Final deliverable

State of the art on new collectors & characterization

Date: 12.01.2015

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IEA Solar Heating and Cooling Program

The Solar Heating and Cooling Programme was founded in 1977 as one of the first multilateral technology initiatives (“Implementing Agreements”) of the International Energy Agency. Its mission is “to enhance collective knowledge and application of solar heating and cooling through international collaboration to reach the goal set in the vision of solar thermal energy meeting 50% of low temperature heating and cooling demand by 2050.

The member countries of the Programme collaborate on projects (referred to as “Tasks”) in the field of research, development, demonstration (RD&D), and test methods for solar thermal energy and solar buildings.

A total of 53 such projects have been initiated to-date, 39 of which have been completed. Research topics include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44)
- Solar Cooling (Tasks 25, 38, 48, 53)
- Solar Heat for Industrial or Agricultural Processes (Tasks 29, 33, 49)
- Solar District Heating (Tasks 7, 45)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52)
- Solar Thermal & PV (Tasks 16, 35)
- Daylighting/Lighting (Tasks 21, 31, 50)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)
- Storage of Solar Heat (Tasks 7, 32, 42)

In addition to the project work, there are special activities:
- SHC International Conference on Solar Heating and Cooling for Buildings and Industry
- Solar Heat Worldwide – annual statistics publication
- Memorandum of Understanding with solar thermal trade organizations
- Workshops and conferences

Country Members

- Australia
- Austria
- Belgium
- China
- Canada
- Denmark
- European Commission

- Germany
- Finland
- France
- Italy
- Mexico
- Netherlands
- Norway
- Portugal
- South Africa
- Spain
- Sweden
- Switzerland
- Turkey
- United Kingdom
- United States

Sponsor Members

- European Copper Institute
- ECREEE

- Gulf Organization for Research and Development
- RCREEE
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1 General scope

An extensive market overview of existing concentrating collectors has been conducted so as to create easy to consult database (like the existing Solar Key mark one for certified collectors).

This database has been periodically updated during IEA Task 48 work and extended with information relating the certification process of such collectors. Concentrating collectors can nowadays be tested according to several standards (see also Kramer, Mehnert et al. 2011), the most important and enhanced one (also basis for certification according Keymark, SRCC, and others) is (Norm ISO 9806:2013[E]).

New components and approaches, currently under development, have been included into the survey and their use in existing solar cooling plants has been investigated.

2 Participating entities

<table>
<thead>
<tr>
<th>Entities</th>
<th>Person in charge</th>
<th>Country</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polimi</td>
<td>Marco Calderoni</td>
<td>Italy</td>
<td>Activity Leader</td>
</tr>
<tr>
<td>Fraunhofer ISE</td>
<td>Jochen Doell</td>
<td>Germany</td>
<td>Contributor</td>
</tr>
<tr>
<td>Fraunhofer ISE</td>
<td>Korbinian Kramer</td>
<td>Kramer</td>
<td>Contributor</td>
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<tr>
<td>CSIRO</td>
<td>Stephen White</td>
<td>White</td>
<td>Contributor</td>
</tr>
<tr>
<td>TECSOL</td>
<td>Daniel Mugnier</td>
<td>Mugnier</td>
<td>Contributor</td>
</tr>
<tr>
<td>Green Chiller</td>
<td>Uli Joakob</td>
<td>Joakob</td>
<td>Contributor</td>
</tr>
<tr>
<td>Industrial Solar</td>
<td>Christian Zahler</td>
<td>Zahler</td>
<td>Contributor</td>
</tr>
</tbody>
</table>

3 Milestones

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-A6.1</td>
<td>Start extensive market overview of concentrating collectors</td>
<td>12</td>
</tr>
<tr>
<td>M-A6.2</td>
<td>Creation of the database on market available concentrating technologies</td>
<td>18</td>
</tr>
<tr>
<td>M-A6.3</td>
<td>Updated version of the database</td>
<td>30</td>
</tr>
<tr>
<td>M-A6.4</td>
<td>Final version of the database on concentrating collectors</td>
<td>42</td>
</tr>
</tbody>
</table>
4 Collector database
An extended research on existing collector manufacturers has been initiated, in co-operation with IEA SHC Task 49. The results are presented into an excel file, which will be updated before each project meeting.
The excel file, as well as a folder containing product technical sheets, is available as attachment and the content of this excel file can be found as well in annex of the present report.

5 Experiences of manufacturers of medium temperature collectors with sorption machines
Some manufacturers of medium temperature collectors have been asked to tell about their experience with sorption machines. Few of them indeed gave useful answers.

