EDITION
2021

WERNER WEISS | MONIKA SPÖRK-DÜR

SOLAR HEAT WORLDWIDE

Global Market Development and Trends in 2020 | Detailed Market Figures 2019

Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Heat Worldwide

Global Market Development and Trends in 2020
Detailed Market Data 2019

2021 EDITION

Werner Weiss, Monika Spörk-Dür

AEE INTEC
AEE - Institute for Sustainable Technologies
8200 Gleisdorf, Austria

IEA Solar Heating & Cooling Programme, May 2021

Supported by the Austrian Ministry for Climate Action

Cover Photo: Newheat - ADEME

Design by STEINHUBER INFODESIGN, Graz, Austria

Acknowledgments

The authors would like to give special thanks to the following contributors to this edition of the Solar Heat Worldwide Report:

Chapter Contributors

Chapter 4.1.1: Small-scale solar thermal heating systems
Dr. Harald Drück, Stuttgart University

Chapter 4.2: Large-scale solar thermal heating systems
Bärbel Epp, Solrico

Chapter 4.3: Solar Heat for Industrial Applications
Wolfgang Gruber-Glatzl, AEE INTEC
Bärbel Epp, Solrico

Chapter 4.4: Photovoltaic-Thermal Systems (PVT)
Carina Seidnitzer-Gallien and Thomas Ramschak, AEE INTEC

Chapter 4.5: PV2heat Systems
Angelo Buckley and Karin Kritzinger, Stellenbosch University

Chapter 4.6: Solar Air Conditioning and Cooling
Dr. Uli Jakob, Dr. Jakob energy research GmbH
Dr. Daniel Neyer, Brainworks GmbH

Chapter 4.7: Solar Air Heating Systems
Victoria and John Hollick, SolarWall Conserval Engineering Inc.

Country Data Contributors

We very much appreciate the long-term co-operation with all national delegates of the IEA SHC Executive Committee, Pedro Dias from Solar Heat Europe and other national experts, who provide the updated solar thermal market data from 68 countries around the globe every year. All these contributors are listed in the Appendix of this report.

Advice and Proofreading

Last but not least, the authors would like to thank Pamela Murphy, Secretariat of the IEA SHC Technology Collaboration Programme for her feedback, ideas for improvement and proofreading of the report.

Table of Contents

1 Background

The Solar Heat Worldwide report has been published annually since 2005 within the framework of the Solar Heating and Cooling Technology Collaboration Programme (SHC TCP) of the International Energy Agency (IEA).

The goal of the report is to: 1) give an overview of the general trends, 2) highlight special applications and outstanding projects, 3) document the solar thermal capacity installed in the important markets worldwide, and 4) ascertain the contribution of solar thermal systems to the supply of energy and the CO_2 emissions avoided as a result of operating these systems.

The collector types detailed in the report are unglazed collectors, glazed flat-plate collectors (FPC) and evacuated tube collectors (ETC) with water as the energy carrier, as well as glazed and unglazed air collectors.

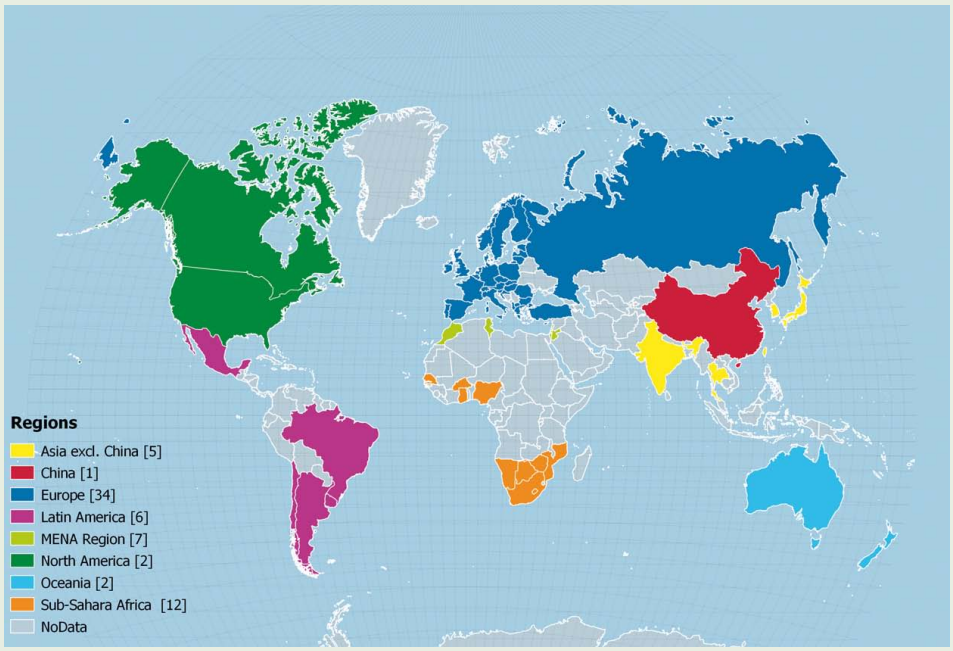
Photovoltaic Thermal (PVT) collectors are included, as the market for these types of collectors has grown in market relevance in recent years. PVT collectors convert solar radiation into both electricity and heat and thus could play an important role in the energy supply of the future.

The report's data was collected through a survey of the national delegates of the SHC TCP Executive Committee, Solar Heat Europe and national experts active in the field of solar thermal energy. As some of the 68 countries included in this report have very detailed statistics and others have only estimates from experts, the data was checked for its plausibility on the basis of various publications.

The collector area, also referenced as the installed capacity, served as the basis for estimating the contributions of solar thermal systems to the energy supply and reductions of CO_2 emissions.

The 2021 edition and all past issues of the report can be downloaded from the following website:
http://www.iea-shc.org/solar-heat-worldwide.

Figure 1: *Countries shown in color have detailed market data. Countries shown in grey have estimated market data. (Source: Natural Earth v.4.1.0, 2020/ AEE INTEC)*



2 Summary

This report is split into two parts. The first part (**Chapters 3 – 4**) gives an overview of the global solar thermal market development in 2020. In addition, general trends are described and detailed 2020 data on successful applications, such as solar assisted district heating, solar heat for industrial processes and hybrid photovoltaic thermal systems, are documented.

The second part (**Chapters 5 – 8**) presents detailed market figures for 2019 from the 68 surveyed countries. In addition to the installed collector areas, this includes the distribution of the collectors across various systems and applications and the solar yields and avoided emissions.

Global solar thermal market developments in 2020

The cumulated solar thermal capacity in operation at the end of 2020 was 501 GW_{th} corresponding to 715 million square meters of collector area[1].

The annual solar thermal energy yield amounted to 407 TWh, which correlates to savings of 43.8 million tons of oil and 141.3 million tons of CO_2.

The worldwide solar thermal market shrank by 4% in 2020 compared to 2019. This was mainly the result of shrinking markets in China, the USA, India and Australia. Contrary to this trend, notable market growth was recorded in Germany, Brazil, Cyprus, the Netherlands, Turkey, the Palestinian Territories and Portugal.

An area with consistent growth is in the number of megawatt-scale systems for district heating and industrial applications.

In 2020, 70 new large-scale solar heating systems with a capacity of 95 MW_{th} were built. Thirty-three of these systems were installed in China and 15 in Europe.

The largest of these systems were the two solar district heating systems in Ludwigsburg, Germany, with a capacity of 10.4 MW_{th} (14,800 m²) and a system in Lasha, China, with a capacity of 9.1 MW_{th} (13,000 m²).

By the end of 2020, 470 large-scale solar thermal systems (> 350 kW_{th}; 500 m²) connected to district heating networks as well as to residential, commercial and public buildings were in operation and are documented in this report. The total installed capacity of these systems equals 1,710 MW_{th} (2.4 million m²), excluding concentrating systems that add 162,784 m².

Interest in solar thermal systems for industrial processes continues to grow steadily. At least 74 solar process heat systems were added in 2020, so the number of operating projects adds up to at least 891 with an overall installed capacity of 791 MW_{th}, corresponding to a collector area of 1.13 million m2.

The market for Photovoltaic Thermal (PVT) collectors and systems saw significant global growth of 9% in 2020. At least 2,052 new PVT systems were commissioned in 2020. The total installed PVT collector area by the end of 2020 was 1,275,431 m², with the capacity divided into 712 MW_{th} (thermal) and 232 MW_{peak} (electric).

One type of system gaining popularity, especially in South Africa, is the PV2heat system. These systems consist of PV modules directly connected to an electrical element that heats water using DC power without inverters. Nearly 12,000 of these systems are in operation in South Africa.

1 The global solar thermal capacity 2020 is based on the latest market data from the 20 largest solar thermal markets in terms of added capacity, which represents 95% of cumulative installed capacity in operation in 2019. This new methodology for determining global installed capacity used in this edition of the Solar Heat Worldwide report is described in detail in **Appendix 8.7**.

Facade-integrated collectors in St. Veit, Austria. *Photo: Greenonetec Solar Industry GmbH.*

Market status worldwide in 2019

While only the data of the leading 20 countries is available for 2020, the report includes very detailed 2019 data on 68 countries.

The top 10 countries in terms of total collector area installed by the end of 2019 were China, Turkey, the United States, Germany, Brazil, India, Australia, Austria, Greece and Israel. However, the picture is clearly different when comparing the data on a per capita basis. The top 10 countries per 1,000 inhabitants are Barbados, Cyprus, Austria, Israel, Greece, the Palestinian Territories, Australia, China, Denmark and Turkey.

With a share of 61.9% of the newly installed capacity in 2019, evacuated tube collectors were the most important solar thermal collector technology, followed by flat plate collectors with a share of 32.5%. In a global context, this breakdown is mainly driven by the dominance of the Chinese market, where around 75.2% of all newly installed collectors in 2019 were evacuated tube collectors.

Nevertheless, it is notable that the share of evacuated tube collectors worldwide decreased from about 82% in 2011 to 61.9% in 2019, and in the same time, flat plate collectors increased their share from 14.7% to 32.5%.

In Europe, the situation is almost the opposite of that in China, with 73.6% of all solar thermal collectors installed in 2019 being flat plate collectors. In the medium-term perspective, however, the share of flat plate collectors decreased in Europe from 81.5% in 2011 to 73.6% in 2019 due to the growing evacuated tube collector markets in Turkey, Poland, Switzerland and Germany. Overall, the share of evacuated tube collectors in Europe increased between 2011 and 2019 from 15.6% to 26%.

Distribution by system type and application

The thermal use of the sun's energy varies significantly from region to region and can be roughly distinguished by the type of solar thermal collector used, the type of system operation (pumped solar thermal systems, thermosiphon systems) and the main type of application (swimming pool heating, domestic hot water preparation, space heating, industrial processes heat, solar district heating and solar thermal cooling).

The calculated number of water-based solar thermal systems in operation was 104 million by the end of 2019, 57% were thermosiphon systems, and the rest pumped solar heating systems.

Employment and turnover

Based on a comprehensive literature survey and data collected from detailed country reports, the number of jobs in the fields of production, installation and maintenance of solar thermal systems is estimated to be 400,000 worldwide in 2019.[2]

The estimated worldwide turnover of the solar thermal industry in 2019 is € 13.4 billion (US$ 16.1 billion).

Solar district heating system Mürzzuschlag, Austria *SOLID Solar Energy Systems GmbH*

2 Background information on the methodology used can be found in the Appendix, **Chapter 8.3**.

3 Worldwide solar thermal capacity in 2020

As shown in the graph below, the global solar thermal capacity of unglazed and glazed water collectors in operation grew from 62 GW_{th} (89 million m^2) in 2000 to 501 GW_{th} (715 million m^2) in 2020. The corresponding annual solar thermal energy yields amounted to 51 TWh in 2000 and 407 TWh in 2020 (**Figure 2**).

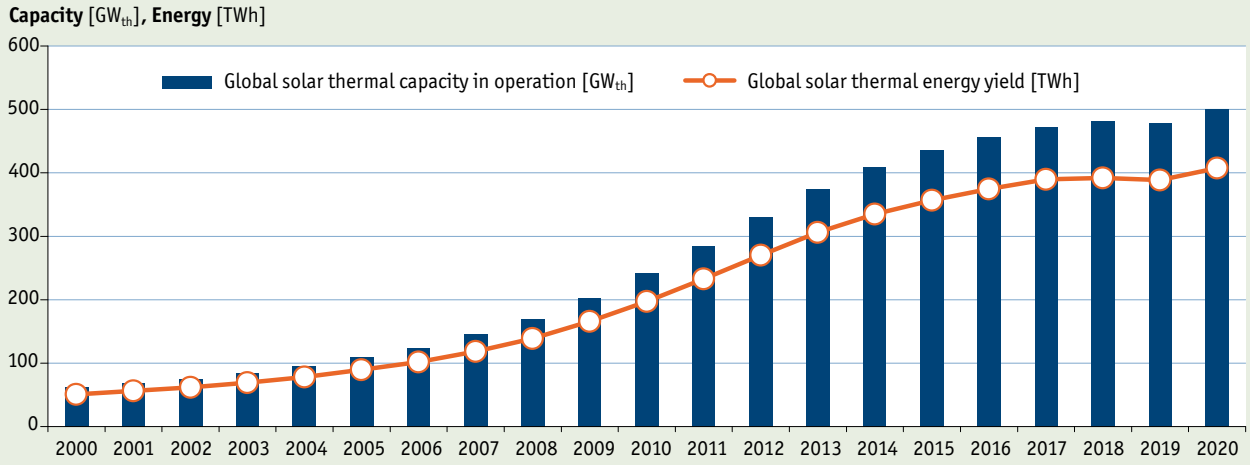


Figure 2: *Global solar thermal capacity in operation and annual energy 2000 – 2020*

Environmental effects and contribution to climate goals

The global solar thermal energy yields of all installed solar thermal systems in 2020 corresponds to a savings of 43.8 million tons of oil and 141.3 million tons of CO_2. This shows the significant contribution of this technology in reducing global greenhouse gas emissions.

3.1 Solar thermal capacity in relation to the capacity of other renewable energy technologies

The cumulated solar thermal capacity in operation by the end of 2020 was 501 GW_{th}[3], which trailed behind wind power's installed capacity of 743 GW_{el} and photovoltaics 708 GW_{el} of installed capacity (**Figure 3**). Geothermal energy and concentrated solar power (CSP) lag behind these three technologies in installed capacity. The total capacity of geothermal power was 14 GW_{el}. and solar thermal power, also referred to as CSP, was 6.5 GW_{el}.

In terms of energy, solar thermal systems supplied a total of 407 TWh of heat, whereas wind turbines supplied 1,742 TWh and photovoltaic systems 901 TWh of electricity.

3 The figures for 2020 are based on the latest market data from Australia, Austria, Brazil, China, Cyprus, Denmark, Germany, Greece, India, Israel, Italy, Mexico, Morocco, the Netherlands, the Palestinian Territories, Poland, South Africa, Spain, Turkey and the United States, which represent about 95 % of the cumulated installed capacity in operation in 2019.

Vacuum tube collector system *Photo: Greenland Systems, Australia*

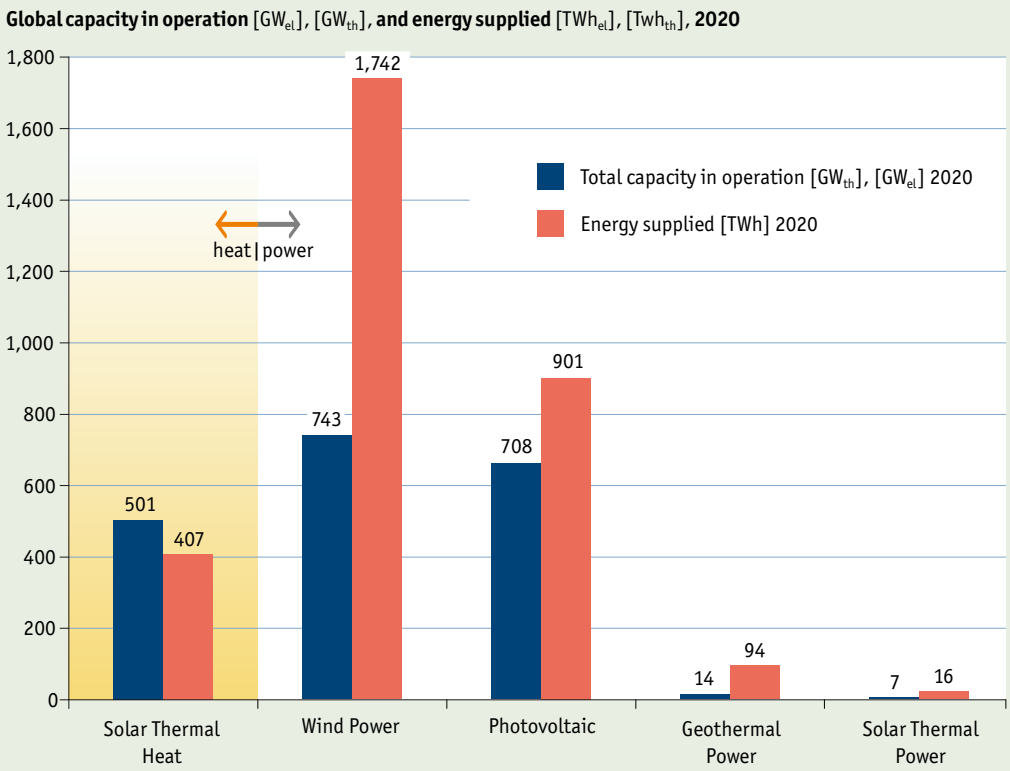


Figure 3: *Global capacity in operation [GW_{el}], [GW_{th}] 2020 and annual energy yields [TWh_{el}], [TWh_{th}] (Sources: AEE INTEC, Global Wind Energy Council (GWEC), Irena Renewable Energy Capacity Statistics 2021, Solar Power Europe GMO report, IEA Global Energy Review 2021).*

4 Solar thermal market development and trends in 2020

Except for a few countries, solar thermal has been going through very challenging times worldwide for several years, resulting in a market decrease of 4% in 2020 compared to 2019. This is mainly due to declines in the Chinese market, which is by far the largest market worldwide. In 2020, the Chinese market declined by around 3%. In addition to China, traditionally strong European markets such as Poland and Greece also experienced market slumps in 2020.

