Medium temperature solar collectors DATABASE

Task 11.1- Small scale and low cost installations for power and industrial process heat applications

Subtask 11.1.1 Medium temperature (150 – 250 ºC) solar collectors for industrial or distributed applications

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Dissemination Level	*PU*

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Executive Summary

This deliverable is part of the results of the WP11 (Medium temperature solar collectors DATABASE) *within the Cooperative Project.*

The WP11 Linear Focusing STE Technologies is devoted to those solar technologies based in line-focus concentrators, i.e. parabolic-trough collectors (PTC) and linear Fresnel collectors (LFC). Tasks composing this WP are aimed at a twofold objective:

- Explore and develop new concepts and technologies suitable for distributed generation. So, the objective within this task is to further increase the research in the field of medium temperature solar concentrating collectors for industrial or distributed applications, to study schemes of integration in thermal applications and power cycles for small scale systems, and the use of new heat transfer fluids in solar collector fields.
- Generate new knowledge and technologies providing solutions to technical constraints faced by the industry nowadays. In particular the activities will be focused in dynamic solar field testing of large solar fields, in the development of new methodologies for on-site characterization of large line-focus solar collectors' fields, and the improvement of operation and maintenance of line-focus STE plants.

More specifically the activities of task 11.1, *Small scale and low cost installations for power and industrial process heat applications* have as objective the development of technology, components, concepts, and schemes for small scale and low-cost installations suitable for electricity production, process heat applications or combined heat and power (CHP) systems.

Subtask 11.1.1 is focused in *Medium temperature (150 – 250 ºC) solar collectors for industrial or distributed applications*. Although the technology of solar thermal collectors for medium temperature applications is not new, few collectors and commercial installations are available worldwide. The sector is growing rapidly. More and more technologies are arising and real installations using these technologies are already being built all around the world for different applications, especially for the generation of the heat required by industrial applications.

Considering the increasing number of available products and the importance of disseminating this information among system designers and end-users, a database of the available solar collectors for medium temperature applications has been developed in this subtask. The information has been gathered from the different collector suppliers and the available technical information published on the different collector models. Aiming a thorough insight into these commercially available solutions, the database includes the most relevant technical information of the different collectors. This deliverable explains the methodology followed for developing the database, the database itself and some conclusions obtained from the data collected.

Although this work is being done in the framework of the European project STAGE-STE, the gathered information will also be used inside the Task 49 (SHC, IEA). The Task 49 is the working group for Solar Heat Integration in Industrial Process (SHIP) of the Solar Heating and Cooling program (SHC) by the International Energy Agency (IEA) (http://task49.iea-shc.org/), taking into account that several partners of T11.1.1 are involved in Task 49 (SHC, IEA).

1 Subtask 11.1.1.

1.1. Introduction

According to the definition presented in Task 49 [1] medium temperature solar thermal collectors refer to collectors whose output exceeds 300 W/m^2 gross collector area for the following conditions: 1000 W/m² hemispherical irradiance, 15 % diffuse fraction and 20 °C ambient temperature at an operating temperature above 100 °C.

Although medium temperature solar applications started more or less at the same time as the Concentrating Solar Power (CSP) systems (some examples are available from the seventies and eighties of last century [2]), until now the market development has not been as relevant as in CSP, more due to the lack of financial support than the technology itself. Currently this technology is developing very fast. Possible uses of these collectors are mainly solar process heat but also solar cooling, desalination, electricity generation using Organic Rankine cycle (ORC), pumping irrigation water, water heating for high consumptions, etc. In Task 49, a database for applications of solar heat integration in industrial processes was created (http://ship-plants.info/).

Existing collectors are based on different technologies (PTC-, LFC, parabolic dishes, ultra-high vacuum flat plate collectors, fixed-mirror, etc...), different designs, concepts, sizes and materials, etc. Therefore, no standardized collector-components are still available. This database will serve as a reference framework in the medium temperature solar thermal collectors market.

In Annex 1 appears an extract of the database with the manufactures and models of collector whose parameters has been gathered. The database itself is in the file STAGE_STE_Small_Scale_Collectors_DATABASE.xlsx.

1.2. Methodology

The methodology followed for developing the database includes three main steps.

