GLOBAL SOLAR WATER HEATING MARKET TRANSFORMATION AND STRENGTHENING INITIATIVE

Guide on Standardisation and Quality Assurance for Solar Thermal

Acknowledgement

This publication is the result of a joint effort from the following contributors: The European Solar Thermal Industry Federation (ESTIF), the United Nations Environment Program (UNEP) through its Division of Technology, Industry and Economics (DTIE) and the Global Environment Fund (GEF).

This publication is part of the "Global Solar Water Heating Market Transformation and Strengthening Initiative" (Global Solar Water Heating: GSWH project).

More information on the "Global Solar Water Heating Market Transformation and Strengthening Initiative" (Global Solar Water Heating: GSWH project) at www.solarthermalworld.org/node/330.

Foreword

The European Solar Thermal Industry Federation (ESTIF) and the United Nations Environment Program (UNEP) through its Division of Technology, Industry and Economics (DTIE) have committed to work together on the "Global Solar Water Heating Market Transformation and Strengthening Initiative" (Global Solar Water Heating: *GSWH project*).

Funded by the Global Environment Fund (GEF), this project's goal is to accelerate the global commercialization and sustainable market transformation of Solar Water Heating (SWH), thereby reducing the current use of electricity and fossil fuels for hot water preparation. It will build on the encouraging market development rates already achieved in some GEF program countries and seek to further expand the market in other GEF program countries, where the potential and necessary prerequisites for market uptake seem to exist.

The GSWH project consists of two components as follows:

- Component 1 - Global Knowledge Management (KM) and Networking: Effective initiation and co-ordination of the country specific support needs and improved access of national experts to state of the art information, technical backstopping, training and international experiences and lessons learned.
- Component 2 - UNDP Country Programs: Work in the country programs is articulated around addressing the most common barriers to solar water heating development: policy and regulations, finance, business skills, information, and technology.

ESTIF, as one of the project's regional partners, is committed to the development of knowledge, products and services. To this effect, ESTIF has been entrusted with the task of elaborating three practical handbooks to include recommendations and best practices in the following areas which have been identified as key for strengthening the solar water heating market:

- Policy and regulatory framework
- Awareness raising campaigns
- Standardization and quality

However, ESTIF is very much aware that practices cannot simply be transposed and must be adapted to local market realities; we must consider best practices and lessons learned in all geographies and markets.

Good reading and sunny regards

The GSWH Team

Structure and Methodology

The content of the following publication is based on the experience acquired by the ESTIF extended team (secretariat staff and experts) in its role of industry association representing and promoting the solar thermal industry at European level.

In the area of standardization and quality the following major projects/initiatives can be mentioned because of their relevance:

- **ESTIF as European industry association is an accredited partner of the "Comité Européen de Normalisation (CEN)** the European standardization body. ESTIF coordinates the European industry contribution to the standardisation work via its mirror group the ESTIF Standard & certification working group
- Thanks to the financial support of the European Commission and the Intelligent Energy Europe (IEE) program, **ESTIF is the initiator of the Solar Keymark**. The Solar Keymark is the quality mark for solar thermal products based on European standards and has become a worldwide reference.
- ESTIF contributes to improved standards and supports directly the work of the **CEN Technical Committee 312 – Thermal solar systems and components** via the Intelligent Energy Europe **project QAiST.**[1] This project also contributes to international standardisation work in CEN and in the IEA Solar Heating and Cooling Program.

The guides are meant to be accessible to a "beginner" and do not take for granted basic knowledge relating to solar thermal, communication, policy and standardisation. That is also why some basic concepts are repeated and defined in different contexts e.g. the different type of solar thermal systems. An effort is made to define the concepts used and to avoid jargon.

The structure is progressive and the subject is approached from the initial assessment to the implementation phase in the three areas. This guide covers all aspects from standardisation to testing and certification.

It covers both the quality of systems and of installation. It also contains a reference and exhaustive mapping of existing standards and certification for solar thermal worldwide.

1 www.qaist.eu

Contents

1 Introduction: A growing market and the need for quality assurance

"New standards, regulations and testing procedures, coupled with appropriate labelling, could aid accelerated market uptake by building up consumer trust in the manufactured products. This is especially important for new solar technologies such as evacuated tubes and combi-systems where many manufacturers are entering the market so that discerning a quality product is difficult for the consumer. Standard testing procedures on such details as hail resistance of the solar collector panel could also enhance international trade of the technologies", IEA (2007)

Solar thermal is one of the main sources of Renewable Heat for domestic use. It is already a mature technology, although continuously developing to improve its performance while reducing costs. **The performance of a good solar thermal system relies largely on the quality of the equipment and of the installation**. Therefore, to meet the increased demand, it is important to ensure that equipments and installations both comply with adequate quality standards[1].

Even if cutting edge technology is now used in product manufacturing, it is still the **application of a relatively simple concept**: solar thermal systems use the energy of the sun to heat water. This heated water can then in turn be used to heat swimming pools, provide domestic hot water or space heating or even feed thermally driven cooling systems and industrial processes.

It is hence somewhat surprising that consumers are usually unaware of the performance currently achieved by solar thermal systems. Indeed, even if it was possible to have a basic home-made solar water heater, today's technically-advanced solar thermal systems can supply a considerable share of a family's hot water and/or space heating needs or even provide process heat at temperatures above 200 °C to a factory.

It is a technology with a great potential, but which has its own specificities in terms of application. If we take the example of a simple solar water heater, it is fairly obvious that, in its operation and application; it has a lot in common with other water heating technologies. It is, of course, easier and safer to deal with solar than with a gas water heater. Nonetheless, it has other more complex requirements, such as the hydraulic components of a system.

Solar thermal systems vary, mainly according to the type of system, collector mounting and kind of application. The most common systems for domestic use are thermosiphon and forced circulation.

Thermosiphon systems, as represented in figure 1, are the easiest to install as they are based on natural convection, i.e. do not require electricity to drive pumps or control units, the storage tank being installed above the collector. They are widely used for domestic hot water supply in warmer climates with ambient air temperatures generally above zero degrees (e.g.: Brazil, Australia, North and South Africa, Asia and in Mediterranean countries).

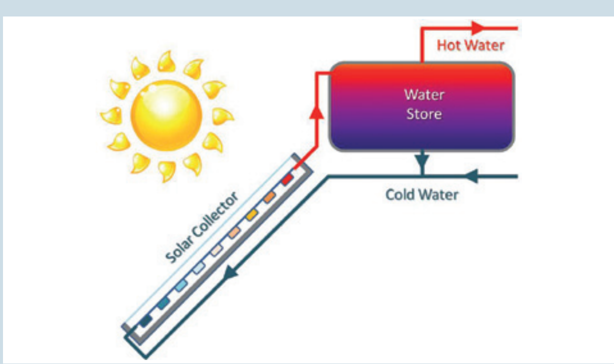

Figure 1
Schematics of a thermosiphon system

1 Adequate in the sense that quality standards need to be developed to provide assurance to the consumer while taking into account the context (product, technology, socio-economic factors, …)

Forced circulation systems are more complex as pumps are used to circulate water between collectors on the roof and storage tank located inside the house. These systems can also cover space heating (solar combi systems) and are more common in colder climates (e.g.: US, Canada, Germany).

Systems solely used for domestic hot water are usually smaller and less complex both to install and operate than systems also providing space heating.

The most common type of application of solar thermal systems is for domestic hot water (DHW) heating (different solutions represented in Figure 2). The relatively constant all-year round demand for hot water can be met by solar energy, although a conventional backup system using e.g. gas, oil or electricity might be required.

Figure 2
Individual dwellings with common solutions for solar water heating: forced circulation (left) and thermosiphon system (right), using either evacuated tubes or flat-plate collectors, J. Seco / ESTIF

In recent years, space heating has become more prevalent and now accounts for approximately half the newly installed solar thermal collector area in countries such as Germany and Austria. The demand on space heating is higher in winter when solar energy is less available and, therefore, ordinary solar thermal systems can only meet part of this demand while the remainder is covered by a back-up system.

Solar heating of outdoor swimming pools (figure 3) is very common in some countries, e.g. USA. Heating of outdoor swimming pools can be done quite efficiently using simple uncovered collectors due to the low temperature requirement of this application. In general, other applications require higher temperatures and therefore collectors with higher performances are required, such as flat-plate collectors (with a transparent cover) or evacuated tubular collectors.

Figure 3
Unglazed collectors for swimming pool heating, Blozoen/ESTIF

These applications are the most common ones. Still, solar thermal covers several other types of applications that have undergone big developments in recent years, such as: solar assisted district heating, solar process heat for industry, thermally driven cooling (using solar heat); solar desalination or solar drying. An example of a larger installation is provided in figure 4.

Figure 4
Large installation using flat-plate collectors, Solahart/ESTIF

The market for all these various applications has developed at an incredibly fast pace over recent years, as demonstrated in figure 5. The technology is reaching a growing number of consumers in more countries than ever before. Consequently, more people are involved in business activities directly or indirectly related to the solar thermal sector. As more countries turn to this technology, a growing number of players are entering the market, at local, national or international level.

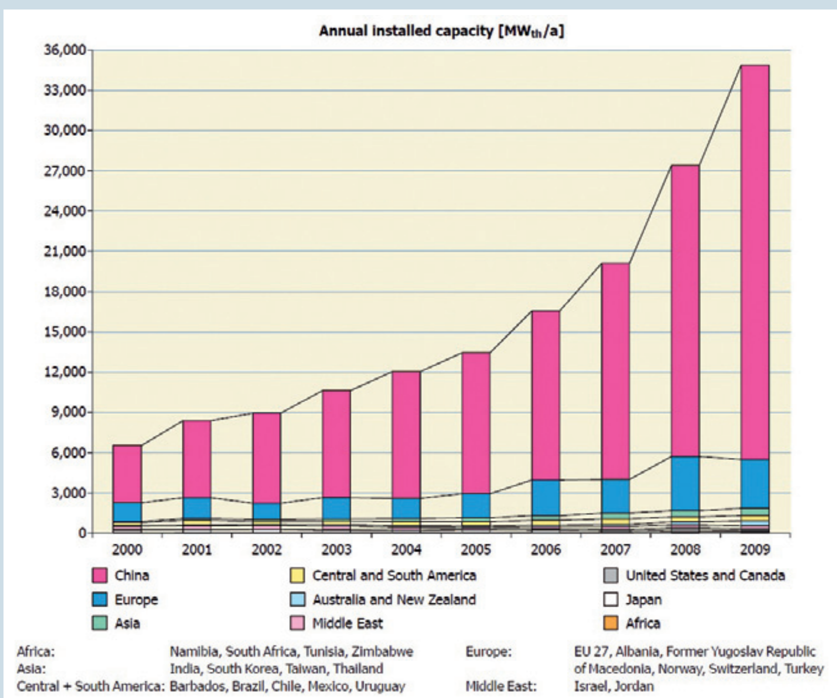

Figure 5
Annually installed capacity of flat-plate and evacuated tube collectors from 2000 to 2009
Source: Solar Heat Worldwide, Markets and Contribution to the Energy Supply '09 (2011), IEA Solar Heating & Cooling Programme

This is partly because it is relatively easy to enter the market as there are only few barriers to entry. Only a low level of investment is required to start a small production plant for flat-plate collectors and simple hot water stores with an easily adopted technology. Besides, in most markets, there are currently only a few rigorous requirements in place.

On one hand, the absence of serious product requirements presents great advantages. One of these advantages would be economic growth (and resulting job creation) generated at local level. Whereas, on the other hand, the market may be swamped with unregulated small businesses, only competing thanks to low-prices & low-quality products. Even when companies decide to import goods, there is a potential threat to quality assurance, as imported products can "appear" to be of poor quality and be difficult to distinguish from high quality products. Unfortunately, such companies may also fail to provide adequate information and support to installers and consumers.