Nonetheless, there was an opposite trend in some countries, but their increased market shares could not compensate for the losses in other markets. Positive market growth was recorded in Germany (26%), Brazil (7%), Cyprus (7%), the Netherlands (7%), Turkey (2%), the Palestinian Territories (2%) and Portugal (1.1%).

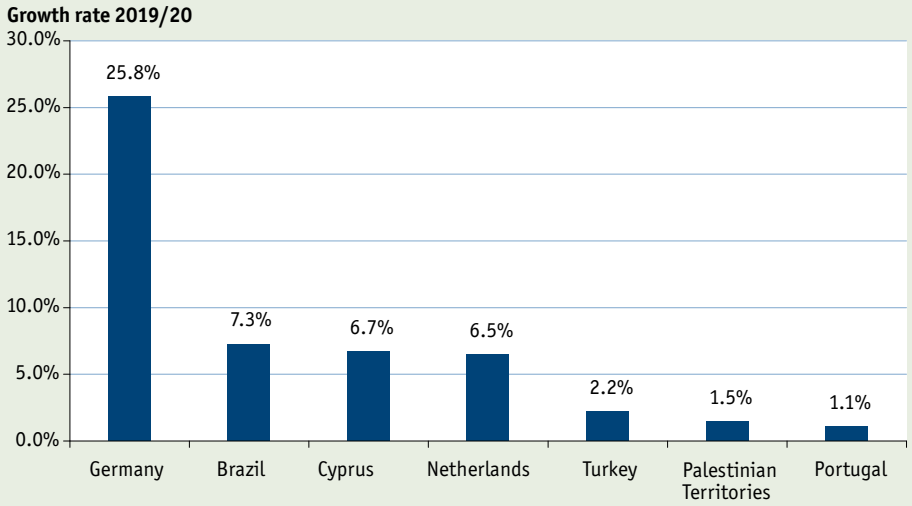


Figure 4: *Countries with the highest growth rates in 2020*

As in previous years, interest in megawatt solar district heating systems and solar heating and cooling applications in the commercial and industrial sectors continues. A number of new installations for these applications were installed worldwide in 2020, and this trend is expected to continue. As impressive as these systems are, the capacity installed in these large systems corresponds to only around 2% of the global market.

4.1 Small-scale solar thermal heating systems

Small-scale solar water heating systems and, to a certain extent, solar combi-systems for combined hot water preparation and space heating for single-family houses, apartment buildings, multi-family houses, hotels and public buildings represent about 60% of the world's annual installations.

In large parts of Europe and China, these applications are under increasing competition from photovoltaic systems and heat pumps and have lost market share in recent years. The systems are predominantly pumped systems that are characterized by complex system technology.

The picture is different for thermosiphon systems. As shown in **Figure 4** above, apart from Germany and the Netherlands, in 2020, the countries that experienced significant market growth had markets dominated by thermosiphon systems.

Typical pumped solar thermal system for water heating for a single-family house. *Photo: Velux-Solar-Heat-Europe*

The section below presents the success factors that led to exceptional market growth in Germany in 2020.

4.1.1 Success story: the German market

Around ten years ago, Germany was with a newly installed capacity of approximately 1.5 GW_{th}, corresponding to 2.1 million m² collector area, by far the largest solar thermal market in Europe. Unfortunately, the market decreased in the following years, reaching a minimum of around 0.36 GW_{th} corresponding to 510,000 m² collector area of newly installed collectors in 2019. The decline of the market was predominantly due to the extremely favorable conditions for PV.

But times have changed, and 2020 saw a significant turnaround. Germany's solar thermal market increased by approximately 26 % compared to 2019 to around 650,000 m², corresponding to nearly 0.5 GW_{th} of newly installed capacity.

The dramatic increase in demand for solar thermal systems is largely due to the new extremely lucrative subsidy scheme[4]. If, for example, a solar thermal system is added to an existing heating system, 30 % of the eligible costs are reimbursed by the federal state. In the case of the replacement of an old oil burner with an efficient gas burner combined with a solar thermal system, 40 % of the eligible system installation cost is subsidized. A maximum 45 % subsidy is possible if an old oil burner is replaced with a renewable heating system consisting of a solar thermal system combined with a biomass burner or a heat pump.

The example of Germany clearly shows that market growth can be achieved if implementing appropriate policy conditions.

4 Bundesförderung für effiziente Gebäude (BEG), **https://www.bafa.de/DE/Energie/Effiziente_Gebaeude/effiziente_gebaeude_node.html**.

Single-family house with evacuated tube collectors in Germany. *Photo: Ritter Energie- und Umwelttechnik GmbH & Ko KG*

Visible hazards that could jeopardize the success

Despite the relatively favorable policy conditions for solar thermal, a new threat is appearing on the horizon – the so-called solar obligations. Today more and more federal states and cities in Germany are implementing solar obligations that require the installation of PV on the roofs of new or renovated buildings. In many cases, the mandatory installation of PV is due to the fact that decision-makers often equate the use of solar energy with the installation of PV – as they tend to be unaware of solar thermal. Solar obligations, which are in fact PV obligations, are a "killer" for solar thermal. Hence, it is essential to be aware of situations where solar obligations are under discussion and promote a technology-neutral solution. This means solar obligations requiring the installation of solar thermal systems, PV systems, or a combination of both.

4.2 Large-scale solar thermal heating systems

In the Scandinavian countries Denmark and Sweden, as well as in Austria, Germany, Spain and Greece, large-scale solar thermal plants connected to local or district heating grids, or installed on large residential, commercial and public buildings have been in use since the early 1980s. It should be noted here that from the early 1980s up to 2016, the large-scale plant market was almost exclusively concentrated in Europe.

Denmark dominated the large-scale system market – especially for solar district heating – for about a decade. In 2020, China took over the lead position with 48% of the installed collector area for large-scale systems. A large proportion of these large-scale plants were built for residential, commercial or public buildings.

In second place for newly installed large-scale systems, Germany is the leading European country in this market segment, accounting for 23% of the newly installed collector area worldwide. Despite the dramatic market slump that Denmark suffered in 2020 – compared to its annual installations over the past decade – Denmark still ranks third with 11% of new capacity installed in this market segment.

By the end of 2020, 470 large-scale solar thermal systems (> 350 kW_{th}, 500 m²) were in operation (**Figure 5**). The total installed capacity of these systems equaled 1,710 MW_{th}, corresponding to 2.4 million m² collector area. These numbers exclude concentrating solar thermal systems and PVT collectors connected to district heating, which would add an additional 162,784 m².

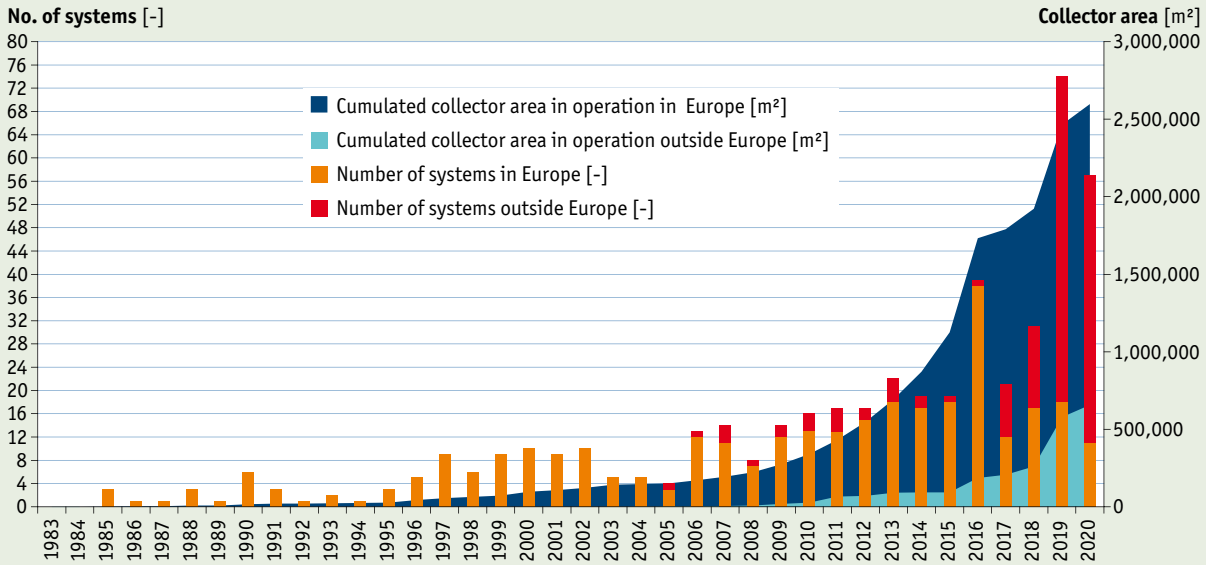


Figure 5: *Large-scale systems for solar district heating and large residential, commercial and public buildings worldwide – annual achievements and cumulated area in operation in 2020. (Data source: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 55, AT, Bärbel Epp - solarthermalworld.org, DE, AEE INTEC).*

4.2.1 Solar district heating systems

The largest sub-sector of the systems described above is solar district heating. By the end of 2020, 262 large-scale solar district heating systems (> 350 kW_{th}; 500 m²) with an installed capacity of 1.410 MW_{th} (2.01 million m²) were in operation. As shown in **Figure 6**, Denmark leads this market segment in terms of both the number of systems and the installed area. In ad-

dition to Denmark (124 systems) and China (18 systems), a number of other countries are showing an increasing interest in this type of plant, as they offer an excellent opportunity for decarbonizing the heat sector in neighborhoods and entire cities.

Countries to note are Germany (43 systems, some of these with seasonal storage), Austria (19 systems), Sweden (22 systems) and Poland (8 systems). Outside China and Europe, there is Saudi Arabia, Asia excluding China (Japan, Kyrgyzstan, Russia), the USA, Canada and South Africa (**Figure 6**).

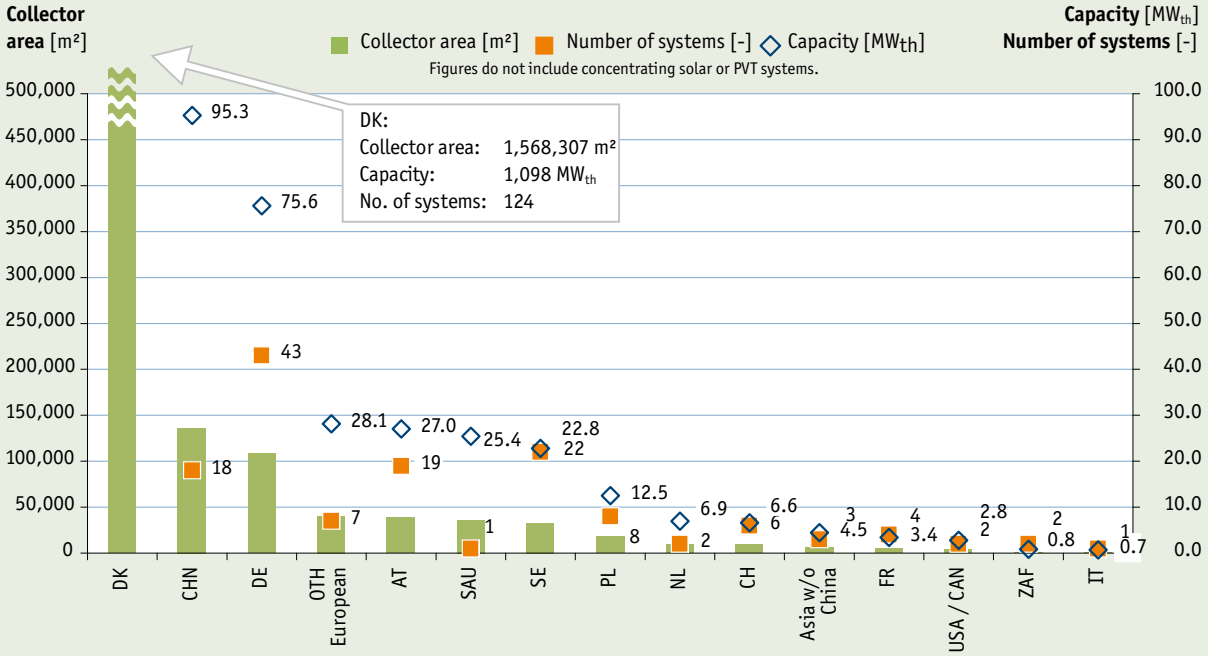


Figure 6: *Large-scale systems for solar district heating– capacities and collector area installed and number of systems in 2020 (Data source: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 55, AT, Bärbel Epp - solarthermalworld.org, DE).*

As shown in **Figure 6**, Denmark had absolute dominance in this sector for more than a decade due to favorable energy policy conditions and a market-dominating company. In 2019, Denmark was still building 134 MW_{th} of new capacity. This changed fundamentally in 2020. Due to the expiration of the attractive energy policy conditions for solar thermal, and at the same time, very favorable policy conditions for large heat pumps, this market completely collapsed in 2020, so much so that only one new plant and three extensions were built. These changes also caused the 2020 closure of the world's leading company in the field of solar district heating.

Germany took over the leading role in solar district heating in 2020. Of the 11 large-scale solar thermal systems (> 500 m²) connected to district heating networks added in Europe, 7 were built in Germany (31,200 m²)[5], 4 in Denmark[6] (14,600 m²), 2 in Austria (6,571 m²) and 1 in Switzerland (784 m²).

The largest European system was installed in the German city of Ludwigsburg with a collector area of 14,800 m².

5 Including one extension in Gutleutmatten.

6 This includes three extensions of existing systems Farsø, Snedsted and Flauenskjold.

The Swiss solar district heating system in Geneva, with a capacity of 0.5 MW_{th}, is equipped with high-vacuum flat plate collectors and began operation in December 2020. *Photo: Magali Girardin / SIG*

Out of Europe, two solar district heating systems were installed in China (13,000 m²) in 2020, with the system installed in Lasha being the world's second largest (11,250 m²).

4.2.2 Large-scale systems for buildings in the residential, public and commercial sector

The second market of interest in the large-scale sector, besides solar district heating, is solar applications for residential, commercial and public buildings. At the end of 2020, around 200 large-scale solar thermal systems (> 350 kW_{th}; 500 m²) were supplying heat to residential, commercial and public buildings worldwide. The total installed capacity of these systems is 299 MW_{th} (426,800 m²).

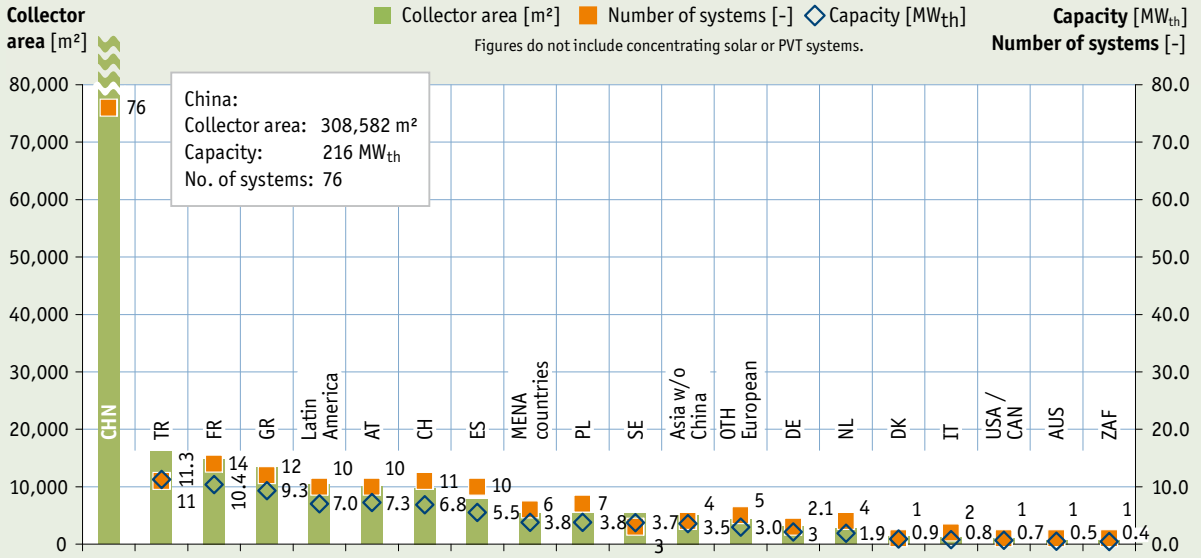
Lasha solar district heating system in Tibet, China with 13,000 m² collector area (9.1 MW_{th}). *Photo: Solareast Holding Company Ltd.*

Solar water heating systems in combination with heat pumps for apartment buildings in Cape Town, South Africa.

