WORKSHOP
SUCCESSFUL APPLICATIONS OF
INDUSTRIAL HEAT PUMPS

Status presentation
of Annex 48
Industrial Heat Pumps
August 28, 2019    Montreal
WRAP UP 11:20

QUESTIONS & DISCUSSION & PANEL DEBATE
WITH THE AUTHORS OF THE PRESENTATIONS

Rainer M. Jakobs
INCREASING ENERGY EFFICIENCY IN INDUSTRY:
APPLICATION OF INDUSTRIAL HEAT PUMPS IN AUSTRIA

V. Wilk, T. Fleckl, A. Arnitz, R. Rieberer
APPLICATION EXAMPLES

• about 70 examples for industrial heat pumps in Austria
• food industry
  • simultaneously heating and cooling
  • heating capacity in the range of several 10 – 100 kW, mostly internal heat consumption (space heating)
• power plants that supply district heat
  • flue gas condensation
  • absorption and compression heat pumps
• industrial companies supplying district heat
  • usually in the MW range, supply temperatures of 60 - 95°C
• more efficient processes and considerable reductions in CO₂ emissions
Taking high temperature heat pumps
to the next level –
Power to heat and heat to power

Professor Neil J Hewitt
Dr Mingjun Huang
Dr Nik Shah
Dr Chris Wilson
Dr Donal Cotter
Centre for Sustainable Technologies
Ulster University
Industrial Heat Pumps in the UK

- First sewage heat recovery system in the UK
- 800kW Carrier heat pumps using sewage as heat source
- Provides heat to 5 remote plant rooms via preinsulated heat network
- Annual heat demand c.1.6GWh
- Average SCOP 3.8 (23 months)
- Saves 152t CO₂/year or 40% of gas alternative
- Generates £112k/year RHI + heat sales
- Annual electricity bill £53K
- IRR >10%

Scottish Borders College

Infintatas Design
High Temperature Heat Pumps
And 200°C?

Sarkar et al, 2007
The Combined Heat Pump
Organic Rankine Cycle
For upgrading low grade heat
Identifying optimal industrial heat pump placement

A. Sophia Wallerand, Ivan Kantor, François Maréchal
ICR 2019, Montreal, Canada
EPFL – IPESE

In cooperation with the CTI

- Energy funding programme
  Swiss Competence Centers for Energy Research

- Schweizerische Eidgenossenschaft
  Confédération suisse
  Confederazione Svizzera
  Confederazione svizra

- Swiss Confederation
  Commission for Technology and Innovation CTI
Heat pump integration method

State-of-the-art summary: industrial heat pump design methods

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Focus</th>
<th>Method Conc.</th>
<th>Math.</th>
<th>PA</th>
<th>Property calc.</th>
<th>Temp. discret.</th>
<th>Detail</th>
<th>Objective</th>
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<th>Fluid T Selection</th>
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</table>
Heat pumps for district heating and industry in Denmark
Status, perspectives and ongoing developments
28.08.2019 – ICR Montreal – Workshop on industrial HPs
B. Zühlsdorf, F. Bühler, W. Meesenburg, P. H. Jørgensen, B. Elmegaard
bez@dti.dk, +45 7220 1258
Energy system and political targets

Political treaties and strategies:

- Energy-Strategy (adopted in 2011)
  - By 2050:
    - Independent of fossil fuels

  - By 2030:
    - 40 % Reduction in GHG emissions
    - 55 % Renewables
    - 33 % Increase in energy efficiency
    - < 10 % fossil fuels in district heating

- Plans for Copenhagen:
  - Carbon neutral by 2025
  - 300 MW heat supply to DH by HPs

Energy system:

- High share of renewables in electricity production:
  - 2017: 65 %
  - Increased share of biomass during last years

- High share of district heating in heat supply:
  - Approximately 65 % of households

→ High potential impact for heat pumps
Overview of industrial HP installations

Survey for IEA HPT Annex 48:

- Data on Total (2007 – 2018) 69 119 MW
- Industrial energy recovery 22 19 MW
- District Heating 47 100 MW

Installed capacity by refrigerants

- R717 93%
- R717+R718 2%
- R744 2%
- Hydrocarbons 2%
- Others 1%

Heat pumps at Bjerringbro Energy central, Denmark
Evaluation of Good Practices for Industrial Heat Pumps in Japan

Yohji UCHIYAMA
Japan Electro–Heat Center

Takenobu KAIDA, Katsumi HASHIMOTO
Central Research Institute of Electric Power Industry

Choyu WATANABE
Chubu Electric Power Co., Inc.

