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

Task 48

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Daniel MUGNIER – 15/10/2014

SHC 2014 Conference

Beijing (China)

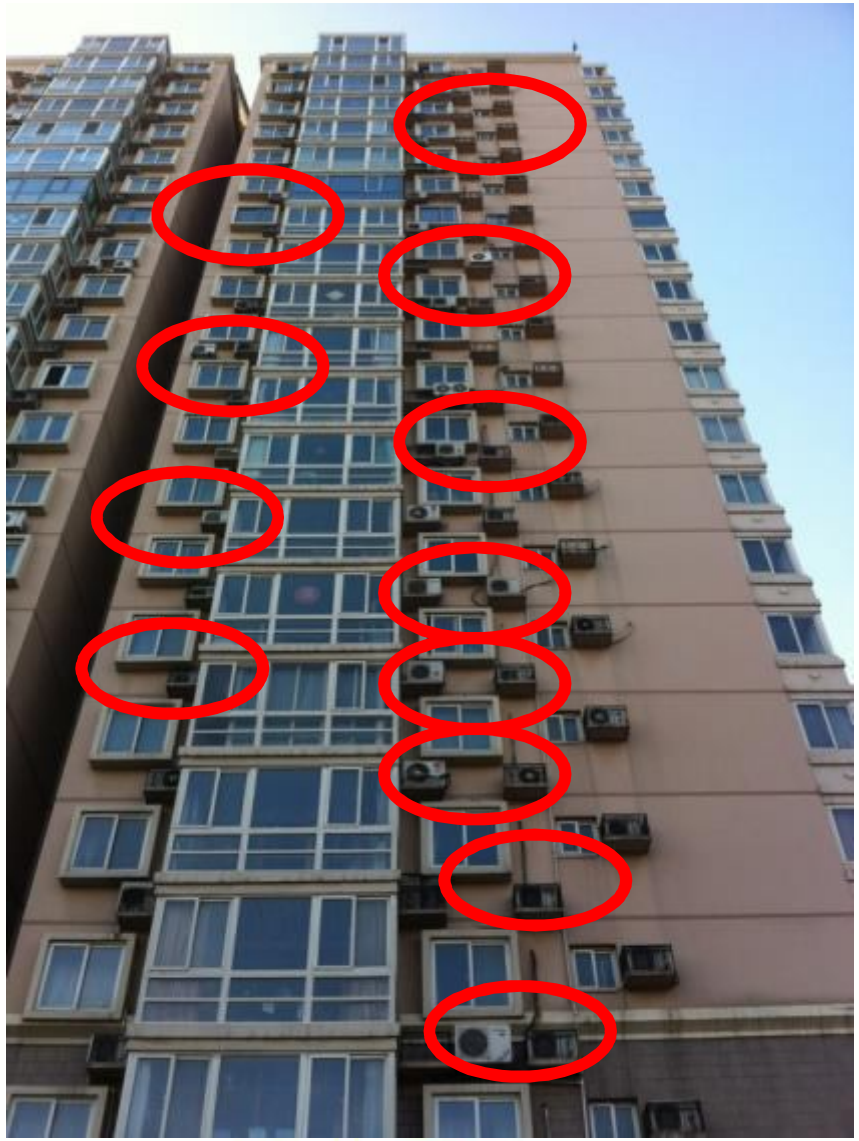
SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

www.tecsol.fr

To Introduce the importance of...

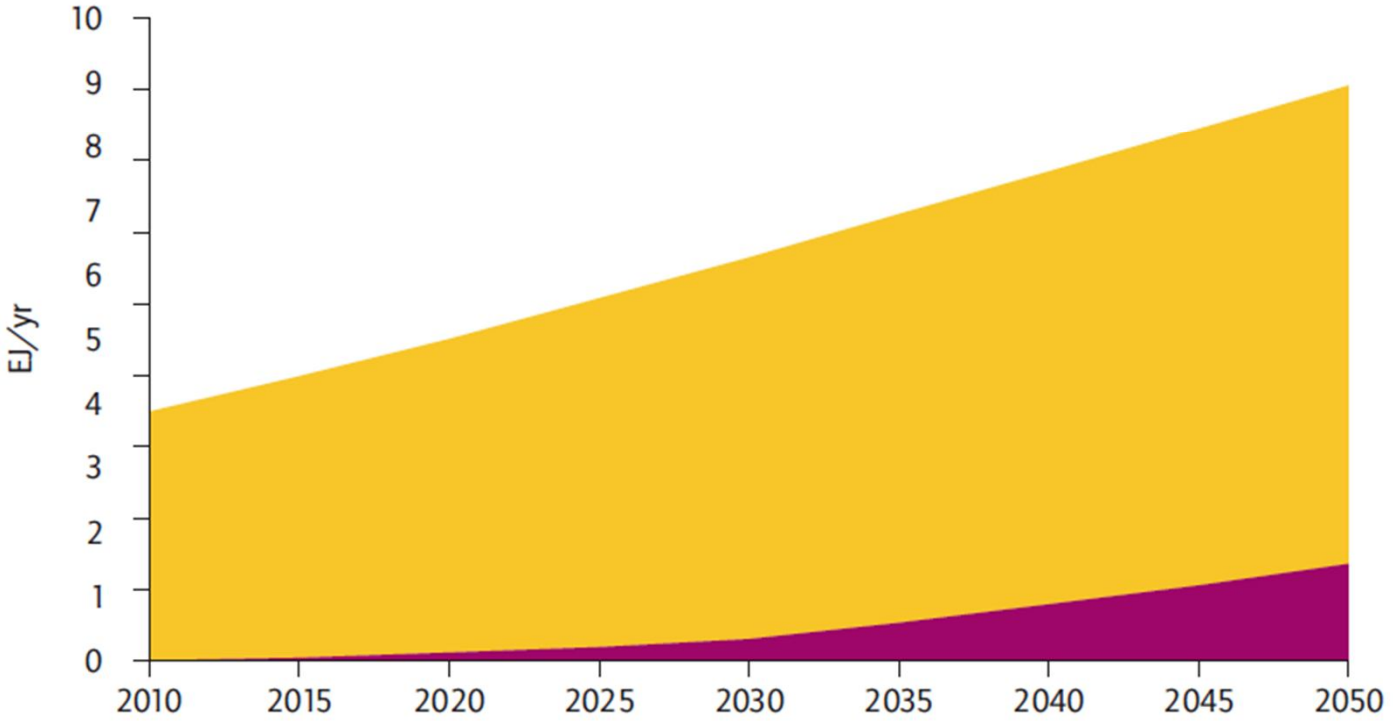
SOLAR COOLING for China...