Photo: Solarex Energy SA (Pty) Ltd., SOLTRAIN.

China leads this market segment with 76 installed systems and a capacity of 216 MW_{th}, followed by Turkey with 11 systems and an installed capacity of 11 MW_{th}. France is in third place with 14 systems and an installed capacity of around 10 MW_{th}.

Figure 7: *Large-scale systems for residential, public and commercial buildings – capacities and collector area installed and number of systems in 2020*



In addition to the European countries of Greece, Austria, Switzerland and Spain, more and more large-scale systems are being built in Latin America (Brazil and Mexico), the MENA region (Dubai, Jordan, Kuwait, United Arab Emirates) and Asia, excluding China (Cambodia, India, Thailand). These systems are often installed on hospitals, hotels and sports centers.

4.3 Solar heat for industrial processes

Across the globe, interest in solar thermal systems for industrial processes (SHIP) has grown steadily. A number of promising projects undertaken in the last couple of years range from small-scale demonstration plants to large 100 MW_{th} systems.

Many industrial processes demand vast amounts of heat, making this sector a promising market for solar thermal applications. Depending on the temperature level of the needed heat, different types of solar thermal collectors are used – air collectors, flat plate and evacuated tube collectors for temperatures up to 100°C and concentrating solar thermal collectors, such as Scheffler dishes, Fresnel collectors and parabolic troughs, for temperatures up to 400°C.

According to a study published by Solrico in early 2021, at least 74 SHIP plants were added in 2020 worldwide, so the number of SHIP projects in operation adds up to at least 891 with an overall installed collector area of 1.13 million m^2 at the end of 2020[7].

For 311 of these systems, more detailed information on the collector area and installed capacity and type of application and collector can be found in the SHIP database, an online portal operated by AEE INTEC in Austria[8].

Lataria-Engiadinaisa-Dairy, Switzerland with 115 m² of parabolic trough collectors *Photo: NEP -Solar heat Europe.*

7 https://www.solarthermalworld.org/news/china-keeps-top-spot-industrial-solar-heat.

8 http://ship-plants.info/.

Please note that only systems with a collector area larger than 50 m² are included in this report. And, the report's definition of SHIP can be found in Appendix, **Chapter 8.6**.

Figures 8 – 11 show the analysis of the 311 systems, which have a total collector area of 976,000 m^2_{gross} and thermal capacity of 491 MW_{th}. It is important to note that the data in these four graphs is dominated by the world's largest SHIP plant, the Miraah in Oman, which has a thermal capacity of 300 MW_{th}. and accounts for 65 % of the total installed thermal capacity of all 311 documented SHIP applications.

The second largest SHIP application is for a greenhouse in Australia (36.6 MW_{th}) and the third largest system is installed at a copper mine in Chile (27.5 MW_{th}) for their copper winning process. Together, those three plants represent 74 % of the total installed thermal capacity.

Figure 8 shows the distribution of the 311 systems in terms of size. The three systems mentioned above exceed 21 MW_{th} of the thermal capacity (30,000 m²), 42 systems have installed capacities between 0.7 MW_{th} and 21 MW_{th} (1,000 m² – 29,999 m²), 59 systems have installed capacities between 0.35 and 0.7 MW_{th} (500 – 9,999 m²) and 207 systems are below 0.35 MW_{th} (< 500 m²).

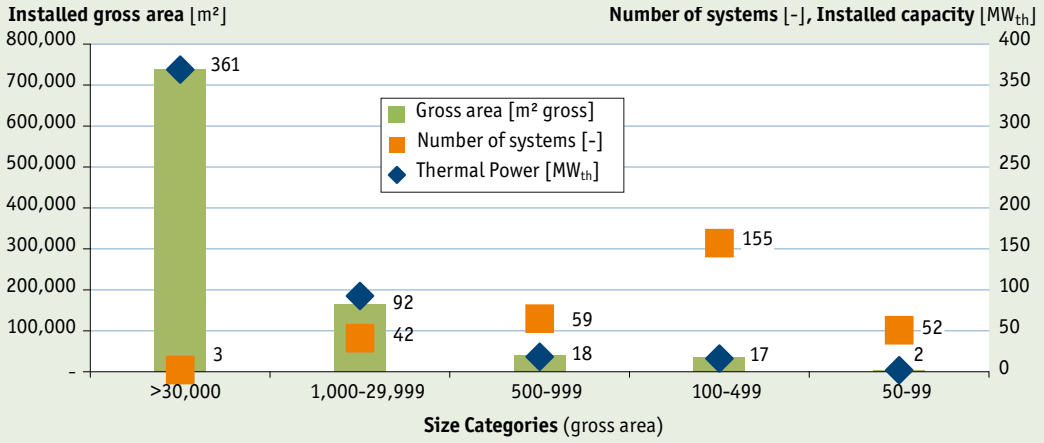


Figure 8: *Solar process heat applications in operation worldwide end of March 2021 by capacity and collector area. (Source: IEA SHC Task49 / IV SHIP database).*

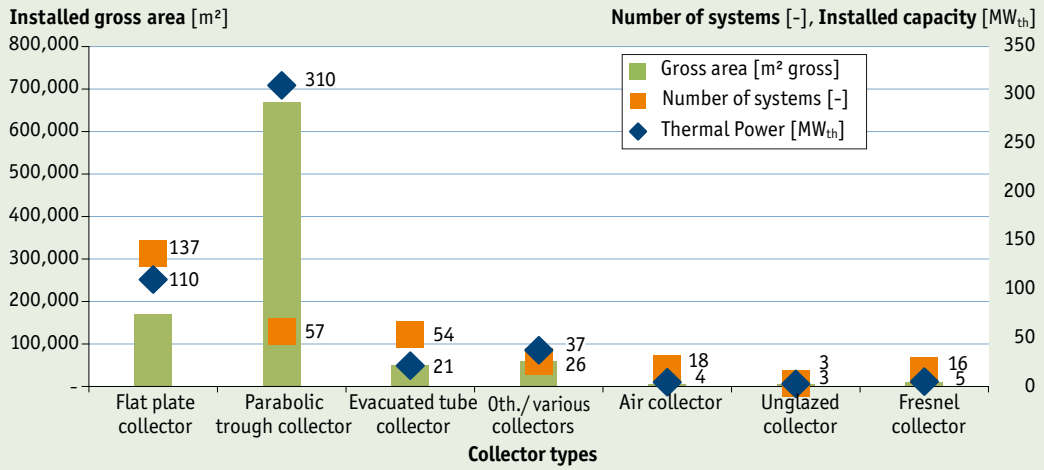


Figure 9: *Solar process heat applications in operation worldwide end of March 2021 by collector type (Source: IEA SHC Task49 / IV SHIP database)*

2.9 MW_{th} flat plate collectors on trackers provide heat for the CONDAT Paper Mill in France *Source: Newheat-ADEME*

Figure 9 shows the 311 systems by collector technology. The majority of the systems use flat-plate collectors to produce solar process heat, followed by parabolic trough collectors and evacuated tube collectors. Parabolic trough collectors have the highest installed gross area, however, without the Miraah plant, it would rank third.

Figure 10 shows the industry sectors of the 311 systems. The main sectors are mining, food and textile. The combined food and beverage sector accounts for 47 % of all installed systems, however, they tend to be small to medium-sized systems, so only represent 10 % of the installed thermal capacity. Another promising sector is the textile industry, with 25 installations and 26 MW_{th} (5 %) installed thermal capacity. The mining industry, which includes two of the three largest systems, is the dominant sector in terms of installed thermal capacity. The 13 systems account for 68 % of the total installed thermal capacity.

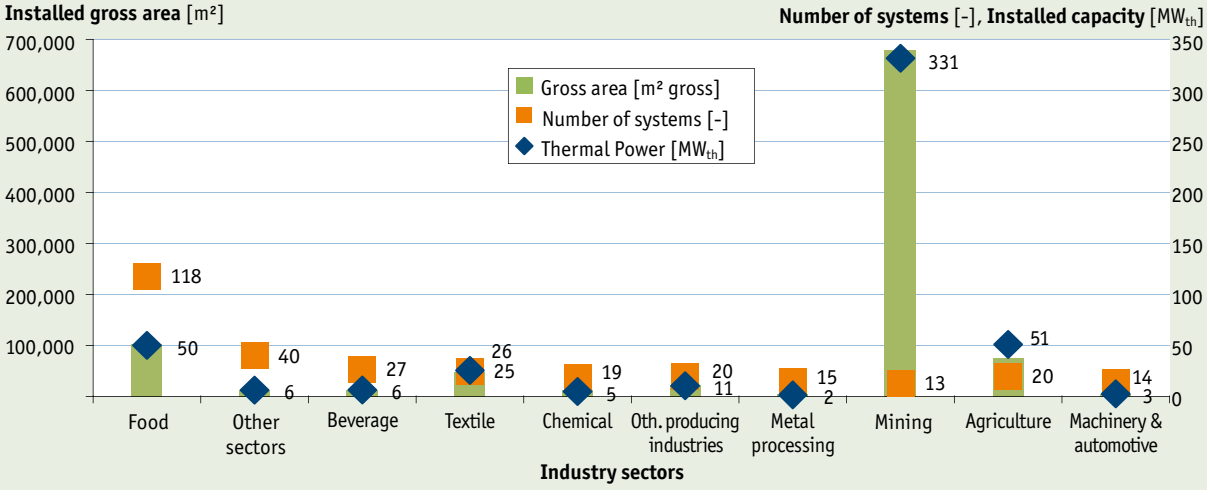


Figure 10: *Solar process heat applications in operation worldwide end of March 2021 by industry sector (Source: IEA SHC Task49 / IV SHIP database).*

Large-scale flat plate collectors for an industrial application in Vienna, Austria. *Source: Greenonetec Solar Industries GmbH.*

The agriculture sector is dominated by the greenhouse in Australia mentioned above, which accounts for 72% of the installed thermal capacity.

It is also worth noting that the combined metal processing, machinery, and automotive industry sectors, with 29 plants, account for 10% of the total installed thermal capacity.

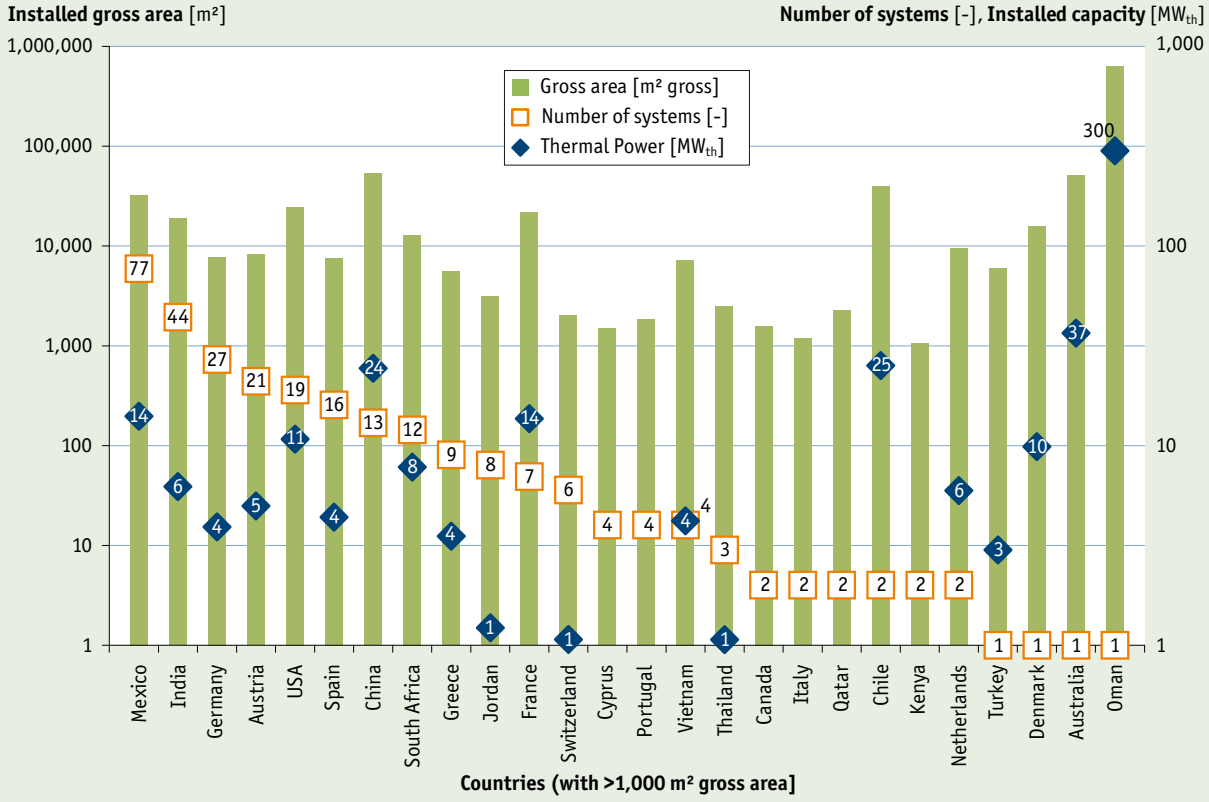


Figure 11: *Solar process heat applications in operation worldwide end of March 2020 by country. (Only countries with at least 0.7 MW_{th} (1,000 m² gross area) are shown, which is 290 of 311 systems, accounting for > 99 % of installed thermal capacity)* (Source: IEA SHC Task49 / IV SHIP database).

Figure 11 documents the global installed solar process heat systems by country. Mexico and India have the highest number of systems, followed by Germany, Austria, the USA and Spain. China has 10+ systems with a high average system size. Oman leads in terms of installed thermal capacity with its only installed system. Similar to that is Chile, with two systems accounting for the second-highest installed thermal capacity by country.

Solar heated greenhouses

In addition to the more traditional industrial sectors that use thermal solar systems highlighted above, a new sector is horticulture. Solar thermal plants are being used to heat greenhouses for flower and vegetable cultivation.

The following table provides an overview of the systems with collector areas larger than 50 m² between 2013 and 2020.

Country	Site	Commissioned	Installed capacity [KW_{th}]	Collector size [m²]	Storage tank [m³]
Netherlands	Nibbixwoud	2020	10.50	15,000	1,450
Ethiopia	Arerti	2020	2.91	4,170	1,400
China	Tibet	2020	3.50	5,000	n/a
Guatemala	Chimaltenango	2020	1.52	2,175	300
Netherlands	Heerhugowaard	2019	6.51	9,300	1,300
USA	Oregon	2019	0.72	1,030	n/a
Austria	Vienna	2018	0.09	126	20
Uganda	Kampala	2017	3.23	4,614	900
South Africa	Krugersdorp	2015	6.40	9,135	2,100
Denmark	Østervang Varpelev	2015	9.89	14,112	4,800
Germany	Bohlingen	2015	0.67	960	n.a.
Australia	Port Augusta	2014	36.05	51,505	no
Ethiopia	Addis Ababa	2014	1.95	2,784	400
Namibia	Okahandja	2014	2.60	3,712	1,900
Kenya	Naivasha	2013	0.34	480	150
Morocco	Aït Melloul	2013	0.71	1,007	150
Mexico	Buenavista, Jalisco	2013	0.05	66	2.5

Table 1: *Solar thermal systems for flower and vegetable cultivation*
(Source: Bosman Van Zaal, G2 Energy, Solar Payback SHIP Supplier Survey 2020, AEE INTEC)

4.4 PVT – Photovoltaic Thermal Systems

Photovoltaic Thermal (PVT) collectors combine the production of both types of solar energy – solar heat and solar electricity – in one collector, thus reaching higher yields per area. This is particularly important if the available roof area is limited and integrated solar energy concepts are needed to achieve a climate-neutral energy supply for consumers, such as in residential and commercial buildings.

In recent years, a growing number of specialized providers of PVT technologies have established themselves, developing strong market momentum worldwide.

4.4.1 General market overview

The PVT data is based on a survey of 36 PVT collector manufacturers and PVT system suppliers in 14 different countries.

In 2020, the total installed PVT collector area was 1,275,431 m², with the capacity divided into 712 MW_{th} (thermal) and 232 MW_{peak} (electric).

