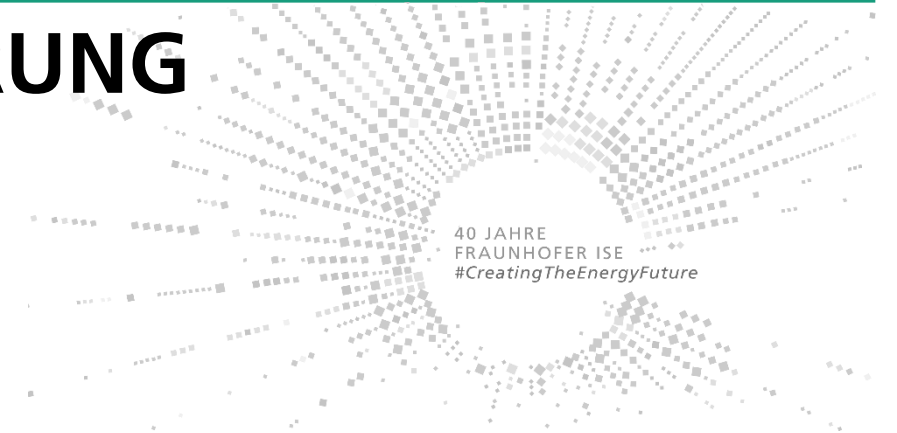


SOLARE KÜHLUNG UND KLIMATISIERUNG

Technologie und Entwicklungen



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Fraunhofer-Institut für Solare Energiesystem ISE