The range of applications, solutions and alternative configurations in the solar thermal market is already quite impressive. However, all these are not always of the highest quality, nor are they supplied with the right information and level of service. Consequently, it becomes harder for consumers to choose appropriate products and also more difficult for installers to have adequate knowledge of all the products on the market.

In some markets, low quality products and installations have already undermined consumers and professionals' confidence in solar thermal technology. Once this confidence has gone and the damage done, it is very hard for a market to recover. Potential consumers will hear from friends or the media about problems occurring in different systems. Even if the number of negative examples is small, its impact on the technology's reputation will exceed by far the positive experiences. Customers will become suspicious of these products and of people and companies offering them. As a result, professionals "run away" from this activity, opting for alternative products (gas or electrical water heaters, boilers or even other renewable energy solutions).

This raises an important question: how can we convince customers and professionals, as well as authorities, that the product they are dealing with is of the adequate quality?

Professionals must be able to trust the information provided to them by their suppliers. This information must be clear, correct, address the main requirements demanded from a product and withstand comparison. Similarly, consumers ought to be able to trust both the product and the installer; and be in a position to weigh up what is stated in terms of system's reliability and performance.

For public authorities it is essential that only products fulfilling minimum requirements related to thermal performance, durability, reliability and safety are considered suitable with regard to legal instruments such as e.g. renewable energy sources acts or incentive schemes.

In different situations, different markets and for different products, including solar thermal, the answer has been to have recourse to standardization and certification.

2 Ensuring safety, durability and performance

Rising living standards throughout the world have led to more demanding requirements from consumers and markets for any kind of product. Some of these requirements are subject to government regulations in response to some complaints from consumers concerning a specific product characteristic. Often, the industry chooses to self-regulate to be in a better position to deal with increasingly demanding consumer requirements.

SAFETY is an important issue and this has resulted in both tougher regulations and self-regulation by the industry. For example, in the European Union this has been the subject of regulations at supra-national level, based on European directives related among others, to specific safety aspects. Therefore, in all EU member states the CE-Marking[2] of products is mandatory. In the United States, the dangers associated with some products have cost millions of US dollars in court cases which have led the industry to self-regulate further, mainly to prevent such actions. The safety requirements may go beyond the usage of the product and may apply to the manufacturing process, reducing risks related to different production stages.

Another important aspect is DURABILITY. Consumers are increasingly asking for value for money, this also means that a product should last. This has created an interesting dichotomy in the market. Of course, companies will try to satisfy their customers in the hope of further sales but, on the other hand, the production of longer lasting products may jeopardize future sales to the same customer. Other options are used in order to induce consumers to buy new products, be it technological developments, design and functionality. However, one component remains crucial: durability. A customer wants to purchase products with a reasonable “life time expectancy”, as a minimum period of use is required for a sound investment. Therefore, labelling a product as complying with quality standards facilitates its marketing by conferring it a guarantee of durability within given parameters, while allowing companies to differentiate and add value to their products on the basis of other characteristics.

Finally, the PERFORMANCE of a product is important to the consumer. In several countries aggressive advertising strategies are allowed, making direct comparisons between products, as is the case in the US. Even in markets where this practice is forbidden or not well perceived, it is currently used within the distribution networks. So how trustworthy are the performance figures provided? And how reliable are the comparisons between different products? It must be clear that performance testing was done under similar conditions, including the same parameters and appropriate instruments, so that products’ performance can be compared fairly.

One of the solutions to meet the need for such regulations is international standardization. “Standardization encourages customer confidence, market growth and technological development. This gives access to cutting-edge technology, improving innovation capability, and effective and profitable competition through factors such as product differentiation.”[3]

International standardization aims at developing standards (for products and services) which can be adopted in a large number of countries. Standardization is also implemented at sub-international level (e.g. by means of European Standards) and on national level. Standardization is the process of establishing criteria and methods by common agreement which are then transposed into a technical document designed to be used as a rule, guideline or definition.

2 The CE marking (abbreviation of “Conformité Européenne” in French which means “European Conformity” in English) is a mandatory conformity mark for products placed on the market in the European Economic Area. As defined in the CE Marking Directive (93/68/EEC).
3 CEN/CENELEC

International standards need to meet specific criteria. According to WTO (World Trade Organisation) the criteria that define a globally relevant standard are:

- Effectively respond to regulatory and market needs (in the global marketplace)
- Respond to scientific and technical developments in various countries
- Not distort the market
- Have no adverse effects on fair competition
- Not stifle innovation and technological development
- Not give preference to characteristics or requirements of specific countries or regions when different needs or interests exist in other countries or regions
- Be performance based as opposed to design prescriptive

It is a consensus building process and this consensus is achieved by bringing together different stakeholders having a particular interest in the development of a standard for a specific product, process or service. Therefore, the standard shall reflect the views and concerns of these stakeholders, ensuring via the standardization process that their expectations for basic requirements are met, be it product safety, durability, performance or other requirements.

2.1 The complementing roles of product standards, testing and certification

The standardization process is important but is not enough by itself. There are complementarities to testing and certification processes that need to be considered.

As referred above, a STANDARD is designed to be used as a rule, guideline or definition.
There can be two main categories:

- Technical standards: consisting of technical specifications or other strict criteria that ensure products, manufacturing processes and services meet fixed quality benchmarks. Furthermore test methods are usually part of technical standards. These test methods are used to check if requirements specified in the standard(s) are fulfilled and also to determine certain product characteristics such as e.g. performance.
- Management and leadership standards: provide a framework for a business to manage its business processes and activities (Quality Management Standards)

Some of these standards are voluntary. In some cases they are made compulsory, as they are included in specific regulations, e.g. with regard to safety aspects or for example in the construction industry. Technical regulations applicable to the building sector are based on existing standards, making these compulsory.

While standards indicate technical guidelines for a product, process, etc., it is imperative to check whether those requirements are fulfilled by a product. This is the role of TESTING. A standard for a product can only be successful if it is taken on-board by the industry that will generate demand for testing according to those specifications. Following that demand more testing centres will offer such services within their portfolio.

In the case of solar thermal, the specificities of the product and of the existing standards led to the creation of specialized testing laboratories or testing centres respectively for these products, providing an alternative to self-testing by manufacturers.

Apart from this, a challenge subsists. How to sell to the market the compliance of the product with standards in a clear and user-friendly way? The answer is product (or services) certification.

A company can obviously opt to self-certify their products. This means that they state to their customers a given performance of their product or the compliance of the product with specific standards. This is obviously an option often chosen by companies as a marketing tool to stress particular characteristics of their products.

To complement this self-certification there are third-party certification schemes available for different sectors, solar thermal included. Such certification schemes allow for an easier identification of compliance with quality requirements, by sanctioning the use of quality labels.

These quality labels are usually voluntary, although they can be recognized or even requested by public authorities, e.g.: for a public tender, to provide public funding within a given support scheme for solar thermal products or to make the product eligible with regard to legal requirements such as e.g. solar ordinances. The certification process involves compliance with existing standards, besides additional rules defined by the certification scheme.

For instance, both SRCC [18] and Solar Keymark [17] insist that a product tested is selected randomly, while this is not the case for the relevant standards (see examples below). This is in line with a main feature of such certification schemes: to assure the consumer that the product he/she is buying is similar to that tested.

For end-users, this certification process provides a greater assurance since the certified product shows proven quality and performance characteristics. This is because it has undergone rigorous tests, complied with the acceptance criteria of the standard requirements and that the compliance was verified by an independent certification body.

The scope of such a third-party certification extend beyond building customers' confidence, in that it may contribute to the creation of distributors or installers' guarantees, or even be used for insurance purposes, apart from the advantages for public authorities referred to above.

Evolving from the development of standards to a certification process

United States **SRCC – Solar Rating and Certification Corporation**
"The modern solar industry was founded in 1974, following the original oil embargo of the previous year. In the years that followed, energy in all its forms became a national priority. While commercial and residential solar thermal systems were available on a limited regional basis, a mechanism had to be put in place that would encourage consumers to purchase these relatively unknown products and new technology with confidence, showing that the technology was valid and that the products would perform in terms of energy and dollar savings. States with potentially large solar markets, such as California and Florida, were the first to establish such a mechanism by establishing state testing and rating programs for solar collectors. However, since there was little consistency between each state's testing requirements and approach to rating solar equipment, such programmes soon became an impediment to manufacturers who marketed in more than one state. It became evident that there was a need for a single, national programme that would allow manufacturers to rate and test the efficiency of their equipment. This would also benefit consumers by providing a uniform, national approach for rating and comparing solar equipment. In an unprecedented move, the trade association for the solar energy industry and a national consortium of state energy offices and regulatory bodies collaborated to lay the groundwork for such a program, which would soon lead to the founding of the Solar Rating & Certification Corporation (SRCC)."

Europe **SK – Solar Keymark**
"In the 1990s the solar thermal market in Europe started to grow considerably, in part due to financial support programmes in various countries. From the beginning to the end of the decade, the European market grew quickly from 250.000 kWth to over 800.000 kWth of newly installed capacity per year. Many companies started exporting their products into other European countries but found hurdles in the form of different requirements in the incentive programmes that became an obstacle to market entry. As a result, if a company wanted to sell one collector or system to different countries in Europe, it had to undergo several different tests and gain additional certificates and approvals. This process was extremely complicated, expensive and cumbersome and hindered the development of solar thermal in Europe and the growth of the solar thermal market and of the manufacturers. As a first step European standards for solar thermal products were elaborated in the period from 1995 to 2000. With the implementation of theses European standards in 2001 national standards existing in several countries were withdrawn. The pan-European standardisation paved the way for pan-European certification. In 2003 the European Solar Thermal Industry and major testing institutes formulated the Solar Keymark Scheme rules as a unified and simple solution in order to get solar thermal products recognised based on the same documents all over Europe. This work, considering its European relevance, was co-financed by the European Union. Today the Solar Keymark is a successful scheme and more than two thirds of the collectors sold had Solar Keymark. Testing, inspection and certification were now organized into a single streamlined process and Solar Keymark is recognised by authorities all over Europe."

Table 1: Evolution of two certification schemes for solar thermal prodcuts

2.2 Important product standards

The development of standardization and certification differs around the world. Many countries still lack any sort of standards aimed at solar thermal products.

It should be noted that solar thermal standards are mostly testing standards. In other sectors, there are product standards specifying how a product has to be built (e.g. certain minimum sizes, materials to be used, etc....). In the case of solar thermal this is not currently the case and standards detail how testing methods should be applied to such products.

2.2.1 Solar Thermal Collectors

Standards applying to collectors are the most advanced, currently several standards exist at international level. Historically, a US ASHRAE standard (93-77) was the first to be widely used. Then the ISO 9806 series of standards was developed and from this, the European standard series EN 12975. Several national standards are also available, most often based on the ISO 9806.

The ASHRAE/ANSI standards (US) for collectors are quite well established, including air collectors, and are more advanced than those in other countries of the region. In Europe the standard series EN 12975 replaced all national standards throughout the European Union countries and is also used by other countries. Recently, the EN standards have been evolving to a greater extent. In Australia and New Zealand there is also a long tradition in terms of standardization, with the long-standing AS/NZS 2712 in the solar thermal field.

At present (2012) the International Standards Organisation (ISO) and the European Committee for Standardization (CEN) are revising the ISO 9806 incorporating new information gained during the development of the EN 12975 standard.

