# State of the art for solar thermal or PV cooling and refrigeration

Task 48

Task 53

TECSOL

**Daniel MUGNIER – 15/10/2014**

**SHC 2014 Conference**

**Beijing (China)**

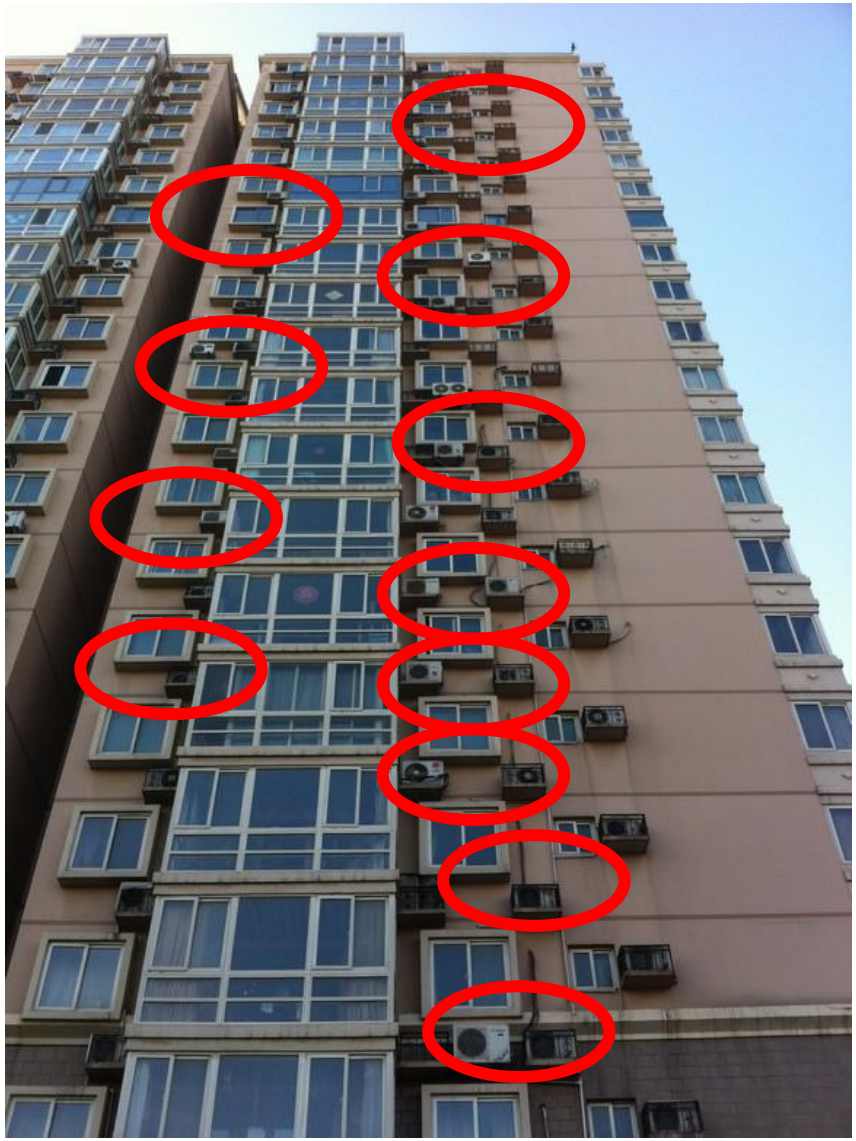
SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

www.tecsol.fr

# To Introduce the importance of…

## SOLAR COOLING for China…

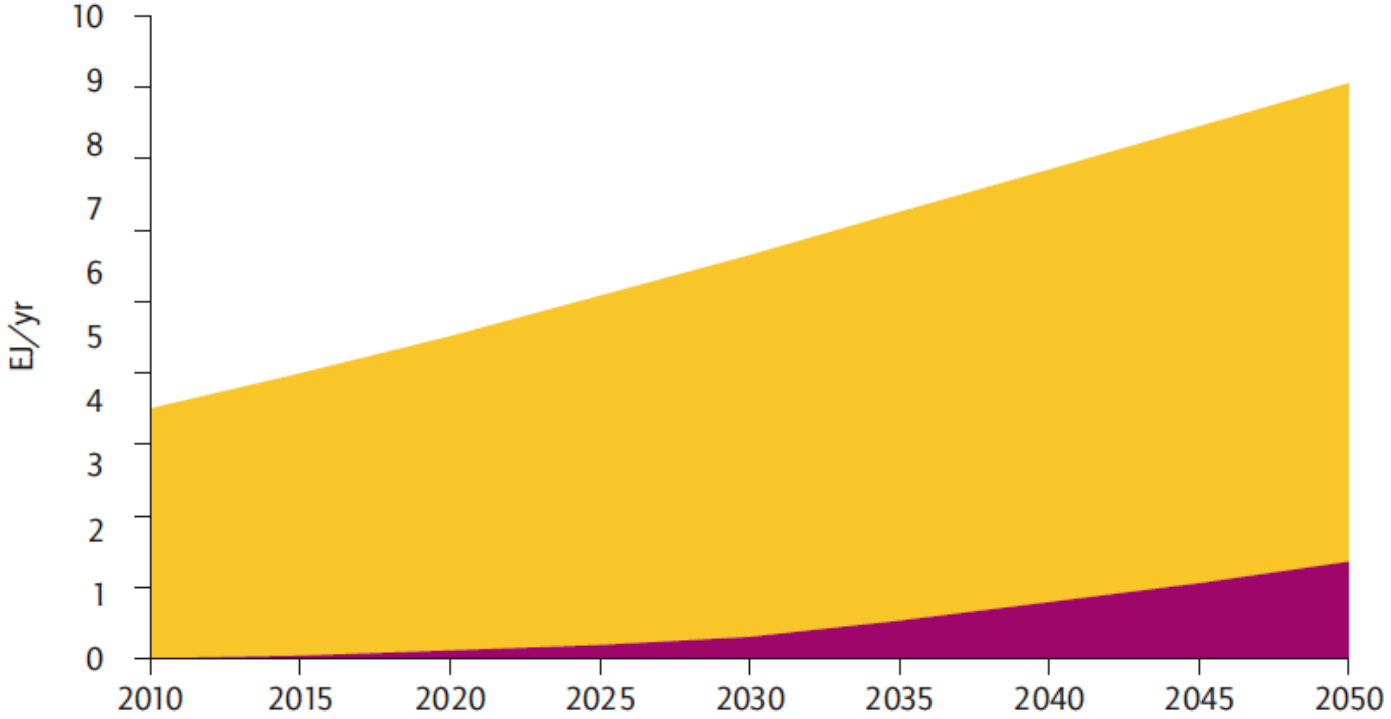
…one picture taken this morning in Datun Road close to CNCC



# IEA Technology Roadmap SHC

## *Share of solar cooling by 2050*

Figure 17: Roadmap vision for solar cooling in relation to total final energy use for cooling (Exajoule/yr)




Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

Solar Cooling nearly 17% of total energy use for cooling!