Inquiries have been sent to the following companies: PSA, DLR, University of Balearic, Industrial Solar, Chromasun, Itcollect, TVP, NEP Solar, Sopogy, Absolicon, Novatec, Smirro, Abengoa, Soltigua, Dr. Vetter, SOLID, ECS, Helioclim.

A special acknowledgment must be addressed to the following companies among the quoted list above because they agreed to share their feedbacks on their solar cooling applications:
- SMIRRO (http://www.smirro.de/)
- HELIOCLIM (http://en.helioclim.fr)
- INDUSTRIAL SOLAR (www.industrial-solar.de)

The main feedbacks are summarized in the following table.

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<table>
<thead>
<tr>
<th>Manufacturer of collectors</th>
<th>Type of sorption machine</th>
<th>Feedback from practical experience on solar cooling</th>
<th>Control strategies implemented</th>
</tr>
</thead>
</table>
| **Smirro – parabolic trough collectors** | • Absorption (NH₃/H₂O)  
• Single stage  
• Dry cooler  
• 20 kW<sub>cold</sub>  
• Nominal working temperature: 180°C  | • Installation sensible points: delivery of some components (e.g. polluted thermal oil ended in meters cleaning and refilling the cycle), issues with a leaking oil gauge glass on the sensible heat storage ended in isolation damages.  
• Operation: not always possible to maintain the 180 °C. Producers cold performance of 11-15 kW could not be proved. Bad working re-cooling systems led to low COPs. Big losses in the heat storage between the absorption machine and the parabolic collectors.  | • An order is implemented in a PLC associated to the collectors, so that every time that a fixed limit temperature is reached, they track to a position in which less radiation is absorbed. |
| **Smirro – parabolic trough collectors** | • Adsorption (H₂O/Zeolithe)  
• Single stage  
• Dry cooler  
• 10 kW<sub>cold</sub>  
• Nominal working temperature: 85°C  | • Operation sensible points: need of the 2 chambers of the chiller to work in parallel. Need that all the piping system is isolated to avoid losses.  | • An order is implemented in a PLC associated to the collectors so that every time that a fixed limit temperature is reached, they track to a position in which less radiation is absorbed.  
• Chiller can have some limit values as constrains for too high or low driving, chilling and recooling temperatures. If a set value of the constraints is reached the chiller stops and changes into the standby mode and waits for further requests. (E.g. minimal driving temperature of 75°C, minimal inlet temperature of 17 °C, the chiller switched off in stand by mode)  |
### Manufacturer of collectors

**Helioclim – parabolic trough collectors**
- Absorption (NH$_3$/H$_2$O)
- Single stage
- Dry cooler
- 10 kW$_{cold}$
- Nominal working temperature: 160°C

### Type of sorption machine

- Hydraulic sensible parts needing caution: thermoelastic issues, rotating unions.
- Control management: tracking system based on theoretical sun position sufficient or do we need an active position controller? Choice of thermal sensors adapted to harsh conditions.
- Installation cautions: fine tuning of solar collector positioning, integration of thermal sensors.
- Operation cautions: waterproofing of rotating unions, magnetite sludge formation.

### Feedback from practical experience on solar cooling

- Automatic focusing based on theoretical sun position. Automatic defocusing when there is no sun power during more than 5 minutes and in case of high wind, fluid temperature and pressure superior to safety values, fluid circulation failure.
- Start of chiller when solar heat loop superior to a minimum value + cooling/heating needs >0

### Control strategies implemented

### Industrial Solar – linear Fresnel
- Absorption (NH$_3$-H$_2$O and H$_2$O-LiBr)
- Double stage
- 2 x 175 kW$_{cold}$, 330 kW$_{cold}$, 600 kW$_{cold}$
- Nominal working temperature: 180°C

- Variable mass flow, reduction of aperture area to avoid overheating at maximum flowrate
- Project dependent: if minimum power from collectors available -> chiller on
6 Collector certification

Certification is a crucial issue for market introduction of new technologies such as medium temperature collectors. Certification schemes are already available and very common for conventional collectors worldwide (EN 12975 and Solar Keymark in Europe, SRCC in USA, AS/NZS 2712:2007 in Australia).

Why collector certification?

Reasons for pushing for the introduction of collector certification are summarized in the following list:
- certification may introduce minimum standards for product quality;
- certification helps investors and designers in choosing the most suitable product for a certain application;
- certification protects market from bad experiences;
- certification can be used as a market tool by manufacturers;
- certification raises market transparency.

