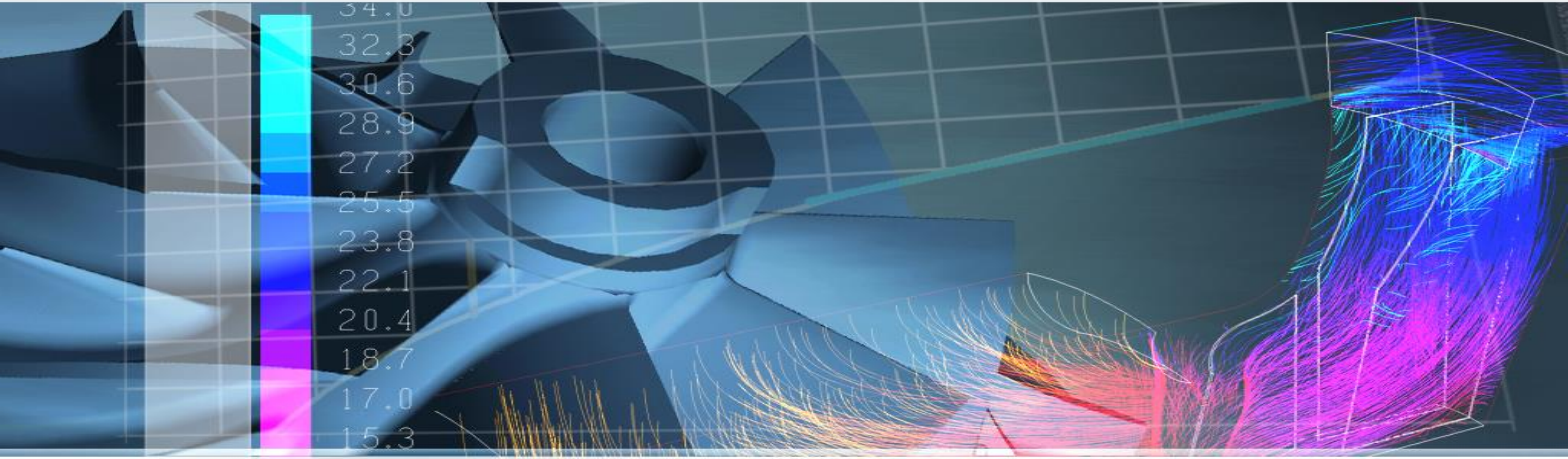
Hall 4A

Chillventa Specialist Forums 2018
Chillventa Fachforen 2018

CONNECTING
EXPERTS.

