Technical Background of Thermally Driven Heat Pumps

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- Cycles

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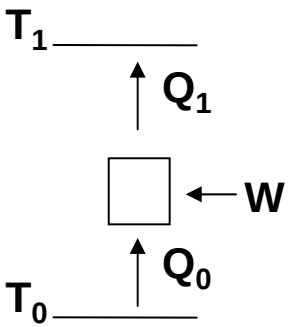
- Use of district heating networks
- CHCP
- Solar cooling
- Use of waste heat

Conclusions

Working Principle – Efficiency Numbers

COMPRESSION

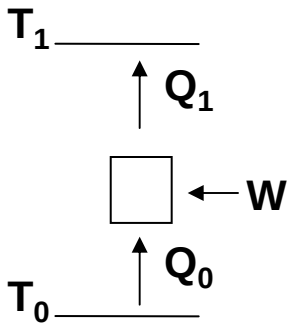


Efficiency

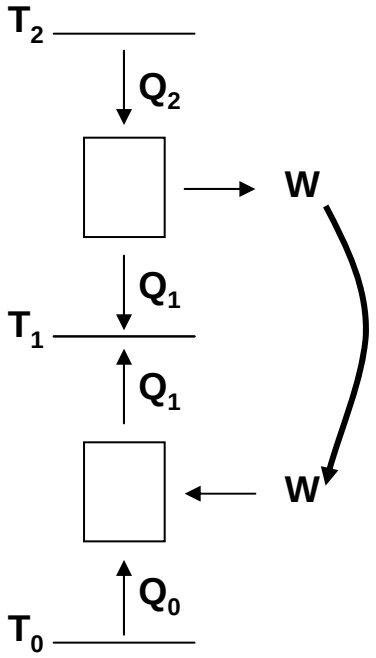
$$\varepsilon_{cold} = \frac{cold \quad Q_0}{electr.\ work \quad W}$$

Working Principle – Efficiency Numbers

COMPRESSION



Power Plant + COMPRESSION



$$W = \frac{T_2 - T_1}{T_2} \cdot Q_2$$

$$Q_0 = \frac{T_0}{T_1 - T_0} \cdot W$$

Efficiency

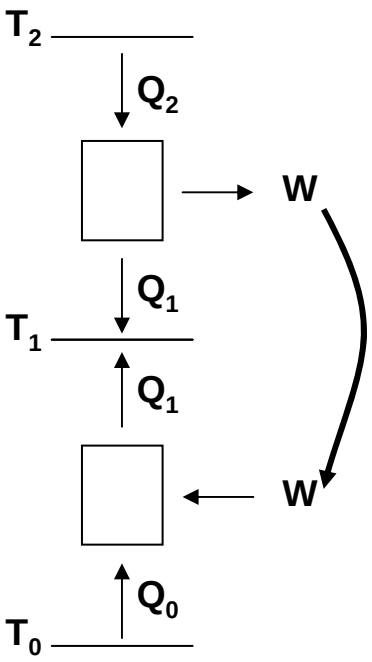
$$\varepsilon_{cold} = \frac{cold \quad Q_0}{electr. \ work \quad W}$$

"COP"

$$COP_{cold} = \frac{cold \quad Q_0}{driving \ \ heat \quad Q_2}$$

Working Principle – Efficiency Numbers

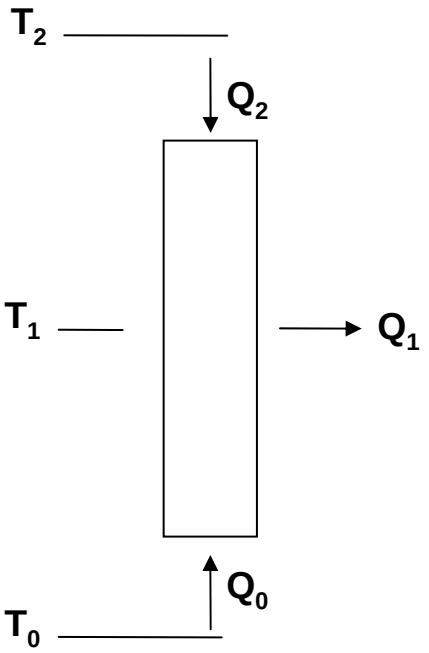
Power Plant + COMPRESSION



$$W = \frac{T_2 - T_1}{T_2} \cdot Q_2$$

$$Q_0 = \frac{T_0}{T_1 - T_0} \cdot W$$

Thermally driven



$$COP_{rev} = \frac{Q_0}{Q_2} = \frac{T_2 - T_1}{T_2} \cdot \frac{T_0}{T_1 - T_0}$$

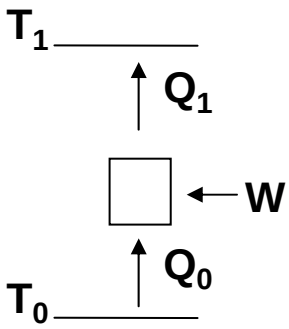
Heat transformation: 3 temperature levels