First, the definition of the most important technical parameters of the collectors to be gathered, such as the main materials, collector designs, certifications (if any) and geometrical, optical and thermal behavior information. The selected parameters were the following: manufacturer information; collector type; material, reflectance, ρ, dimensions and other information of the primary/secondary reflector; material, transmittance, τ, dimensions of the flat cover (if exists); material, absorptance, α, emittance, ε, geometrical information, and other specifications of the receiver (absorber and glass envelope); type, accuracy, and other specifications of the tracking system; and additional information of the system. Details of the complete parameters list are presented in section 2.

Then, the existing information on solar thermal collectors was collected and the defined technical information was extracted. It was noted that the information on different existing collectors varies depending on the employed sources and that the different suppliers were having different collector models and continuous evolution on their products.

Finally, the different suppliers were contacted to check the validity of the available information.

Aiming a permanent update of the gathered information, an online form is presently under construction. Following the same format and data parameters of the original database, such form will enable the introduction of information on new collectors by manufacturers. Such information will then be screened by the core database technical commission and, upon approval, will be made available to the general public online.

2 Parameters on the medium temperature solar thermal collectors database

The following parameters about medium temperature solar thermal collectors are included in the database:

- Number: manufacturer ID;
- Manufacturer: full name of the company manufacturing the collector;
- Location: city and country where the headquarters of the manufacturer is situated;
- Model: specific model of the collector. Some manufacturers have several collector models;
- Stationary/tracking: stationary option is marked when the collector does not present a movement system, while tracking is selected when the collector include a movement system to track the Sun along the day;
- Type: collector technology, to be chosen among PTC, LFC, parabolic dish, high-vacuum flat plate and fixed mirror solar concentrator (FMSC);
- Primary reflector (material, reflectance, dimensions and other specifications): description of the main features of the primary reflector, which is the element that concentrates the solar radiation onto the receiver. The typical material types are silvered-glass (thick or thin), aluminium (several kinds of protective layers) and polymer film. The material model and manufacturer is also specified, when known. The reflectance is the ratio of the energy flux reflected by a surface to the radiation incident on it [3]. Dimensions include width, length and thickness. Concentrator characteristics are also mentioned in some cases;
- Secondary reflector (material, reflectance, dimensions and other specifications): description of the main features of the secondary reflector, which is an element located around the receiver to re-concentrate on it the radiation reflected by the primary reflector;
- Flat cover (material, transmittance, dimensions and other specifications): description of the main features of the flat cover, which is an element located on the aperture plane of some collectors to protect the rest of the components (reflector, receiver, etc.) and to decrease the thermal losses. The transmittance is the ratio of the energy flux transmitted by a material to the incident radiation on it [3]. Dimensions include width, length and thickness;
- Receiver (material, absorptance, emittance, inlet diameter, outlet diameter, evacuated or non-

evacuated and other specifications): description of the main features of the receiver, which is the element of a solar collector absorbing radiant solar energy and transferring it to a fluid in the form of heat. The absorptance is the ratio of the energy flux absorbed by a surface element to the radiation incident on it [3]. The emittance is the ratio of the radiant energy emitted by a material from its surface to the radiant energy emitted by a black body under the same conditions [3];

- Receiver cover (material, transmittance, inlet diameter, outlet diameter and other specifications): description of the main features of the receiver cover, which is an element located around receiver in some solar collectors to protect it and decrease the thermal losses;

- Tracking system (type, accuracy and other specifications): description of the main features of the sun-tracker, which is the element of a solar collector that permits it to follow the Sun along the day. Some common types of tracking systems are: sun (electro-optical) sensor, sun position algorithm (date/time based, open loop system), and hybrid sun-tracker (combination of sensor and date/time based);

- Stagnation protection: method to avoid the collector reaching the stagnation temperature. In tracking collectors, the stagnation protection is to defocus it;

- Size (width and length): main dimensions of the collector; the width corresponds to width of the flat surface which accepts the solar radiation (aperture plane), including the gaps between adjacent reflectors. The length also includes the gaps between adjacent reflectors composing the collector unit;

- Focal length: distance between the vertex of the parabola and the focus. In parabolic-trough collectors, the receiver is located in the focal line;

- Geometric concentration ratio: it is defined as the ratio of solar collector aperture area to the receiver aperture area;

- Rim angle: in the cross section of a parabolic-trough collector, is the angle between the optical axis and the line between the focus (focal point) and one of the edges of the reflector (mirror rim);

- Acceptance angle: the angular range over which all or almost all rays are accepted without moving all or part of the collector [4];

- Certification: type of certification scheme fulfilled by the collector;

- Operating pressure: pressure range that may be covered by the collector –inside the receiver- during normal operation;

- Operating temperature: temperature range that may be covered by the collector -inside the receiver- during normal operation;

- Performance: the global or overall collector efficiency or performance is the ratio of the thermal power transferred to the heat transfer fluid in the collector to the available radiant solar power [3]. If possible, the performance is indicated by the following terms: η_0 (peak collector efficiency [3]), a_1 (heat loss coefficient [5]) and a_2 (temperature dependence of the heat loss coefficient [5]).