ILK Dresden

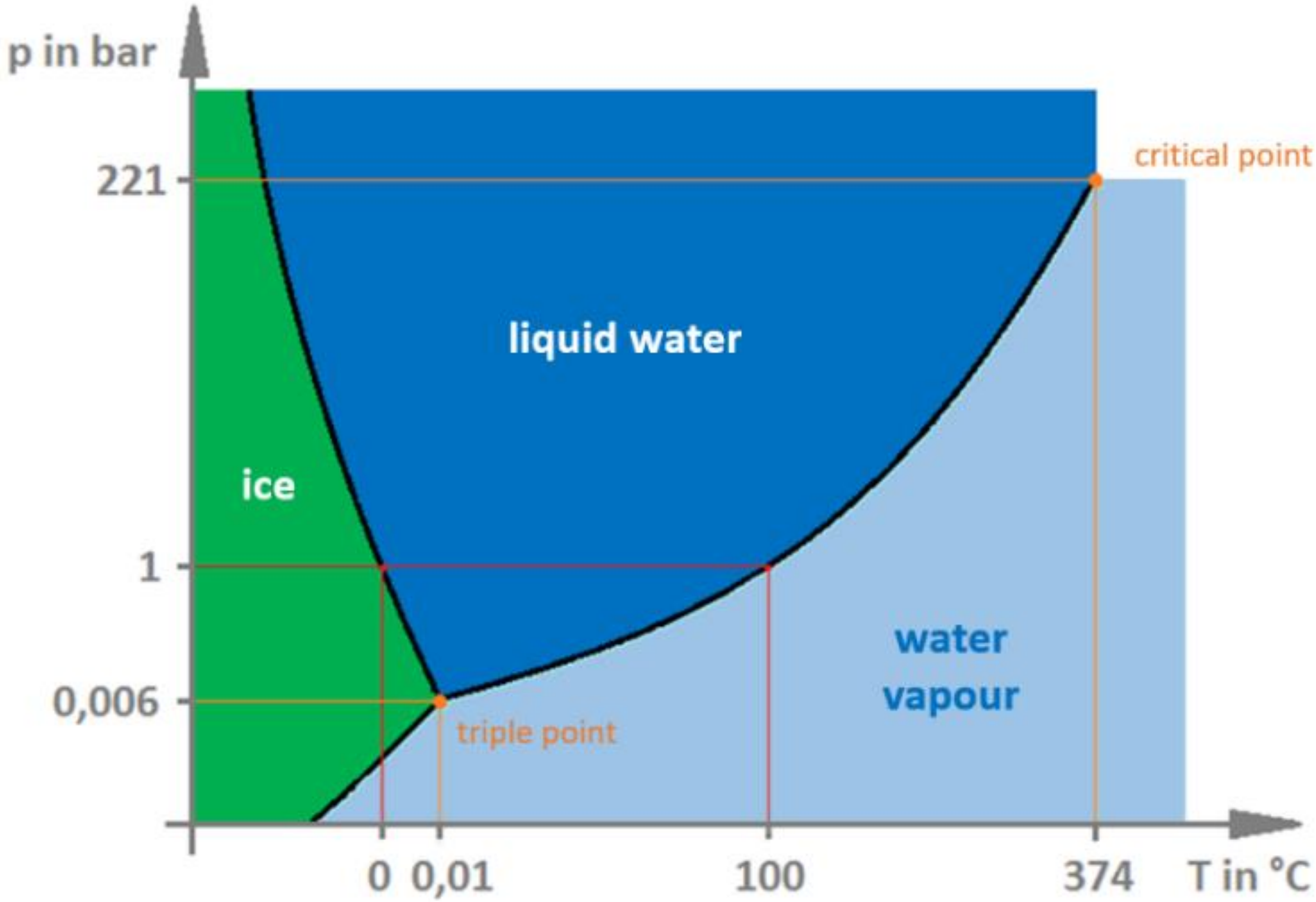


Institute of Air-handling and Refrigeration (ILK Dresden)

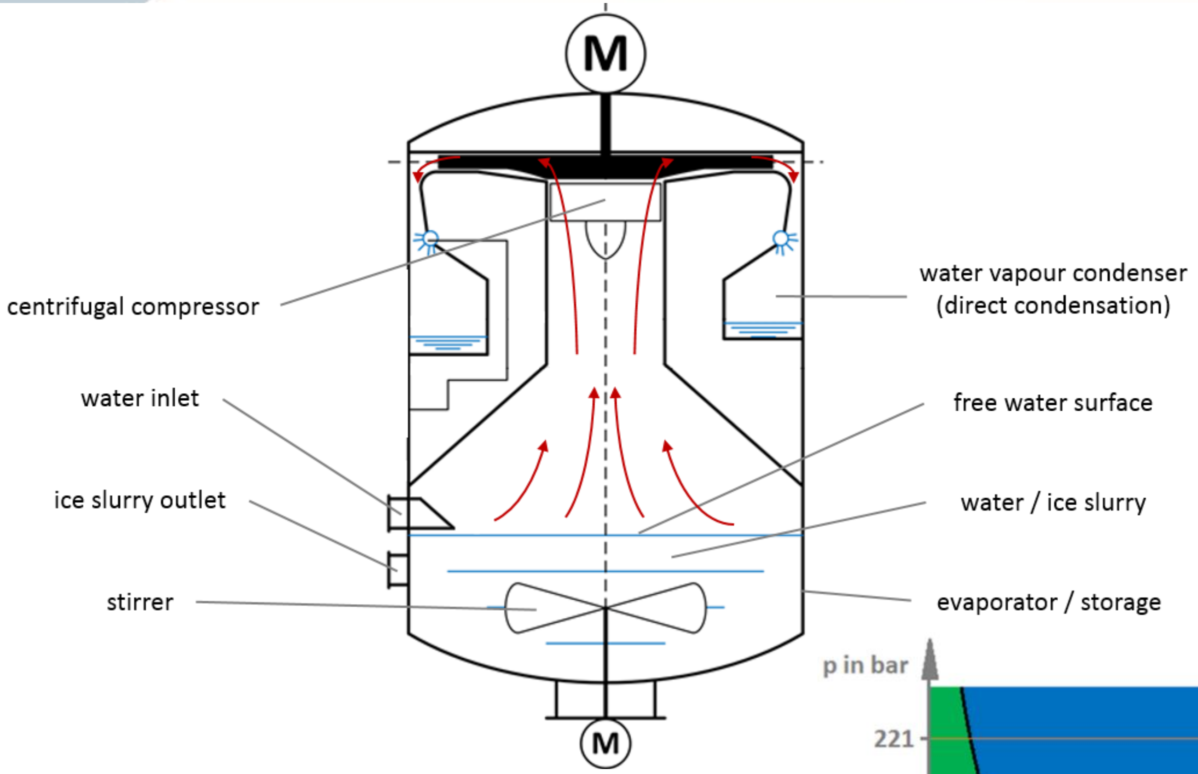
Reduction of energy costs and integration of renewables by using vacuum ice slurry in heat pump and cooling systems

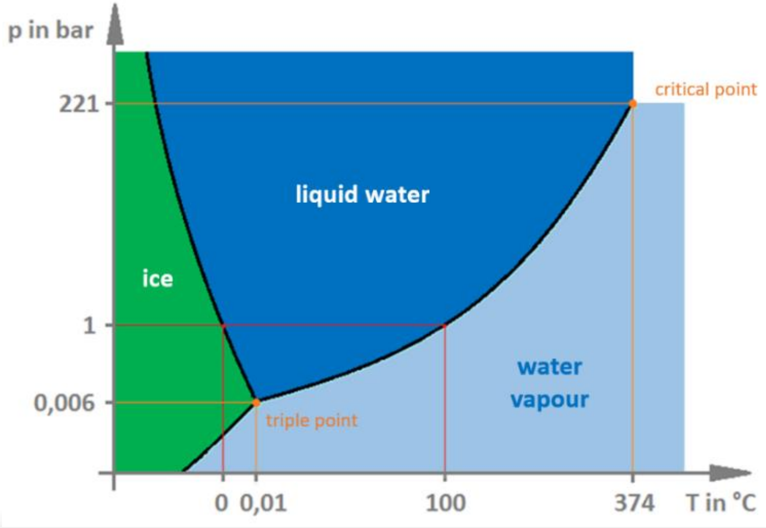
Ice slurry generation by vacuum freezing

How does vacuum ice slurry work?



