Worldwide overview on Solar Cooling and SHC Tasks 48 and 53

Daniel MUGNIER – 27/03/2015

Shanghai (China)
To Introduce the importance of...

SOLAR COOLING for China...

...one picture taken in China in October 2015
Solar Cooling nearly 17% of total energy use for cooling!
IEA Technology Roadmap SHC – Market potential by 2050

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

Big potential of growth especially in China

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

<table>
<thead>
<tr>
<th>Solar thermal collector</th>
<th>Heat transfer medium</th>
<th>Collector temperature</th>
<th>Application for cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air collector</td>
<td>Air</td>
<td>40-60°C</td>
<td>Air-conditioning</td>
</tr>
<tr>
<td>Flat plate collector</td>
<td>Water, Water-Glycol</td>
<td>70-90°C</td>
<td>Air-conditioning, slab cooling</td>
</tr>
<tr>
<td>Evacuated tube collector</td>
<td>Water, Water-Glycol</td>
<td>90-120°C</td>
<td>Air-conditioning, slab cooling</td>
</tr>
<tr>
<td>Parabolic trough / Fresnel collector</td>
<td>Thermal oil, Water</td>
<td>120-250°C</td>
<td>Refrigeration, air-conditioning, slab cooling</td>
</tr>
</tbody>
</table>

*Source: JER*
Market development of solar thermal cooling

Total amount of installed Solar Cooling systems in Europe & the World

Source: Solem Consulting / TECSOL

About > 1,200 systems installed worldwide (2014)
Market share of solar driven sorption chillers (IEA SHC Task 38 / 2009)

Trend in 2014

Adsorption: 13%
Absorption: 71%
DEC Solid: 14%
DEC Liquid: 2%

Sources: EURAC, Tecsol
Desert Mountain High School, USA

Solar Panels: 5,000 m² → 3.5 MW
Cooling load: 500 tons / 1750 kW
In operation since 2014

Preliminary results after 6 months of operation:
- Very stable and reliable operations
- Chiller COP_{thermal} 0.7 – 0.75
- Peak Hour COP_{electric} 42
- Full day COPs_{electric} 25-30
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

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)

<table>
<thead>
<tr>
<th></th>
<th>DHW Production (kWh)</th>
<th>Cooling Production (kWh)</th>
<th>Parasitic elec. Consumption (kWh)</th>
<th>Useful Solar Yield (kWh/m²)</th>
<th>Overall elec efficiency (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>from 18/03/2013</td>
<td>4 654</td>
<td>0</td>
<td>110</td>
<td>19.4</td>
<td>42.3</td>
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<tr>
<td>april 2013</td>
<td>11 598</td>
<td>0</td>
<td>290</td>
<td>48.3</td>
<td>40.0</td>
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<tr>
<td>may 2013</td>
<td>16 478</td>
<td>0</td>
<td>380</td>
<td>68.7</td>
<td>43.4</td>
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<tr>
<td>june 2013</td>
<td>7 497</td>
<td>2 765</td>
<td>902</td>
<td>42.8</td>
<td>13.4</td>
</tr>
<tr>
<td>July 2013</td>
<td>9 482</td>
<td>3 983</td>
<td>1 190</td>
<td>56.1</td>
<td>13.5</td>
</tr>
<tr>
<td>August 2013</td>
<td>8 628</td>
<td>1 970</td>
<td>840</td>
<td>44.2</td>
<td>14.2</td>
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<tr>
<td>September 2013</td>
<td>9 316</td>
<td>676</td>
<td>554</td>
<td>41.6</td>
<td>18.9</td>
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<tr>
<td>October 2013</td>
<td>7 843</td>
<td>0</td>
<td>240</td>
<td>32.7</td>
<td>32.7</td>
</tr>
<tr>
<td>November 2013</td>
<td>4 789</td>
<td>0</td>
<td>220</td>
<td>20.0</td>
<td>21.8</td>
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<tr>
<td>December 2013</td>
<td>3 851</td>
<td>0</td>
<td>157</td>
<td>16.0</td>
<td>24.6</td>
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<tr>
<td>January 2014</td>
<td>3 734</td>
<td>0</td>
<td>190</td>
<td>15.6</td>
<td>19.7</td>
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<tr>
<td>February 2014</td>
<td>6 435</td>
<td>0</td>
<td>218</td>
<td>26.8</td>
<td>29.5</td>
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<tr>
<td>March 2014</td>
<td>12 880</td>
<td>0</td>
<td>348</td>
<td>53.6</td>
<td>30.9</td>
</tr>
<tr>
<td>April 2014</td>
<td>14 085</td>
<td>0</td>
<td>360</td>
<td>58.7</td>
<td>39.1</td>
</tr>
<tr>
<td>May 2014</td>
<td>12 633</td>
<td>281</td>
<td>326</td>
<td>54.0</td>
<td>40.2</td>
</tr>
<tr>
<td>June 2014</td>
<td>8 847</td>
<td>944</td>
<td>685</td>
<td>39.7</td>
<td>15.2</td>
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<tr>
<td>July 2014</td>
<td>5 586</td>
<td>2 959</td>
<td>851</td>
<td>26.8</td>
<td>12.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>148 308</td>
<td>13 578</td>
<td>7 861</td>
<td>674.5</td>
<td>20.6</td>
</tr>
</tbody>
</table>

