

Solar Hot Water Standards and Certifications – Success Stories

Deliverable D4



IEA SHC TASK 69 | SOLAR HOT WATER FOR 2030

Solar Hot Water Standards and Certifications – Success Stories

**This is a report from SHC Task 69: Solar
Hot Water for 2030**

Editor

Elsabet Nielsen, DTU – Technical University of Denmark

Jianhua Fan, DTU – Technical University of Denmark

Reviewers:

Ken Guthrie,

Date December 2025

Filename of deliverables: Task69_D.D4_success stories

Report number: D.4 / DOI: 10.18777/ieashc-task69-2026-0007

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Cover Photo: Thermosyphon Systems on a residential home

Editor**Elsabet Nielsen and Jianhua Fan**

Technical University of Denmark (DTU)

Denmark

Reviewer

Ken Guthrie,

Contributors**Harry Suehrcke**

Sunspin Pty Ltd

Australia

Ken Guthrie

Sustainable Energy Transformation

Australia

Lucia Torlai

Solar Heat Europe

Belgium

Andreas Bohren

SPF Institute for Solar Technology

Switzerland

Monika Spörk-Dür

AEE - Institute for Sustainable

Technologies

Austria

Elsabet Nielsen, Jianhua Fan

Technical University of Denmark (DTU)

Denmark

Li Bojia, Li Haimeng

China Academy of Building Research

(CABR)

China

Luis Christian Navntoft

Solarmate S.A

Argentina

Marisol Oropeza

MATTERS MX

México

Danielle Johan

ABRASOL

Brazil

Khalid Salmi (SHAMCI Program manager)

Regional Center for Renewable Energy

and Energy Efficiency (RCREEE)

Egypt

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- Solar Heat for Industrial and Agricultural Processes (Tasks 29, 33, 49, 62, 64)
- Solar District Heating (Tasks 7, 45, 55, 68)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59, 63, 66)
- Solar Thermal & PV (Tasks 16, 35, 60)
- Daylighting/Lighting (Tasks 21, 31, 50, 61)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)
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1 Executive Summary

This report focuses on how standards and quality certification for solar hot water (SHW) systems and their installation have influenced their development in different markets.

In total, ten success stories about standards and quality certification for SHWs and their installations have been written for different markets, including the EU, Australia, Asia, Sub-Saharan Africa, Latin America, and the Middle East.

The common stories are that the successful development and sustainability of the market for SHWs require stable government policies, robust quality standards and certifications, trained/skilled installers, as well as increasing market awareness and consumer confidence.

2 Success Stories

2.1 Europe

2.1.1 Solar Keymark

Prepared by Lucia Torlai and Andreas Bohren



2.1.1.1 Solar Keymark: the main ST quality mark globally

The [Solar Keymark](#) (SK) is a voluntary third-party certification mark for solar thermal products, owned by CEN/CELENEC. It is considered the main Quality label for Solar Thermal products in Europe, demonstrating to end-users that a product conforms to the relevant European standards. To assure constant quality. Although it is increasingly recognized and adopted worldwide, the Solar Keymark is currently only issued in Europe, where it is also the basis for most **public support schemes** at the European, national, and regional levels. As such, it can be considered an exemplary Success Story for standardization in the European Context.

The Solar Keymark label can certify Solar thermal collectors, as well as Solar thermal systems, storages, and controllers. As of 2025, the [Solar Keymark Database](#) comprises **1,059 Solar Keymark Certificates**, issued by 11 accredited certification bodies in Europe. Of the total granted licences, 850 are attributed to solar thermal collectors, and 207 to factory-made and custom-made solar thermal systems.

2.1.1.2 Background of the Solar Keymark

In the 1990s, Europe's solar thermal market expanded rapidly, supported by national incentives, from 250,000 kWth to over 800,000 kWth of newly installed capacity per year. However, differing national requirements forced companies to undergo multiple costly tests and approvals, creating trade barriers that hindered growth. To address this, the Solar Keymark was launched in the early 2000s, initially supported by two EU-projects (ALTENER and later IEE). In 2003, the European Solar Thermal Industry and major testing institutes formulated the Solar Keymark Scheme Rules as a unified solution to gain recognition across Europe. The same year, CEN approved the SK scheme rules, based on the EN 12975 and EN 12976 standards. The first SK certificate was issued shortly after. Its aim was to harmonise testing and certification, reduce trade barriers, and assure product quality through accredited testing and factory inspections. Driven by ESTIF (now Solar Heat Europe) with support from CEN, and a network of testing labs and certification bodies, adoption grew rapidly, with more than 1,360

certificates granted by 2020. To further strengthen the scheme, the Solar Certification Fund was created in 2009 to support project dealing with the improvement of the standards and the schemes.

2.1.1.3 How the Solar Keymark Standardisation works in Europe

The Role of CEN in Solar Keymark Standardisation

The European Committee for Standardization, known as CEN, is one of three European Standardization Organizations officially recognized by the EU and the European Free Trade Association (EFTA) as responsible for developing and defining voluntary standards at the European level. Its members are the National Standardization Bodies (NSBs) of 34 countries. Together, CEN and its members work to create European Standards that respond to the needs of businesses and users of standards. Within this framework, CEN/TC 312 “Thermal solar systems and components” plays the key role in ensuring homogeneous testing procedures for solar thermal systems and components. The standards and specifications defined by CEN/TC 312 are essential for manufacturers of solar thermal collectors, systems and components, solar water heater stores, combi systems, and control equipment, as well as for European and national authorities, energy service companies, engineers, and consumers.

Procedure for Obtaining Solar Keymark Certification

Solar Keymark (SK) certification can currently be granted to solar collectors (according to EN 12975 and EN ISO 9806), factory-made solar thermal systems (EN 12976), and custom-built solar thermal systems, including solar water heaters and combi systems (EN 12977). The certification process starts with an independent third-party testing of randomly selected samples at an accredited testing laboratory. The manufacturer must produce products under a quality management system like ISO 9001. This is regularly checked by inspectors, and physical product inspections are conducted every two years. All certified products must display the official Keymark logo and an identification code. For every certified product, a datasheet with relevant information is published under <https://solarkeymark.eu/database/>.

Administration of the Solar Keymark

The Solar Keymark is administered through the Solar Keymark Network (SKN), which serves as a working group of stakeholders and an exchange platform for institutions active in Solar Keymark testing and certification. Meeting twice a year, the SKN brings together the SKN Chairperson, Manager, and Secretariat (Solar Heat Europe), as well as recognized testing laboratories, empowered certification bodies, manufacturers, and industry representatives (one to two per country), along with observers and guests. This network ensures consistent administration, transparency, and the sharing of expertise across all parties involved in Solar Keymark certification.

The network operates in an open and democratic manner. All documentation related to network governance, as well as the specific requirements for the Solar Keymark certification of solar thermal products, is publicly available on the Solar Keymark website. Additionally, the Solar Keymark initiative comprises several Working Groups (WGs) that address specific technical matters or issues of particular interest. A list of these WGs can also be found on the Solar Keymark website. Participation is free and open to all; simply submit a request to the Manager.

2.1.1.4 Benefits of the Solar Keymark

Ensuring Quality and Market Access

The Solar Keymark represents a reliable system of testing, standardization, and certification that ensures product safety, quality, and compatibility. By adhering to standardized procedures, manufacturers can access multiple markets without having to repeat the same tests across different countries. This certification enables businesses to comply with legislation, reduce costs, eliminate inefficiencies, and stay current with technological innovations, meeting customer expectations more effectively.

Advantages for Manufacturers and Certification Bodies

For manufacturers, the Solar Keymark is a well-established quality mark, essential for market recognition and competitiveness, particularly in Europe, where it is often required for sales and subsidies. Its streamlined certification process reduces administrative and financial burdens, as entire product “families” can be certified together. Beyond Europe, the Solar Keymark also facilitates entry into international markets, including regions such as the MENA and the United States. Certification bodies and test labs benefit by joining the Solar Keymark

Network, which fosters knowledge exchange and ensures consistency through comparative “Round Robin” testing, strengthening reliability and accreditation.

Benefits for Certification Bodies and Test Labs

Accredited certification bodies and their recognised testing laboratories are mandatory members of the Solar Keymark Network, which promotes knowledge exchange and supports continuous improvement in testing and certification procedures. The network also organizes comparative “Round Robin” tests across different laboratories, ensuring consistency, accuracy, and reliability in results. This strengthens the credibility of certification practices while building a collaborative environment among experts in the solar sector.

Consumer Confidence and Subsidy Eligibility

For consumers, the Solar Keymark provides assurance of high-quality, safe, and durable products that meet strict performance standards. This transparency builds trust and confidence in solar technologies. Moreover, many national and international subsidy schemes require or recognize the Solar Keymark, making certified products eligible for financial support. As a result, consumers not only gain access to products that guarantee durability and efficiency but can also benefit from reduced costs through available subsidies.

2.1.1.5 Barriers and challenges

Misuse of the Solar Keymark: The misuse of the Solar Keymark Certificate is prosecuted to protect its value. Non-certified products using the Keymark should be reported to the Keymark Manager Organisation (KMO). Certified products that do not conform to the certificate should be reported to the issuing certification body. Other suspected cases should be reported to the Solar Keymark Manager. Reported concerns are investigated, with corrective action sought directly from the responsible entity. Unresolved cases can be escalated up to the CEN Management Center, which may pursue legal action if necessary.

Limited Awareness among End-Users and Installers: Many consumers and even small installers are unaware of the Solar Keymark and its benefits. The label often remains “business-to-business,” recognized mainly by manufacturers and policymakers. Targeted awareness campaigns, digital tools, and installer training could highlight the value of the label in ensuring product quality, durability, and eligibility for subsidies.

High Testing and Certification Costs for SMEs: Certification involves laboratory testing, factory inspections, and ongoing surveillance, which can be costly for small and medium manufacturers. This can slow the adoption of the Solar Keymark among innovative SMEs.

Competition with other labels and technologies: in some markets, competing national labels and the strong push for PV and heat pumps can overshadow Solar Keymark’s visibility. On the other hand, following the success of Solar Keymark, the Heat Pump Keymark is also more established under CEN, and there is room for complementarity. Integrating the Solar Keymark with EU eco-design and energy labelling frameworks, as well as facilitating cross-communication with other system certifications, would help maintain the Solar Keymark’s relevance and position it as the pan-European reference.

2.1.1.6 Conclusion

The Solar Keymark is a robust, credible certification scheme in Europe. As such, it supports the Solar thermal industry by promoting high-quality certified products. Furthermore, it provides a reliable guideline for selecting solar thermal products not only for the end user but also for support schemes in Europe and beyond.

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About Solar Keymark- [Solarkeymark.eu](http://solarkeymark.eu) [About Solar Keymark – Solar Keymark](#)

2.1.2 Denmark

Prepared by Elsabet Nielsen and Jianhua Fan

2.1.2.1 Background

Following the energy crises of the early 1970s, the Danish government sought to reduce its dependency on oil and prioritized energy conservation and renewable energy systems. Among other things, in 1979, the state introduced a 30% subsidy of the costs for approved solar heating systems, contributing to the continued development and installation of solar heating systems in Denmark. Around 1990, the subsidy was restructured to be proportional to the calculated output of the solar heating system, thereby increasing competition for the development of efficient solar heating systems. In the mid-1990s, sales peaked, primarily due to a nationwide campaign that promoted the combination of solar heating systems with natural gas systems. Around 1997, the state subsidy was reduced in size and ended entirely in late 2001, resulting in the market nearly collapsing. It takes several years for the market to recover after the withdrawal of subsidies [1]. Following 2001, various subsidy schemes have been introduced, which may also include solar thermal heating systems.