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 48

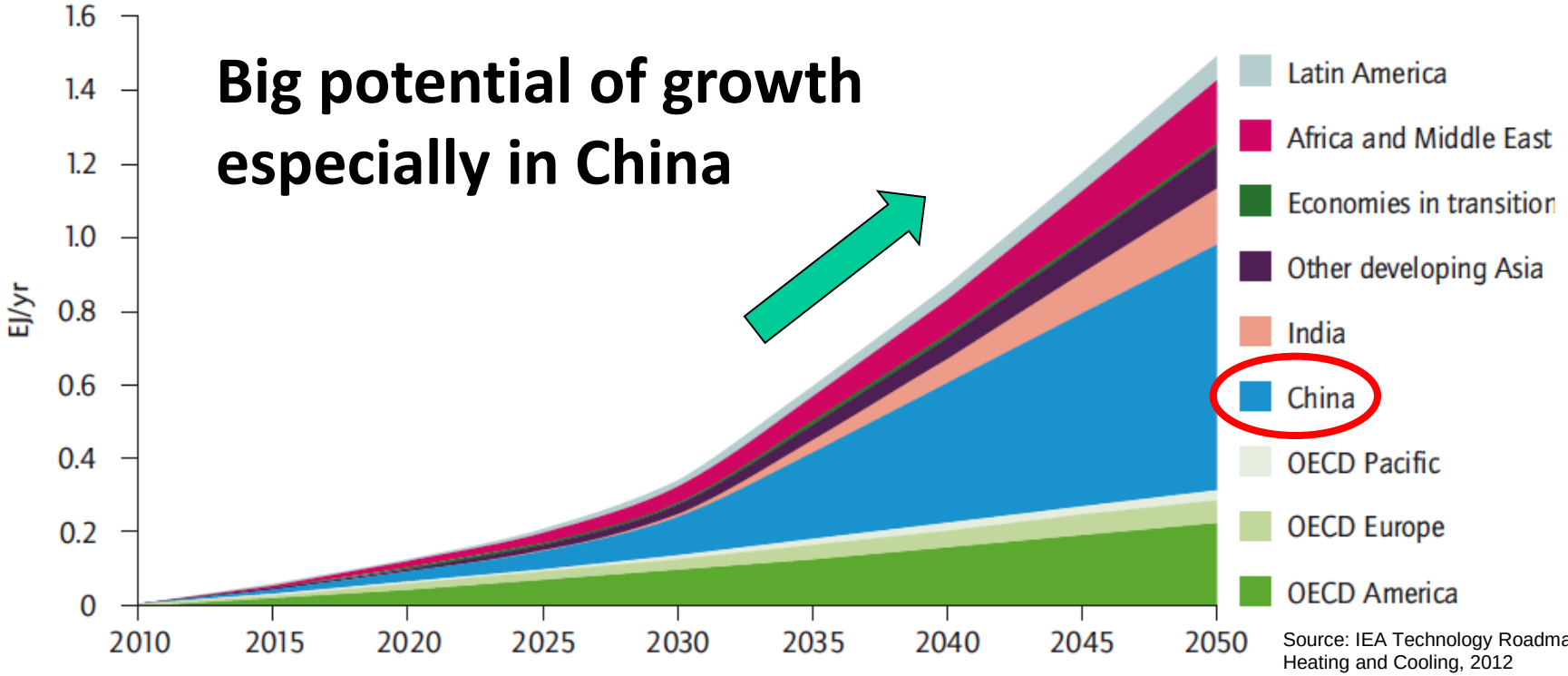
Task 53

TECSOL

# IEA Technology Roadmap SHC – *Market potential by 2050*



Figure 16: Roadmap vision for solar cooling (Exajoule/yr)



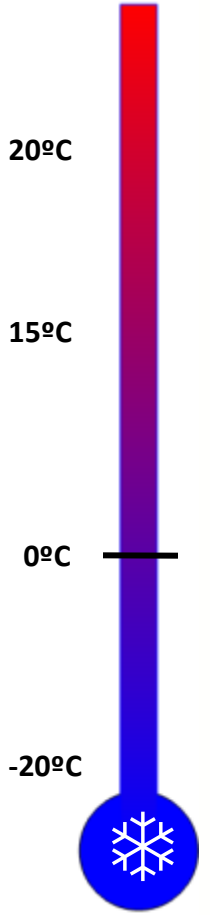

Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

1.5 x $10^{18}$ J/a = 416.7 TWh/a Solar Cooling by 2050

Systems could enter the market between 2015 and 2020

# Solar thermal collector technologies versus Application for solar cooling

| Solar thermal collector | Heat transfer medium | Collector temperature | Application for cooling |
|---|---|---|---|
| Air collector  | Air | 40-60ºC | Air-conditioning |
| Flat plate collector  | Water, Water-Glycol | 70-90ºC | Air-conditioning, slab cooling |
| Evacuated tube collector  | Water, Water-Glycol | 90-120ºC | Air-conditioning, slab cooling |
| Parabolic trough / Fresnel collector  | Thermal oil, Water | 120-250ºC | Refrigeration, air-conditioning, slab cooling |



# Small-scale capacity adsorption chillers

**SorTech**
**eCoo10**
**Water / Silica gel**

Soruce: SorTech

**InvenSor**
**LTC10 & HTC18**
**Water / Zeolithe**


Source: InvenSor

- **Cooling capacity range:** **10 kW to 18 kW**
- **Heating temperatures:** **60 – 95° C**
- **Cold water temperatures:** **15° C**
- **COP :** **0.6 – 0.65 (0.7*)**

*** High Efficiency Modus**





SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 48

TECSOL

# Small-scale capacity absorption chillers

**EAW**
**SE15**
**Water / Lithium bromide**

Source: EAW

**Pink**
**PC19**
**Ammonia / Water**

Source: Pink

- **Cooling capacity range:** **15 kW to 19 kW**
- **Heating temperatures:** **65 – 95° C**
- **Cold water temperatures:** **6 – 7° C** **($NH_3$ -5° C)**
- **COP :** **0.65 – 0.75 (0.5)**

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 48

TECSOL

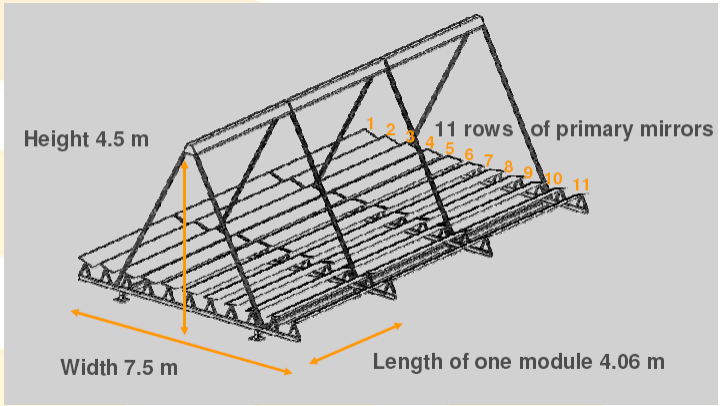
# Latest progresses : Integrated hydraulic unit for comfortable system integration