...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!

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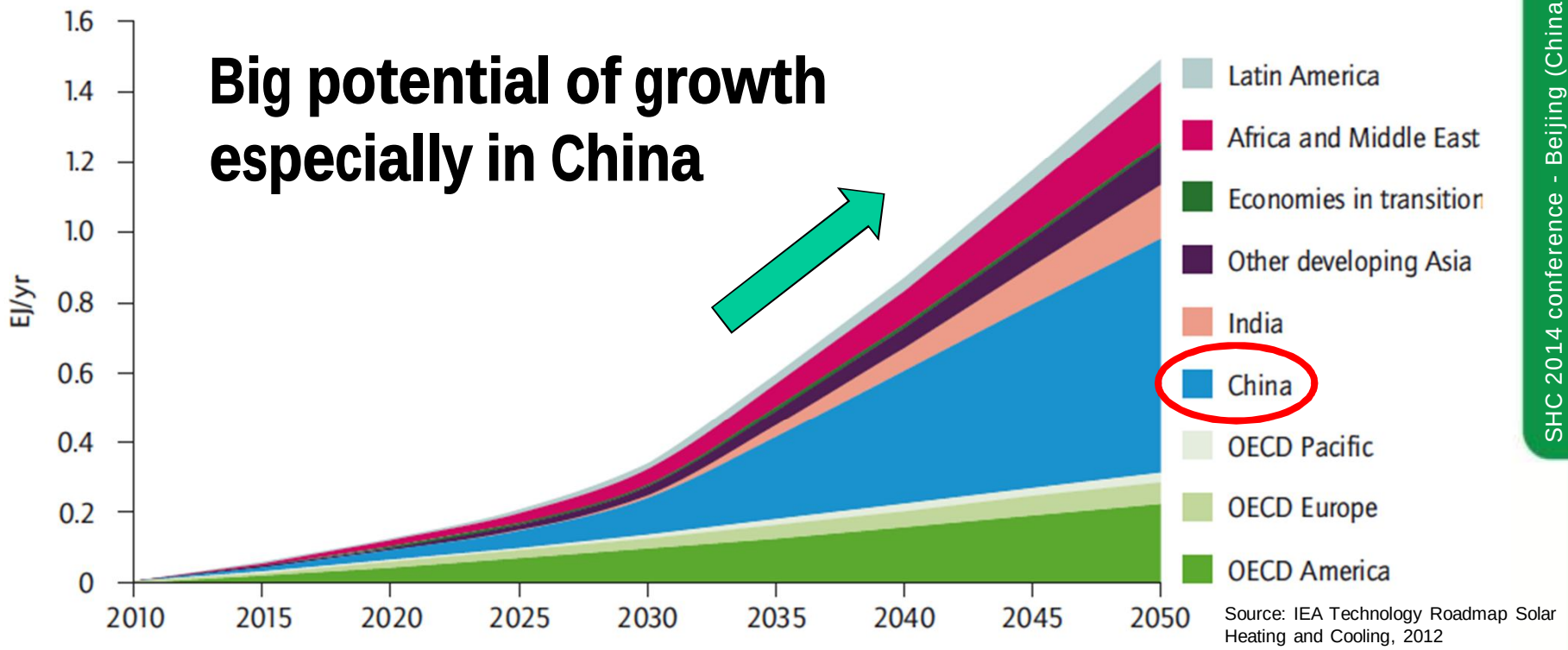
IEA Technology Roadmap SHC – *Market potential by 2050*

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



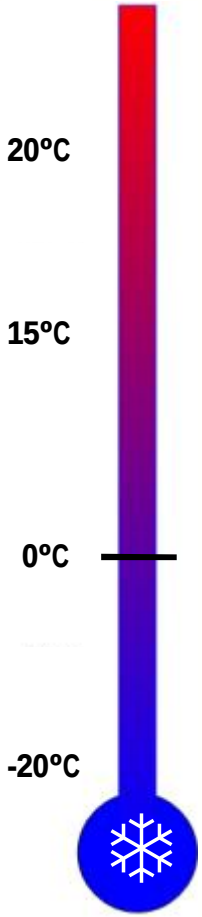
Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

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	40-60°C	Air-conditioning
Flat plate collector 	Water, Water-Glycol	70-90°C	Air-conditioning, slab cooling
Evacuated tube collector 	Water, Water-Glycol	90-120°C	Air-conditioning, slab cooling
Parabolic trough / Fresnel collector 	Thermal oil, Water	120-250°C	Refrigeration, air-conditioning, slab cooling



Source : JER

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**

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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)**

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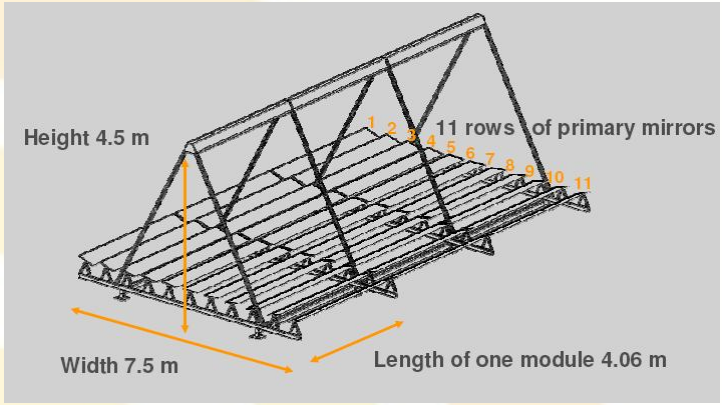
Latest progresses : Integrated hydraulic unit for comfortable system integration