The vast majority of the PVT collector area is installed in Europe (732,955 m²), followed by Asia, excluding China (306,098 m²) and China (141,966 m²), which together account for 659 MW_{th}, 214 MW_{peak} of the total installed capacity. The

remaining installed collector area is shared between the MENA countries (Egypt and Israel (58,309 m²)), the Sub-Sahara African countries (Ghana and South Africa (22,783 m²)), the USA (7,248 m²), Australia (1,639 m²) and Latin America (537 m²).

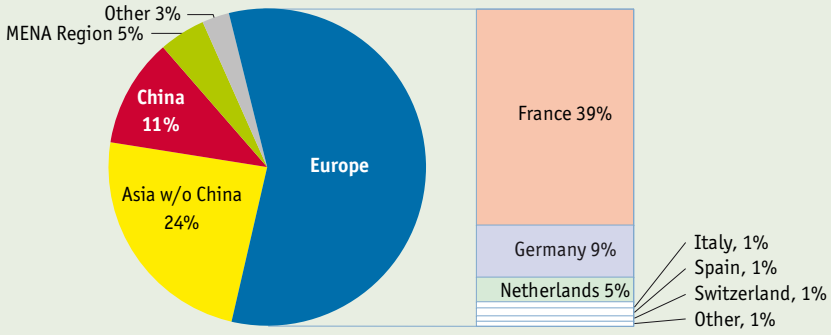


Figure 12: *Distribution of the total installed collector area by economic region in 2020 (Source: AEE INTEC)*

In the European market, France is the leader with an installed collector area of 500,992 m², followed by Germany with 119,275 m² and the Netherlands with 57,420 m². In Spain, Italy, and Switzerland, collector areas range between 12,600 m² and 16,600 m². And, in the remaining European countries, collector areas are less than 11,000 m².

Table 2 shows the cumulated installed collector area by PVT collector type at the end of 2020.

Country	Water Collectors [m²]			Air Collectors [m²]	Concentators [m²]	TOTAL [m²]
	uncovered	covered	evacuated tube			
Australia	1,540	0	0	99	0	1,639
Austria	659	1,292	0	0	0	1,951
Belgium	880	0	32	290	15	1,217
Brazil	26	0	0	0	0	26
Chile	213	101	0	0	10	325
China	141,721	74	0	0	171	141,966
Croatia	775	0	0	0	0	775
Denmark	109	0	0	0	0	109
Dubai	23	7	0	0	0	30
Ecuador	0	66	0	0	0	67
Egypt	0	0	0	0	21	21
France	28,481	611	0	471,900	0	500,992
Germany	115,636	3,308	0	87	180	119,210
Ghana	22,000	0	0	0	0	22,000
Greece	0	4	0	0	0	4
Guadeloupe	0	4	0	0	0	4
Hungary	525	53	0	0	0	578
India	0	601	0	0	255	856
Israel	58,288	0	0	0	0	58,288
Italy	13,358	2,270	0	0	0	15,628
Korea, South	280,814	0	0	0	0	280,814
Luxembourg	635	0	0	145	0	780
Macedonia	443	131	0	0	0	574
Maldives	0	0	0	0	21	21
Martinique	0	63	0	0	0	63
Netherlands	55,585	62	0	0	1,773	57,420
Norway	646	0	0	0	0	646
Pakistan	0	7	0	0	0	7
Paraguey	0	0	0	0	51	51
Poland	114	36	0	0	0	150
Portugal	335	118	0	0	0	452
Singapore	371	0	0	0	0	371
Slovenia	30	10	0	0	0	40
South Africa	0	0	32	0	751	783
Spain	1,552	15,094	0	0	0	16,646
Sweden	1,200	20	0	0	31	1,251
Switzerland	9,024	64	0	3,530	0	12,617
Tibet	24,000	0	0	0	0	24,000
United Kingdom	891	426	252	348	0	1,916
United States	7,248	0	0	0	0	7,248
Uruguay	0	2	0	0	0	2
Other	629	3,250	16	0	0	3,895
TOTAL	767,749	27,672	332	476,399	3,278	1,275,431

Table 2: *Cumulated collector area by PVT collector type at the end of 2020 (Source: AEE INTEC)*

With a share of 60% of the installed area, uncovered PVT water collectors are the dominating PVT technology produced, followed by air collectors at 37% and covered PTV water collectors at 2%. PVT concentrators and evacuated tube PVT collectors play only a minor role in the total installed area.

Of the 5,624 systems with uncovered PVT collectors installed at the end of 2020 corresponding to a gross area of 767,749 m², 36% were used for domestic hot water preparation in single and multifamily houses, hotels, and hospitals. Around 33% of these systems supplied heat and electricity to households and electric heating for domestic hot water and space heating (combi-systems).

Country	Water Collectors						Air Collectors		Concentrators		TOTAL	
	uncovered		covered		evacuated tube							
	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]
Australia	875	293	0	0	0	0	54	17	0	0	929	310
Austria	338	113	697	214	0	0	0	0	0	0	1,035	328
Belgium	500	167	0	0	17	5	158	49	9	2	683	223
Brazil	15	5	0	0	0	0	0	0	0	0	15	5
Chile	121	41	55	17	0	0	0	0	6	1	181	58
China	80,495	26,953	40	12	0	0	0	0	89	18	80,624	26,983
Croatia	440	147	0	0	0	0	0	0	0	0	440	147
Dubai	62	21	0	0	0	0	0	0	0	0	62	21
Denmark	13	4	4	1	0	0	0	0	0	0	17	6
Ecuador	0	0	35	11	0	0	0	0	0	0	36	11
Egypt	0	0	0	0	0	0	0	0	12	2	12	2
France	16,177	5,417	330	101	0	0	257,151	80,223	0	0	273,657	85,741
Germany	65,716	2,204	1,784	549	0	0	47	15	93	19	67,641	22,587
Ghana	12,496	4,184	0	0	0	0	0	0	0	0	12,496	4,184
Greece	0	0	2	1	0	0	0	0	0	0	2	1
Guadeloupe	0	0	2	1	0	0	0	0	0	0	2	1
Hungary	298	100	28	9	0	0	0	0	0	0	327	109
India	0	0	324	100	0	0	0	0	133	27	457	126
Israel	33,107	11,085	0	0	0	0	0	0	0	0	33,107	11,085
Italy	7,587	2,540	1,225	377	0	0	0	0	0	0	8,812	2,917
Korea, South	159,498	53,406	0	0	0	0	0	0	0	0	159,498	53,406
Luxembourg	361	121	0	0	0	0	79	25	0	0	440	145
Macedonia	251	84	71	22	0	0	0	0	0	0	322	106
Maldives	0	0	0	0	0	0	0	0	11	2	11	2
Martinique	0	0	34	10	0	0	0	0	0	0	34	10
Netherlands	31,571	10,571	34	10	0	0	0	0	920	186	32,525	10,767
Norway	367	123	0	0	0	0	0	0	0	0	367	123
Paraguey	0	0	0	0	0	0	0	0	27	5	27	5
Poland	65	22	19	6	0	0	0	0	0	0	84	28
Portugal	190	64	63	20	0	0	0	0	0	0	253	83
Singapur	210	70	0	0	0	0	0	0	0	0	210	70
Slovenia	17	6	5	2	0	0	0	0	0	0	22	7
South Africa	0	0	0	0	17	5	0	0	390	79	407	84
Spain	881	295	8,142	2,505	0	0	0	0	0	0	9,024	2,800
Sweden	682	228	11	3	0	0	0	0	16	3	708	235
Switzerland	5,125	1,716	34	11	0	0	1,924	600	0	0	7,083	2,327
Tibet	13,632	4,564	0	0	0	0	0	0	0	0	13,632	4,564
UK	506	169	205	71	136	42	190	59	0	0	1,061	341
USA	4,117	1,378	0	0	0	0	0	0	0	0	4,117	1,378
Uruguay	0	0	1	0	0	0	0	0	0	0	1	0
Other	357	120	1,753	539	9	3	0	0	0	0	2,119	662
TOTAL	384,443	146,012	13,626	4,592	147	55	234,379	80,988	1,887	343	712,480	231,990

Table 3: *Total installed PVT capacity in 2020 divided into thermal and electrical power (Source: AEE INTEC)*

[PM8]

4.4.2 Market development of PVT collectors between 2017 and 2020

Based on the market data of the 36 PVT manufacturers, the PVT market is experiencing steady global growth, 9% on average from 2018 and 2020. This trend is also observed in the European market with only a slightly lower growth rate of 8%, which corresponds to an increase of the yearly new installed capacity of 31.7 MW_{th} and 10.5 MW_{peak}.

Concentrating PVT system for the Hilton Hotel, Cape Town South Africa: 103 kW_{th} and 17kW_{peak} combined with 4 x 44 kW heat pumps.

Photo: Solarus Smart Energy Solutions

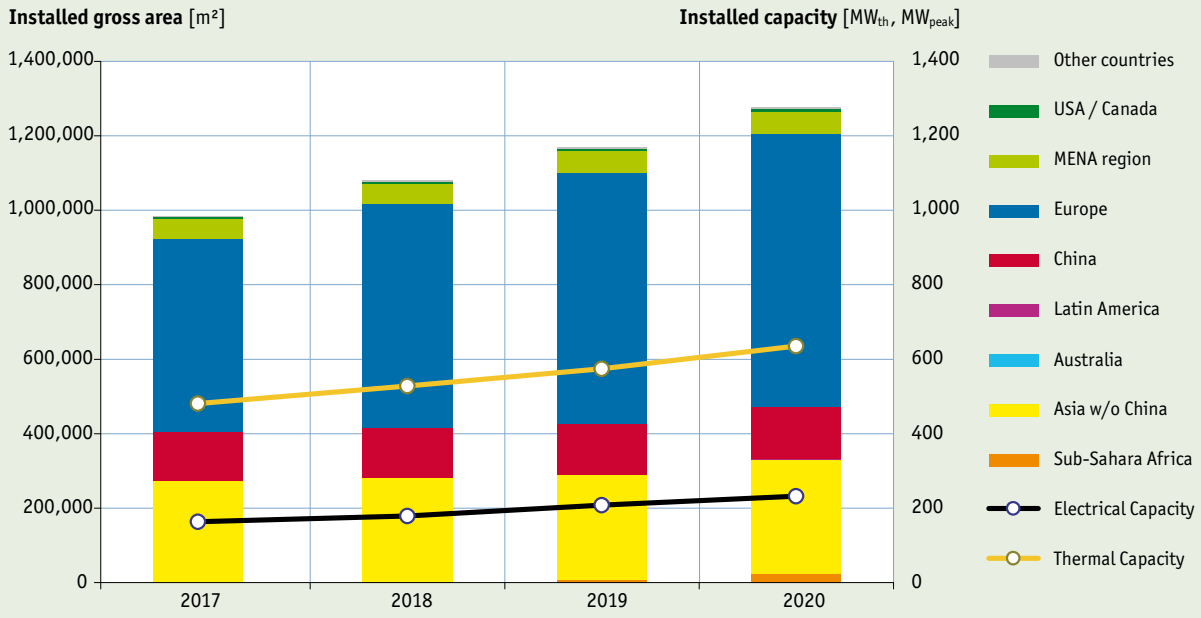


Figure 13: *Global market development of PVT collectors from 2017 to 2020. (Source: IEA SHC Task 60 survey, AEE INTEC).*

The following figure shows the total installed collector area and the distribution by PVT technologies by country in 2020 in Europe.

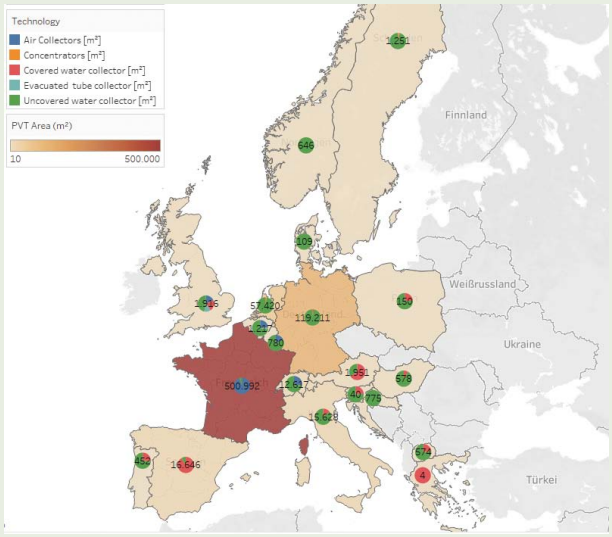


Figure 14: *Total installed collector area and PVT technology in Europe at the end of 2020.*
(Source: AEE INTEC).

4.4.3 Distribution by type of application

In 2020, suppliers of PVT technology commissioned at least 2,052 new systems worldwide. The cumulated number of PVT systems in operation at the end of 2020 was 27,920.

The breakdown is 81.7% used for solar air(pre) heating/cooling of buildings followed by 6.6% domestic hot water preparation for single-family houses, 6.3% for solar combi-systems that supply heat both domestic hot water and space heating. Around 1.4% of the worldwide installed capacity provided heat and electricity to larger domestic hot water systems for multifamily houses, hotels, hospitals, schools, etc. The remaining systems account for around 3.9% and deliver heat and electricity to other applications, including swimming pool heating, district heating applications and solar heat for industrial applications.

Evacuated tube PVT collectors. *Photo: Naked Energy*

Table 4 shows PVT systems by application.

PVT applications	Number of installations [#]	Total collector area [m²]
Swimming pool heating	250	20,732
Domestic hot water systems SFH	1,882	63,028
Large domestic hot water systems	385	155,404
Solar combi systems for SFH	1,795	28,292
Large solar combi-systems	348	62,488
Solar air systems	23,139	502,788
Solar district heating systems	64	22,042
Solar heat for industrial applications	57	22,533
Not classifiable		398,123
TOTAL		1,275,431

Table 4: *PVT systems by application (Source: AEE INTEC)*

As shown in **Figure 15** below, solar air systems dominate the PVT market. In a global context, this distribution is mainly driven by the dominance of the French market, where almost all of the manufactured PVT collectors are air collectors. Nevertheless, uncovered water-based PVT collectors are the most common technology.

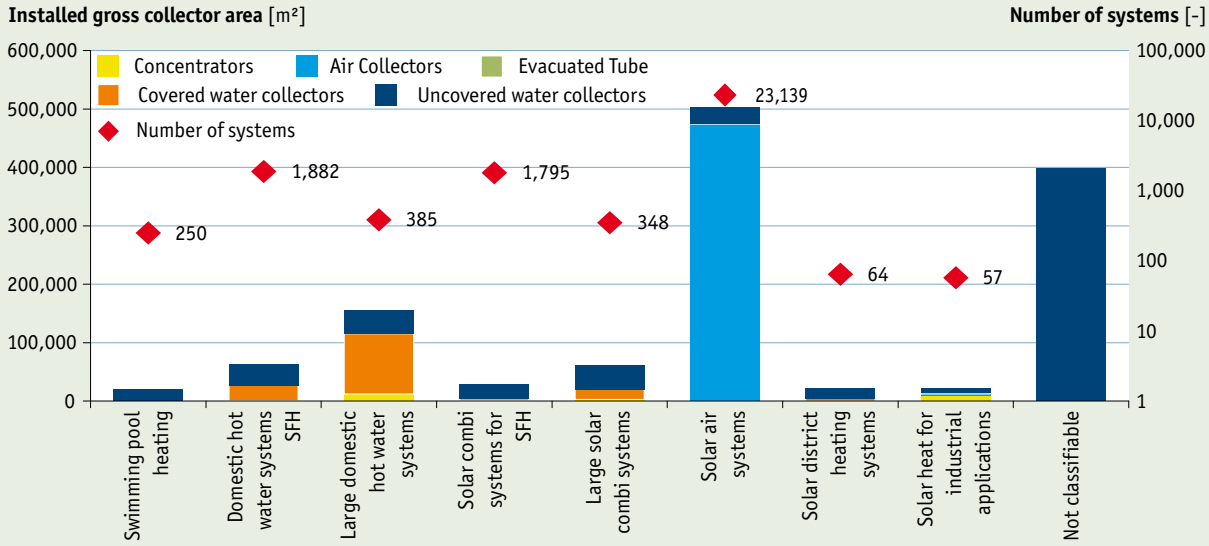


Figure 15: *PVT systems in operation worldwide by application, collector type and collector area at the end of 2020. (Source: AEE INTEC).*

Uncovered PVT collectors reduce the gas consumption for hot water heating by 50 % at a hotel in Sao Paulo, Brazil.

Photo: ***www.2Power.de***

4.5 PV2heat Systems

One type of system that is gaining popularity, especially in South Africa, is PV2heat.

Solar thermal collectors (both flat plate and evacuated tube) and heat pumps have historically dominated the market for hot water preparation in South Africa, but this is changing. The country is seeing a shift towards heating water directly with electricity using photovoltaic (PV) technologies. These systems consist of PV modules directly connected to an electrical element that heats the water with DC power without the need for inverters. The systems usually include an AC element connected to the electricity grid, which is used as a backup heater when needed.

