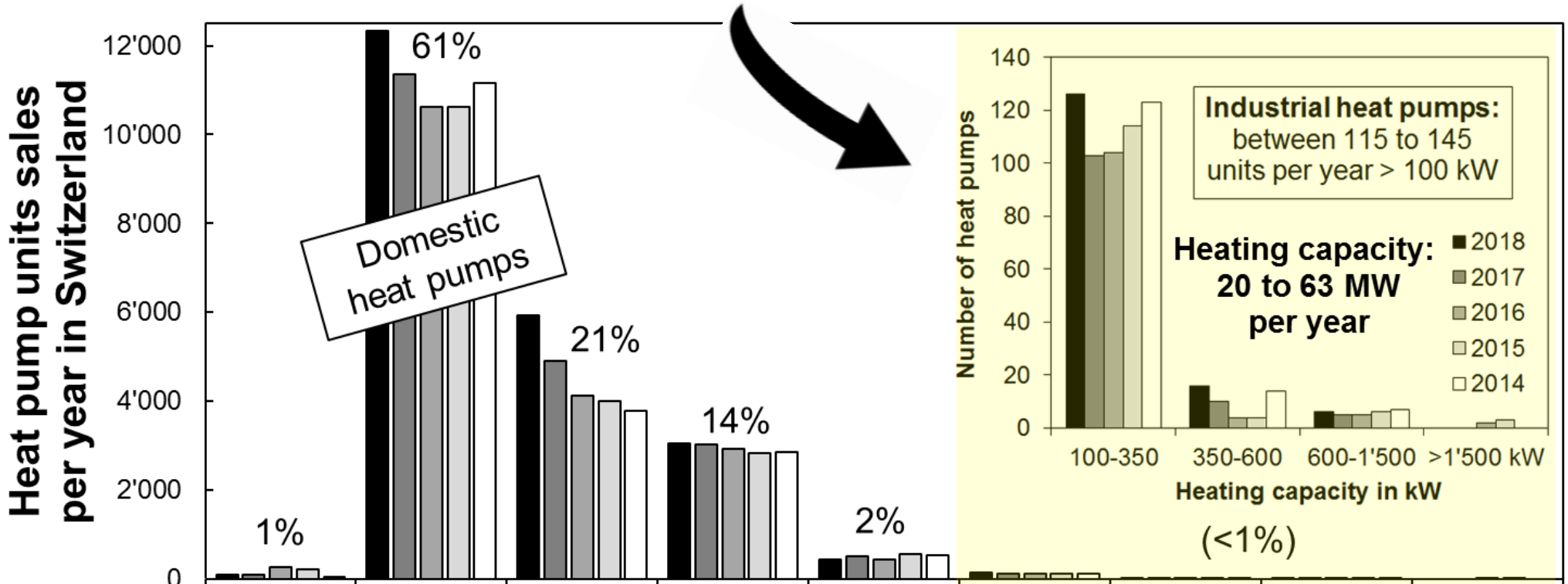
Industrial heat pump sales between 115 and 145 units per year



	<5 kW	5-13	13-20	20-50	50-100	100-350	350-600	600-1'500	>1'500 kW
2018	84	12331	5920	3055	426	126	16	6	0
2017	97	11354	4896	3024	506	103	10	5	0
2016	268	10623	4116	2924	426	104	4	5	2
2015	215	10626	3986	2822	542	114	4	6	3
2014	47	11161	3779	2857	519	123	14	7	0

Heating capacity in kW and unit sales per year

Data source: www.fws.ch

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Challenges to further spread industrial heat pumps into the market

- **Low level of awareness of the technical possibilities and economically feasible application potential** of industrial heat pumps among users, consultants, investors, system planners, manufacturers and installers
- **Lack of knowledge about the integration** of heat pumps into existing industrial processes
- **Tailor-made designs**, i.e. small batch sizes (low economies of scale)
- **Longer amortization periods** than for gas or oil-fired boilers (required are ≤ 3 years). With lower electrical current and higher gas prices smaller amortization periods are reached.
- **Competing heating technologies** (with fossil fuels at low energy prices)
- **Requirements of heat storage** to compensate for the time lag between demand and supply (e.g. heat pump for band load, gas boiler for heating peaks)
- **Lack of available compressors** for high temperatures **and refrigerants** with low global warming potential (GWP) and zero ozone depletion potential (ODP)

