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Project Deliverable 5.4:

Guidelines for Standardisation on STE

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1. INTRODUCTION

The commercial deployment of Solar Thermal Electricity (STE) plants during the first two decades of this Century has shown that there is a lack of standards for this sector, because a clear imbalance between its standardization and commercial development has become evident. However, standards are essential to foster the industrial development of any emerging technology. The *learning curve* of new technologies can be developed in a faster and more efficient manner if standards defining qualification, commissioning and evaluation procedures, as well as terminology, are available.

Due to the lack of appropriate standards EPC contractors, engineering firms, suppliers and promoters had to develop their own procedures for qualifying components and for commissioning of solar fields and solar power plants, as well as their technical specifications for tendering and quotation. This had led to the existence of many different specifications and procedures, which led to a highly unfavorable situation for further development of the STE sector. The lack of common standards and procedures caused a feeling of insecurity and distrust in many companies otherwise willing to enter into the STE market.

The different levels of expertise in the companies directly involved in the commercial deployment led to different levels of quality in the procedures thus defined, while the lack of standards specially developed for the STE sector did allow the use of sometimes very different procedures and approaches. At the same time, the changes in the Spanish legal framework regulating the installation and commercial exploitation of STE plants made companies pay more attention to these issues than to a standardization effort. This underlying deficit has affected the commercial development of the STE sector in Spain and other countries Worldwide.

Since the need for common standards became so evident, several national and international committees have been implemented to develop standards for the STE sector. The objective of this report is to show the standardization initiatives and procedures currently active to develop standards for STE components, subsystems and plants. This information will be useful for anybody willing to participate in this standardization effort, because the way how to proceed for the elaboration of new standards is explained. This report thus provides guidelines to participate in the current initiatives for standardization related to the STE sector.

2. STANDARDIZATION HIERARCHY

There are several different categories of standards depending on the geographical scope:

- National standards,
- European standards
- International standards

National standards are standards that have been developed within the framework of an official national standardization entity (e.g., AENOR in Spain, AFNOR in France, DKE or DIN in Germany, SAC in China, etc.). These standardization entities provide the framework for the elaboration of national standards, which may be related to any subject. Standardization work in these entities is developed by technical committees or sub-committees, each of which covers a

specific sector. So, a new technical committee or subcommittee is implemented when standards for a new sector are to be developed. The geographical scope of national standards is limited to the country where the standards have been elaborated, but in many cases relevant standards can be adopted in practice on a voluntary level by other countries.

CEN, alongside CENELEC and ETSI, is recognized by the European Union as a European Standardization Organization. Members are national standardization bodies. The legal framework for this cooperation is set out in EU Regulation 1025/2012, which entered into force on 1 January 2013. The European organizations bring together knowledge and expertise from its members, from business and industry and from other stakeholders, in order to develop European Standards for products, materials, services and processes. When they are correctly applied, European Standards ensure quality, performance and interoperability. They help to protect the environment, as well as the health and safety of consumers and workers.

CEN and CENELEC closely cooperate with their international counterparts, respectively the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). This close cooperation has been materialised by the signature of the Vienna Agreement (ISO-CEN) and the Dresden Agreement (IEC-CENELEC). The main objectives of these agreements are to provide a:

- Framework for the optimal use of resources and expertise available for standardization work;

- Mechanism for information exchange between international and European Standardization Organizations (ESOs) to increase the transparency of ongoing work at international and European levels.

European Standards (ENs) are documents that have been ratified by one of the three European Standardization Organizations (ESOs), CEN, CENELEC or ETSI; recognized as competent in the area of voluntary technical standardization as for the EU Regulation 1025/2012. An EN (European Standard) “carries with it the obligation to be implemented at national level by being given the status of a national standard and by withdrawal of any conflicting national standard". Therefore, a European Standard (EN) automatically becomes a national standard in each of the 33 CEN-CENELEC member countries. Standards are voluntary which means that there is no automatic legal obligation to apply them. However, laws and regulations may refer to standards and even make compliance with them compulsory.

International standards are developed within the framework of international standardization entities (e.g., ISO, IEC, etc..), which implement specific technical committees or subcommittees for the development of standards related to specific fields. Since the geographical scope of the standards developed by these entities is the entire World, the technical committees implemented for the development of a new international standard is composed of experts from different countries.

Depending on the desired geographical scope, initiatives for new standards must be addressed to national, European or international standardization entities.