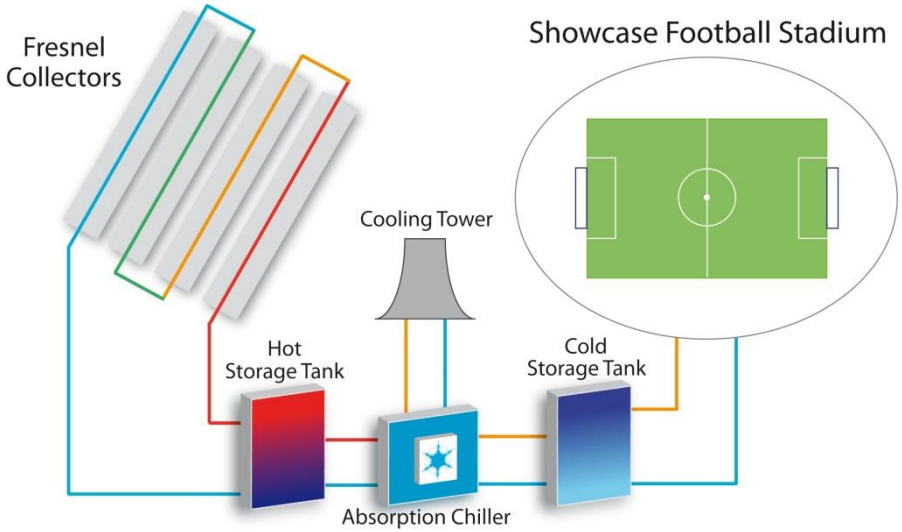

Source: InvenSor

Source: SorTech

# High-temperature applications

**Example** : Footbal Stadium in Dubai



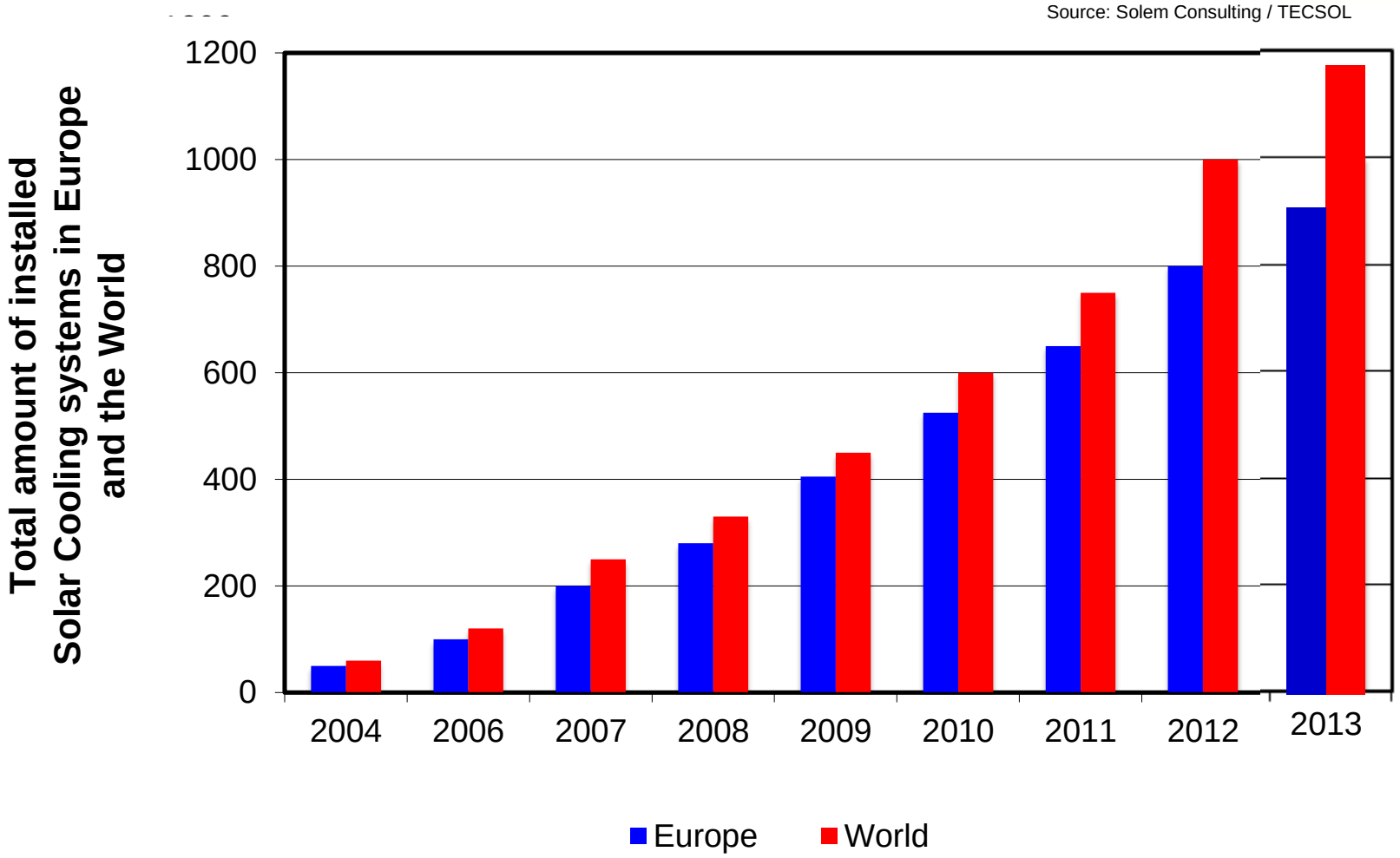

INDUSTRIAL SOLAR
thermal solutions

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 48

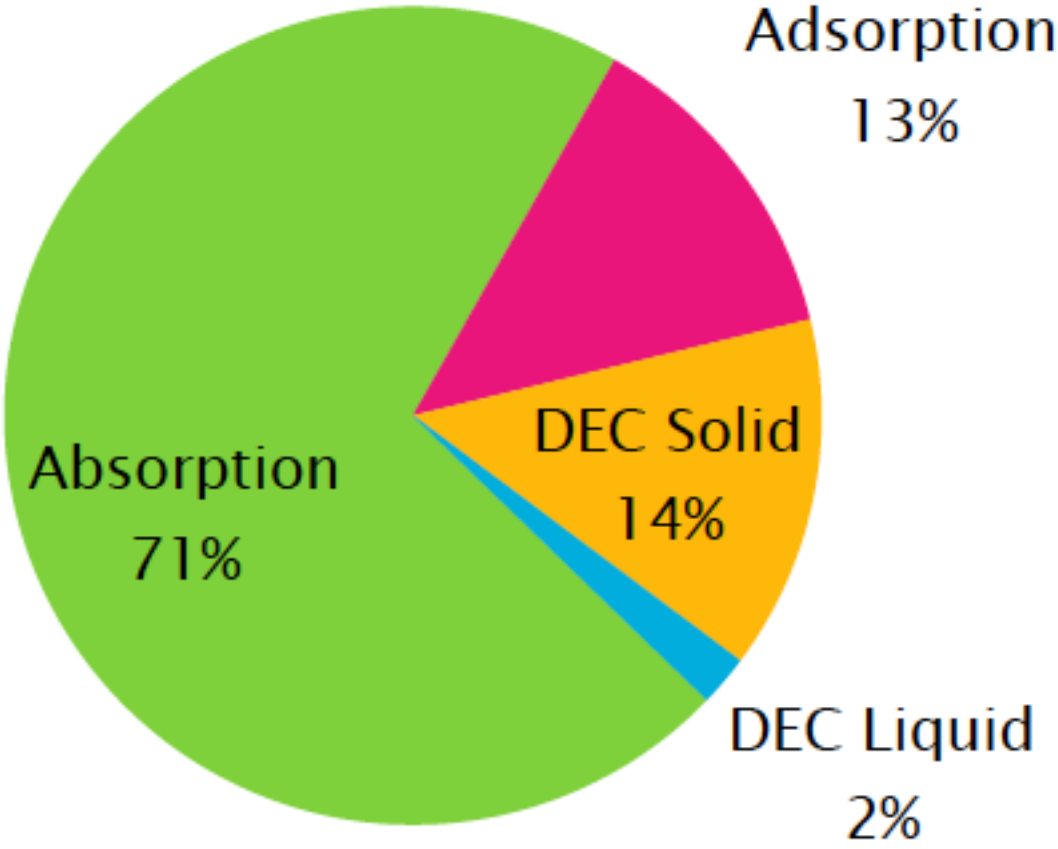
TECSOL

# Market development of solar thermal cooling




**About > 1,200 systems** installed worldwide (2013)

# Market share of solar driven sorption chillers (2009)




Sources: EURAC, Tecsol

# Technical status

- **Mature components available** (both solar and refrigeration, A/C)
- **Main progress made in last decade**
  - *Small scale heat driven chillers*
  - *Increasing number of high efficient double and – recently – triple effect absorption chillers*
  - *Development of systems using single-axis tracking solar collectors*
- **Main technical shortcomings are still on system level**
  - *Energy efficient heat rejection system*
  - *Energy management*
  - *Bottleneck: good trained technical staff almost not available*