The growth in the installation of PV2heat technologies is in some way fueled by the simpler installation, only requiring wiring from the panels to the tank instead of insulated pipes, as is the case with traditional solar water heaters. The hot water tank can also be installed much closer to the taps, resulting in a shorter wait time for the flow of hot water. Another advantage of these very simple systems is that there is no risk of frost damage to pipes and storage tanks.
However, the greatest incentive for installing these systems is the mandated regulation that stipulates that not more than 50% of the annual hot water volume consumed in households be heated by fossil fuel-derived energy[9]. This 50% requirement is deemed to be 100 liters of hot water tank size per bedroom per residence. There is no "deemed to be" interpretation for a PV2heat system yet, allowing for the installation of systems with a lower solar energy yield at an obviously reduced cost.

PV2heat system at the Mariendal Experimental Farm of Stellenbosch University in South Africa consisting of 1.5 kW_{peak} PV and a 200-liter hot water tank. *Photo: SOLTRAIN*

PV2heat systems have some disadvantages, though, when compared to conventional solar thermal collectors – PV panels require approximately 3 – 4 times the roof area to install the same thermal capacity as conventional solar thermal collectors and present a higher risk of theft.

Although the country currently has no testing standards for PV2heat technologies, most municipalities allow for the installation of locally supplied PV2heat technologies.

9 SANS 10400-XA Energy usage in buildings: A homeowner's guide to compliance in home design. Sustainability Institute. Online available: https://www.nedbank.co.za/content/dam/nedbank/site-assets/AboutUs/About%20Nedbank%20Group/Green%20and%20Caring/11056_SANS%20Guide_Homeowners2019.pdf

Through the SOLTRAIN project (**www.soltrain.org**), the Center for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University has been collecting data since 2018 on PV2heat installations in South Africa. At the end of 2018, there was an estimated 2,400 PV2heat systems installed in the country. This number grew to 11,700 systems installed by December 2020. It is estimated that these installed systems shared a total PV capacity of 9,869 kW_{peak} at the end of 2020, indicating an average PV capacity of 850 W_{peak} of PV per system. See **Figure 16** below.

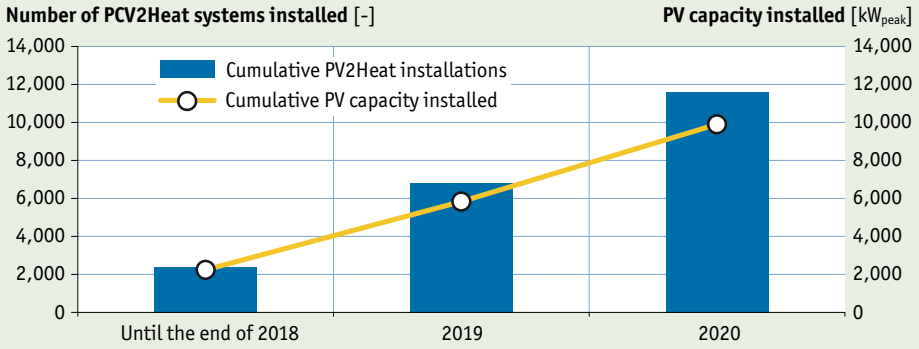


Figure 16: *Cumulative PV2heat systems and capacity installed in South Africa*

The technical capabilities of locally available PV2heat products indicate that most, if not all, of these systems are installed within the residential sector for domestic hot water.

The degree to which PV2heat technologies are being used to retrofit existing geysers would be interesting to quantify since PV2heat technologies provide a unique degree of simplicity for integration to existing hot water tanks compared to solar thermal water heating systems. However, it is expected that the larger percentage of PV2heat installations are in new building developments since its uptake is largely driven by the regulations mentioned above.

The electrical elements for PV2heat systems in South Africa are rated between 900 W to 4 kW (DC) and are integrated with storage tanks ranging from 100 to 300 liters.

4.6 Solar air conditioning and cooling

4.6.1 Small and medium-size applications

The global market for cooling and refrigeration will continue to grow, particularly in emerging countries, and by 2050 37 % of the total electricity demand growth will be due to the electricity demand of air conditioning[10]. Thus, there is enormous potential for cooling systems that use solar energy, both solar thermal and PV driven solar cooling and air conditioning systems, as presented, for example, in the GIZ 2017 feasibility study for social housing buildings in Mexico[11]. A major argument for using solar thermally driven systems is that they consume less conventional energy (up to factor five[12]) and use natural refrigerants, such as water and ammonia. In Europe, their application is also pushed by the European F-gas Regulation No. 517 / 2014. Another driver for solar cooling technology is its potential to reduce peak electricity demand, particularly in countries with significant cooling needs with grid constraints. Today, for example, in India, 30% of total energy consumption in buildings is used for space cooling, which reaches 60% of the summer peak load and is already stretching the capac-

10 https://www.iea.org/futureofcooling/

11 http://task53.iea-shc.org/Data/Sites/53/media/events/meeting-09/workshop/09-jakob_results-from-feasibility-studies-of-solar-cooling-systems-in-mexico-and-the-arab-region.pdf

12 http://task53.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task53-C3-Final-Report.pdf

Concentrating solar collectors supply heat and steam to power absorption chillers for the Härnösand hospital's radiology department in Sweden.

Photo: Absolicon.

ity of the Indian national electricity supply[13]. In other countries, like the USA, the peak load through air conditioning reaches > 70% on hot days.

These mature cooling technologies are grabbing the attention of the OECD and emerging countries because cooling demand will continue to grow over the next decades and national electric grids need protection against overloads.

Solar sorption cooling applications are particularly adapted for medium to large size units (100 kW to several MWs). For several years now, China has been promoting a voluntary policy to develop such green sorption devices. And in 2019, Germany changed its incentives scheme for both vapor compression and sorption-based technologies to only support chillers and air conditioners that use natural refrigerants (sorption chillers 5 kW – 600 kW) in combination with a minimum required performance[14].

Solar thermal cooling is still a niche market, with about 2,000 systems deployed globally as of 2020. And due to changing distribution channels and B2B sales of the sorption chillers, the tracking of newly installed solar-driven systems is difficult and can only be estimated. Small units with a capacity lower than 20 kW are getting more compact (and thus cheaper upfront costs) and targeting the mass markets. Medium to large-scale projects, 350 kW – 2,000 kW, are dominated by engineered systems. Of the small and medium capacity (< 350 kW) solar cooling systems worldwide, 70% are installed in Europe. According to a survey carried out in early 2019 by SOLRICO for REN21,[15] only a small number of new solar cooling systems in the small and medium-range were installed in 2018, mainly in Italy and Germany. Awareness of small to medium-scale solar thermal driven systems is rising, and several international initiatives (e.g., MI IC7, K-CEP, IEA SHC Programme, etc.), research projects (e.g., SunbeltChiller, HyCool[16], sol.e.h.²[17], Zeosol[18], etc.) and commercial solar thermal cooling projects are running, for example in China, Spain, the USA, Egypt, Mali, Greece, Austria, Africa, and Thailand.

4.6.2 Solar Cooling with a cooling capacity larger than 350 kW

Solar cooling using thermal absorption chillers with a cooling capacity larger than 350kW/100RT[19] has improved significantly in performance, and at the same time, decreased in cost. There have been significant improvements in the performance of large flat plate collectors at temperatures up to 120°C. This increase in performance combined with an economy of

13 **Low energy cooling and ventilation in indian residences, https://doi.org/10.1080/23744731.2018.1522144**

14 **https://www.bafa.de/DE/Energie/Energieeffizienz/Klima_Kaeltetechnik/klima_kaeltetechnik_node.html**

15 Not published internal communication

16 Jakob, Uli; Kiedaisch, Falko (2019) Analysis of a solar hybrid cooling system for industrial applications, SWC 2019-SHC 2019, paper ID 12143.

17 Neyer, Daniel; et al. (2019) Solar Heating and Cooling in hot and humid climates – sol.e.h.² Project Introduction, SWC 2019-SHC 2019, paper ID 10400.

18 Roumpedakis, Tryfon; et al. (2019) Performance results of a solar adsorption cooling and heating unit, SWC 2019-SHC 2019, paper ID 11465

19 Ton of refrigeration is a unit of power used in North America to describe the capacity of heat extraction in industrial air conditioning and refrigeration equipment.

scale makes solar cooling applications cost-competitive for large office buildings, hotels, hospitals, and commercial/industrial applications.

The advantage of solar energy for cooling is because the supply, solar radiation, is available when the demand, cooling, is at its peak. In other words, cooling is needed when the sun is shining, which means during peak demand. Solar cooling saves money by avoiding the need to purchase electricity at its highest cost. Solar thermal energy is also an easy way to store the solar heat and shift it for cooling demands in the evenings and nights while keeping the remaining energy for morning cooling.

The electricity needed by a solar cooling system to run pumps and the cooling tower, is quite low. Depending on the climate, it may give Energy Efficiency Ratios (kW_{th}/kW_{el}) of 20 to 40in systems with optimized variable speed driven auxiliaries. Thus, the electric demand for air conditioning in a building is cut by more than 80% compared to conventional HVAC equipment.

Even though the technical and economic conditions for solar cooling and air conditioning have improved significantly in recent years, this remains a challenging market, as reflected in the comparatively low number of solar cooling systems built in recent years.

The world's largest solar cooling application is located in Arizona, USA and was commissioned in May 2014. The installation covers a roof-mounted solar thermal collector field with a capacity of 3.4 MW_{th} (4,865 m²) that supplies heat to a single-effect lithium bromide absorption chiller with a cooling capacity of 1.75 MW.

Four other large solar cooling systems were installed in 2018; two systems in Italy and one in Singapore, all of which use evacuated tube collectors, and one system in Jordan that uses Fresnel collectors to provide the heat for the chiller.

In 2020, two larger solar cooling plants were commissioned. One is a plant with 660 kW cooling capacity in Graz, Austria and the second plant was commissioned in the UAE.

Country	Site	Commissioned	Installed capacity [kW_{th}]	Collector size [m²]	Collector type	Cooling capacity [kW_{cold}]
Austria	Graz	2020	2,450	3500	Flat plate	660
UAE	Dubai	2020	496	708	Flat plate	n.a.
Switzerland	Zurich	2019	800	1143	Evacuated tube	600
Singapore	Mandai Depot	2018	2,308	3,297	Evacuated tube	850
Italy	Borgoricco	2018	1,046	1,494	Evacuated tube	700
Italy	Laives	2018	n.a.	n.a.	Evacuated tube	176
Jordan	Japan Tobacco International factory	2018	700	1,254	Fresnel	n.a.
Singapore	IKEA Alexandra	2017	1,730	2,472	Flat plate	880
Nicaragua	Hospital Militar Escuela, Dr. Alejandro Dávila Bolaños	2017	3,115	4,450	Flat plate	1,023
India	Office, Gujarat State Electricity Corporation	2017	1,102	1,575	Evacuated tube	528
India	Swiss Embassy, New Delhi	2017	630	441	Parabolic trough	210
China	Tianjin Zhongbei	2015	n.a.	n.a.	Evacuated tubes	698
Arizona, USA	Desert Mountain High School Scottsdale	2014	3,407	4,865	Flat plate	1,750
Johannesburg, South Africa	MTN Headquarter	2014	272	484	Fresnel	330
China	Dezhou Institute	2014	n.a.	720	Parabolic trough	n.a.
United Arab Emirates	Sheikh Zayed Desert Learning Center	2012	794	1,134	Flat plate	352
Jamaica	Digicel, Kingston		687	982	Flat plate	600
Singapore	United World College	2011	2,710	3,872	Flat plate	1,500
Qatar, Doha	Showcase football stadium	2010	700	1,408	Fresnel	n.a
Istanbul, Turkey	Metro shopping center	2009	840	1,200	Evacuated tube	n.a.
Spain, Sevilla	Sevilla University, Escuela Superior de Ingenieros	2009		352	Fresnel	n.a.
Lisbon, Portugal	CGD Lisbon	2008	1,105	1,579	Flat plate	585
Rome, Italy	Metro Cash&Carry	2008	2,100	3,000	Flat plate	700

Table 5: *Large-scale solar cooling systems installed between 2008 and 2020*

Sources: Blackdot Energy, Industrial Solar GmbH, Ritter XL Solar, SOLID Solar Energy Systems, SOLRICO, Vicot Solar Energy, Cosmosolar

4.6.3 Trends and outlook

The demand for cooling and refrigeration will continue its rapid growth, particularly in emerging countries (several hundred million AC units are estimated to be sold per year by 2050[20]). This means there is a huge potential for cooling systems that use solar energy – thermal systems and photovoltaic (PV) systems. A major argument for this application is that it consumes less than conventional energy sources and generally uses natural refrigerants, such as water and ammonia.

One of the main trends in the upcoming years will be that more and more hybrid system solutions for solar cooling will come onto the market. They will offer high CO_2 savings and small to medium cooling capacity ranges with good economic efficiency at the same time. In the area of medium-temperature systems (solar collector temperatures around 160 – 180 °C) and double-effect absorption chillers, there will be solutions with better efficiency and profitability since they will have smaller solar fields and lower heat rejection capacities to achieve an investment advantage of up to 40% compared to conventional solar cooling systems.

Furthermore, the focus on potential markets for solar cooling technologies is becoming more and more important to get out of a niche market. Therefore, the know-how capitalized in OECD countries (Europe, USA, Australia, etc.) on solar cooling, both thermal and PV, has to be adapted and transferred to Sunbelt countries in Africa, MENA region and Asia, which are all dynamic emerging economies. New developments and innovations for affordable, safe and reliable cooling systems for the Sunbelt regions (sunny and hot climates between the 20th and 40th degrees of latitude in the northern and southern hemisphere) have started, including in IEA SHC Task 65[21] that will focus on medium to large cooling and air conditioning systems between 2 kW and 5,000 kW.

4.7 Solar air heating systems

The main uses for solar air heaters are applications that require warm air, such as heating of buildings including ventilation air and process or crop drying systems.

Space heating consumes more energy than hot water in most buildings. In colder climates, space heating is usually the largest consumer of energy in a building. As it is the air in the buildings that is heated, air collectors are ideally suited to heat this air directly without heat exchangers. To take advantage of the lower winter sun angles and eliminate any snow accumulation typical of roof-mounted systems, most solar air collectors used for heating buildings are wall-mounted. When heat is not needed during the summer, the panels are generally only used to run an air-to-water heat exchange.

Solar air heating systems can be building integrated and typically reduce between 20–30% of the conventional energy used to heat a building. The air is generally taken off the top of the wall and the heated or pre-heated fresh air is then connected to existing or new fans and ducted into the building via the ventilation system.

Process applications are different as they operate either all year or during the harvest season, allowing the panels to be roof-mounted to capture the higher sun angles.

Solar air heaters in agriculture are primarily for drying applications requiring low temperature rise.

20 https://www.iea.org/futureofcooling/

21 https://task65.iea-shc.org

0.6 MW_{th} façade integrated solar air system at Hyalite Hall, Montana State University, Bozeman, USA. *Photo: SolarWall.*

Solar air heating systems have been used globally for the past 30 years by schools, municipalities, military, agricultural and commercial and industrial entities, as well as in residential buildings.

Storage of the heat is possible, but most solar air systems do not include storage to minimize costs.

The following table lists those countries where more than 10,000 m² of solar air collectors are documented.

Country	Air Collectors [m²]		TOTAL [m²]
	unglazed	glazed	
Canada	425,344	51,613	476,957
Australia	300,000	12,800	312,800
Japan		283,161	283,161
United States	126,103	70,000	196,103
United Kingdom	23,600		23,600
Denmark	4,300	18,000	22,300
Germany		19,760	19,760
India	0	12,250	12,250
France (mainland)	10,558	1,000	11,558
China	7,700	3,000	10,700
Turkey	9,970		9,970
Mexico	752	8,773	9,525
Hungary	3,418	2,300	5,718
Austria		5,448	5,448
Norway	200	4,106	4,306
Spain	1,300	1,000	2,300
Nigeria	0	1,670	1,670
Senegal	0	1,203	1,203

Table 6: *Countries with larger solar air collector markets – Total installed air collector areas in 2019*

By the end of 2019, a total of 1,039 MW_{th} (1,484,274 m²) of glazed and unglazed air collectors were installed worldwide. The annual worldwide market in 2019 was in the range of 20 MW_{th} (26,700 m²).

Solar space heating with air collectors is not as common in Europe, while in North America, building-integrated solar air collectors are the most popular form of solar thermal systems in the commercial, industrial and institutional markets due to their low cost and architectural integration into buildings. Architects are creative as they integrate solar air heaters into the facades.

Thermosiphon systems for a neighborhood in Station St Edithvale, Australia. *Photo: Rinnai Australia Pty Ltd.*

5 Detailed global market data and country statistics in 2019

The following chapters of the report provide detailed solar thermal market figures for the year 2019 and country figures for 68 countries.

