Solar cooling: worldwide overview and new technological opportunities

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Why SOLAR COOLING? Why in sunny regions?

Chain of consequences

increasing standards of living & climatic changes

increasing cooling and air-conditioning demand

increasing electricity consumption & black-outs

…in sunny areas

✓ Commitment of the countries to reach ambitious objectives

THROUGH

✓ Renewable Energy & Energy Efficiency measures

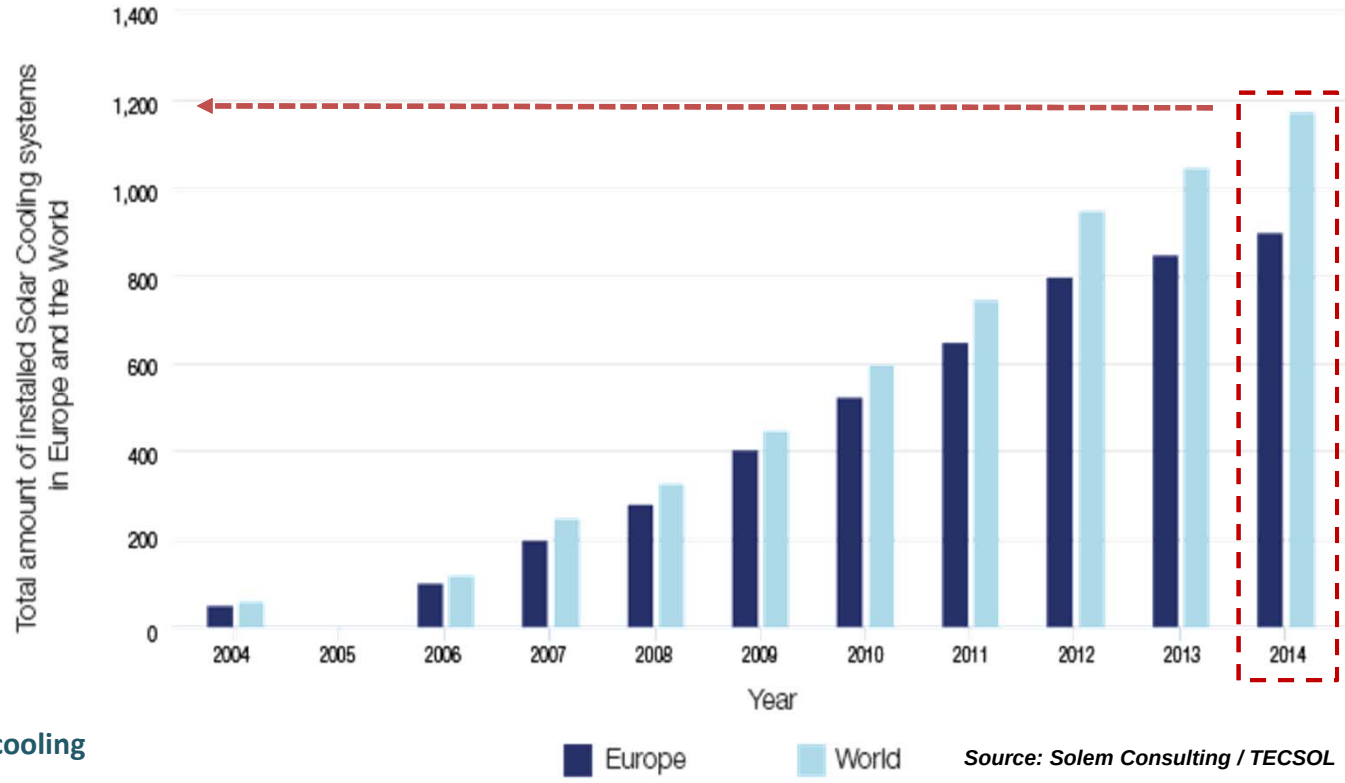
✗ Unsustainable increase in the share of electricity consumption for A/C

✓ An infinite energy source nearly in phase with cooling demand

World Market so far

Still a niche market

1,200 systems
installed worldwide
(2015)