# Energy performance

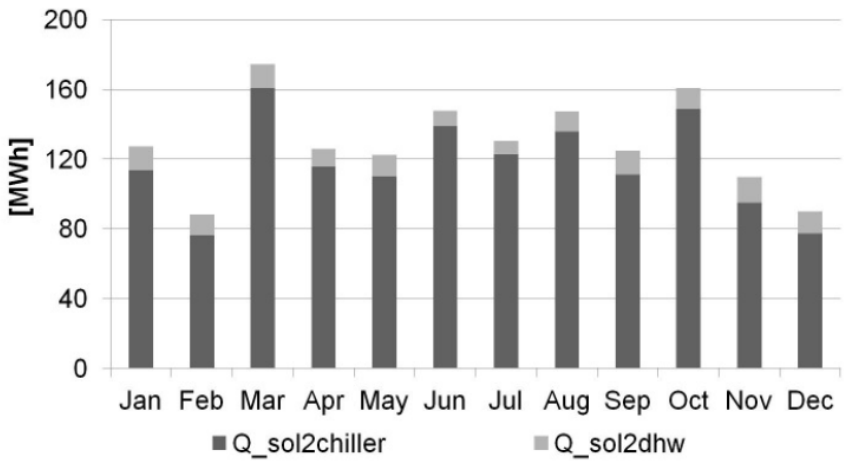
- **Many systems lead to measurable energy savings** when compared to a best practice conventional reference solution

- **Best values of overall electric COP range up to 6-8**, which means that
  6-8 kWh of useful cooling are produced with 1 kWh of invested electricity

- **Target value for electric COP > 10**

- **However**: also many systems do not achieve these values in practice due to
  - *Non-optimal design*
  - *Non-optimal operation (e.g. control, part load)*

# UWC SEA - EAST Tampines, Singapore


Campus area:
76,000m²/ 820,000ft²

Students: approx. 2700

Solar Panels:
3900 m²/2.73 $MW_{therm}$

Chiller size:
1500kW/420 tons

Storage:
For Cooling 60 m³
For Hot Water 7 m³

**Electrical efficiency of 6,3 in 2013**

# Desert Mountain High School, USA

SOLID solarinstallation+design

Solar Panels: 5,000 m² → 3.5 MW

Cooling load: 500 tons /1750 kW

In operation since 2014

# SERM Montpellier SAC/DHW system

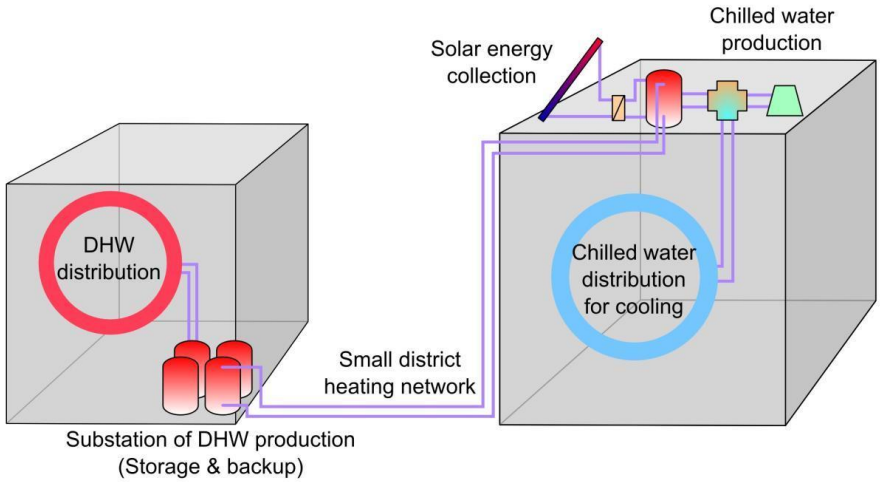
Montpellier Heating and System net utilities
=> System owner