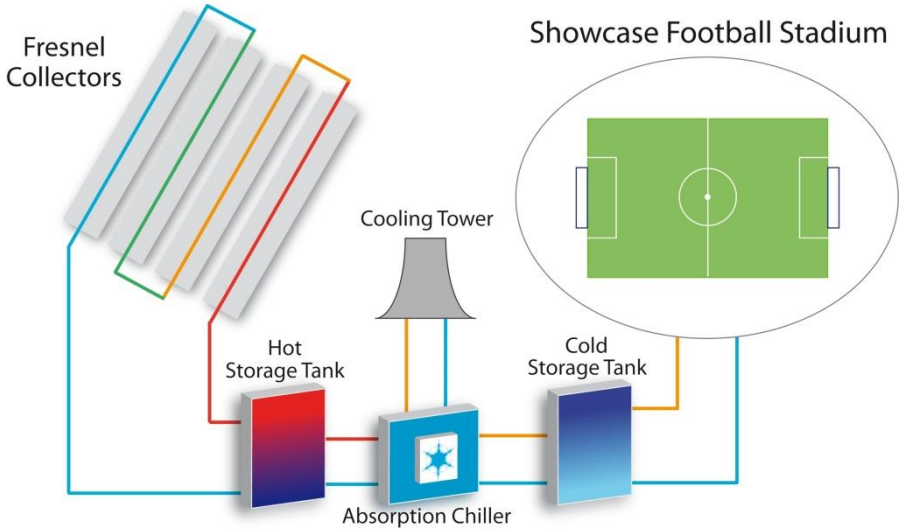
Source: InvenSor

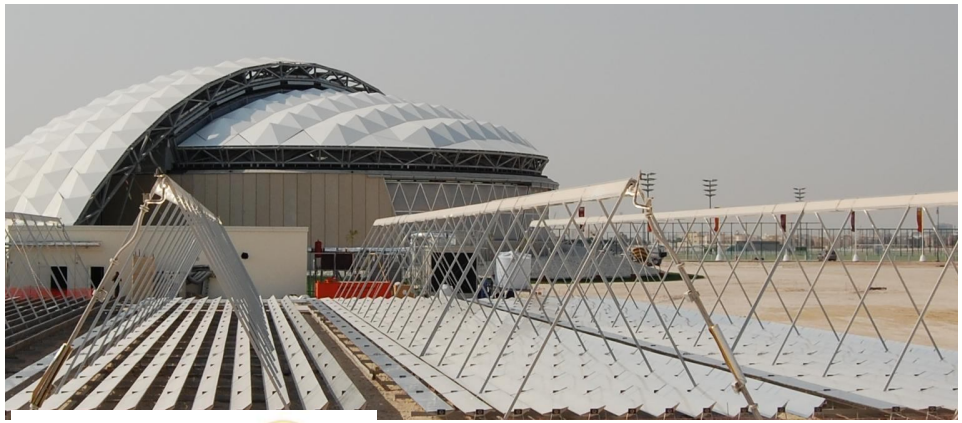
Source: SorTech

High-temperature applications

Example : Footbal Stadium in Qatar







INDUSTRIAL SOLAR
thermal solutions

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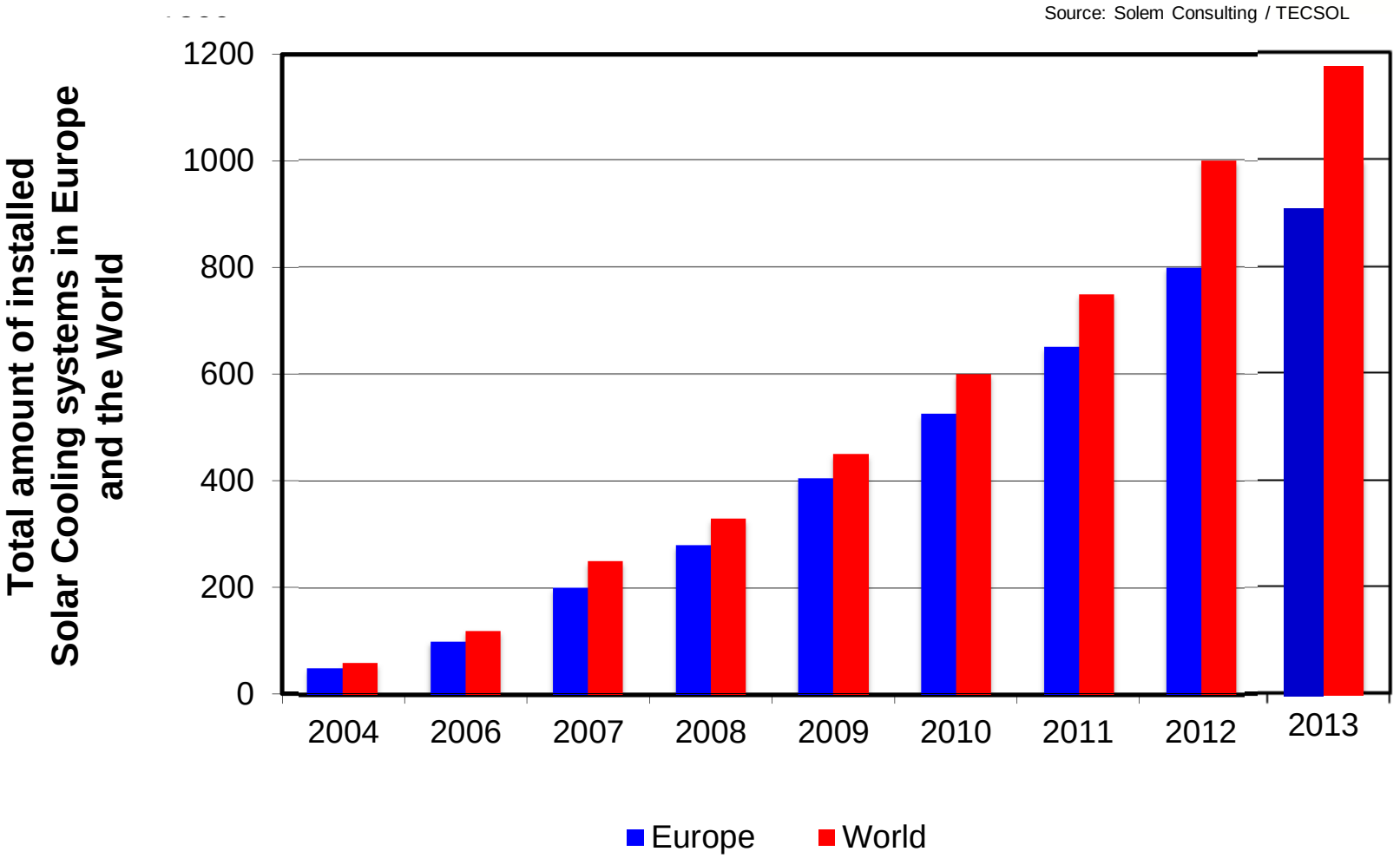
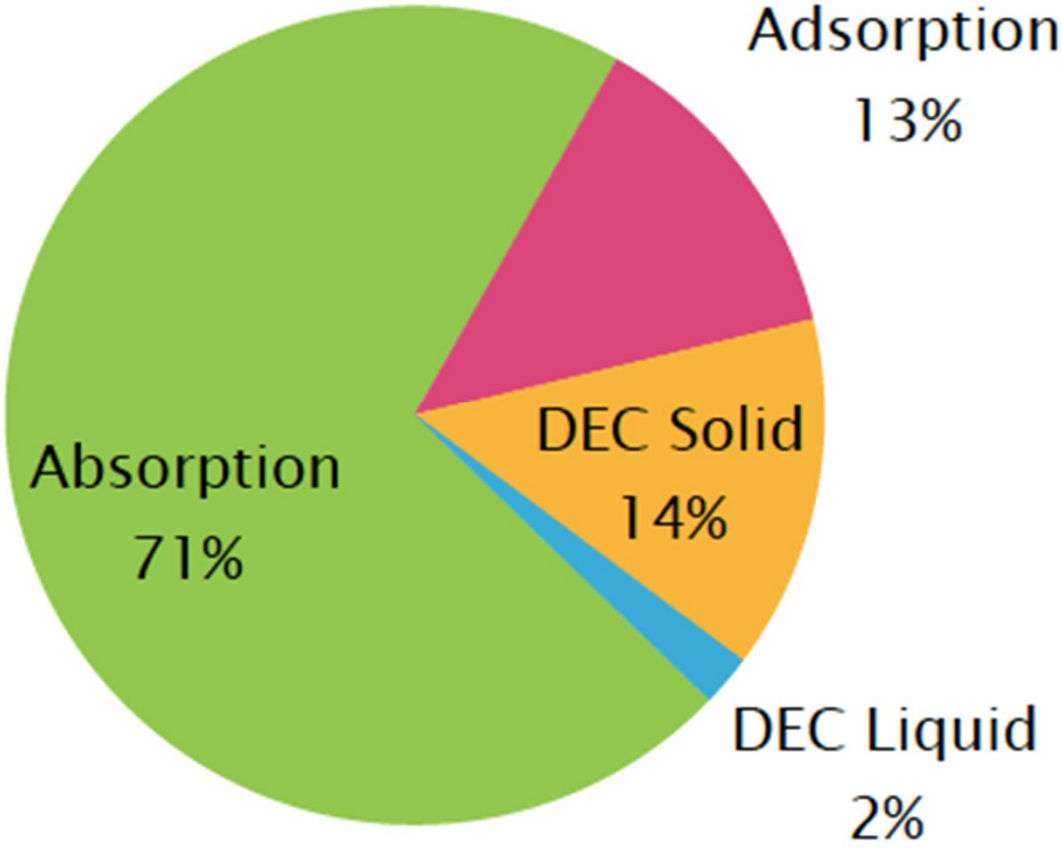
Market development of solar thermal cooling