3. DEVELOPMENT OF NEW NATIONAL STANDARDS FOR STE

As previously explained in section 2 of this document, development of new standards for the STE sector at national level must be addressed to one of the official standardization entities in that

country (e.g., AENOR in Spain, AFNOR in France, DKE or DIN in Germany, SAC in China, ASME, UL, ASHRAE and many others depending on the technical area in USA etc.) to create a specific standardization technical committee or sub-committee. At present, there are three countries with specific technical committees for new standards related to the STE sector: Spain, Germany and USA. However, in Germany there is no standardization activity independent on the international standardization – the national committee has been created as a mirror committee to the international committee IEC TC 117.

3.1. Development of Spanish standards for the STE sector

Spain is currently the country devoting more efforts to the development of new standards for the STE sector. This effort is coordinated by AENOR (the Spanish official standardization entity). The Subcommittee AEN/CTN 206/SC117 "*Thermoelectric Solar Energy Systems*" was created by AENOR on March 2nd, 2010, promoted by CENER, CIEMAT, PROTERMOSOLAR and TORRESOL ENERGY, to support the development of new STE standards. This subcommittee is comprised not only of renewable energy R&D Centers such as CENER, CIEMAT, CTAER, etc., but also industrial partners ranging from manufacturers to EPC providers, STE project developers, plant owners, O&M contractors, etc. The purpose of this subcommittee is to create a series of Spanish UNE Standards (UNE: Una Norma Española) that will define procedures not only to qualify components (receiver tubes, sun tracking systems, reflectors, etc.), but also subsystems (solar field and thermal storage system) and complete STE plants, based on the experience gathered during the last decades.

The development of commercial projects to install 2,3 GWe of STE plants in Spain put this country as the world leader along the whole value chain of STE technology, which covers from R&D activities up to the plant erection at the site. There are in between important sectors such as component manufacturing, EPC contractors and financing institutions. All of them missed the applicable norms and standards to have a common understanding on terminology and performances both at component and at system levels. Huge scientific challenges must be undertaken by Research Centers and by the Industry to contribute to reducing costs, increasing efficiency and enhancing reliability of concentrating solar technologies. There was therefore a real need for norms and standards in this field, and the AEN/CTN 206/SC117 "*Thermoelectric Solar Energy Systems*" subcommittee was created to tackle this challenge. This Subcommittee was included within the Technical Committee AEN/CTN 206 "Electrical Energy Production" (see Figure 1).

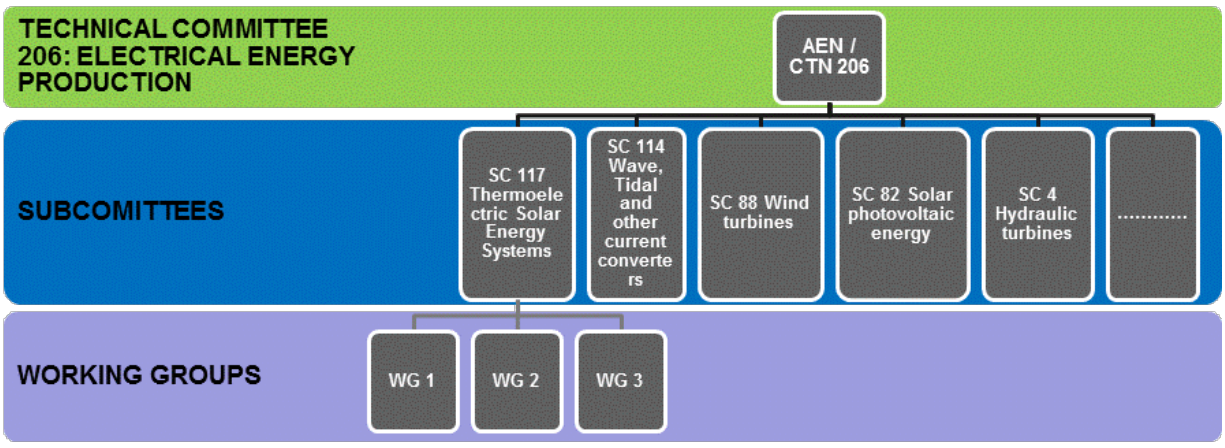

Figure 1. Organization of the Subcommittee AEN/CTN 206/SC117 "*Thermoelectric Energy Systems*".

The Subcommittee AEN/CTN 206/SC117 is composed of three Working Groups (WG1, WG2 and WG3 in Figure 1) that work in close collaboration with the participation of more than eighty experts.