TECSOL : engineering company

AXIMA GDF SUEZ : Company in charge of the works

*Building A view*

*Picture of the collector field*




240 m² DG FP collectors + 35 kW absorption chiller

solar circuit in drainback mode

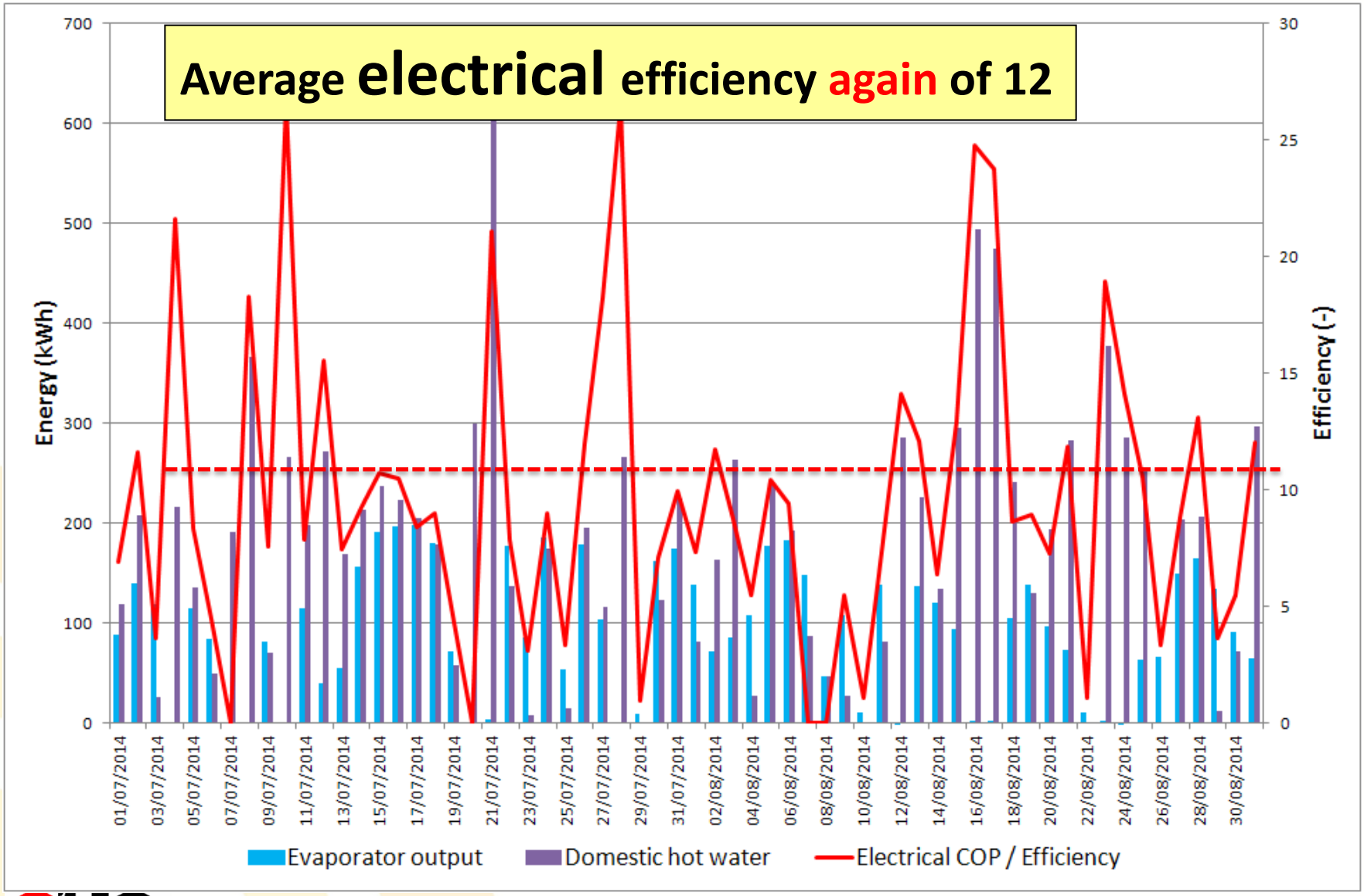
# Full year balance (march 2013/ mars 2014)

| | DHW Production (kWh) | Cooling Production (kWh) | Parasitic elec. Consumption (kWh) | Useful Solar Yield (kWh/m2) | Overal elec efficiency (-) |
|---|---|---|---|---|---|
| from 18/03/2013 | 4 654 | 0 | 110 | 19.4 | 42.3 |
| april 2013 | 11 588 | 0 | 290 | 48.3 | 40.0 |
| may 2013 | 16 478 | 0 | 380 | 68.7 | 43.4 |
| june 2013 | 7 497 | 2 765 | 902 | 42.8 | 13.4 |
| july 2013 | 9 482 | 3 983 | 1 190 | 56.1 | 13.5 |
| august 2013 | 8 628 | 1 970 | 840 | 44.2 | 14.2 |
| september 2013 | 9 316 | 676 | 554 | 41.6 | 18.9 |
| october 2013 | 7 843 | 0 | 240 | 32.7 | 32.7 |
| november 2013 | 4 789 | 0 | 220 | 20.0 | 21.8 |
| december 2013 | 3 851 | 0 | 157 | 16.0 | 24.6 |
| january 2014 | 3 734 | 0 | 190 | 15.6 | 19.7 |
| february 2014 | 6 435 | 0 | 218 | 26.8 | 29.5 |
| march 2014 | 12 860 | 0 | 348 | 53.6 | 30.9 |
| april 2014 | 14 085 | 0 | 360 | 58.7 | 39.1 |
| may 2014 | 12 633 | 281 | 326 | 54.0 | 40.2 |
| june 2014 | 8 847 | 944 | 685 | 39.7 | 15.2 |
| july 2014 | 5 586 | 2 959 | 851 | 26.8 | 12.4 |
| **TOTAL** | 148 308 | 13 578 | 7 861 | **674.5** | **20.6** |

** elec consumption linked to the solar useful production (pumps solar, DHW, generator, evaporator, condensor circuits) without measuring back up elec consumption.*

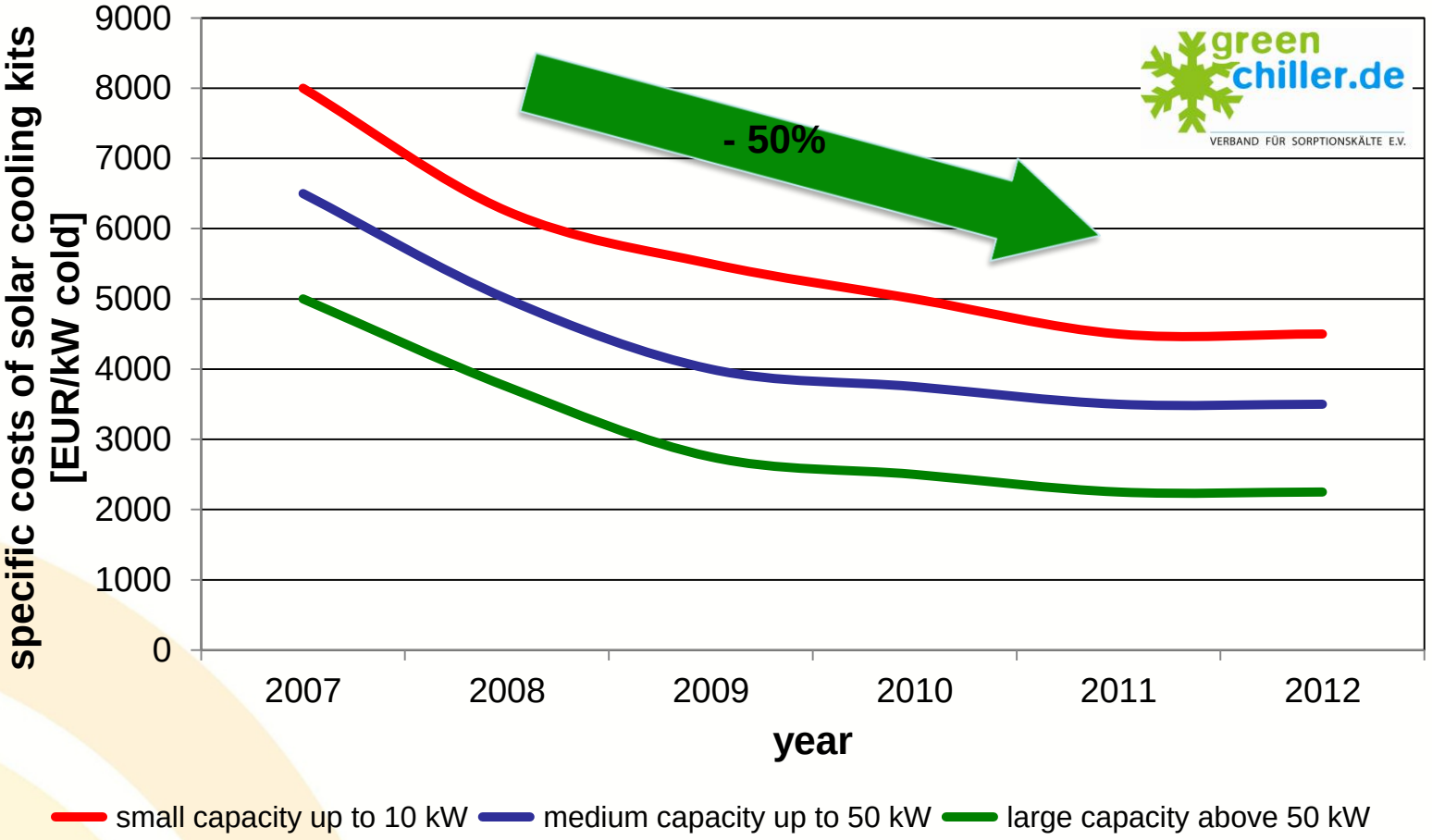
Global Electrical efficiency of **nearly 21** in average for a full year & a **solar yield of 674 kWh/m².y**