How does vacuum ice slurry work?



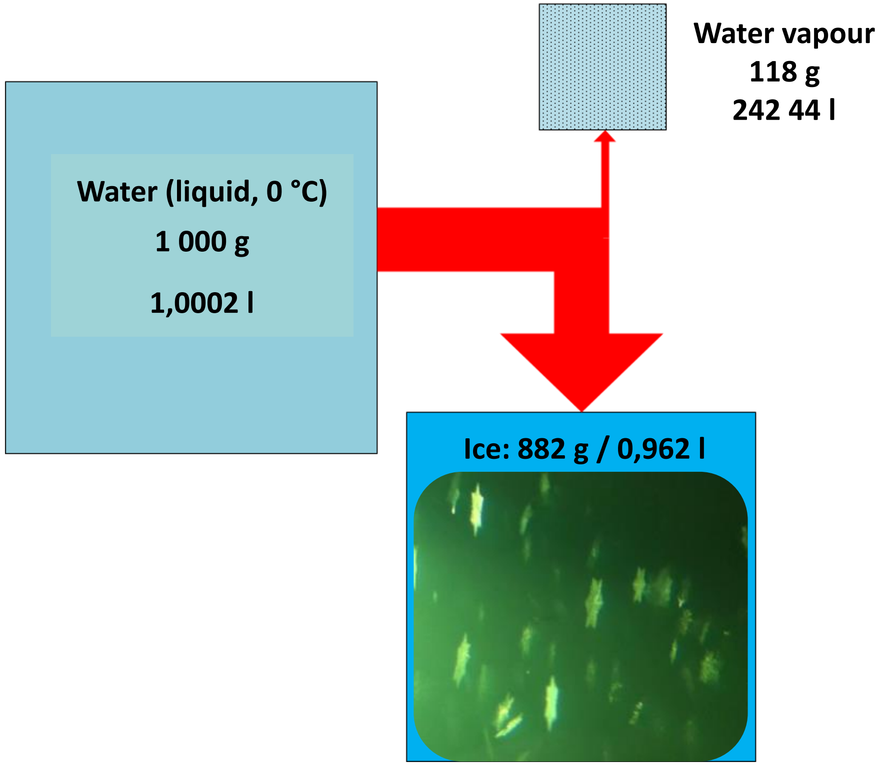


Heat of evaporation (6,1 mbar; 0,01 °C)

