Commercial and Industrial Heat Pump Application

IEA HPT Annex 35/48

IZW e.V.

Information centre on heat pumps and refrigeration

Germany

Dr.-Ing. Rainer M. Jakobs

Agenda

- Background
- Market overview, barriers for applications
- Technology
- Case Studies
- Summary and outlook

- Report: Download http://www.izw-online.de/annex35/index.php

IEA HPP - IETS Annex 35/13: Application of industrial Heat Pumps

- As a joint venture of the IEA Implementing Agreements Industrial Energy-related Technologies and Systems (IETS) and Heat Pump Programme (HPP)
- 9 IEA countries A CDN D DK F JAP Korea NL S
  15 participating organizations
- Operating agent: IZW e.V. Germany
- Start date: 01st May 2010 End date: 30th April 2014
- Report: 31st October 2014 689 pages
  39 R&D projects 115 applications
  85 publications of the participants

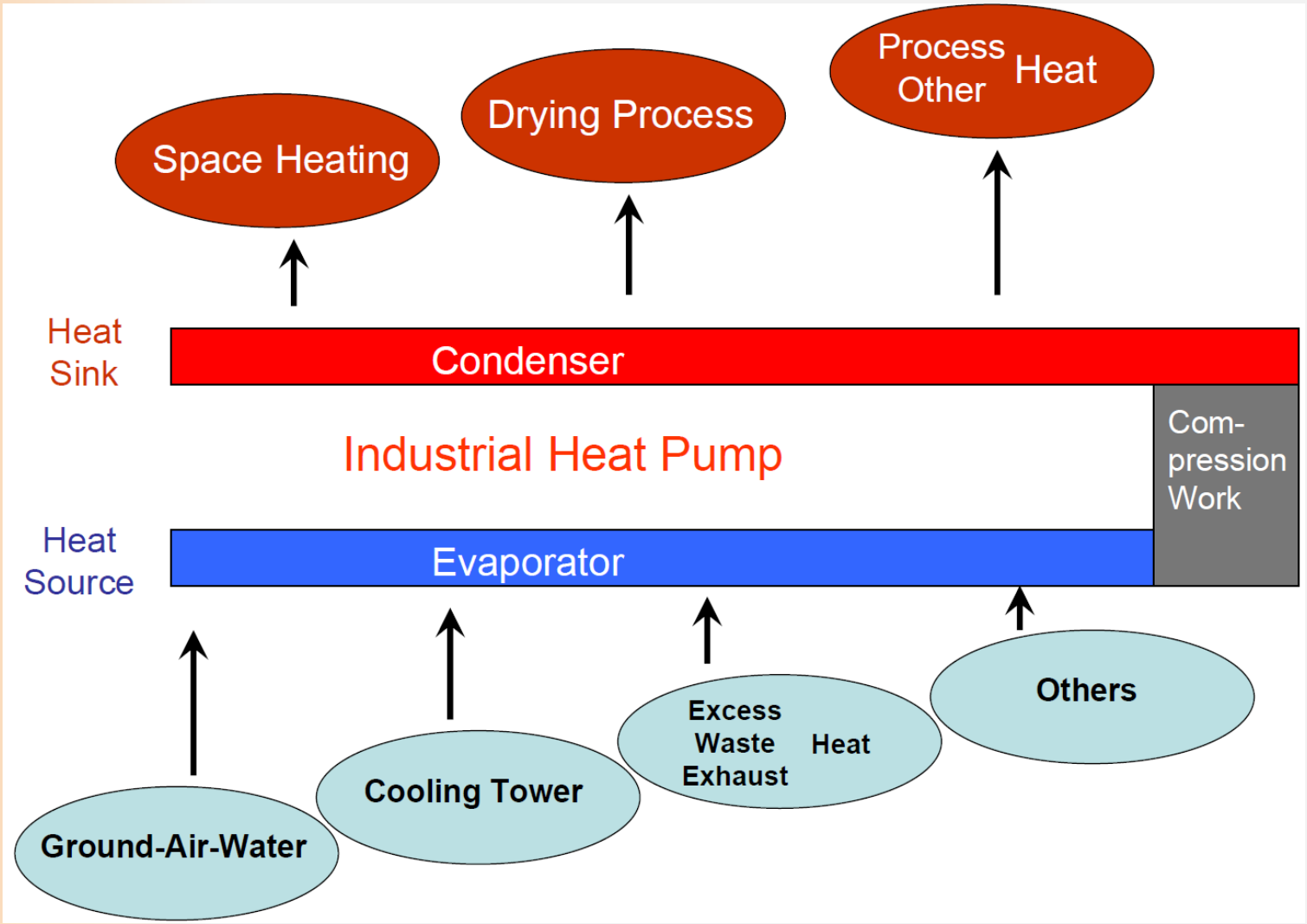
Tasks Structure of the HPP Annex

- **Task 1:** Market overview, barriers for application
- **Task 2:** Modeling calculation and economic models
- **Task 3:** Technology, high temperature heat pumps, process technological integration, refrigerants
- **Task 4:** Application and monitoring, easy to install standard solutions, operating experience, energy effects
- **Task 5:** Communication, awareness of potential (policy paper), internet, database, training