The following table provides an overview of standards related to solar thermal collectors.

Standards related to Solar Thermal Collectors:

Country(ies)	Standard	Description
Australia/New Zealand	AS/NZS 2712:2007	Solar and heat pump water heaters - Design and construction
Brazil	ABNT/NBR10184/1988 EN 12975 ANSI/ASHRAE 93-2003 ANSI / ASHRAE 96-1980 RA1989 ASTM E 823-81 FSEC-GP-5-80 Jan 1985	Flat Plate solar Collectors for Liquids
Canada	CSA F378-87 (R2004)	Solar Collectors
Canada	CSA F378-87 (R2004)	Solar Collectors
China	GB/T 17049-2005	All glass evacuated solar collector tube
China	GB/T 17581-1998	Evacuated tube solar collector
China	GB/T 6424-1997	Specification for flat plate solar collectors
European Union	EN 12975-1:2006	Thermal solar systems and components - Solar collectors - Part 1: General Requirements
European Union	EN 12975-2:2006	Thermal solar systems and components - Solar collectors - Part 2: Test methods
European Union	prEN12975-3-1	Qualification of solar absorber surface durability
India[4]	IS 12933:2003	(IS 1516) Solar Flat plate Collector Part 1-5
International	ISO 9806-1	Test methods for solar collectors - Part 1: Thermal performance of glazed liquid heating collectors including pressure drop
International	ISO 9806-2	Test methods for solar collectors - Part 2: Qualification test procedures
International	ISO 9806-3	Test methods for solar collectors - Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop
Mexico	NMX-001:	Solar energy – thermal performance and functionality of solar collectors for water heating – test methods and labelling
South Africa	SANS 1307:2009	Domestic solar water heaters
South Africa	SANS 6211-1	Domestic solar water heaters Part 1: Thermal performance using an outdoor test method
South Africa	SANS 6211-2	Domestic solar water heaters Part 2: Thermal performance using an indoor test method
United States of America	ASHRAE 93-2010	Methods of Testing to Determine the Thermal Performance of Solar Collectors (ANSI approved)
United States of America	ASTM E905-87 (2007)	Standard Test Method for Determining Thermal Performance of Tracking Concentrating Solar Collectors

Table 2: List of standards related to solar thermal collectors existing in the main solar thermal markets (non-exhaustive)

4 The BIS operates a scheme for testing and inspection of solar flat plate collectors, based on IS 12933:2003, whereby the manufacturers are required to apply to BIS for obtaining the license to mark their product with ISI. The manufacturers whose product has been certified by BIS in conformity with the relevant Indian Standard are eligible to get support under various MNRE programs.

2.2.2 Comparing existing standards

Most of the existing standards for solar thermal products are mainly testing standards[5]. Therefore these standards provide guidelines for procedures to be followed when testing solar thermal products.

The following tables provide an overview and comparison of the requirements described in some of the solar thermal standards commonly used today. These compare testing requirements related to: High temperature resistance, Exposure, External thermal shock, Internal thermal shock, Rain penetration, Impact resistance and Mechanical Load[6].

High temperature resistance

Standard	Test procedure
EN 12975-2	Collector A minimum 1 h with G > 1000 W/m² and ambient temperature 20 – 40 °C, wind speed < 1 m/s
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A minimum 1 h with G (W/m²): class A) 950 - 1049 ; B) 1050 - 1200 ; C) > 1200 , ambient temperature (°C): A) 25 - 29,9 ; B) 30 - 40 ; C) > 40 wind speed < 1 m/s
Standard 100-8	no procedure specified
CAN/CSA-F378-87	Collector A minimum 1,5 h with G (I) = 950 + 5*(30-Tamb) W/m², wind speed < 5 m/s
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A according to ISO 9806-2
AS/NZS 2712	Collector A performance according to AS/NZS2535.1 Gmean = 1050 W/m² with max 20 W/m² deviation at 6 points Tamb > 30 °C (Level 1) / >38 °C (Level 2), 12 h irradiation on / 12 h irradiation off for 10 days

Table 3: Comparison of testing requirement for solar thermal collectors with regards to high temperature resistance

Exposure

Standard	Test procedure
EN 12975-2	Collector A according to ISO 9806-2 Class A (Template)
	30 days with H > 14 MJ/m²
	30 h with G >850 W/m² and Tamb >10°C
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A, B, C
	30 days with H (MJ/m²)>: A) 14 ; B) 18 ; C) 20
	30 h with G (W/m²)>: A) 850 ; B) 950 ; C) 1050
	and Tamb (°C) >A) 10 ; B) 15 ; C) 20
Standard 100-8	Collector A 30 days with G > 17 MJ/m²
CAN/CSA-F378-87	Collector A, first the collector will be filled according to Ba / Bb / Bc drain and close. Exposition phase started after closing of pipes 30 days with G > 17 MJ/m²
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A according to ISO 9806-2
AS/NZS 2712	no procedure specified

Table 4: Comparison of testing requirement for solar thermal collectors with regards to Exposure

5 Only a few standards such as e.g. the European Standards EN 12975-1, EN 12976-1 and EN 12977-1 specify requirements related to the product.
6 This information was compiled on the framework of the European project QAiST: Quality Assurance in Solar Heating and Cooling Technology, co-financed by the European Union, under the Intelligent Energy Europe Programme.

External thermal shock

Standard	Test procedure
EN 12975-2	Collector A 2 times according to ISO 9806-2 Class A minimum 1 h with G (W/m²) and Tamb (°C) as in 30 h exposure
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A 2 times minimum 1 h with G (W/m²) and Tamb (°C) as in 30 h exposure
Standard 100-8	Collector A 3 times according to ISO 9806-2 Class B minimum 1 h with G >950 W/m² and Tamb > 15°C
CAN/CSA-F378-87	no procedure specified
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A according to ISO 9806-2
AS/NZS 2712	no procedure specified

Table 5: Comparison of testing requirements for solar thermal collectors with regards to external thermal shock

Internal thermal shock

Standard	Test procedure
EN 12975-2	Collector A 2 times according to ISO 9806-2 Class A minimum 1 h with G (W/m²) and Tamb (°C) as in 30 h exposure
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A 2 times minimum 1 h with G (W/m²) and Tamb (°C) as in 30 h exposure
Standard 100-8	Collector A 1 time according to ISO 9806-2 Class B
	minimum 1 h with G >950 W/m² and Tamb >15 °C
CAN/CSA-F378-87	Collector A 1 time minimum 1 h with G >900 W/m²
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A according to ISO 9806-2

Table 6: Comparison of testing requirement for solar thermal collectors with regards to internal thermal shock

Rain penetration

Standard	Test procedure
EN 12975-2	Collector A, Test duration 4 h
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A, Test duration 4 h
Standard 100-8	no procedure specified
CAN/CSA-F378-87	Collector A, Test duration 30 min.
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A according to ISO 9806-2
AS/NZS 2712	Collector A 10 min. rain penetration, 4 h drying with shaded aperture

Table 7: Comparison of testing requirement for solar thermal collectors with regards to rain penetration

Impact resistance

Standard	Test procedure
EN 12975-2	Collector A according to ISO 9806-2 or with 7.53 g ± 5% mass and 25 mm ± 5% diameter ice ball 10 times with 23 m/s ± 5%
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A or B max. 5 cm from the edge max. 10 cm from the corner. Steel ball 150 gram ± 10 g each 10 times at
	0,4 / 0,6 / 0,8 / 1,0 / 1,2 / 1,4 / 1,6 / 1,8 / 2,0 meter in height
Standard 100-8	Collector A according to ISO 9806-2 for none tempered glass
CAN/CSA-F378-87	no procedure specified
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A according to ISO 9806-2
AS/NZS 2712	Collector A - no glass pieces > 50 mm with ice ball according to EN 12975 with steel ball 63 gram at 2.9 m height, 3 different positions, 150 mm from corner or edge

Table 8: Comparison of testing requirement for solar thermal collectors with regards to Impact resistance

Mechanical Load

Standard	Test procedure
EN 12975-2	Collector A minimum: minimum positive load 1000Pa and, minimum negative load: 1000 Pa
ISO 9806-1	no procedure specified
ISO 9806-2	no procedure specified
Standard 100-8	no procedure specified
CAN/CSA-F378-87	Collector A + 1500 Pa, - 2000 Pa
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	no procedure specified
AS/NZS 2712	Collector A positive and negative load

Table 9: Comparison of testing requirement for solar thermal collectors with regards to Mechanical Load

Thermal performance

Standard	Test procedure
EN 12975-2	Collector B, pre-conditioning 5h with G > 700 W/m², Steady State (minimum global irradiation G >700 W/m², diffuse fraction < 30 %, Wind speed 2 - 4 m/s. Volume flow 0.02 kg/(s*m²), deviation mass flow ± 1%, deviation inlet temperature ± 0.1 K, Tout-Tin >1 K, deviation Irradiation ± 50 W/m², Tm-Tamb at η0 ± 3K) or Quasi-Dynamic Testing (Wind speed 1 - 4 m/s. Volume flow 0.02 kg/(s*m²), deviation mass flow ± 1%, deviation inlet temperature ± 1 K, Tout-Tin >1 K)
ISO 9806-1	Collector A, tilt-angle latitude ± 5° but not less than 30°, diffuse fraction < 20 %. Collector area: 0.1 % accuracy, minimum global irradiation G >800 W/m². Wind speed 2 - 4 m/s. Volume flow 0.02 kg/(s*m²), max. drift ± 10 %, deviation mass flow ± 1%, deviation Irradiation ± 50 W/m². Deviation Tamb ± 1 K, deviation inlet temperature ± 0.1 K. Tout-Tin >1.5 K, Tm-Tamb at η0 ± 3K. Conditioning phase minimum 15 min and measurement phase minimum 15 min.
ISO 9806-2	Collector A according to ISO 9806-1
Standard 100-8	Collector A, 5 minutes measurement points / 0.07 g/(s*m²) according to ISO 9806-1
CAN/CSA-F378-87	Collector A according to ANSI/ASHRAE
ANSI/ASHRAE standard 93	Minimum global irradiation G >800 W/m², deviation irradiation ± 32 W/m², diffuse fraction < 20 %. Max. Tamb 30 °C. Wind speed 2.0 - 4.0 m/s, volume flow 0.02 g/(s*m²). deviation inlet temperature ± 2% or 1°C deviation mass flow ± 2% or 0.000315 l/s. Deviation Tamb ± 1,5 K. Conditioning phase 2*times constant or minimum 10 minutes. Measurement phase minimum 0.5*times constant or minimum 5 minutes.
AS/NZS 2735.1	Collector A, tilt-angle latitude ± 5° but not less than 30°, diffuse fraction < 20 %. Collector area: 0.1 % accuracy, minimum global irradiation G >800 W/m². Wind speed 2 - 4 m/s. Volume flow 0.02 kg/(s*m²), max. drift ± 10 %, deviation mass flow ± 1%, deviation Irradiation ± 50 W/m². Deviation Tamb ± 1 K, deviation inlet temperature ± 0.1 K. Tout-Tin >1.5 K, Tm-Tamb at η0 ± 3K. Conditioning phase minimum 15 min and measurement phase minimum 15 min.
AS/NZS 2712	no procedure specified

Table 10: Comparison of testing requirement for solar thermal collectors with regards to thermal performance

Final inspection

Standard	Test procedure
EN 12975	Collector A
ISO 9806-1	no procedure specified
ISO 9806-2	Collector A, B, C
Standard 100-8	Collector A
CAN/CSA-F378-87	Collector A
ANSI/ASHRAE standard 93	no procedure specified
AS/NZS 2735.1	Collector A
AS/NZS 2712	no procedure specified

Table 11: Comparison of testing requirement for solar thermal collectors with regards to final inspection

2.2.3 Solar Thermal Systems and Components

Systems and system components, other than collectors, are at very different stages in the standardization process. There is progress for systems in Europe, with European standards series covering Factory-Built Systems (EN12976) and Custom-Built Systems (EN 12977). The latest standards also include components, such as stores and controllers.