> 26 industrial HTHP products with heat supply temperature ≥ 90 °C available

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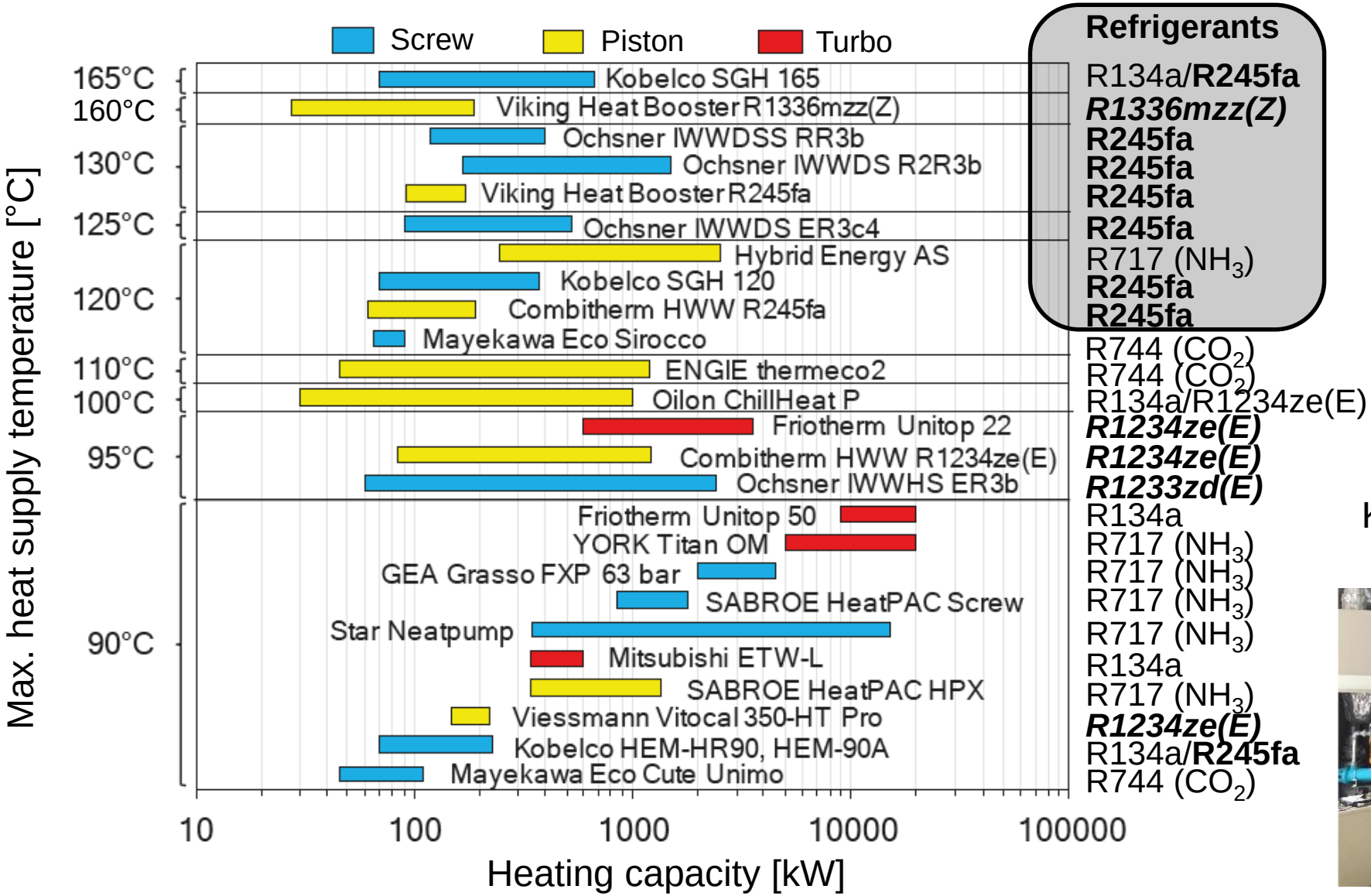
R245fa is predominantly used in industrial HTHP … but has a high GWP of 804