- Stagnation temperature (non-tracking collectors): the temperature reached when stagnation persists until the losses of the solar thermal collectors equal the absorbed energy [1];

- Weather conditions for normal operation (wind speed, temperature, humidity, other specifications): description of the weather parameters at which the collector is kept in operation under safety conditions;

- Stow conditions (tracking collectors): maximum wind speed admissible during collector operation, above which the collector is sent to the stow position;

- Heat transfer medium: description of the heat transfer medium to be used inside the collector;

- Applications: typical applications susceptible to be covered by the solar collector;

- Web: web-site address;

3 Information on certification on medium temperature solar thermal collectors

In this section, the certification and standardization of the medium temperature collectors is presented.

3.1. Certification

The certification consists in confirming the characteristics of a product by a third party and its conformity to some establish standards. This process is generally done by an external testing laboratory which should have passed a process of accreditation by an accreditation entity (see Figure 1).

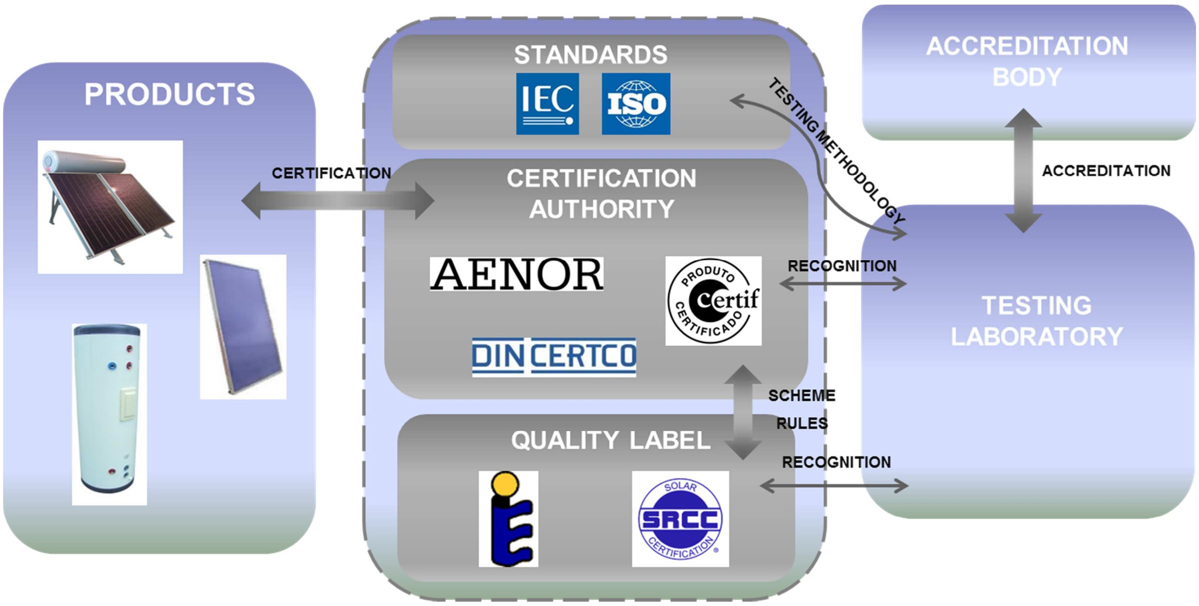

Figure 1. Certification scheme

The certification process of a solar product follows these steps:

- Audit at the factory and sample selection;
- Performance, reliability, durability and safety tests of the products by a recognized laboratory;
- Certification issued by the certification authority.

The certification labels existing for solar thermal collectors are: Solar Keymark in Europe and SRCC in United States of America.