In 1981, the test station for solar heating was established at the Danish Technological Institute. The goal was to ensure the quality of new renewable energy technologies, primarily solar thermal collectors and hot water tanks. From the start, a collaboration agreement was made with the Technical University of Denmark, DTU, which initially handled the developmental aspects of the work as well as tests of solar collectors and tanks. A key element was the development of suitable testing methods and corresponding test stands, resulting in significantly improved solar thermal collectors and tanks on the market [2].

To spread awareness of various renewable energy technologies among potential consumers, an Information Secretariat for Renewable Energy was established at the Danish Technological Institute in the early 1980s. This secretariat continued its work on consumer information until the late 1990s, including through the magazine VE-Information, which helped increase knowledge and trust in solar thermal heating systems [2].

2.1.2.2 Component development

In the early 1980s, experimental tests were conducted on many solar collectors and hot water tanks from various manufacturers. The products were improved incrementally, both in terms of efficiency and durability.

The developed hot water tanks included PUR-foam insulation enveloped by 60 cm x 60 cm white cabinets, with all pipe connections located at the bottom of the tanks. Additionally, all necessary equipment for the solar heating systems was installed below the tanks at the bottom of the cabinets. This resulted in very low heat losses from the hot water tanks [3]. These types of hot water tanks, with PUR-foam insulation and all pipe connections at the bottom of the tank, are currently used for all hot water tank applications in Denmark. This differs from similar hot water tanks used in most other countries, where pipe connections are typically located at the top or sides of the tank, resulting in high heat losses [4].

Consequently, the solar heating sector has contributed to reducing Danish energy consumption.

2.1.2.3 Survey among natural gas customers

In 1979, the Danish Parliament decided to establish a natural gas network in response to the oil crisis of 1973/74 and subsequent oil price increases. The natural gas network was inaugurated in 1984 by Queen Margrethe. By 1995, 228,000 homeowners in natural gas areas had been connected to the natural gas network, while 178,000 homeowners had not yet made the connection.

To address this issue, 358 telephone interviews were conducted in mid-1995 among the homeowners who had not yet been connected to the natural gas network [5, 6].

The survey aimed to elucidate the reasons why homeowners had not yet converted to natural gas. Additionally, the survey revealed an interest in using solar heating systems. Most of the homeowners interviewed were negative toward natural gas solutions, citing both economic reasons and a lack of confidence in natural gas boilers. However, many homeowners were positive towards solar heating and wished to convert to natural gas if the natural gas boiler could be combined with a solar heating system. The combination offered an economic advantage, as solar heating could be obtained for about half the price, since the conversion often required a new hot water tank, which could be replaced with a solar heating tank. Furthermore, natural gas boilers have very low efficiencies during summer periods, when heating demands are low. Therefore, the energy savings of the solar

heating systems are high. All in all, the simple payback period of the solar heating system was reduced from the usual 10-12 years to 6-8 years.

The systems typically consisted of wall-mounted natural gas boilers and separate hot water tanks that could be heated by both the boiler and solar collectors.

2.1.2.4 Technological development

Based on the interest in combined solar heating/natural gas solutions, Danish companies have developed units consisting of a natural gas boiler and a hot water tank, which can be heated by both solar collectors and the natural gas boiler. The units were developed in cooperation between the companies and the Technical University of Denmark and included a detailed laboratory test of the units [7-12]. Figure 1 shows such a combined solar heating/natural gas unit.

The price of solar heating systems, as well as the installation price, was further reduced by using these prefabricated, efficient natural gas boiler/solar tank units.

The survey showed a much greater interest in solar heating than in natural gas. About one-third expressed interest in solar heating, either as a solar heating system or a solar-prepared hot water tank. Based on the survey results, a campaign was launched by the solar heating industry and natural gas companies, targeting homeowners wishing to connect to the natural gas grid and install a solar heating system. The campaign was extended to all gas customers already connected to the gas grid.



Figure 1: A unit consisting of a natural gas boiler and a hot water tank in one 60 cm x 60 cm cabinet [11].

In 1996, this resulted in a boom, with approximately 4,000 systems installed, as shown in Figure 2. Installers and subsidy administration at the Energy Agency struggled to keep up, and the Agency had to borrow from development funds to cope with the pressure. The first steps towards gradually phasing out state subsidies were therefore taken [5].

Inspired by the success of natural gas companies, oil companies launched a similar campaign that combined solar heating systems with oil boilers. The campaign had limited success, as the oil companies were unable to attract customers through direct mail, unlike the gas companies [5].

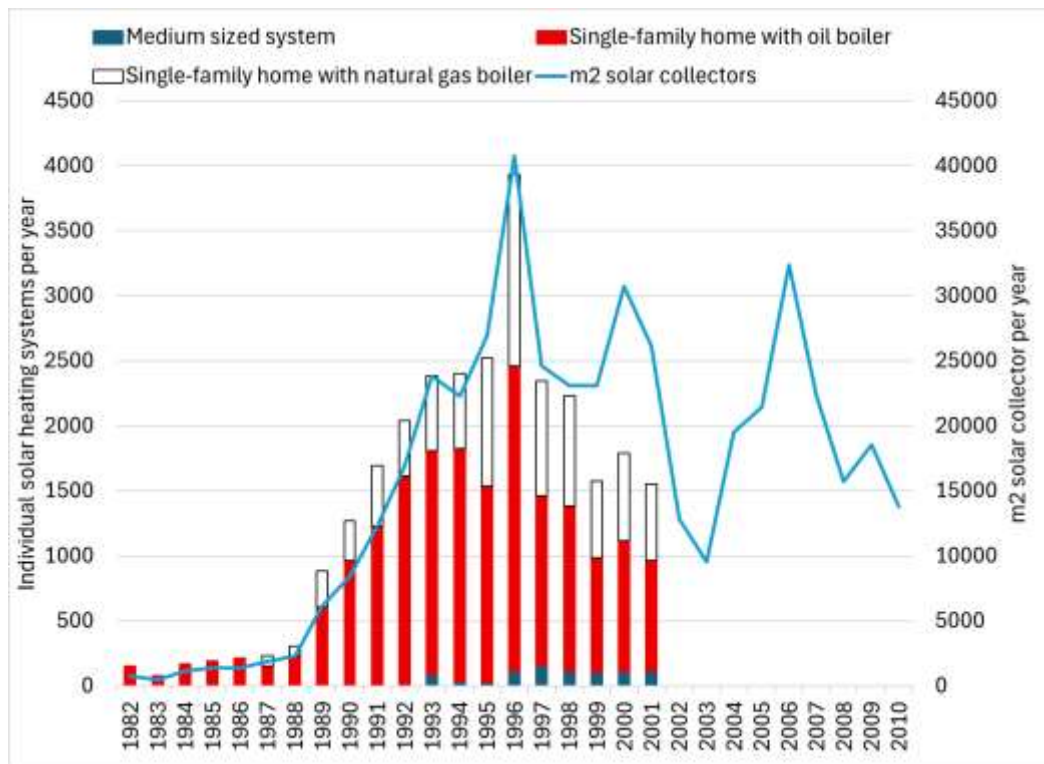


Figure 2: Yearly installed solar heating systems in Denmark until 2010 [1,13].

2.1.2.5 Solar energy can help meet the energy frame in the building code

In 2006, new energy regulations were introduced into the building code. New and renovated buildings had to comply with stricter energy frames, and solar heating systems, like other energy-saving measures, could help meet these requirements. Therefore, the Danish Solar Heating Association published a brochure advertising solar thermal heating systems, resulting in another sales boom in 2006, even without subsidies (see Figure 2) [14].

2.1.2.6 Current situation

Today, approximately 68% of all households are connected to district heating. Currently, the district heating network is expanding, and the low heating price with district heating is difficult to match with domestic solar energy systems.

Outside district heating areas, many homeowners are installing heat pumps. Heat pumps, like gas boilers, also have very low efficiencies during summer periods with low heat demand, making the combination with solar heating systems attractive.

2.1.2.7 Outlook

Maybe the experience from the campaigns and the efforts on natural gas/solar heating combinations in the 1990s mentioned above can be of inspiration in connection with future campaigns and efforts aiming to revitalize the solar heating market on heat pump/solar heating combinations, and in this way pave the way for new Danish solar heating success stories.

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2.2 Oceania

2.2.1 Australia

Prepared by Harry Suehrcke and Ken Guthrie

2.2.1.1 Background and history of relevant Australian Standards

Australia has had a long experience of solar water heater development and sales, with a well-established industry and standard testing and performance evaluation methods.

In the mid 1980's outdoor testing was carried out at the University of NSW under the leadership of Prof Graham Morrison [1,2]. Morrison developed an outdoor test method to evaluate the performance of a solar hot water system that would allow accurate estimation of the performance across a range of loads and a range of climate types characterised by ambient temperature and solar irradiance. This was achieved by running the appliance at a range of load/irradiance ratios and produce characteristic equations for each appliance. The test required 6+ weeks of outdoor testing and whilst it could be used to estimate the performance over a range of climate and loads, each product required a complete test to get a result. This test procedure was adopted as Australian Standard AS 2984:1987 *Solar water heaters - Test for thermal performance - Outdoor test*

It was also adopted as an ISO standard ISO 9459-3:1997 *Solar heating — Domestic water heating systems Part 3: Performance test for solar plus supplementary systems*. This standard is now withdrawn.

With the availability of better computer modelling options and climate data, Australian Standards committee CS028 developed a new standard based on component testing, and system simulation (CTSS). In this approach, the water heater components are first tested and their performance characteristics determined. For example, the efficiency characteristic of a solar thermal collector is determined for various operating temperatures, say following ISO 9806, or the 24 h heat loss value of the hot water storage tank is measured at a specific temperature difference (55 K in the AS/NZS 4692.1:2005 test). By incorporating also material properties and dimensions, such as the type of pipe insulation and its thickness, the performance characteristics for the entire water heater can be determined.

Now, using the component performance characteristics and climate data as input to a TRNSYS simulation (Klein *et al.*, [15]), significant information can be obtained. Carrying out a full annual TRNSYS simulation provides accurate estimates of the performance of products for a range of climates and varying loads. The simulations also readily enable evaluating alternate configurations of the components. For example, once the tank and collector components are characterised, the performance of a single hot water storage tank with one, two, or even three collectors can be quickly and accurately assessed.

The CTSS approach also offers manufacturers valuable insights into the working of their products. For instance, the simulation allows manufacturers to observe the impact of a particular temperature sensor position or the change in a thermostat set point temperature. This contrasts with “black box” testing methods that may only provide results for a specific test condition. Key contributions for the CTSS development were made by Prof. Morrison, who developed TRNSYS models, including thermosyphon and heat pump water heaters (Morrison *et al.* [16], Morrison and Clift [17]).