Refrigerants
R134a/**R245fa**
R1336mzz(Z)
R245fa
R245fa
R245fa
R245fa
R717 (NH_3)
R245fa
R245fa
R744 (CO_2)
R744 (CO_2)
R134a/R1234ze(E)
R1234ze(E)
R1234ze(E)
R1233zd(E)
R134a
R717 (NH_3)
R717 (NH_3)
R717 (NH_3)
R717 (NH_3)
R134a
R717 (NH_3)
R1234ze(E)
R134a/**R245fa**
R744 (CO_2)

OCHSNER ENERGIE TECHNIK

HeatBooster S4 (Viking Heating Engines AS)

Kobelco SGH 120/165 (Steam Grow HP)

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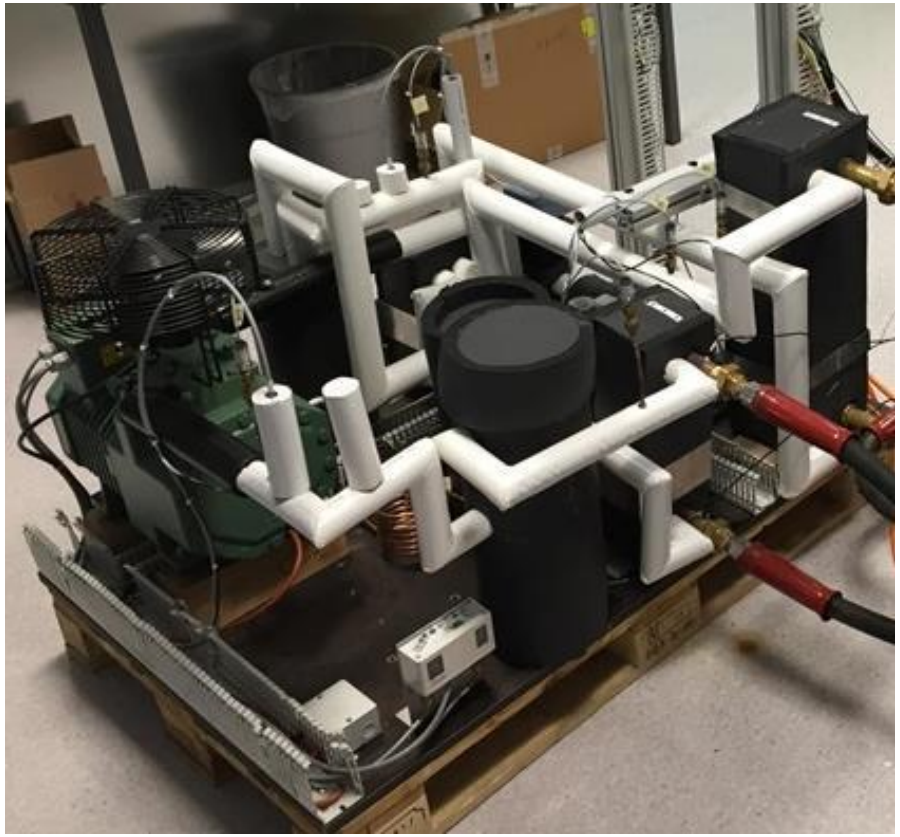
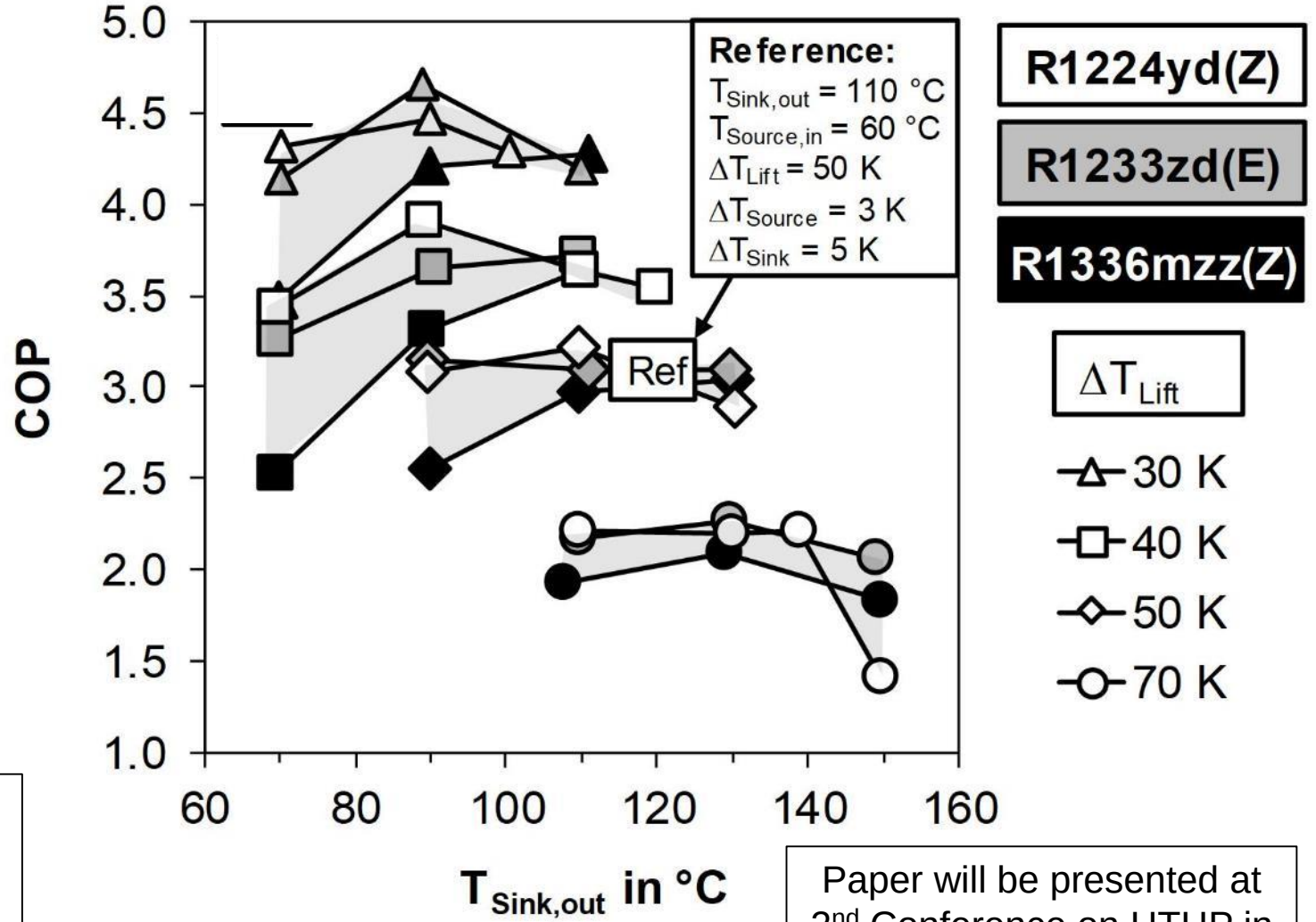
Laboratory scale HTHP at NTB Buchs to research new low GWP HFO and HCFO refrigerants R1224yd(Z), R1233zd(E), and R1366mzz(Z)





