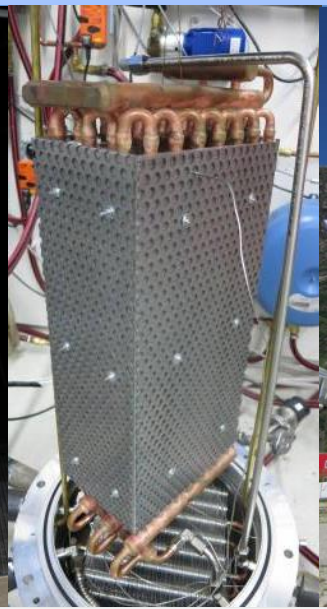
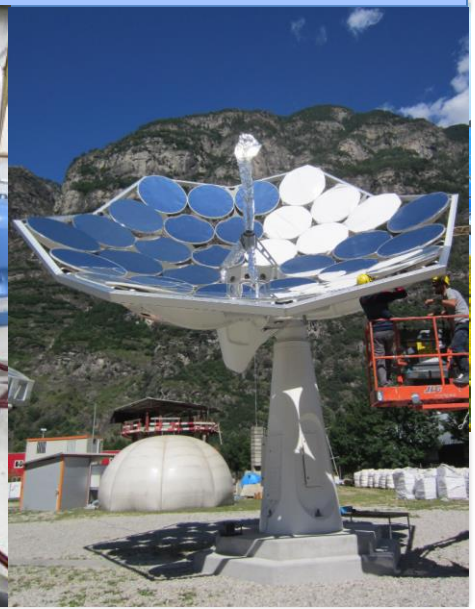
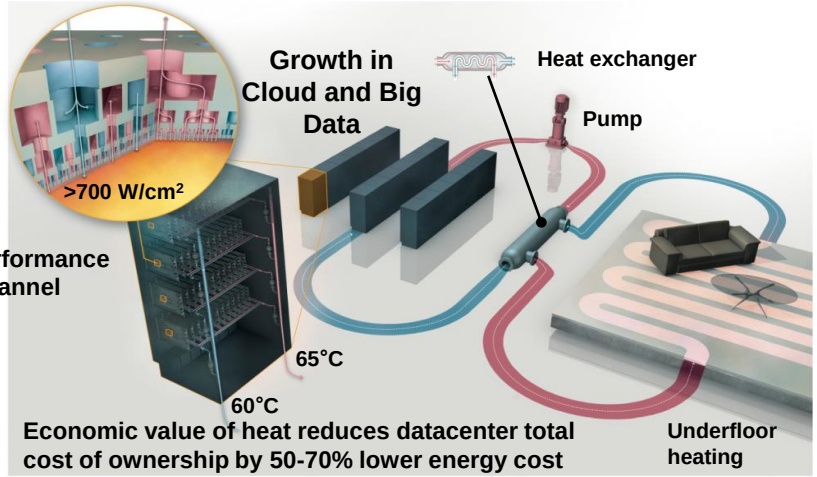
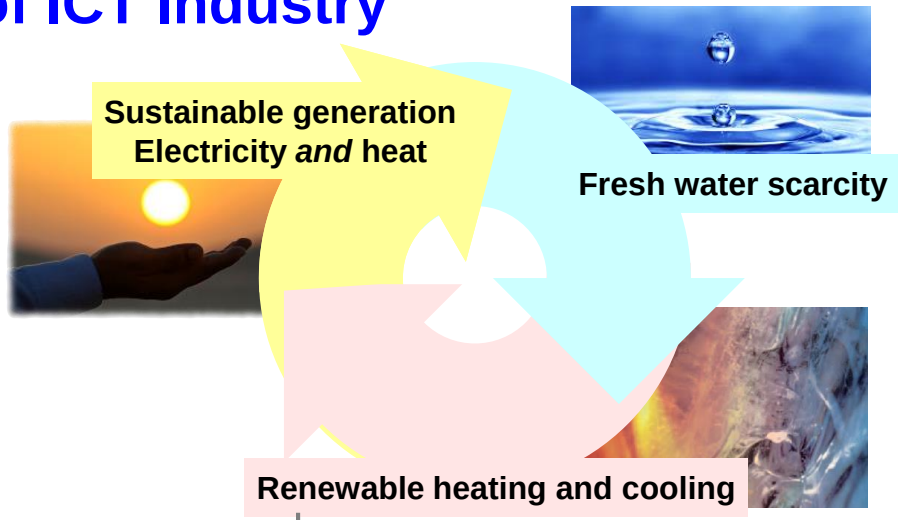
Sustainable Data Centers and Energy Conversion Technologies