Background of the presented data

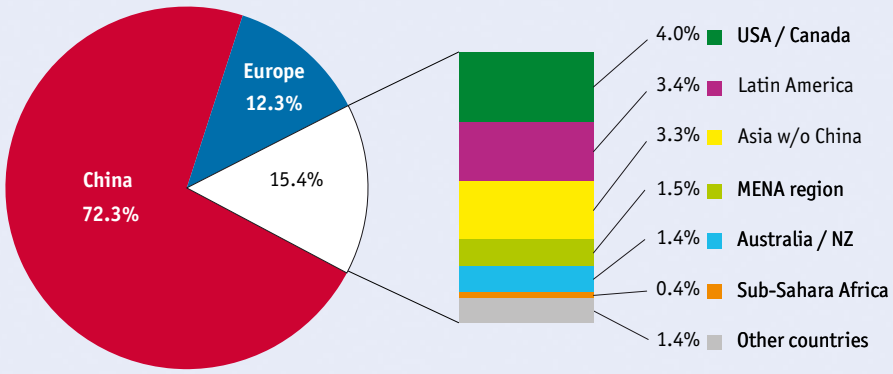
The figures in the following chapters are the collector area in operation in 2019 and not the cumulated collector area installed in a country, meaning that system lifetimes are considered. To determine the collector area and respective capacity in operation, either official country reports on the lifetime were used or, if such reports were not available, a 25-year lifetime for a system was calculated. The collector area in operation was then calculated using a linear equation. For China, the methodology of the Chinese Solar Thermal Industry Federation (CSTIF) was used until 2018. According to the CSTIF approach, the operation lifetime was 10 years. From 2019 on, an increased lifetime is used to calculate the cumulated collector area accounting for the fact that the share of large systems in China has increased over the past few years. According to this approach, a lifetime of 11 years is used for 2019, increasing to 12 years in 2020. For Germany, a lifetime of 20 years is used according to the statistical rules of the country.

The analysis further distinguishes between different types of solar thermal collectors: unglazed water collectors, glazed water collectors including flat plate collectors (FPC) and evacuated tube collectors (ETC), and unglazed and glazed air collectors. Concentrating collectors are not within the scope of this report.

5.1 General market overview of the total installed capacity in operation

By the end of 2019, an installed capacity of 479 GW_{th}, corresponding to a total of 684 million m^2 of collector area, was in operation worldwide.

The vast majority of the total capacity in operation was installed in China (346.5 GW_{th}) and Europe (58.9 GW_{th}), which accounted for 84.6% of the total installed capacity. The remaining installed capacity was shared between the United States and Canada (19.1 GW_{th}), Latin America (16.1 GW_{th}), Asia excluding China (15.7 GW_{th}), the MENA[22] countries Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (7.3 GW_{th}), Australia and New Zealand (6.9 GW_{th}), and the Sub-Sahara African countries Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa and Zimbabwe (1.9 GW_{th}). The market volume of "all other countries" is estimated to amount to 5% of the total installations, excluding China (6.6 GW_{th}).



Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w/ o China:	India, Japan, South Korea, Taiwan, Thailand
Latin America:	Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Figure 17: *Share of the total installed capacity in operation (glazed and unglazed water and air collectors) by economic region in 2019*

22 Middle East and North Africa

Country	Water Collectors [MW_{th}]			Air Collectors [MW_{th}]		TOTAL [MW_{th}] excl. concentrators
	unglazed	FPC	ETC	unglazed	glazed	
Albania		190.4	7.2			198
Argentina	37.2	31.0	62.5			131
Australia	3,960.6	2,417.8	158.2	210.0	9.0	6,756
Austria	197.4	3,274.2	59.8		3.8	3,535
Barbados		173.2				173
Belgium	31.5	397.2	72.6			501
Botswana		9.7	1.6			11
Brazil	4,662.5	7,376.3	112.5			12,151
Bulgaria		107.1	3.8			111
Burkina Faso		2.2	0.8			3
Canada	536.4	49.7	36.0	297.7	36.1	956
Cape Verde		1.6				2
Chile	45.9	181.8	38.0		0.2	266
China+		37,678.9	308,764.4	5.4	2.1	346,451
Croatia		168.6	9.3			178
Cyprus	1.5	568.9	16.5			587
Czech Republic	350.0	326.7	104.9			782
Denmark	14.4	1,285.3	6.4	3.0	12.6	1,322
Estonia		7.4	5.9			13
Finland	8.3	26.7	14.6			50
France (mainland)	65.4	2,082.9	163.2	7.4	0.8	2,320
France (overseas)++		210.0				
Germany	346.2	12,100.9	1,475.3		13.8	13,936
Ghana		2.1	0.8			3
Greece		3,391.2	16.1			3,407
Hungary	12.8	179.4	55.9	2.4	1.6	252
India	0.0	3,010.6	7,421.9	0.0	8.6	10,441
Ireland		200.7	85.1			286
Israel	27.3	3,365.9				3,393
Italy	30.7	2,897.2	458.0			3,386
Japan		2,362.1	44.8		198.2	2,605
Jordan*	4.2	687.7	190.5			882
Korea, South		1,037.9	300.2			1,338
Latvia		24.5	2.4			27
Lebanon		236.4	249.5			486
Lesotho		1.1	0.6			2
Lithuania		6.0	8.4			14
Luxembourg		41.2	6.2			47
Northern Macedonia		45.7	33.1			79
Malta		41.2	10.3			51
Mauritius**		93.0				93
Mexico	1,075.9	1,232.2	1,004.6	0.5	6.1	3,319
Morocco+++		577.5				578
Mozambique	0.3	0.6	1.7			3
Namibia	1.1	33.3	1.0			35
Netherlands	57.7	376.3	50.0			484
New Zealand***	4.9	100.1	6.8			112
Nigeria		1.0	5.1	0.0	1.2	7.3
Norway	1.3	26.5	3.0	0.1	2.9	34
Palestinian Territories		1,280.1	5.8			1,286
Poland		1,644.9	346.9			1,992
Portugal	1.5	804.2	21.4			827
Romania	0.2	79.4	73.8	0.6		154
Russia	0.1	15.7	2.7	0.0	0.0	18
Senegal		2.3	2.9	0.0	0.8	6.0
Slovakia	0.7	103.5	19.8			124
Slovenia		87.5	16.5			104
South Africa	906.1	471.8	255.4	0.0	0.0	1,633
Spain	111.3	2,886.7	162.5	0.9	0.7	3,162
Sweden	119.7	216.3	50.8			387
Switzerland	127.2	974.3	98.3			1,200
Taiwan	1.4	1,150.7	93.3			1,245
Thailand****		110.3				110
Tunisia		718.7	49.1			768
Turkey		12,324.3	5,751.5	7.0		18,083
United Kingdom	366.2	435.7	220.2	16.5		1,039
United States	15,778.7	2,135.8	124.1	88.3	49.0	18,176
Uruguay		60.5				60
Zimbabwe		15.3	36.2			51
All other countries (5% of world market excluding China)	1,520.3	4,025.2	1,033.5	33.4	18.2	6,631
TOTAL	30,407	118,183	329,434	673	366	479,063

Table 7: *Total capacity in operation in 2019 [MW_{th}[w12]]*

Note: If no data is given: no reliable database for this collector type is available
** cumulated collector area by end of 2015
**** cumulated collector area by end of 2016
++ France overseas calculated based on Eurobserver Reports 2015-2019
* cumulated collector area by end of 2014
*** cumulated collector area by end of 2009
+ Exports excluded
+++ 2021 revised timeseries according to MDPI Switzerland 2021

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL (excl. concentrators) [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		272,023	10,294			282,317
Argentina	53,132	44,237	89,282			186,651
Australia	5,658,000	3,454,000	226,000	300,000	12,800	9,650,800
Austria	282,065	4,677,407	85,482		5,448	5,050,402
Barbados		247,368				247,368
Belgium	45,000	567,385	103,650			716,035
Botswana		13,839	2,289			16,128
Brazil	6,660,733	10,537,530	160,723			17,358,986
Bulgaria		152,977	5,370			158,347
Burkina Faso		3,182	1,089			4,271
Canada	766,287	70,991	51,423	425,344	51,613	1,365,658
Cape Verde		2,313				2,313
Chile	65,550	259,711	54,305		300	379,866
China+		53,827,000	441,092,000	7,700	3,000	494,929,700
Croatia		240,838	13,308			254,146
Cyprus	2,213	812,670	23,567			838,450
Czech Republic	500,000	466,776	149,923			1,116,699
Denmark	20,500	1,836,176	9,197	4,300	18,000	1,888,173
Estonia		10,565	8,360			18,925
Finland	11,800	38,155	20,788			70,743
France (mainland)	93,450	2,975,600	233,100	10,558	1,100	3,313,808
France (overseas)++		300,000				
Germany	494,600	17,287,000	2,107,500		19,760	19,908,860
Ghana		2,994	1,087			4,081
Greece		4,844,500	23,000			4,867,500
Hungary	18,300	256,334	79,850	3,418	2,300	360,202
India	0	4,300,838	10,602,779	0	12,250	14,915,867
Ireland		286,734	121,586			408,320
Israel	39,000	4,808,434				4,847,434
Italy	43,800	4,138,911	654,303			4,837,014
Japan		3,374,466	64,025		283,161	3,721,652
Jordan*	5,940	982,482	272,084			1,260,506
Korea, South		1,482,784	428,842			1,911,626
Latvia		35,042	3,490			38,532
Lebanon		337,650	356,389			694,039
Lesotho		1,579	878			2,457
Lithuania		8,600	12,050			20,650
Luxembourg		58,910	8,900			67,810
Northern Macedonia		65,243	47,268			112,511
Malta		58,807	14,702			73,509
Mauritius**		132,793				132,793
Mexico	1,536,953	1,760,322	1,435,142	752	8,773	4,741,942
Morocco+++		825,000				825,000
Mozambique	495	921	2,493			3,909
Namibia	1,560	47,612	1,385			50,557
Netherlands	82,382	537,577	71,432			691,391
New Zealand***	7,025	142,975	9,644			159,645
Nigeria		1,473	7,267	0	1,670	10,410
Norway	1,849	37,869	4,276	200	4,106	48,301
Palestinian Territories		1,828,757	8,225			1,836,982
Poland		2,349,860	495,630			2,845,490
Portugal	2,130	1,148,819	30,570			1,181,519
Romania	340	113,440	105,470	800		220,050
Russia	137	22,406	3,787	2	64	26,396
Senegal		3,241	4,083	0	1,203	8,527
Slovakia	1,000	147,850	28,270			177,120
Slovenia		125,000	23,500			148,500
South Africa	1,294,473	674,005	364,828	0	0	2,333,306
Spain	158,938	4,123,911	232,124	1,300	1,000	4,517,273
Sweden	171,007	309,000	72,578			552,585
Switzerland	181,770	1,391,890	140,360			1,714,020
Taiwan	1,937	1,643,874	133,244			1,779,055
Thailand****		157,536				157,536
Tunisia		1,026,723	70,104			1,096,827
Turkey		17,606,182	8,216,454	9,970		25,832,606
United Kingdom	523,111	622,495	314,554	23,600		1,483,760
United States	22,541,021	3,051,087	177,285	126,103	70,000	25,965,496
Uruguay		86,419				86,419
Zimbabwe		21,848	51,670			73,518
All other countries (5% of world market excluding China)	2,171,921	5,750,312	1,476,382	47,702	25,976	9,472,294
TOTAL	43,438,420	168,833,248	470,619,640	961,749	522,525	684,375,582

Table 8: *Total installed collector area in operation in 2019 [m²]*

Note: If no data is given: no reliable database for this collector type is available
* cumulated collector area by end of 2014
** cumulated collector area by end of 2015
*** cumulated collector area by end of 2009
**** cumulated collector area by end of 2016
\+ Exports excluded
++ France overseas calculated based on Eurobserver Reports 2015-2019
+++ 2021 revised timeseries according to MDPI Switzerland 2021

The total installed capacity in operation in 2019 was divided into flat plate collectors (FPC): 118.1 GW_{th} (168.8 million m^2), evacuated tube collectors (ETC): 329.4 GW_{th} (470.6 million m^2), unglazed water collectors: 30.4 GW_{th} (43.4 million m^2), and glazed and unglazed air collectors: 1 GW_{th} (1.5 million m^2).

With a global share of 68.8%, evacuated tube collectors were the predominant solar thermal collector technology, followed by flat plate collectors with 24.7% and unglazed water collectors with 6.3% (**Figure 18**). Air collectors play only a minor role in the total numbers.

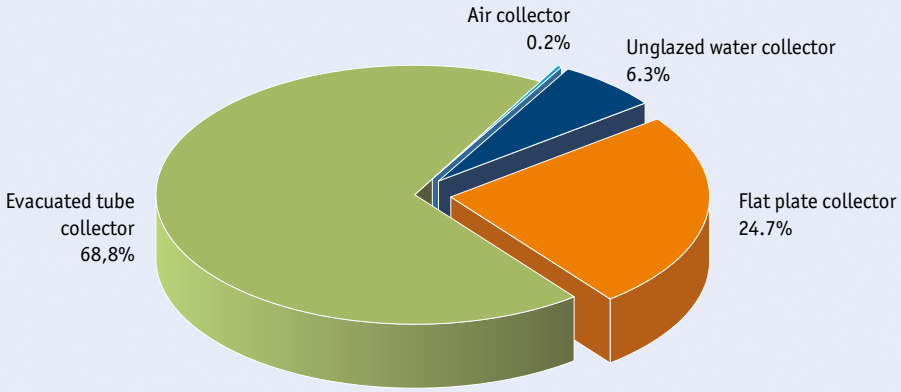


Figure 18: *Distribution of the total installed capacity in operation by collector type in 2019 – WORLD*

By contrast, in Europe, the second largest market to China, flat plate collectors were the dominant collector type (**Figure 19**). Compared to 2018, the share of evacuated tube collectors increased in Europe by 0.8% and the share of unglazed water collectors remained stable by 3.1%.

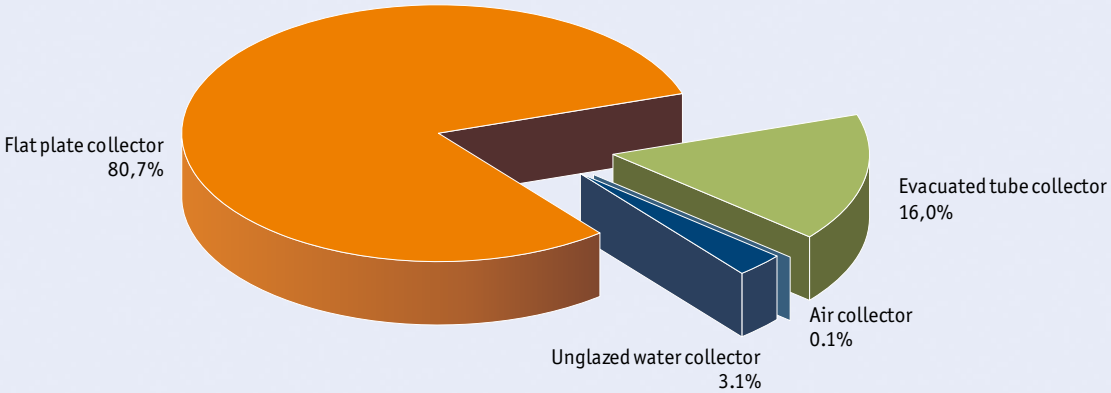


Figure 19: *Distribution of the total installed capacity in operation by collector type in 2019 – EUROPE*

Figure 20 shows the cumulated installed capacity of glazed and unglazed water collectors in operation for the 10 leading markets in 2019 in total numbers.

Compared to the year 2018, Turkey moved past the United States to the second position, Greece moved past Israel to the ninth position, and Germany, Brazil, India, Australia and Austria remained stable, taking positions four to eight.

China remained the world leader in total capacity and a market dominated by evacuated tube collectors. The United States held its third position due to its high number of installed unglazed water collectors. Besides the United States, only Australia, and to some extent Brazil, have large numbers of unglazed water collectors installed. In the large European markets, Germany, Austria and Greece, flat plate collectors were the most dominant collector technology. In Turkey, over the past several years there has been a strong trend towards evacuated tube collector technology.