Paper in TS-413.2 – Technical Session Industrial Heat Pumps (3), August 29, 2019 10:40 to 12:00, Room 524b

Paper will be presented at 2nd Conference on HTHP in Copenhagen, Sept. 9, 2019

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Application examples in Switzerland (food applications)

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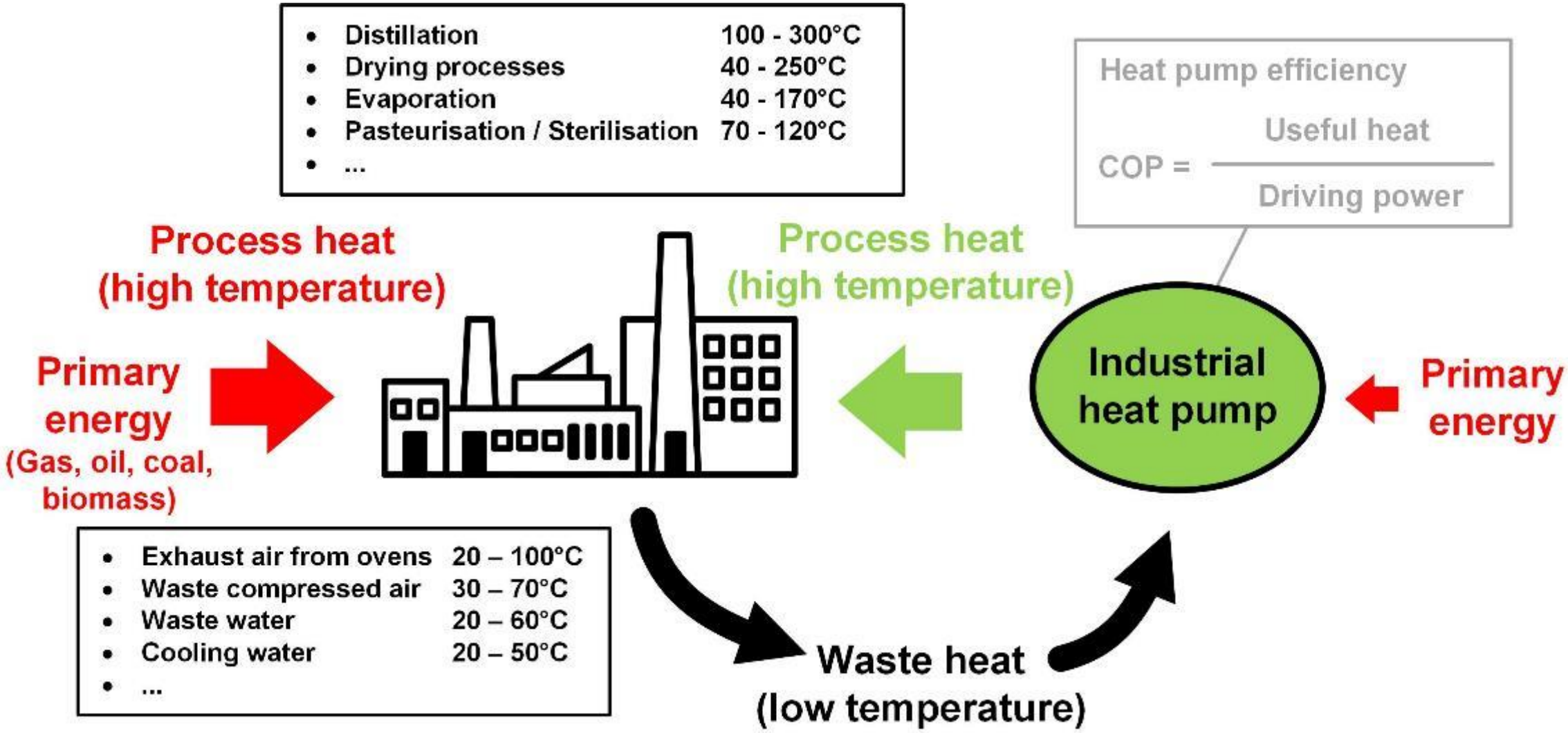
Efficient transformation of useful (waste) heat to higher temperatures



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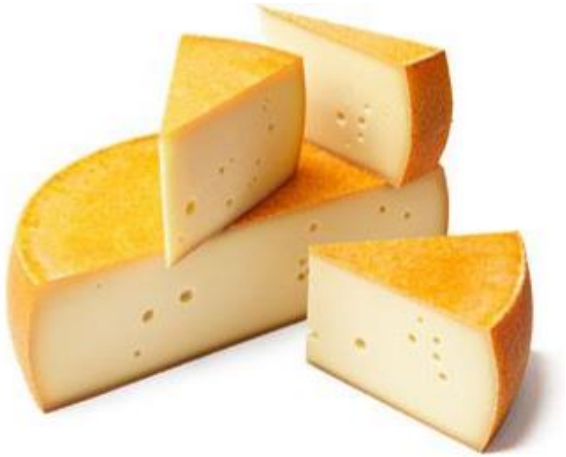
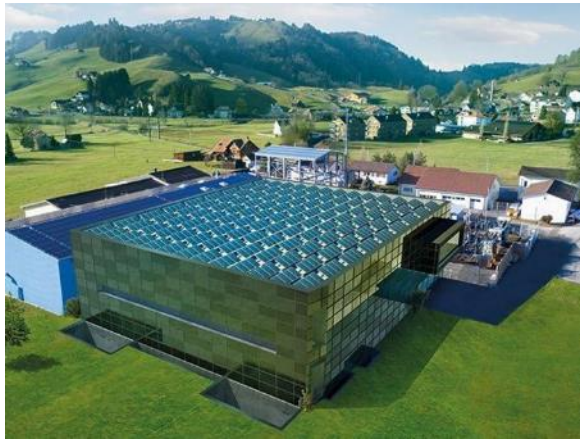
Cheese Factory in Gais Appenzell

