IEA SHC Task 48 / IEA SHC Task 53
Solar Cooling monitoring and assessment

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Solar Heating and Cooling can be complex
Rating systems for Solar Heating and Cooling

- Fair key figure … comparable with SEER?
- How to combine gas and electricity in one key figure?
- Benchmarks for and against
  - Solar cooling
  - Conventional system

→ Technical and economic evaluation Excel TOOL
Introduction

- Several Key Performance Indicators developed in IEA SHC Task 48 and adapted for IEA SHC Task 53
  - Efficiency on building & component level
  - Electricity / Primary Energy / CO2 Emissions

- Excel Tool for evaluation of systems
  - Technical assessment
  - Indicative economic analysis

- 10 examples were collected in Task48
Technical Assessment – Selected Key Figures

- **Seasonal Performance Factor (SPF)**
  - Electrical - SPF\(_{el}\)
  - Thermal - SPF\(_{th}\)

  \[ SPF_{el} = \frac{\sum Q_{out}}{\sum Q_{el,in}} \quad SPF_{th} = \frac{\sum Q_{out}}{\sum Q_{in}} \]

- **Equivalent Seasonal Performance Factor (SPF\(_{equ}\))**

  primary energy flows expressed in electrical equivalent units used to compare with any (non-) renewable system

  \[ SPF_{equ} = \frac{\sum Q_{out}}{\sum Q_{el,in} + \sum \frac{\varepsilon_{el} * Q_{th,in}}{\varepsilon_{in}}} \]
Technical assessment – boundary
# Systems & components

- **Technical and economic data available for**

<table>
<thead>
<tr>
<th>components</th>
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</table>
| **Solar Thermal Collectors (SC)** | • Flat Plate Collector  
• Evacuated Tube Collector |
| **Photovoltaic (PV)** | • Photovoltaic Panels  
• BOS (balance of system)-components |
| **Heating (H1, H2)** | • Natural Gas Boiler  
• Pellets Boiler  
• Heat Pump (not reversible/reversible)  
• Absorption Heat Pump (not reversible/reversible)  
• Combined Heat&Power Plant  
• District Heating (as heat source) |
| **Cooling (C1, C2)** | • Air-Cooled Vapour Compression Chiller  
• Water-Cooled Vapour Compression Chiller  
• Absorption Chiller (Single Effect & Double Effect)  
• Adsorption Chiller  
• District Cooling (as cold source) |
| **Storage (HS, CS, BS)** | • Hot Storage  
• Cold Storage  
• District Cooling (as cold source) |
10 EXAMPLES at a glance

- **LOCATION**
  - P.R.China; 3
  - Austria; 3
  - France; 1
  - Italy; 1
  - Germany; 1

- **SOLAR USE**
  - C+SH; 4
  - C+SH+DHW; 2
  - C-only; 2
  - C+DHW; 2

- **COOLING CAPACITY**
  - large (> 150 kW); 1
  - medium (30-150 kW); 5
  - small (< 30 kW); 4

### Example Sites
- Singapore; 1
- P.R.China; 3
- Austria; 3
- France; 1
- Italy; 1
- Germany; 1

### Example Uses
- C+SH; 4
- C+SH+DHW; 2
- C-only; 2
- C+DHW; 2
SUB-system Efficiency

- Electrical efficiency of thermal cooling

![Graph showing SPF values for different monthly cold production ranges. SPF values range from 3 to 17.]
SUB-system Efficiency

- Electrical efficiency of thermal cooling

Comparable with SEER of vapor compressor chiller
Labelling

- 4 sub-system’s and building performance!

- Rated **Primary Energy savings** of (non-renewable)

\[ f_{\text{sav.NRE.PER.i}} = 1 - \frac{\text{PER}_{\text{NRE.ref.i}}}{\text{PER}_{\text{NRE.i}}} \]
SUB-system vs. system

- Thermal performance of the chiller / System
Indicative Economic Analysis

- Method & input values based on VDI- and EN-standards
- Annualized costs for
  - Investment
  - Replacement & residual value
  - Maintenance & service
  - Operational costs (energy, water)

→ Levelized costs of energy
  (Cooling + Space Heating + Domestic Hot Water)

\[
\text{cost ratio} = \frac{\text{levelized costs SHC}}{\text{levelized cost REF}}
\]
Economic base (I)

Standard costs for main components

- **Air cooled VCC**: $y = 1680x^{-0.17}$
- **Water cooled VCC**: $y = 3700x^{-0.45}$
- **Adsorption chiller**: $y = 4300x^{-0.46}$
- **SE Absorption chiller**: $y = 3096x^{-0.514}$
- **DE Absorption chiller**: $y = 1258.9x^{-0.301}$
- **Other**: $y = 1530.9x^{-0.258}$
- **Other**: $y = 6543.5x^{-0.534}$
## Economic base (II)

### Economics

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Period under consideration</td>
<td>25 a</td>
</tr>
<tr>
<td>Credit period</td>
<td>10 a</td>
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<tr>
<td>Inflation rate</td>
<td>3 %</td>
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</table>

### Energy costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>Electricity (energy)</td>
<td>10 ct/kWh</td>
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<tr>
<td>Electricity (peak power)</td>
<td>80 €/kW.a</td>
</tr>
<tr>
<td>Natural gas</td>
<td>5 ct/kWh</td>
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<tr>
<td>Water</td>
<td>2.5 €/m³</td>
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Cost Competitiveness!

Solar can be cost competitive!
Conclusions

- Sub-systems vs. Building performance
- Overall performance depends on
  - Component efficiency
  - System design
  - Control strategies
- Efficiency of solar cooling:
  - Electrical: SPF_{el} >15
  - Primary Energy Savings >50%
- Cost competitiveness is possible!
More details already available IEA Task 48

B7 – Key Performance Indicators
B7 – Assessment Tool
C2 – Benchmarks / Examples

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

Updates for IEA SHC Task 53
to follow this summer

http://task53.iea-shc.org/
Thank you for your attention!

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