Web-Forum Solarthermie, Bauzentrum München

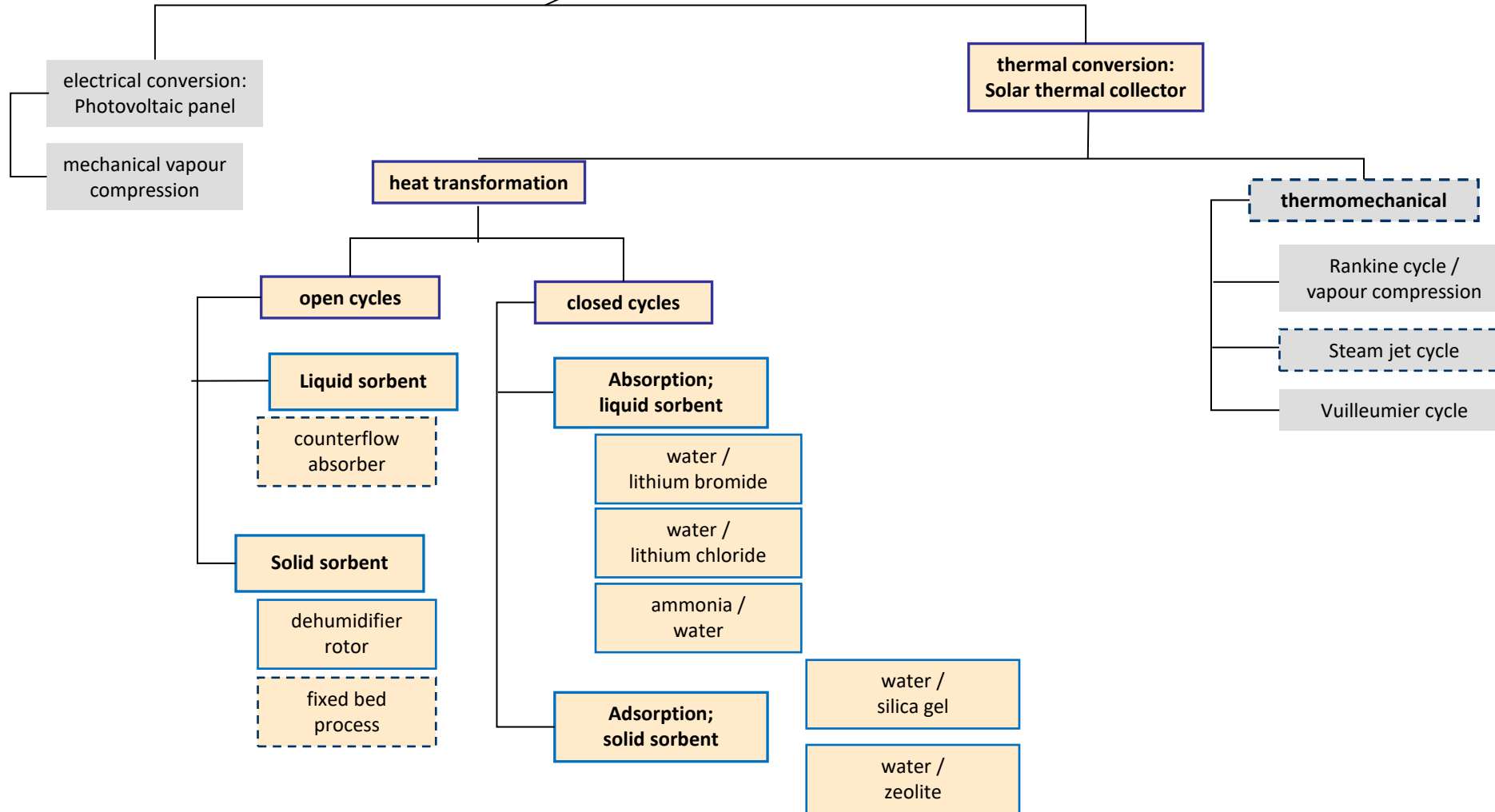
22.07.2021

www.ise.fraunhofer.de

AGENDA

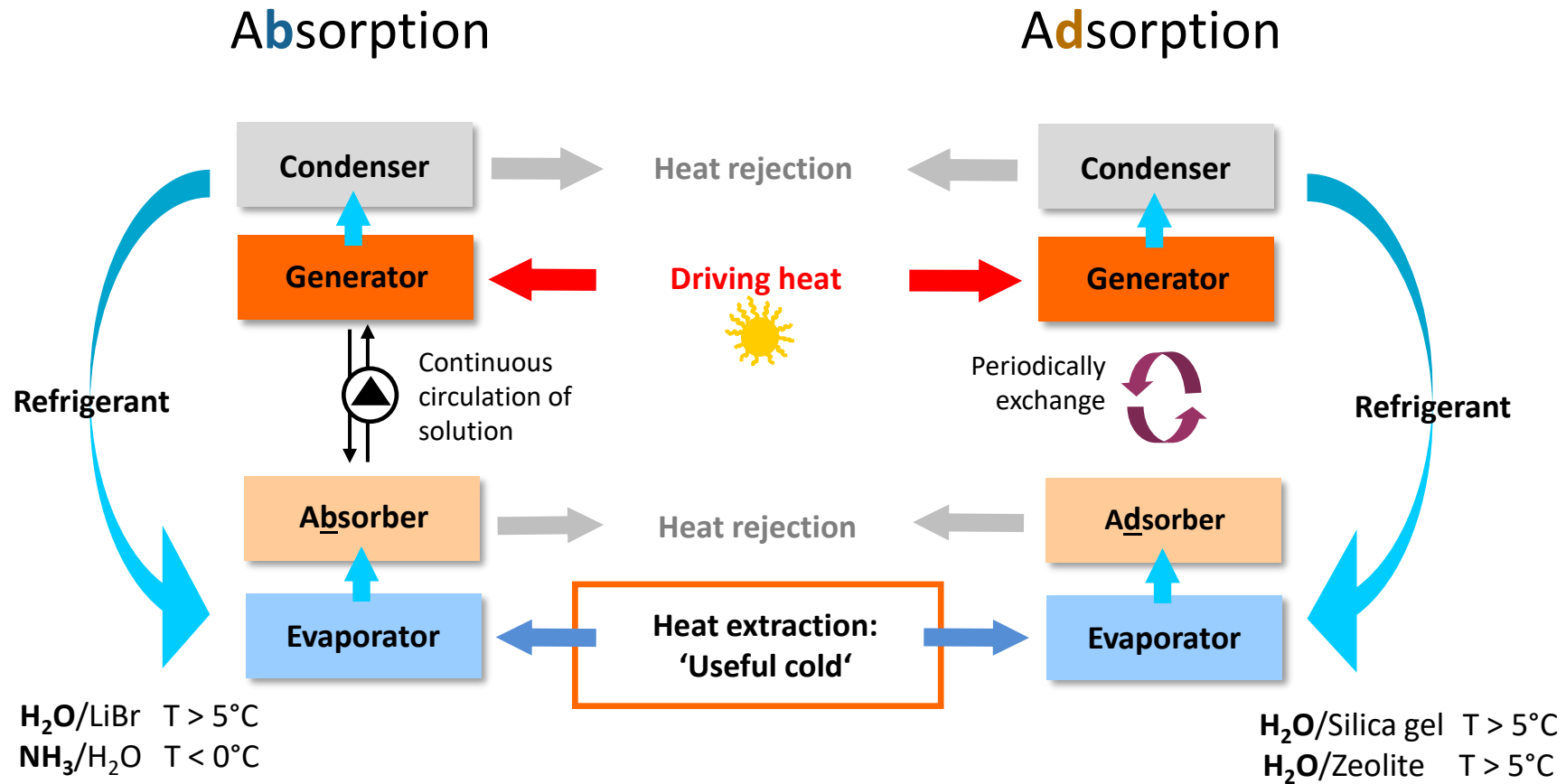
- Was heißt Solare Kühlung? -> Technologien solarthermische Kühlung u. PV/Kompressions-Kühlung
- Systemintegration
- Umsetzungs- und Projektbeispiele
- IEA-SHC Task 65: Solar Cooling for the Sunbelt Regions

Wie geht solare Kühlung?