- SOLAR KEYMARK Certification Scheme (Europe)

The aim of Solar Keymark is to reduce trade barriers and promote the use of high quality solar thermal products in the European market and beyond. The Solar Keymark is a voluntary third-party certification mark for solar thermal products, demonstrating to end-users that a product conforms to the relevant European standards and fulfils additional requirements (http://www.estif.org/solarkeymarknew/index.php). For solar thermal collectors the testing standard used is the international ISO 9806:2013 [4].

A brief description of the most important elements in the regulations and certification /subsidy schemes related to solar thermal products in several European countries can be found here: http://qaist.unidev.eu/index.php?/topic/339-country-reports/ .

- SRCC Certification Scheme (USA)

The Solar Rating & Certification Corporation currently administers a certification, rating and labelling program for solar collectors and a similar program for complete solar water heating systems in United States of America (http://www.solar-rating.org/about/purpose.html). For non-concentrating solar thermal collectors the testing standard used is the SRCC™ Standard 100-2014-07 [6] and for solar thermal concentrating collectors the SRCC™ Standard 600 2014-07 [7]. Both this standards have reference to ISO 9806:2013 [4].

3.2. Standardization

New solar thermal collectors are continually being launched on the market and submitted to national certification entities. Existing testing and characterization procedures do not always match these new products.

The main test procedures described in the standards were initially developed for conventional non-concentrating and stationary collectors. The most commonly used standards for testing solar collectors for low temperature applications were until 2013, the European Standard EN 12975-2 [8] in Europe and ASHRAE 93 [9] and ASTM E905 [10] in the USA. In different countries, other standards also exists from the national standardization committees (See Table 1), but most of those standards are also for conventional low-temperature collectors for domestic hot water and does not apply to concentrating/tracking collectors used for medium temperature applications.

Table 1. Standard for solar thermal products [11]

Country	Standard	Scope
Australia/New Zealand	AS/NZS 2712:2007	Solar and heat pump water heaters
Brazil	ABNT/NBR 10184/1988	Flat Plate solar Collectors for Liquids
Canada	CSA F378-87 (R2004)	Solar Collectors
China	GB/T 17049-2005	All glass evacuated solar collector tube
India	IS 12933:2003	Solar Flat plate Collector Part 1-5
Mexico	NMX-001	Solar collectors for water heating
South Africa	SANS 1307:2009	Domestic solar water heaters
South Africa	SANS 6211-1	Domestic solar water heaters

Within the European standard committee CEN 312 some others standards related to solar thermal products are published, as seen in Table 2.

Table 2. European Standards for solar thermal products

Standard	Title	Public. Date
EN 12975-1 [12]	Thermal solar systems and components – Solar collectors	2010
EN 12976-1 / -2 [13,14]	Thermal solar systems and components – Factory made	2006

Table 2. European Standards for solar thermal products

Standard	Title	Public. Date
	systems	
EN 12977-1 / -2 / -3 / -4 / -5 [15-18]	Thermal solar systems and components – Custom built systems (solar water heaters, combisystems, stores, combistores and control equipment)	2012
EN ISO 22975-3 [19]	Thermal solar systems and components – Solar collectors (Part 3-1: Qualification of solar absorber surface durability)	2014
EN ISO 9488	Solar energy – Vocabulary	1999

An International Standard ISO 9806-1:1994 [20] also existed in an international level since 1994. The American Standard ASTM 905 [10] is specific for concentrating solar thermal collectors. However, this last Standard does not mention the possible issues of the tracking errors on concentrators.

In the last decade, the standardization process has culminated in a single global ISO 9806:2013 standard for all heating collectors (glazed flat plate collectors and evacuated tube collectors, unglazed collectors, air heating collectors and concentrating/tracking collectors). The new ISO 9806 Standard revision also includes revised performance test conditions, and for the first time, reliability tests for concentrating/tracking collectors. This Standard was a harmonization work between different existing standards and the inputs from different working groups: standard EN 12975-2:2006 and ISO 9806-1:1994; inputs from the committee ISO TC 180; inputs from the European project QAiST (Quality Assurance in Solar heating and cooling Technology) combining most of the European testing laboratories experience; inputs from the Task 43 "Solar Rating and certification" of the IEA. Table 3 summarizes the existing standards for concentrating/tracking solar thermal collectors.