eg107 Veranstaltung / Datum auf Folienmaster anpassen

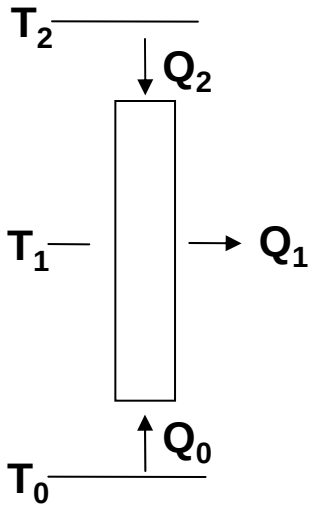
guenther, 1/24/2008

Working Principle – Efficiency Numbers

COMPRESSION



Thermally driven



Efficiency

$$\varepsilon_{cold} = \frac{cold \quad Q_0}{electr. \ work \quad W}$$

$\varepsilon_{cold} =$ 2 to 5
large systems: up to 7

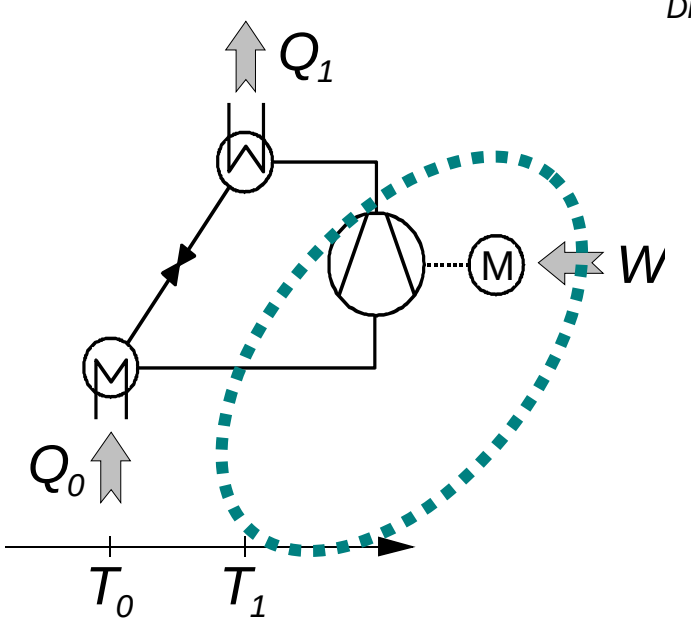
Coefficient of Performance

$$COP_{cold} = \frac{cold \quad Q_0}{driving \quad heat \quad Q_2}$$

$COP_{cold} =$ 0,7 to 1,3
(small and large systems)