h_V = 2500 kJ/kg

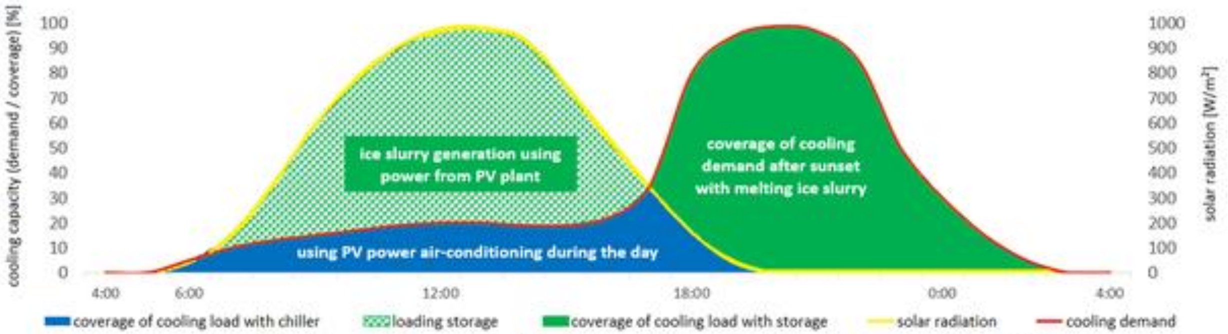
Heat of fusion

h_{fus} = 333,5 kJ/kg

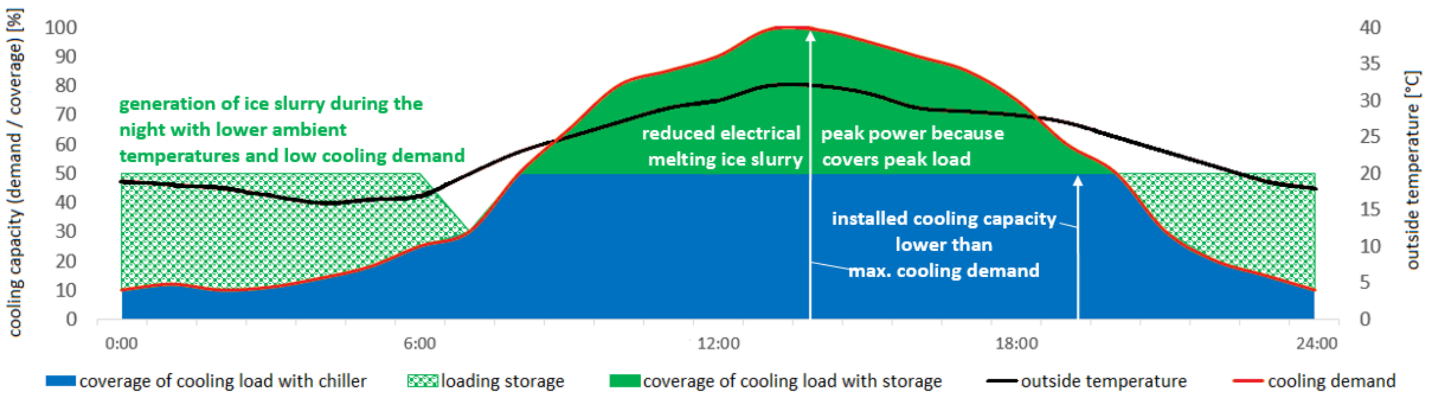


Why cold thermal energy storage?

- Cooling/Refrigeration mostly driven by electricity
- ~16 % of electricity consumption in Germany for cooling
- 40…60 % of electricity consumption in warmer climates
- Peak power demand!
- Cold thermal stores useful energy
- Integration of renewables needs storage, “Power-to-Cold”



Decoupling of cold generation and cooling demand increasing the self-consumption of PV power
Example: theater with performance in the evening



Comparison of cold storage technologies

Sensible heat storage

- Uses temperature difference
  (6/12 °C -> 25 kJ/kg ~ 7 kWh/m³)
- Very small difference usable
- Leads to very big tanks
- Stratification issues

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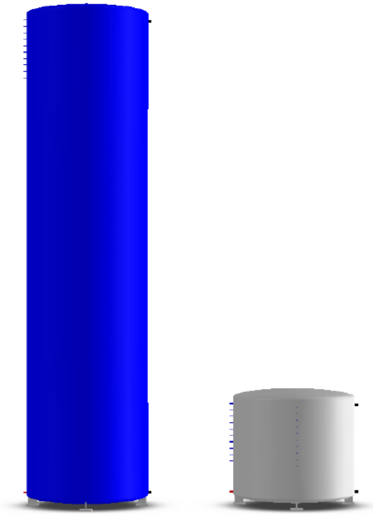
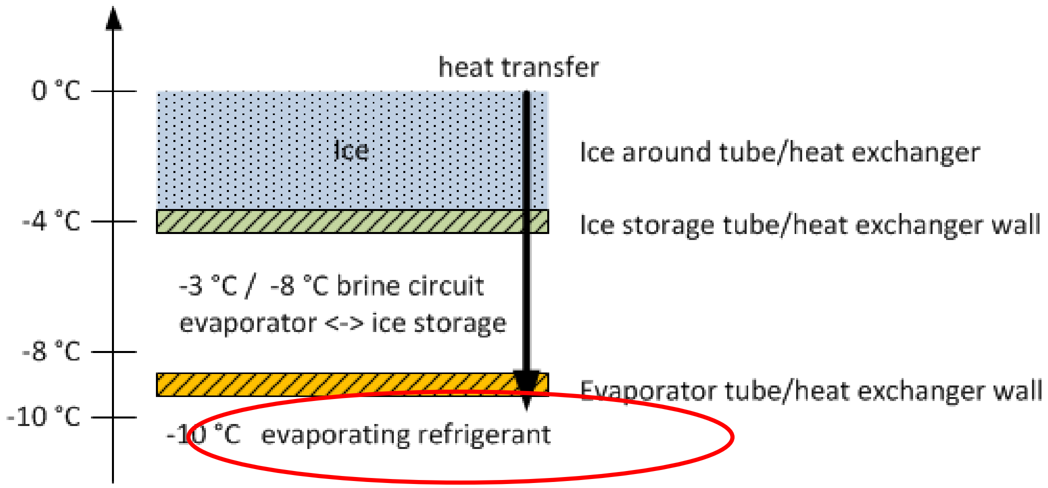


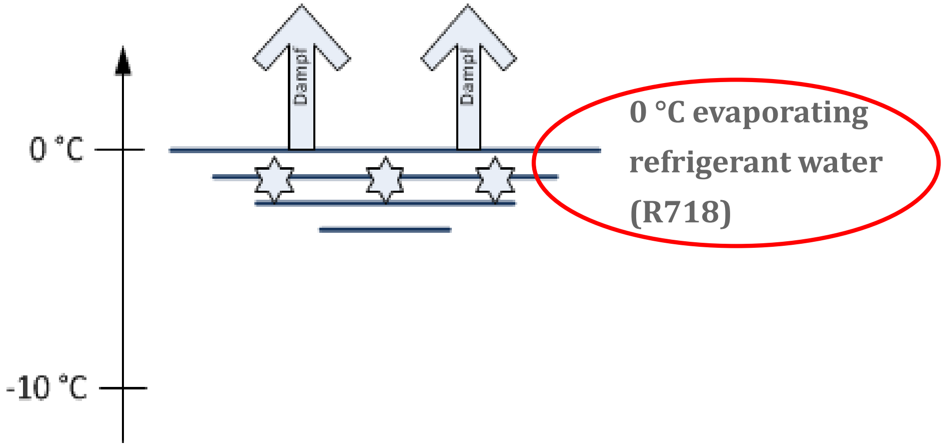
Latent heat storage

- Uses latent heat of fusion
  Water / Ice (333 kJ/kg ~ 93 kWh/m³)
- High storage density
- Melting point close to application temperature