European experience with standards

There is a European standard for collector testing and certification (Norm prEN ISO 9806:2012 and EN 12975-1:2006-A1:2010). This standard provides:
- requirements on function
- requirements on materials
- testing instructions for function tests
- testing instructions on performance tests

Based on this standard (and precessing), Solar Keymark label was introduced in Europe in 2003. Solar Keymark is a volunteer label which adds further quality requirements to EN 12975, although some countries are introducing it as a mandatory label for access to subsidy programs. It experienced a quick growth in labeled products after 2007: in January 2011 around 1,200 collector models were labeled. It is operated by the existing network of accreditation bodies, empowered bodies, certification bodies and several accredited testing laboratories. Today through the enhancement of the standards a certification for concentrating collectors is possible.
Path towards certification procedure for medium temperature collectors are summarized in the following picture:

*Process for introduction of a certification procedure for medium temperature collectors (source: Korbini Kramer - Fraunhofer ISE - TestLab Solar Thermal System)*
ANNEX
<table>
<thead>
<tr>
<th>ID</th>
<th>Collector typology</th>
<th>Manufacturer</th>
<th>Product name</th>
<th>Temperature range</th>
<th>Size of single module [m]</th>
<th>Efficiency curve</th>
<th>IAM</th>
<th>Web</th>
<th>Research or commercial readiness level</th>
<th>Documented experience with sorption cooling</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Improved flat plate collectors - double glazing</td>
<td>Arcon</td>
<td>HT-SA 28/10 AR-glass+ETFE-film</td>
<td>up to 120 °C</td>
<td>see attachment</td>
<td>see attachment</td>
<td>-</td>
<td><a href="http://www.arcon.dk/">www.arcon.dk/</a></td>
<td>commercial</td>
<td>yes</td>
<td></td>
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<tr>
<td>2</td>
<td>Improved flat plate collectors - double glazing</td>
<td>ökoTech</td>
<td>ökoTech HT collector</td>
<td>up to 120 °C</td>
<td>see attachment</td>
<td>see attachment</td>
<td>-</td>
<td><a href="http://www.oekotech.biz">www.oekotech.biz</a></td>
<td>commercial</td>
<td>yes</td>
<td></td>
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<tr>
<td>3</td>
<td>Improved flat plate collectors - vacuum + internal reflector</td>
<td>SRB Energy Research</td>
<td>Evacuated flat solar collector</td>
<td>up to 300 °C</td>
<td>0,64 x 3</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://www.srbenergy.com/">www.srbenergy.com/</a></td>
<td>commercial</td>
<td>yes</td>
<td></td>
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<tr>
<td>4</td>
<td>Improved flat plate collectors - vacuum</td>
<td>TVP Solar</td>
<td>MT Power</td>
<td>up to 200 °C</td>
<td>0,7 x 1,7</td>
<td>see attachment</td>
<td>-</td>
<td><a href="http://www.tvpsolar.com">www.tvpsolar.com</a></td>
<td>commercial</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Improved flat plate collectors - vacuum</td>
<td>Solarfocus</td>
<td>CPC Kollektor</td>
<td>-</td>
<td>2,125 x 1,155</td>
<td>( \eta_0 = 0,74 )</td>
<td>a1 = 3,3</td>
<td>a2 = 0,012</td>
<td>not available on website</td>
<td>see attachment</td>
<td><a href="http://www.solarfocus.at">www.solarfocus.at</a></td>
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<tr>
<td>6</td>
<td>CPC Evacuated tubes collectors</td>
<td>Ritter XL Solar</td>
<td>CPC 45 XL</td>
<td>up to 140 °C</td>
<td>2,033 x 2,427</td>
<td>( \eta_0 = 0,644 )</td>