Table 3. Summary of published standards useful for concentrating/tracking solar thermal collectors

Revision year	Name	Scope
2013	ISO 9806 [4]	Glazed and unglazed, concentrating solar collectors
2010	ASHRAE 93 [9]	Concentrating and non-concentrating collectors
2001	ASTM E905-87 [10]	Tracking Concentrating Solar Collectors with C>7.

The international technical committee IEC/TC 117, created in 2012, is dealing with issues related to thermal performance and durability of concentrating/tracking CSP systems and their components considering inputs from experts of various countries. In this committee, two working group has recently been created at the end of 2014 in order to define the testing standards for PTC (future standard IEC 62862-3-2) and for LFR (future standard IEC 62862-5-2). An important issue about concentrators is the requirement of in-situ measurements in order to characterize large-size solar collectors such as

LFRs, PTCs and fixed-mirrors. For instance, it is not always feasible to perform such tests in a laboratory for this type of collectors.

Table 4. Standard drafts from the IEC TC 117 related to medium temperature

Standard Project	Title	Public. Date
prIEC 62862 - 3 – 2 [21]	Systems and components (Parabolic-Troughs)	2016-12
prIEC 62862 - 3 – 3 [22]	Systems and components (Solar Receivers)	2016-12
prIEC 62862 - 5 – 2 [23]	Systems and components (Linear Fresnel Collectors)	2017-03

Within the above standards two main collector models and test methodologies exist for accessing the collector performance. The first is based on stationary conditions were the fluid state at the collector inlet and the environmental conditions are kept constant during the test. In the second, a quasi-dynamic model accepts changing environmental conditions only imposing a constant fluid state at collector inlet. This more complete model can be reduced at reference conditions to the usual stationary model which is presented here since it allows for a fast comparison between different collector and simplified thermal output calculations.

The collector power output equation is:

$\dot{q} = A(\eta_0 G - a_1 \Delta T - a_2 \Delta T^2)$ [W]

where $\dot{q}$ is the useful power extracted from the collector [W] and the operating conditions are:

G: Solar irradiance on collector aperture plane [W/m²]

ΔT: Temperature difference between collector mean fluid temperature and ambient air temperature [K]

and the collector performance parameters:

η_0: peak collector efficiency [-]

a_1: heat loss coefficient [W/(m²K)]

a_2: temperature dependence of heat loss coefficient [W/(m²K²)]

A: collector area corresponding to the performance parameters

Besides these parameters the collector’s thermal capacity and its angular response defined as the change in the performance at non normal incidence angles (Incidence Angle Modifier) are obtained in the tests.

4 Conclusions

The present deliverable shows the work performed within the subtask 11.1.1 of European project STAGE-STE focusing on medium temperature solar collectors for industrial or distributed applications. This work has been done in collaboration with the Task 49 (SHC, IEA) [1] working group for Solar Heat Integration in Industrial Process (SHIP).

The result of this subtask is a database including all the main parameters published on the medium-temperature solar collectors found in the market. The gathered information has been revised by suppliers. The resulting database aims to give an overview of the existing technologies to system designers and end-users. The different collectors studied within this subtask were the different existing designs (PTC, LFC, parabolic dishes, ultra-high vacuum flat plate collectors, fixed-mirror, etc...) and all the main components are listed (reflectors, receiver, tracker, etc…).

39 suppliers were contacted covering in total 76 collectors. Most of the collectors, the 76%, are based on PTC, followed by the 16% of and LFC concepts (see Figure 2). Analysing gathered geometrical information and employed materials and components, it is clearly noticed that there is a lack in standardized solutions, even within the same collector's category.

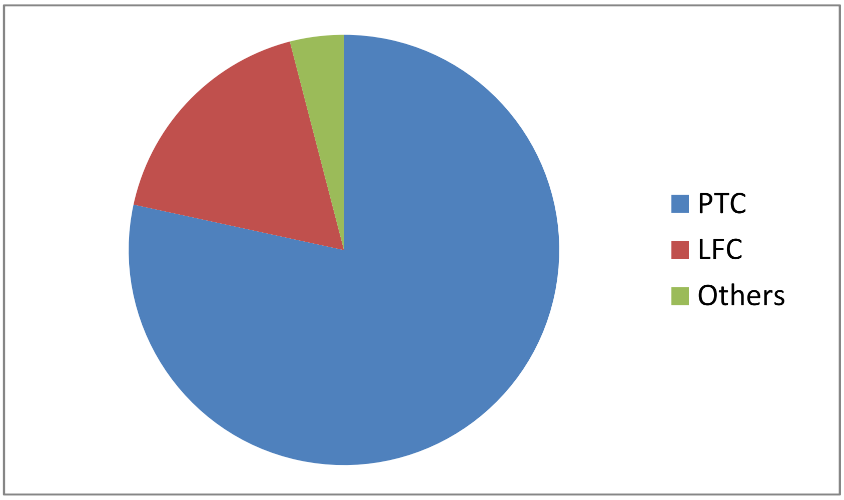

Figure 2. Medium temperature collectors database: Classification by collector type.