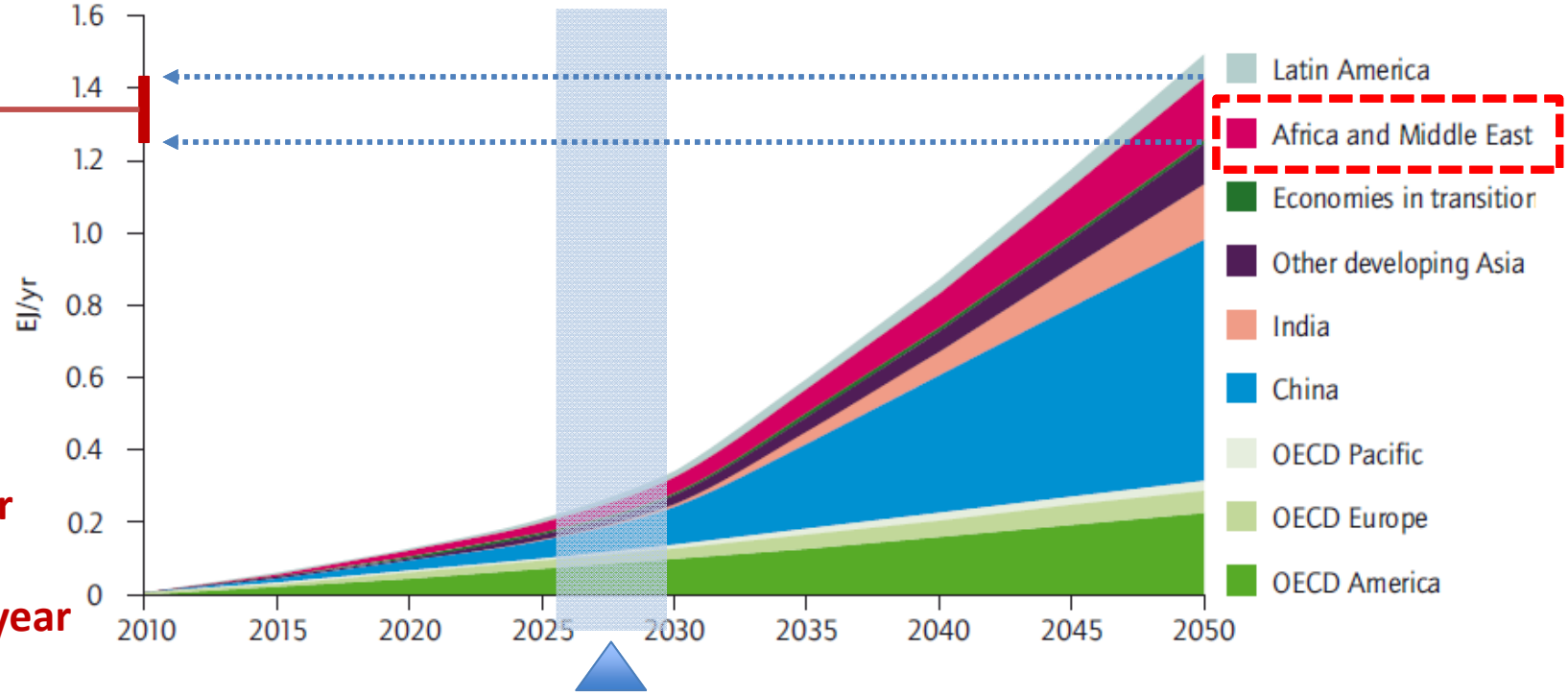


Source: Solem Consulting / TECSOL

Open Issues

- **Cost reduction per $kWh_{cooling}$**
- **Heat rejection**
- **Electricity consumption**