The European standards are well established not only inside Europe but also in some countries beyond (e.g. Tunisia) but it is still unclear how the international harmonization of standards applicable to systems will evolve. Latest ISO developments show that there is a common will to increase efforts towards enhanced international cooperation. This is seen in the latest revision of ISO/DIS 9459-4[7] aiming at some harmonization with the EN 12977 series.

Country(ies)	Standard	Description
Australia/New Zealand	AS/NZS 2712:2007	Solar and heat pump water heaters - Design and construction
Canada	CSA F379-09	Packaged Solar Domestic Hot Water Systems (liquid-liquid heat transfer)
China	GB/T 19141-2003	Specification of domestic solar water heating system
European Union	EN 12976-1:2006	Thermal solar systems and components - Factory made systems - Part 1: General Requirements
European Union	EN 12976-2:2006	Thermal solar systems and components - Factory made systems - Part 2: Test methods
European Union	EN 12977-3:2008	Thermal solar systems and components - Custom built systems - Part 3: Performance test methods for solar water heater stores
European Union	EN 12977 2:2011	Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems
European Union	EN 12977-4:2012	Thermal solar systems and components - Custom built systems - Part 4: Performance test methods for solar combistores
European Union	EN 12977-5:2012	Thermal solar systems and components - Custom built systems - Part 5: Performance test methods for control equipment
International	ISO 9459-5	Solar heating -- Domestic water heating systems - Part 5: System performance characterization by means of whole-system tests and computer simulation
Mexico	NMX-003	Solar energy – minimal requirements for the installation of solar thermal systems for water heating
Mexico	NMX-004	Solar energy – thermal assessment of solar thermal systems for water heating – test methods
South Africa	SANS 9459-2	Solar heating - Domestic water heating systems Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems

Table 12: List of standards related to solar thermal systems in different countries (non-exhaustive)

7 ISO/DIS 9459-4 "Solar heating -- Domestic water heating systems -- Part 4: System performance characterization by means of component tests and computer simulation"

2.2.4 **Other relevant standards**

There are other standards relevant to the solar thermal sector which, for example, cover issues related to terminology and definitions (e.g. ISO 9488: Solar energy - vocabulary), to installation or to the calculation of energy requirements. Further information is available in the annex document "Solar Thermal Standards Worldwide".

Matters relating to installation and maintenance will be addressed in chapter **V. Quality of planning, installation, maintenance**.

2.2.5 **Towards International Harmonization**

As mentioned earlier, there are ongoing efforts towards the harmonization of (international) standards for solar thermal products. Within the International Energy Agency Implementing Agreement for Solar Heating and Cooling (IEA-SHC) a task was initiated in 2009 to deal with these specific matters: IEA-SHC Task 43 - Solar Rating and Certification Procedure [19]. The Task's objective is to create a global framework for coordinating and harmonizing standards as well as testing and certification procedures used worldwide.

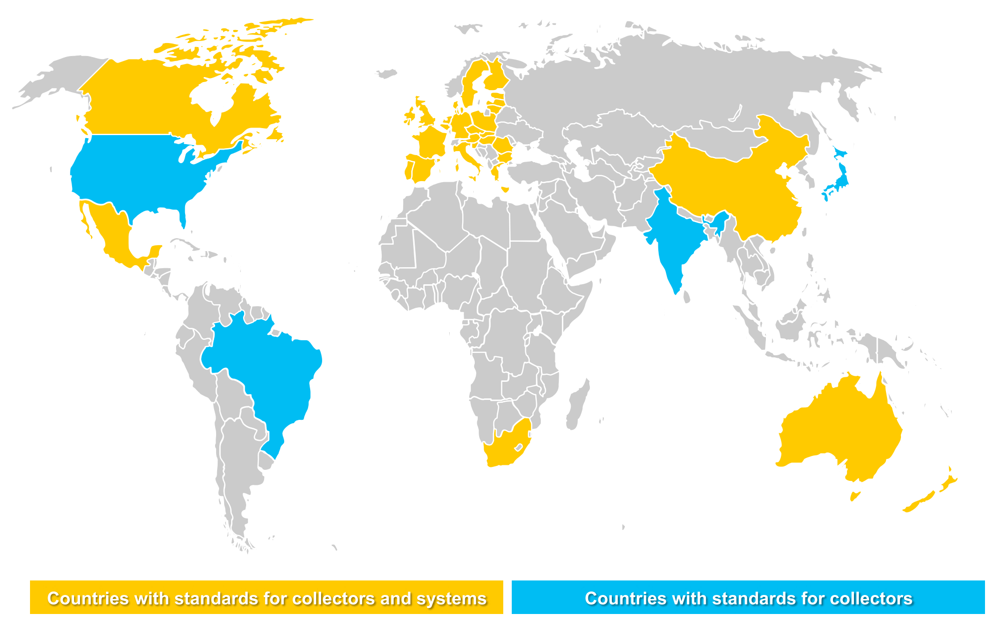

Figure 6
World map of countries with solar thermal standards

This global research effort towards the harmonisation and development of testing procedures and characterization methods will focus on the testing of both conventional and advanced solar thermal products. The outcome of this research should be less time and resources spent by companies, laboratories and certification bodies on testing and certification, while still ensuring consumer protection and providing credible information on solar heating and cooling benefits. The scope of Task 43 includes performance testing and characterization, qualification testing, environmental impact assessment, accelerated aging tests, numerical and analytical modelling, component substitution procedures, and entire system assessment and certification.

The work carried out by this IEA-SHC Task could be incorporated in revised ISO standards, which could then underpin a global certification scheme creating a large and open international market for solar thermal products. However, is it essential to coordinate this process with the revision of the European standards.

The first step towards global certification of solar collectors has already been taken, as it has been agreed in technical committees ISO TC 180 and CEN TC 312 to aim at a common EN/ISO 9806 standard for solar collectors testing methods. A draft of this standard has been developed and will go out for consultation during 2012. Once a common international EN/ISO standard is established it will, in principle, be possible to elaborate a global certification scheme for solar collectors.

There are many benefits to implementing such scheme, for instance, a manufacturer can sell its products in several markets after only one testing and one certification. Besides from the obvious costs reduction advantage, this should also encourage sector growth. Several examples can be provided, i.e. new markets: a manufacturer who wants to enter a new market (even as OEM) faces a clear challenge as his products will need to go through a long and cumbersome testing procedure.

There is a tendency around the world towards accepting/adapting the EN/ISO Standards - and especially the Solar Keymark certification scheme is used as a model for countries currently establishing or updating their national certification schemes. As an example of this international work, there is presently a joint initiative from the SRCC in the USA and the Solar Keymark Network in Europe to investigate the options for harmonization.

2.3 Testing if a sample of the product conforms with the standards

2.3.1 The advantage of third party testing

Third party testing is performed by an independent test laboratory. It provides an independent verification and assessment to ensure that a product matches the requirements provided by standards and/or the specifications as stated by the manufacturer.

Therefore third-party testing is essential for assurance issues. It has obvious advantages for public authorities and regulatory bodies, as well as for the consumers. Furthermore, several regulations require declarations of conformity for products subject to mandatory third-party testing.

This tends to affect more the solar thermal industry, as there are safety regulations linked to construction products or electrical appliances that may in future be applied to solar thermal. For instance, thermosiphon systems with electrical element already fall under safety requirements for electrical appliances in several countries.

As referred to above, many companies do not have the resources or expertise required to perform tests according to standards. In this case, they have no option but to resort to dedicated testing facilities. Nevertheless, even if the company has its own testing facility, third party testing provides assurance to the company itself. Testing by externally renowned test laboratories is a widely used marketing tool and tests results may also help companies define other strategies, such as the length and extension of the warranties on their products.

It is also important to remember that test laboratories have the added expertise coming from the experience of carrying numerous tests with different products, sometimes even according to different standards. They also improve their experience and common understanding of the requirements laid down in the standards by means of networks, conferences and sets of inter-laboratory comparisons.

Product testing at solar thermal testing and competence centres with highly qualified and long-term experienced staff is also advantageous during the R&D process, since the manufacturer can benefit from the available experience gained from testing a large amount of products. Furthermore R&D projects can be carried out in direct co-operation with the testing and competence centre.

As mentioned, third party testing should be done by independent testing laboratories. For matters related to certification or declaration of conformity, these should be handled by accredited testing laboratories; although this does not mean that other testing facilities cannot perform adequate testing. However, obviously an accredited testing laboratory carries more authority.

2.3.2 Self-testing

The existing standards are not solely intended for test laboratories. On one hand, they include product requirements that are highly important for the manufacturer when designing and manufacturing his product. On the other hand, they are also providing guidelines so that testing and/or processes can be carried out under similar conditions thus allowing manufacturers to develop their own activity based on product and manufacturing standards.

With reference to testing, carrying out self-testing is more relevant for activities related to R&D for components or new systems. Applying specific test methods can help identify and eliminate products defects, check the behaviour of different materials or components from different suppliers or check improvements in the manufacturing process. This is more immediate than having to deal with a test laboratory, which is likely to be more cumbersome, in case of an early error detection and prevention. Nevertheless, this implies that the company is able to afford and justify the required investment in the adequate equipment and in qualified staff. A smaller company may not be able to finance such an investment. Furthermore product testing at solar thermal testing and competence centres also has some advantages as mentioned in the previous chapter.

When a company can set up their own testing facility, it is obviously important that there is a good understanding within the company of testing methods to be applied. The cooperation with dedicated test laboratories can be very useful, as there are clarifications or fine-tuning of testing procedures which are discussed between experts from these institutions and that would be of relevance for less experienced researchers not used to carry out such tests.

2.3.3 Accredited testing laboratories

Accreditation of test labs is an assessment and recognition of technical conformity and competence of entities carrying out product testing (or calibration). The accreditation aims at ensuring that different test labs are assessing in the same way and achieving similar results for similar products.

Being an accredited laboratory is synonymous with accuracy and professionalism, recognizing the expertise of its human resources, equipment, methods, laboratory facilities and procedures needed to deliver reliable and reproducible results and applicable requirements of good practice.

Accredited testing laboratories must operate a quality management system according to EN/ISO/IEC 17025 . The laboratories must prove the expertise of their personnel with respect to the specific test methods and prove the quality of their equipment. Accreditation bodies issuing accreditation certificates to the testing laboratories based on periodical audits. Accreditation bodies themselves must fulfil EN/ISO/IEC 17011.

Third party certification schemes[9] for solar thermal products require the use of accredited testing laboratories that perform their tasks according to ISO/IEC 17025:2005[10] , besides the specific rules of the certification scheme, including the relevant standards applicable for the products under the scope of the scheme.

9 Certification scheme or certification programme are synonymous.
10 Or even further standards with the EN ISO/IEC 17000 series of standards

3 Certification to ensure that products in the market conform with standards

Certification represents a third party attestation that a product, service, person or management system meets specified requirements.

In the case of solar thermal products[11], the certification may apply to:

- Solar thermal collectors
- Solar Thermal systems
- Heat stores
- Components being part of a collector or a system

There may also be distinctions according to the kind of collector (i.e.: the Chinese Golden Sun has a specific certification for all glass evacuated solar collector tube[12]) or the type of system. In Europe certification for factory made systems already exists and certification for custom-built systems is planned.