© Calmac

Comparison of cold storage technologies





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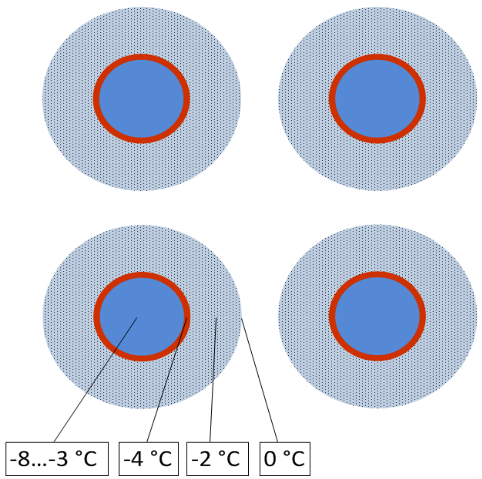
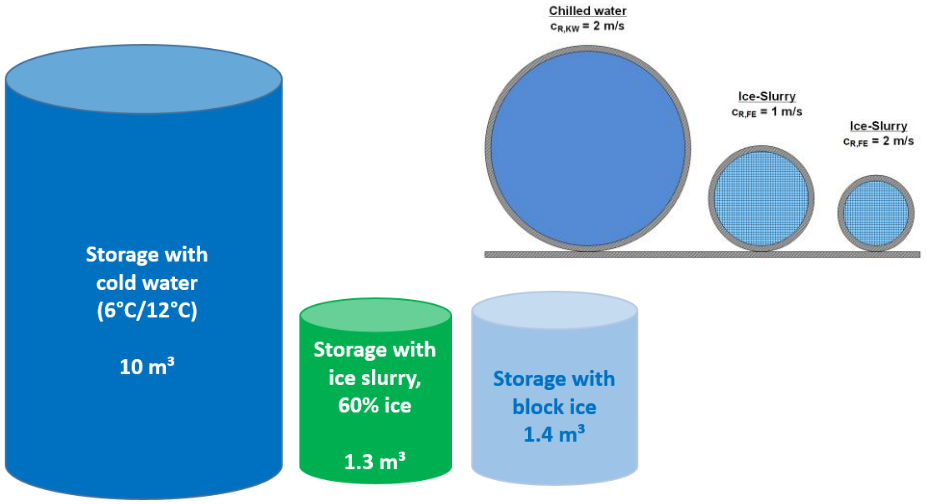


Advantages of vacuum ice slurry

- 7 times higher energy density than chilled water storage
- ~30 % higher efficiency than block ice storage
- Flexible operation; 0…100 % discharging
- Cheap storage medium (PCM)
- Pumpable storage medium
- Sustainable, using water (R718) as refrigerant