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

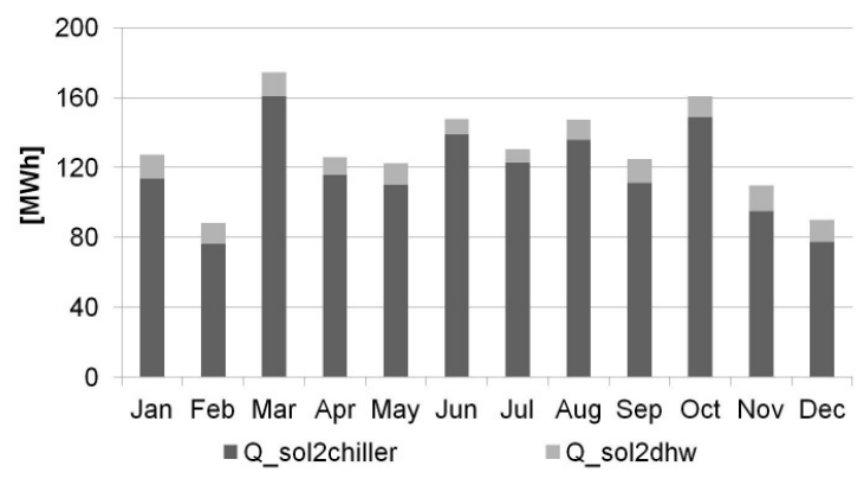
- **Many systems lead to measurable energy savings** when compared to a best practice conventional reference solution

- **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

SHC 2014 conference - Beijing (China), 15/10/2014

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

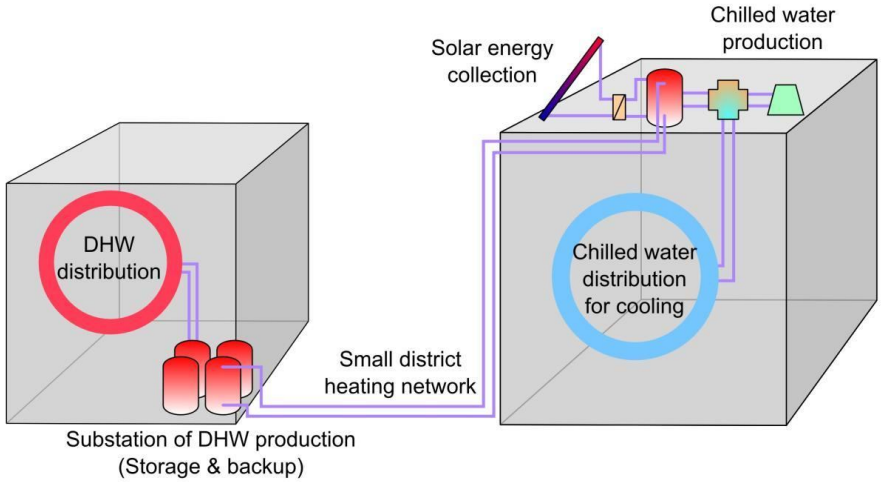
Montpellier Heating and System net utilities
=> System owner

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 Yazaki abs. chiller
+ solar circuit in drainback mode