# Monitoring results for Summer 2014



# Cost development of solar cooling Kits (2007-2012)

Source: Solem Consulting / Green Chiller




**Cost reduction of 45-55%** within last 5 years!

# Economic viability

- **First cost 2-5 times higher than for conventional technology**
- **Total first cost found in realized installations**: 2000 – 5000 € per kW of cold production (for entire system including solar collector field)
- **Payback time depends strongly on boundary conditions**
  - *Annual numbers of use (cooling, heating, hot water, …)*
  - *Conventional energy cost*
  - *Climatic conditions*
- **Best conditions: payback** < 10 years very difficult to reach

# Conclusion for solar thermal cooling

- About 1,200 solar cooling systems installed worldwide (2013)
- Several new small and medium-scale Absorption and Adsorption chillers were developed worldwide in the last few years, especially in Europe
- Standardized Solar Cooling Kits available to bring down the costs
- Solar heat is particularly of interest if a solar thermal system is used for other heat needs, too (e.g. heating, DHW)

# Need of a new Generation solar cooling systems

Solar thermal « traditionnal » cooling has **difficulty to emerge as a economically competitive solution**

Main reasons :

- **Technical** : Limit on adaptability due to hydraulics, complexity
- **Economical** : Investment cost, especially for small systems

⇒ Still need **intensive R&D** for quality improvment and best solution selection (ongoing IEA SHC Task 48)

⇒ Very innovative concepts such

Source : Climatewell

# How to find a solution for small/medium size ?

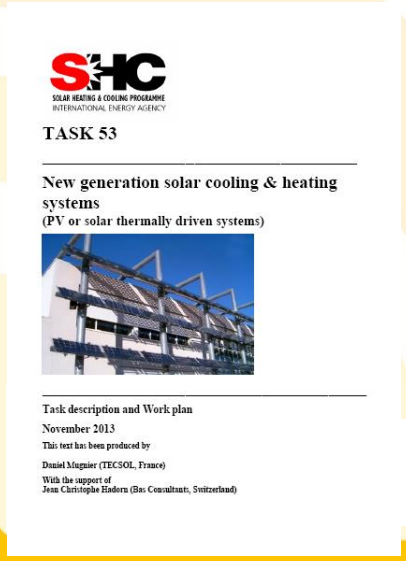
* A very **important priority** : solar for cooling,
especially for small to medium size

*Example : 10% of the entire Saudi Arabia oil production for national cooling*

* **New context on economics** for PV and trend towards selfconsumption

* A real **growing market**…

… but **strong need** of:


SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

TASK 53

New generation solar cooling & heating systems
(PV or solar thermally driven systems)

Task description and Work plan
November 2013
This text has been produced by
Daniel Mugnier (TECSOL, France)
With the support of
Jean Christophe Hadorn (Bas Consultants, Switzerland)