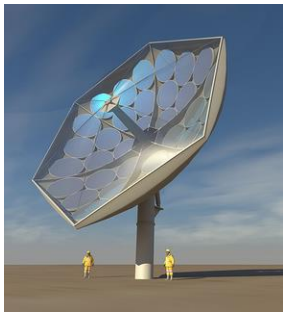
Smarter Energy: Impact Outside of ICT Industry



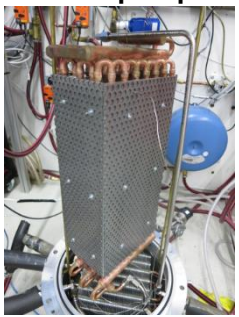


Zero-emission datacenter

High-concentration PV/thermal

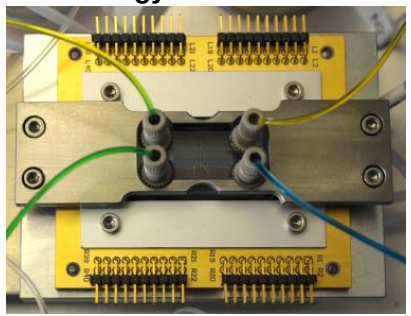


Adsorption heat pump



Membrane distillation desalination

Electrochemical redox energy conversion



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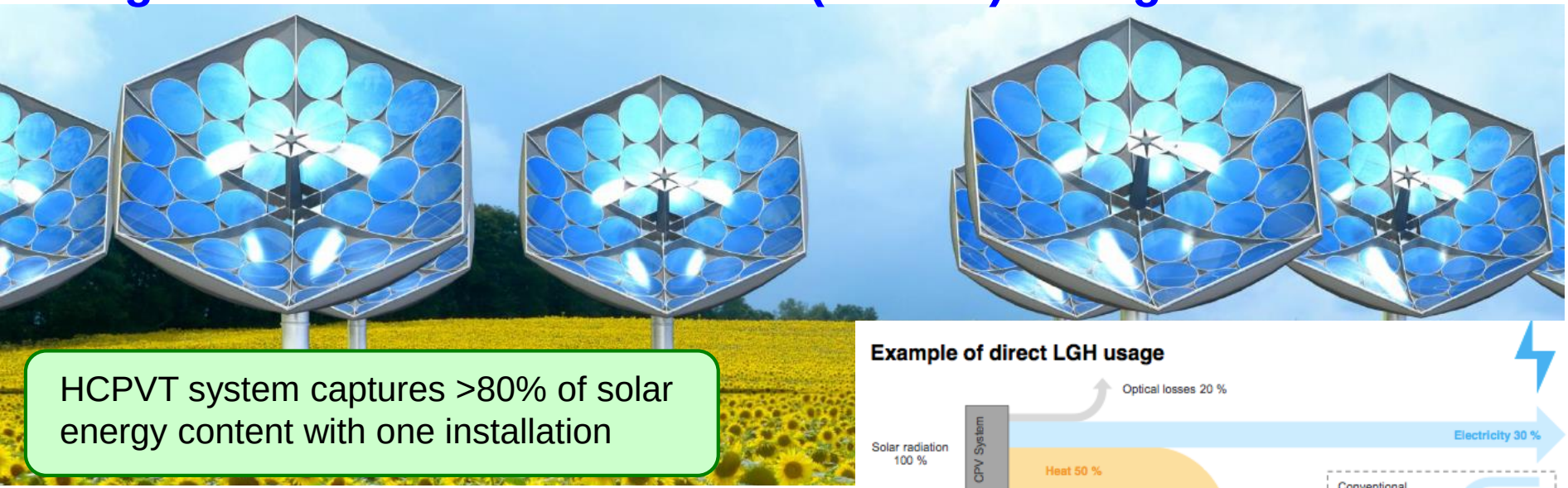
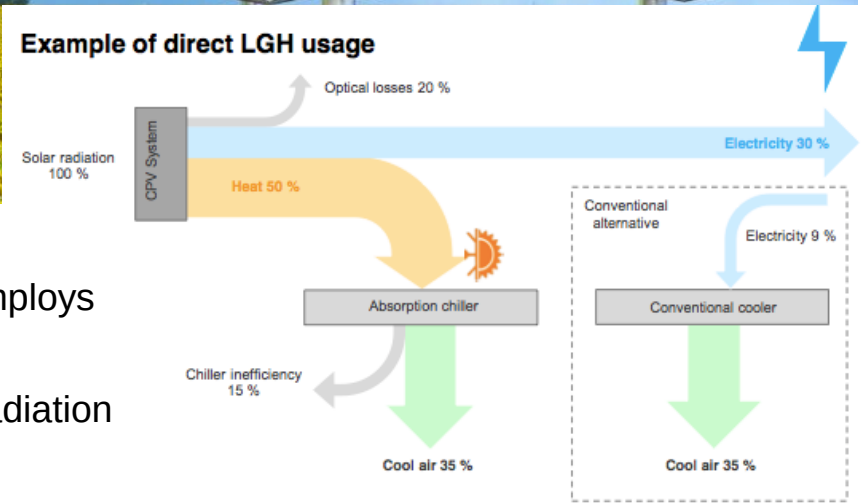
High Concentration PV/thermal (HCPVT) Multigeneration