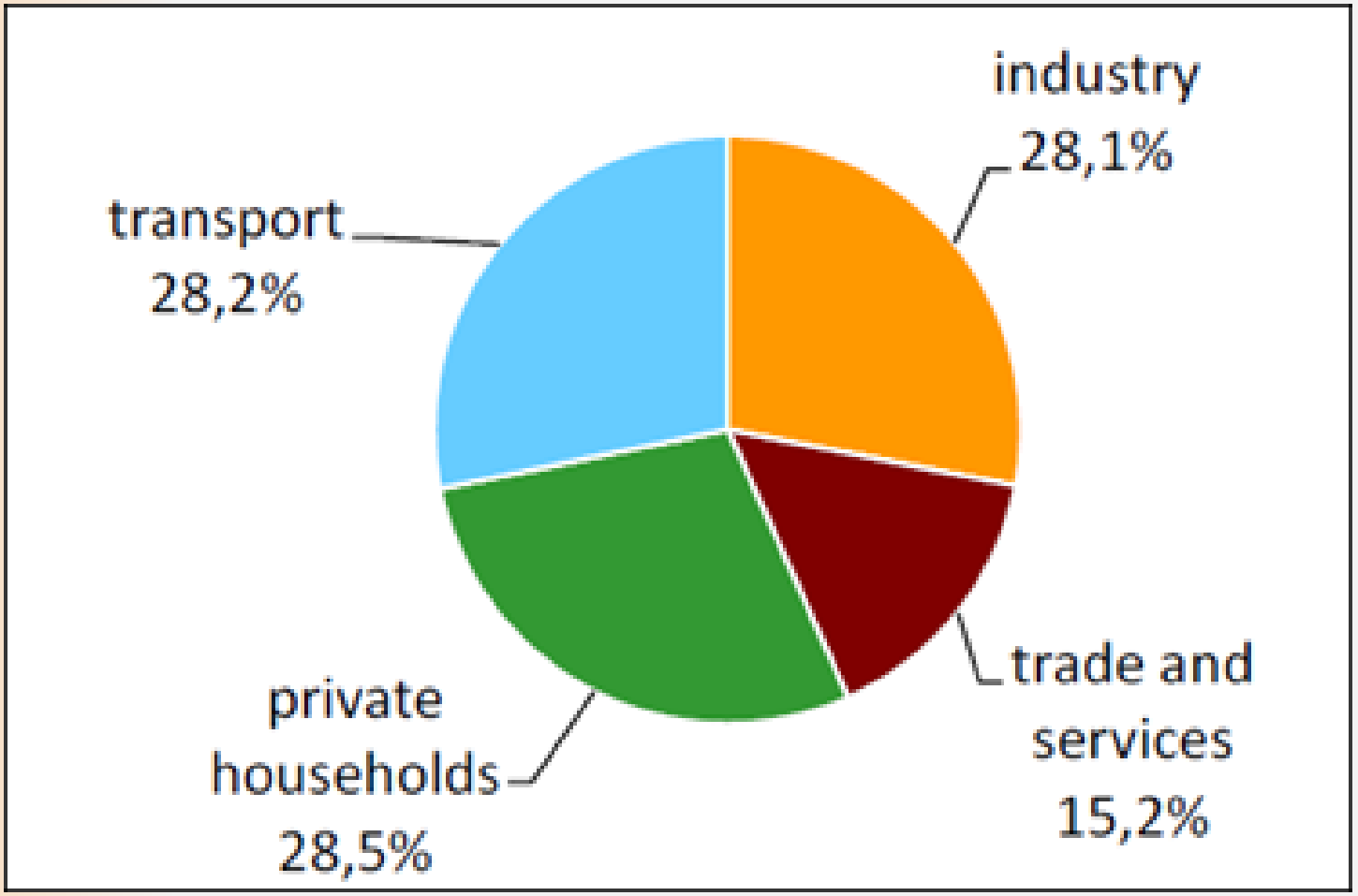
Results - Final Report HPP Annex 35

Task	Members		Sum.	Intro.	OA	A	CDN	DK	F	D	Jap	Korea	NL	S	Total pages
	Cover and Content	Pages			**2**										**2**
	Executive Summary	Pages			**10**										**10**
	Basics of IHP	Pages			17										**17**
1	**HP Energy situation, energy use, market overview, barriers for application**	Pages	1-5	6-9		10-24	25-31	32-37	38-50	51-63	64-70	71-77	78-93	94-100	100
2	**Modeling calculation + economic models**	Pages		1-29		30-34			35-57				58-76		76
3	**R & D Projects**	Pages	7	12		13--25	26-55	56-75	76-89	90-106	107-148	149-159	160-178		178
4	**Case studies**	Pages	9	14		15-47	48-80	81-94	95	96-148	149-185	186-197	198-214		214
	Appendix	Pages									16		34		46
5	**Communication, awareness of potential**	Pages		1-4		5-16							8		34
	Publication	Pages			17-26										
	Annex Meetings	Pages			27-27										
	Workshops	Pages			28-34										
	Policy Paper	Pages			1-12										12
												Total pages:			**689**