Vision for solar cooling – ROADMAP until 2050



0.2 EJ/year

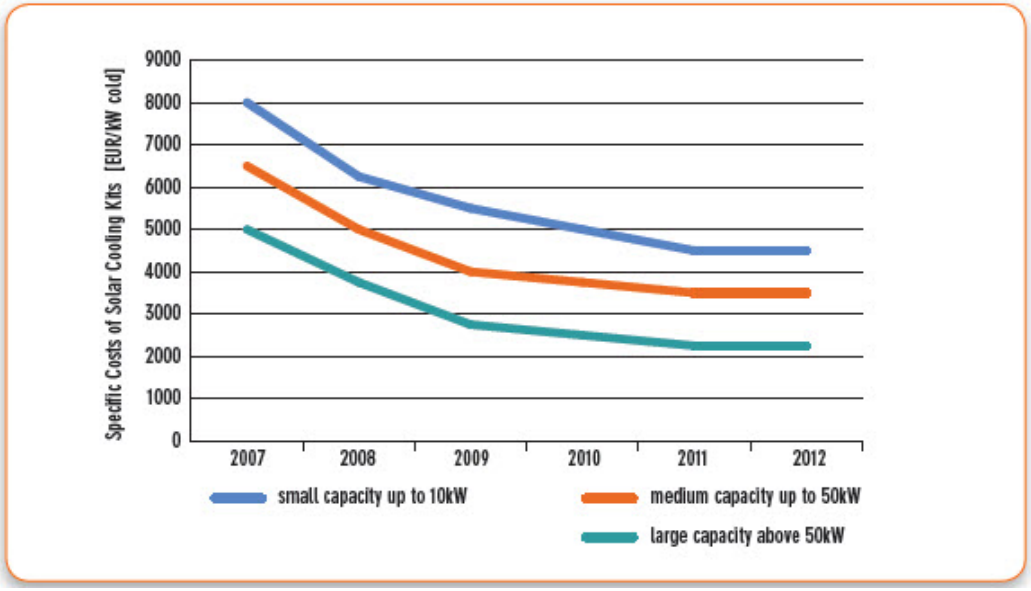
56000 GWh/year

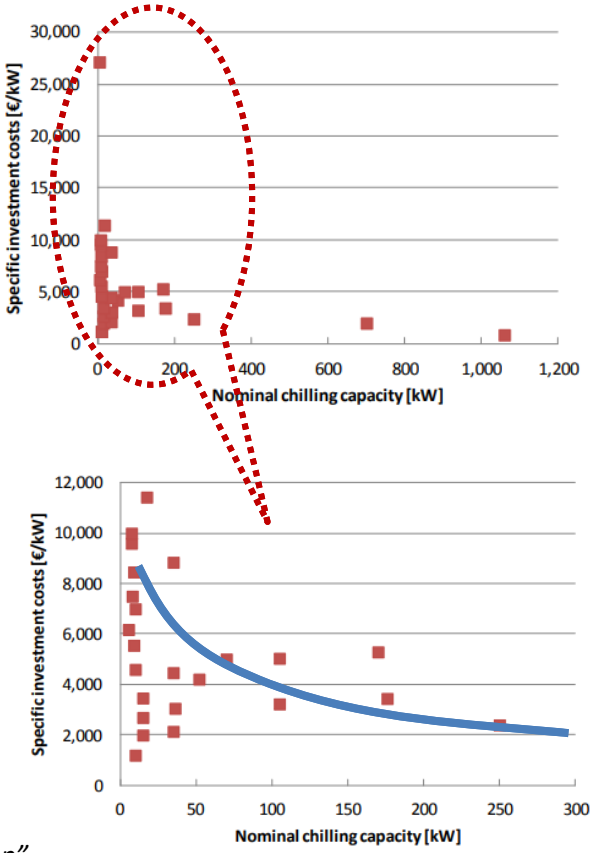
The Challenge is NOW…HERE

Cost of solar cooling technology is expected to reduce

Electricity cost is expected to continuously increase

Investment Costs





The expected cost in 2020 is 2000 €/kW$_{capacity}$ for small sizes

H2020 Project ZEOSOL, GRANT AGREEMENT N:760210.

"Integrated solar heating and cooling unit based on a novel zeolite chiller and heat pump"

Main conclusions on solar cooling market

Thermal Solar cooling

- ✓ development of new, small scale heat driven chillers < 35 kWc
- ✓ development of high efficient double/triple effect absorption chillers
- ✓ development of single-axis tracking concentrating collectors

HOWEVER

- ✗ High investment cost
- ✗ heat rejection in hot and humid countries
- ✗ Standard solutions are still missing