Ensuring the quality of the products to consumers and public authorities is a key element toward the development of a sustainable market for solar thermal products. High quality solar thermal products installed by trained installers will meet high safety standards, durability and performance requirements and will guarantee that policy support reaches its goal in creating benefits for the individuals and for the community.

Quality assurance can be provided by quality marks[13], based on a certification procedure as stipulated in the relevant certification programmes and standards. These quality marks are granted to products by Certification bodies either running the certification scheme or empowered to certify under that scheme.

For instance, in the US, the Solar Rating & Certification Corporation (SRCC) runs its own certification and rating programmes for collectors and for heating systems[14]. The corporation is an independent third party certification body and was established solely for solar thermal products, resulting from the combined initiatives of public bodies and solar thermal industry.

On the other hand, the European Solar Keymark operates under the supervision of the European standardization body (CEN) and is run by the Solar Keymark Network. This Solar Keymark Network consists of the scheme's main stakeholders, such as industry (companies and trade associations); certification bodies, inspectors and testing laboratories[15]; these network members decide on the certification process described in the Solar Keymark scheme rules.

3.1 Ensuring similar quality on tested and produced goods

Certification requirements should contain appropriate procedures to ensure that every single product on the market is similar to the tested products.

There are two important elements required to ensure that a tested product is similar to any other product from the same production line:

- Random selection of the tested product
- requiring manufacturers to have a quality management system in place

The sample being submitted for testing should be selected at random by the designated test laboratory or certification body representative. This is the best way to ensure that the sample is similar to the goods sold.

11 It is also possible to have installers' certification schemes – see chapter VI
12 Based on the standard GB/T 17049
13 Also referred to as quality labels or seals
14 OG-100, OG 600 and OG-300
15 In fact, participation in the Solar Keymark Network is compulsory for the Certification Bodies, Inspectors and Testing Laboratories dealing with the Solar Keymark.

Even if a collector, store or system is selected randomly, the manufacturer will need to ensure that the production quality is consistent over time, so that the products coming out of the production line always retain the same quality and characteristics. A certification scheme should therefore require that a manufacturing process quality control is in place in the factory according to the specification of EN ISO 9000 series of standards, covering the full process: from the raw material reception to the final product storage.

3.2 Certification schemes according to ISO/IEC Guide 28:2004

The ISO/IEC Guide 28 "Conformity assessment – Guidance on a third-party certification system for products" provides a blue print for a third-party certification scheme in which a competent certification body assesses the conformity of a product with a given standard. It lays down the process and includes model documents, such as an application form to be used by companies which apply for certification for one of their products.

The general certification process described in Guide 28 serves as the basis for many different product certification schemes worldwide. For solar thermal, the CEN Solar Keymark certification scheme is one such example.

Certification process according to ISO/IEC Guide 28 (simplified):

1. Application for certification: The company applies to the certification body for certification of its product (=assessment of conformity of the product with given standard(s));
2. Initial assessment: The certification body performs (or lets perform):
   a. an initial type test of the product, and;
   b. an assessment of the production process and quality (management) system;
3. Decision: Based on the results of the initial assessment the certification body decides about the application;
4. Licensing: The certification body allows the company to use the certificate and/or certification mark ("mark of conformity") under certain conditions;
5. Surveillance: The certification body regularly repeats all or parts of the steps of the initial assessment to ensure that the product and the production process continue to be in conformity with the standard(s).

This model process can provide a high level of confidence. On one hand it requires to sample the product initially tested. On the other hand, the company's quality management system is being assessed. Such system should allow continuous control of the manufactured goods production at any stage, including materials and components used in the process. By stipulating surveillance, Guide 28 aims at further strengthening the certification.

4 Setting up testing facilities and competence centres

4.1 Assessing the need for a testing facility for solar thermal in a country

4.1.1 Main points to consider

To achieve a global decrease in greenhouse gas emissions it is essential to use more renewable energies for hot water preparation, replacing conventional electricity or fuel consuming boilers. Using solar thermal heat for hot water preparation and space heating is the most effective, natural and sustainable way of using renewable energies. Some regions in the world have almost 300 days of sunshine a year; however, in many of these countries the market for solar thermal systems and components is still very small and does not offer many products of good quality. The implementation of a solar thermal testing centre with state of the art equipment usually leads to a higher quality level of solar thermal systems and components placed on the market. An improved quality will also result in increased confidence in the solar thermal products as well as in the amount of energy saved and CO_2-emissions avoided by solar thermal energy.

4.1.1.1 Market development and national production

At some point, a developing market will require testing laboratories. This usually becomes obvious when the lack of testing facilities hinders the further development of the market and/or the introduction of quality assurance measures. On the other hand, the market must reach a minimum critical size to ensure viability of long term investment in solar testing centres.

Therefore, it is clear that the market for solar thermal systems and components in general will benefit from the presence of such a test institution. Since the testing institution gives local manufacturers the possibility to test their products close by, the length of time for developing new products and improving existing products will be greatly reduced. It is important that both, thermal performance and quality (durability and reliability) of the solar thermal products can be determined at the local testing centre.

It is obvious that a foreign testing centre and consultancy cannot satisfy requests from the local market. The reason behind this is, on the one hand, that prices for such services must be adjusted to the local price levels. On the other hand, it is very important that the competences in the field of solar thermal be provided and implemented locally in each country.

4.1.1.2 Policies

For the further promotion of solar thermal systems and components, different solutions could be considered to encourage the creation of local testing facilities.

Public support schemes to stimulate the uptake of the solar thermal technology should always consider quality assurance measures as one key element. This means that a financial incentive to the consumer or a solar thermal ordinance[16] should require products to be certified, or at least, to demand test certificates according to relevant standards. A solution could be, for example, a certification scheme such as Solar Keymark Certification [29], serving as a basis for issuing a label on products[17].

Depending on the label scheme rules, certain requirements must be fulfilled. Usually such requirements are related to the quality and also to performance aspects of the product. If the requirements selected are sufficiently high, the quality of the products will increase and so will the customer's confidence in solar thermal products. Therefore, the market could not only be stabilized but also boosted.

At the same time, the demand for testing is created, requiring setting up a testing facility.

16 Solar thermal ordinances consist of regulations applicable for buildings (or other technical regulations) that demand a minimum use of solar thermal products. For more information see www.solarordinances.eu
17 See Chapter V for further information on setting up a certification scheme.

4.1.2 Evaluation matrix to access the need and capabilities to establish a Solar Thermal Competence and Testing Centre

To assess the need for a testing centre for solar thermal systems and components, several aspects have to be considered. We propose below (figure 7) several factors that should be taken into account and that should simplify this evaluation. As with any simplification, there is a risk of overlooking important aspects; therefore the proposal below is not a substitute for a more in-depth analysis which should be part of a good business plan.

The first, and more obvious step is to identify the need to establish a solar thermal competence and testing centre in the country. This need, or the demand of product testing, will depend on different factors, as described below.

- Market growth expected for solar thermal products, which may depend on several elements, amongst others:
    - Local energy costs – the higher the cost of the conventional energy, the more competitive solar thermal products are;
    - Support mechanisms in place or foreseen - mechanisms to promote the uptake of the solar thermal market, supporting policies aiming at reduction of CO_2 emissions or of energy imports;
    - Market awareness and confidence in solar thermal products - this is an important element to consider, as lack of confidence/awareness can be one of the biggest hurdles for the adoption of this technology.

- Evolution in terms of quality assurance in the market, which depends, amongst others, on the following points:
    - Demand for certification – the requirement by public authorities of certification within building regulations or in order to provide financial incentives is one major driver for the demand for testing;
    - Local producers in the market – the need for local testing gains relevance for locally-based manufacturers (even if foreign manufacturers may be potential clients, on start up the critical demand should be identified locally);
    - Level of innovation in the market – the more innovative the market is, the more likely new products will be introduced in the market, requiring testing as a support to the product development process.

Another critical aspect to take into consideration refers to the conditions required to set up a testing centre. There are some points to assess in this case which are described below.

- Framework conditions required for setting up a testing centre:
    - Adequate location – having a good location available (open area, adequate climate, easily reachable, low bureaucracy) will be a key success criteria for the investment;
    - Local expertise on solar thermal – the existence, or the possibility of educating and retaining qualified personnel, is essential to the success of such an operation;
    - Financial mechanisms to support the investment – this is an important aspect to start up a new investment (it is different to sustainability), being either public support or other investment mechanisms.

- Sustainability requirements for a testing centre:
    - Evaluation of existing testing facilities - this should be well assessed, as a strong and/or abundant competition will push down prices and make it harder to gain new clients (national competitors should be considered first while not ignoring potential foreign players);
    - Predictability of the market – the sustainability of a testing centre depends also on the predictability of the market (even positive prospects may be worthless if not clear in the medium term);
    - Capacity to grow/evolve – in order to survive, a testing facility needs to be able to evolve, to adapt to the market, to offer new/better services.

These are some of the main points that should be taken into account when assessing the needs and capabilities for establishing a solar thermal competence and testing centre. Obviously, there are other points that may also be relevant. This assessment should be adapted to each case. As an example we can refer the capacity to have a long term strategy (e.g. 10 years) for the testing centre (related also to the location and funding options); the possibility of having the testing centre paired with a public body (e.g. university) or even the need in the market to test products periodically.

Therefore, there is not one-size-fits-all solution. As shown on figure 7, these criteria may be shown in a table to facilitate the assessment. On the example provided, it is possible to weigh the different factors according to their relevance. Besides, it is also possible to include new factors or to revise the factors to be considered.

In brief, the example provided should be a good customizable tool for an initial assessment.

Evaluation Summary

	Weight	Grading
Need and capabilities for establishing a Testing Centre		***1: low / 5: high***
Need for competence and testing centre	*50%*	*1: low / 5: high*
Potential for market growth	45%	1: low / 5: high
Quality assurance prospects	55%	1: low / 5: high
Capability to establish competence and testing centre	*50%*	*1: low / 5: high*
Framework conditions	40%	1: low / 5: high
Sustainability requirements	60%	1: low / 5: high

Detail of the Evaluation

	Weight	Grading
Need for competence and testing centre		
Potential for market growth	100%	1: low / 5: high
Local energy costs	25%	1: low / 5: high
Support mechanisms in place or foreseen	25%	0: none / 5: strong
Market awareness and confidence	35%	1: low / 5: high
Factor XYZ	15%	*1: bad / 5: good*
Quality assurance prospects	100%	1: low / 5: high
Demand for certification	35%	0: none / 5: strong
Local producers in the market	35%	0: none / 5: strong
Level of innovation	20%	1: low / 5: high
Factor XYZ	10%	*1: bad / 5: good*

	Weight	Grading
Capability to establish competence and testing centre		
Framework conditions	100%	1: low / 5: high
Adequate location	35%	1: bad / 5: good
Local expertise on solar thermal	35%	1: low / 5: high
Investment support mechanisms	25%	1: low / 5: high
Factor XYZ	5%	*1: bad / 5: good*
Sustainability requirements	100%	1: low / 5: high
Evaluation of existing testing facilities	35%	1: strong / 5: weak
Predictability of the market	35%	1: low / 5: high
Capacity to evolve/grow	20%	1: weak / 5: strong
Factor XYZ	10%	*1: bad / 5: good*

Figure 7
Example of an evaluation matrix to access the need and capabilities to establish a Solar Thermal Competence and Testing Centre

4.1.3 Potential activities and expected results of a testing facility

For boosting a country's solar thermal market, a reliable and independent test and development institution is essential.