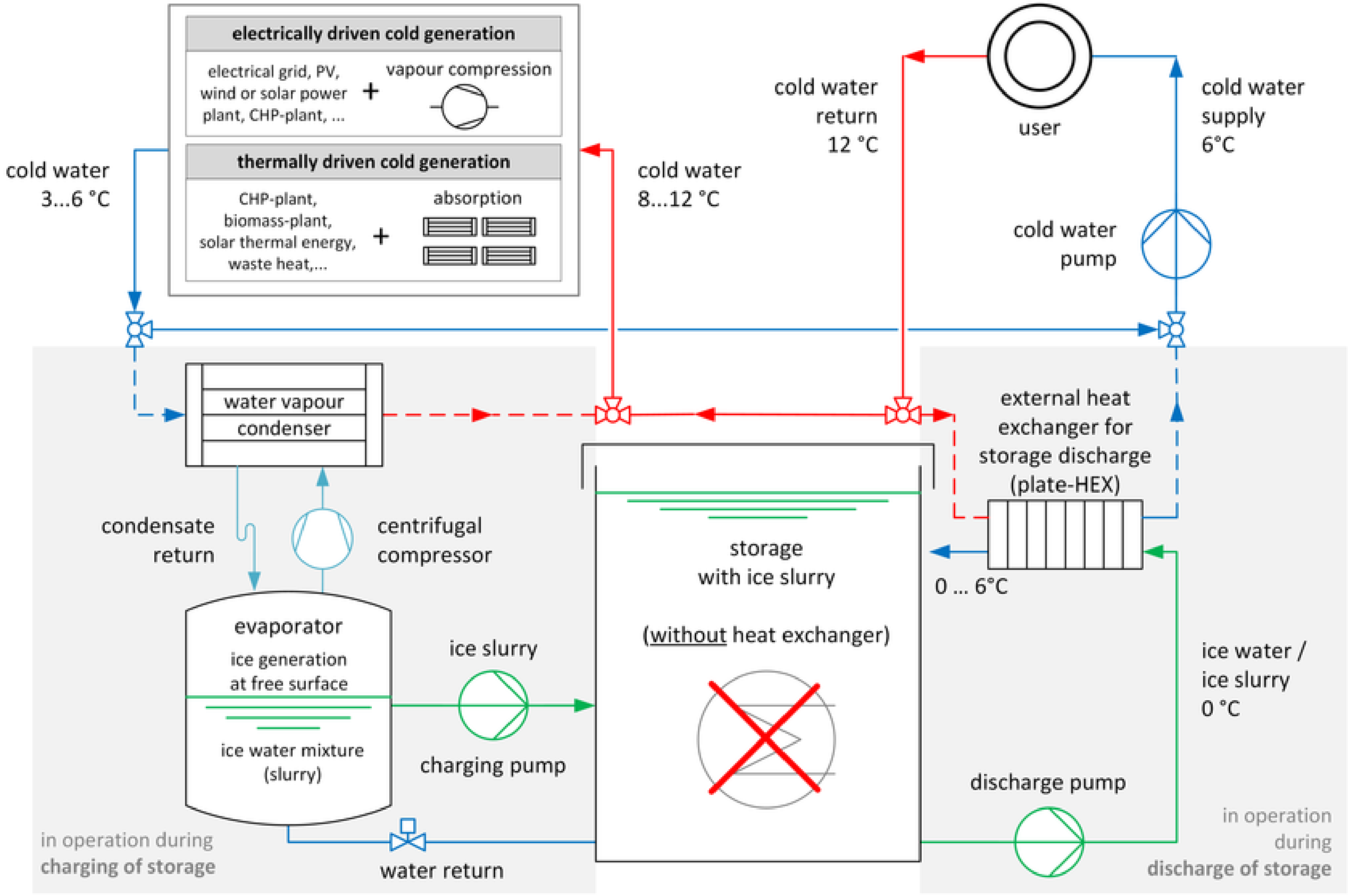


Comparison of storage volume for the same capacity

Storage with cold water		Storage with ice slurry		Storage with block ice
pumpable medium	+ →	pumpable medium		rigid medium
low energy storage density		high energy storage density	← +	high energy storage density

Ice slurry storages combine the advantages of cold water and ice block

Integration of vacuum ice cold thermal storage in chilled water system



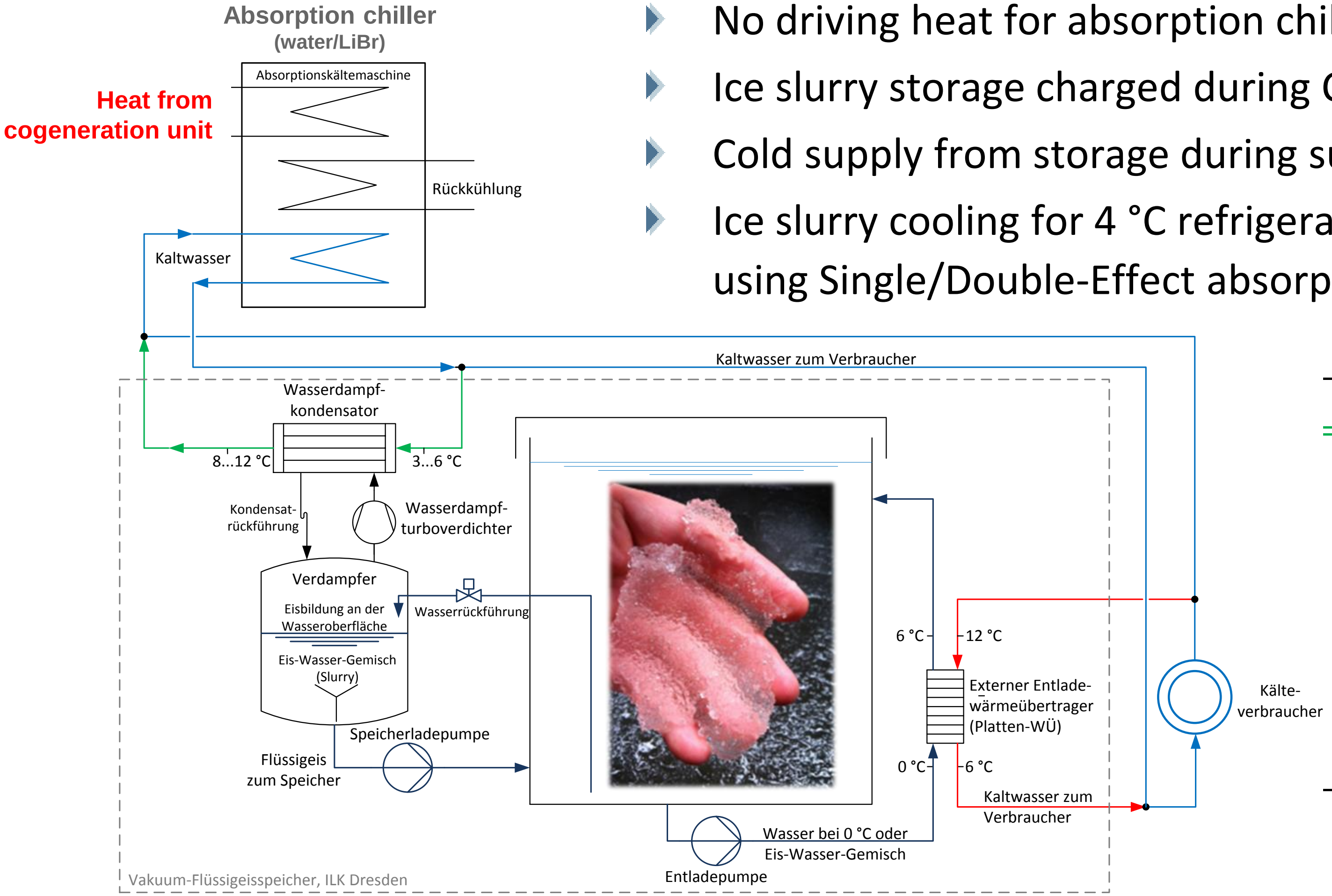
Vacuum ice slurry cold thermal energy storage - example