The CTSS model was first used in an Australian and New Zealand Standard AS/NZS 4234 1993 after validation of performance by comparison with outdoor system testing [3,4,5]. It was subsequently adopted as an ISO standard as ISO 9459-4:2013 *Solar heating — Domestic water heating systems Part 4: System performance characterization by means of component tests and computer simulation.*

AS/NZS 4234 has been updated several times [Clift et al, 6] and is now a generalised method Australian/New Zealand Standard AS/NZS 4234 2021: *Heated water systems - Calculation of energy consumption.* The TRNSYS modelling details are included in a ‘Miscellaneous Publication’ SA/SNZ MP 104:2021 *Modelling of heated water systems in accordance with AS/NZS 4234:2021, using TRNSYS.* A supplementary publication AS/NZS4234:2021 Sup 1:2021 *Heated water systems – Calculation of energy consumption- Parameters and outcomes for software simulations (Supplement to AS/NZS 4234:2021)* includes the details of the modelling to allow other simulation environments to be used if they can duplicate the results.

The products that can be evaluated include hot water heat pumps, which are now characterised by the separate standard AS/NZS 5125.1:2014, *Heat pump water heaters – Performance assessment Part 1: Air source heat pump water heaters.*

AS/NZS 4234 and its companion publications are currently being updated by Standards Australia Committee CS028 to improve accuracy for a wider range of products.

2.2.1.2 The use of these standards to provide market support for product sales in Australia

These evaluation methods were used in the State of Victoria to support Solar water heater system subsidies after 1999. Subsidies varied based on performance – amount of hot water delivered, and amount of boost energy required to provide hot water. AS/NZS 4234 was used to evaluate the performance in Climate Zone 4 (cool temperate) and these results made available on a website that showed system performance

Soon after the State of Victoria developed the subsidy scheme, the Australian Government announced a subsidy scheme for some renewable technologies. SHW was included and the Australian Government built upon the data that was available in Victoria to extend it Australia wide to allocate Renewable Energy Certificates based on the performance in 4 climates across Australia for solar water heaters and 5 climates for heat pump water heaters (climate Zones HP5 is a subset of Climate zone 4 that is at higher altitude [7]).

In the mid-2000s the State of Victoria began a scheme of ‘white’ energy savings certificates. Solar water heaters were also included in that scheme which is now called the Victorian Energy Upgrades program [8]

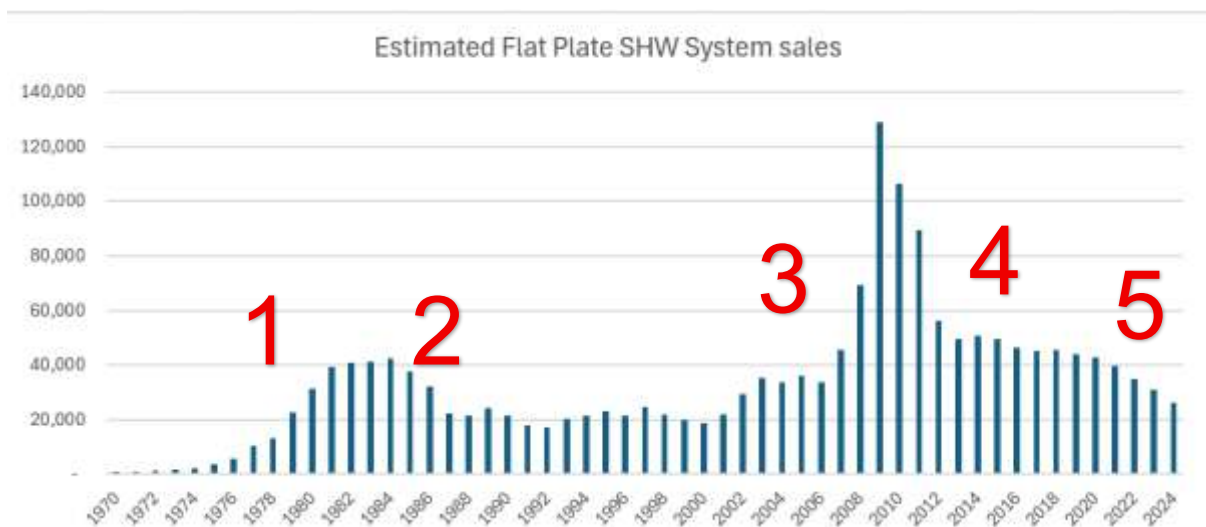
At a similar time, the State of Victoria required greater sustainability in new housing so required all residential buildings to be built to a higher energy efficiency level using the NatHERS (Nationwide House Energy Rating scheme) [9] program as well as installing either a rainwater tank or a solar water heater. This has subsequently changed and it is now a solar water heater, a heat pump water heater or a rainwater tank [10].

The state of New South Wales has also developed a ‘white certificate’ scheme that includes solar water heaters and HP water heaters [11]. It operates in a similar manner to the Victorian scheme and until recently both states used the same database of products.

2.2.1.3 Australian Market

The development of the Australian Market since 1970 is shown on the graph below. [14]. Key points noted on the graph are explained below:

1. The rapid increase in sales in the late 1970's was a response to the concerns about energy raised by the oil crisis
2. The reduction in the mid-1980s followed concerns about collector breakage due to freezing in inland areas due to clear night skies in a widespread drought period in the early- mid 1980s. following that freezing tests were required in Australian Standards [12]. There was also some conflict between electricity suppliers and solar suppliers [13] that further depressed the market for the next decade.
3. The Victorian and Australian government schemes led to an increase in sales from 2000 to 2010.
4. After 2010 sales reduced due to competition for roof space from PV and subsequently competition from Heat pumps which were also supported by the same schemes and use the same modelling performance evaluation methods.
5. Now "solar water heaters" are increasingly PV powered heat pumps in many households



2.2.1.4 What were the key success factors?

Preparedness – the evaluation procedures and methods were developed and available to be used as Australian Standards when the subsidy schemes were initially developed. This allowed for the subsidy to be based on a comprehensive evaluation of the performance of the system rather than estimates/averages or the performance of components.

Consistency – All the schemes used the same or a similar methodology, so suppliers were able to get the modelling done for all schemes without having to duplicate effort to have evaluations done under different requirements for different schemes.

Constancy - Long term use of the same methodology allows suppliers to understand and have confidence in the methodology and allows for them to build in house expertise or for an industry to be built to supply modelling services to smaller suppliers.

Regular updating -As the methods became more widely used and new products were developed the Standards Committee updates the method regularly to cover new technologies and to close any loopholes that were being exploited by a few suppliers.

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2.3 South African Development Community, SADC

2.3.1 SOLTRAIN+

Prepared by Monika Spörk-Dür

2.3.1.1 About the SOLTRAIN+ project

SOLTRAIN+ (<https://soltrain.org/>) is a training and technology demonstration project that began in 2009 with the SOLTRAIN initiative, funded by the Austrian Development Cooperation. The primary objective is to facilitate the transition from fossil fuel-based energy for hot water preparation to renewable energy sources, with a focus on solar thermal, while also enhancing energy security, as load shedding issues are prevalent in many of the participating countries. The initiative has been implemented within the SADC (Southern African Development Community) countries, Botswana, Lesotho, Mozambique, Namibia, South Africa, and Zimbabwe.

The project's approach is multifaceted and comprises training, demonstration projects, involvement of policy, finance and governmental institutions regarding financial incentives and regulations as well as awareness raising and research and development.



Figure 1: A multifaceted approach to support the transition to renewable heating and cooling in the SADC region.
Source: SOLTRAIN+

2.3.1.2 Technical Trainings

From the very beginning, training on different levels has been provided, ranging from hands-on training for installers, 'Train the trainer' courses for teachers at vocational training centers, to university-level courses. The technologies covered include small thermosiphon systems, as well as large pumped solar thermal systems, solar thermal systems combined with heat pumps, energy efficiency, and heat recovery measures. The country partners' institutions serve as 'Centers of Competences' in the SOLTRAIN+ project, organizing and hosting training activities and technical tours. At the institutions, training equipment is available (solar trailers at most of the partner institutions and test facilities at Stellenbosch University and University of Pretoria) to showcase the possibilities of the technology not only during training and trade fairs but also for research and development purposes.

Within the framework of the SOLTRAIN initiative, over 5,000 people have been trained in more than 200 training courses.

The level of training reached in the practical training courses e.g., is NQF¹ Level 3 in Namibia, in South Africa, plumbers who would like to become qualified solar water geyser and heat pump installers are invited to perform a summative "trade test" according to the Institute of Plumbing South Africa (IOPSA) procedures and rules to be listed as accredited installers after the trainings².

In the SOLTRAIN+ project, activities have been expanded to further SADC countries, and successful training courses were recently held in Malawi, Tanzania, Eswatini, and Zambia by the country partners. The statistics are shown in Table 1.

¹ National Qualification Framework (Namibia); Regulations setting up the National Qualifications Framework for Namibia, https://namqa.org/wp-content/uploads/2024/02/cd1_REGULATIONS-NATIONAL-QUALIFICATIONS-FRAMEWORK.pdf (accessed 01/10/2025)

² The "trade test" include Knowledge Modules, Practical Skills Modules and Work Experience Modules prior to the final summative assessment.

"Become a solar water geyser or heat pump installer with IOPSA", <https://iopsa.org/news/3672242> (accessed 01/10/2025)



Figure 2: Training course held in Malawi from 07-08 April 2025 Photo: SOLTRAIN+

Table 1: SOLTRAIN+ ACHIEVEMENTS – Expansion to rest of SADC

Country & Partners	Female	Male	Total
Eswatini (Ministry of Mineral Resources and Energy; VOCTIM)	19	42	61
Malawi (Ministry of Energy; TEVETA; Lilongwe Technical College)	11	24	35
Tanzania (Ministry of Energy; TAREA)	17	23	40
Zambia (Ministry of Energy; TEVETA)	4	31	35

VOCTIM- Vocational and Commercial Training Institute

TEVETA- Technical, Entrepreneurial and Vocational Education and Training Authority Malawi / Technical Education, Vocational and Entrepreneurship Training Authority Zambia

TAREA- Tanzania Renewable Energy Association

2.3.1.3 Demonstration systems

One major piece in the jigsaw of the SOLTRAIN+ project is the installation of demo projects. Companies that successfully completed the training courses are eligible to apply for funding, and up to 50% of the cost of the systems can be funded by the SOLTRAIN+ project following the rules developed by the project's steering committee team. The installed systems must be Keymark certified or hold a similar certificate (e.g., certified according to the South African Bureau of Standards (SABS)). After the installation of the solar thermal systems, the SOLTRAIN team conducts a quality assessment to ensure high-quality installations. The installation company is obliged to revisit the site after one year to prove the proper operation of the systems. The company further assures a 24-month warranty on the installed systems following the final inspection. In the event of technical problems, leaks, or malfunctions with the installed systems, the company is responsible for repairing the issues and any resulting damage.

The demo systems serve to raise awareness of the technology and showcase that the technology works in different fields of application, from small systems for family houses and tourism lodges to larger systems at educational institutions and hospitals, and large systems for industrial applications and district networks, the collector areas being installed reaching from 2 sqm to more than 550 sqm. At the same time, companies gain experience with the installation of various systems and technologies, including flat plate and ETC systems, as well as PVT, thermosiphon, and pumped systems. PV2Heat installations have been conducted within the framework of a research study. The systems are currently monitored at NEI Namibia Energy Institute. The demonstration systems can be visited as part of training courses and technical tours, and therefore also serve to raise awareness among various stakeholder groups.

During the SOLTRAIN initiative, more than 900 systems with a total collector area of approximately 8,500 sqm have been installed, resulting in annual CO₂ savings of approximately 2,300 tons and a reduction in electricity bills of nearly 19 million ZAR.