<td>a1 = 1,749</td>
<td>a2 = 0,005</td>
<td>commercial</td>
<td>see attachment</td>
<td><a href="http://www.rittersolar.de">www.rittersolar.de</a></td>
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<tr>
<td>7</td>
<td>Improved Evacuated tubes collectors</td>
<td>Viessmann</td>
<td>Vitosol 200-T SD2</td>
<td>up to 270 °C</td>
<td>1,33 - 1,60 - 3,19 m²</td>
<td>( \eta_0 = 0,82 )</td>
<td>a1 = 1,62</td>
<td>a2 = 0,0068</td>
<td>commercial</td>
<td>see attachment</td>
<td><a href="http://www.viessmann.it">www.viessmann.it</a></td>
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<td>Improved Evacuated tubes collectors</td>
<td>Viessmann</td>
<td>Vitosol 200-SPL</td>
<td>up to 130°C</td>
<td>Aperture area : 1,69 m²</td>
<td>( \eta_0 = 0,71 )</td>
<td>a1 = 0,95</td>
<td>a2 = 0,005</td>
<td>commercial (Solar Keymark certification ongoing)</td>
<td>see attachment</td>
<td><a href="http://www.viessmann.it">www.viessmann.it</a></td>
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<td>9</td>
<td>Parabolic trough collectors</td>
<td>Nep Solar</td>
<td>PolyTrough 1200</td>
<td>up to 200 °C</td>
<td>1,2 x 24 , see attachment</td>
<td>( \eta_0 = 0,68 )</td>
<td>a1 = 0,04</td>
<td>a2 = 0,0015</td>
<td>commercial</td>
<td>see attachment</td>
<td><a href="http://www.nep-solar.com">www.nep-solar.com</a></td>
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<td>10</td>
<td>Parabolic trough collectors</td>
<td>Nep Solar</td>
<td>PolyTrough 1800</td>
<td>up to 250 °C</td>
<td>1,85 x 20 , see attachment</td>
<td>( \eta_0 = 0,68 )</td>
<td>a1 = 0,03</td>
<td>a2 = 0,0010</td>
<td>commercial</td>
<td>see attachment</td>
<td><a href="http://www.nep-solar.com">www.nep-solar.com</a></td>
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<tr>
<td>11</td>
<td>Parabolic trough collectors</td>
<td>Solitem</td>
<td>Trough PTC1800</td>
<td>up to 180 °C</td>
<td>5,02 x 1,8</td>
<td>( \eta_0 = 0,6833 )</td>
<td>a1 = 1</td>
<td>a2 = 0,0033</td>
<td>commercial</td>
<td>see attachment</td>
<td><a href="http://www.solitem.de">www.solitem.de</a></td>
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<tr>
<td>12</td>
<td>Parabolic trough collectors</td>
<td>Soligua</td>
<td>PTM 18, 24, 30, 36</td>
<td>up to 250 °C</td>
<td>depending on module - see attachment</td>
<td>( \eta_0 = 0,71 )</td>
<td>a1 = 0,6</td>
<td></td>
<td>commercial</td>
<td>see attachment</td>
<td><a href="http://www.soligua.com">www.soligua.com</a></td>
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<td>13</td>
<td>Parabolic trough collectors</td>
<td>Solarlite</td>
<td>4600</td>
<td>up to 400 °C</td>
<td>12 x 4,6</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://www.solarlite.de">www.solarlite.de</a></td>
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<td>not available on website</td>
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<td>14</td>
<td>Parabolic trough collectors</td>
<td>Trivelli Energia</td>
<td>SWCH</td>
<td>up to 300 °C</td>
<td>8,2 x 1,25</td>
<td>not publishable</td>
<td>not publishable</td>
<td><a href="http://www.trivellienergia.eu">www.trivellienergia.eu</a></td>
<td>commercial</td>
<td>yes</td>
<td></td>
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<td>15</td>
<td>Parabolic trough collectors</td>
<td>Dr. Vetter</td>
<td>Itcollect</td>
<td>up to 200 °C</td>
<td>2,16 x 0,55 (for roof integration)</td>
<td>( \eta_0 = 0,658 )</td>
<td>a1 = 1,788</td>
<td></td>
<td>R&amp;D</td>
<td>see attachment</td>
<td><a href="http://www.itcollect.de">www.itcollect.de</a></td>
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</table>