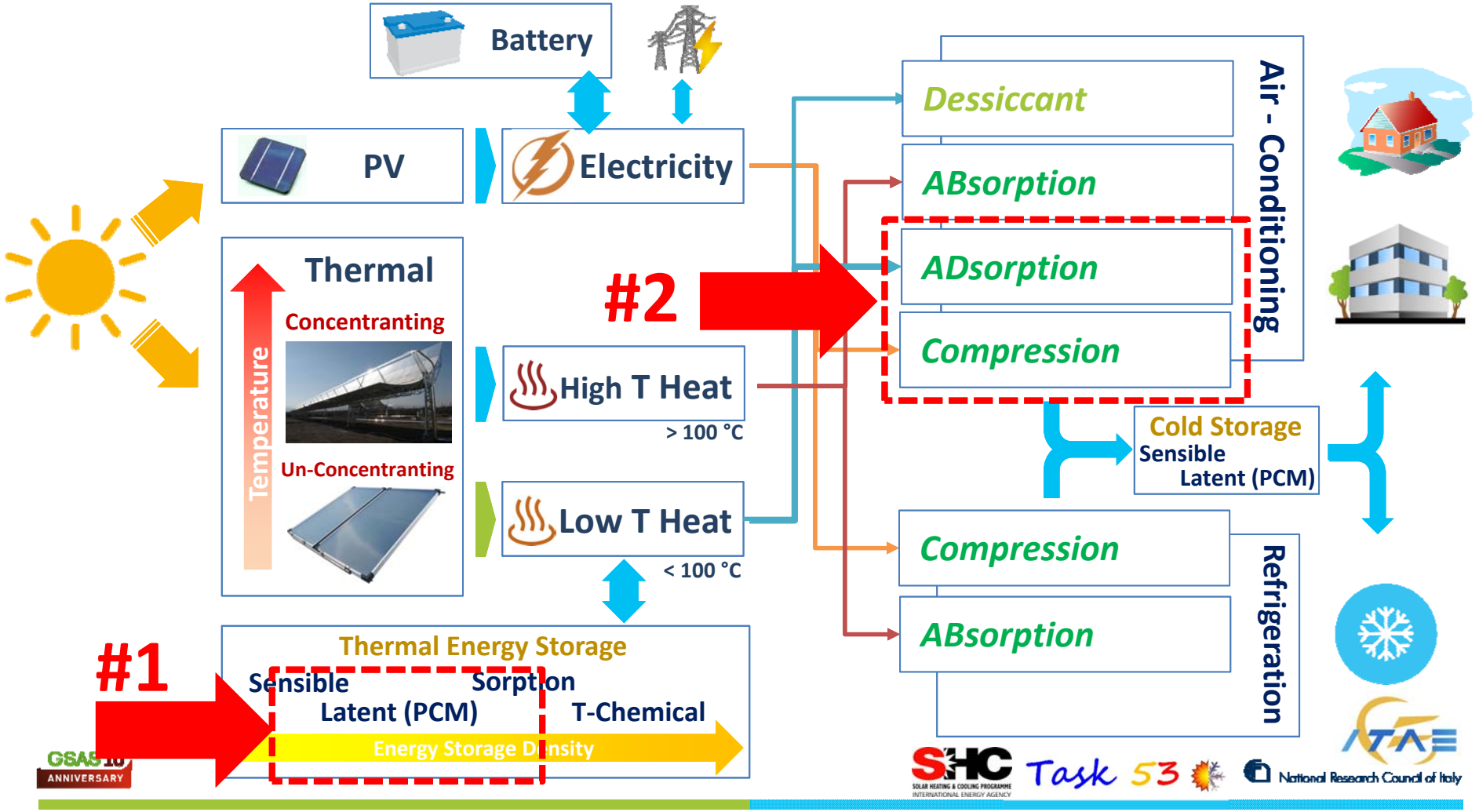
PV solar cooling

- ✓ Components are market-available.
- ✓ Small systems require low effort for planning and installation

BUT

- ⊘ Coincidence of A/C demand and solar energy need to be improved using battery or cold storage
- ⊘ The cost for this is currently still high, but expected to drop