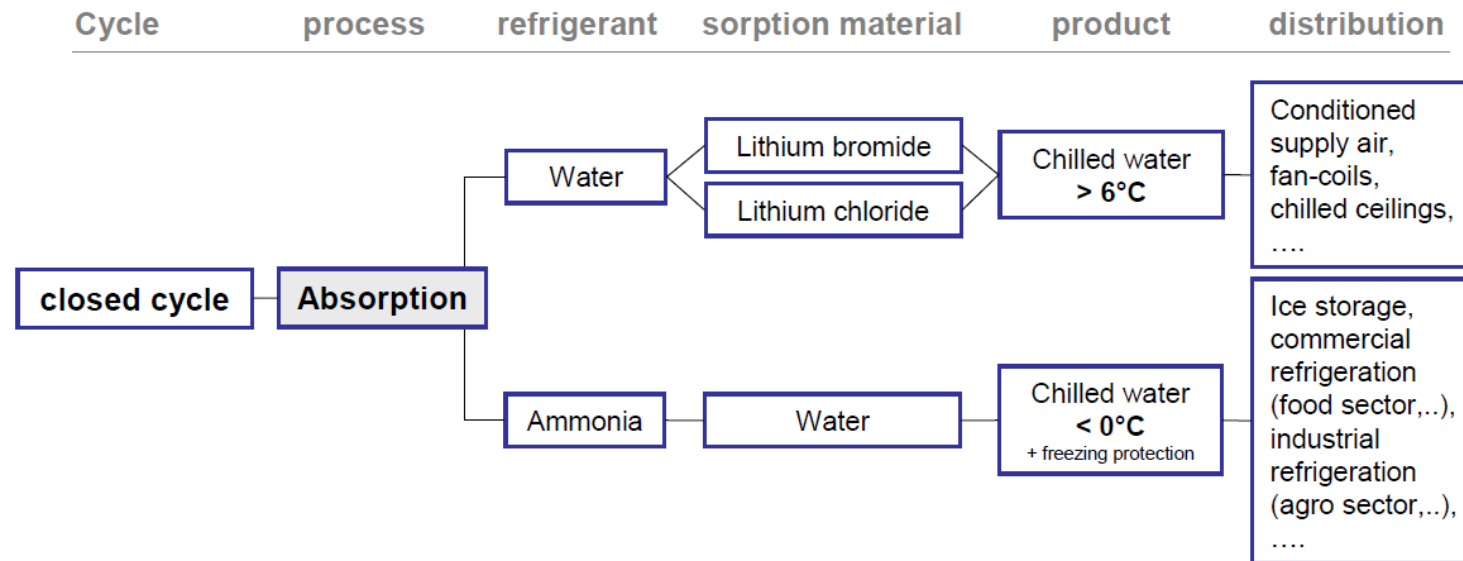


© Fraunhofer ISE

Ab- / Adsorption



Kühlen mit Wärme: Absorptionskältetechnik



Typical operation conditions single-effect and double-effect water/LiBr chillers

Driving temperature (hot water), input:	75°C* - 95°C	180°C (or steam 8 bar)
Chilled water temperature, output:	6°C - 18°C	7°C
Heat rejection temperature, input:	27°C - 35°C	30°C
Thermal Coefficient of Performance COP:	0.6 - 0.75	1.35

* Neue Geräteentwicklungen können mit niedrigeren Antriebstemperaturen bei verringerter Kälteleistung betrieben werden

Kühlen mit Wärme

■ Absorptionskälteanlagen (Beispiele)



 **YAZAKI**

Ab 17.6 kW Nennkälteleistung



EAW

Ab 15 kW Nennkälteleistung



Niedrige Antriebstemperaturen ($> 60^{\circ}\text{C}$),
hohe Rückkühltemperaturen:

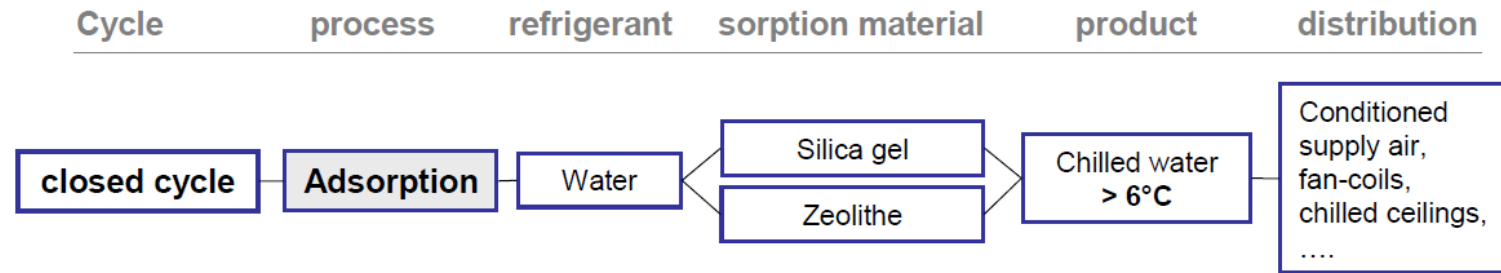
Fa. Bälz/TU Berlin

BIENE (50 kW Nennkälteleistung);

HUMMEL (160 kW Nennkälteleistung)

Bilder: Hersteller

Kühlen mit Wärme: Adsorptionskältetechnik



Typical operation conditions

Driving temperature (hot water), input:	60°C - 90°C
Chilled water temperature, output:	6°C - 18°C
Heat rejection temperature, input:	25°C - 35°C
Thermal Coefficient of Performance COP:	0.5 - 0.63

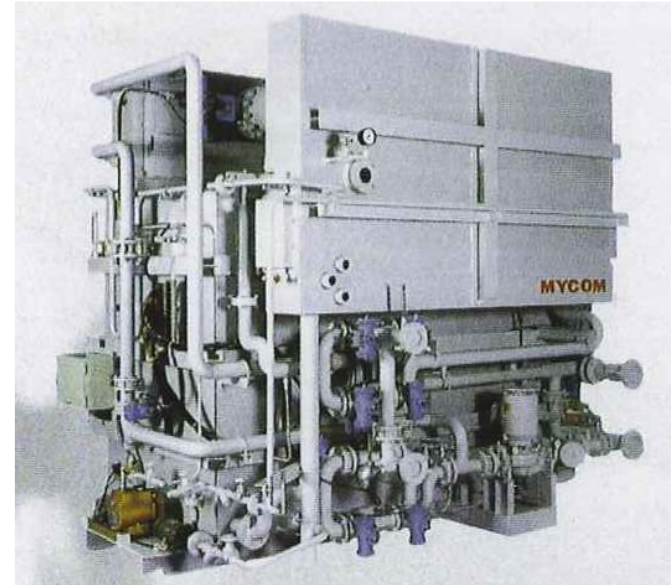
Kühlen mit Wärme

- Geschlossene Adsorptionskälteanlagen (Beispiele)