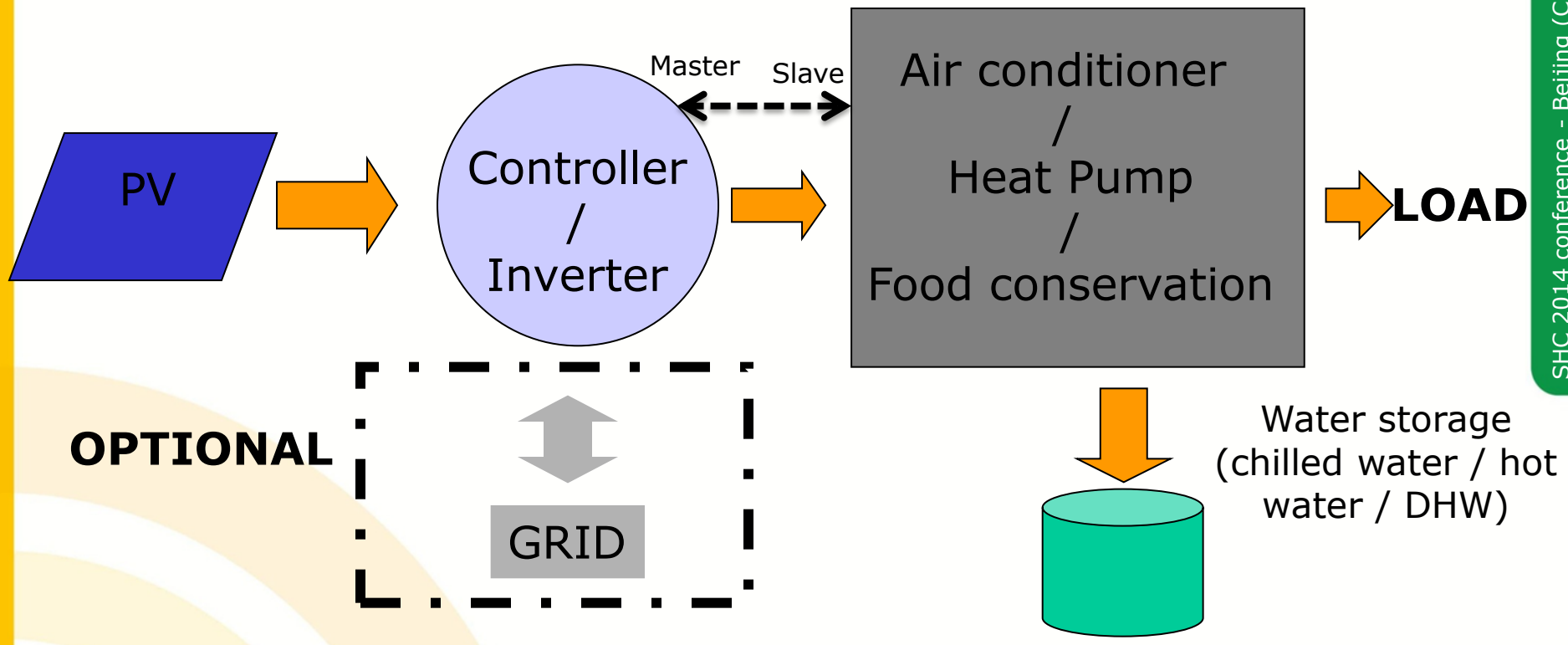
**IEA SHC**
**Task 53**

* standards
* thermal management optimum
* monitoring & best practice

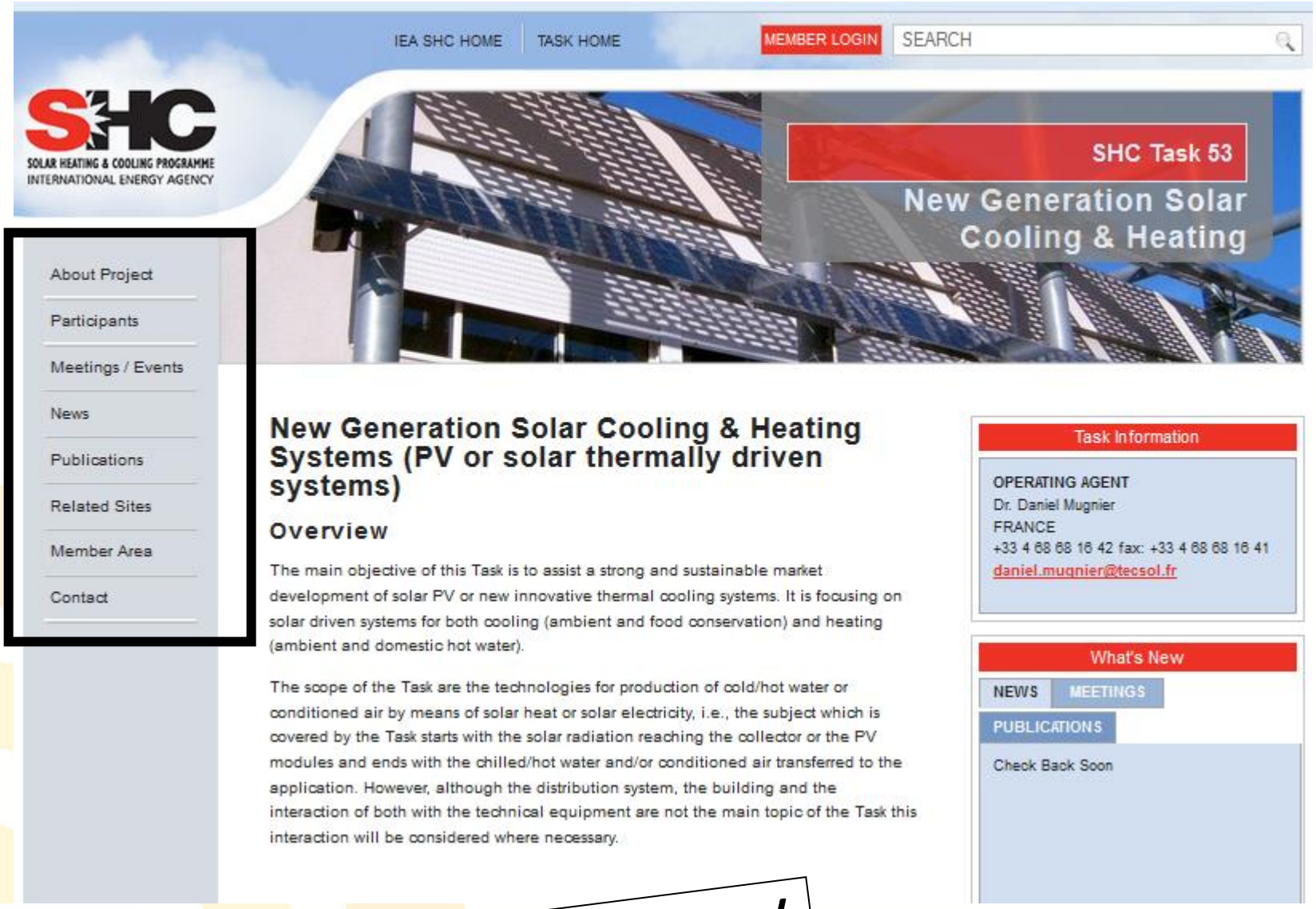
Task 53

TECSOL

# Example of Basic concept for the PV approach



# IEA SHC Task 53 Website




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

# Which systems do we have?

**NG systems close to market**

PV CH (Cooling/ Heating) on the Market

STDCH

- SolabCOOL (NL)

- **SUNCOOL**/Climatewell (SE)

**R&D Systems close to Market**

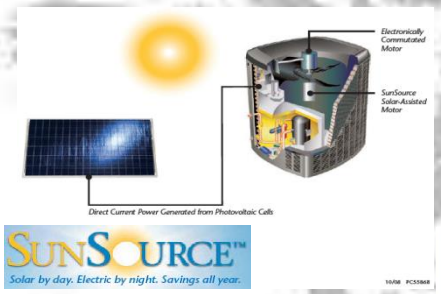
PV CH (Cooling/ Heating)

- BIG HEATING company (GER)
- Helioherm

STDCH

- FREESCOO (IT)
- Climatewell (SE)

# State of the art of this new **Market**






LENNOX
Innovation never felt so good.™



COSSECO

VIESSMANN
climate of innovation

HOTSPOT ENERGY




(no claim for completeness)

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 53

TECSOL

# Main categories

Solar air conditioners : Splits

PV+ HP coupling for Office/Commercial

hotspot energy

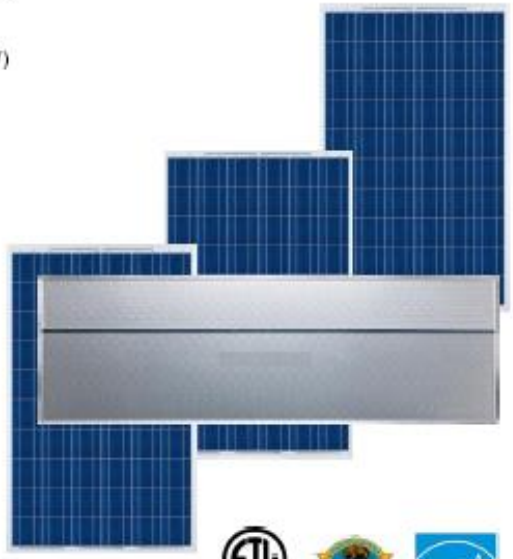
# Solar Air Conditioner

SEER 35 • Solar Hybrid Heat Pump

Model ACDC12

Connect Up To Three Panels (Max 840W)
Runs On Solar Power & AC Power
11,000 BTU Cooling/12,000 BTU Heat
Plug-And-Play Solar Connection
No Batteries Required

HotSpot Energy LLC
(757) 410-8640



**Home**

Keep the inside cool all day for next to nothing in energy costs. Preventing daytime heat build-up also cuts evening cooling costs.

**Office**

Keep the work area comfortable during business hours for pennies per day. Cool or heat up to 750 Sq. Ft. (69m²).

**International**

Compatible with 50hz and 60hz power, use it anywhere in the world.