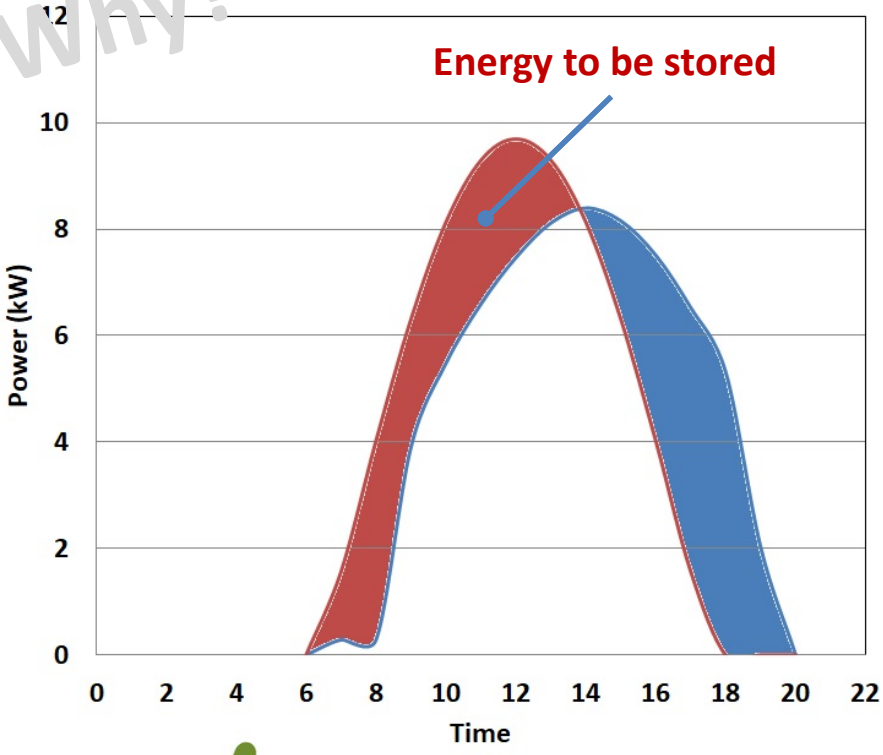
Solar Cooling Technologies ROADMAP

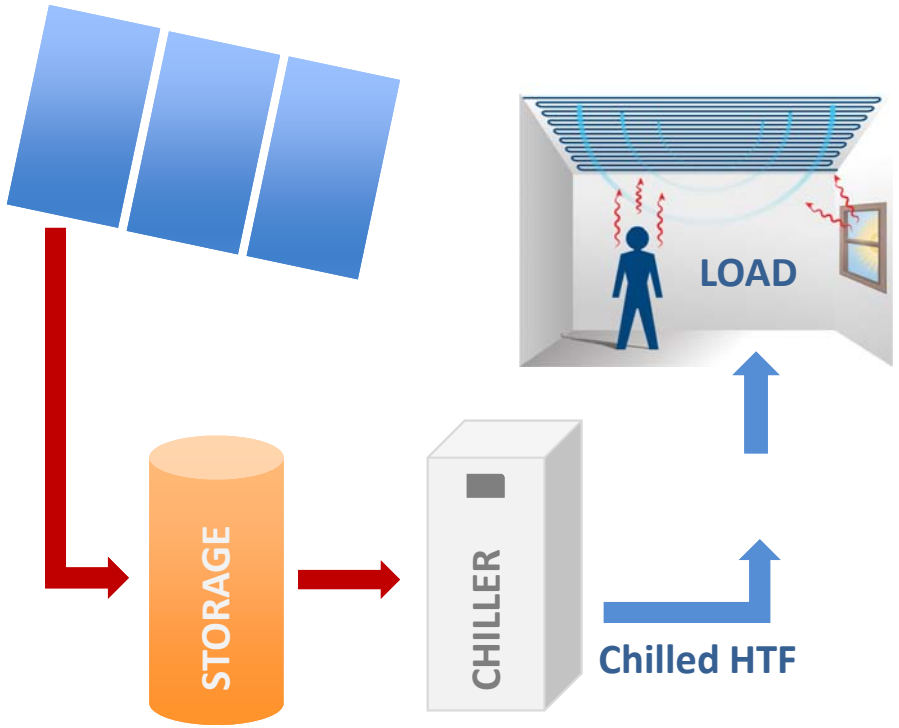


Technological Opportunity #1

Advanced Thermal Energy Storages

Why?





Rule of Thumb: 4 $m^2/kW_{capacity}$ → 50 – 100 l/m^2 → 200-400 $l/kW_{capacity}$

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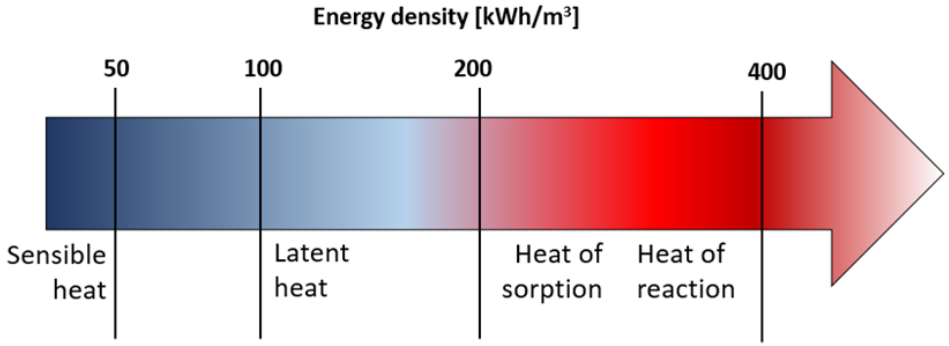
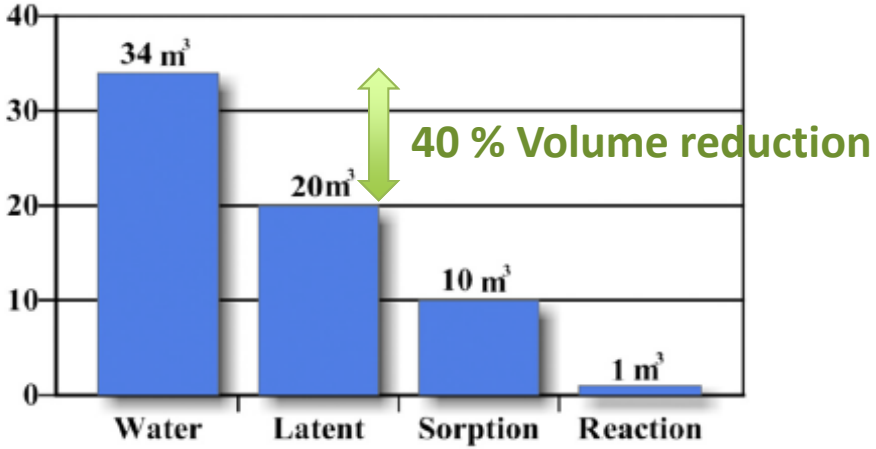
Technological Opportunity #1