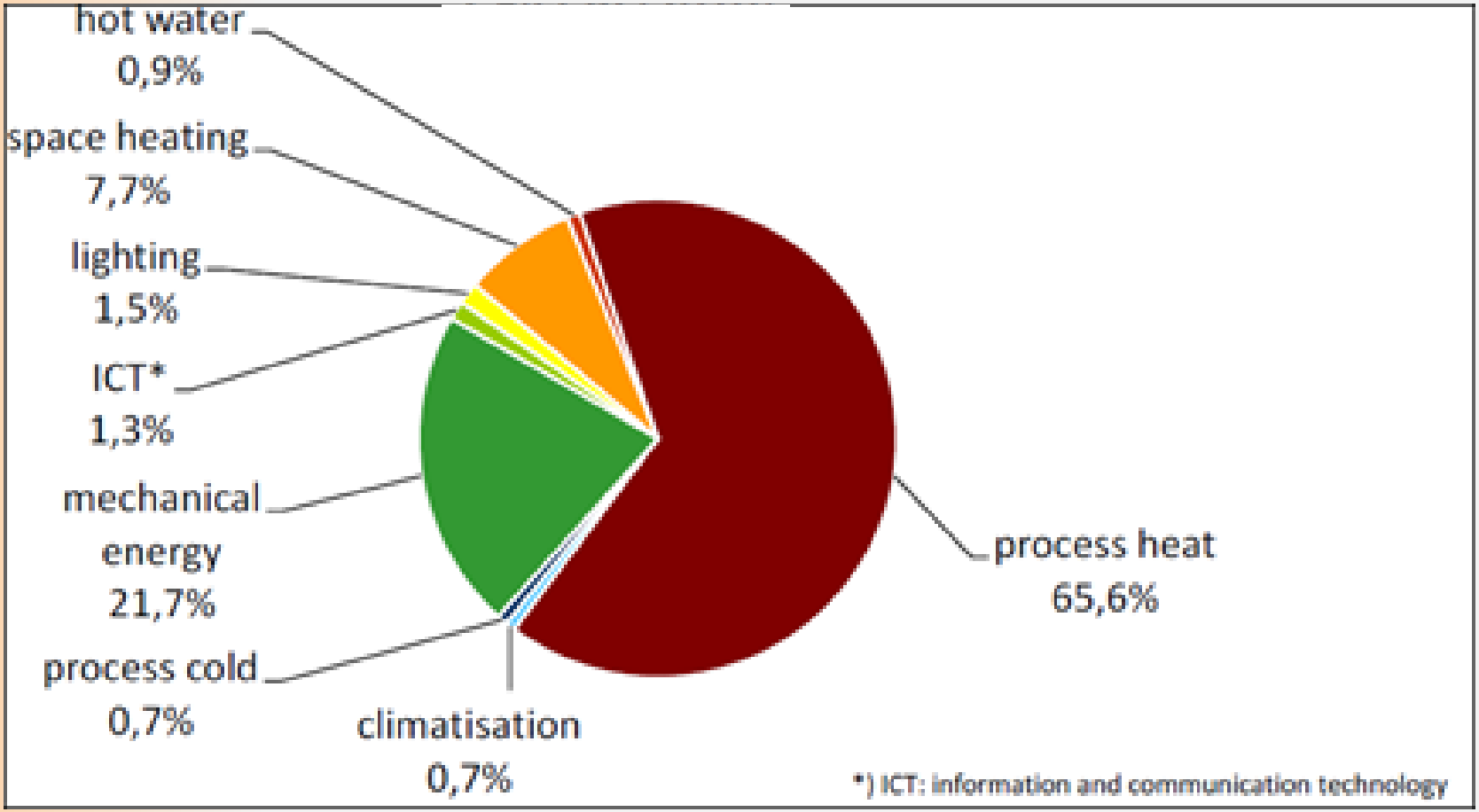
Heat Source and Heat Sink in Industrial Heat Pumps



Final energy consumption (9,060 PJ) in Germany 2010 by sector /BMWI 2012

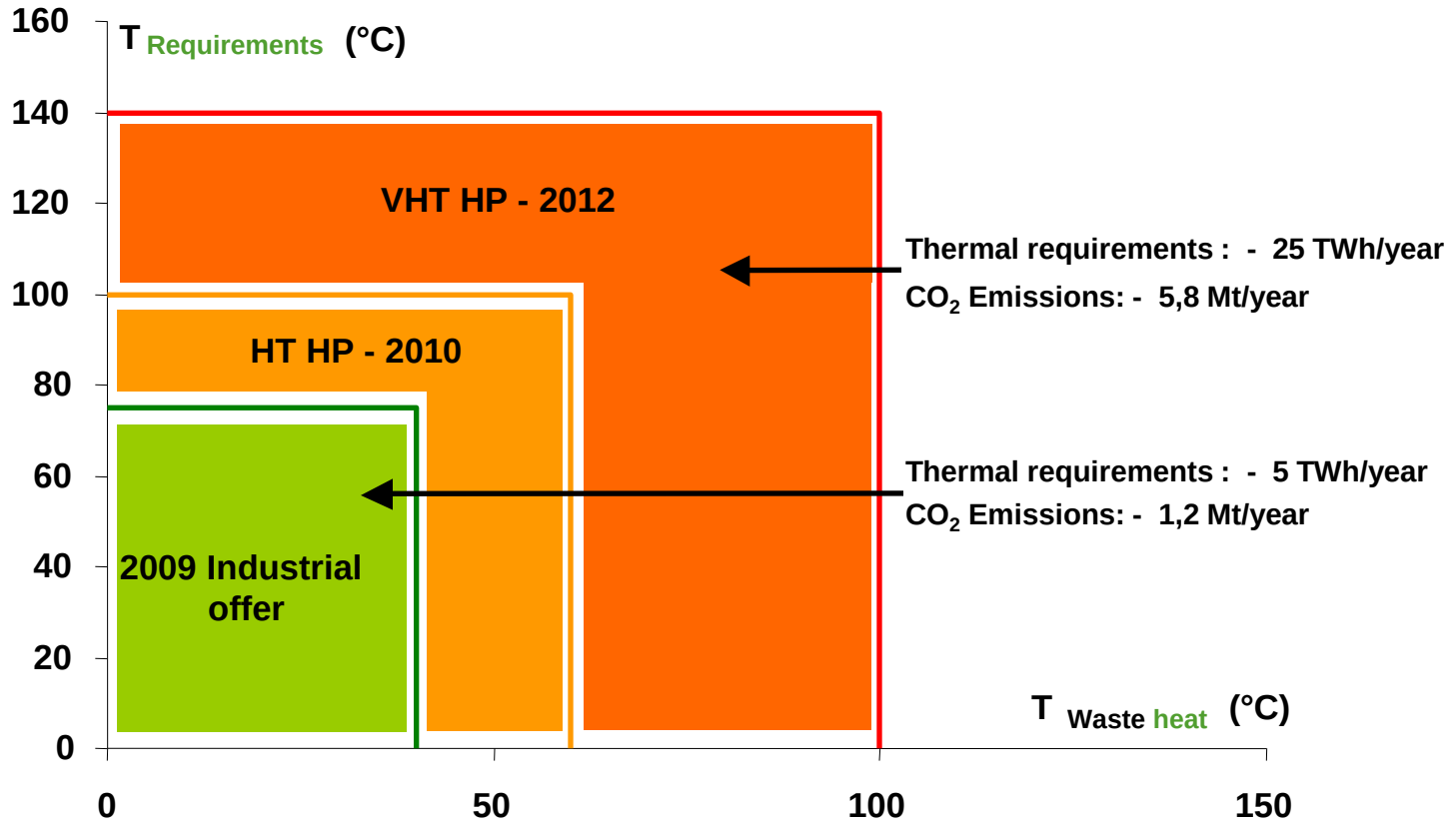


Final energy consumption (2,542 PJ) in the Germany industry 2010 by sector /BMWI 2012



Greater market with higher temperature (France)

HP operating range



Heat Pump Energy situation, energy use, market overview, barriers for application

The country reports show that the industrial energy consumption in the participating countries varies between 17 to 58 % with great differences of the manufacturing sectors.