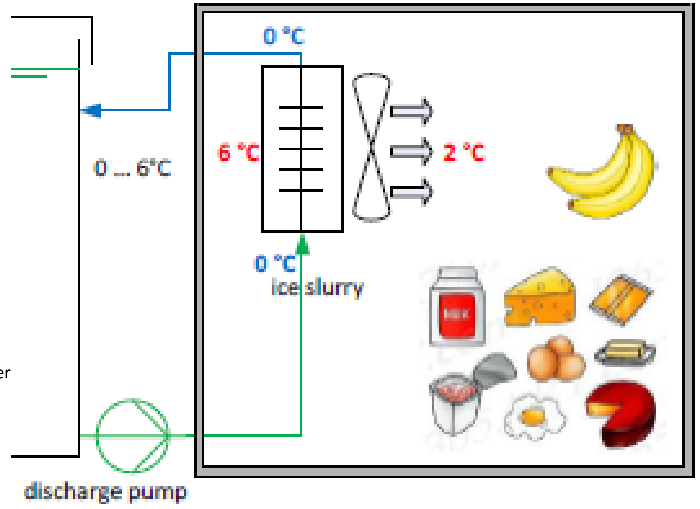
Göttingen, Germany

- Charging capacity: 180 kW
- Storage capacity: 1 MWh
- Discharging capacity: 300 kW
- Load management at local chilled water network

Transition to a more flexible trigeneration
New applications for water/LiBr absorption chillers

- In future Operating time of the CHP is based on the feed-in of renewable energy, e.g. PV during daytime
- No driving heat for absorption chiller during sunshine hours
- Ice slurry storage charged during CHP operation (at non-sunshine hours)
- Cold supply from storage during sunshine hours/CHP idle time
- Ice slurry cooling for 4 °C refrigerated warehouses and icy water supply water using Single/Double-Effect absorption chillers (no ammonia)