Ultra-High SEER
Solar Air Conditioner

Intertek

**ACDC12-Hybrid**

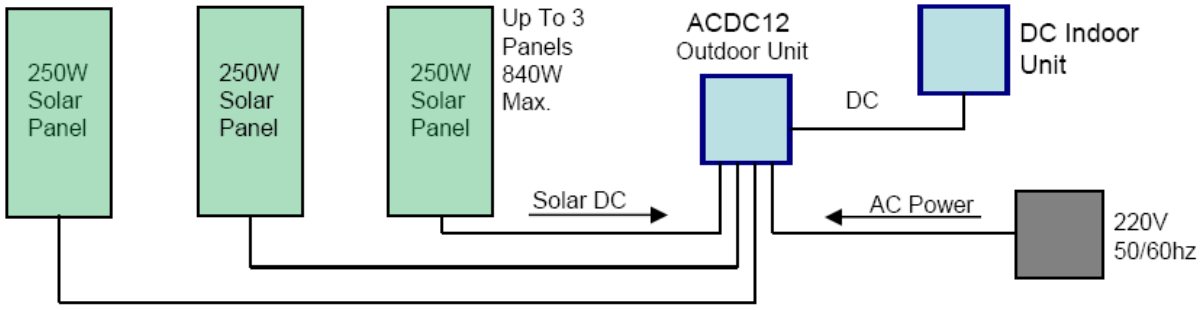
**Retail/List-$1695ea FOB Factory**

**Dealer Price: 4-49 units $1290ea FOB Factory**

**Distributor Price: 50+ units $891ea FOB China**

***Unit includes 3m lineset**

## Connects Directly To Solar Panels



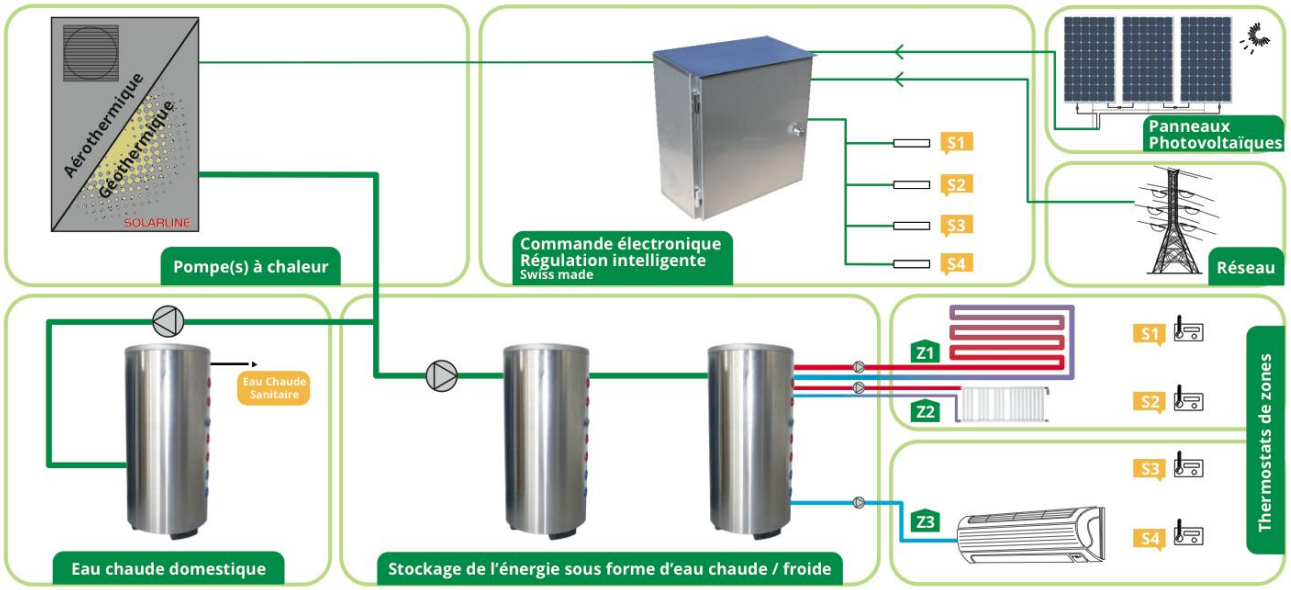

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 53

TECSOL

# Typical **ALREADY** EU market available solution

## Efficient Geothermal Heat Pump : COP of 5,3
## Field test since 2011 in Switzerland




COSSECO

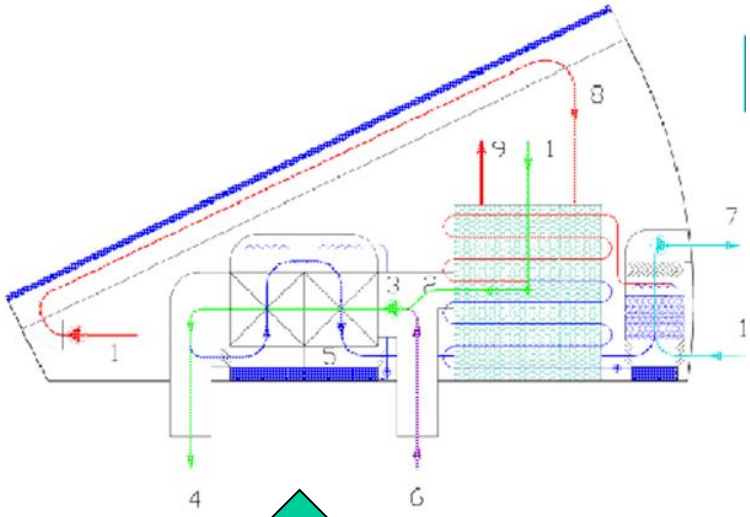
PV booster => **overall yearly COP of 6,9**

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

TECSOL

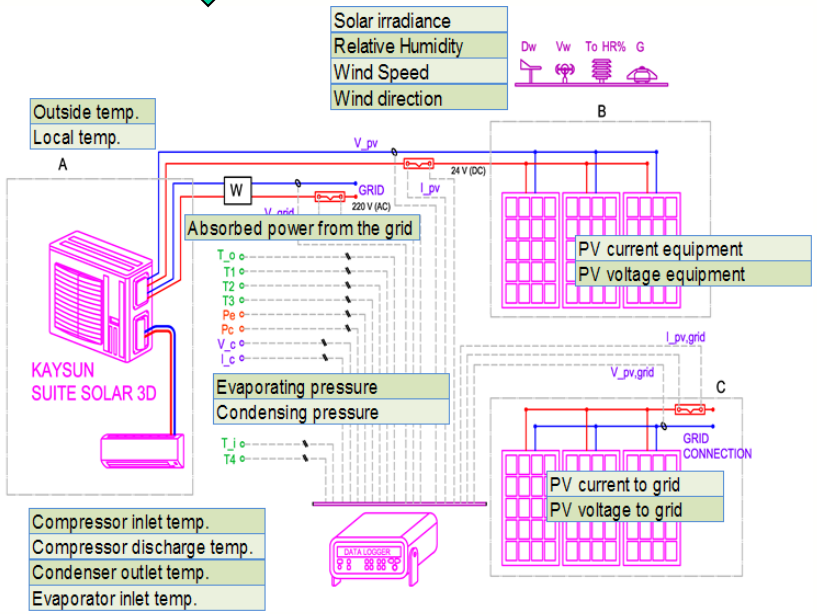
# State of the art of the future new **Market**

## Active R&D participants in Task 53




Concept for compact solar thermal air conditioner based on fixed & cooled adsorption beds (Source: Solarinvent)

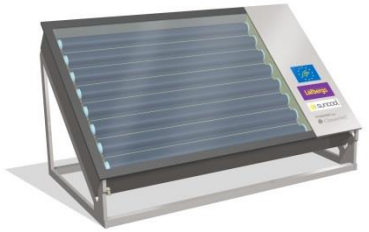
Testing principle for a Chinese PV split unit (Source: Universidad Miguel Hernández de Elche)



Source : Cosseco

http://task48.iea-shc.org/

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



Source : Climatewell

# Thanks for your attention !

Contact : Daniel Mugnier, TECSOL

daniel.mugnier@tecsol.fr

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 48

Task 53

TECSOL