Figure 3: PVT demonstration system installed by Greenline Africa at a hospital in Cape Town, South Africa (left) and two thermosiphon systems with ETC at CPS sisters' youth hostel in Harare, Zimbabwe. Photos: Solarus Smart Energy Solutions (left), Werner Weiss, AEE INTEC (right)

2.3.1.4 Centers of Competence

The project's country partners are Centers of Competence in the partner countries. They bundle solar thermal knowledge, run workshops and training courses, organize awareness raising events, provide advice to installing companies concerning demo system installations, inform policy and financial institutions, develop guidelines regarding policy regulations, and offer assistance for Vocational Training Centers' and tertiary institutions' solar thermal curricula. At Stellenbosch University, a test center has been established where research work can also be conducted. Other country partners can run practical student courses using a solar thermal trailer equipped with both a solar thermosiphon and a small pumped system. The solar thermal trailer is also equipped with monitoring equipment.

In the future, SACREEE (Southern African Center for Renewable Energy and Energy Efficiency) is intended to take the lead in coordinating activities within the Southern African region.



Figure 4: Handover of Solar Trailer in Mozambique (left) in the frame of the SOLTRAIN project. The Solar Trailer is equipped with a flat plate thermosiphon system as well as a small pumped system on top of the trailer. Solar Trailer in Zimbabwe (right).

2.3.1.5 Awareness Raising

Raising awareness is still key because the technologies are not yet widely known, and partly, the technology also struggles with a bad reputation due to poorly installed systems that have not been maintained correctly. In this connection, the demo systems of the project are crucial for demonstrating the effectiveness of the technology and showcasing the reduction in electricity consumption.

The awareness activities within the project focus on stakeholders from different sectors, like the health sector, the educational sector, governmental institutions, financing, housing companies, the tourism sector, and industries (for example, food and beverage), just to name a few. In the SOLTRAIN+ project, there is also a focus on energy efficiency and energy audits in both the building and industrial sectors, aiming to reduce energy consumption first

and then consider renewable energy solutions, with a particular emphasis on solar thermal solutions in a second step.

Recently, due to climate change, the carbon reduction potential of solar thermal solutions has also garnered interest.

Table 1: Total collector area, total capacity, number of demo systems installed, electricity savings, avoided electricity costs, and CO₂ reduction of systems installed within the frame of the SOLTRAIN initiative funded by the Austrian Development Cooperation.

Country	Total collector area [m ²]	Total capacity [kWth]	Number of systems [-]	Electricity savings [kWh/a]	Avoided Electricity Cost [€/a]	CO ₂ reduction [tco ₂ /a]
Mozambique	263	184	39	253,279	35,079	80
Namibia	1,554	1,088	358	1,553,876	215,212	487
South Africa	4,867	3,407	244	3,822,606	529,431	1,206
Zimbabwe	700	490	121	651,003	90,164	203
Lesotho	410	287	69	410,490	56,853	130
Botswana	693	485	72	721,845	99,976	227
TOTAL	8,486	5,940	903	7,413,099	1,026,714	2,333

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2.4 Asia

2.4.1 China

Prepared by Li Haimeng and Li Bojia

2.4.1.1 Background

Under the background of China's dual carbon policy, energy conservation and emission reduction in the construction sector are a key link in achieving China's carbon peak and carbon neutrality goals [1]. As one of the top three renewable energy application technologies globally, solar thermal utilization has the advantages of diverse forms and easy integration with buildings. With the promotion of clean energy technology policies and the rapid development of solar thermal utilization technology, China's solar energy industry has been ranked first in the world for 14 consecutive years, making it the country with the largest production and usage of solar thermal utilization systems in the world. Solar thermal utilization technology products and engineering applications have made and are making great contributions to energy conservation and carbon reduction efforts at home and abroad.

The annual newly installed capacity and growth rate of China's solar thermal utilization system from 2004 to 2023 are shown in Figure 1. As of the end of 2023, China's cumulative solar heat collection area is 545 million square meters, accounting for 72.8% of the global market share [2]. The application forms of solar thermal utilization systems include hot water supply, heating, air conditioning, regional heating, and industrial and agricultural applications. Among them, solar hot water systems are the most mature, widely used, and rapidly industrialized application form in China, accounting for 96.5% of the total solar thermal utilization systems [3].

The sustained decline in growth of China's solar water heater market after 2013 stems from the combined impact of multiple factors closely linked to China's national conditions. Policy-wise, the "Home Appliances to the Countryside" policy (2009-2011), a key national initiative to boost rural consumption, initially drove the industry's rapid development but also overdrawn rural market demand in advance. After the policy was withdrawn, market demand naturally declined. In terms of market competition, electric and gas water heaters gained an edge. Backed by China's growing real estate sector and the widespread popularization of natural gas pipelines in cities and towns, they offered weather-independent convenience. Moreover, the integration of e-commerce and offline channels further helped them seize market share from solar water heaters. Product limitations also played a role. Due to China's urbanization-driven change in building forms, solar water heaters, with their large size and need for specific rooftop installation space, were hardly adaptable. Furthermore, urbanization improved rural electricity and gas infrastructure, giving rural consumers more choices and diverting demand, which exacerbated the decline in growth.

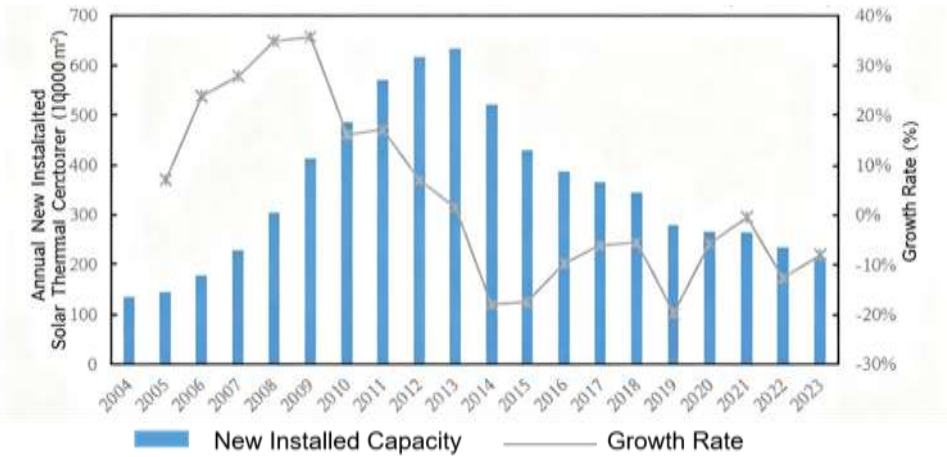


Figure 1: Annual newly installed capacity and growth rate of solar thermal utilization systems in China

2.4.1.2 Chinese Standards improved the quality of the system types

China's solar thermal utilization standard system has established a comprehensive chain, spanning from product manufacturing and engineering application to carbon emission reduction accounting. With national standards such as "Flat Plate Solar Collectors" and "Technical specification at the project level for assessment of greenhouse gas emission reductions—Solar thermal applications" at its core, this system works in synergy with a series of standards covering building integration and system engineering design. Together, they form a standardized framework that spans the entire lifecycle, including product manufacturing, project development, and operational assessment. The "Flat Plate Solar Collectors" standard facilitates the standardization and mass production of core components by specifying unified modular dimensions and stringent performance indicators. Driven by this standard, leading enterprises like Sunrain and Linuo Ritter have established automated production lines [4]. Their products are optimized for China's

diverse and complex climate conditions, with enhanced performance in areas such as freeze resistance, pressure tolerance, and corrosion resistance, meeting the demands of large-scale commercial hot water, district heating, and industrial/agricultural heating projects. It is reported that standardization has driven the cumulative installed area of flat plate collectors in China to exceed 120 million square meters, with annual new installations accounting for over 70% of the market share. Furthermore, standards like the "Technical specification for GHG emission reduction assessment" have been translated into English, facilitating international application and signifying the maturity and openness of China's standard system.

2.4.1.3 China Standards Build a Sustainable Ecosystem

The core advantage of this standard system lies in establishing a virtuous cycle mechanism where "high-quality hardware ensures actual emission reduction effectiveness, and scientific methodology quantifies environmental value." At the hardware level, product standards like "Flat Plate Solar Collectors" ensure the reliability, energy efficiency, and system compatibility of collectors from the source through strict modular specifications and performance requirements. This provides a solid physical foundation for actual carbon emission reduction. At the assessment level, the "Technical specification at the project level for assessment of greenhouse gas emission reductions—Solar thermal applications" provides a clear and verifiable methodology to scientifically convert the thermal output of collection systems into monitorable, reportable, and verifiable carbon emission reduction data. The synergistic effect of these two aspects creates a closed-loop management system: product standards ensure the actual effectiveness of emission reduction projects, while the carbon reduction standard provides an authoritative tool for quantifying their environmental value. This mechanism not only improves the quality of individual systems but also drives the entire industrial chain towards higher standards and reliability, ensuring the authenticity and credibility of the environmental benefits of solar thermal projects.

2.4.1.4 Challenge and Opportunity

This comprehensive standard system has developed a set of "China Methods" for carbon accounting, which are grounded in China's national conditions and validated by the market. By fully considering local factors such as energy structures, project development models, and climatic characteristics, it ensures the accuracy, practicality, and credibility of carbon accounting results. The system not only provides core support for the healthy development of the domestic market and regulates corporate competition but also, through the release of English-translated standards, offers practical solutions for the global solar thermal sector, particularly for countries with similar development backgrounds.

However, the further advancement of this system still faces significant challenges. In terms of standard promotion, although key standards have been translated into English, obtaining full recognition from major international carbon credit mechanisms such as VCS and GS remains an obstacle, limiting the enhancement of its global influence. At the implementation level, in large-scale engineering projects, non-standard operations in any part of the entire industrial chain—from collector production to system integration, installation, construction, and later operation and maintenance—could lead to deviations between actual system performance and emission reduction outcomes, posing ongoing challenges to the end-to-end enforcement of the standards.

Therefore, promoting international mutual recognition of standards to enhance global acceptance, accelerating standard iteration to adapt to emerging trends such as energy storage integration and smart control, and strengthening quality control across the entire industrial chain to ensure the effective implementation of standards will be key priorities for the system's future development. These are also critical pathways for its transition from "Chinese Standards" to "International Standards."

2.4.1.5 Conclusion

In conclusion, China's solar thermal utilization standard system has established a robust foundation for high-quality development, effectively bridging product manufacturing, engineering applications, and carbon emission reduction accounting. By establishing a virtuous cycle where "high-quality hardware ensures real emission reductions and scientific methodology quantifies environmental value," the system has significantly enhanced the reliability and credibility of solar thermal projects. The development of the "China Methods" for carbon accounting, rooted in local conditions yet with global relevance, demonstrates China's proactive contribution to international efforts to reduce carbon emissions.

Looking ahead, the key focus will be on transforming challenges into opportunities for growth and development. The priority directions include actively promoting international standard mutual recognition to enhance global acceptance,

accelerating the iteration of standards to cover integrated applications such as solar with energy storage and smart management, and strengthening whole-process quality control to ensure consistent implementation across the industrial chain. Through these efforts, China's solar thermal standards are poised to evolve from a national success story into an internationally recognized benchmark, providing scalable solutions for global energy transition and making substantial contributions to achieving carbon neutrality goals worldwide.