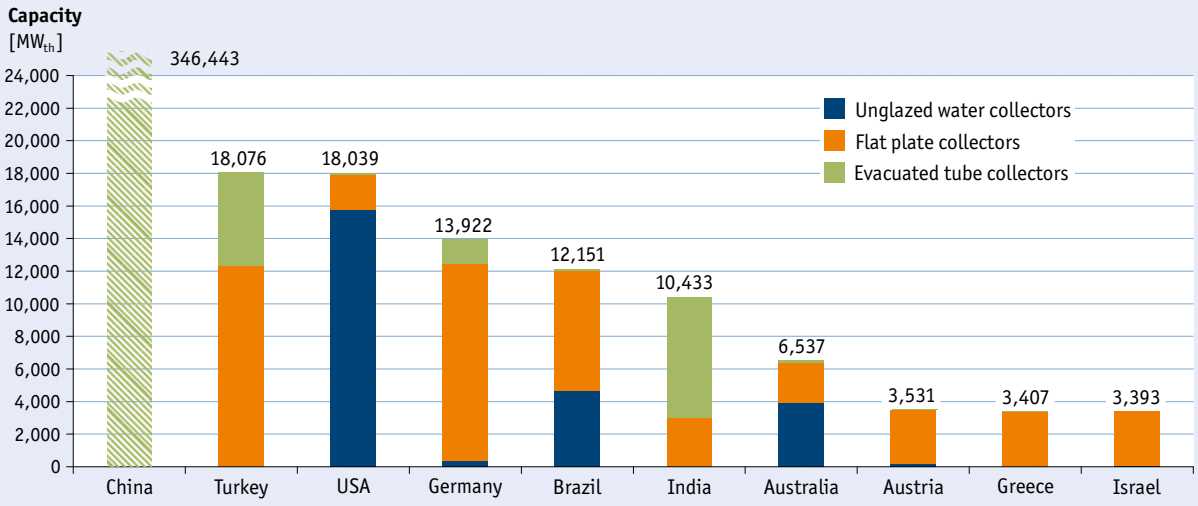


Figure 20: *Top 10 countries of cumulated water collector installations in 2019 (absolute figures in MW_{th})*

The top 10 countries with the highest market penetration per capita are shown in **Figure 21**. The leading countries in cumulated glazed and unglazed water collector capacity in operation in 2019 per 1,000 inhabitants were Barbados (577 kW_{th}/1,000 inhabitants), Cyprus (469 kW_{th}/1,000 inhabitants), Austria (400 kW_{th}/1,000 inhabitants), Israel (398 kW_{th}/1,000 inhabitants), Greece (320 kW_{th}/1,000 inhabitants), the Palestinian Territories (271 kW_{th}/1,000 inhabitants), Australia (260 kW_{th}/1,000 inhabitants), China (249 kW_{th}/1,000 inhabitants), Denmark (224 kW_{th}/1,000 inhabitants) and Turkey (221 kW_{th}/1,000 inhabitants).

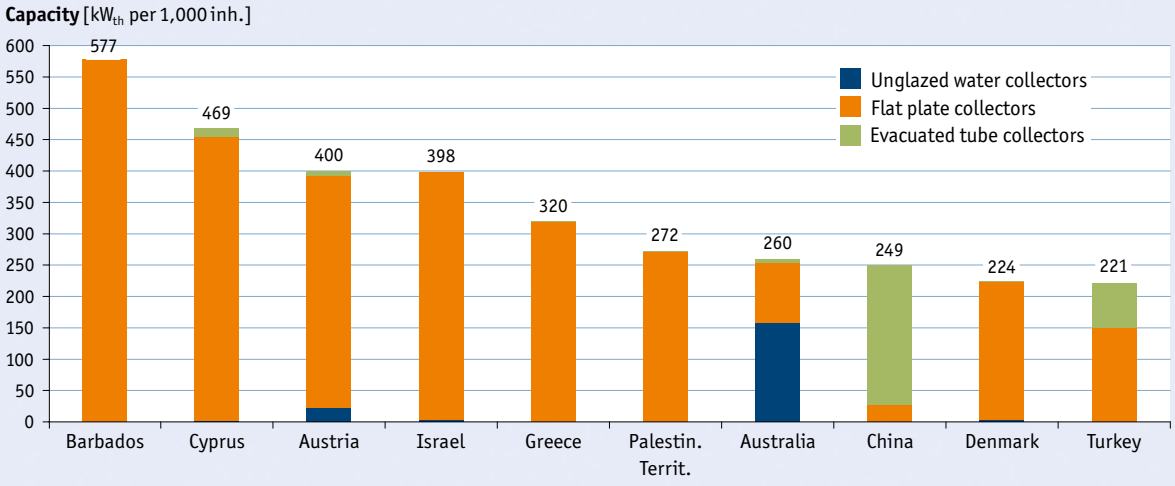


Figure 21: *Top 10 countries of cumulated water collector installations per 1,000 inhabitants in 2019 (relative figures in kW_{th})*

Storage collector for solar water heating in Mexico. *Photo: Greenonetec Solarindustrie GmbH.*

5.2 Total capacity of glazed water collectors in operation

With 346.5 GW_{th}, China was once again the overriding leader in terms of total installed capacity of glazed water collectors in 2019. With > 10 GW_{th} of installed capacity, Turkey, the United States, Germany, Brazil and India were next. Several countries, namely Australia, Austria, Greece, Israel, Italy, Mexico, Spain, Japan, France, Poland, South Africa, South Korea, Denmark, the Palestinian Territories, Taiwan, and Switzerland had more than 1 GW_{th} of water collectors installed by the end of 2019 (**Figure 22**).

In terms of total installed capacity of glazed water collectors in operation per 1,000 inhabitants, there was a continued dominance by five countries: Barbados, Cyprus, Israel, Austria and Greece. China ranks eighth in terms of market penetration. Nevertheless, it is remarkable that China, with its 1.37 billion inhabitants, exceeds solar thermal per capacity levels of the large European markets in Germany, Turkey, Denmark and Spain (**Figure 23**).

Figure 24 shows the accumulated collector area of glazed water collectors in relation to the gross domestic product (GDP) of the respective countries. This new graph highlights a different level of comparison between countries. In this analysis, it is interesting to see that the order of the leading countries has changed significantly. In the top 10 countries, there are at least six countries with a relatively low GDP per 1,000 inhabitants, while the countries with medium or high relative GDP are mainly in the middle or the last third of the ranking.

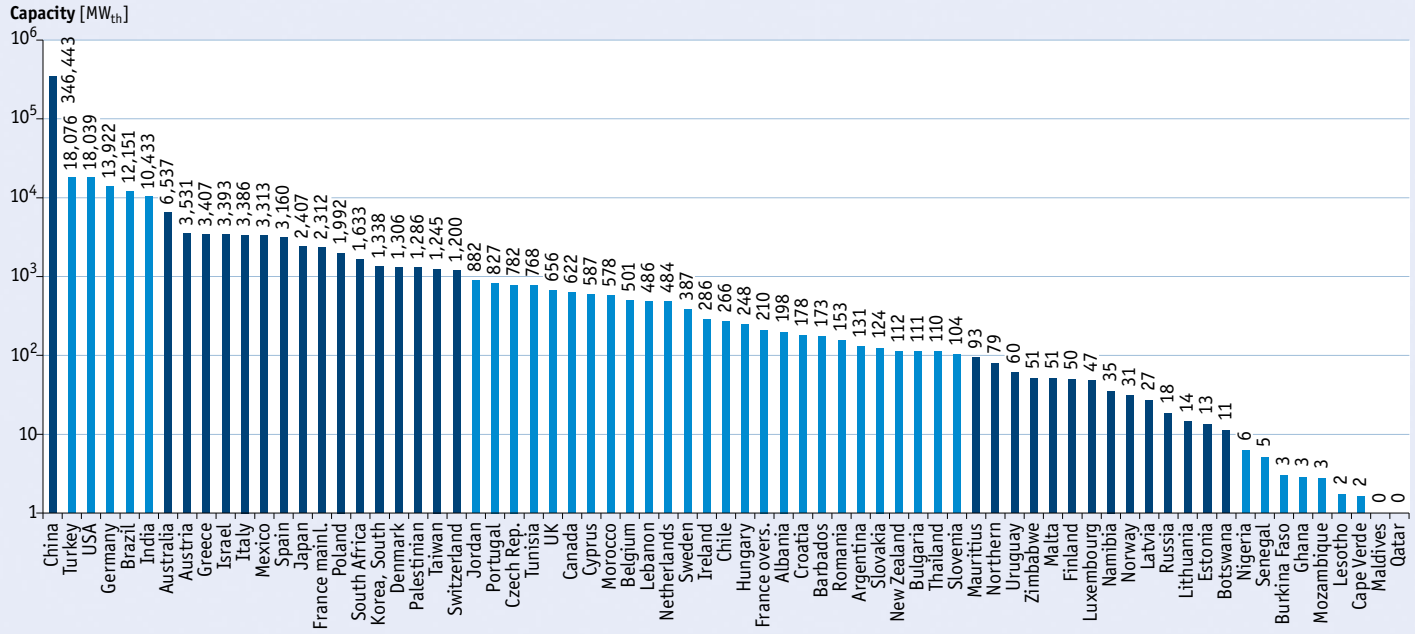


Figure 22: *Total capacity of glazed water collectors in operation by the end of 2019*

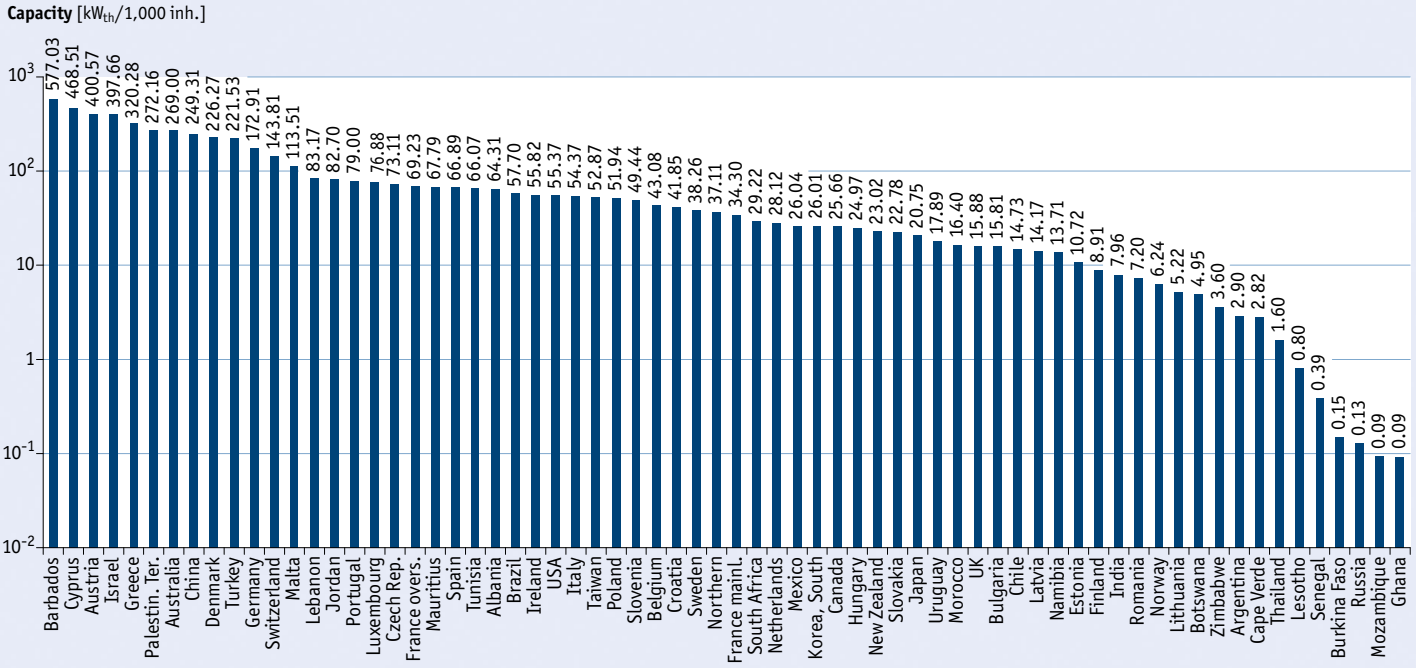


Figure 23: *Total Capacity of glazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2019*

From this graph, it could be deduced that the spread of thermal solar systems depends not only on the income of the residents but also on the energy policy framework.

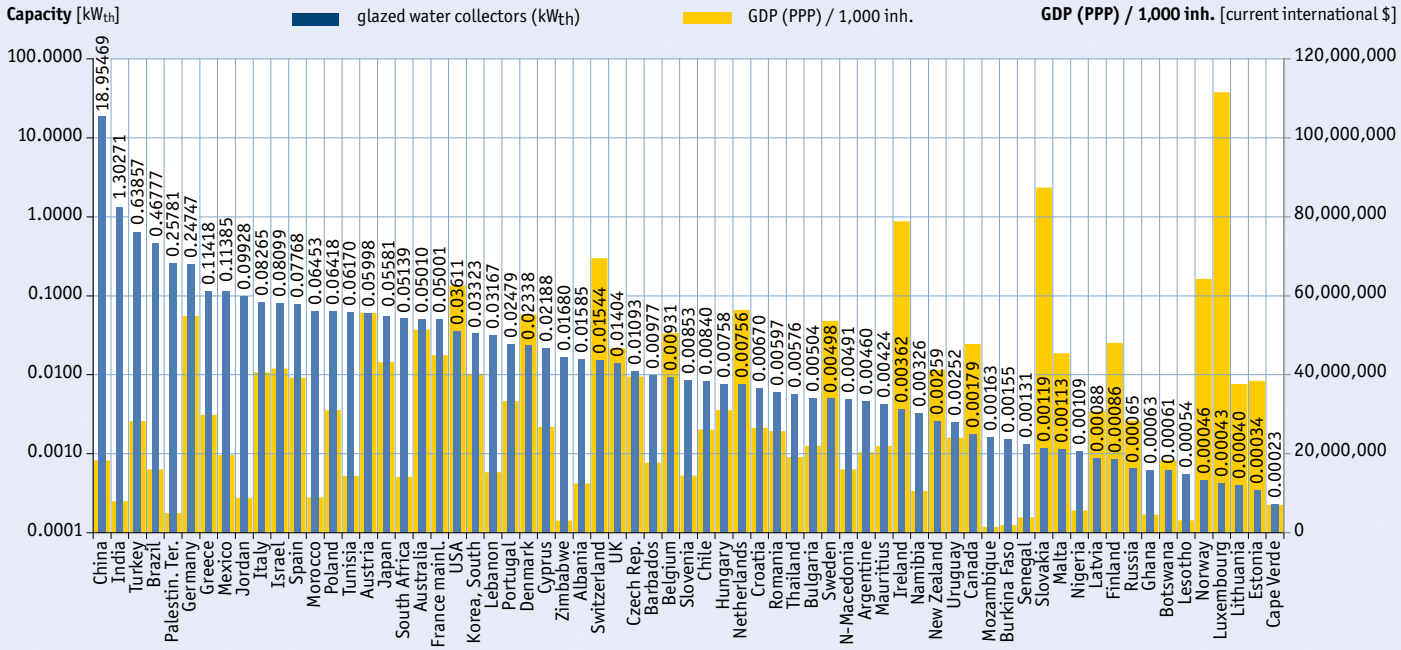


Figure 24: *Cumulated capacity of glazed water collectors per GDP/1,000 inhabitants in 2019*[23]

The following figures show the solar thermal market penetration per capita worldwide and in Europe.