Working Principle – basic cycle

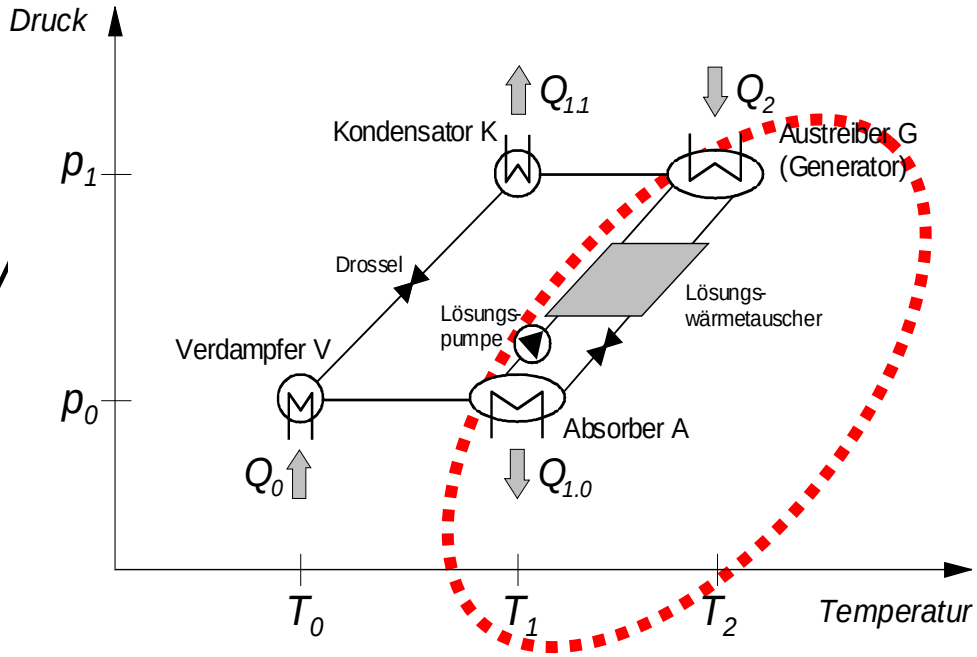
COMPRESSION



temperature lift

mechanical compressor
electricity or work

ABSORPTION



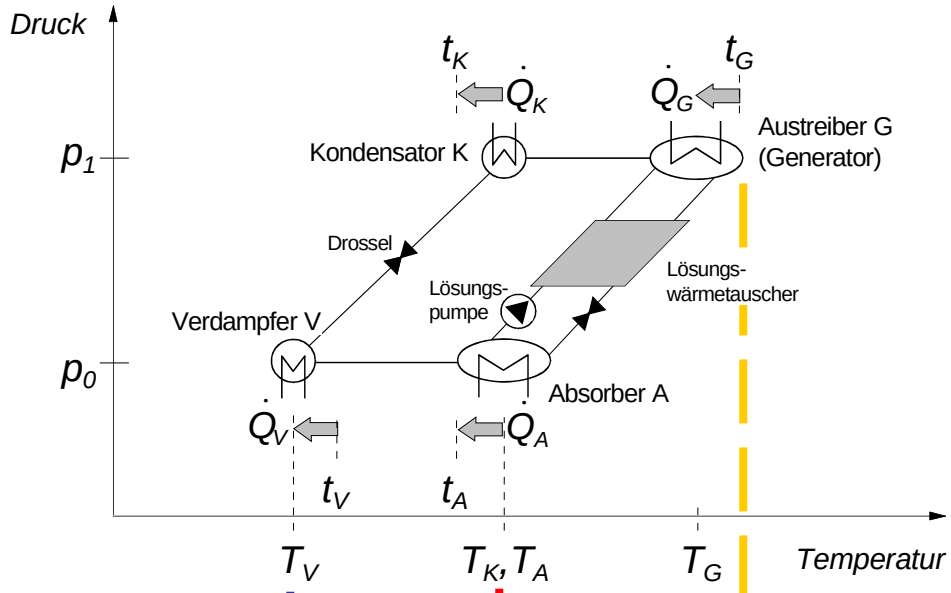
temperature lift

thermal ‚compressor'
heat @ T_2

Working Principle – basic cycle

Single-Effect-Machine

Water/LiBr



COP

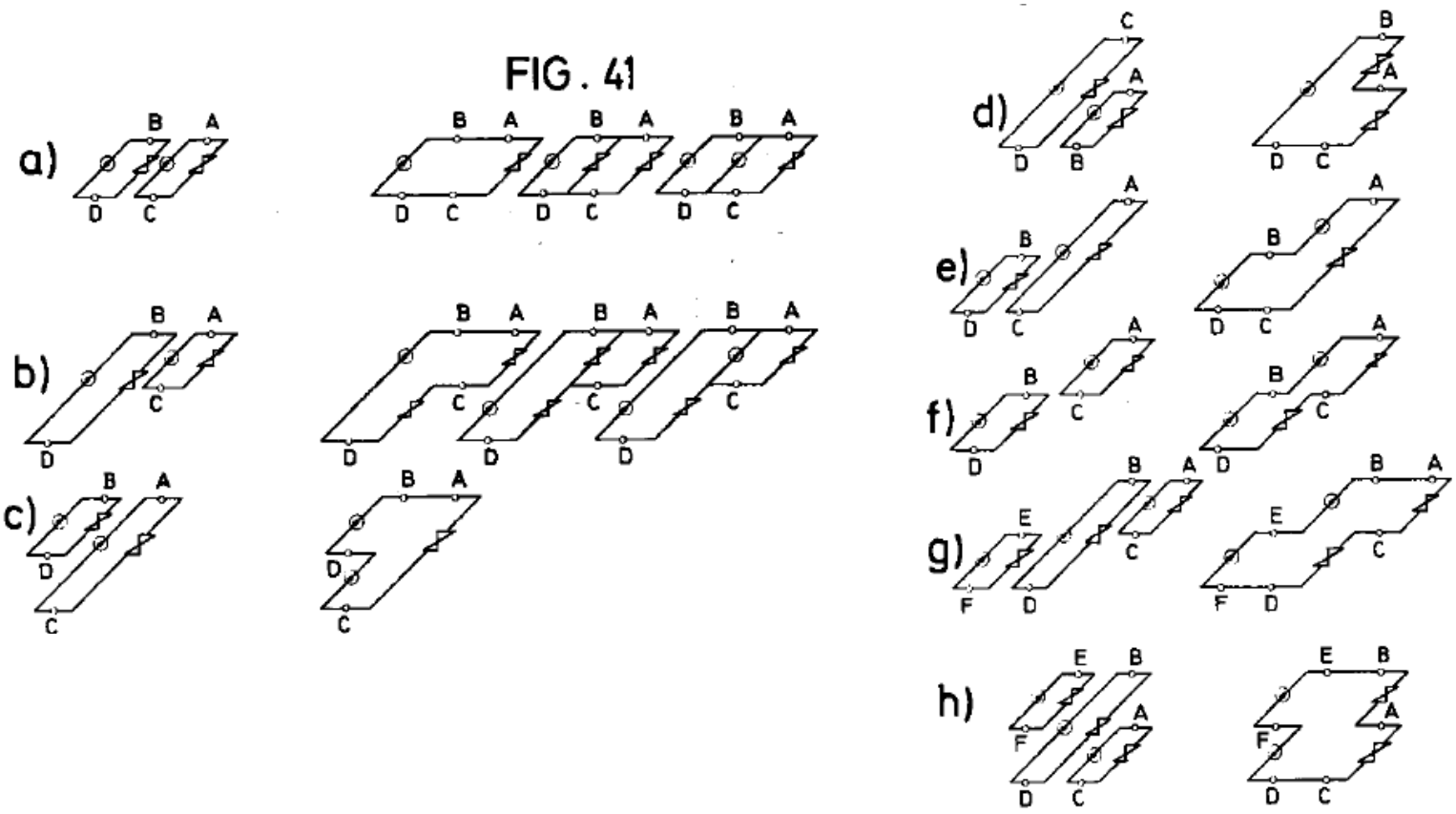
(**C**oefficient **o**f **P**erformance)

$$COP_{cold} = \frac{Q_V}{Q_G}$$ **chiller**

$$COP_{heat} = \frac{Q_A + Q_K}{Q_G} = COP_{cold} + 1$$ **heat pump**

ambient heat | **useful cold** | **waste heat** | **useful heat** | **driving heat**