The barriers can be solved, as shown in the results of the Annex:

- short payback periods are possible (less than 2 years),
- high reduction of CO_2-emissionen (up to more than 50%),
- temperatures higher than 100 °C are possible,
- supply temperatures lower than 100 °C are standard.

Technology EDF projects to reach temperatures > 100 °C

Alter ECO Project

Partnership : Rhodia, Arkema, Danfoss, CIAT, …

VHT HP
140°C – 250 kW

Integrator : CLAUGER

Technical Partnership

EDF /Johnson Controls

HT/VHT HP
100°C/120°C – 700 kW

Manufacturer : JCI

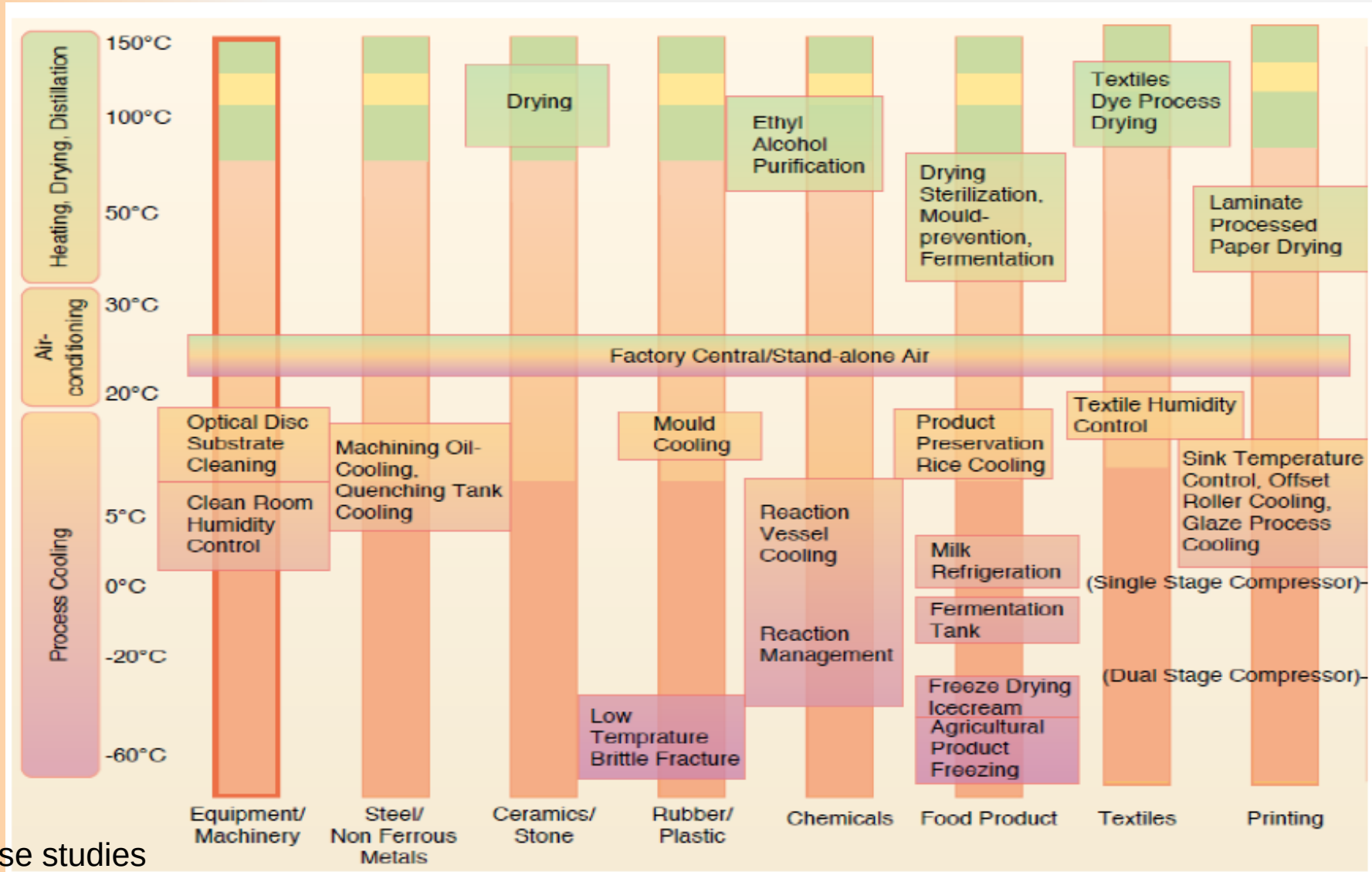
ANR PACO Project

Partnership : Johnson-Control, France Évaporation, CETHIL, AgroParistech, Matmeca …

