Parabolic Trough Technology
State of the Art and New Developments

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Content

State of the Art
- Collector / Components
- System

New Developments
- Collector / Components
- System

Summary
State of the Art Collector

Technical Data
Module:
- 5,77 m x 12 m
Collector:
- 12 Modules
- 830 m²
Focal Length:
- 1,71 m
## Collector Structure Development

<table>
<thead>
<tr>
<th></th>
<th>LS-1</th>
<th>LS-2</th>
<th>LS-3</th>
<th>Euro-trough</th>
<th>Helio-trough</th>
<th>Sener-trough 1</th>
<th>Sener-trough 2</th>
<th>Ultimate Trough</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aperture width in m</strong></td>
<td>2,55</td>
<td>5</td>
<td>5,77</td>
<td>5,77</td>
<td>6,78</td>
<td>5,77</td>
<td>6,87</td>
<td>7,51</td>
</tr>
<tr>
<td><strong>Length per Module/SCE in m</strong></td>
<td>6,3</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>19</td>
<td>12,27</td>
<td>13,23</td>
<td>24</td>
</tr>
<tr>
<td><strong>SCA length in m</strong></td>
<td>50,2</td>
<td>47,1</td>
<td>99</td>
<td>147,8</td>
<td>191</td>
<td>-</td>
<td>158,8</td>
<td>242,2</td>
</tr>
<tr>
<td><strong>Focal length in m</strong></td>
<td>0,68</td>
<td>1,40</td>
<td>1,71</td>
<td>1,71</td>
<td>1,71</td>
<td>1,71</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td><strong>Torsion force carried by</strong></td>
<td>Torque tube</td>
<td>Torque tube</td>
<td>V-truss Framework</td>
<td>Torque box</td>
<td>Torque tube</td>
<td>Torque tube</td>
<td>Torque tube</td>
<td>Torque box</td>
</tr>
</tbody>
</table>

![Collector Structure Development](image)
Key Component: Receiver Tube
Heat Collecting Element HCE
Receiver Technology

- L = 4060 mm
- D = 70 mm (80, 90, ...)
- Glass d = 125 mm
- Solar Transmittance: 97%
- Solar Absorptance: 96%
- Thermal Emittance: < 10%
- Vacuum: 10^{-3} \text{ mbar}
- Overall Heat Loss: < 250 \text{ W/m}
Solar Field Construction – Civil Works and Pylons
Collector Assembly – Steel Structures and Mounting Jigs
Solar Field Installation
Parabolic trough power plant characteristics

**Typical data** (approx. Values)
- Thermal oil circuit operating Temperature: 400 °C
- Nominal Power: 50 – 300 MW
- Solar field size: 500.000 – 2,5 Mio m²
- Molten salt storage capacity: 0 – 10 full load hours
- Fossil fired Back-up heater
- Annual full load hours: 2.000 - 5.000 h/a

**Solar thermal power plants** provide flexible and predictable power on demand

- **Total Investment:** 2.200 - 5.000 €/kW
- **Power Block:** 1.000 €/kW
- **Solar field:** 200 - 400 €/m²
Andasol 1, 2, 3 Guadix, Spain
3x 50 MW, 3700 Full Load Hours
Parabolic Trough: Commercial Technology
Economies of Scale

280 MW Anlage Solana (Abengoa) operational since 2013
Storage Capacity 6 h, Solar Field 2.2 Mio m², Production 980 GWh/a
Quo Vadis?

Mature – No more R&D required?

Air travel

- 70 years ago: Luxury for few
- Today: Normality for (almost) everybody

How was this achieved?

- Economies of scale
- Technologie changes
- New materials
New Developments: Alternative Materials

Concrete Structure
+ Precasting Technology
+ Low Material Cost
+ Low Labour Cost
+ High Local added Value
+ High Weight
- Manufacturing Tolerances
- Surface Quality
- Suspension and Tracking
- Site Logistics
Direct solar steam generation

Advantages:
+ Increased Temperature
  + improved performance
+ No secondary circuit:
  + reduced investment
  + reduced losses
+ non-toxic, non-inflammable medium

Challenges:
- Two-phase Flow
- Temperature gradients
- Increased operating pressure
- No cost effective storage yet
Solarlite Kanchanaburi (TSE 1)

- Industry partner: Solarlite
- 5 MW parabolic trough plant with direct steam generation (30 bar, 330° C)
- Recirculation Process
- Location: Thailand
- Operational since 11/2012
New Development: Once Through Process

DLR – CIEMAT Co-operation

- Extension of the DISS-testfacility on the Plataforma Solar de Almería
- Successful demonstration of safe operation under transients
  - Live steam temperature
  - Dry-out point
- Next step: Improved performance based on local DNI prediction
New Development: Molten salt as heat transfer medium

Advantages:
+ Increased temperature
+ Direct Storage
+ Increased storage capacity
+ low-cost medium for heat transfer storage
+ not hazardous to water

Challenges:
- High melting point
- Freeze protection / trace heating
- Procedures for filling, draining, malfunctions
- Corrosion / Material selection
- Long term stability

Current research effort:
Completion and operation of Évora Molten Salt Platform to demonstrate solutions to the challenges
Summary and Conclusions

- Parabolic troughs are regarded a mature technology and are the most widely applied CSP technology in the present early markets

- Developments to improve their competitiveness build on:
  - Economies of scale
  - New materials
  - Increased Operating Temperatures

- Success factors for the future:
  - Stable framework for market and technology development
  - Continuous feedback from operation into research
  - Close co-operation between industries and research