Huge amount of possible cycles

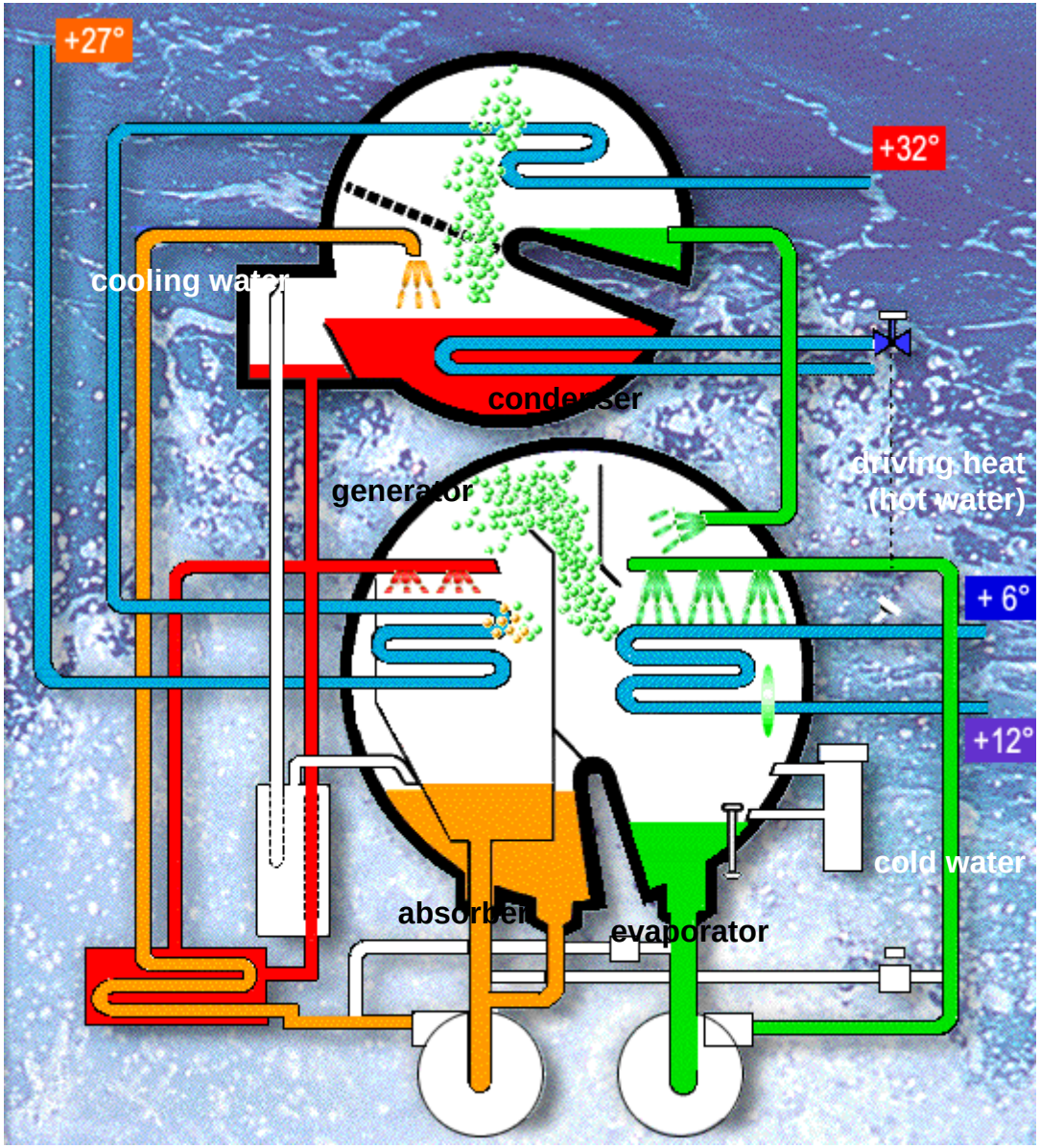


Source:
European Patent EP 0 597 822 A2
G. Alefeld, 1982

Technologies

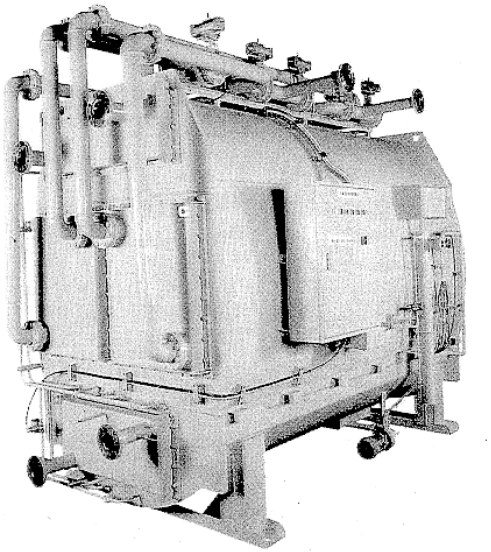
Absorption chiller
(with working pair
water / lithium bromide solution)