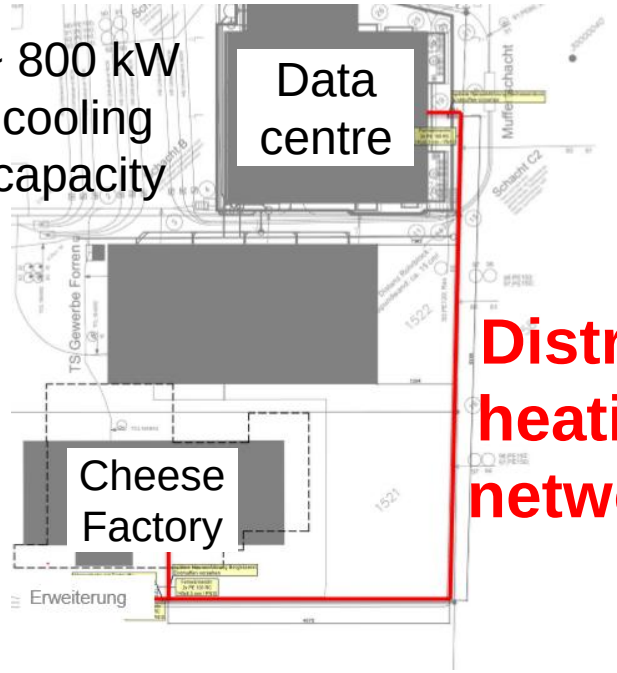


Data Centre



Waste heat from server rooms 16 to 20 °C

~ 800 kW cooling capacity



District heating network

Cheese Factory

- Energy demand ~1'800 MWh/a
- ~10 Mio. liters of milk per year
- ~300 tons of cheese per year
- **Temperature levels:**
  - **Heat recovery** (washing water, ventilation heating): **<42 °C**
  - **Space heating/hot water** (storage): **65 °C**
  - **Process heat 1** (cheese vats, cleaning water): **92 °C**
  - **Process heat 2** (multi-purpose heater, pasteurisation): **105 °C**

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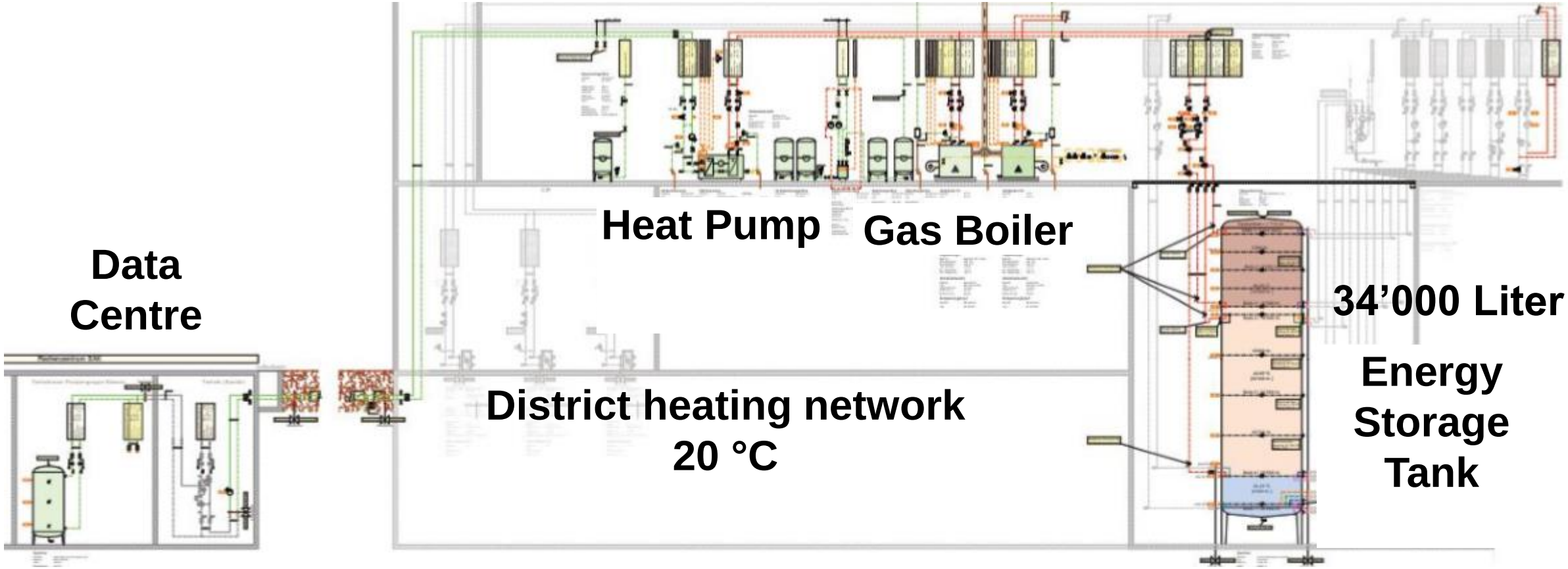