 **FAHRENHEIT**

(5) 10 – 100 kW
Nennkälteleistung

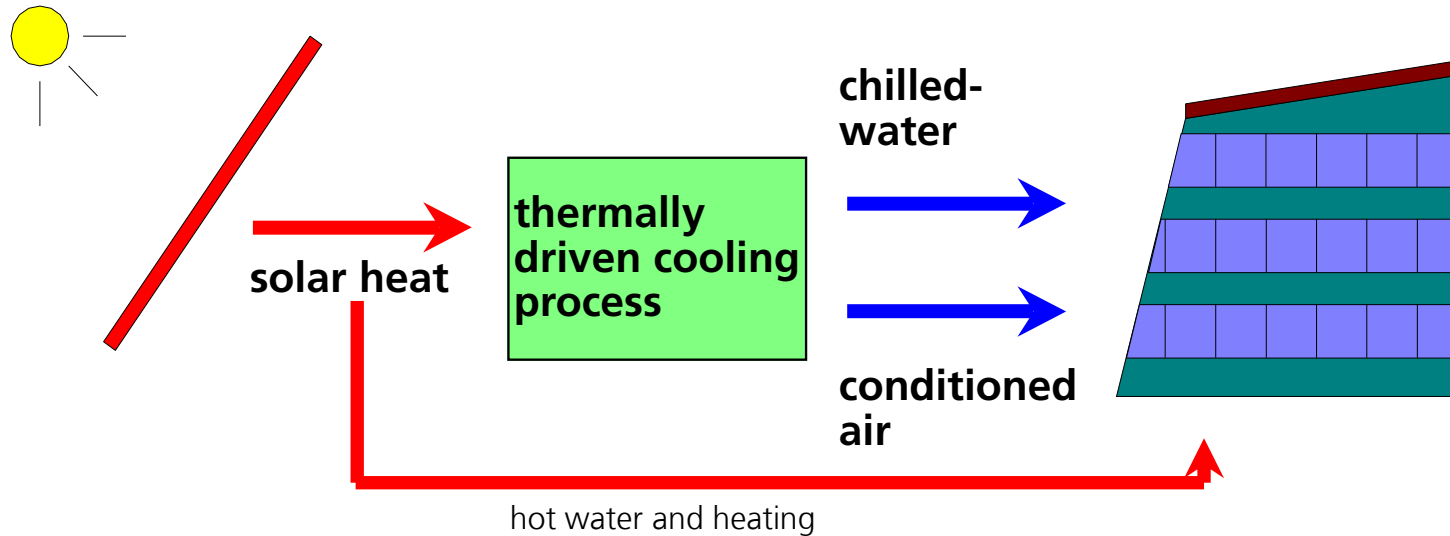


MAYEKAWA
MYCOM

> 70 kW Nennkälteleistung

Bilder: Hersteller

Solarthermische Klimatisierung: System



Klassifikation

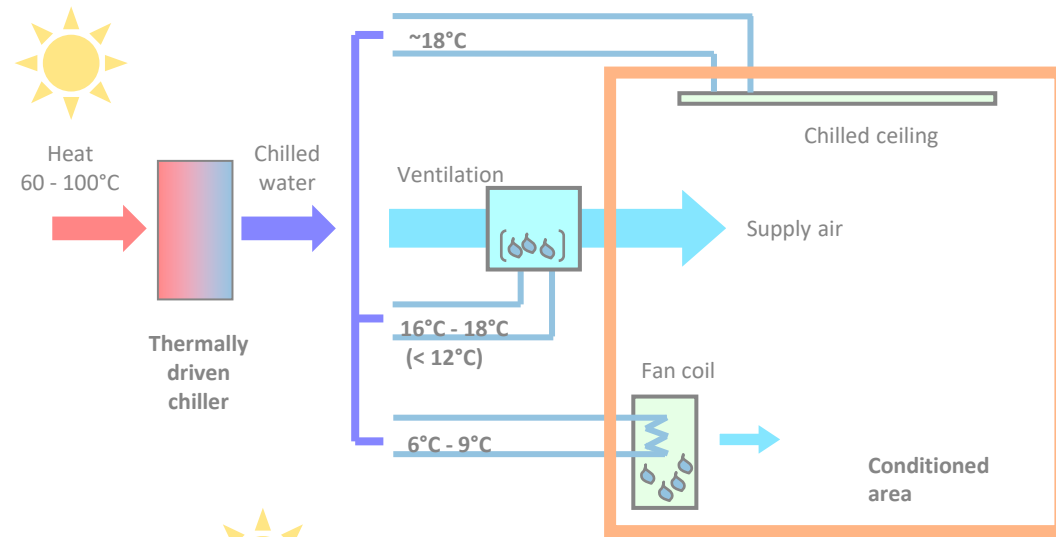
- Geschlossene Sorptionssysteme: Kaltwassernetz
- Offene Sorptionssysteme: direkte Luftklimatisierung (Temperatur und Feuchte) -> DEC (Desiccant Evaporative Cooling)

© Fraunhofer ISE

Solarthermische Klimatisierung: Geschlossene vs. Offene Anlagen

Closed cycles:

