Methodology for self-assessment for solar process heat

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• Scope of SHIP

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• Discussion
Industrial Solar

• History
  – Solar thermal collector optimized for industry

• Today
  – Various solutions for industrial energy supply
  – Consulting for companies & policy
Scope of SHIP (I)

- SHIP sub-sector of solar thermal market
- Fuel saver for conventional fuels
- Different technologies
Scope of SHIP (II)

- Huge market

- Key characteristics
  - Demand profile (flat)
  - Capacities (large)
  - Temperatures (high)
  - Industrial energy prices (low)
## Scope of SHIP (III)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Processes</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>Pressurization, Sterilization, Drying, Concentration, ...</td>
<td>60°C – 180°C</td>
</tr>
<tr>
<td>Tinned food</td>
<td>Sterilization, Cooking, Bleaching, Pasteurization, ...</td>
<td>60°C – 120°C</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>Crystallization, Fermentation, Molding, ...</td>
<td></td>
</tr>
<tr>
<td>Textile</td>
<td>Bleaching, Dying, Drying, Degreasing, Fixing, ...</td>
<td>60°C – 180°C</td>
</tr>
<tr>
<td>Paper</td>
<td>Cooking, Drying, Bleaching, ...</td>
<td>60°C – 150°C</td>
</tr>
<tr>
<td>Chemical</td>
<td>Distillation, ...</td>
<td>60°C – 260°C</td>
</tr>
<tr>
<td>Meat</td>
<td>Washing, Sterilization, ...</td>
<td>60°C – 100°C</td>
</tr>
<tr>
<td>Beverages</td>
<td>Washing, Sterilization, Pasteurization, ...</td>
<td>60°C – 80°C</td>
</tr>
<tr>
<td>Bricks / blocks</td>
<td>Curing, ...</td>
<td>60°C – 140°C</td>
</tr>
<tr>
<td>Plastics</td>
<td>Distillation, Extension, Drying, ...</td>
<td>80°C – 220°C</td>
</tr>
<tr>
<td>Automotive</td>
<td>Drying, ...</td>
<td>80°C – 250°C</td>
</tr>
<tr>
<td>Metal</td>
<td>Heating of baths, ...</td>
<td>60°C – 180°C</td>
</tr>
<tr>
<td>Tobacco</td>
<td>Curing, Drying, ...</td>
<td>40°C – 150°C</td>
</tr>
</tbody>
</table>
Technologies

- Tracked concentrating collectors
- Evacuated flat-plate and vacuum tube collectors, CPC collectors
- Flat-plate collectors
- Unglazed collectors

- Space cooling
- Industrial process heat
- Domestic hot water and space heating
- Pool heating

Working temperature in °C
Technologies

- High temperature
- High space efficiency  (more kWh per m²)
- Low wind load    (roof tops)
- Accurate control
- Proven in industrial applications
Integration
### Integration

<table>
<thead>
<tr>
<th></th>
<th><strong>Strengths</strong></th>
<th><strong>Weaknesses</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-heating</strong></td>
<td>Easy integration</td>
<td>If condensate temperature is high (e.g. economizer) efficiencies of collectors go down</td>
</tr>
<tr>
<td></td>
<td>Non-concentrating collectors can be used</td>
<td></td>
</tr>
<tr>
<td><strong>Supply level</strong></td>
<td>Easy integration</td>
<td>Mostly Concentrating collectors have to be used</td>
</tr>
<tr>
<td></td>
<td>Collector selection to specific process temperature</td>
<td></td>
</tr>
<tr>
<td><strong>Process linked</strong></td>
<td></td>
<td>Difficult integration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inflexible if process changes</td>
</tr>
</tbody>
</table>
Self-assessment

• Key criteria
  – Installed thermal capacity in MW$_{th}$ or t/h
  – Available area (< 300 m², roof or ground)

• Further criteria
  – Irradiation
  – Energy costs
  – Heat supply
  – Load profile
  – Energy efficiency opportunities
## Space

<table>
<thead>
<tr>
<th></th>
<th>Roof</th>
<th>Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>Secured</td>
<td>?</td>
</tr>
<tr>
<td>Costs</td>
<td>None</td>
<td>?</td>
</tr>
<tr>
<td>Shading</td>
<td>Less</td>
<td>?</td>
</tr>
<tr>
<td>Reduced cooling</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Wind / Weight problem</td>
<td>?</td>
<td>No</td>
</tr>
</tbody>
</table>
Irradiation & energy costs

- Irradiation (excellent in Lebanon)

- Energy costs
  - Heavy fuel oil / diesel (fluctuations)
  - Electricity
Heat supply

• Boiler
  – Heat carrier
  – Inlet & outlet temperature / pressure
  – Turn-down ratio

• Processes
  – Inlet & outlet temperature
Load profile

Graph 1: Load profile for North-South and East-West orientations.

Graph 2: Collector power over time for different days:
- Best day: 08 Jul North-South
- Spring day: 23 Mar North-South
- Winter day: 06 Dec North-South

For more information, visit www.industrial-solar.de
Load profile

- Load profile
  - Seasonal cycles? (e.g. fruit / ice cream)
  - Operation days per week / hours per day?
  - Batch or continuous process(es)?
  - Daily profile

- Storage
  - Steam only “buffered”
  - Hot water / thermal oil reasonable

The flatter the load profile the better!
Self-assessment

• Key criteria
  – Installed thermal capacity in MW\textsubscript{th} or t/h
  – Available area (< 300 m\textsuperscript{2}, roof or ground)

• Further criteria
  – Irradiation
  – Energy costs
  – Heat supply
  – Load profile
  – Energy efficiency opportunities
Low hanging fruits

- Electricity > Diesel > Fuel oil
- 365 days & 24 h
- Continuous demand
- Low temperatures
- Large systems (economies of scale)
- Concrete roofs > corrugated sheets
- High irradiation
Realizing SHIP projects

- System thinking
  - Collector
  - Periphery
  - Load profiles
  - Integration
  - Engineering
  - Installation
  - Maintenance

[Diagram of a solar thermal system]
Realizing SHIP projects

- Data needed (load profiles)
- Financing
- Reliable provider
Example

- Copper mine in Chile
- Flat plate
- 39,300 m²
- 70 °C
Example

- Meat factory in Austria
- Flat plate
- 1067 m² HT flat-plate collectors
- Guaranteed solar yield: 400 kWh/(m²*year)
Example

- Heat for dehumidification
  - 160 m³/day Solar heating up to 60°
- Preheating feed water for steam production
  - Solar heating up to 98°
  - 25 m³/day
Example

- Metal industry (Switzerland)
- Evacuated tube (CPC)
- 400 m²
- 95 °C
Example

- Pharmaceutical industry
- Air collector (evacuated tube)
- 130 m²
Example

- Pharmaceutical Industry (Jordan)
- Fresnel collector
- 400 m²
- 200 °C (steam)
Example

First Measurement Results

FIGURE 4. Measurement Data from June 19th, 2015. A day with several high clouds and thus fluctuations in DNI.
Example

Video with more details:

https://www.youtube.com/watch?v=ibiUoACea6o
Discussion

Thank you for your attention!

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