Reliable, in this context, means objective and well experienced in the field of solar thermal technology and applications.
The institution should be active in the following fields:

- Assistance in product development by advising local manufacturers and by testing local products during the development phase to improve the overall quality and performance of solar thermal products;
- Testing of solar thermal products according to national and international standards – these tests serve as a basis for both further product development and quality assurance;
- Activities to improve quality assurance in solar thermal (e.g. taking part at conferences, active cooperation in the field of international standardisation and certification).

An additional field of activity is the evaluation of products and issuing reports, which could serve as a basis for a certification scheme. The quality of the products to be sold can also be enhanced thanks to certification schemes.

4.2 Establishing a testing facility for solar thermal equipment

For establishing a testing centre for solar thermal equipment, the following requirements have to be considered:

- Institutional, financial and technical requirements;
- Requirements related to the operation of the test institution, which has to be compliant with related standards; Requirements connected to staff qualification

4.2.1 Institutional and financial requirements

An independent solar thermal competence and testing centre must be operated by either a public institution or an independent financial organisation. The financial side of the test laboratory must not affect the quality and results of the tests performed at the centre. Before setting-up a testing centre a business plan for a ten year period must be developed as a core element. The business plan should list the expenditures and incomes on an annual basis.

Typical **expenditures** are the initial investment and its depreciation, the personnel costs (see also section related to staff below), the infrastructure costs (e.g. rents), for the operating costs (e.g. electricity and water) and maintenance including the calibration of the measurement equipment. If the testing centre is accredited also the fees for the accreditation, including the required audits, must included. It is important to distinguish between the fixed and the variable costs. **Fixed costs** are those that do not depend on the level of activity (e.g. depreciation of investment, rent for facilities, accreditation). With or without activity these costs exist and cannot be avoided. **Variable costs** are those directly related to the work performed (for instance, work-hours of technical staff, electricity used for operating the testing equipment). If the activity increases these costs increase in consequence and vice-versa.

The **income** is predominately based on the fees paid by clients for product testing. Other paying services such as assistance in developing new products, consultant services and factory inspection are additional income sources. There are other activities that may help to sustain and further develop the testing and competence centre, such as organizing training seminars or being involved in projects linked to research or to the development of testing standards.

Whereas expenditures can be determined with more accuracy, incomes are very unpredictable, since it is not possible to determine exactly how many tests will be required several years ahead. Therefore, it is important to have a business plan that accommodates different scenarios.

Furthermore there is some competition between testing centres and if business turns out to be attractive new centres might be established. To avoid financial problems it is strongly recommended to base the assessment of the expected turnover (income) and results on conventional assumptions.

A typical business plan for a testing facility shows that the costs for testing are predominately based on the labour costs. This is particularly obvious when outdoor testing facilities are used. When the testing facility uses a solar simulator, this equipment will also represent a significant cost factor and the impact of the labour costs will decrease proportionately.

Based on this fact three recommendations can be made:
- it is financial advantageous to establish test centres in regions where there is a favourable balance between a good educational level of personnel and relatively low labour costs;
- it is preferable to invest in qualitatively high and reliable testing facilities since the share of the costs related to the facility itself only has a marginal influence on the overall testing fee;
- establishing a testing centre equipped with outdoor testing facilities will imply that the determination of the thermal performance of solar collectors and systems will become much more cost effective than investing in a solar simulator.

History has shown that in most cases a basic funding is necessary, at least during the start-up phase of a testing centre. This ensures some stability and predictability for such an investment, and can also be used to reduce the testing fees in the start-up phase, facilitating the early acquisition of clients, to help generating experience, knowledge, good reputation and efficiency gains. Therefore, this basic funding can facilitate the penetration of a market for product testing, enabling the testing laboratory to cover its operating costs quicker.

4.2.2 Technical requirements

To operate a solar thermal competence and testing centre a certain infrastructure is necessary. First a well-equipped test laboratory is important, second is the required staff and last, but not least, the testing portfolio.

4.2.2.1 Equipment

The necessary equipment can be divided as follows:

- Equipment necessary for performing the tests;
- Further equipment necessary for samples pre-preparations and for the performed tests evaluation.
- Depending on the samples to be tested the equipment varies. For testing complete solar thermal systems other standards apply than for component (e.g. collectors, stores, controllers, …). Generally, the equipment must satisfy all the related standards requirements.
- Before a new solar thermal competence and testing centre is established, the local demand for testing services has to be determined. In most cases, the most economic solution could be test equipment satisfying all the requirements of most of the European and international standards related to performance, durability and reliability testing of solar thermal systems and components. A very interesting solution is the so-called “all in one” test facility at which different products can be tested, such as e.g. solar thermal systems, collectors and stores, using only one test facility [30]. An example of such a test facility is shown on the following figures:

Figure 8
All-in-one mobile test facility at the South African Bureau of Standards (SABS), Pretoria

Figure 9
Mobile, stand-alone collector and systems test facility at Macedonian Hydro-Meteorological Institute, Skopje

- Another main component of the situational requirements is the test site. On one hand, space is required for the test facility itself and, in the case of outdoor testing, large and open areas are necessary to prevent any distortion of the test results. Buildings, trees and others can influence the boundary conditions such as solar radiation; wind speed can also affect the test results. On the other hand, a workshop or similar support infrastructure is needed for preparing the test samples. If collector tests are performed, several smaller in- and outdoor test facilities become necessary to determine the reliability and durability of the solar thermal collectors in an effective way.

4.2.2.2 Staff qualification and training

The staff employed at the solar thermal competence and testing centre must be well educated. As a rule of thumb, during the start-up phase approximately three people are required to operate the testing centre. Depending on the tasks covered by the employees the training requirements may vary. The following list shows the required minimum personnel for a proper operation of a solar thermal competence and testing centre:

Director/Manager of the Solar Competence and Testing Centre

Scope of duties:

The director or manager is responsible for acquiring adequate orders related to testing of solar thermal systems and collectors. The director attends relevant conferences and networking meetings. She/he represents the Solar Competence and Testing Centre to the outside world, both locally and overseas. The director/manager has the overall financial and technical responsibility.

Required skills:

Advanced university degree in mechanical engineering, energy engineering or equivalent. Approximately at least five to ten years of international experience in the related field and managerial responsibility. Fluent spoken and written English.

Senior test engineer of the Solar Competence and Testing Centre

Scope of duties:

The senior test engineer supervises tests performed at the Solar Competence and Testing Centre. The senior test engineer is responsible for test scheduling, data evaluation and test reports. She/he communicates with customers and acts as the quality manager. This is of great importance if the test centre aims at obtaining accreditation or is already accredited.

Required skills:

University degree in mechanical engineering, energy engineering, or equivalent. Five years of working experience in the related field. Fluent spoken and written English.

Test engineer of the Solar Competence and Testing Centre

Scope of duties:

The test engineer is responsible for carrying out the tests at the Solar Competence and Testing Centre. She/he prepares all the test sample installations.

Required skills:

Technical education in plumbing, installation technique, sanitary or equivalent. Education in measuring techniques and solar thermal. Two years of working experience. Knowledge of English language is an asset.

4.2.2.3 Testing portfolio

The solar thermal competence and testing centre should aim to cover most test procedures included in the corresponding national and international standards. During the start-up and learning phase, the testing centre could focus on a specific standard or test procedure but should gradually gain experience in the other available test procedures.

A common approach is to start the solar thermal testing centre only with testing solar thermal systems according to the international standard ISO 9459-2. This test procedure is not too complicated and suitable for the start-up phase of a testing centre.

In the next phase the focus should be on testing solar thermal collectors e.g.according to multi-national standards such as EN 12975-2. After a certain period, the employees should cope with procedures for testing the durability, reliability and the thermal performance of collectors. The portfolio could then be extended to system testing according to ISO 9459-5 or EN 12976-2. If demand for testing is rising, the testing centre can gain experience with testing components, such as water stores[18].

Testing of a solar thermal system components, like testing controllers for solar thermal systems and of solar thermal combi-stores, can increase considerably the portfolio.

18 This is becoming relevant in the European market, under the EN 12977-3 (hot water stores) and EN12977-4 (combistores) standard.

4.2.2.4 International standards

The major standards for testing solar thermal systems and components are listed below[19]. These standards should be considered during the planning and setting up phase of a Solar Thermal Competence and Testing Centre.

System testing:
- ISO 9459-2: Solar heating – Domestic water heating systems – Part 2: Outdoor test method for system performance characterization and yearly performance prediction of solar-only-systems
- ISO 9459-5: Solar heating – Domestic water heating systems – Part 5: System performance characterization by means of whole-system tests and computer simulation
- EN 12976: Thermal solar systems and components – Factory made systems – Part 1: General requirements and Part 2: Test methods

Collector testing:
- ISO 9806-1: Test methods for solar collectors – Part 1: Thermal performance of glazed liquid heating collectors including pressure drop
- ISO 9806-2: Test methods for solar collectors – Part 2: Qualification test procedures
- ISO 9806-3: Test methods for solar collectors – Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop
- EN 12975: Thermal solar systems and components – Solar collectors – Part 1: General requirements and Part 2: Test methods

Testing of hot water stores:
- EN 12977-3: Thermal solar systems and components – Custom built systems – Part 3: Performance test methods for solar water heater stores

Testing of custom build domestic hot water and combisystems as well as related components:
- EN 12977-1: Thermal solar systems and components – Custom built systems – Part 1: General requirements for solar water heaters and Combisystems
- EN 12977-2: Thermal solar systems and components – Custom built systems – Part 2: Test methods for solar water heaters and combisystems
- EN 12977-4: Thermal solar systems and components – Custom built systems – Part 4: Performance test methods for solar combistores
- EN 12977-5: Thermal solar systems and components – Custom built systems – Part 5: Performance test methods for control equipment

19 See section II.B. for further information.

5 Setting up and introducing a certification scheme

5.1 Assessing framework conditions

A certification scheme can be a powerful tool to ensure good quality products and/or services in the market. And, good quality is an important factor for the longer term success of solar heating and cooling solutions. However, a certification scheme is relatively complex, requires several important players, and creates additional costs for companies having their products certified. Because of the latter, a certification scheme may make sense only in markets and for products reaching a certain minimum volume. This is shown on figure 10 below.

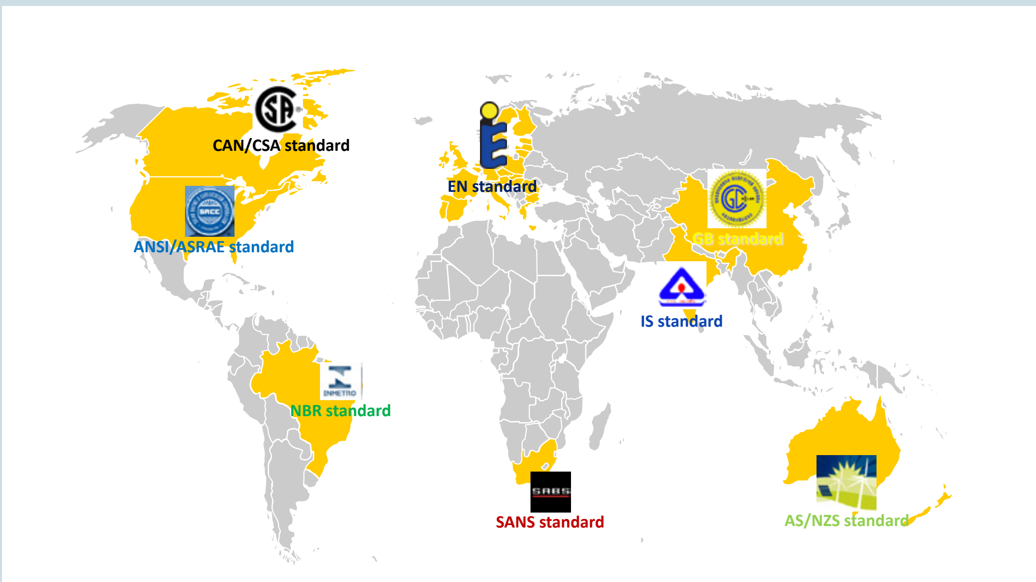

Figure 10
World map of solar thermal quality labels and applicable standards

A requirement to have products certified, combined with a costly certification process, may actually kill a nascent market, as the players do not sell enough solar thermal products to offset the (high) costs of product certification. At an early stage of a market development, it may make more sense at first to require only (third-party) testing, not yet certification, to avoid imposing stifling burdens on the industry.