*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

Average electrical efficiency again of 12
High-temperature applications

Example: Fresnel Collectors in South Africa

MTN (Mobile TelephoneNetworks) Headquarter
Johannesburg

Absorber type: SCHOTT PTR 70
Fresnel-Kollektoren: 2 Strings of 11 Modules
Solar cooling capacity: 275 kW$_{th}$
Yearly production: 391 MWh
Collector area: 484 m$^2$
CO$_2$-savings: 47,000 kg/y
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)
### Structure of Task 48

<table>
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<th>Subtask B</th>
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<td>Quality procedure on component level</td>
<td>Quality procedure on system level</td>
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<th>Subtask C</th>
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<tr>
<td>Market support measures</td>
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<th>Subtask D</th>
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<td>Dissemination and policy advices</td>
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**4 Subtasks & 25 activities**

3,5 years – 20 experts

From October 2011 to March 2015
Task 48 investigation results:

- **Project management**
  - Incentive schemes
  - Roadmapping
  - Training material
  - System cost analysis

- **System components**
  - Solar DEC best practices
  - Heat rejection
  - Chiller
  - New collectors
  - Pumps

- **System technical optimisation**
  - Life cycle analysis
  - Design tool
  - Self detection procedures
  - System performance modelling

- **Solar Ab(ad)spption best practice examples**

*Source: IEA SHC Task 48*
Task 48 result (A4) : Pumps
Impact of pump costs on overall system costs

Percentage on overall costs

33% Collector field
33% Piping & installation
20% chiller
< 5% pumps

⇒ Investment costs not completely negligible (even if minor effect on overall system costs)
⇒ But bad quality pumps can have a big impact

Source : IEA SHC Task 48 – ZAE Bayern
Task 48 investigation results:

- **Project management**
  - Incentive schemes
  - Roadmapping
  - Training material
  - System cost analysis

- **System components**
  - Heat rejection
  - Chiller
  - New collectors
  - Pumps

- **Solar Ab(ad)sorption best practice examples**

- **Solar DEC best practices**

- **System technical optimisation**
  - Life cycle analysis
  - Design tool
  - Self detection procedures
  - System performance modelling

Source: IEA SHC Task 48
Task 48 result (B7): Technical and economic costs analysis

Results: Cost ratio (SHC/REF)

Source: IEA SHC Task 48 – UIBK

SHC as competitive as reference system on its life duration
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 improvement and best solution selection (ongoing IEA SHC Task 48)

⇒ Very innovative concepts such
Example of Basic concept for the PV approach

- PV
- Controller / Inverter
- Master / Slave
- LOAD
- Air conditioner / Heat Pump / Food conservation
- Optional: Water storage (chilled water / hot water / DHW)
- GRID

Task 53
New Generation Solar Cooling & Heating Systems (PV or solar thermally driven systems)

Overview

The main objective of this Task is to assist a strong and sustainable market development of solar PV or new innovative thermal cooling systems. It is focusing on solar driven systems for both cooling (ambient and food conservation) and heating (ambient and domestic hot water).

The scope of the Task are the technologies for production of cold/hot water or conditioned air by means of solar heat or solar electricity, i.e., the subject which is covered by the Task starts with the solar radiation reaching the collector or the PV modules and ends with the chilled/hot water and/or conditioned air transferred to the application. However, although the distribution system, the building and the interaction of both with the technical equipment are not the main topics of the Task this interaction will be considered where necessary.

http://task53.iea-shc.org/
IEA SHC Task 53 Subtask A

Which systems do we have?

NG systems close to market  R&D Systems close to Market

PV CH (Cooling/ Heating) on the Market

- SolabCOOL (NL)
- SUNCOOL/Climatewell (SE)

PV CH (Cooling/ Heating)

- BIG HEATING company (GER)
- Helioherm

STDCH

STDCH

- FREESCOO (IT)
- Climatewell (SE)
State of the art of this new Market

(no claim for completeness)
Main categories

Solar air conditioners : Splits

PV+ HP coupling for Office/Commercial
Thanks for your attention!

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http://task48.iea-shc.org/
http://task53.iea-shc.org/