Continuous process,
system diagram

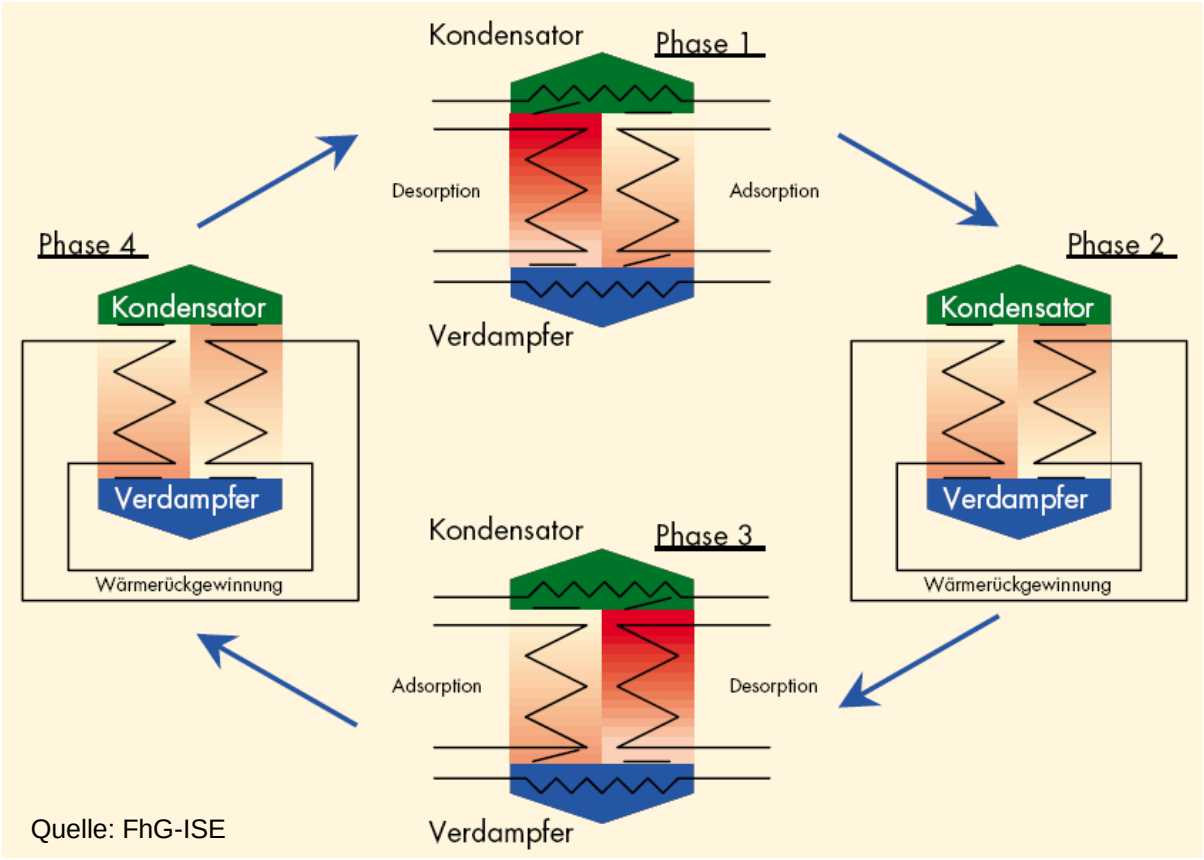


Adsorption chiller
(with water / silica gel working pair)

Discontinuous process



Quelle: Nishiyodo

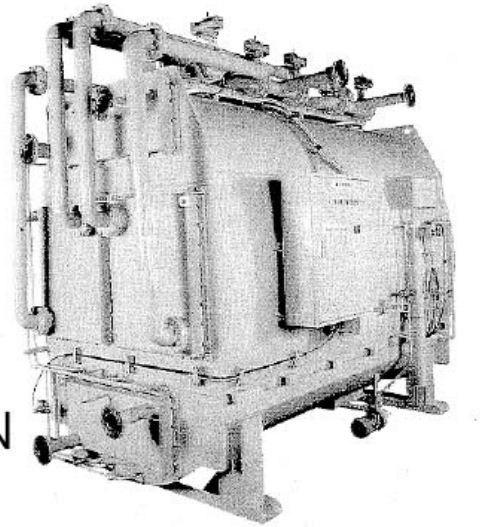


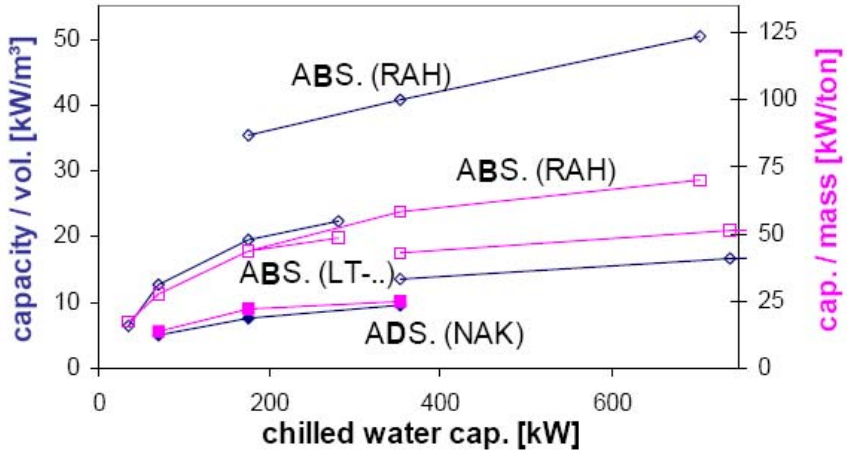
Quelle: FhG-ISE

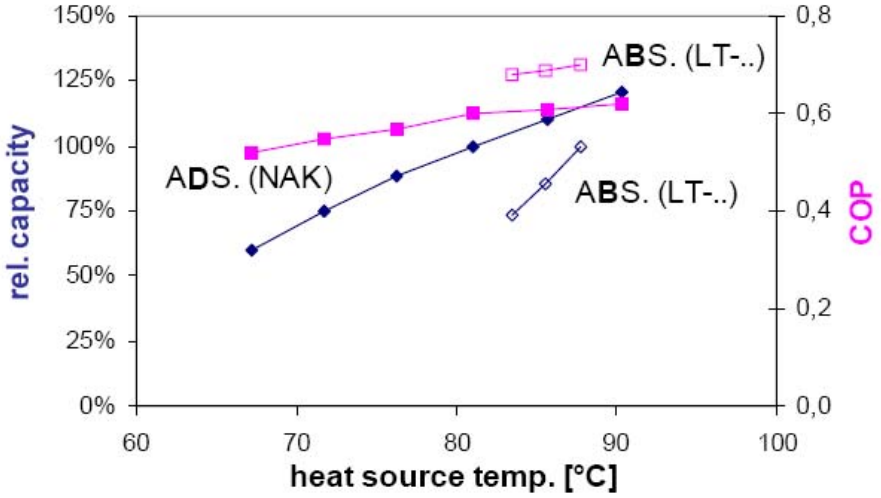
Comparison: Absorption - Adsorption

ABSORPTION

ADSORPTION







Recently many developments of small scale thermally driven water chillers (5-20 kW) for residential application (www.polysmart.org)