In this sense, considering the geometrical information on the difference collectors (sizes, focal length, geometrical concentration, rim angle, acceptance angle, etc.), there are important differences between the different collectors. The smallest collector has an aperture of 0.5 m and a length of 2.1 m and is based on the PTC geometry. On another hand, the biggest collectors are Fresnel type solutions.

When observing the employed components and materials, big differences are detected between the different collectors. This is especially visible when analysing the reflectors and the absorber tubes where several technologies are being used. Regarding the reflectors, the lack of standardized mass produced curved thick glass reflectors for this small scale concentrating collectors make that other alternative solutions, such as the aluminium and silvered-polymer reflectors, are used in many of the collectors.

Almost all the PTC does not use any glass cover on the aperture plane, protecting the reflective surfaces. Concerning the LFC, 9 of the 13 collectors listed use a secondary concentrator. With regards the receiver, more than 70% of the collectors utilize non evacuated tubes.

Finally, when discussing the applications for these collectors, most of the suppliers consider that the applications with highest potential for their collectors are industrial process heat, solar cooling, power generation with ORC and desalination. Related to this, most of the collectors use heat transfer fluids (HTF) based on pressurized water and thermal oil, depending on the temperature limitations, although some collectors can also be used in direct steam generation applications using water-vapour as HTF.

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[13] EN 12976-1:2006. Thermal solar systems and components. Factory made systems. General requirements Part 1: General requirements, Brussels: European committee for standardization (CEN); 2006.

[14] EN 12976-2:2006. Thermal solar systems and components. Factory made systems. General requirements Part 2: Test methods; Brussels: European committee for standardization (CEN); 2006.

[15] EN 12977-1. Thermal solar systems and components. Custom built systems. Part 1: General requirements for solar water heaters and combisystems. Brussels: European committee for standardization (CEN); 2012.

[16] EN 12977-2. Thermal solar systems and components. Custom built systems. Part 2: Test methods for solar water heaters and combisystems. Brussels: European committee for standardization

(CEN); 2012.

[17] EN 12977-3. Thermal solar systems and components. Custom built systems. Part 3: Performance test methods for solar water heater stores. Brussels: European committee for standardization (CEN); 2012.

[18] EN 12977-4. Thermal solar systems and components. Custom built systems. Part 4: Perfromance test methods for solar combistores. Brussels: European committee for standardization (CEN); 2012.

[19] EN ISO 22975-3 Solar energy -- Collector components and materials -- Part 3: Absorber surface durability, 2014

[20] ISO 9806-1 Test methods for solar collectors -- Part 1: Thermal performance of glazed liquid heating collectors including pressure drop, 1994

[21] prIEC 62862-3-2: Solar thermal electric plants - Part 3-2: Systems and components - general requirements and test methods for parabolic trough collectors, 2014.

[22] prIEC 62862-3-3 Solar thermal electric plants - Part 3-3: Systems and components - General requirements and test methods for solar receivers, 2014.

[23] prIEC 62862-5-2: Solar thermal electric plants - Part 5-2: Systems and components - general requirements and test methods for linear Fresnel collectors, 2014.

List of abbreviations and definitions

Acronyms

CSP	concentrating Solar Power
CHP	combined heat and power
FMSC	fixed mirror solar concentrator
IEA	International Energy Agency
LFC	linear Fresnel collectors
ORC	organic Rankine cycle
PTC	parabolic-trough collectors
QAiST	Quality Assurance in Solar heating and cooling Technology
SHC	Solar Heating and Cooling program
SHIP	Solar Heating and Cooling program
SHIP	Solar Heat Integration in Industrial Process
WP	Work Package