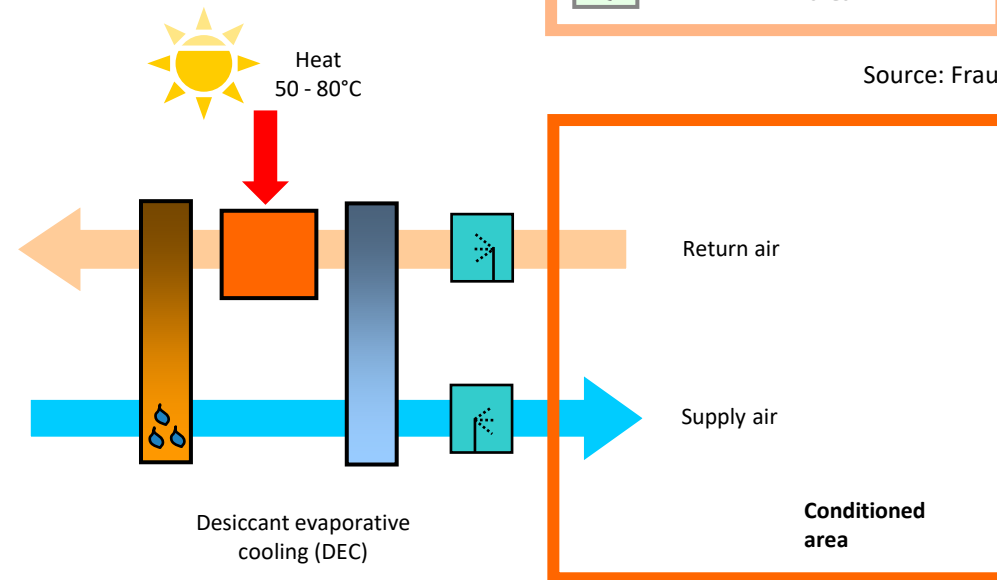
chilled water as
distribution medium



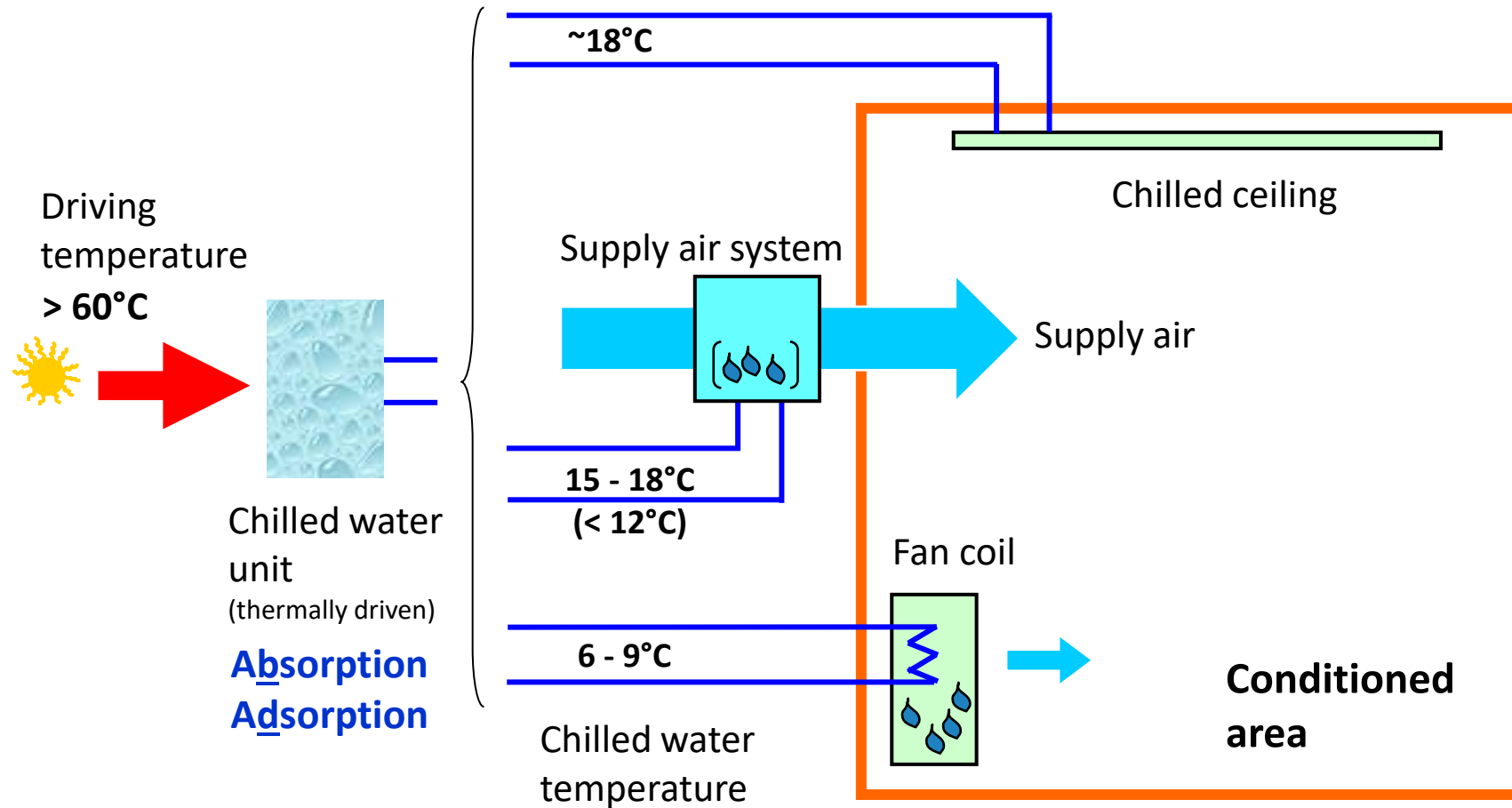
Source: Fraunhofer ISE

Open cycles:

conditioned air as
distribution medium




Geschlossene Sorptionsanlage: Verteilung über Kaltwassernetz





© Fraunhofer ISE




Solarthermische Klimatisierung: Antrieb durch Solarkollektoren

Driving Temperature	Collector type	Cooling technology / system
low (60-90°C)	Flat plate 	Open systems: direct air-conditioning Closed systems: systems with high distribution temperatures (chilled ceiling)