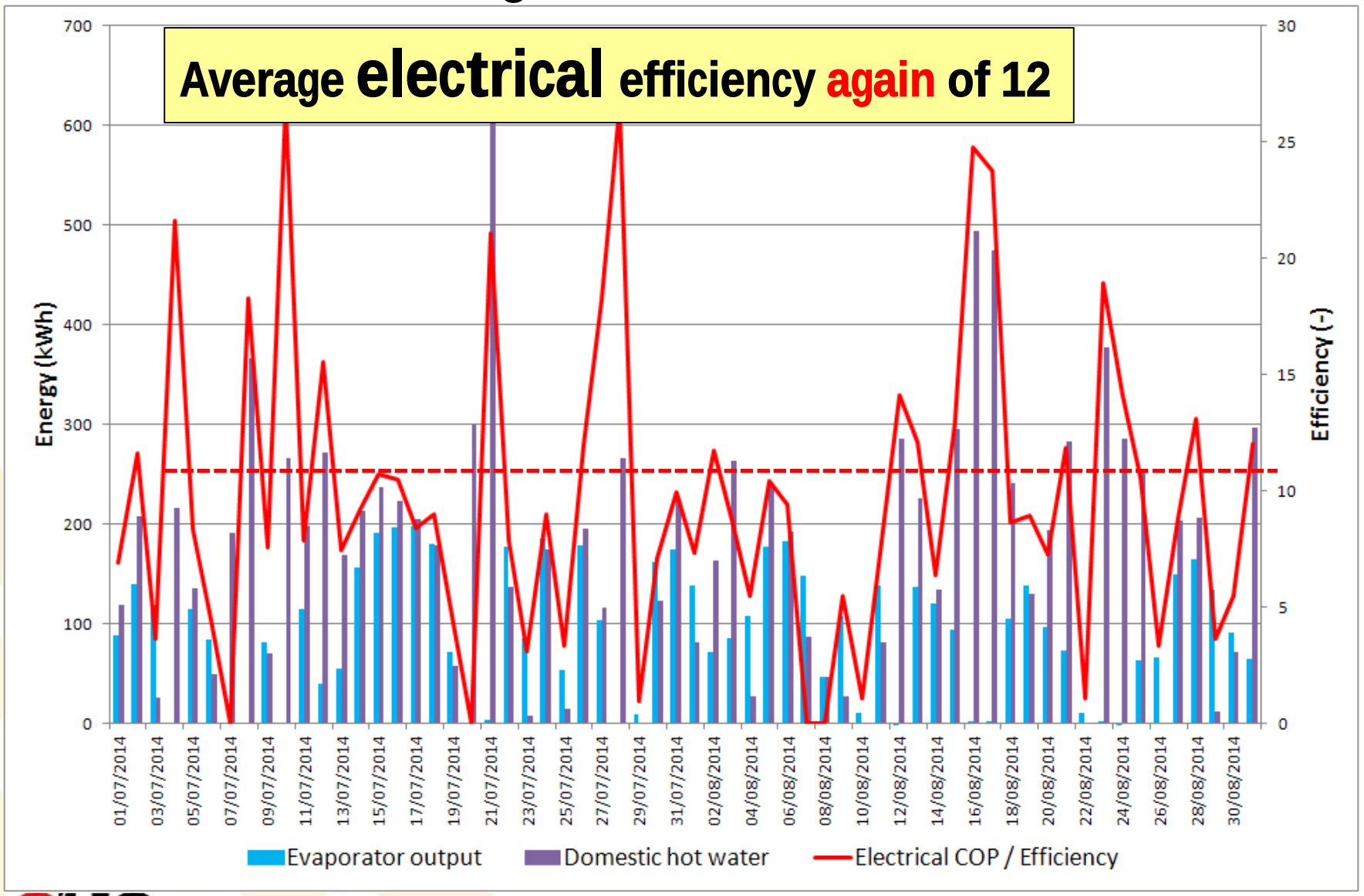
Full year balance (march 2013/ mars 2014)

	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



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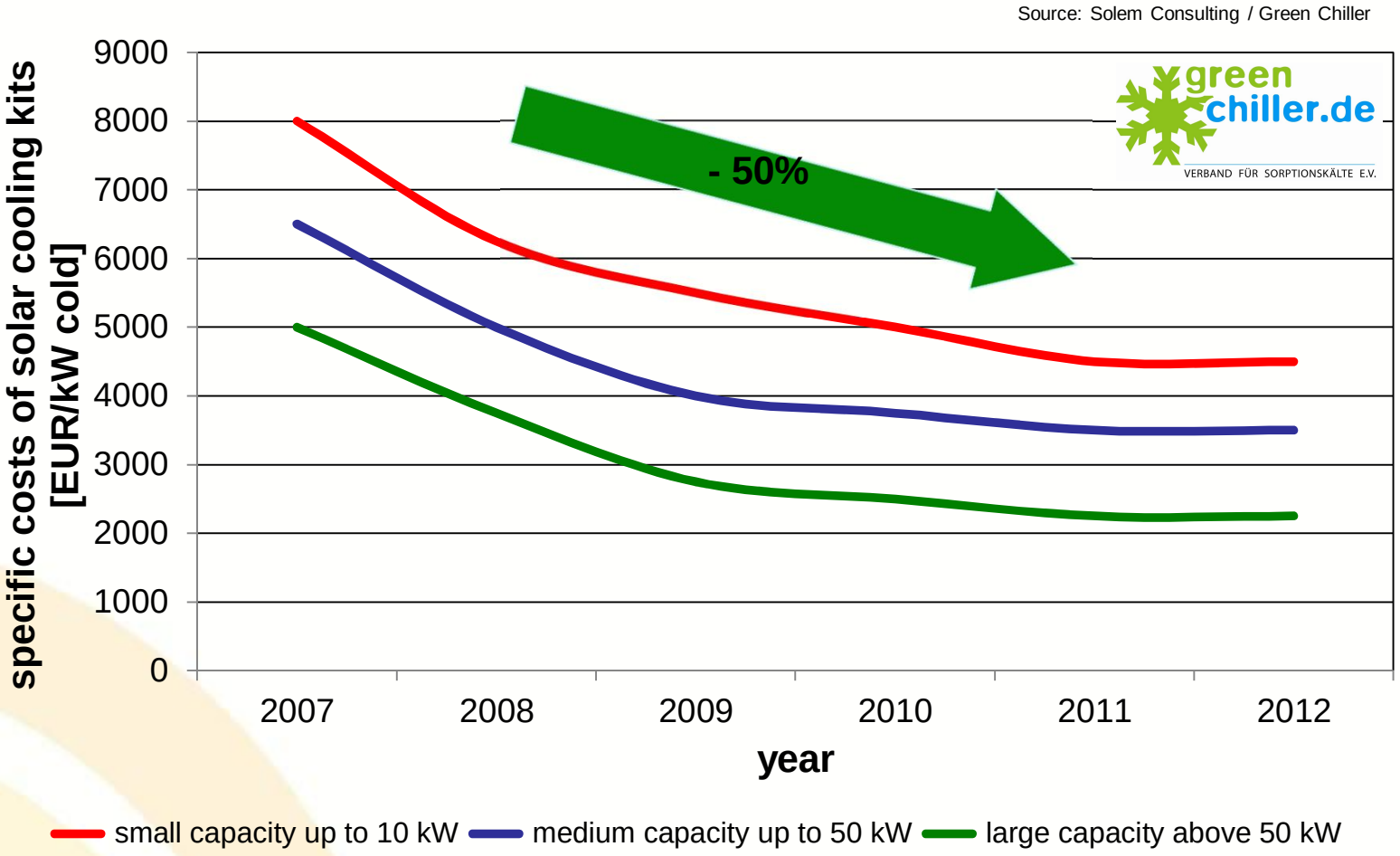
Cost development of solar cooling Kits (2007-2012)