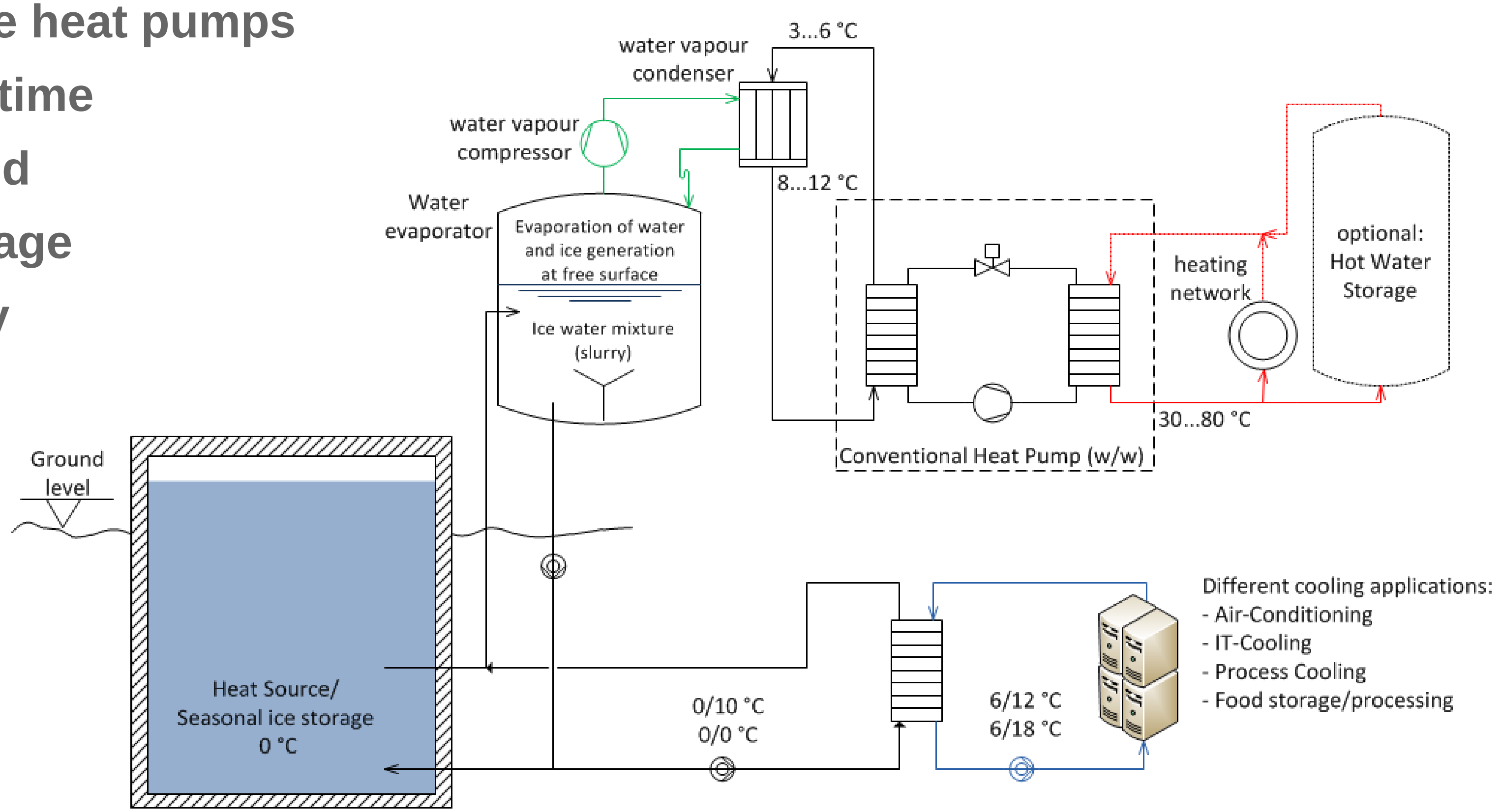


heat pump applications

Combined Heating and Cooling with ice storage

Storage tank based heat pump

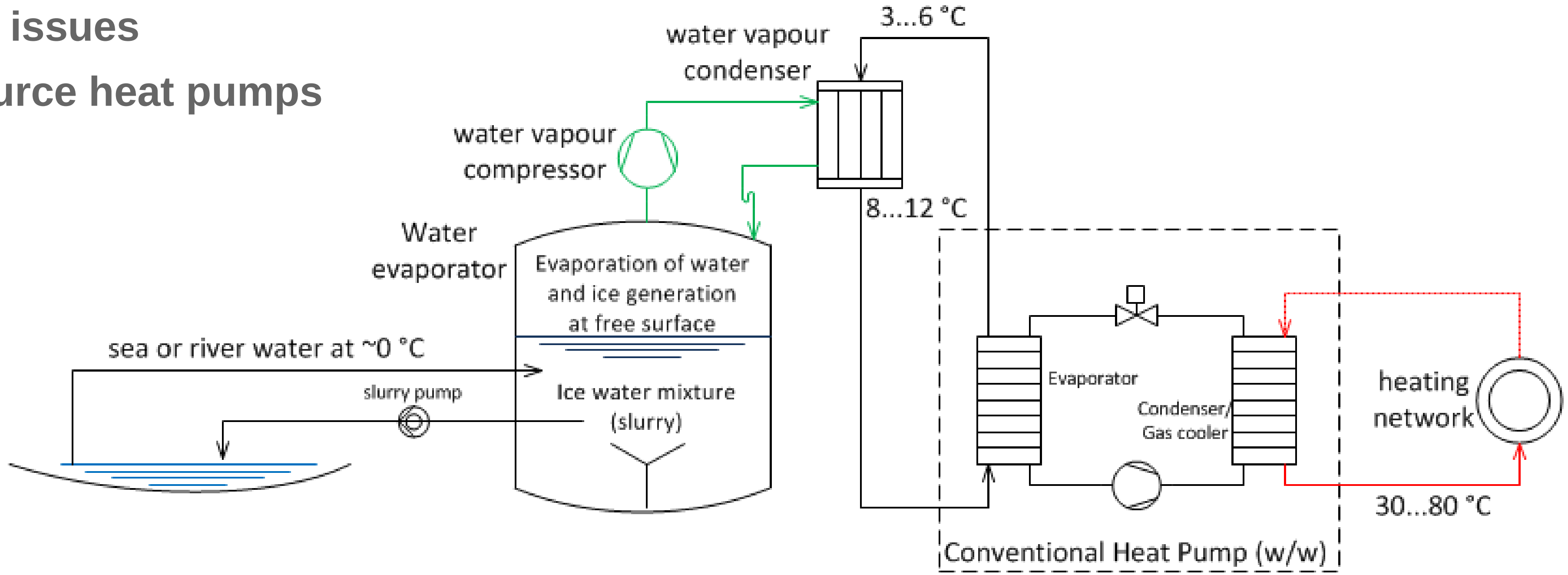
- Combined use of hot and cold side of the heat pump → **Highest efficiency**
- Constant temperature of heat source ►higher than air temperature!
- Avoiding noise issues of air source heat pumps
- Ice slurry storage for balancing of time shifted heating and cooling demand
- Additional regeneration of ice storage by ambient or solar thermal energy



Surface waters as heat pump heat source

<u>Using lakes, rivers or the sea as heat source</u>

- Constant temperature of heat source ►higher than air temperature!
- No problems with water near freezing temperature
- No pollution issues, no glycol
- No investment for ground heat exchanger
- No thermal regeneration issues
- Avoiding noise of air source heat pumps



Vacuum ice slurry at Chillventa

- **ILK Dresden:** **Hall 5, Stand 5-123**

Hall 4A

CHILLVENTA