aosol
energias renováveis

rotartica

ClimateWell

SorTech AG

PINK

EAW

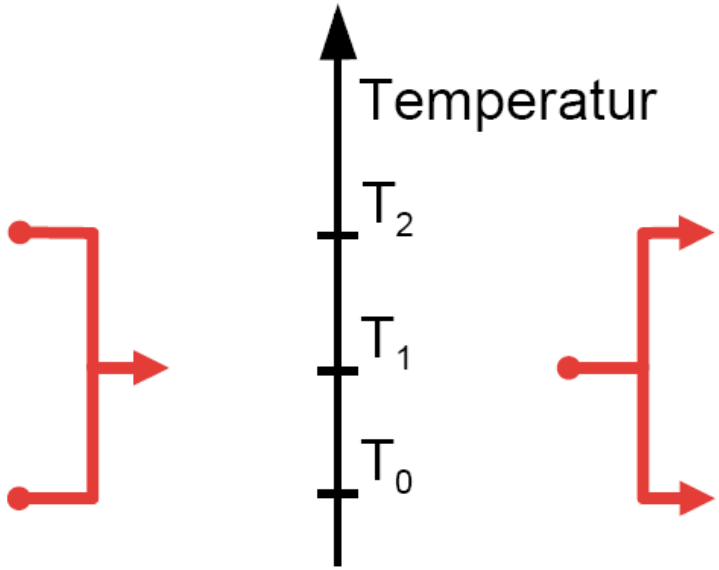
Robur

ECN

SK SonnenKlima GmbH

no claim for completeness

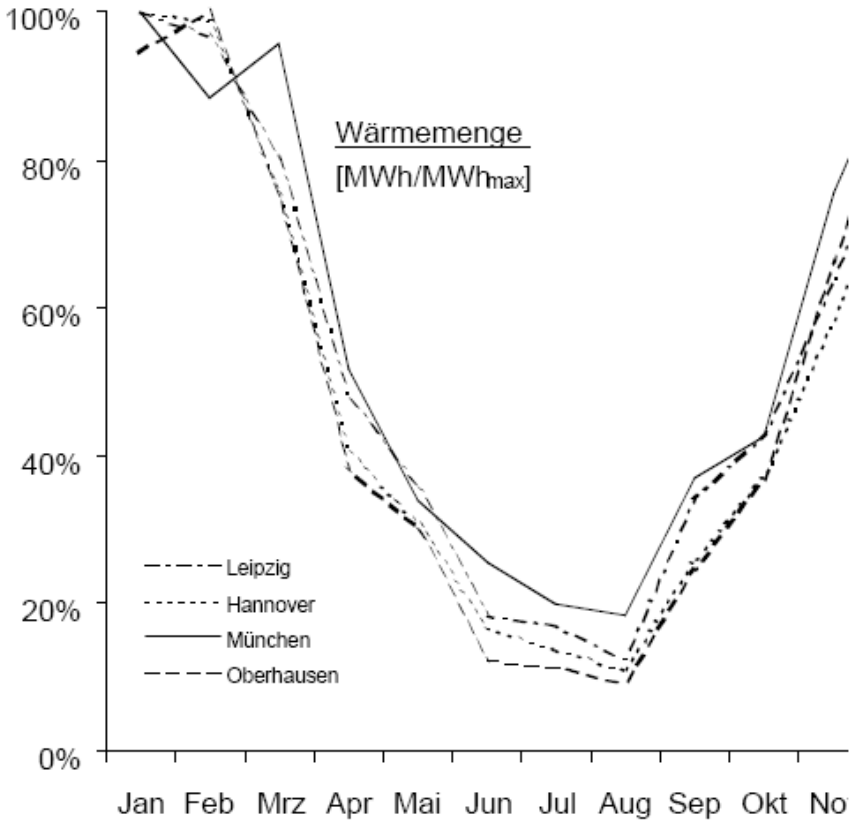
heat transformation process



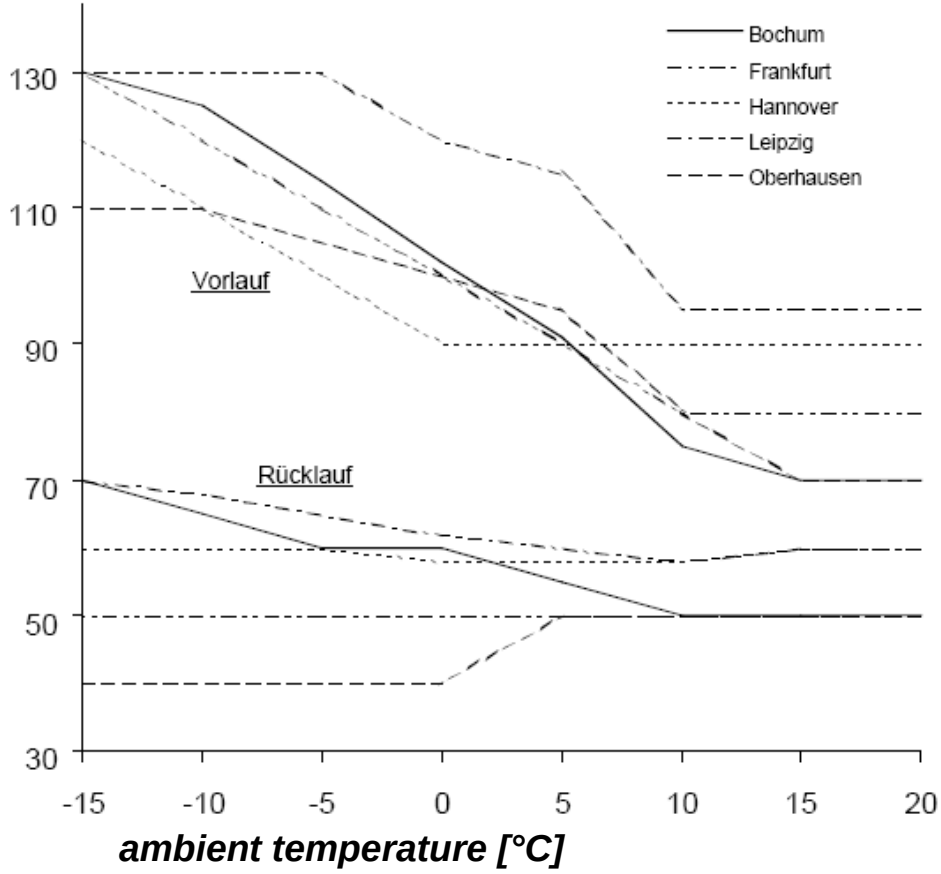
heat pump / chiller **heat transformer**