HCPVT system captures >80% of solar energy content with one installation



- Solar provisioning of electricity and heat today typically employs two separate power stations → **doubled cost**
- Current solar systems capture <35% of incoming solar irradiation → **>65% waste**

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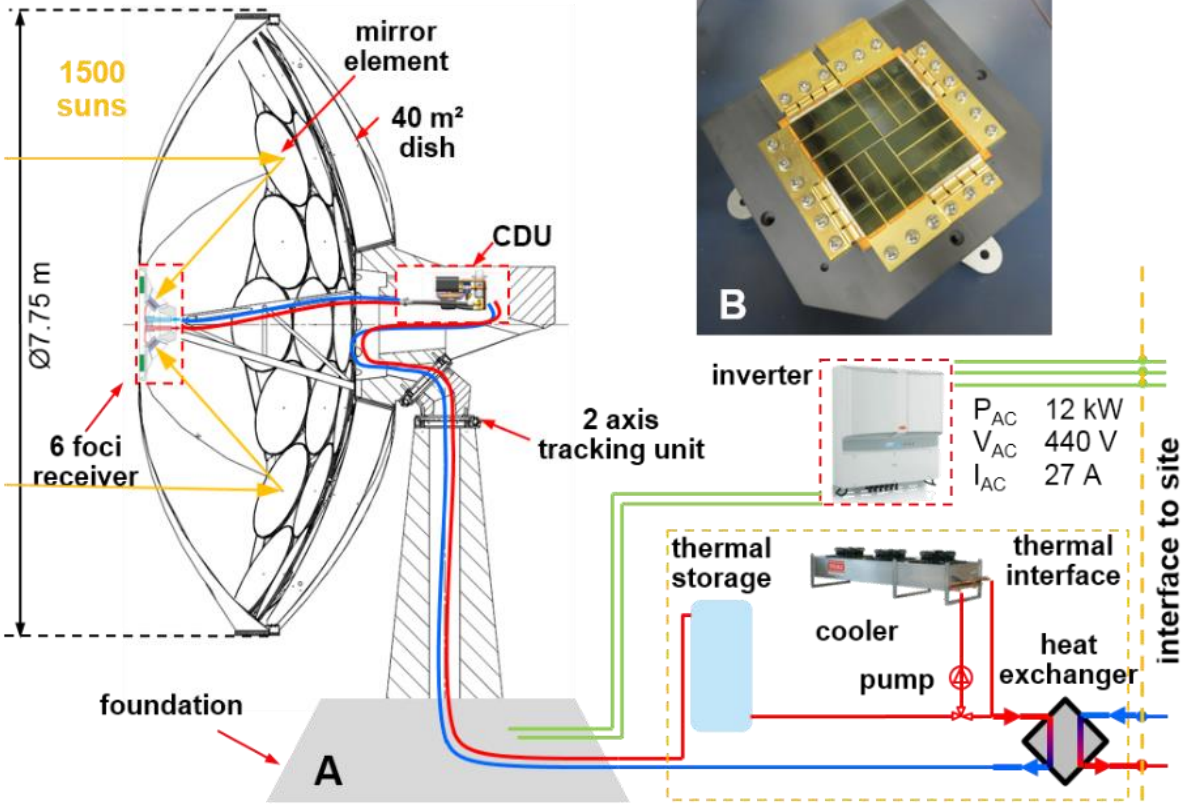