Montreal, August 28, 2019
Best Practice in Machinery Industry (No.21)

Process Outline

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<td>Industry</td>
<td>Machinery (Parts production of vehicle)</td>
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<tr>
<td>Process applied</td>
<td>Cutting, Washing</td>
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<tr>
<td>Heat source</td>
<td>Simultaneous heating/cooling (heating 65℃, cooling 15℃)</td>
</tr>
<tr>
<td>Objective</td>
<td>Eliminating the conventional boiler system</td>
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<tr>
<td>HP system</td>
<td>Water-water/Air-water heat pump (6+8=14 units)</td>
</tr>
<tr>
<td>Heating capacity</td>
<td>22kW/unit (6 units), 43kW/unit (8 units)</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>R134a</td>
</tr>
<tr>
<td>Effects</td>
<td>CO2 reduction 80%, energy cost saving: 79%, Pay back time: 5 year</td>
</tr>
</tbody>
</table>

Before

1. Input energy (Electric power)
2. Cooling energy
3. Heating energy
4. Boiler

After

1. Input energy (Electric power)
2. Cooling energy
3. Heating energy
### Best Practice in Machinery Industry (No.21)

#### Effects of Application

**Saving of energy, steam and CO₂ emission**

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<th>After</th>
<th>Difference</th>
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<tr>
<td>Electricity consumption [MWh/y]</td>
<td>193</td>
<td>570</td>
<td>+377 (+195%)</td>
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<tr>
<td>Fuel consumption [kL/y]</td>
<td>470</td>
<td>0</td>
<td>−470 (−100%)</td>
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<tr>
<td>Steam consumption [kL/y]</td>
<td>6,953</td>
<td>0</td>
<td>−6,953 (−100%)</td>
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<tr>
<td>CO₂ emission [ton-CO₂/y]</td>
<td>1,364</td>
<td>270</td>
<td>−1,094 (−80%)</td>
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</table>

**Economical effect**

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<tr>
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<th>Before (old)</th>
<th>After (new)</th>
<th>Difference</th>
</tr>
</thead>
</table>
| Investment               | • Boiler/piping 75.3[million yen]  
  • Steam heating system 10.5[million yen]  
  • Cooling system 50.4[million yen]  
  Total: 136.2[million yen] | Heat pump system (14 units) 91[million yen] | −45.2 [million yen] |
| Operation cost           | • Electric bill (193MWh) 2.34[million yen/y]  
  • Heavy oil charges 28.1[million yen/y]  
  • Water charges 2.45[million yen/y]  
  Total 32.9[million yen/y] | • Electric bill (570MWh) 6.89[million yen/y] | −26 [million yen/y]  
  (−79%) |
INDUSTRIAL HEAT PUMP APPLICATIONS IN SWITZERLAND – HEAT PUMP INTEGRATION CASE STUDIES

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- Institute for Energy Systems IES
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- Tel. +41 81 377 94 34
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ICR 2019, The 25th IIR International Congress of Refrigeration
Montréal, Québec, Canada
August 28, 2019
Potential for industrial heat pumps in Switzerland

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: BFE (2016)  
Source: Wolf et al. (2017)
Cheese Factory in Gais Appenzell

From waste heat to cheese

Rechenzentrum Ost
~800 kW cooling capacity

Waste heat from server rooms 16 to 20 °C

Data centre

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: <42°C
  - Space heating/hot water: 65°C
  - Process Niveau 1: 92 °C
  - Process Niveau 2: 105°C

Source: Amstein + Walthert

ICR 2019, August 29, 2019

cordin.arpagaus@ntb.ch
## Application examples in Switzerland

### Slaughterhouse Zurich – Meat Production

<table>
<thead>
<tr>
<th>Process applied</th>
<th>Hot water for cleaning processes up to 90°C and space heating</th>
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<tbody>
<tr>
<td>Location</td>
<td>Zurich (in the middle of the city, historical building)</td>
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<tr>
<td>Year of installation</td>
<td>2011</td>
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<tr>
<td>HP manufacturer</td>
<td>Thermea, Germany</td>
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<tr>
<td>Contractor</td>
<td>ewz Energiedienstleistungen</td>
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<tr>
<td>Consultant</td>
<td>City of Zurich</td>
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<td>Refrigerant</td>
<td>CO₂ (R744)</td>
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<td>Compressor</td>
<td>Screw</td>
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<tr>
<td>Heating/cooling capacity (kW)</td>
<td>800/564</td>
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<tr>
<td>Heat source</td>
<td>Waste heat from refrigeration processes (closed water loop with storage tank) and waste heat from compressed air generation</td>
</tr>
<tr>
<td>Heat source (°C) in/out</td>
<td>20/14</td>
</tr>
<tr>
<td>Heat sink (°C) in/out</td>
<td>Water, 30/90</td>
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<tr>
<td>Efficiency (COP)</td>
<td>3.4</td>
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<tr>
<td>Savings CO₂</td>
<td>30% (510 t/a), saving of 2’590 MWh fossil</td>
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</table>
TASK 1 + 2

IHP cases:

- A ~ 65
- DK ~ 80
- F ~ 30
- Jap ~ 100
- CH ~ 20
- NL ~ 10
- D ~ 20
- UK ~ ...

total > 320 cases
Challenging Heat & Electricity Prices

→ Focus on Countries with favorable Price Ratios:
  - Sweden
  - Finland
  - Bulgaria
  - Netherlands
  - France
  - etc.

→ Focus on Rural Areas without Gas Networks
Content in HPT Magazine no 2/2019

Industrial Heat Pumps - Good examples from ongoing Annex

Even though heat pumps often are thought of as domestic products, they do have a large potential also in industrial implementations. However, such implementations may
Next possibility to learn more about industrial heat pump applications
11:30 - 12:00

QUESTIONS & DISCUSSION & PANEL DEBATE
WITH THE AUTHORS OF THE PRESENTATIONS

Rainer M. Jakobs
Many thanks for your kind attention
Next possibility to learn more about industrial heat pump applications