Use of district heating

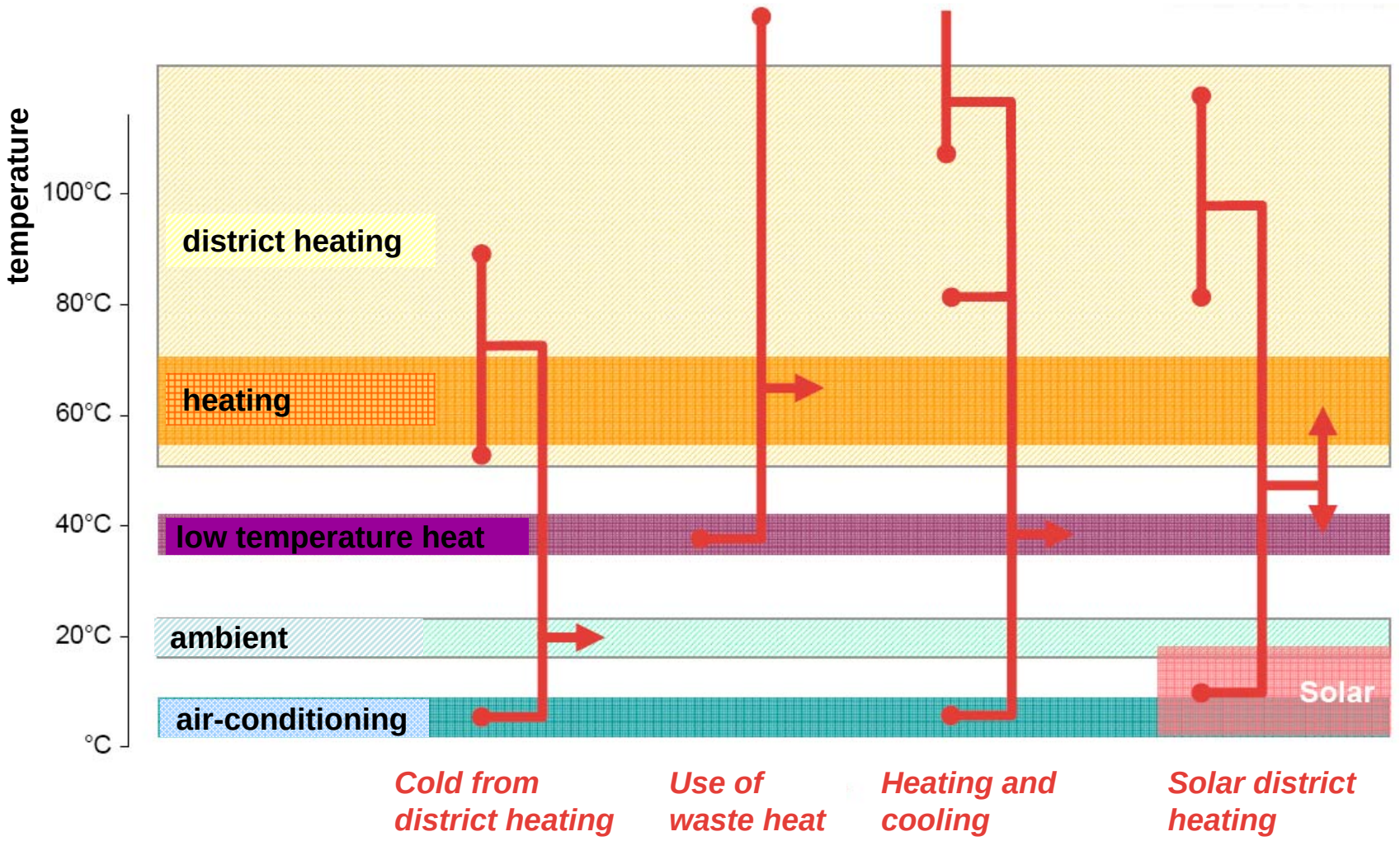
delivered heat



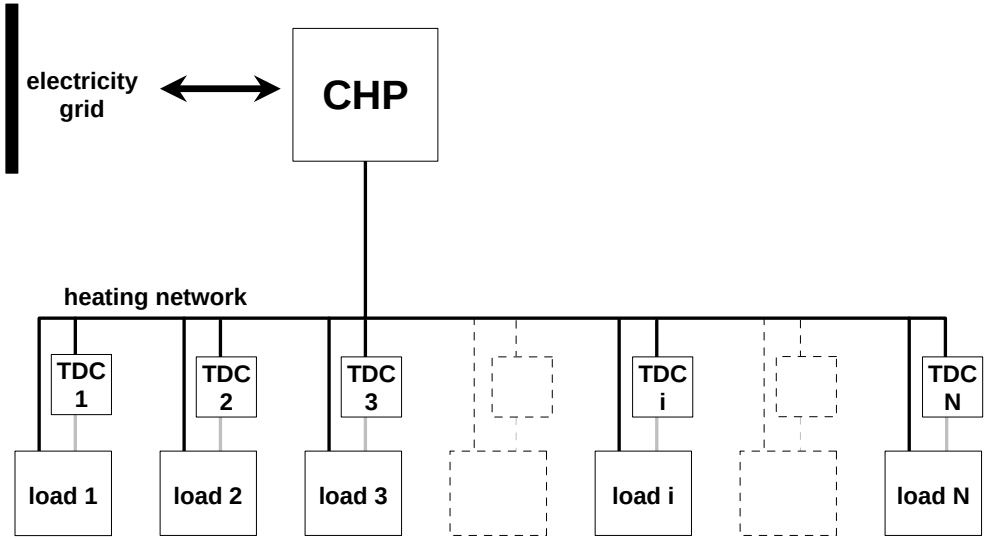
forward and return temperature [°C]



Use of district heating



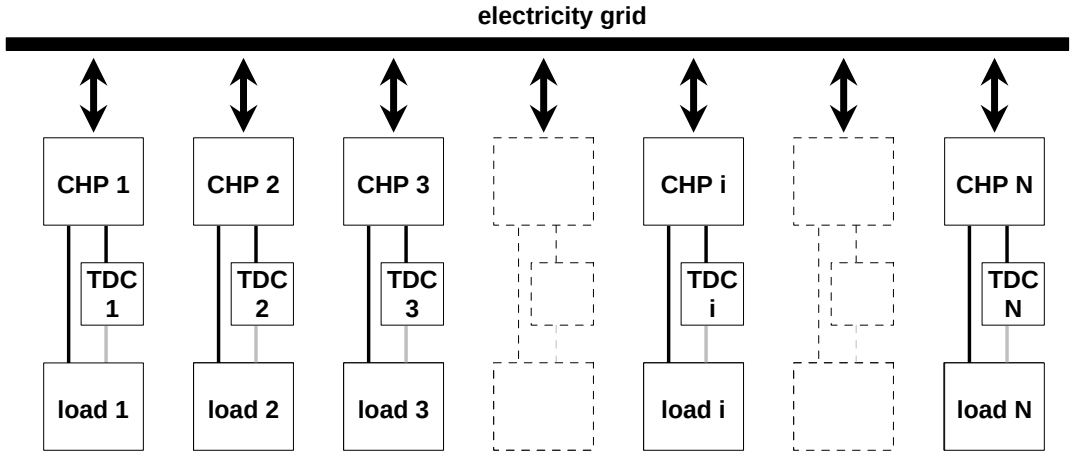
Combined heating, cooling and power (CHCP)



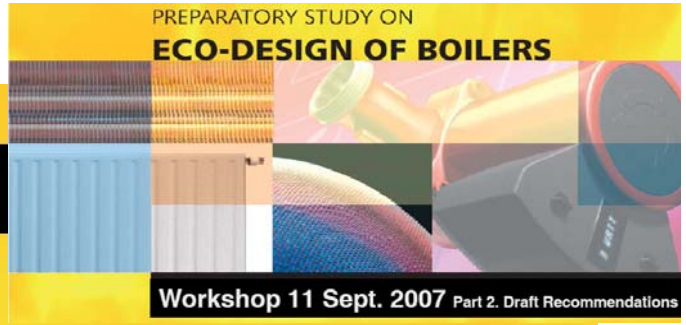
PolySMART Project
www.polysmart.org

Decentralized CHP + decentralized TDC

Centralized CHP + decentralized TDC



The next generation of domestic heating systems



Label classes (efficiency limits and typical examples)

Class	Limit	Examples		
A+++	>120%	Vertical el. GSHP	Best Gas Abs. HP	
A++	>104%	Gas-fired Abs. HP	Hor. El. GSHP	
A+	>88%	Best condens+ solar	Vent. Air HP	← LLCC 96%**
A	>80%	Best condens	Outside Air HP	
B	>72%	Avg. Condens	Outside Air HP	← LLCC 76% *
C	>64%	Best LT	Low Condens	
D	>56%	Avg. LT	Best atmo. + solar	
E	>48%	Low-end LT	Best atmo.	← Base 54%*
F	>40%	Avg. atmospheric	Electric res. + solar	← Base 45%**