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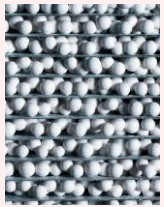
Heat Driven Heat Pumps or Adsorption Chillers

Improve adsorption capacity

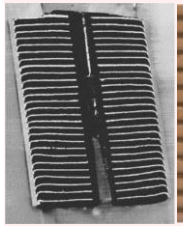
Adsorbents

Silica gel

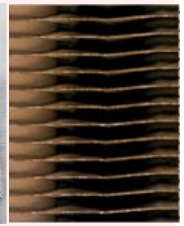
Zeolite



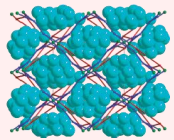
Activated carbon



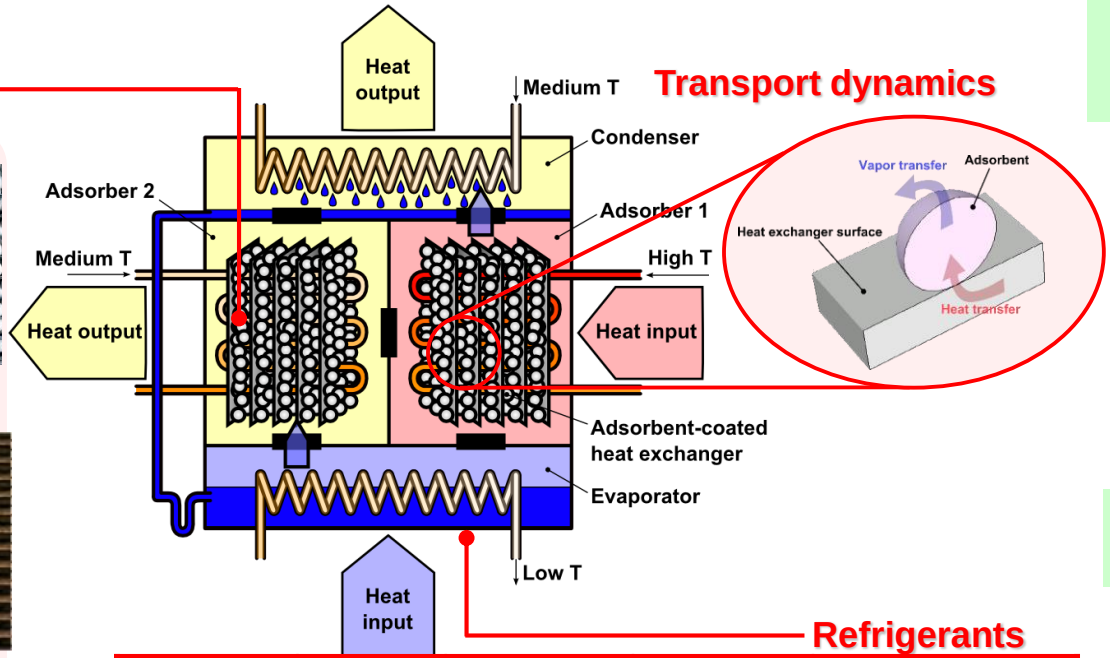
Alumino-phosphates



MOFs



Salt composites



Improve dynamic utilization

Select for application

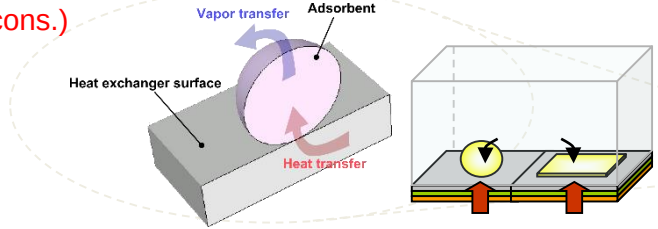
Refrigerants

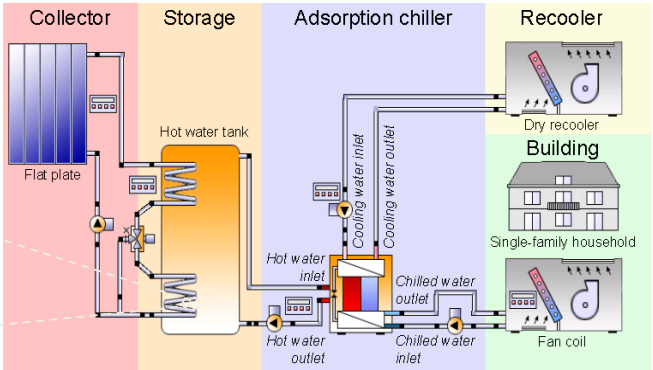
Name	Formula	Boiling point [°C]	Latent heat [kJ/kg]	Latent heat density [kJ/m^3]
Water	H_2O	100	2 258	2 163
Methanol	CH_3OH	65	508	872
Ammonia	NH_3	-34	1 368	932
Sulphur dioxide	SO_2	-10	605	534

Summary of Expertise

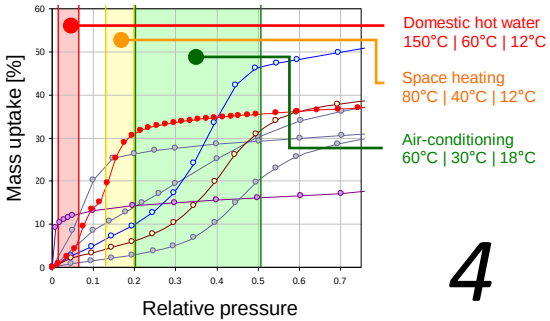
2 **1** Location-specific modeling of solar thermal and waste heat driven cooling system, define CAPEX (cost) and OPEX (el. energy cons.)

Physical modeling of heat & mass transport with sorption phenomena, understand basic physics of system





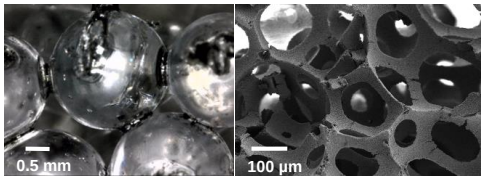
3 Synthesis of adsorbents with tailored application-specific properties **for hot climates**

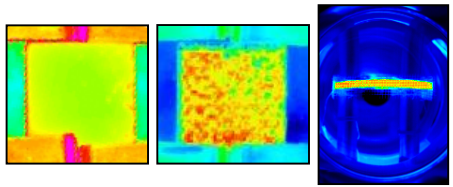


4

Characterization via vapor sorption isotherms and adsorbate diffusion coefficient measurements, **1600 W/kg specific cooling power (>8x higher)**

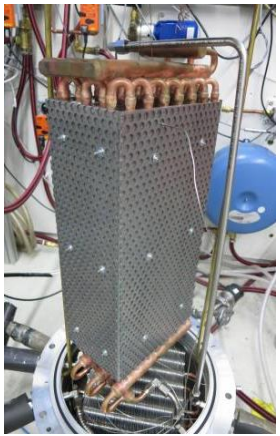
5 Adsorbent assembly for optimized heat & mass transport rates, **10x faster cycling**





6 *In situ* transient thermography and cooling power characterization **10% higher COP**

7 Test facility for 1 kW heat exchanger characterization, **3x lower cost lower driving T**



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Summary: Breakthrough Innovations

- **Reuse ICT heat for heating and cooling ➔ Zero-emission datacenter**
  - Technology lead >10x lower convective thermal resistance than in energy industry
- **Convert heat from Solar HCPVT and datacenters into cooling**
  - Needs high efficiency HCPVT receiver and district cooling
  - Heat driven heat pump 10x better due to lower conductive resistance and better isotherm
- **Innovation in heat pumps**
  - Leading characterization of sorption dynamics and thermal/mass transport resistance
  - Steeper sorption isotherm optimized for necessary temperature/pressure window
  - Better thermal contact for faster cycling and >10x higher overall SCP
  - Heat pump with high exergetic efficiency ➔ Thermal Transformer
- **Microchannel flow boiling to be used in low grade heat steam engines**
  - Rankine cycle with limited efficiency ➔ Should use near isothermal expander
- **Common part: Massively reduced convective and conductive heat transfer**

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Thank you very much for your kind Attention!

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See Conference Paper: Ruch et al., Sustainable data centers and energy conversion technologies (2017).

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