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

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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 ?

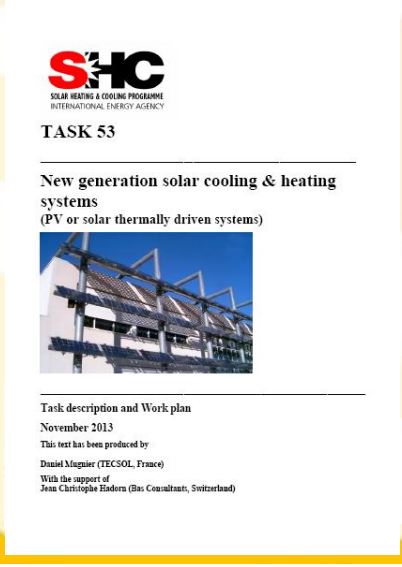
* A very **important priority** : solar for cooling,
especially for small to medium size

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: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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

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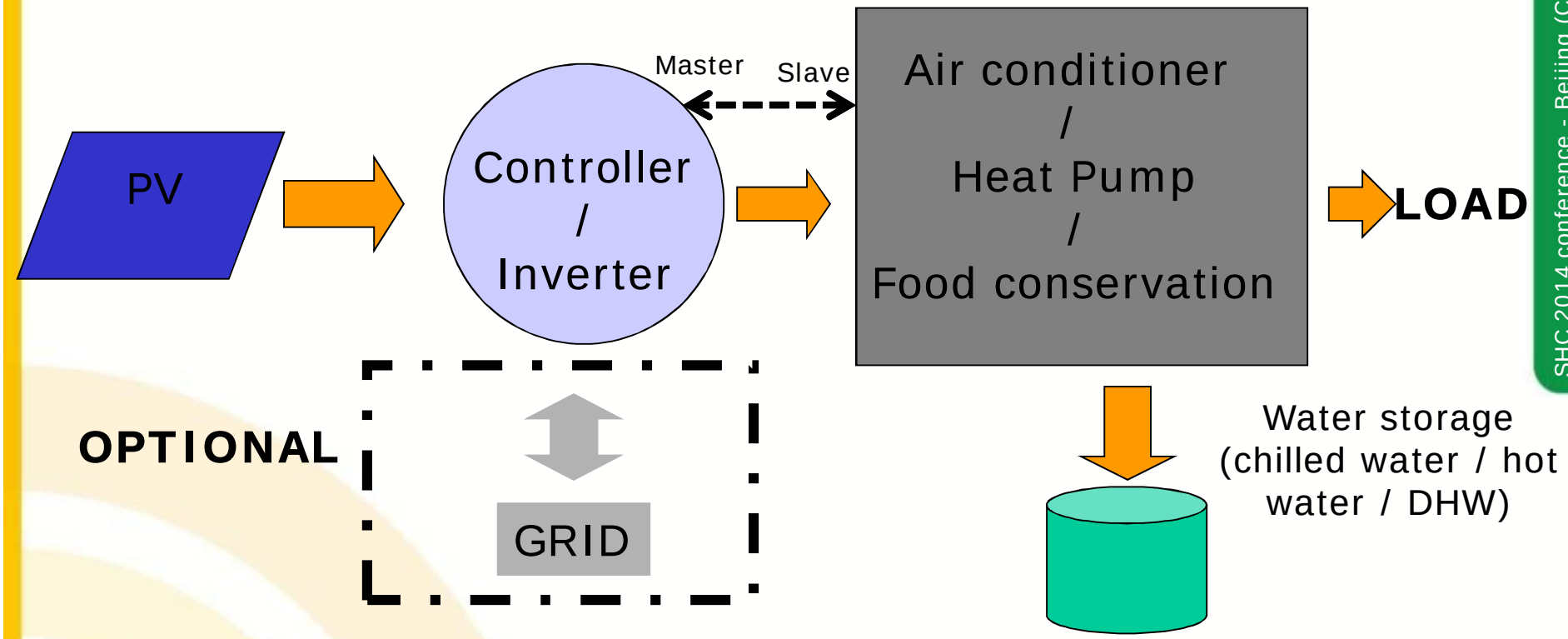
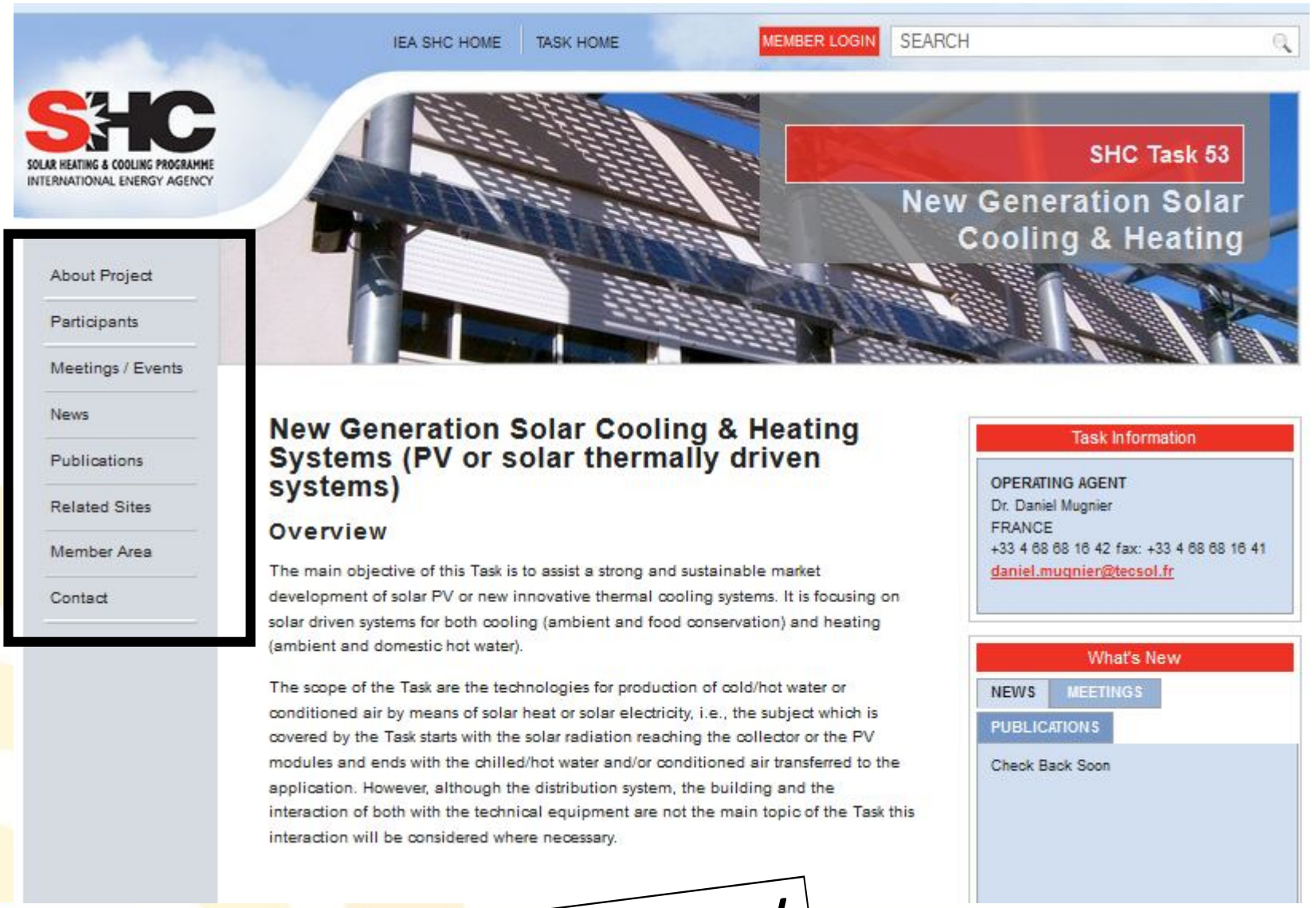
Example of Basic concept for the PV approach