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2.5 Latin America

2.5.1 Barbados

Prepared by Luis Christian Navntoft, Marisol Oropeza, and Danielle Johan

2.5.1.1 Background

Barbados has a population of approximately 284,996 inhabitants and a land area of 431 km², with nearly 100% access to electricity. According to the most recent population census, the country has 94,173 households, of which 48% have either a solar water heater (SWH) or another type of water-heating system.

Although Barbados has many renewable electricity initiatives and produces its own oil and natural gas, it lacks refinery capacity, which is why the country is forced to rely on imported refined fuels. Most electricity is generated from thermal power plants using Fuel Oil (74%), Kerosene (17.4%), Bagasse (5.6%), Diesel (2.2%), and Natural Gas (2%), with a small contribution (0.6%) from photovoltaic solar. All electricity is produced by Barbados Light and Power (BLP), a single utility.

As shown in Figure 2.1, the residential sector accounts for approximately 15% of Barbados' total final energy use. This dependence on imported fuels leads to volatile electricity prices, which is why Barbados has focused strongly on expanding the renewable energy market.

2.5.1.2 Pilot Projects

During the 1970s, electricity prices in Barbados rose from \$0.10 BBD in 1974 to \$ 0.40 BBD in 1984. BLP electricity bills include a base rate plus a monthly fuel-adjustment charge indexed to crude oil prices. Because the base rates changed only slightly, fuel adjustments significantly increased household bills.

In 1973, looking for ways to reduce church electricity expenses, Canon Andrew Hatch built a rudimentary SWH using an old oil drum and available materials to heat water for the church's community center. A local entrepreneur recognized the opportunity, established a company on the island, and soon installed a solar water heater in the home of the Prime Minister.

The Prime Minister was impressed by the energy savings, which triggered the creation of national incentive programs that became the foundation of Barbados' solar thermal expansion.

2.5.1.3 Incentive Programs

Barbados introduced incentive programs for both consumers and manufacturers. Several of these remain effective today:

- Fiscal Incentives (1974)

- A 30% tax was imposed on electric and gas water heaters, increasing their cost relative to solar energy systems. At the same time, import duties were removed for components used in the local manufacturing of SWHs. This reduced the system prices by approximately 20%.
- Mandatory SWHs in Public Buildings (1977)
 - Laws require all new public buildings to install solar water heaters.
- Homeowner Tax Benefit (1980–1992)
 - The full cost of purchasing and installing an SWH—up to USD 1,750—could be deducted from income taxes. The program ended in 1992 during a period of government restructuring and recession.
- Improved Homeowner Tax Benefit (1996–present)
 - The program was reinstated and expanded: homeowners may deduct up to USD 1,750 annually for home improvements, repairs, energy-efficiency upgrades, and SWH installations.
- Certification
 - Barbados does not have accredited certification bodies for solar water heaters, nor official certification procedures for SWH products. The entity responsible for standardization is the Barbados National Standards Institute (BNSI).

2.5.1.4 Outreach Activities

Barbados' diffusion strategies differ from those of larger Latin American countries due to its small population and favorable climate.

To understand these strategies, it helps to look at the evolution of the market:

- After the 1974 incentives, entrepreneur Solar Dynamics began local manufacturing.
- The Prime Minister's positive experience led to word-of-mouth promotion, which was extremely effective in a small community.
- By 1980, with mandatory SWHs in public buildings, annual installations rose from 900 to 2,800 by 1989.
- Two competitors emerged: SunPower and AquaSol.
- Because savings showed up clearly in monthly electricity bills, public trust grew rapidly.
- Companies offered temperature guarantees: if the SWH did not reach the promised temperature, the customer would receive a 100% refund.
- Financial institutions offered up to three years of credit, matching SWH payback periods, overcoming the barrier of high upfront cost.
- Barbados does not enforce product certification, but manufacturers voluntarily sent systems to the Solar Rating & Certification Corporation (SRCC) in Florida, where all three companies passed quality and safety testing.
- Because the population is small, poor-quality products would have damaged the market quickly through word-of-mouth. Instead, consistent product quality helped the market grow.
- The government also organized installer training and distributed informational materials explaining SWH benefits and tax incentives.

2.5.1.5 Results

Barbados has nearly 200,000 m² of installed solar collector area.

Given the country's dependence on imported fossil fuels, the benefits of solar water heaters were immediately visible.

The local market is now approaching saturation, and Barbadian manufacturers have become suppliers to other Caribbean nations.

Solar thermal expansion contributed to the creation of the Barbados Renewable Energy Association (BREA) in 2013, which promotes renewable energy and coordinates public–private actors (though primarily focused on renewable electricity).

Barbados' success stems from:

- Strong reliance on imported fuels (high-cost savings from SWHs)
- Rapid national implementation (small population and territory)
- Local production of reliable systems
- Word-of-mouth trust building
- Financial incentives and temperature guarantees

These strategies, while highly effective in Barbados, are more difficult to replicate in large countries, where outreach requires broader and more formalized mechanisms.

2.5.1.6 References

2018, Navntoft L. C., Oña Polit R., Dubrovsky H.; “*Calentadores Solares de agua: Estudios de casos d enormes de Calidad, procedimientos de verificación e instrumentos de información al consumidor para América Latina y el Caribe*”. Informe para el BID (Banco Interamericano de Desarrollo) available in Spanish at: <https://fundacionbariloche.org.ar/wp-content/uploads/2019/04/3.-Resumen-Ejecutivo-Calentadores-Solares-T%C3%A9rmicos.pdf>

2.5.2 Brazil

Prepared by Luis Christian Navntoft, Marisol Oropeza, and Danielle Johan

2.5.2.1 Background

Brazil has approximately **208,974,078 inhabitants** and **69.6 million households**, with an average household size of **3.0 persons**. Roughly **86%** of dwellings are single-family houses.

Much of northern Brazil **does not use water heaters**, largely due to the region's warm climate. In the north, average annual temperatures range from **20°C to 28°C**, and **90% of households do not heat water**. In contrast, in the central-southern region—where temperatures range from **10°C to 20°C**—**98% of households use water heaters**. Combining these differences, **75.3% of Brazilian households heat water**, while **24.7% do not**.

Among households that heat water:

- **91.5% use electric water heaters**
- **7.2% use natural gas**
- **1.3% use other systems**

Most heaters are **electric instantaneous shower-type heaters** (“chuveiros”), typically rated at **3 kW**. Their distribution is more concentrated in the central-southern region, which also corresponds to the highest-income population (Brecht, 2016). Over **60% of Brazil's population** lives in these regions.

Access to water infrastructure differs as well:

- **90%** of residents in the south–southeast have potable water and sewage service
- Only **21%** in the north have access to both

Given the prevalence of electric instantaneous heaters, Brazil has an estimated **47.4 million electric units**, with a *simultaneous potential load* of **108,140 MW** if all were used at once — a demand level beyond the capacity of any electrical grid.

Their usage patterns generate significant **load peaks**:

- Morning peak: **7:00–8:00**
- Evening peak: **18:00–20:00**

These peaks, combined with droughts in the 2000s (Brazil relies heavily on hydropower), population growth, and industrial expansion, caused the famous “**Apagões**” (blackouts). Electricity use for a conventional household is shown in figure 1

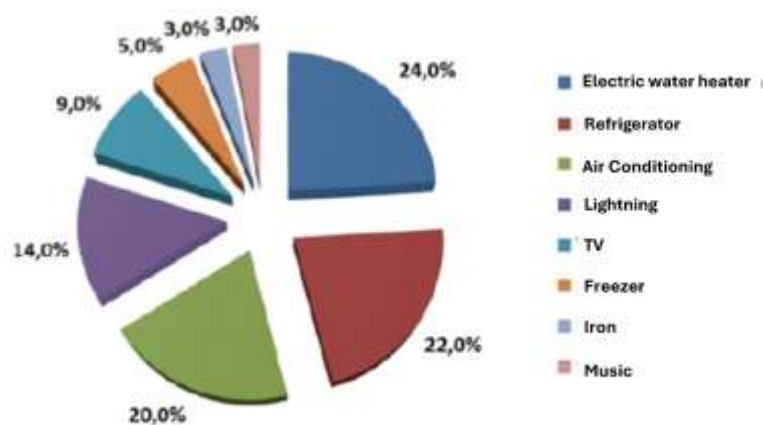


Figure 1. Use of electricity in Brazil for 2018.

As a result, Brazil redesigned its national energy strategy, introducing:

- National energy efficiency programs
- Efficiency labelling for appliances
- Minimum efficiency performance standards
- Promotion of renewable energy sources (Brecht, 2016)

The **National Energy Efficiency Plan 2030**, approved in 2011, aims to reduce electricity consumption by **10% by 2030**. Solar thermal energy plays a key role in reducing the grid stress caused by electric water heating during peak hours.

Brazil today has **the largest solar thermal market in Latin America**.

As shown in figure 2, annual production of collector area increased from:

- **50,000 m² in 1985** →
- **500,000 m² in 2001**
- **2.000.000 m² in 2025**

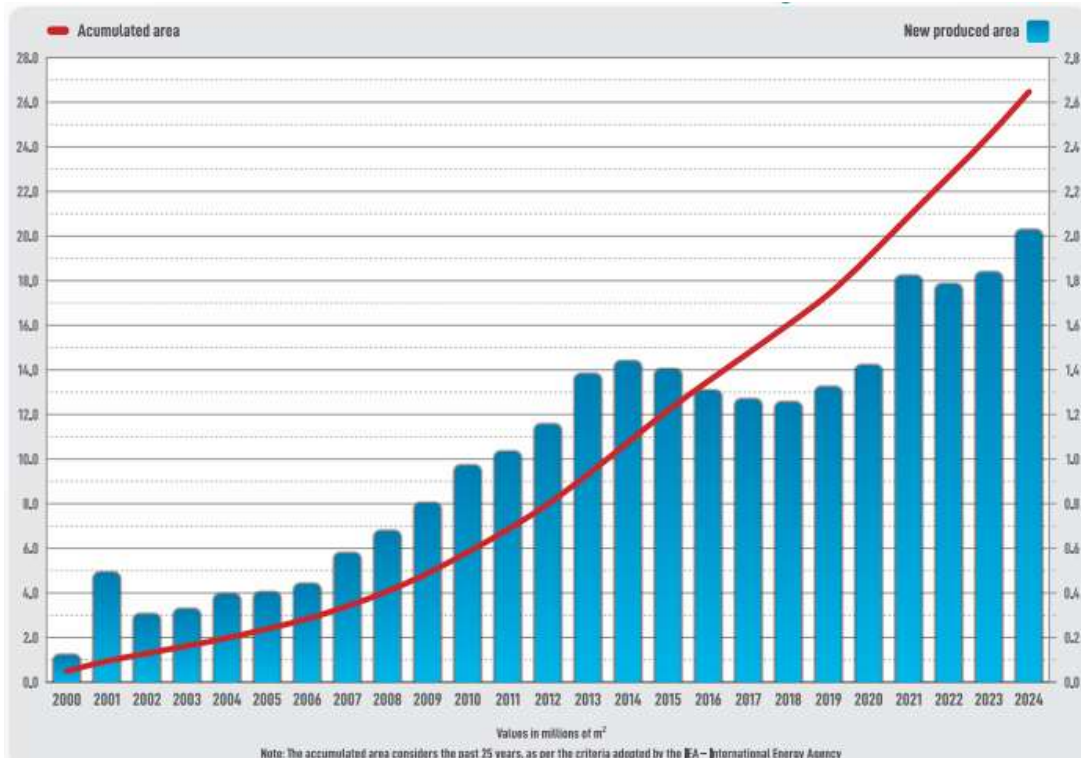


Figure 2. Accumulated Area and new produced area in Brazil for the period 2000-2024 (ABRASOL).