Solarthermische Klimatisierung: Antrieb durch Solarkollektoren

Driving Temperature	Collector type	Cooling technology / system
low (60-90°C)	Flat plate 	Open systems: direct air-conditioning Closed systems: systems with high distribution distribution temperatures (chilled ceiling)
middle (80-110°C)	Vacuum tube 	Closed systems: Chilled water for cooling and dehumidification Process cooling , air-conditioning with ice-storages

Solarthermische Klimatisierung: Antrieb durch Solarkollektoren

Driving Temperature	Collector type	Cooling technology / system
low (60-90°C)	Flat plate 	Open systems: direct air-conditioning Closed systems: systems with high distribution distribution temperatures (chilled ceiling)
middle (80-110°C)	Vacuum tube 	Closed systems: Chilled water for cooling and dehumidification Process cooling , air-conditioning with ice-storages
high (130-200°C)	Concentrating 	Closed systems: Double effect processes with higher efficiency Systems with high temperature lift (e.g. ice-storages with dry heat rejection)

Projekt Solarthermie 2000plus: Solare Kühlung

■ Zwei Anlagen mit Abwärmenutzung

FESTO AG & Co. KG, Esslingen/Berkheim

Bild: FESTO AG & Co. KG

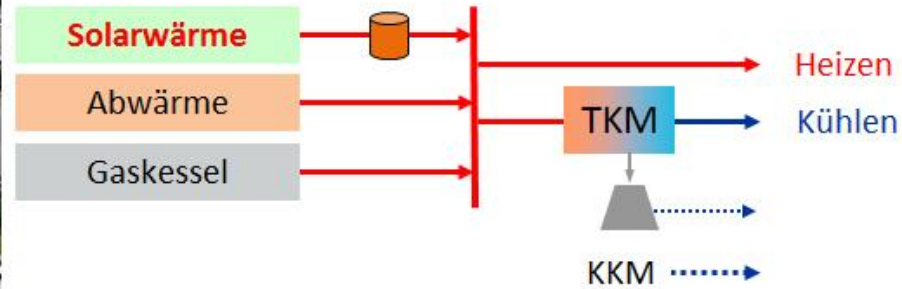
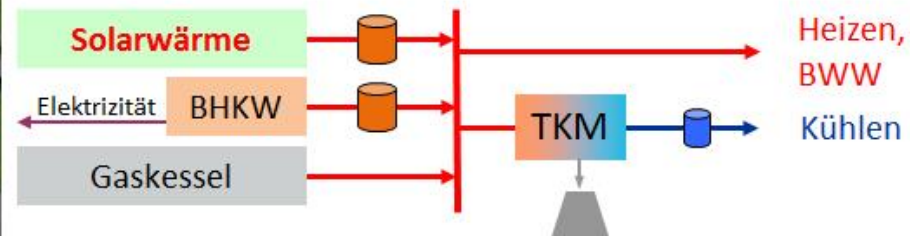


Bild: HS Offenburg

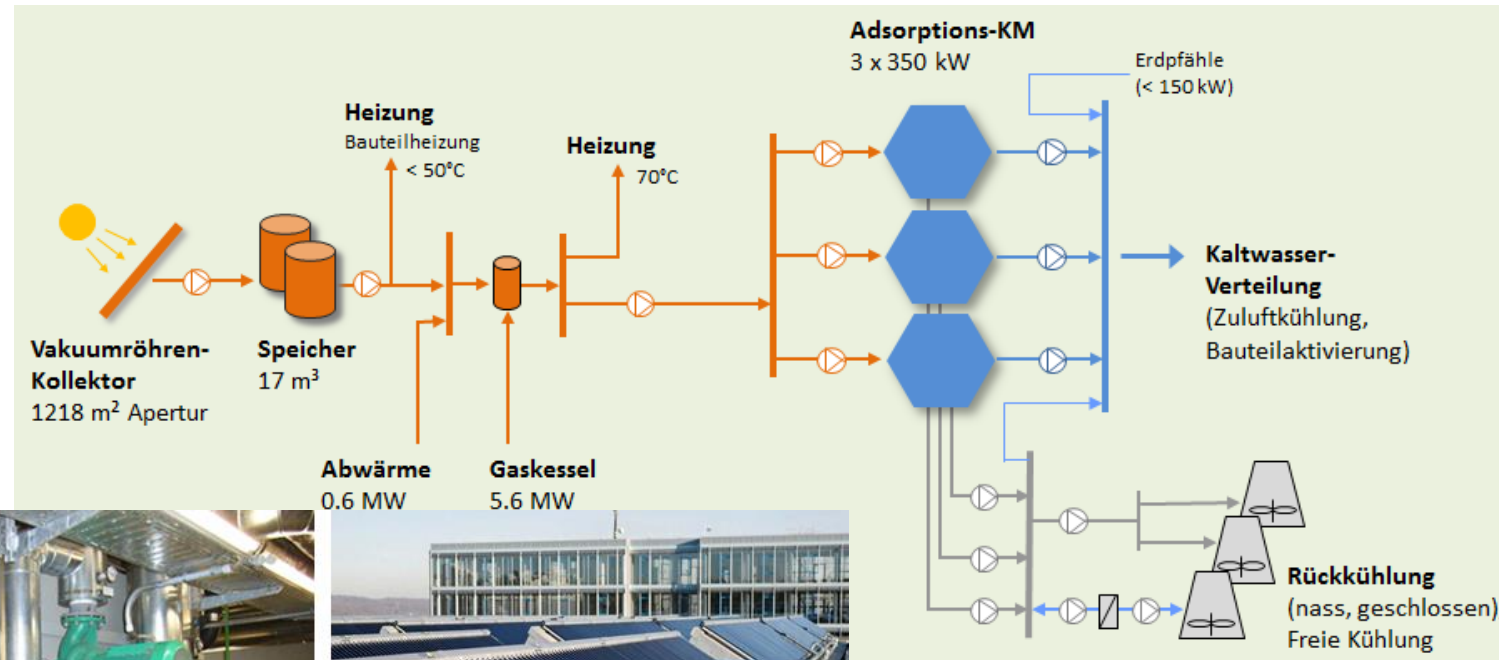
Deutsche Telekom AG, Rottweil



© Fraunhofer ISE

Anlage FESTO AG & Co. KG, Esslingen

- Adsorptionskälteanlage
- Parallele Wärmeversorgung aus Abwärme + Solarkollektor (+ Gaskessel)