IEA SHC Task 53 Website



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

IEA SHC Task 53 Subtask A

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

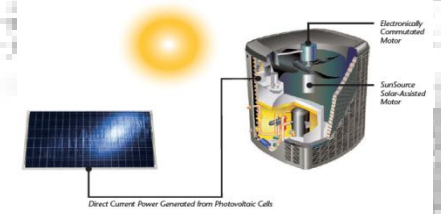
PV CH (Cooling/ Heating)

- BIG HEATING company (GER)
- Helioherm

STDCH

- FREESCOO (IT)
- Climatewell (SE)

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



SUNSOURCE™
Solar by day. Electric by night. Savings all year.

LENNOX
Innovation never felt so good.™

HOTSPOT ENERGY

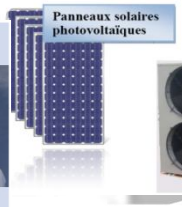
Sud Concept
ACCELERATEUR D'INNOVATION

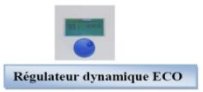
CENTROSOLAR
CENPAC plus

SOLAR LINE

FREECOLD

CLIMATISATION SPLIT SOLAIRE DIRECTE





COSSECO

VIESSMANN
climate of innovation

SOLAR AIR
COOLING HEATING

(no claim for completeness)

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Main categories

Solar air conditioners : Splits

PV+ HP coupling for Office/Commercial

hotspot energy

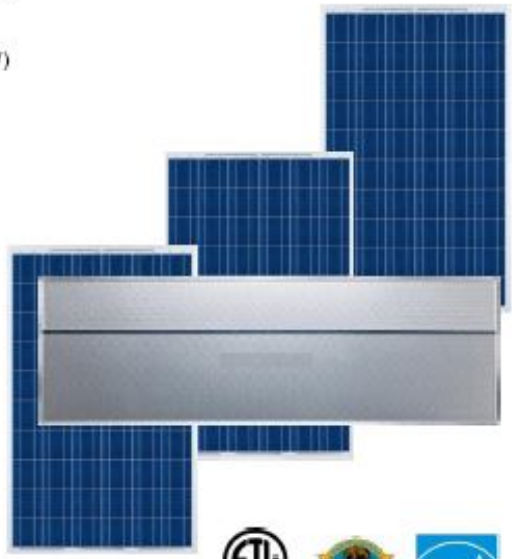
Solar Air Conditioner

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

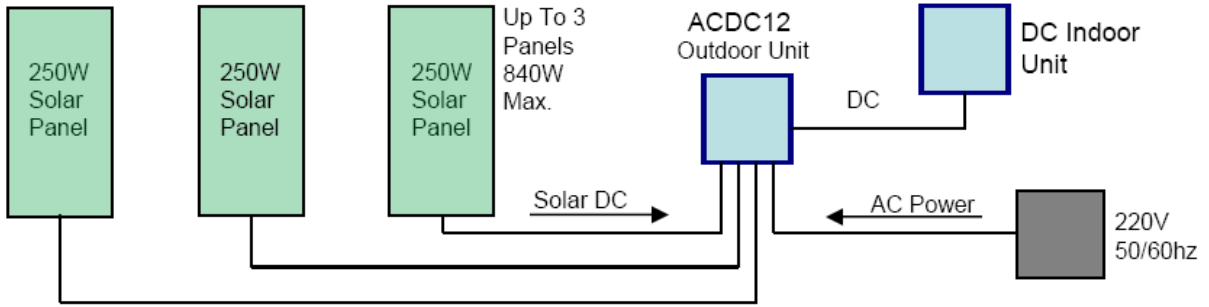
Compatible with 50hz and 60hz power, use it anywhere in the world.