WG1 and WG2 are divided into sub-groups devoted to specific subjects (typical meteorological year, terminology, STE plants, solar reflectors, flexible connections for receiver tubes, etc..). More information about the scope and activities of the three Working Groups composing the Subcommittee AEN/CTN 206/SC117 is given in the following paragraphs.

Working group WG1: This group is led by CIEMAT-PSA (contact person: Eduardo Zarza, e-mail: eduardo.zarza@psa.es) and it is composed of two subgroups:

2 Subgroup for Typical Meteorological Year (TMY): it is devoted to Terminology and Meteorological data

3 Subgroup for general issues, monitoring and commissioning of STE plants

At the time of writing this document three Spanish standards have been already prepared by this WG1 and issued by AENOR:

1 Standard UNE-206009 "Centrales termosolares. Terminología" (Solar Thermal Electric Plants. Terminology), issued in September 2013,

2 Standard UNE-206011 "*Centrales termosolares. Procedimiento de generación de Año Solar Representativo*" (Solar Thermal Electric Plants. Procedure for Generating a Representative Solar Year), issued in June 2014,

3 Standard UNE-206010 "*Ensayos para la verificación de las prestaciones de las centrales termosolares con tecnología de captadores cilindroparabólicos*" (Tests for verifying the performance of solar thermal power plants with the technology of parabolic troughs), issued in April 2015,

A new UNE standard for "*Ensayos para la determinación del rendimiento del campo solar de las centrales termosolares con tecnología de captadores cilindroparabólicos*" (Test for verifying the efficiency of solar fields with parabolic trough collectors) will also be issued in 2016 by AENOR.

Working group WG2: This group is led by CENER (contact person: Marcelino Sánchez, e-mail: msanchez@cener.com). Since its objective is the development of standards for the components of the STE plants this working group is composed of eight subgroups (see Figure 2):

1. Subgroup for receiver tubes
2. Subgroup for solar tracking systems
3. Subgroup for structures
4. Subgroup for heat transfer fluids
5. Subgroup for reflectors
6. Subgroup for joints and other components
7. Subgroup for specific sensors
8. Subgroup for collectors

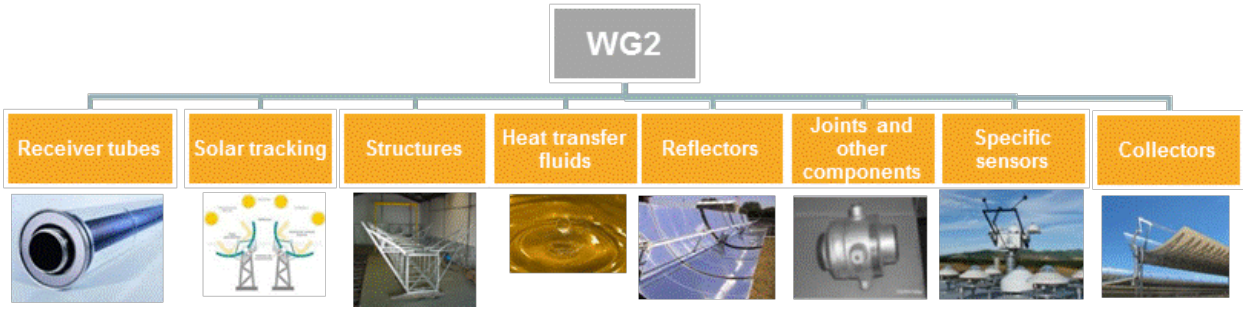

Figure 2. Organization of Working Group 2 (WG2) of AEN/CTN2016/SC117.

WG2 is creating Spanish standards UNE that will define quality control and evaluation procedures to qualify components of STE plants, making the access to this market easier to new components. Several draft standards were prepared until de end of 2015 for receiver tubes, solar reflectors and parabolic trough collector qualification. It is expected that these standards will be officially issued by AENOR in 2016-2017.

Working group WG3: Due to the relevance of thermal storage for STE plants a specific working group was implemented in AEN/CTN206/SC117 for this subject. This group is led by CIEMAT-PSA (contact person: Javier León Alonso, e-mail: Javier.leon@psa.es) and it is devoted to thermal storage system standardization for concentrating solar thermal applications. Until December 2015 a draft UNE standard defining basic criteria and guidelines to calculate the global efficiency of a molten-salt thermal storage system for parabolic-trough plants using a heat transfer fluid in the solar field has been prepared and it is expected to be issued by AENOR in 2016.