For a certification system to work, several measures must be in place. And this needs to be assessed before any such scheme is developed and enforced:

1. The relevant product standard(s) need(s) to exist and be established, so that conformity can be tested and certified.
2. One or more test laboratories must exist or be established that have the competence and equipment to carry out the tests according to the given standard(s).
3. A certification body must exist or be established which assesses the conformity of the product with the standard, awards the certificate, carries out product control and fights misuse of the certificate or mark of conformity.

Before establishing a new certification scheme, governments should always consider using an existing one – for example from neighbouring countries. This reduces the burden on companies active in several markets, as they do not need to re-test and re-certify their products for every single market.

5.2 Obligation or requirement for support schemes

The existence of a solar thermal certification scheme does not automatically mean companies having their products certified - there must be a compelling reason to invest time and money into product certification. Governments who have backed the establishment of a certification scheme often support its uptake in the market by making it compulsory or with tying financial incentives. The latter is particularly easy for governments to defend, otherwise facing criticisms of just creating unnecessary costs for companies.

Nevertheless, governments should indeed be careful with their requirements in the solar thermal market. For example, in requiring certification under a new certification scheme for a product to be eligible for public grant money, the government could inadvertently reduce competition in the market, as many products have not been certified so far. Even waiting times for slots in solar thermal testing laboratories can unfairly prevent products from benefitting from public support. Therefore, governments should announce their requirements well in advance (1-2 years) and/or foresee long enough transition times for products already in the market.

Instead of making the certification compulsory in the market (e.g. by introducing related building codes) or in financial support schemes, governments can also choose to create softer incentives for certification: certified products could benefit from special treatment, such as slightly higher financial incentives or a slightly higher value for the certified product in an energy performance calculation of the building.

The final goal should be to extend the scope of quality assurance measures; for instance, requiring certification as quality assurance indicator related to legal instruments along simple financial incentive schemes. Other mechanisms can be considered, such as introduction of requirements for solar thermal within building regulations. The main advantage is that quality assurance measures will endure even after the end of a specific financial incentive scheme.

5.3 Financing of the scheme

Establishing, operating, maintaining and improving product certification scheme is costly. Running costs are usually borne by companies having their products certified – through testing and certification fees.

However, governments should consider supporting the development and maintenance of a good certification scheme as a tool for the long-term development of the solar thermal market. Especially as, in a small market, the initial costs for the development of standards, scheme rules, testing laboratories, certification bodies etc. cannot be financed by the solar thermal industry alone.. Financial support for these developments should be considered a good investment for the government.

5.4 Communication

Communication must be a key element in the introduction of a new certification scheme: It must be explained to the industry, the planners and installers. The end consumer should be made aware of the existence of the certification scheme and the advantages of purchasing certified products/services.

Especially early on, certification and conformity marks face a chicken-egg problem: As long as they are unknown, consumers do not ask for them and therefore there is little incentive for the companies to have their products certified. But at the same time, the small number of certified products results in low awareness of the certification by the end-consumer. Solar awareness raising campaigns should therefore include information and promotion of existing or coming certification schemes.

6 Quality of planning, installation, maintenance

6.1 Certification, qualification and training

It is common to encounter misunderstandings when using concepts such as certification, accreditation and training. In fact, the translation of such terms into the different languages can create some confusion. Therefore, before going deeper into the analysis of the complementarities between these different concepts, it is important to clarify what is meant by the different terms.

As referred earlier, **accreditation** relates to the conformity and competence assessment of those bodies that perform conformity assessment services, while **certification** represents a third party attestation that a product, service, person or management system meets specified requirements.

There may be accreditation of an awarding body, which is the procedure by which an authoritative body[20] gives formal recognition that an awarding body[21] is competent to issue qualifications (certificate, diploma, title or label). Furthermore, we can also have accreditation of an education/training programme or of an education/training provider, which consists in a process of quality assurance executed by an authoritative body through which accredited status is granted to an education/training programme or provider meeting predetermined stringent and uniform standards.

In addition, we have the certification of learning. This is the process of issuing a certificate, diploma or title formally attesting that a set of learning outcomes (knowledge, skills and/or competences) has been acquired by an individual having been assessed and validated by a competent body against a predefined standard.

Figure 11 shows possible interaction in relation to installer certification scheme.

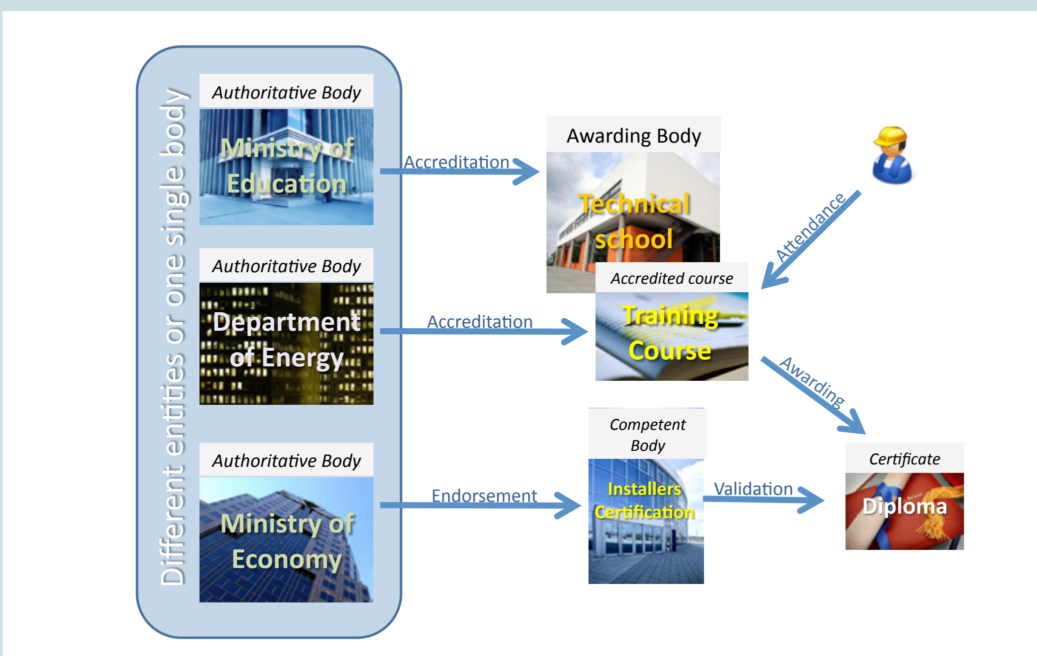

Figure 11
Example of process related to an installer certification scheme

20 Broader definition for a body with authority, legitimacy.
21 Awarding bodies are organisations that are empowered to award qualifications, such as vocational qualifications. In many cases a body may provide educational programs and award qualifications, such as universities.

In brief, we can use the example of a solar thermal installer following a training course accredited by the country's "Department of Energy". Such training course was provided by a technical school recognized (accredited) by the Ministry of Education. The installer received a diploma from this training course, which was accepted by the "Installers Certification Agency", an awarding body endorsed by the Ministry of Economy. This Agency provided the installer with an Official Certificate, allowing him/her to carry out his/her activity.

Within the training process and, apart from certification, it is also important to consider **qualifications**. In this case, qualifications are perceived as professional qualifications, i.e. the professional experience achieved through full-time pursuit of the profession or through a training course not forming part of a certificate or diploma. Qualification consists of the assessment and validation process which is obtained when a competent body validates that an installer has reached the learning level to given standards and/or possesses the necessary competence to do a job in a specific area of work. A qualification confers official recognition of the value of learning outcomes in the labour market and in education and training. This is also referred to as validation of competences.

In summary, an installer can obtain certification after successfully completing the required (and recognized) training or education. Alternatively, he/she may obtain equivalent qualification, by the validation of his/her experience and knowledge.

6.2 Ensuring the quality of training

Training and education are key elements to encourage a wider adoption of solar thermal energy. Good training is essential to guarantee successful solar thermal professionals. Training and education should not solely apply to installers.

The sector also needs qualified professionals in several other areas, such as R&D, design and maintenance. And we could go even further, as some professional groups have a decisive role to play in the market, such as architects and planners who are the interface between end consumers and the industry. Usually, these professionals' education and training do not include solar thermal technologies and unfortunately, this is still the case for current training courses in many countries. For this reason, many of these professionals do not feel comfortable recommending solar thermal to their customers, or even discourage them to avoid dealing with a technology they do not master.

While bearing this in mind, we are focussing here on the training of installers. It is clear that a lack of installers training can lead to poor planning and defective installations, thus creating quality problems and decreasing the wider acceptance of solar heating.

The quality of the training provided depends on the quality of the:

- content;
- training providers;
- learning conditions.

These factors need to be adjusted for each country. Practices related to training/education vary widely around the world. Therefore, the training of installers should also take into consideration training structures/ schemes already in existence. A system working perfectly in one country may not be suitable for another. These systems cannot simply be "exported", although there are lessons to be learned from other countries' experience.

Courses content should be designed according to the needs of the country. For instance, in a new market with a hot climate and low income, it is likely that most systems sold will be thermosiphons. Training should be provided covering the basic principles of solar thermal (irradiation, hydraulics), with training courses of very short duration and low cost. Otherwise, installers may not be motivated to take up the course.

Training should have a practical component and, in most cases, this should be the main component. Some countries have longer training programmes where trainees can also work in the field, as bridging the gap between theoretical training and gaining practical experience is very important.

Training should adapt to market realities. The market evolves, requiring for instance installers to be able to deal with bigger commercial installations or with combi-systems.

Figure 12
Roof mounting of solar thermal collectors, Austria Solar/ESTIF

To ensure high level training providers, there should be "train-the-trainer" programmes. For more coherent and comparable training courses, these programmes can provide trainers with common methodological approaches and criteria. This can also be achieved by promoting a stronger link between trainer and awarding body, for instance with an agreement giving details on training standards as well as practical arrangements.

Training standards need to be elaborated and regularly updated by a working group of experts. Contents should be harmonized and a quality control applied to the courses. Contents and methodologies should be updated, based on the evaluation of the learning outcomes and feedback, both from participants and other stakeholders.

Training facilities should also include space for practical training. In many countries there are no adequate training facilities for solar thermal. In such cases, cooperation with the industry, i.e. using their training facilities, could be an interesting option.

Another important factor is availability countrywide. For an installer, the training will imply a period of absence from work, meaning lower or even no income. Installers are reluctant to spend much time and money on solar thermal training, all the more if the local solar thermal market is not large enough to justify such an investment. Successful courses should carefully consider the costs to be borne by the installer and develop their training offers accordingly, so that installers can attend training courses in a location close to their city of residence.

Training can be provided by both public and private centres. It is advisable for the training centres to be equipped with both the most relevant and the latest technologies available on the local market.

When planning a training programme in a country, the involvement of the trade associations or "guilds", experts, regional/local authorities is essential to gain input for the objectives, contents, size, cost, duration, timing and location for the courses. These partners will also be important to promote training courses to the target groups.