GOAL: size reduction

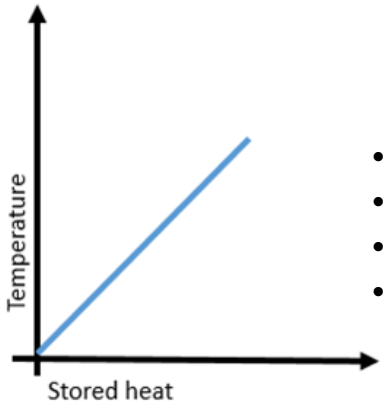


volume needed to store 1850 kWh, with consideration of 25% heat losses, based on a 70°C temperature increase for water



Technological Opportunity #1

Sensible VS PCMs



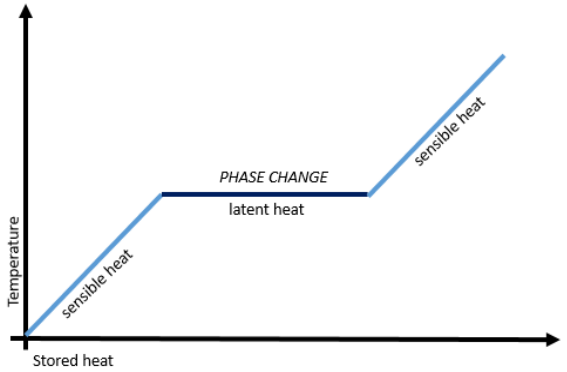
- *Water*
- *Rocks*
- *Concrete*
- *Organic oils…*

Advantage

- ☑ Simple
- ☑ Cheap
- ☑ Reliable

Disadvantage

- ☒ Low storage density
- ☒ Need for good insulation



PCMs

- *Organics*
- *Inorganics*
- *Eutettics…*

Advantage

- ☑ Simple
- ☑ High storage density
- ☑ Constant temperature

Disadvantage

- ☒ Cost
- ☒ Need for insulation
- ☒ Other…

Type	Tank cost [€]	Capsule cost [€/capsule]	PCM cost [€/capsule]	Others [€]	Total Cost [€]
Sensible	998	-	-	-	998
PCM	998	15.37	476.62	100	1574.62

+ 58 % cost

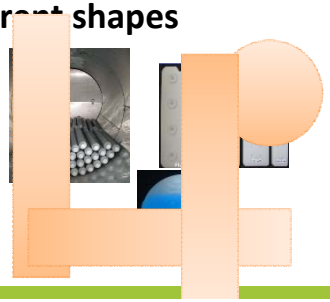
Technological Opportunity #1

KEY TRENDS

Development of high-performing materials…

PARAFFINS
HYDRATED SALTS
BIO-MATERIALS
SUGAR ALCOHOLS
FATTY ACIDS

…in different shapes



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MARKET DRIVER

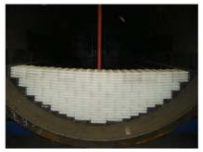
Cost of PCMs will reduce due to scale effect