This growth was largely a response to the energy crisis caused by widespread use of electric showers.

Currently:

- Over **100 domestic manufacturers** operate in Brazil
- Annual production: **2 million m²**
- Total installed area (2025): **26+ million m² (ABRASOL)**

2.5.2.2 Pilot Projects

One of the earliest promoters of solar water heating in Brazil was the state of São Paulo, which in July 2008 made the installation of solar thermal systems mandatory for:

- All new residential and non-residential buildings
- Buildings undergoing major renovations

This state-level solar ordinance was an important milestone. By 2015, it is estimated to have resulted in the installation of 110,000 m² of collector area.

However, at that time, Brazil still lacked a national strategy for promoting solar thermal energy in key sectors (housing, industry, tourism), and demonstration projects had not yet been widely developed.

In 2008, commissioned by the German Federal Ministry for the Environment (BMU), the German Technical Cooperation Agency (GIZ) launched the “1,000 Solar Roofs Project” (“Projeto 1000 Telhados Solares”), implemented between 2009 and 2013. The project’s goal was to promote solar water heaters as an environmentally friendly and energy-efficient option across various regions and industrial sectors in Brazil.

This project is widely recognized as extraordinarily successful.

A key milestone was the Mangueira demonstration project in Rio de Janeiro, where 496 social housing units were equipped with solar water heaters. The project was financed by CAIXA, the state development bank, with technical cooperation from GIZ.

The positive technical and institutional experience gained from the “1,000 Solar Roofs” pilot became the foundation of Brazil’s most influential national program for solar thermal energy:

2.5.2.3 Incentive Programs

Minha Casa Minha Vida (MCMV)

(My House, My Life)

MCMV is a **national housing credit program** for low-income families earning up to **1,600 Brazilian reais** (approximately USD 588) per month.

Since **2012**, all **single-family homes** financed under MCMV must include a **solar water heater system**. For multi-family buildings, the requirement is optional.

Key features:

- Up to **2,000 BRL** (~USD 610) may be financed to cover both equipment and installation
- Loans provided by **CAIXA**, Brazil’s federal housing bank
- Systems must comply with **INMETRO certification requirements**
- Installations should preferably be done by technicians certified under **QUALISOL**, Brazil’s professional certification program for solar thermal installers

Other incentive programs in Brazil follow similar rules and usually refer back to the **MCMV requirements** for product certification and installation quality. Figure shows the promotion of solar thermal heaters in social housing.



Figure 3. Promotion of solar thermal in social housing in Brazil.

2.5.2.4 Certification

Early market growth in Brazil was characterized by the installation of non-certified systems, primarily due to the price difference between domestic and imported products, as well as the absence of mandatory quality controls.

To address this, manufacturers organized under ABRAVA (currently ABRASOL) took the initiative to develop quality standards and technical norms for solar thermal systems. Beginning in 1996, certification was introduced voluntarily, but adoption was initially limited because uncertified systems remained cheaper.

Over time, more manufacturers chose to differentiate themselves by certifying their products. As this trend gained momentum, manufacturers began advocating for mandatory certification of all solar water heaters—both imported and locally manufactured—and for national promotion programs to require certified products.

By 2016, Brazil's certification scheme had:

- 50 certified manufacturers
- 284 certified SWH models

The authority responsible for:

- defining requirements
- accrediting laboratories
- accrediting product certification bodies

is INMETRO (National Institute of Metrology, Quality, and Technology).

Although in many countries these three roles (standards, accreditation, certification) are independent, in Brazil INMETRO centralizes them, and this arrangement has proven effective.

In 2012, INMETRO—together with ABRAVA and other institutions—introduced Ordinance 301, which made certification mandatory for all solar water heaters sold in Brazil, requiring compliance with technical standards by 2015.

Due to industry requests and testing capacity limitations, implementation was phased in over several years.

Brazil currently has:

- Two accredited solar thermal testing laboratories
- A certification framework based on ABNT standards, aligned with EN 12975/76 and ISO methodologies
- Mandatory certification for all systems participating in incentive programs such as MCMV

2.5.2.5 Market Surveillance

Brazil also established market surveillance actions to ensure:

- Only certified products are sold
- Imported systems meet equivalent standards
- Installations comply with established guidelines

INMETRO maintains an official registry of all certified solar thermal systems.

2.5.2.6 Standards

Solar water heaters in Brazil are tested and certified under ABNT (Brazilian Association of Technical Standards) requirements.

Outreach Activities

Brazil has invested heavily in dissemination and public education, particularly due to:

- high electricity consumption caused by electric showers
- peak-load stress on the grid

- national housing programs requiring SWHs

Promotional strategies include:

Technical material for installers and interested users

ABRASOL and federal agencies have produced:

- Installer manuals
- Technical design guides
- Illustrated step-by-step installation procedures
- Training videos
- Best-practices documentation
- Maintenance and troubleshooting guides

These materials support the professionalization of the sector and help ensure proper installation—critical to system performance.

The QUALISOL program (Currently QUALISOLAR) further strengthens installer competencies through:

- professional certification
- system design training
- installation-quality requirements for MCMV and other incentive programs

2.5.2.7 Results

Brazil is the largest solar thermal market in Latin America, with:

- Over 26 million m² of installed collectors
- A strong domestic manufacturing base (100+ companies)
- Mandatory certification and market surveillance
- Large-scale housing programs driving widespread adoption

2.5.2.8 References

2018, Navntoft L. C., Oña Polit R., Dubrovsky H.; “*Calentadores Solares de agua: Estudios de casos d enormes de Calidad, procedimientos de verificación e instrumentos de información al consumidor para América Latina y el Caribe*”. Informe para el BID (Banco Interamericano de Desarrollo) available in Spanish at:

<https://fundacionbariloche.org.ar/wp-content/uploads/2019/04/3.-Resumen-Ejecutivo-Calentadores-Solares-T%C3%A9rmicos.pdf>

2025. Abrasol (Associação Brasileira de Energia solar Térmica): <https://abrasol.org.br/wp-content/uploads/2025/06/Solar-Heating-Systems-Production-and-Sales-2025.pdf>

2.5.3 Chile

Prepared by Luis Christian Navntoft, Marisol Oropeza, and Danielle Johan

2.5.3.1 Background

Chile has high access to electricity and a diversified energy matrix, but the country heavily relies on imported fossil fuels. Over the last decade, strong national policies have accelerated the adoption of renewable energy, particularly solar photovoltaic and solar thermal technologies.

Domestic hot water (DHW) usage is widespread, and a significant portion of the population resides in temperate or cold regions, which increases heating demand. Natural gas—both piped and imported LNG—is widely used in urban centres, while LPG and electricity are common alternatives.

The residential sector represents roughly 15% of final energy consumption (as shown in earlier figures). Water heating is a major component of household energy use.

Chile has emerged as one of the most dynamic markets for solar thermal energy in Latin America. Since nearly all solar water heating equipment is imported, certification and regulation are crucial.

2.5.3.2 Pilot Projects

Solar thermal technology gained momentum in Chile through pilot programs implemented by:

- The Ministry of Housing and Urbanism (MINVU)
- The Ministry of Energy
- CORFO (Corporación de Fomento de la Producción)
- International cooperation agencies such as GIZ

Pilot projects tested:

- Technical performance under Chile's diverse climates
- Economic benefits for households
- Installation procedures
- Quality assurance requirements

These pilots helped define the standards later incorporated into incentive programs and national regulations.

2.5.3.3 Incentive Programs

Chile has implemented several large-scale incentive programs to promote solar water heaters (SWHs), particularly in the housing sector:

Law Nº 20.897 (formerly 20.365)-No longer available

This law establishes a tax credit for the incorporation of solar thermal systems in new residential buildings. Key features:

- Applies primarily to new housing developments
- Homebuyers benefit indirectly through reduced construction costs
- Systems must be certified under approved standards
- Created a strong market driver between 2010 and 2017

Subsidy from the Family Heritage Protection Program (PPPF)

MINVU's PPPF program subsidizes improvements to existing homes. Support includes:

- Funding to retrofit solar water heaters
- Certification requirements
- Aimed at lower- and middle-income households

Reconstruction Program Solar Subsidy

Following natural disasters, Chile introduced subsidies that encouraged including SWHs in post-disaster housing reconstruction. These programs helped increase adoption in vulnerable communities.

2.5.3.4 Certification

Solar water heaters used in Chile's incentive programs must be certified, but equipment sold outside subsidy programs does not require mandatory certification.

Because most SWHs are imported, Chile developed a certification system focused on:

- Verifying foreign certificates
- Conducting conformity assessments
- Performing local testing when needed

Chile does not require full retesting of imported systems if international certifications are valid.

Certification is handled by accredited inspection and certification bodies, supervised by the Superintendence of Electricity and Fuels (SEC).

Chile has one accredited solar thermal testing laboratory, which evaluates SWHs not certified at origin.

2.5.3.5 Standards

While Chile has its own national standards (INN norms), certification primarily relies on internationally recognized ones:

- EN 12975 (solar collectors)
- EN 12976 (factory-made systems)
- EN 12977 (custom-built systems)

These standards form the basis for evaluating the performance and safety of SWHs used in Chile.

Outreach Activities

Chile has engaged in extensive educational and promotional initiatives:

- MINVU and Ministry of Energy maintain updated webpages with SWH information
- Training courses for installers, technicians, and inspectors
- Public awareness campaigns, especially during early years of Law 20.365
- Instructional manuals and technical guidelines developed with CORFO and GIZ
- Workshops and seminars targeting developers, construction companies, and municipalities

These outreach efforts helped build market trust and familiarity with solar thermal systems.

2.5.3.6 Results

Between 2011 and 2017, Chile experienced rapid growth in SWH installations, driven primarily by:

- The tax credit for new housing (Law 20.365/20.897)
- PPPF retrofitting subsidies
- Reconstruction programs
- Increasing awareness of energy efficiency

Figure 1 shows installations from 2011 to 2017, with a sharp rise during the peak years of the tax-credit program. As of 2025, the total installed area of solar collectors is 455.891 m² (Solar Heat worldwide, 2025).