After completion of a training course, the installer must have the skills required to dimension and install a solar water heating system. These skills must meet customers' requirements regarding performance and reliability, incorporate quality craftsmanship, and comply with all applicable codes and standards. All this should be possible with the help of basic instructions, a manufacturer installation manual, specifications of major components, schematics and drawings. The installer must be able to demonstrate key competences under a qualification scheme combining theoretical knowledge and practical skills.

Figure 13
Installation of solar air collectors, ISE/ESTIF

Today the situation is very different worldwide. In many countries there is no formal training/education for installers of solar thermal systems. For countries where this exists, the range of courses is extremely varied. There are manufacturers and public or private training bodies offering a multitude of courses, ranging from one day to two-year programmes – at different levels of quality and costs.

Apart from promoting training courses for solar thermal installers, components of the solar thermal training should also form part of the standard training and education for heating installers and roofers.

Making financial incentives for solar thermal dependent on a certified level of qualification from installers has proven to be a double-edged sword. Whilst it can help increase the quality of the installations, such a measure can compromise the effect of the financial incentive scheme if there are not enough certified installers in the market.

6.3 Ensuring the quality of the planner/installer

Installers of solar water heating systems must be able to undertake a set of key tasks to be classified as competent installers. It is important to stress that the required qualifications should reflect the fact that there are several types of domestic solar water and space heating installations as well as various system configurations. These installed systems vary according to the region, reflecting climate, cultural differences and requirements resulting from national standards and directives.

In this respect, courses in each country should be adapted to meet the specific needs of a given country. The scope of the training and the knowledge to be acquired should be clearly defined. Although for instance, higher qualifications should be required for a system designer who should be familiar with many aspects of the design as he/she may have to adapt it to fit a particular application or customer's need, whereas an installer will usually only be contracted for small solar thermal systems (mainly domestic).

The practical training is a very important element and it is appropriate that courses cover the key competences referred to above and include practical training with solar thermal installations.

Tasks to be considered can be divided into three categories:

- Safety
- System performance
- Good working practice

While these tasks are usually based on conventional designs, equipment, and practices used in today's industry, they should not limit or restrict innovative equipment, design or installation practice in any way. They should answer the main market requirements, both current and for the near future. Therefore, as with any developing technology in growing markets, it is fully expected that the skills required from the practitioner will develop and change as new materials, techniques, codes and standards evolve and market demands increase.

The minimum qualifications required for a course in the installation of domestic solar water heating systems depend on the specific qualifications targeted, as well as on the pre-qualification already available. In particular, it is important to have some plumbing qualification, although some training with electrical installations and roofing techniques would also be relevant. It would be very useful if installers (or students) had plumbing and basic electrical skills before starting a course.

For plumbing these skills include cutting pipes, soldering pipe joints, gluing pipe joints, lagging, sealing fittings, testing for leaks and installing vented and unvented heating systems.

With regard to electrical aspects, installers should be familiar with basic electrical concepts and terms. They should have the ability to understand wiring diagrams and be able to do electrical wiring and create weatherproof connections.

The roofing component applies in particular to the roof mounting of solar collectors, for which basic knowledge on roofing would be relevant.

6.4 Installers' Certification and/or Qualification

6.4.1 Existing Schemes

There are currently some installers' certification or qualification systems implemented in different countries, for instance Canada, South Africa or France.

- Canada has a voluntary certification scheme for installers of small-scale solar thermal systems. The Canadian solar Industries association (CanSIA) plays an important role in the certification of installers in the solar sector, having developed a programme for experienced installers, as well as a training programme focused on new practitioners. The certification is based on the standard CSA F383-08 - Installation Code for Solar Domestic Hot Water Systems.

- In South Africa, the qualification and certification of solar thermal installers, as well as for other fields, is based on the National Qualification Framework (NQF) by the South African Qualifications Authority (SAQA). There are two reference standards relevant for the certification of installers:
  - SANS 10106:2006 - The installation, maintenance, repair and replacement of domestic solar water heating systems
  - SANS 10254:2004: The installation, maintenance, replacement and repair of fixed electric storage water heating systems

- France has a well developed voluntary qualification scheme for installers of solar thermal systems. This is called QualiSol and it is managed by Qualit'EnR, a French association consisting of craft unions and renewable energy industry associations. It is a voluntary three-year commitment renewed annually. To be able to use the "Qualisol" label, a company must prove its solar thermal technical knowledge by previous experience or by successfully completing a recognised training course. This process is complemented by a quality audit of one installation made by the installer (within three years of engagement in the QualiSol program). It does not use any specific standard for solar thermal systems (therefore being only qualification) but it requests an official commitment from the installers, on topics ranging from advice to after-sale services or installation rules.

6.4.2 Awarding Certification/Qualification

In most cases, certification/qualification schemes require a validation of competences. This is usually done by means of a training course culminating in a certificate (diploma or other). Therefore training programmes already in place should be taken into account; however, training programmes should be relevant and consistent with the requirement of the certification/ qualification scheme. One of the options is to have training programmes and training providers approved by an authoritative body.

The recognition of the competences of installers already working in the market should also be taken into account. This can be demonstrated by the installations already done by that installer, showing that they meet the stipulated quality requirements. In cases where an examination is required, then experienced installers should be allowed to move directly to the examination phase (without taking up training).

6.4.3 **Audit**

A common way to assess the quality of an installer's work is to perform the audit on an installation in operation which was done by the installer. Audits are a valid means to provide evidence of the quality achieved. In this respect, they can be included as a part of the certification process. Nevertheless, audits are quite expensive, time-consuming and an administrative burden. Therefore, their use should be adequately assessed, also taking into account that they should be limited to a random selection of installations for each installer.

It should be clear that these refer to the process of certification/qualification of the installer. Therefore, it is not addressing the possibility of having installations audited per se, but it is just for the purpose of assessing the capabilities of an installer.

The audit of an installation can be simply an administrative one, or on-site or both. The administrative audit consists of an analysis of certain procedures related to the audit, using check-lists provided by the installer and/or client. This is not as reliable but it has much lower costs and shorter administrative procedures. The on-site audit implies sending an auditor to the site of the installation, resulting in higher costs.

As a general rule, audits should be conducted during the period of validity of certification/ qualification and should be initiated based on a random selection from installation references. However, it should also be possible to have audits initiated on the basis of complaints about installations.

Audits should be used as a positive incentive for correcting mistakes and improving quality. If audits reveal the poor quality of an installation, these results should be discussed with the installer in order to guide him/her towards an improved performance of his/her work.

The clear objective of a certification/qualification scheme is to increase the number of highly qualified market players. In this respect, the use of the audit results can be an excellent tool to improve the quality of installations, by indicating common mistakes. These can be addressed during future training courses or being disseminated to the installers, in newsletters and/or providing pedagogical materials addressing such problems.

6.4.4 **Renewal/Recertification**

It is usual for the certification/qualification of installers to have a limited validity. This means that it should be renewed regularly.

In this respect, the duration of validity is an important element. Should a renewing interval be fixed, it is crucial not to make it too short so as to avoid creating an unnecessary burden for the installer. However, the interval should also not be too long as the installer should be able to comply with higher demands from the market and the technological development of solar thermal systems.

This interval should be defined considering the reality and needs of the country. In a new market, the objective should be to have more people trained, therefore not overload the process with renewals. In more developed markets, the main need may be to improve the competences of the installers, therefore promoting a shorter renewal period.

The criteria for renewing the certification/qualification should be based on the same criteria required for its acquisition, simplifying the procedure and the renewal process should be managed by the same body awarding the original certification/qualification.

6.4.5 Company or individual certification

One of the points for which there are different approaches, depending on the country concerned, is who should hold of the certification: a company[22] or an individual.

This is not something that concerns the solar thermal installers in particular but arises from the practice in a country concerning the provision of professional credentials to perform an activity.

One of the main arguments in favour of granting a certification to a company is that the company is liable for the quality of the installation. In this case, if the customer has a complaint, the certification or equivalent qualification is given to at least one "technical referee", namely a responsible person appointed within the company who has the necessary knowledge, skills and/or competences required by the quality scheme. Sometimes, this situation develops as a result of additional requirements regarding companies' responsibility, such as insurance or internal quality assurance procedures. One of the arguments against this option is that a company does not hold competences and skills, the workers do.

The main argument in favour of certifying an individual is that the installation is always carried out by the individual having gained the required qualification which is not guaranteed if certification is granted to a company. One argument against this option comes from the concern expressed by some trade associations that with a personal certificate there is a danger that companies are too dependent on employees having obtained certification /qualification.

Experience shows that both schemes, although different, can meet the required quality standards.

22 In this context the term company refers also to installers acting as independent workers/sole operator

7 Summary

Nowadays, adequate quality assurance is a precondition for a sustainable market development. This is also true for the solar thermal technology as it still needs to find its way into mass market, in spite of being technologically mature and one of the main sources of renewable heat for domestic use.

An essential condition for market growth is consumer confidence on such products, both in terms of safety, durability and performance. This quality assurance needs to be backed by adequate testing and certification, on the basis of well-developed quality and adequate standards.

In solar thermal there are already several product standards existing, either for solar thermal collectors or for solar thermal systems and components. Even if there are differences between some of these standards, there is today a clear tendency for international harmonisation and important steps in that direction have been already taken.

While standardisation is important, it is imperative to have proper testing in place to check whether the requirements described in the standards are fulfilled by a product. While testing being an essential condition for quality assurance, third party testing and product certification are crucial to convey that assurance to the market operators and consumers.

There are already well-established test laboratories in several markets, representing an excellent choice for manufacturers. Though, there are still many markets where testing facilities are needed.

Setting up testing facilities is key to market development. These should be promoted, though it is essential to have an adequate assessment of the need and capabilities to establish a solar thermal competence and testing centre in a country. These range from market development and national production, to policies in place, potential activities and expected results of a testing facility. Institutional, financial and technical requirements should be properly assessed, in particular the technical personnel, as staff qualification is a key factor for a successful testing laboratory.

Quality assurance in the most developed solar thermal markets has benefitted greatly from the existence of certification schemes for solar thermal products. There are several certification schemes consolidated, set up according to the main requirements laid out by ISO. There are, nonetheless, many other variables to consider when introducing a certification scheme in a country (or group of countries). A certification scheme will be more successful if introduced simultaneously with specific obligation or requirements defined by public authorities in a country. Furthermore, the success of such schemes also depends on the formula chosen for its financing and for its promotion towards customers and market players.

The performance of a good solar thermal system relies largely on the quality of the installation besides, of course, the quality of the equipment. Therefore, adequate quality assurance measures need to take into account planning, installation and maintenance of the solar thermal systems. This means that special attention needs to be devoted to training, qualification and certification of installers.

Presently, there are not yet many examples of certification schemes for installers, though interesting developments are happening in this area. There is no perfect solution, though different models may be considered.

It is a technology with a great potential, but which has its own specificities in terms of application. If we take the example of a simple solar water heater, it is fairly obvious that, in its operation and application, it has a lot in common with other water heating technologies. It is, of course, easier and safer to deal with solar than with a gas water heater. Nonetheless, it has other requirements that are more complex, such as the hydraulic components of a system.

All these topics are addressed in depth in this publication. The aim of this document is to provide a solid introduction to the topics covered, and to give recommendations for the adoption of quality assurance measures in more markets.

Promoting adequate quality assurance measures is not the single challenge that the solar thermal sector faces in order to reach mass market but it is undoubtedly one of the main and most pressing ones. And it is a step in the right direction. We believe this publication helps to get you on the way.

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