Tailoring for each specific application and location is possible

APPLICATIONS

market

Greenbox system for pharmaceuticals



research

Doha 2022 FIFA World Cup

FORECASTS

Market value expected to reach US$1.5 billion by 2020

Middle-East and Africa as 2nd growing world market

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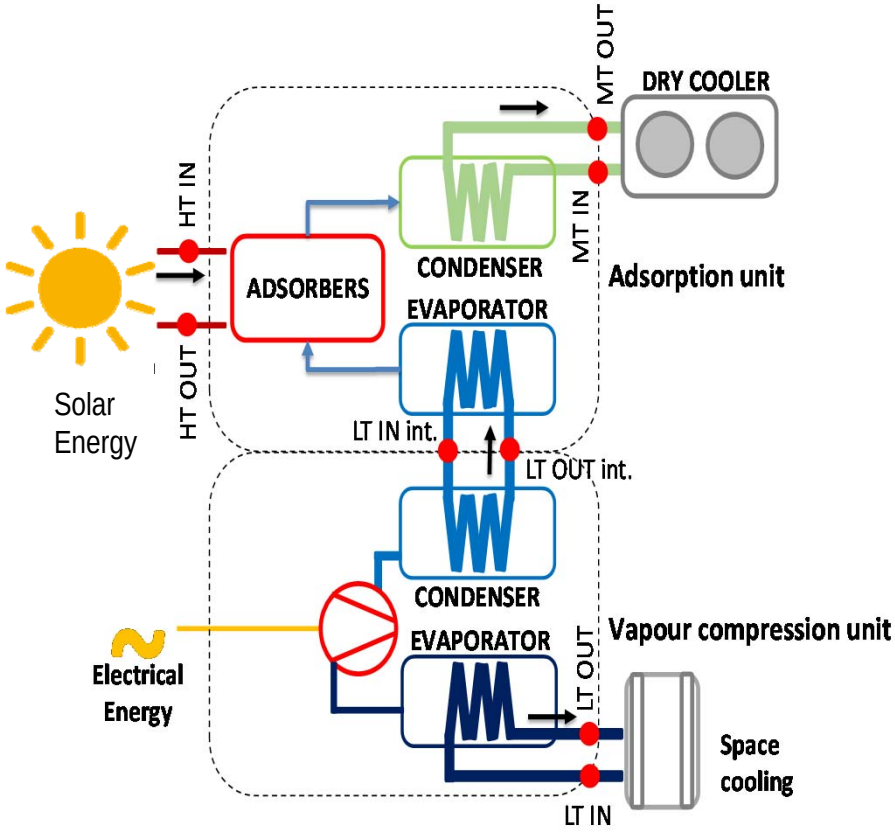
Technological Opportunity #2

Hybrid Chiller: HOW IT WORKS

1. It consists of a “series” connection of a thermally-driven unit and a traditional vapor compression unit
2. It allows to exploit the benefits and main peculiarities of both components:

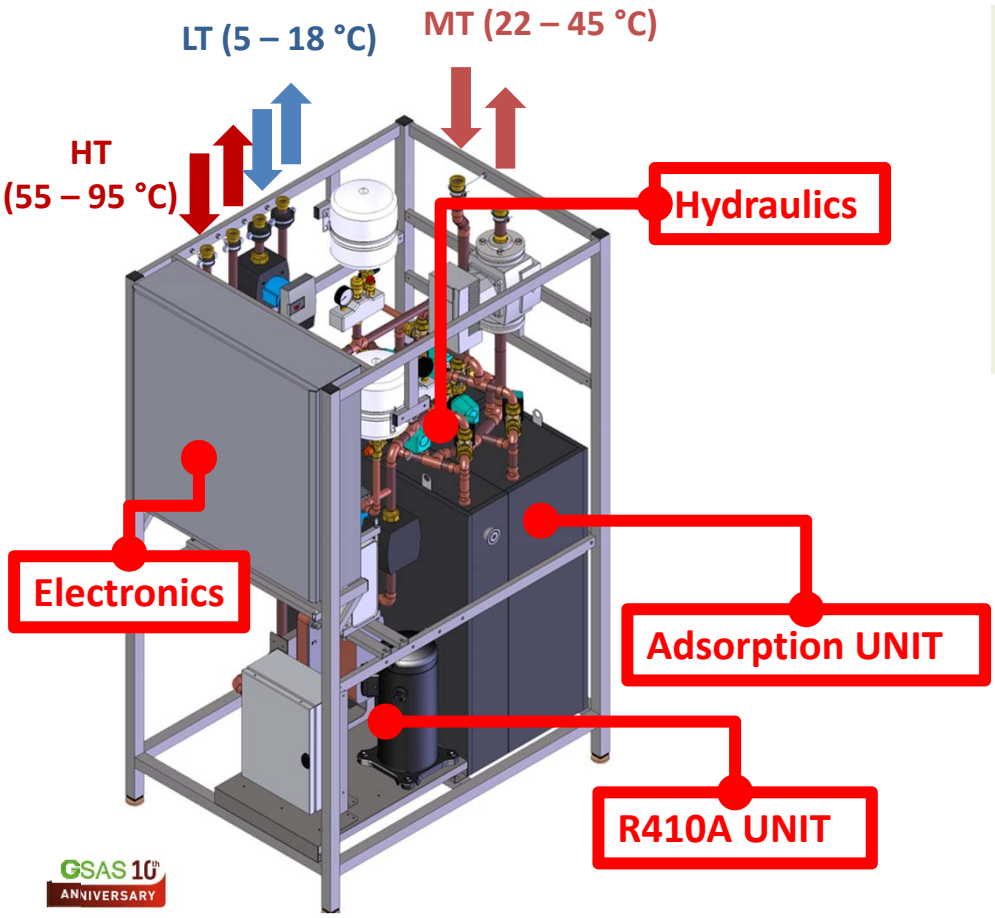
- sorption systems have electricity consumption extremely low and need limited maintenance

- electric chillers offer high precision in temperature regulation and fast response to temperature fluctuations.