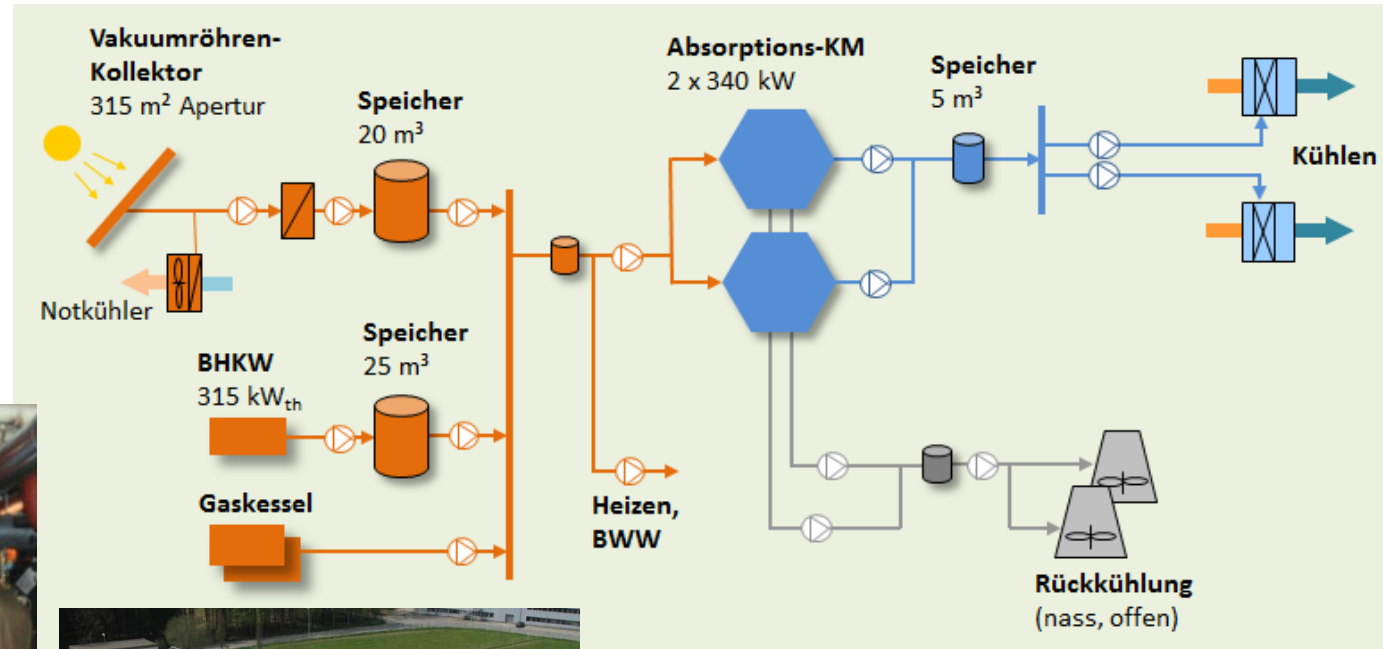


Bilder: ISE (links),
HS Offenburg (rechts)

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Anlage Deutsche Telekom AG, Rottweil

- Absorptionskälteanlage
- Sequentielle Wärmeversorgung aus Abwärme + Solarkollektor (+ Gaskessel)

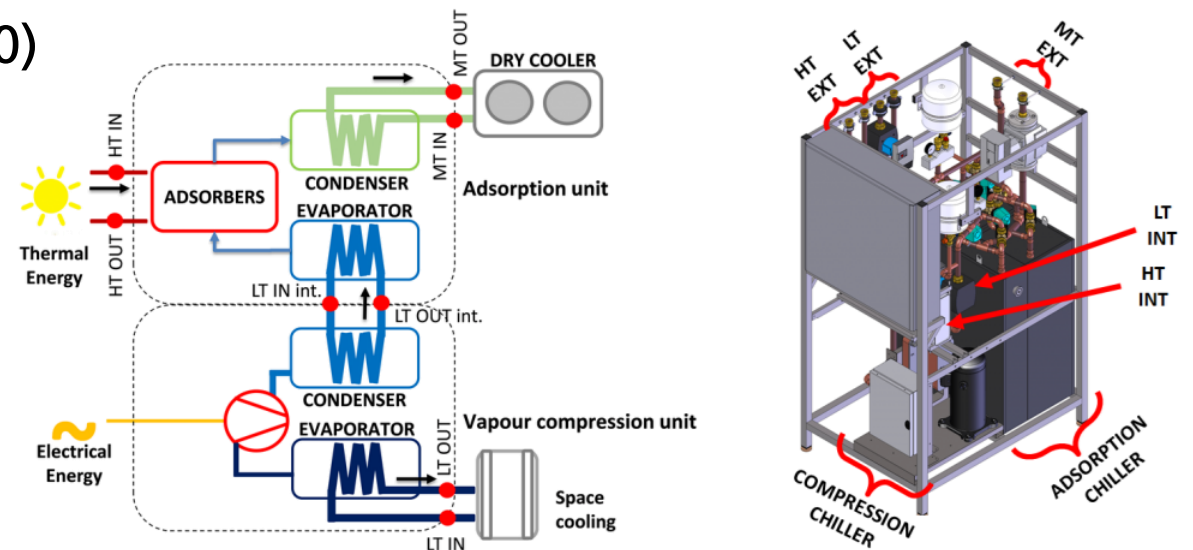


Bilder: HS Offenburg

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Hybridkonzepte – Projekt HyCool