VHT HP with water
140°C – 700 kW

Manufacturer JCI/F-Évaporation

Case Studies



Application, Industry	Member Country	Year	System	Refrigerant	**C**ooling **H**eating **D**rying **W**aste heat	Heating Capacity	Supply tempe-rature	Pay back period	Reduction CO_2	Reduction energy/cost	Report page
Food: meat, sausage	A	eld	Mech Compr	R-134a	W	257 kW	55 °C		75%		420
Ice rink	A	2013	Mech Compr	R-717	W	413 kW	60 °C		75%		422
Food: brewery	A	2012	Mech Compr	R-717	W	370 kW	63-77 °C	5.7 a		64,000 €/a 18.3 %	426
Fish farm	CDN	eld	Mech Compr	R-22	H	109	10–12 °C	1.3 a			460
Wood drying low temp	CDN	eld	Mech Compr		D	5.6 kW	n. a.			21.5%	463
Wood drying high temp	CDN	eld	Mech Compr		D	2 x 65 kW	Up to 100 °C			50%	471
Washing metal items	DK	2011	Mech Compr	R-134a	H	25 kW	60 °C	2.5 a	20 t/a	50%	493
Food: Slaughter-house	D	2011	Mech Compr	R-744	C&H	800 kW	90 °C		510 t/a		500
Food: Dairy	D	2011	Mech Compr	R-717	W	3.45 MW	58 °C		30-40%		506

Application, Industry	Member Country	Year	System	Refrigerant	**C**ooling **H**eating **D**rying **W**aste heat	Heating Capacity	Supply tempe-rature	Pay back period	Reduction CO_2	Reduction energy/cost	Report page
Food: Dairy	D	2011	Mech Compr	R-717	W	3.45 MW	58 °C		30-40%		506
Coating Powder	D	2012	Mech Compr		D	240 kW	45 °C	5 a			531
Food: Malt production	D	2010	Mech Compr	R-717	D	3,250 kW	35 °C				546
Food: Brewery	D	2012	Mech Compr	R-134a	H	77 kW	55 °C	< 6 a			547
Food: Noodle production	Jap	2008	Mech Compr	R-744 trans.	C & H	C 56 kW H 72 kW	5 °C 90 °C	8.2 a	31%	25%	557
Transformer casing (painting)	Jap	2009	Mech Compr	R-744 trans.	D	110 kW	80–120 °C		13%	12%	565
Automotive (painting)	Jap	2009	Mech Compr	R-407E	D	566 kW	n. a.	3 – 4 a	47%	63%	569
Automotive – Washing process	Jap	2009	Mech Compr	R-134a	C & H	8 x 45.3 kW 6 x 22,3 kW	65 °C		86%	73%	575
Greenhouse	Jap	2010	Mech Compr	R-410A		6 x 18 kW	20 °C		63%	50%	580
Food: Drying of french fries	NL	2012	Mech Compr	R-717	D	880 kW	70 °C	4 a		70%	NL-06
Greenhouse Tomatoes	NL	2003	Mech Compr	R-134a	C&H	3 x 1.25 MW	42-50 °C	> 10 a	40-60 %	29%	NL-27

Case studies

Some applications in Austria

Compression heat pump in in a brewery:

- NH_3 Compression HP (COFELY)
- 370 kW heating capacity
- Waste heat from:
  - + air compressor
  - + chillers
- Heat upgrade from ca. **40 to 77°C**
- Space and process water heating
- ROI: 5,7a