Technological Opportunity #2

Hybrid Chiller: the concept



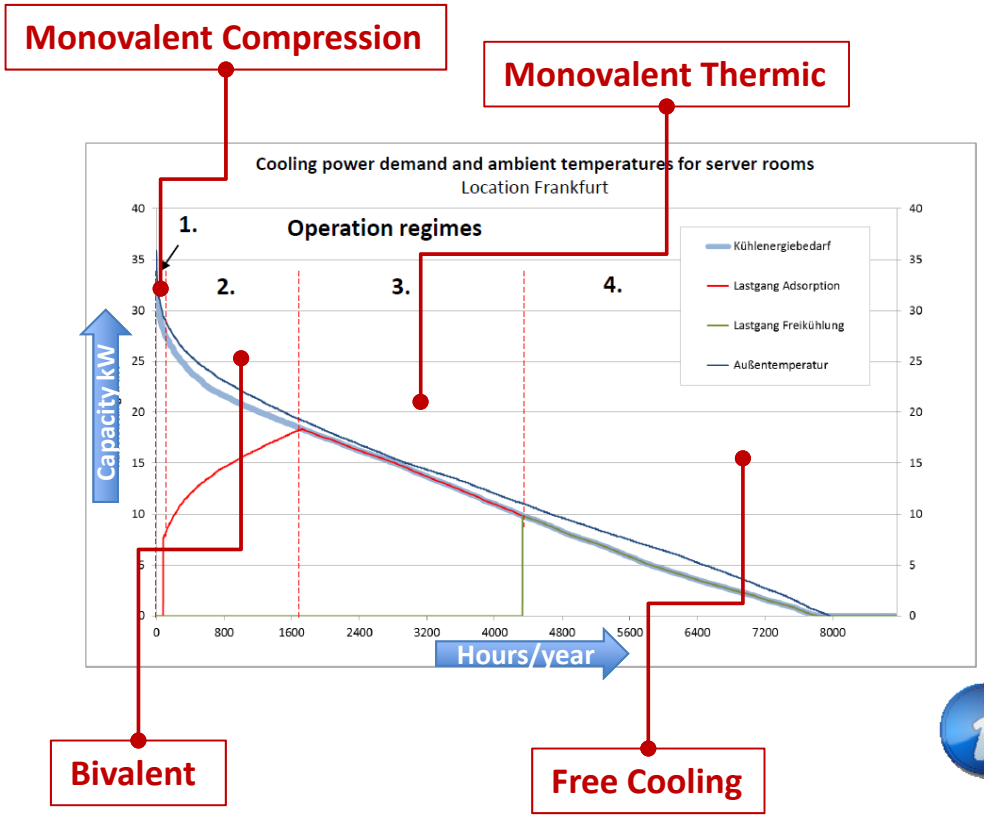
A commercial silica gel adsorption unit with 2 adsorbers working in counter-phase

nominal power: 10 kW
nominal COP: 0.6

+

An OEM vapor compression chiller, employing R410a as refrigerant.
nominal power: 10 kW
nominal COP: 3.4

Hybrid Chiller: commercial UNIT



With Cold water temperature 16/19 °C
European Seasonal Energy Efficiency Ration ESEER: (electrical) 19,6
(max thermic) 0,65

Current specific cost: 0.6 – 0.8 k€/kW$_{capacity}$

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Main conclusions on new generation SCS

- Technical analysis on solar cooling systems highlights that storage and hybrid chillers can play a key role for higher efficiency and cost reduction
- PCMs possess the right features for replacing sensible media (Water) for heat storage in SCS
  - More R&D efforts are still required, mainly addressed at cost reduction
- Hybrid chillers are a very promising techinical opportunity allowing a «smart» exploiment of the solar energy souce (Thermal and PV)
- They have just entered the market
  - Their effectiveness in hot climate regions has to be still proved

For more information…

…you can visit the following web sites:

Task 53

http://task53.iea-shc.org/publications

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