Symbols

A	collector area corresponding to the performance parameters
a_1	heat loss coefficient [W/(m²K)]
a_2	temperature dependence of heat loss coefficient [W/(m²K²)]
G	Solar irradiance on collector plane [W/m²]
$\dot{q}$	useful power extracted from the collector [W]
ΔT	temperature difference between collector mean fluid temperature and ambient air temperature [K]
η_0	peak collector efficiency [-]
α	absorptance [-]
ε	emittance [-]
ρ	reflectance [-]
τ	transmittance [-]

ANNEX1 Medium temperature solar collectors manufactures and models DATABASE

Nº	Manufacturer	Location	Model
1	Industrial Solar	Freiburg (Germany)	LF-11
2	NEP Solar	Zürich (Switzerland)	Polythrough 1800
3	FEROtec s.r.l	Prato (Italy)	F-PTC250
			F-PTC125
4	Soltigua	Gambettola (Italy)	PTM 18
			PTM 24
			PTM 30
			PTM 36
			FTM 18
			FTM 24
			FTM 30
			FTM 36
5	SRB energy	Almussafes (Spain)	UHV (Ultra High Vacuum)
6	Solera Sun Power / Smirro GmbH	Geislingen (Germany)	Smirro 300 Smirro TM
7	Vicot	Dezhou City, Shandong Province (China)	Vicot
8	TVP solar	Geneva, (Switzerland)	Thermal Vacuum Power Charged™
9	Sopogy	Honolulu, (Hawaii, USA)	SopoNova
			SopoHelios
			Sopotitan
			SopoFlare
10	Solitem	Aachen (Germany)	PTC1100
			PTC1800
			PTC3000
			PTC4000
11	Chromasun	San Jose (USA)	Chromasun Micro-Concentrator (MCT)
12	Inventive Power	Zapopan, Jalisco, (Mexico)	Power Trough 110
13	SLT Energy LTD.	Gujarat (India)	Sol Yatna
			Sol Spectra
14	Rackam	Sherbrooke, Quebec (Canada)	S10
			S20
15	Trivelli energy SRL	Cava Manara (Italy) Bressana Bottarone - Pavia (Italy)	SolarWing Evolution SolarWing EVO
16	Tecnología solar concentrada (TSC)	Palma de Mallorca (Spain)	CCStaR
17	Solar mirrortec	Austria	SMT 8
18	Airier Natura	Karnataka (India)	Airier Celsium250
			Airier Celsium350
19	Dr. Vetter	Baden-Baden (Germany)	IT Collect (roof integration)

20	Thermax	Pune (India)	SolPac P60
21	Abengoa solar (developed and previously manufactured by IST, USA)	Sevilla (Spain) Denver, CO, USA	PT-1 (ground-mounted version)
			RMT (roof mounted- version)
22	Absolicon Solar Concentrator	Härnösand (Suecia)	T10 (thermal version)
			MT10 (thermal version)
			X10 PVT (thermal + PV version)
23	Solarlite CSP Technology	Duckwitz (Germany)	SL2300
			SL4600
24	Koluacik	Antalya (Turkey)	SPT-0312
			SPT-0324
			SPT-0424
			SPT-0524
			SPT-0536
25	Dezhou Mingnuo	Dezhou (China)	PT-3E
26	Huayuan New Energy Project	Dezhou (China)	HY-Trough12572I-3
			HY-Trough12572E-3
			HY-Trough12574I-3
			HY-Trough12574E-3
			HY-Trough10218-3
			HY-Trough07042I-3
			HY-Trough12572I-6
			HY-Trough12572E-6
			HY-Trough12574I-6
			HY-Trough12574E-6
			HY-Trough10218-6
			HY-Trough07042I-6
27	SolarX Energy	New York (USA)	SolarX 164 (also, SolarX Hybrid and SolarX Thermal Scissor, but no information is available)
28	Solel Solar		IND-300
29	NOVATEC SOLAR	Germany	Nova-1
30	Solar Power Group		Fresdemo
31	Solar Euromed	France	Augustin Fresnel-
32	Alsolen-Alcen	France	Alsolen
33	INERSUR	Spain	LINEAR FRESNEL
34	Feranova	Germany	FRT-1
35	Ultra Conserve Pvt. Ltd		OptiTrough 300
36	Industrie-Montagen-Kornmüller GmbH	Seitenstetten (Austria)	IMK-CSP-trough
37	Millionsun Energy Co.Ltd	China	CSPT-L
38	Millenium Energy Systems	Spain	“Milenio”
39	Global CSP	UK	