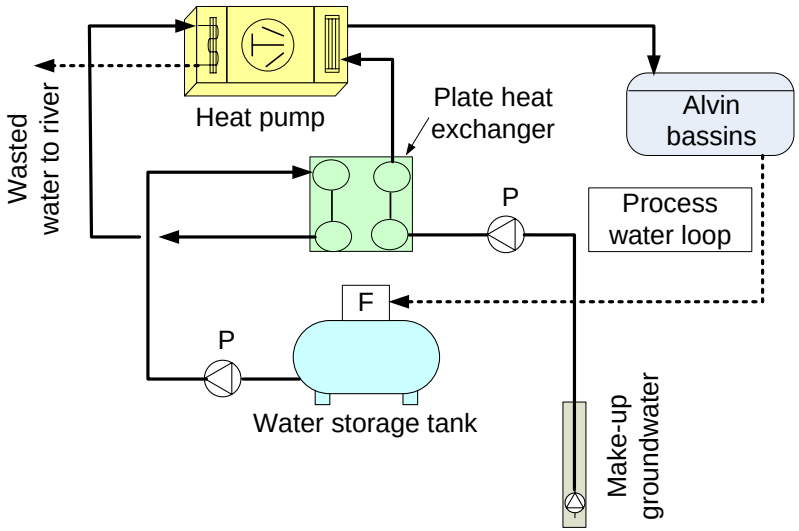
Source: klima:aktiv

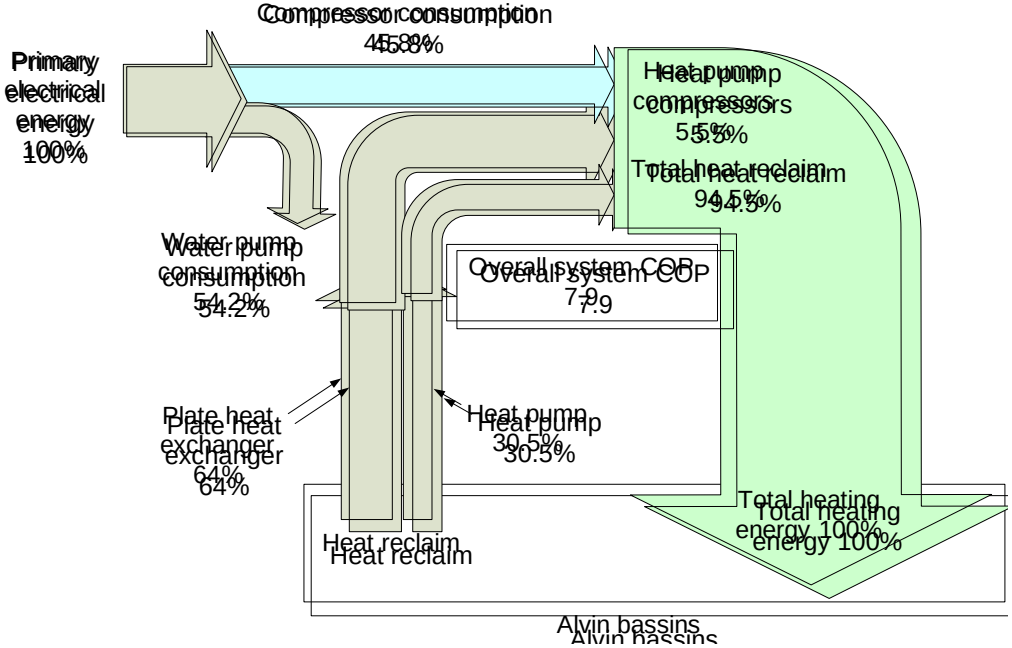
Company: MOHREN SEIT 1834

*www.**mohrenbrauerei**.at*

HP @ Mohrenbrauerei (Source: klima:aktiv, 2012)

Fish farm heat recovery





(b)

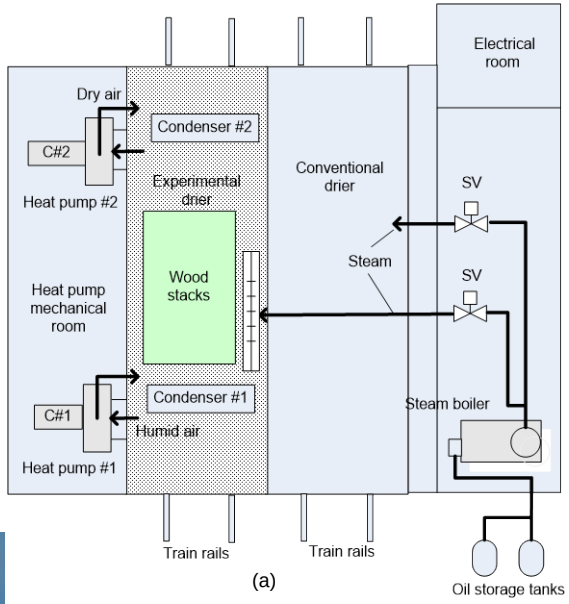
Overall system COP: 7.9
Payback period: 1.28 year

Heat pump-assisted drying [2]

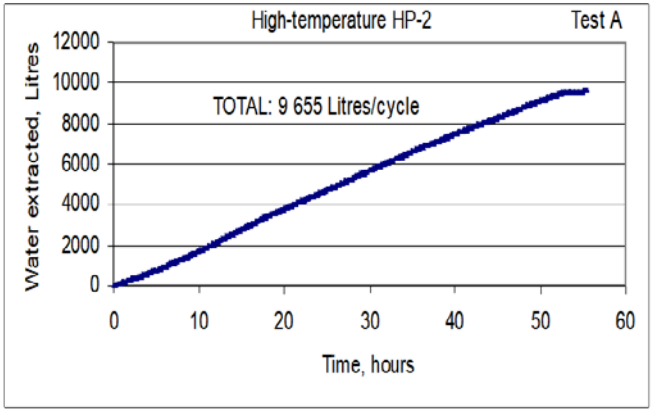
Industrial high-temperature HP for softwood drying (354 m³)

White Spruce
Balsam Fir

- 2 HPs – total 130 kW
- HFC-236fa
- Split HPs with remote condensers



(a)



(b)

- > 19 300 Liters of water removed/cycle
- SMER:1.46 to 2.52 kgw/kWh (compressors + blowers)
- Energy savings: 27 to 57% vs. oil

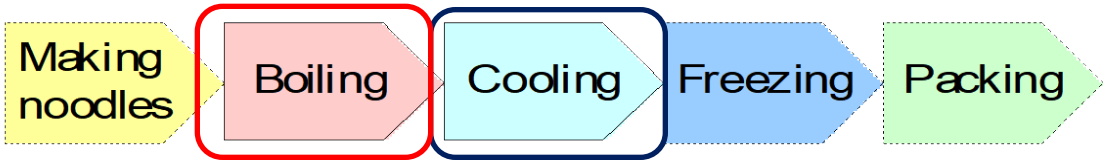
Example: Malt production

Electric compression heat pump in malt production	
Industrial branch	Food - malt production
Type of heat pump	Electric compression heat pump
Heating capacity	3,250 kW
Heat source description	Process exhaust air
Heat source temperature	23 °C
Heat sink description	Process heat for a kiln
Heat sink temperature	35 °C
COP	6,3
refrigerant	R717 (Ammonia)
Installation cost	1.820.000 € (Heat Pump & Installation)
Payback period	5,3 a
Internal return rate (IRR)	24 %

Simultaneous Cooling and Heating Heat Pump for Noodle Production *

Industry	Frozen Noodle Production
Process	Boiling, Cooling
Application	Simultaneous Hot Water (83 °C) and Cold Water (10 °C) Supply
Purpose	Reduction of Boiler Steam (Fuel Light Oil)
System Overview	Water-to-Water Heat Pumps with CO_2 Refrigerant (2 Units) with Heating Capacity 72 kW, COP 3.1 (from 20 °C to 90 °C) and Cooling Capacity 50 kW, COP 2.0 (from 10 °C to 5 °C), total COP 5.1
Effect	Primary energy consumption was reduced by 19%.

Manufacturing processes of frozen noodles



Water-to-Water Heat Pumps with CO_2 Refrigerant (2 units)

*: Yoneda, H. (March 2011). "The Operative Results of the Heat Pump Introduction in the Noodles Production Factory", Utilization Examples of Heat Pumps in Industry, JSRE Seminar Text Book.