Ultra-High SEER
Solar Air Conditioner

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



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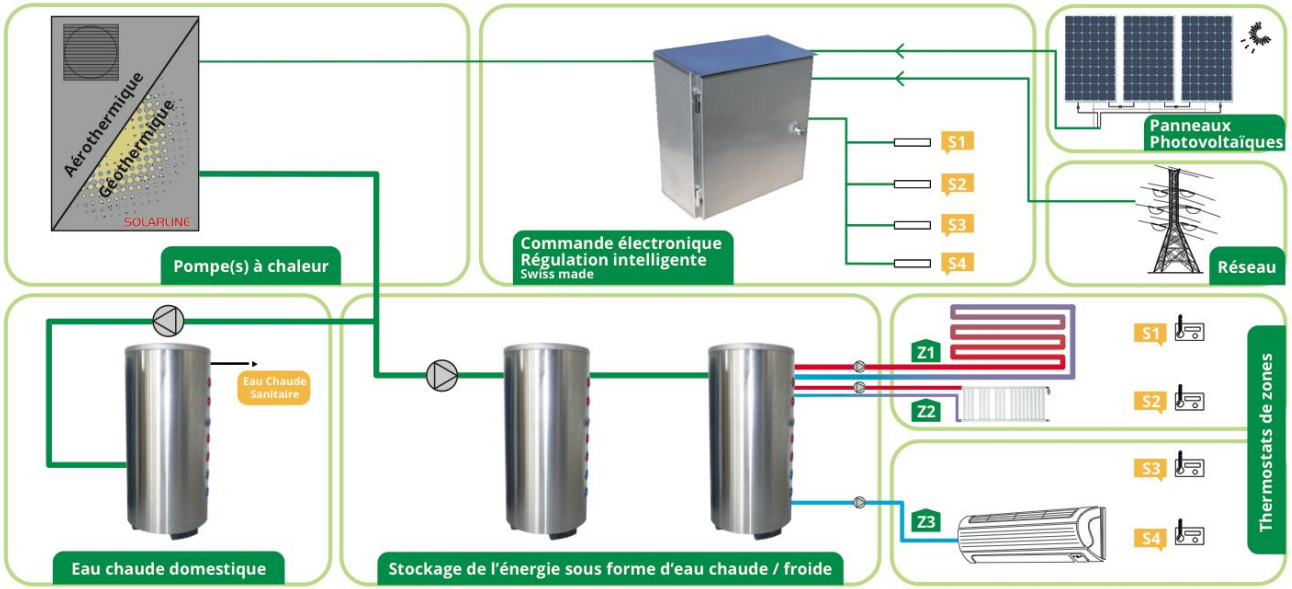
Typical **ALREADY** EU market available solution

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



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

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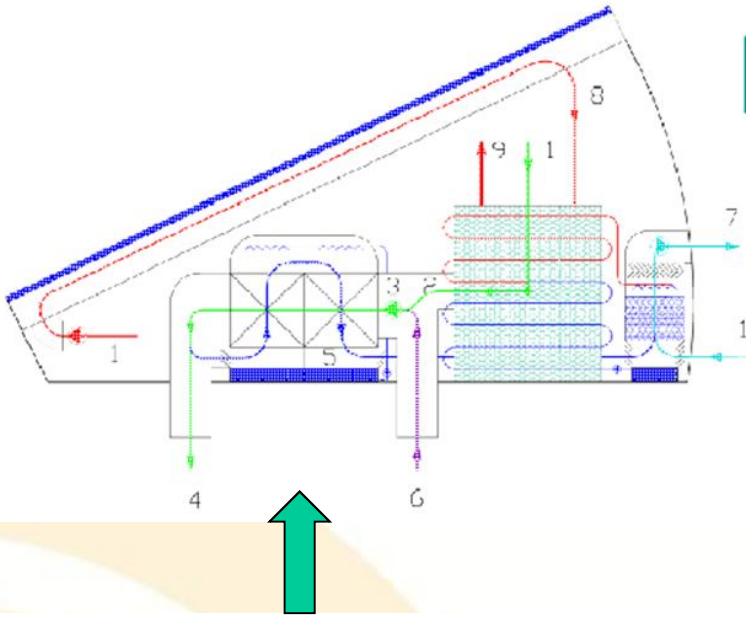
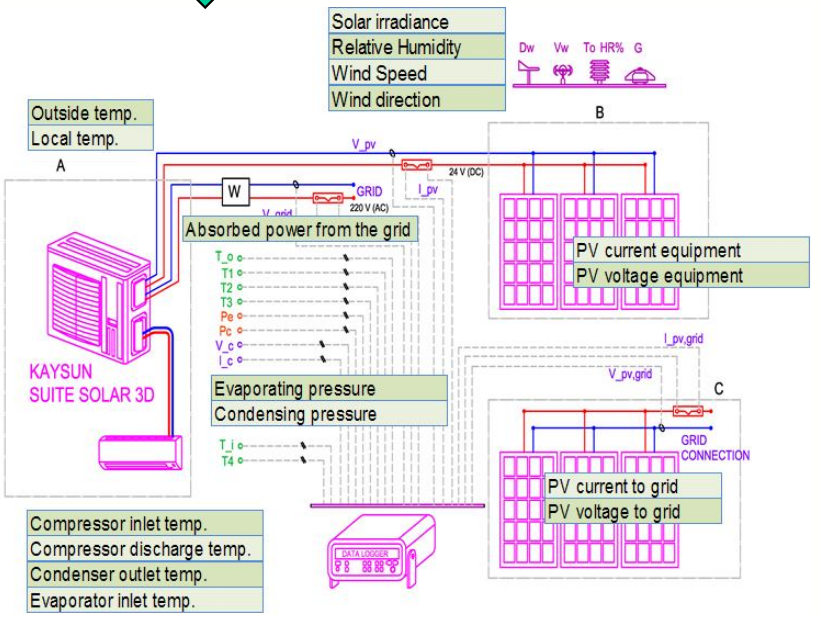
State of the art of the future new **Market**

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)



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

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

Source : Climatewell

Thanks for your attention !

Contact : Daniel Mugnier, TECSOL

daniel.mugnier@tecsol.fr

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