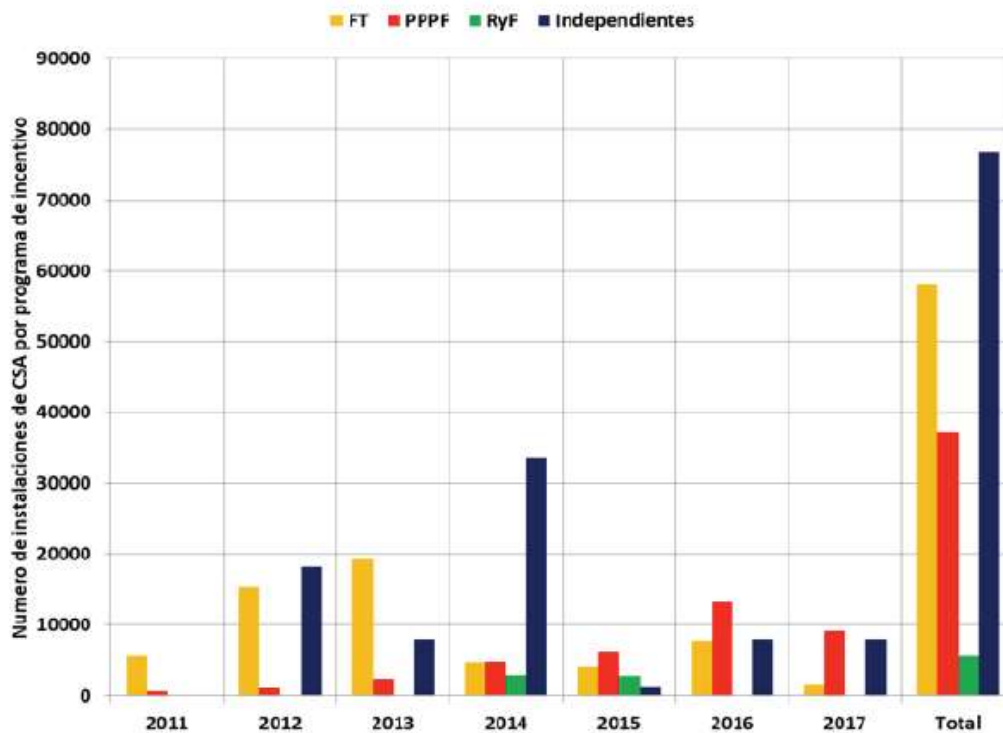


Figure 1. Evolution of installed solar collector area in Chile from 2011 to 2017.

Other key results:

- Chile has a mid-sized solar thermal market in Latin America, smaller than Brazil or Mexico but larger than Colombia
- Nearly all systems are imported, leading to strong dependence on international certification
- The combination of policy incentives, mandatory certification in subsidy programs, and strong outreach matured the market
- After the initial rapid growth, installations stabilized when the core programs reached saturation

Chile's experience demonstrates the importance of:

- Strong, well-designed incentives
- A robust certification model suitable for import-heavy markets
- Technical training and outreach
- Integration of solar thermal into public housing policy

2.5.3.7 References

2018, Navntoft L. C., Oña Polit R., Dubrovsky H.; "*Calentadores Solares de agua: Estudios de casos de normas de Calidad, procedimientos de verificación e instrumentos de información al consumidor para América Latina y el Caribe*". Informe para el BID (Banco Interamericano de Desarrollo) available in Spanish at:

2.5.4 Mexico

Prepared by Luis Christian Navntoft, Marisol Oropeza, and Danielle Johan

2.5.4.1 Background

Mexico has one of the largest solar thermal markets in Latin America, second only to Brazil in total installed area. The country's climate, high solar radiation levels, and widespread use of LPG for water heating make solar water heaters (SWHs) economically attractive for households.

Key characteristics:

- Mexico has high coverage of domestic hot water use.
- Approximately 47% of households use some form of water-heating system.
- The dominant technology is LPG water heaters, representing 82% of installed systems.
- Natural gas is widely used in large urban centres and new housing developments.
- Electricity plays a minor role in water heating due to historically higher tariffs.

Mexico's energy matrix includes a significant share of fossil fuels, making solar thermal a key opportunity for reducing household energy expenditures and national emissions.

SWH adoption is driven by:

- favourable climate
- rising LPG prices
- national energy-efficiency programs
- large-scale housing programs
- strong participation from manufacturers and importers

2.5.4.2 Pilot Projects

Mexico has implemented a variety of pilot projects led by:

- CONUEE (National Commission for Efficient Energy Use)
- FIDE (Electricity Savings Trust)**
- INFONAVIT and FOVISSSTE housing institutes
- SENER (Secretariat of Energy)**
- International cooperation agencies (GIZ, USAID, IDB)

Early pilot programs focused on:

- testing SWH performance under different climatic conditions
- evaluating economic savings for households
- determining technical standards appropriate for Mexico

- introducing SWHs into low-income and social housing
- validating installer training methodologies

These pilots provided essential data and were later integrated into large-scale national programs.

2.5.4.3 Incentive Programs

Mexico has a robust policy framework that supports the adoption of solar thermal energy, particularly through national housing programs and energy efficiency standards.

- Hipoteca Verde (Green Mortgage) – INFONAVIT. This program is one of the largest drivers of solar water heater installations in Mexico.
 - Key elements:
 - Provides additional credit to homeowners who install energy-saving measures.
 - SWHs are included as eligible technologies.
 - Systems must meet certification and performance requirements.
 - Applies mainly to new homes financed through INFONAVIT.
 - Hipoteca Verde has resulted in hundreds of thousands of solar water heater installations.
- FIDE SWH Incentive Programs. FIDE offers programs enabling households to:
 - access financing for certified solar water heaters
 - repay systems through their electricity bill
 - select equipment from an approved list of certified systems
 - Although LPG is the primary fuel being displaced, the electric-utility billing system makes financing more accessible and reliable.
- Sustainable Housing Programs. Through CONAVI, SEDATU, and INFONAVIT, Mexico promotes sustainable housing that includes:
 - high-efficiency building envelopes
 - solar thermal systems
 - energy-efficient appliances
 - integration of renewable energy technologies
 - SWHs play an increasing role as sustainable construction criteria evolve.
- State and Municipal Incentives. Some states and municipalities (e.g., Mexico City, Jalisco, Baja California) offer:
 - rebates
 - tax reductions
 - local financing
 - incentives for hotels, hospitals, and multifamily buildings
 - These programs complement national initiatives.



Figure 1. Example of local manufactured solar thermosiphon installed in Mexico City in a multifamily building under the city incentives.

2.5.4.4 Certification

Mexico has one of the most advanced certification frameworks for solar water heaters in Latin America.

Certification is managed by:

- ANCE (National Association of Standardization and Certification)
- ONNCCE (National Body for Standardization and Building Certification)
- CONUEE, which oversees energy efficiency regulations

Testing must be performed in accredited laboratories such as:

- INAOE (National Institute of Astrophysics, Optics and Electronics)
- CIATEQ (Advanced Technology Center)
- CIDETEQ
- Additional laboratories recognized under international agreements

2.5.4.5 Standards

Mexico has modern and comprehensive standards for solar water heating:

- NMX-ES-001 (Collectors) – performance and safety
- NMX-ES-004 (Thermosiphon systems) – durability and quality
- NOM-027-ENER (Thermal performance) – energy efficiency
- NOM-003-ENER (Storage tanks) – insulation and safety

Participation in incentive programs (e.g., Hipoteca Verde) requires:

- laboratory testing
- certification
- inclusion in an official product registry

This ensures confidence in product quality and long-term performance.

2.5.4.6 Outreach Activities

Mexico's outreach efforts are well-developed and include:

- national communication campaigns on energy efficiency
- manuals and technical guides for installers
- consumer guides explaining SWH benefits
- training and certification programs
- online databases of certified systems
- workshops and conferences organized by CONUEE, ANCE, GIZ, and industry groups

Public awareness of SWH benefits is relatively high due to:

- strong government promotion
- rising LPG prices
- widespread participation from developers and builders

2.5.4.7 Results

Mexico has experienced significant growth in solar thermal installations, especially between 2010 and 2016, driven by:

- Hipoteca Verde
- sustainable housing policies
- increased certification requirements
- greater consumer confidence in quality

Key achievements:

- With 6.384.324 m² of installed collector area (Solar Heat worldwide, 2025), Mexico is the second-largest solar thermal market in Latin America by installed area.
- Mexico has a strong solar thermal local industry where half of the manufacturers produce flat plate type, and the other half produce tanks and import evacuated tubes from China.
- Strong integration of SWHs in social housing
- High market visibility and numerous certified brands
- Growing industrial and commercial applications (hotels, laundries, hospitals). Mexico has the most solar industrial process heat applications in Latin America

Challenges include:

- sporadic budget fluctuations in national programs

- dependency on imported systems for some segments
- lack of mandatory SWH certification outside incentive-based programs
- slower adoption in regions with lower LPG prices or warmer climates

Overall, Mexico has built a strong foundation for continued solar thermal growth and remains a regional leader in regulation, certification, and large-scale deployment.

2.5.4.8 References

2018, Navntoft L. C., Oña Polit R., Dubrovsky H.; “*Calentadores Solares de agua: Estudios de casos d enormes de Calidad, procedimientos de verificación e instrumentos de información al consumidor para América Latina y el Caribe*”. Informe para el BID (Banco Interamericano de Desarrollo) available in Spanish at:

<https://fundacionbariloche.org.ar/wp-content/uploads/2019/04/3.-Resumen-Ejecutivo-Calentadores-Solares-T%C3%A9rmicos.pdf>

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2.6 Middle East

2.6.1 SHAMCI

Prepared by Khalid Salmi

2.6.1.1 SHAMCI: Driving Quality in Solar Thermal Energy Across the Arab Region



The Solar Heating Arab Mark and Certification Initiative (SHAMCI) is the first regional quality assurance and certification scheme dedicated to solar thermal products and services in the Arab world.

Developed by the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) in collaboration with the Arab Industrial Development and Mining Organization (AIDMO) and endorsed by the Arab Ministerial Council of Electricity (AMEC), SHAMCI fills a long-standing gap in the region’s solar thermal landscape: the need for unified, credible, and locally relevant quality standards.

By aligning market practices with international best practices for industrial quality and conformity assessment, SHAMCI strengthens both consumer protection and investor confidence, which are two critical ingredients for sustainable energy transitions.

2.6.1.2 Regional Solar Potential and Market Context

Across the Arab region, solar resources are among the highest globally, with average Global Horizontal Irradiation reaching approximately 2,100 kWh/m² annually (Figure 1). Yet market uptake of solar water heating (SWH) systems varies significantly.

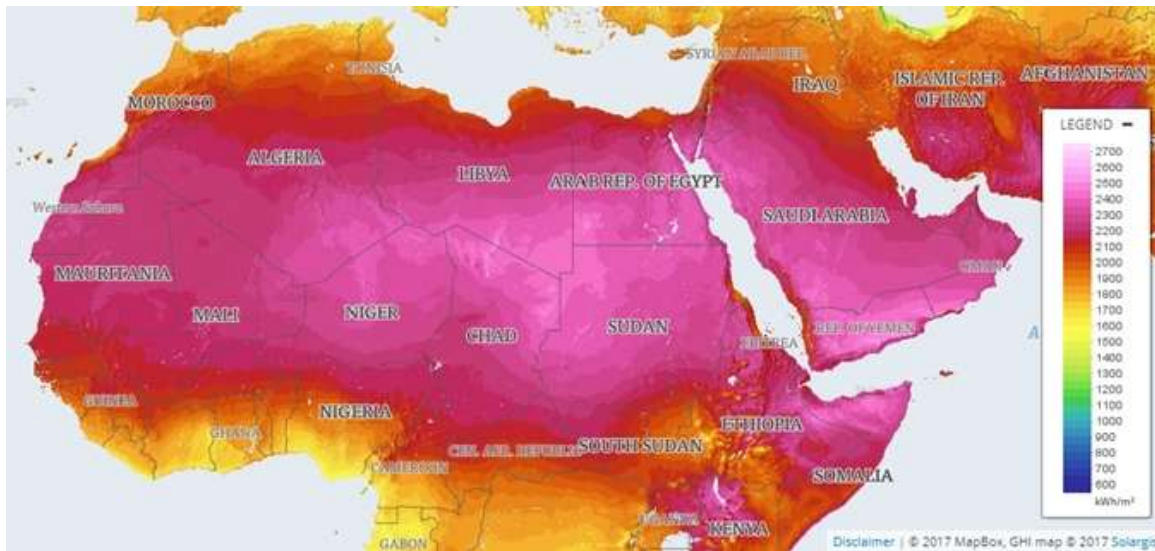


Figure 1: Global solar radiation (kWh/m²).