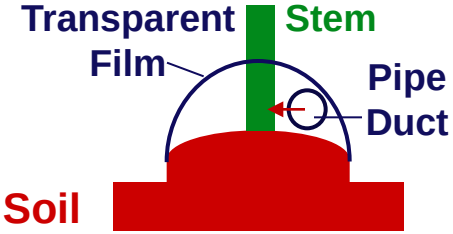
Applying Heat Pump Technology to Agricultural Production *

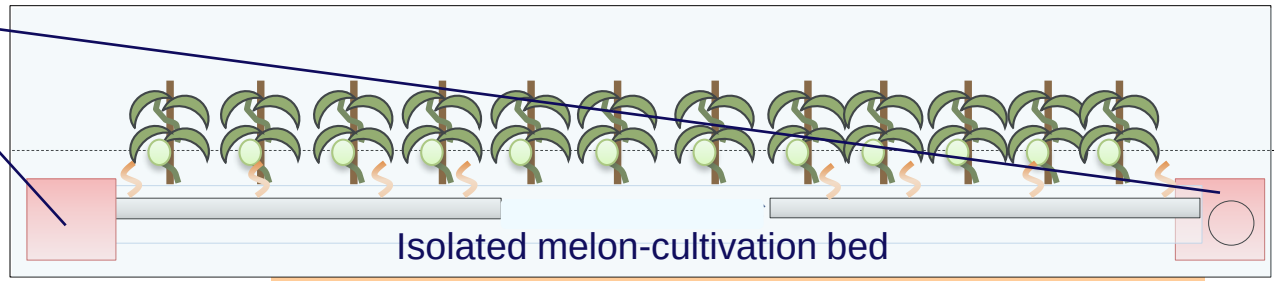
Industry	Fruit Cultivation
Process	Green House Air-conditioning
Application	Space Heating in Winter and Space Cooling in Summer
Purpose	Reduction of Fuel Heavy Oil in Winter and Air-conditioning in Summer
System overview	Air-to-Air Inverter-controlled Greenhouse Heat Pumps using R410A (7 Units) with Heating Capacity 18 kW (20 °C) and Cooling Capacity 16 kW (27 °C) , Twin Type 6 Sets and Single Type 1 Set
Effect	Primary energy consumption was reduced by 49%.

Twin Type

Outdoor Unit 2 Indoor Units

Type	Twin	Single
Number of Indoor Units	2	1
Cooling (Standard) COP	5.48	3.86
Heating (Standard) COP	5.50	4.90
Heating (Cold climate) COP	3.77	3.20



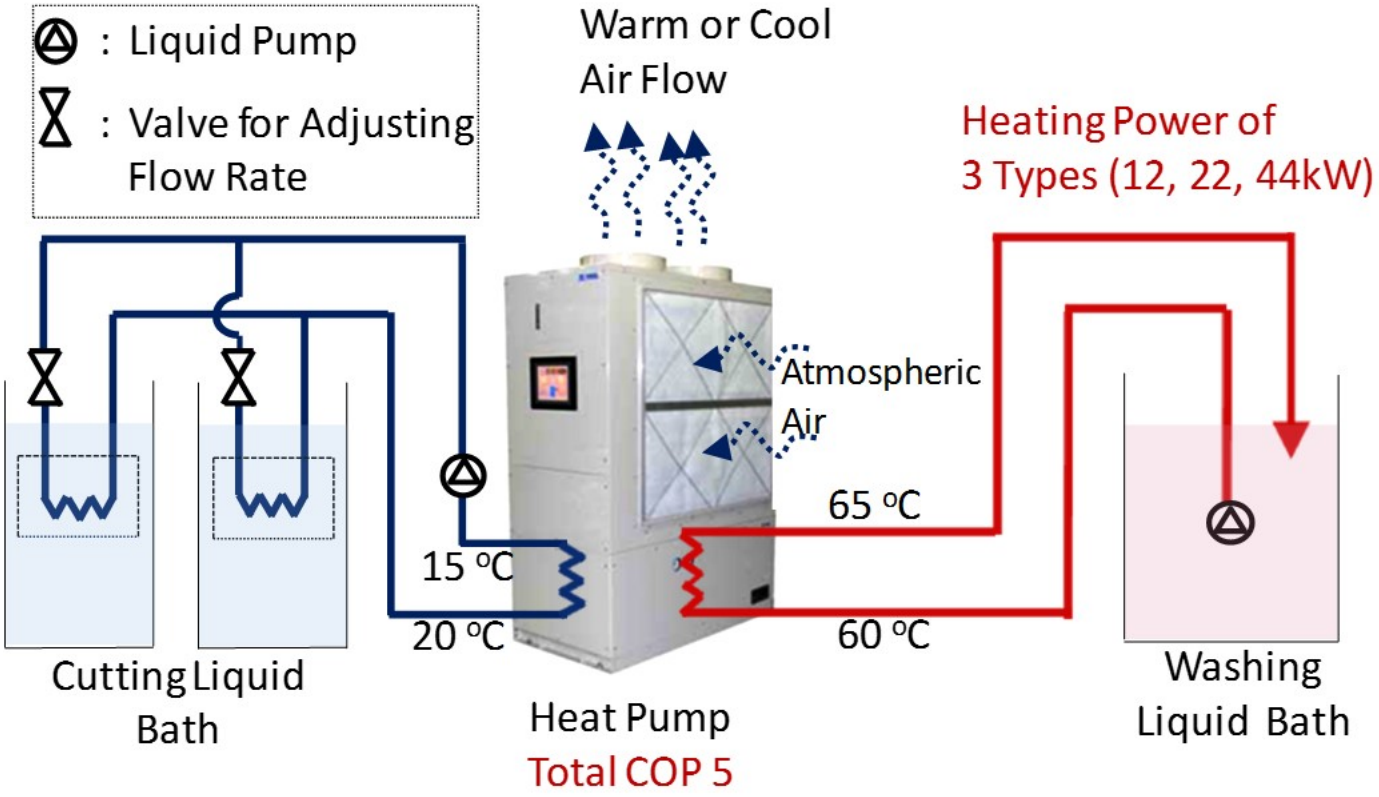


Cross sectional view of a greenhouse

*: JEHC (Sep. 2011). Electro-Heat Hand Book, Japan Electro-Heat Center (JEHC), Ohmsha, Tokyo, ISBN 978-4-274-21037-2.