*Subtask A – Activity 6 Final Report January 2015*
<table>
<thead>
<tr>
<th>ID</th>
<th>Collector typology</th>
<th>Manufacturer</th>
<th>Product name</th>
<th>Temperature range</th>
<th>Size of single module [m]</th>
<th>Efficiency curve</th>
<th>IAM</th>
<th>Web</th>
<th>Research or commercial readiness level</th>
<th>Documented experience with sorption cooling</th>
<th>comments</th>
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<tbody>
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<td>16</td>
<td>Parabolic trough collectors</td>
<td>CIEMAT</td>
<td>Capsol</td>
<td>up to 250 °C</td>
<td>1 x 2</td>
<td>see attachment</td>
<td>see attachment</td>
<td><a href="http://www.psa.es/webesp/projects/capsol/results.php">www.psa.es/webesp/projects/capsol/results.php</a></td>
<td>R&amp;D</td>
<td>not available on website</td>
<td></td>
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<tr>
<td>17</td>
<td>Parabolic trough collectors</td>
<td>Smirro</td>
<td>Smirro</td>
<td>up to 250 °C</td>
<td>1,14 x 3</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://smirro.de">http://smirro.de</a></td>
<td>commercial</td>
<td>yes</td>
<td></td>
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<td>18</td>
<td>Parabolic trough collectors</td>
<td>Absolicon</td>
<td>MT10</td>
<td>up to 160 °C</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://www.absolicon.com">www.absolicon.com</a></td>
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<td></td>
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<tr>
<td>19</td>
<td>Parabolic trough collectors</td>
<td>Pro Target</td>
<td>n.a.</td>
<td>up to 400 °C</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://www.protarget-ag.de/">www.protarget-ag.de/</a></td>
<td>R&amp;D</td>
<td>not available on website</td>
<td></td>
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<td>20</td>
<td>Parabolic trough collectors</td>
<td>Abengoa</td>
<td>PT-1</td>
<td>up to 250 °C</td>
<td>2,3 x 6,1</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://www.abengosasolar.com">www.abengosasolar.com</a></td>
<td>commercial</td>
<td>not available on website</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Parabolic trough collectors</td>
<td>Whitestar Energy</td>
<td>W11-C</td>
<td>up to 160 °C</td>
<td>n.a.</td>
<td>Aperture area: 2.112 m²</td>
<td>see attachment</td>
<td>see attachment</td>
<td><a href="http://www.whitestarenergies.com">www.whitestarenergies.com</a></td>
<td>R&amp;D</td>
<td>not available on website</td>
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<tr>
<td>22</td>
<td>Parabolic trough collectors</td>
<td>Focal Point Energy</td>
<td>Energy Driver™</td>
<td>up to 250 °C</td>
<td>3,048 x 12,192 (10 ft. x 40 ft.)</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://focalpointenergy.com">http://focalpointenergy.com</a></td>
<td>commercial</td>
<td>not available on website</td>
<td></td>
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<tr>
<td>23</td>
<td>Parabolic trough collectors</td>
<td>Helioclim</td>
<td>Helioclim Solar Collectors</td>
<td>up to 220 °C</td>
<td>1,48 x 3,08</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://en.helioclim.fr">http://en.helioclim.fr</a></td>
<td>commercial (Solar Keymark certification ongoing)</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Parabolic trough collectors</td>
<td>SLT Energy</td>
<td>SOL Yatna CSP</td>
<td>up to 400 °C</td>
<td>12 x 5</td>
<td>n.a.</td>
<td>n.a.</td>
<td><a href="http://sltenergy.com">http://sltenergy.com</a></td>
<td>R&amp;D</td>
<td>not available on website</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Parabolic trough collectors</td>
<td>Archimede Solar Energy</td>
<td>HCESH</td>
<td>up to 550 °C</td>
<td>see attachment</td>
<td>see attachment</td>
<td>see attachment</td>
<td><a href="http://www.archimedesolarenergy.it">http://www.archimedesolarenergy.it</a></td>
<td>R&amp;D</td>
<td>not available on website</td>
<td>ASE produces receiver tubes</td>
</tr>
</tbody>
</table>
| 26 | Fresnel collectors | Novatec Solar | Nova - 1 | up to 500 °C | 44,8 x 16,56 | $n_0 = 0.67$  
$\alpha_1 = 0.056$  
$\alpha_2 = 0.000213$ | see attachment | see attachment | www.novatecsolar.com | commercial | not available on website |
| 27 | Fresnel collectors | Industrial Solar | LF-11 | up to 400 °C | 4,06 x 7,5 | $n_0 = 0.635$  
$\alpha_1 = 0$  
$\alpha_2 = 0.00043$ | see attachment | see attachment | www.industrial-solar.de | commercial | yes |
| 28 | Fresnel collectors | Chromasun | MCT | up to 200 °C | 3,39 x 1,23 | $n_0 = 0.565$  
$\alpha_1 = 0.054$  
$\alpha_2 = 0.0032$ | see attachment | see attachment | http://chromasun.com | commercial | yes |
| 29 | Fresnel collectors | Soltigua | FTM 18, 24, 30, 36 | up to 250 °C | depending on module - see attachment | $n_0 = 0.60$  
$\alpha_1 = 0.38$ | see attachment | see attachment | www.soltigua.com | commercial | yes |
| 30 | Fresnel collectors | KGDS | n.a. | n.a. | n.a. | n.a. | n.a. | http://solar.kgisl.com/ | R&D | not available on website |
| 31 | Fresnel collectors | Hitachi | HSLPF | up to 340 °C | 115,7 x 9,8 | see attachment | see attachment | www.hitachizosen.co.jp/ | R&D | not available on website |
| 32 | Point focussing collectors | Isomorph | Linear Mirror II | up to 100 °C | Aperture area: 13.8 m² | see attachment | see attachment | www.isomorph-production.it | R&D | not available on website |