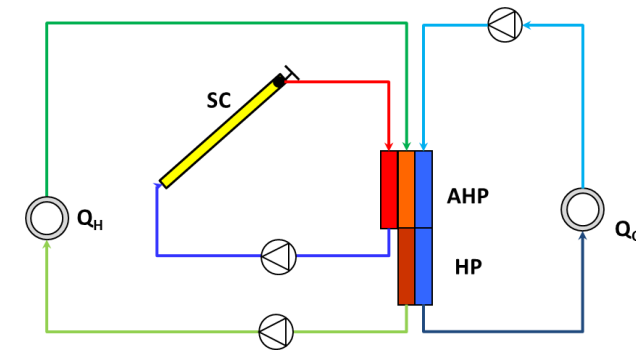
- $T_{LT} = 5^{\circ}\text{C}$, Development target -10°C
- Integrated vapour compression module (R290)
 - Redundancy and high energy efficiency
 - Peak and interim loads
- Sorption module for cooling the condenser
 - $T_{\text{cond VCC}} \sim 20^{\circ}\text{C} \rightarrow \text{EER}_{\text{HHP}}$ increases up to 7-8
 - e.g. Barcelona 4,748 h $\rightarrow 0.031 \text{ €/kWh}_{\text{cold}}$



Source:
www.ecotherm.com
www.hycool-project.eu
www.fahrenheit.cool

Hybridkonzepte – SolarHybrid

- Prototypes in Hardware-in-the-Loop (HiL) & simulation study
 - 20 kW NH₃/H₂O absorber (ACM)
 - 20 kW NH₃ vapor compression (VCC)
- Solar direct driven absorber + complementing compressor
 - No hot water storage
 - SPF_{el} > 15
 - Primary Energy Savings up to 80 %
 - CR < 1 possible



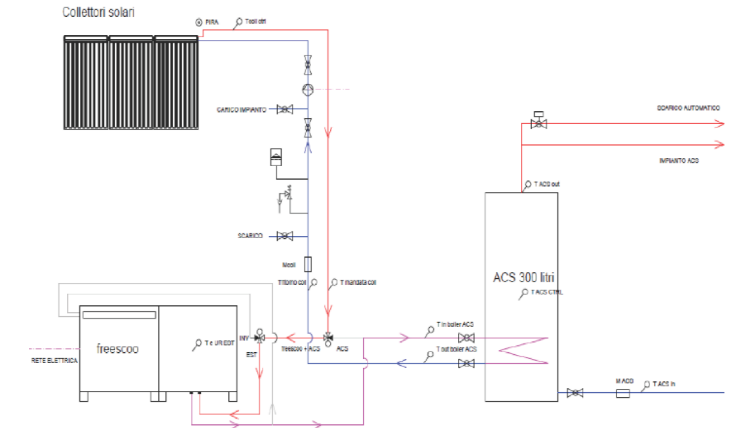
Source:
www.uibk.ac.at

DEC Konzept freescoo VMC 3.0

- Thermally driven HVAC with active dehumidification, partial cooling and 100% air change for residential & offices
 - Based on advanced fixed and cooled adsorption beds
 - Volume air flow rate 350 m³/h
 - Max. cooling power 3.2kW
 - Min. hot water temperature required 55°C
 - EER 12 (> 25 at partial load)



Source:
www.freescoo.com
www.unipa.it



- Test plant in Pantelleria (IT) for RES integration in small islands (coop. ENEA)

IEA-SHC Task 65 Objective & scope

Objective

- Focus on innovations for **affordable, safe and reliable solar cooling systems for the Sunbelt regions worldwide**
- Implementation/adaptation of components and systems for the different boundary conditions is **forced by cooperation with industry** and with support of target countries like UAE through Mission Innovation IC7
- The innovation driver and the **keyword is adaptation** of existing concepts/technologies to the sunbelt regions using solar energy either solar thermal (ST) or solar PV

Scope

- Build on previous tasks 25, 38, 48 and 53
- **Target size segment** on cooling and air conditioning between 2 kW and 5,000 kW (PV and ST)
- Task duration: July 2020 – June 2024
- <https://task65.iea-shc.org>



Zusammenfassung

- Solare Kühlung und Klimatisierung: Antrieb PV oder Solarthermie (oder beides)
- Thermisch: Ab- oder Adsorptionskälte, abhängig von Temperaturen und Leistungsklasse
- Offene Sorptionssysteme für Luftkonditionierung
- Wirtschaftlichkeit in Deutschland für Gebäudeklimatisierung häufig schwierig aufgrund geringer Betriebsstunden -> wird interessant bei zusätzlicher Nutzung von Wärme
- Weltweit Kälte ein Wachstumsmarkt, im Sunbelt ist Solare Kühlung (PV und Solarthermie) eine kommerziell verfügbare Technologie, die immer wirtschaftlicher wird

Dr. Gerrit Földner..

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<https://task65.iea-shc.org>

40 JAHRE
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