Heat Pumps for Cutting and Washing Process

Industry	Automobile Parts Production
Process	Cutting, Washing
Application	Heating of Washing Liquid in the Washing Process (65°C), Cooling of Cutting Liquid in the Cutting Process (15°C)
Purpose	Reduction of Boiler Steam (Fuel Crude Oil)
Effect	Primary energy consumption was reduced by 73%.



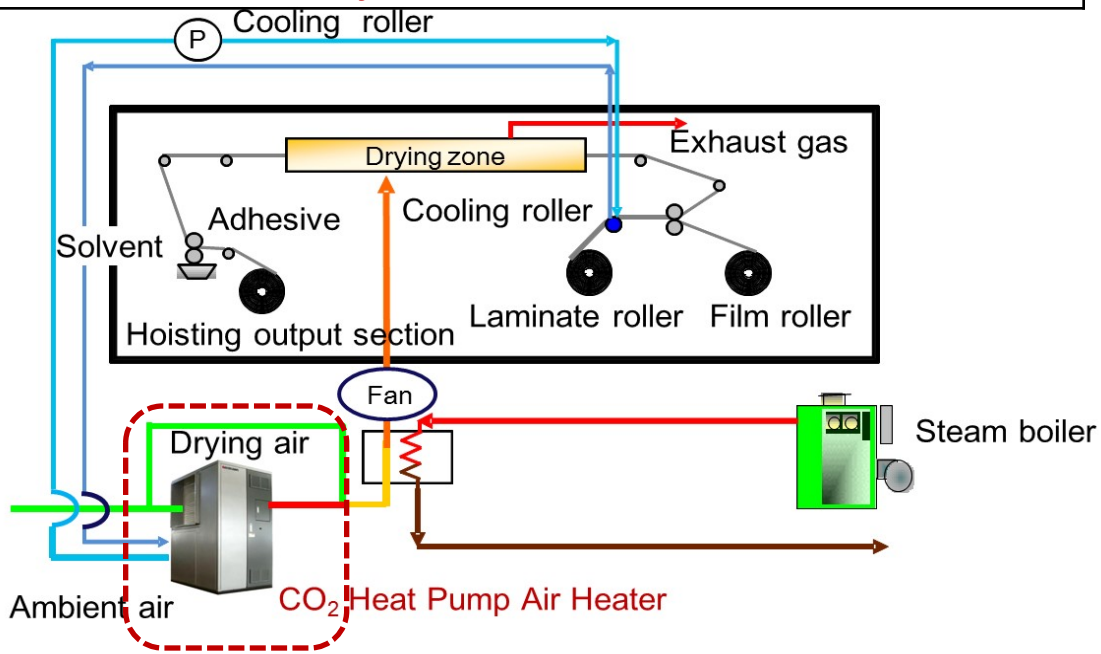
Air-to-Water and Water-to-Water Heat Pump With R134a Refrigerant

Shiba, Y., Tanifuji, K., Nakayama, H. and Sakuraba, I. (2012). "Development and Introduction of a Heat Pump for Washing Process", Proc. of the 2012 JSRAE Annual Conference, F114.

CO_2 Heat Pump Air Heater for Drying Process *

Industry	Laminate Printing
Process	Drying, Cooling
Application	Hot Air Supply to Drying Zone and Cool Water Supply to Cooling Roller
Purpose	Reduction of Steam (Fuel Gas)
System Overview	Water-source Heat Pump Using CO_2 Refrigerant (1 Unit) for Hot Air Supply with Heating Capacity 110 kW, Operating Range of Hot Air Leaving Temperature 80 to120 °C and That of Heat Source Water Entering Temperature 5 to 32 °C, COP
Effect	Primary energy consumption was reduced by 46%.

Reciprocating-type compressor
Heating air: from 20 to 100 °C Heating Capacity: 110 kW **Heating COP: 3.4**
Cooling water: from 30 to 25 °C Cooling Capacity: 81 kW, **Cooling COP: 2.5**
Total COP: 5.9



*: Kando, M. (2012). "Case Studies of High Temperature Heat Pump to the Industrial Field from System Study to Operation", Proc. of the 2012 JSRAE Annual Conference, F112.

Summary

The main objectives of the project include

- market overviews in the participating countries (country reports),
- systems aspects and opportunities,
- apparatus technologies (R&D projects)
- and system technologies (case studies).

The project collected

- 39 R&D-projects
- 115 case studies.

These examples show successful integration of heat pumps.

Payback periods, which are lower than 1.5 years are possible in some examples.

CO_2-emissions and energy costs can be reduce by more than 80 % in some cases.

Summary

- Heat pumps can provide high temperatures up to 100 °C at large heating capacities (several MW).
- Industrial heat pump systems reach payback times between 2 and 7 years
- Heat pumps become especially economical feasible, when both hot and cold side are used
- Heat pumps are ready for the industry!

Barriers and threats:

- Insufficient knowledge about industrial processes among HVAC planners
- Rising electricity prices (e.g. in Germany), while gas and oil prices remain stable or decrease

Outlook

- Main Goal of the new HPT-Annex 48 is to overcome difficulties and barriers for the market introduction of industrial heat pumps.
- Collected cases studies of industrial branches with a large potential, should be analyzed
- Development of a web based information platform for heat pumps in the industrial and commercial application
- Creating information material for IHP (training) courses
- The IHP potential for more efficient use of energy and reduction of greenhouse gas emission should be prepared for policy makers

Many thanks for your kind attention

Herzlichen Dank für Ihre freundliche Aufmerksamkeit