3.2. Development of German standards for the STE sector

In Germany, the technical committee DKE 374 "Solarthermische Anlagen zur Stromerzeugung" was implemented by DKE (the German official standardization entity for standardization in the electrotechnical field) as a mirror committee reflecting the international standardization of IEC/ TC-117 “Solar thermal electric plants” (see Section 4). There is no intention to develop independent national standards as the international standards shall be adopted and used.

3.3. Development of American standards for the STE sector

In USA, development of new standards related to the STE sector is taking place within the framework of ASME (American Society of Mechanical Engineers). ASME's standards are developed by technical committees – mechanical engineers and others who represent various facets of their industries, from manufacturers and installers to insurers, inspectors, distributors, regulatory agencies and end users. Expert people may participate in the development process of ASME standards regardless of nationality or residency. At present ASME offers the so-called *Performance Test Codes* (PTC), which provide uniform rules and procedures for the planning, preparation, execution, and reporting of performance test results. ASME PTCs are developed by specific technical committees and they provide protocols for establishing testing parameters and methods of measurement. They also provide mathematical examples on computing the test results and statistical methods to determine the quality of the tests by calculating the test uncertainty.

ASME has already developed 48 Performance Test Codes (PTCs), covering four main categories of equipment and systems: a) Power Production, b) Combustion and Heat Transfer, c) Fluid Handling, and d) Emissions. One of these PTC is PTC-52, which is fully devoted to "*Concentrating Solar Power Plants*" and it is under development at present. However, standardization related to thermal storage for STE plants is within the framework of PTC-53 "*Mechanical and thermal energy storage*". So, current standardization efforts for concentrating solar thermal technologies in USA are currently within the framework of PTC-52 and PTC-53. The committee staff secretary for these two performance test codes is Frederic Constantino (e-mail: constantinof@asme.org)

4. DEVELOPMENT OF NEW INTERNATIONAL STANDARDS FOR STE

Conscious of the lack of standardization in this field, the Spanish AENOR Committee launched a proposal to IEC (International Electrotechnical Commission) in 2011 for the establishment of a new IEC Technical Committee devoted to STE plants. The request was accepted –twenty countries gave a positive vote, and nine of them communicated their interest to participate actively in the standardization work. So the IEC SMB (Standardization Management Board) approved the creation of the technical committee IEC/TC 117 "*Solar Thermal Electric Plants*", allocating the secretariat to the AENOR Spanish National Committee. At the kick-off meeting of this international standardization committee, which was held in Madrid (Spain) in March 2012, its internal organization was approved and has been further developed in following annual meetings. IEC/TC117 is at the moment consisting of project teams (PT) which deal with individual projects with the aim of developing an international standard (IS) or a technical specification (TS).

At present, 12 countries are actively participating P-members of IEC/TC117 (Switzerland, China, Germany, Spain, France, Israel, Italy, Japan, Portugal, Sweden, Russia and USA), and another twelve countries are O-members (observers)- .

The chair for the TC from the beginning was Mr. Amnon Mahalel (Siemens) from Israel, who did resign in November 2014. Dr. Werner Platzer (Fraunhofer ISE) from Germany has been voted for and installed as chair in April 2015.

The secretariat of TC 117 is held by Spain, with Secretary Mr Eduardo García Iglesias and Assistant Secretary Mrs Carmen Martín Marino (e-mail: camartin@aenor.es).

The work is organized in project teams (PT) (see Figure 3·which are coordinated by a Convenor and can be initiated and proposed by national committies (NC). The project teams currently (January 2016) running are:

PT 62862-1-1	Terminology
PT 62862-1-2	Procedure for generating a representative solar year
PT 62862-2-1	Solar thermal electric plants - Part 2-1: Thermal energy storage systems - General characterization
PT 62862-3-2	Solar thermal electric plants - Part 3-2: Systems and components - General requirements and test methods for parabolic-trough collectors
PT 62862-3-3	Solar thermal electric plants - Part 3-3: Systems and components - General

requirements and test methods for solar receivers

PT 62862-5-2 Solar thermal electric plants - Part 5-2: Linear Fresnel systems - General requirements and test methods for linear Fresnel collectors