Source: Amstein + Walthert

Cheese Factory in Gais Appenzell

- **IWWHS 570 ER6c2**
- **~520kW**
- 2-stage screw compressor
- **Economizer cycle**
  - Refrigerant mass flow ↑
  - Discharge temp. ↓
  - Subcooling ↑ (COP ↑)
- **R1234ze(E)**
  (130 kg, safety group: A2L, mildly flammable, special measures for fire protection and escape routes)
- **2020/21 first operation**
  (using waste heat from data centre)

Performance data (W18-14/W82-92)

Part load (%)	100	75	50
Effective part load (%)	100	81	62
Condenser heating capacity (kW)	**520**	**419**	**321**
Condenser water flow rate (m^3/h)	44.7	36.0	27.6
Temperature difference condenser (K)	10.0	10.0	10.0
Evaporator capacity (kW)	338	264	195
Evaporator water flow rate (m^3/h)	82.7	82.7	82.7
Temperature difference evaporator (K)	3.5	2.7	2.0
Compressor power (kW)	182	155	126
COP_H (-)	**2.85**	**2.70**	**2.55**

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Chocolate Factory in Flawil

maestrani

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HP manufacturer: CTA AG
Contractor: Seiz AG
Consultant: Carnotech AG

Temperature range from 5 to 70 °C
Space for 8 heat pumps à 220 kW
Application: Cooling and heating of chocolate conching machines
Savings fossil fuels = 2'590 MWh
Savings CO_2 emissions = 30% (510 t/a)

	Cooling	Heating
Cooling capacity	222.6 kW	183.7 kW
Electrical power	70.4 kW	96.8 kW
Heat source in/out	5/11°C	11/17°C
Heating capacity	289.8 kW	276.2 kW
COP	4.12	2.85
Hot water in/out	35/45°C	**60/70°C**
Refrigerant	R-1234ze	**R-1234ze**
Piston compressors	4	4
No. of cooling cycles	2	2

Sources: www.maestrani-schokolade.ch, www.cta.ch

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GVS Schaffhausen, Landi – Beverages

Heat sink: 80 to 95 ºC
- **process water for disinfection of beverage filling plants and wine tanks**
- space heating of storage rooms
- district heating of production site

Heat source: 37 ºC
- waste heat from refrigeration (cooling of storage rooms)

Heat pump type:	**ISWHS 60 ER3**
Heating capacity:	63 kW
Cooling capacity:	48 kW
Compressor:	Screw, ÖKO 1 (R245fa)
COP Heating:	4,2
EER Cooling:	3,2
Year of installation:	2017

Source: Ochsner, Ennovatis Schweiz AG

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Nutrex – Vinegar fermentation and pasteurization

Applications:

- **Cooling: Vinegar fermentation** process over 10 days at 30°C
- **Heating: Vinegar pasteurization >70°C** to obtain a non-perishable food
- **Cooling capacity: 136 kW**
- **Heating capacity: 194 kW, COP 3,4**
- **Savings CO_2 emissions: ~310 t/a**
- **Savings fuel: up to 65'000 L/a**

Technical details of the application

Heating capacity: 194 kW

COP: 3,4

Refrigerant: R134a

Heating source: Water

Supplied temperature: > 70°C

By VIESSMANN climate of innovation

Left: Production of the vinegar/fermentation
Right: Heat pump in machine room
Source: Viessmann/Nutrex

Source: EHPA (2017): Large scale heat pumps in Europe

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Slaughterhouse Zurich – Meat Production