Countries such as Jordan, Lebanon, Palestine, Tunisia, and Morocco have developed mature markets that are largely dominated by thermosiphon technologies. Palestine continues to lead in household penetration, followed by Jordan and Lebanon. Conversely, adoption remains marginal in Gulf countries, Libya, Sudan, and Yemen, where policy gaps, weak regulatory frameworks, and the absence of certification schemes have limited both consumer trust and private-sector investment.

This uneven landscape highlights the need for standardized quality assurance mechanisms that can stabilize markets and foster long-term sector growth.

2.6.1.3 SHAMCI in Egypt and Jordan

Egypt and Jordan stand at the forefront of SHAMCI implementation. In Egypt, the Ministry of Industry has formally recognized SHAMCI as an official national certification scheme, placing it on an equal footing with established marks, such as the Solar Keymark.

The Egyptian Organization for Standardization and Quality (EOS) now serves as the exclusive certification body responsible for evaluating manufacturers and importers based on SHAMCI requirements before products can enter the domestic market. This step has introduced a new level of discipline and accountability into Egypt’s SWH sector, helping ensure product durability, safety, and performance. Figure 2 shows the first SWHs to be tested according to SHAMCI in the NREA testing laboratory in Egypt.



Figure 2: NREA testing laboratory in Egypt (Photo by RCREEE).

Jordan's progress has been equally significant. The Jordan Standards and Metrology Organization (JSMO) adopted SHAMCI as a national certification scheme, establishing clear application procedures, fees, and a renewable two-year certification cycle.

This achievement was the product of strong coordination between RCREEE, JSMO, and the Ministry of Energy and Mineral Resources. With this decision, Jordan became the second country in the region to institutionalize SHAMCI, contributing to a more structured and transparent quality environment for both manufacturers and consumers.

So far, four companies have applied for SHAMCI certificates in Egypt, and three in Jordan. SHAMCI certificates have already been awarded to two companies in Egypt and two companies in Jordan, and their certified products are now available in both the Egyptian and Jordanian markets.

2.6.1.4 Benefits of SHAMCI

The benefits of SHAMCI extend well beyond certification:

- For government authorities, the scheme enhances consumer protection, strengthens monitoring and inspection capacities, and creates a common reference point for regional cooperation on industrial quality.
- For manufacturers, it offers a cost-effective pathway to demonstrate compliance, gain credibility, and access regional markets with reduced administrative and testing burdens.
- For consumers, SHAMCI serves as a trusted signal of product reliability, helping them make informed purchasing decisions and ensuring that installed systems perform as expected over their operational lifetime.

2.6.1.5 SHAMCI Network

Central to SHAMCI's governance is the SHAMCI Network, which is a regional platform that brings together energy agencies, industry representatives, testing and inspection laboratories, certification bodies, research institutions, NGOs, and development partners (Figure 3).



Figure 3: The SHAMCI Network

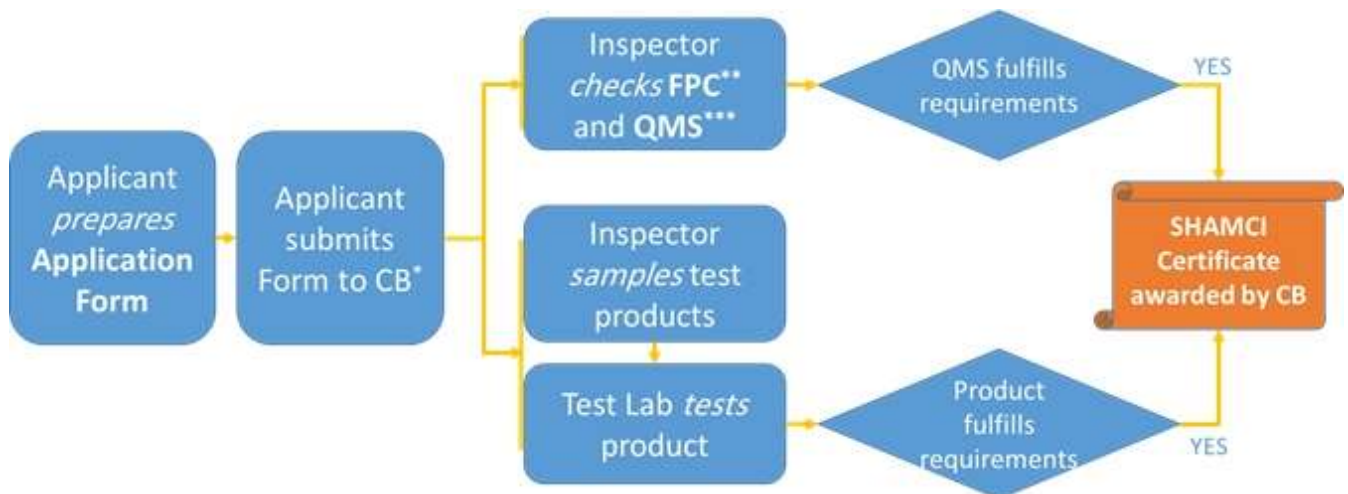
Today, the network includes 59 members from 22 Arab countries and serves as a collaborative hub for policy alignment, technical exchange, and continuous improvement of the scheme. Its responsibilities range from updating certification procedures and harmonizing conformity assessment practices to approving laboratories and maintaining the registry of certified products.

This collective approach ensures that SHAMCI remains technically sound, regionally consistent, and responsive to evolving market needs.

2.6.1.6 How the SHAMCI Scheme Operates

The SHAMCI certification process follows a well-structured and transparent sequence of steps. Applicants begin by submitting an official application to a national certification body, accompanied by the required documentation and fees.

This is followed by a rigorous conformity assessment phase, which includes factory inspections, evaluation of Quality Management Systems, and laboratory testing of selected samples under Factory Production Control (FPC) protocols.



Based on the findings, the certification body then issues or declines the SHAMCI certificate. The clarity of this process helps reduce ambiguity for manufacturers and ensures that all certified products meet a consistent and verifiable quality baseline.

2.6.1.7 Conclusion

As Arab countries advance their renewable energy targets and decarbonization strategies, the role of high-quality infrastructure becomes increasingly crucial. SHAMCI has emerged as a cornerstone of this infrastructure for solar thermal technologies. By offering a harmonized framework that balances technical rigor with practical implementation, the initiative strengthens markets, protects consumers, and provides a foundation for regional industrial growth.

With formal adoption in Egypt and Jordan and strong engagement through the SHAMCI Network, the initiative is now well-positioned to serve as the reference quality mark for solar thermal products across the Arab region, supporting not only cleaner energy systems but also a more competitive and trustworthy marketplace.

3 Summary, conclusions, and recommendations

The success stories are related to the implementation and growth of the solar thermal energy market, particularly the market for solar hot water (SHW) systems.

In total, ten success stories about standards and quality certification for SHWs and their installations have been written for various markets, including the EU, Australia, Asia, the SADC region, and Latin America.

The ten success stories from different parts of the world draw several common conclusions regarding the development of the SHW market, standards and quality certification, and the influence of government policies.

The common stories are that the successful development and sustainability of the market for SHWs require stable government policies, robust quality standards and certifications, trained/skilled installers, as well as raising market awareness and consumer confidence.

The key conclusions that can be drawn from the success stories are:

1. Quality standards and certification are essential for market success

A robust quality infrastructure is a critical foundation for sustainable market growth and consumer and investor confidence in solar thermal technology.

- Major success stories are tied to established certification marks, such as the Solar Keymark in Europe, which is a voluntary third-party mark that serves as the basis for most public support schemes, and

SHAMCI (Solar Heating Arab Mark and Certification Initiative), the first regional quality assurance scheme in the Arab world.

- Countries continuously improve their testing methods; for example, Australia shifted from outdoor testing to Component Testing and System Simulation (CTSS) for performance evaluation. China has established a comprehensive standard system, spanning from product manufacturing to carbon emission reduction accounting, which ensures the scientific quantification of environmental impact.
- Certification is often mandatory for equipment used in government incentive or subsidy programs, as seen in Brazil and Chile, which helps to professionalize the sector and ensure system reliability.

2. Government policy and incentives drive adoption

Strong, well-designed government policies, often coupled with financial incentives, are the primary driver for large-scale adoption of solar energy systems.

- Significant market expansion often follows a national energy crisis or high energy costs. Brazil's rapid solar thermal growth was largely a response to the energy crisis caused by electrical load peaks from widespread use of electric showers. Similarly, Barbados' success was driven by a dramatic increase in electricity prices (x4) resulting from its dependence on imported fossil fuels.
- Effective policies include financial incentives (tax benefits, subsidies), mandatory SWH installation in public buildings (Barbados), or white certificate energy upgrade schemes (Australia).
- Integrating SWHs into large-scale social or public housing programs (e.g., in Chile and Mexico) is an effective mechanism for widespread, rapid deployment.
- Stricter energy regulations in building codes can also drive adoption, as new and renovated buildings may use solar heating to comply with energy requirements in building codes (Denmark).

3. Market scale and structure vary by region

Solar thermal markets differ significantly in size and their reliance on domestic versus imported manufacturing.

- China is the undisputed global leader in solar thermal, with a cumulative heat collection area of 545 million m² as of 2023, accounting for 72.8% of the global market share.
- In Latin America, Brazil is the largest market, followed by Mexico.
- Brazil and Barbados have a strong domestic manufacturing base and local production of reliable systems. In contrast, Chile's market is heavily dependent on imported equipment.
- The main fuel that solar thermal is substituting varies. For example, it targets electric instantaneous heaters in Brazil and LPG water heaters in Mexico.

4. Training and professionalization are key to sustained performance

The documents highlight the need to move beyond product quality to ensure installation and maintenance quality.

- Projects like SOLTRAIN+ in the SADC region use a multifaceted approach that includes comprehensive technical training for installers, "train the trainer" courses for vocational teachers, and university-level courses.
- Professional programs like the QUALISOL program in Brazil (now QUALISOLAR) certify installers and set quality requirements, which are recognized as critical for proper system performance.

5. Sustained relevance of SHWs requires strategies

The SHW market faces competition from other technologies and requires measures to stay relevant, such as innovation and adaptation

- The SHW market faces competition from other technologies, such as cheap solar PV (Australia) and the expansion of natural gas and/or district heating infrastructure (China, Denmark).
- The combination of SHWs with other technologies, such as natural gas boilers and heat pumps, can lower the costs for SHWs (e.g., Denmark).
- Expanding into new markets, such as commercial, industrial, and social housing applications (Mexico, Brazil), is important for sustained growth.

Based on the findings from the success stories, a high quality of components is documented. It is therefore recommended to:

- Train and certify installers.

- Focus on establishing attractive business cases for certified installers, as they are the ones who meet customers and homeowners and ultimately sell and install the systems.
- Raise consumer awareness of SHW technologies and their advantages, e.g., by nationwide campaigns and through social media.
- Educate and inform the politicians and decision makers about SHW technologies and their advantages, e.g., by lobbying firms operating close to the parliament and through social media.