G	≤40%	Low-end atmospheric	Electric resistance	

**= for loads XXL, 3XL, 4XL; *= for other loads

Source: Robur

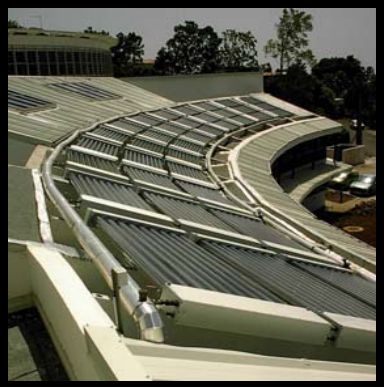
Solar cooling










IEA Solar Heating & Cooling
Task 25 Solar Assisted Air-Conditioning of Buildings

Conclusions

Thermally driven heat pumps & chillers

- **potential to save primary energy**
- **flexible use of heat** at different temperature levels
- **Cooling and heating** applications
- Sorption technology market available (large capacities)
- Many possible cycle combinations (single effect, double effect, double lift,…)
- **Reduce peak stress on electricity grids**

Applications:

- Solar cooling
- Use of district heating in summer for cooling
- Industrial applications (combined heating and cooling)
- Efficient combined heating, cooling and power generation (CHCP)
- Next generation of domestic heating systems
- Use of waste heat (for cooling, heat transformer,…)