Process applied	**Hot water for cleaning processes up to 90°C and space heating**
Location	Zurich (in the middle of the city, historical building)
Year of installation	2011
HP manufacturer	Thermea, Germany
Contractor	ewz Energiedienstleistungen
Consultant	City of Zurich
Refrigerant	**CO_2 (R744)**
Compressor	Screw
Heating/cooling capacity (kW)	800/564
Heat source	**Waste heat from refrigeration processes** (closed water loop with storage tank) and **waste heat from compressed air generation**
Heat source (°C) in/out	20/14
Heat sink (°C) in/out	**Water, 30/90**
Efficiency (COP)	3.4
Savings CO_2 emissions	30% (510 t/a), saving of 2’590 MWh fossil fuels

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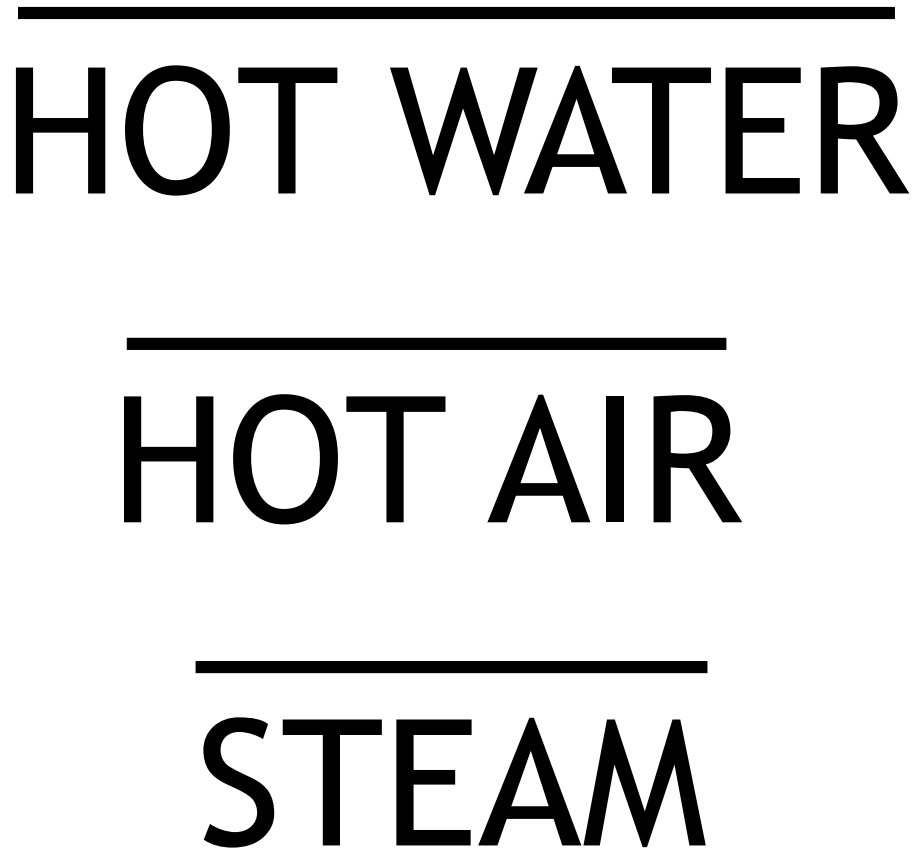
Potential applications



- **Hot water generation for washing and cleaning processes** (food, meat, product washing) in combination with cooling generation
- **Hot air generation and air preheating for drying processes** (wood, paper, sewage sludge, starch, bricks, pet food) by waste heat recovery
- **Process steam generation** (low pressure steam) **for the sterilization and pasteurization of food** (e.g. milk) using cooling water or humid exhaust air
- **Heat recovery by flue gas condensation** in biomass incinerators
- **Local and district heating networks** (e.g. of municipal utilities and municipalities)

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Conclusions

- **115 to 145 units of industrial heat pumps (>100 kW) sold per year**
- **Refrigerants used: R245fa,** R134a, R1234ze, R744 (CO_2)
- The **next generation of refrigerants with very low GWP** needs to be introduced
- **Laboratory HTHP at NTB** allows testing new **HFO & HCFO refrigerants**
- **Application examples in the Swiss food industry**:
  - **chocolate** (hot water, space heating, cooling)
  - **cheese** (process heat)
  - **vinegar** (fermentation, pasteurization)
  - **meat** (cleaning processes)
- Max. identified heat sink temperature: 92 °C (cheese factory)
- **Potential applications: hot water, hot air, steam**
- **Savings: 30 to 40% reduction of CO_2 emissions** & large amounts of **fossil fuels**

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Thank you for your attention

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