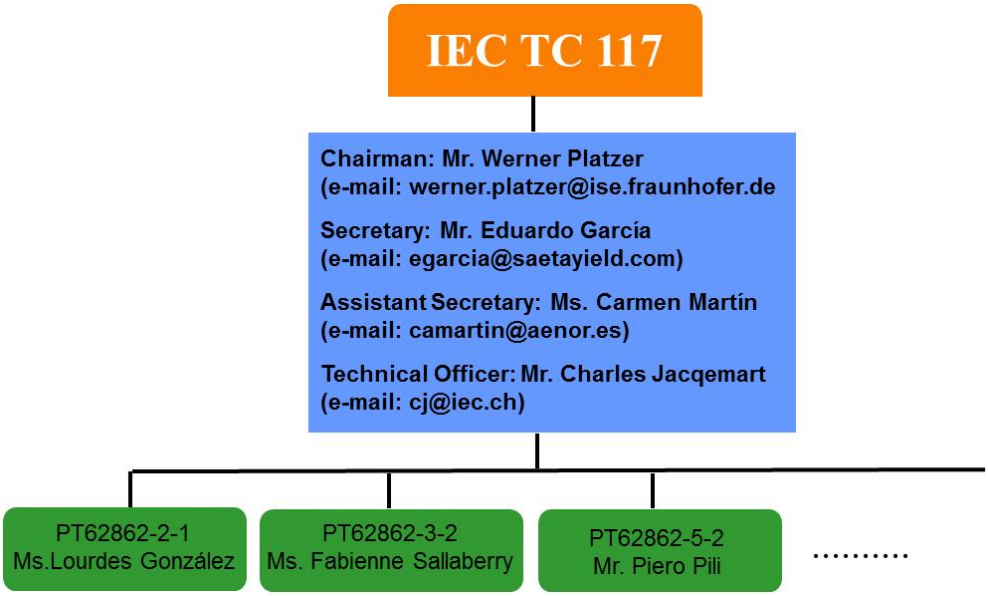

Figure 3. Actual organization of IEC/TC 117 "Solar Thermal Electric Plants".

The corresponding Convenors of these project teams are:

IEC 62862-3-2	Ms. Fabienne Sallaberry / CENER
IEC 62862-3-3	Ms. Gali Pahl / Rioglass/Israel
IEC 62862-5-2	Mr. Piero Pili/Elianto/Italy
IEC/TS 62862-1-1	Ms Lourdes Gonzalez /Ciemat/Spain
IEC/TS 62862-1-2	Mr Ibon Salbidegoitia / Meteo for Energy /Spain
IEC/TS 62862-2-1	Mr. Javier León /CIEMAT/Spain (temporary interim leader)

The general structure of the documents from TC117 has been adopted as

62862-1-X General topics
62862-2-X Thermal energy storage systems
62862-3-X Parabolic trough systems
62862-4-X Central receivers systems
62862-5-X Linear Fresnel systems
62862-6-X Parabolic dish systems

Where X is number identifying a specific standard or technical specification.

The process implemented to develop a new IEC/TC117 standard related to STE plants is the following:

1. The proposal to develop a new standard must be submitted to IEC/TC117 by any of the national standardization entities collaborating with IEC/TC117 (e.g., AENOR, AFNOR, DKE,

..). The proposal must include the Index or content proposed for the standard, as well as the name of the person who will coordinate the Project Team in charge of the development of the new standard. According with the terminology used in IEC the person coordinating a *Project Team* is called "*Convenor*". The proposal must be prepared using the form that IEC has available for this purpose.

2. Once the proposal is received at IEC/TC117, it is given a reference and distributed for voting to the national standardization entities. The national standardization entities must, in turn, inform their relevant national committees which the new standard is related to and present a vote to the secretariat of TC 117 within the time period defined by IEC/TC117. Any national committee giving a positive vote and thus supporting the development of the new standard must nominate at least one expert person to participate in the international *Project Team* that will be implemented by IEC/TC117 to develop the new standard under the coordination of the Convenor.
3. The proposal is accepted if at least three national standardization entities (in addition to that submitting the proposal) give a positive answer. In this case, a *Project Team* is implemented with all the expert people nominated by the national standardization entities during the voting process. If the proposal is approved, the *Convenor* shall undertake the coordination of the *Project Team*, defining the time schedule and actions he/she may consider convenient for a proper development of the new standard.
4. When the content of the new standard has been discussed, developed sufficiently and approved within the project team a committee draft for voting is being prepared and sent to national committees for a final 3 month public commenting period. After a positive feedback a final draft of the standard FDIS will be produced and issued for 2 month final voting. If 2/3 majority of P-members voting approve and if less than 25% of all votes submitted are negative, the international standard can be issued for official publication. The issue of the new standard by IEC is the end of the process.