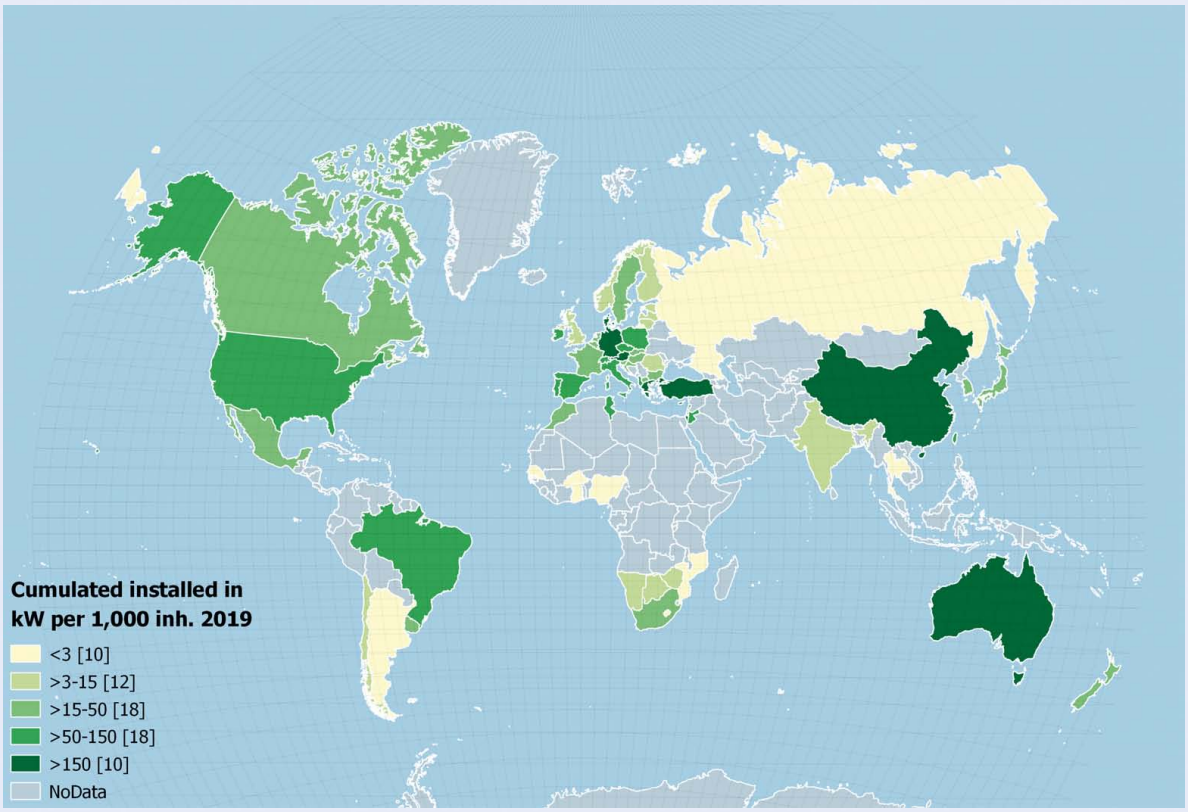


Figure 25: *Solar thermal market penetration per capita in kW_{th} per 1,000 inhabitants – WORLD*

23 Source of GDP: UN Data (https://data.un.org/Data.aspx?q=gdp&d=WDI&f=Indicator_Code%3aNY.GDP.MKTP.PP.CD accessed 7.4.2020)

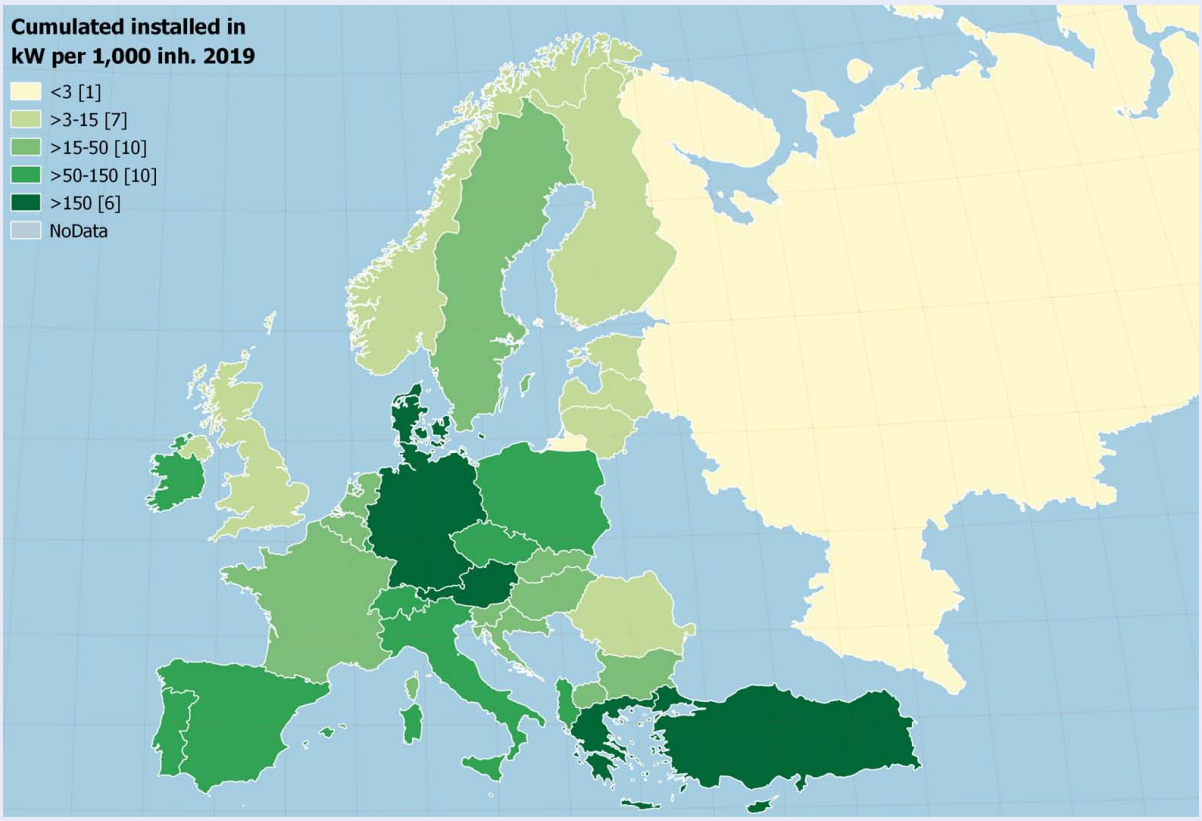


Figure 26: *Solar thermal market penetration per capita in kW_{th} per 1,000 inhabitants – EUROPE*

5.3 Total capacity of glazed water collectors in operation by economic region

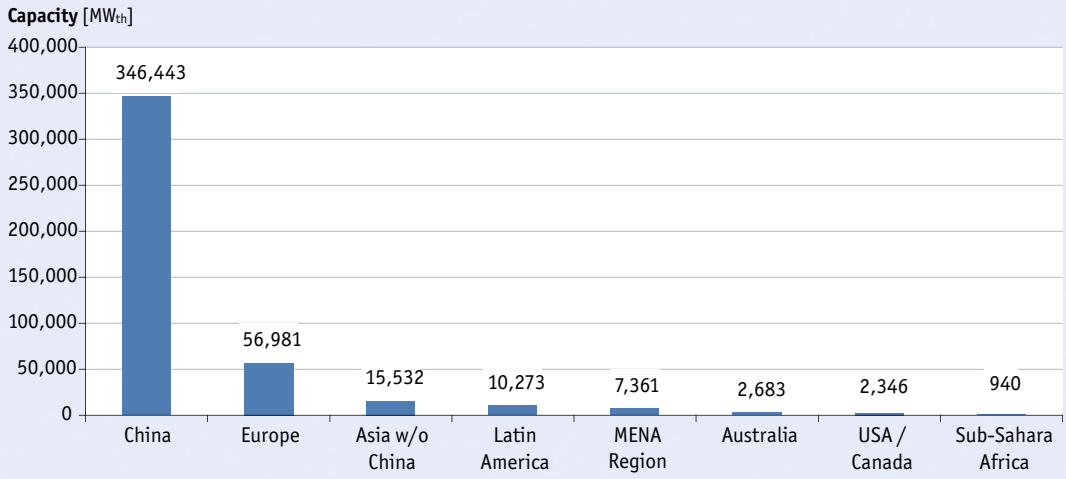


Figure 27: *Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region in 2019*

In terms of market penetration per capita by economic region, China again takes the lead. Remarkably, the MENA countries and Australia are ahead of Europe, which only confirms the very unbalanced market distribution in Europe (**Figure 28**). Whereas some European countries like Cyprus, Austria and Greece belong to the world market leaders in terms of high market penetration, others like the Baltic countries have negligible solar thermal market penetration.

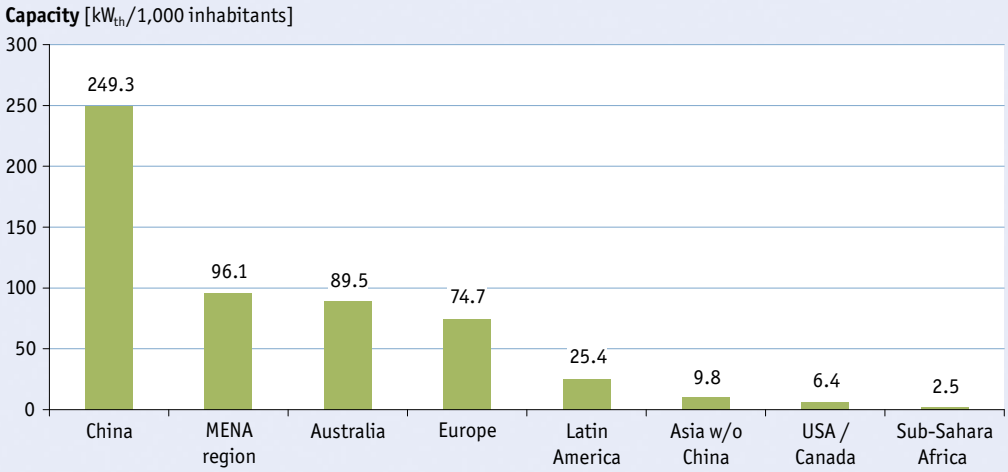


Figure 28: *Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region and in kW$_{th}$ per 1,000 inhabitants in 2019*

Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w/o China:	India, Japan, South Korea, Taiwan, Thailand
Latin America:	Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

5.4 Total capacity of unglazed water collectors in operation

Unglazed water collectors are mainly used for swimming pool heating. This type of collector has lost a significant market share over the past decade. The percentage of unglazed water collectors in the total installed collector capacity was reduced from 21%[24] in 2005 to just 6% in 2019. **Figure 29** and **Figure 30** show the total installed capacity of unglazed water collectors and total installed capacity of unglazed water collectors per 1,000 inhabitants at the end of 2019.

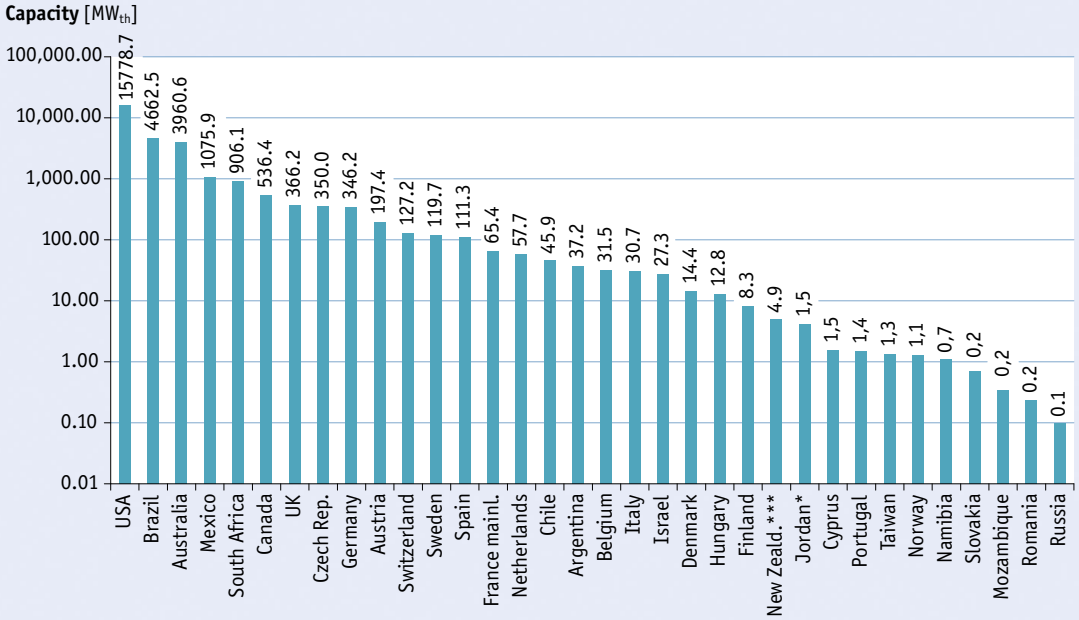


Figure 29: *Total capacity of unglazed water collectors in operation in 2019*

24 Solar Heat Worldwide (Ed.2008), Figure 3

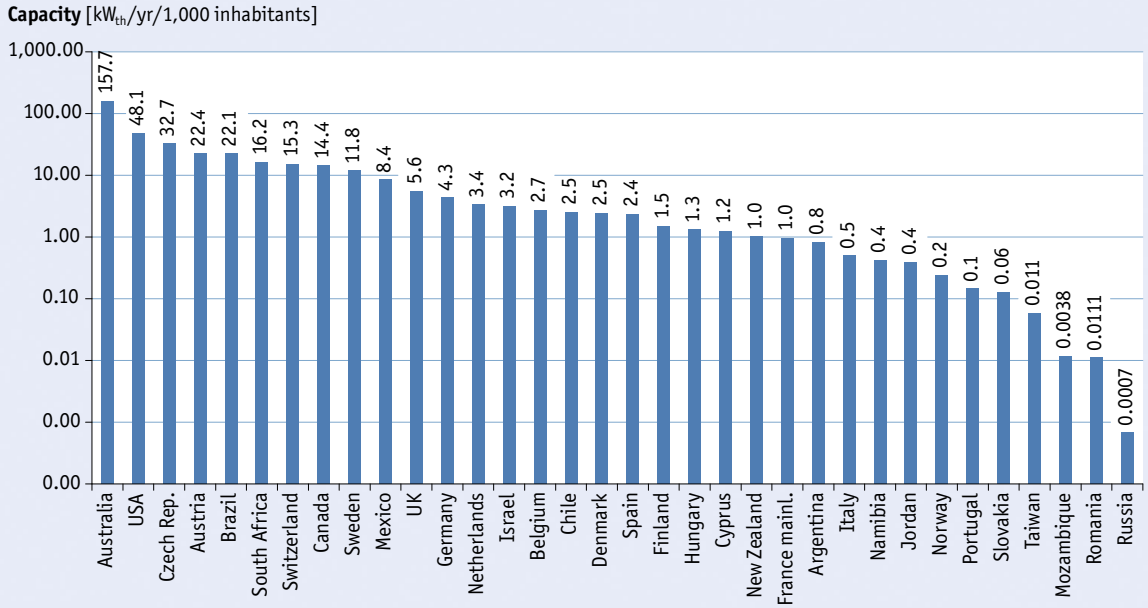
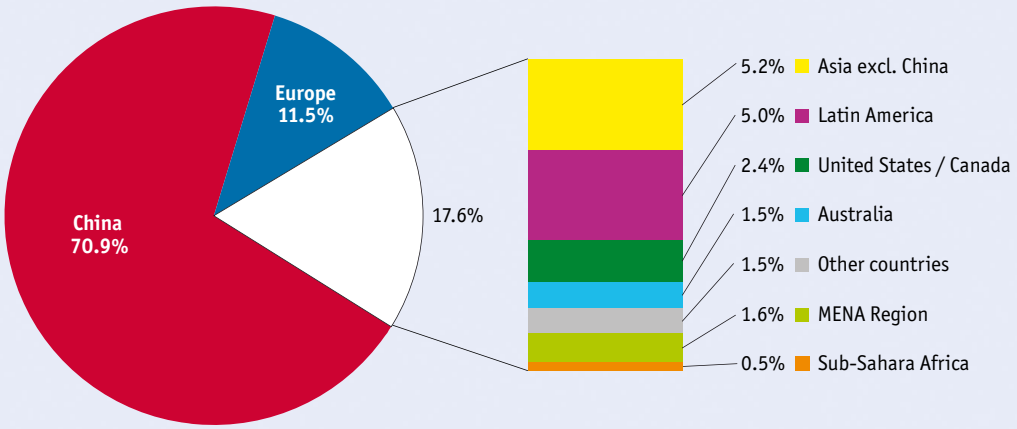


Figure 30: *Total capacity of unglazed water collectors in operation in kW$_{th}$ per 1,000 inhabitants in 2019*

5.5 Newly installed capacity in 2019 and market development

In 2019, a total capacity of 26.1 GW$_{th}$, corresponding to 37.3 million m² of new solar collectors, was installed worldwide.

The main markets were in China (18.5 GW$_{th}$) and Europe (3.0 GW$_{th}$), which accounted for 82.4 % of all new collector installations in 2019. The rest of the market was shared between Latin America (1.3 GW$_{th}$), Asia excluding China (1.4 GW$_{th}$), the United States and Canada (0.6 GW$_{th}$), MENA countries (0.4 GW$_{th}$), Australia (0.4 GW$_{th}$), and Sub-Sahara African countries (0.1 GW$_{th}$). The market volume of "all other countries" is estimated to amount to 0.4 GW$_{th}$ (542,000 m²).



Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w/o China:	India, Japan, Korea South, Taiwan, Thailand
Latin America:	Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Lebanon, Palestinian Territories, Tunisia

Figure 31: *Share of newly installed capacity (glazed and unglazed water and air collectors) by economic regions in 2019*

Country	Water Collectors [MW_{th}]			Air Collectors [MW_{th}]		TOTAL [MW_{th}] excl. concentrators
	unglazed	FPC	ETC	unglazed	glazed	
Albania		15	2			17
Argentina	24	16	28	0	0	69
Australia	266	110	12			388
Austria	0	63	0		1	64
Barbados*		9				9
Belgium		16	3			19
Botswana		2	0			2
Brazil	464	439	22			925
Bulgaria		16	0			17
Burkina Faso*		0	0			0
Canada	1	0	1	7	3	12
Cape Verde**		0				0
Chile		18				18
China		4,590	13,932	0		18,522
Croatia		13	1			14
Cyprus		49	0			49
Czech Republic		11	5			16
Denmark		136		0		136
Estonia		1	0			1
Finland		2	1			2
France (mainland)	1	30	2	1		33
France (overseas)		53				
Germany		309	49			358
Ghana**		0	0			0
Greece		253	0			253
Hungary		8	3			11
India		191	1,080		0	1,270
Ireland		9				9
Israel		252				252
Italy		92	14			106
Japan		41	0		1	42
Korea, South		2	12	0	0	15
Latvia		16	0			16
Lebanon		15	13			29
Lesotho		0	0			0
Lithuania		1	1			1
Luxembourg		2	0			2
Northern Macedonia		3	8			11
Malta		0	0			0
Mexico	83	102	100			286
Mozambique**		0	0			1
Namibia		3	0			
Netherlands	2	30	17			49
Nigeria		0	2		1	3
Norway		1	0			1
Palestinian Territories		32	0			32
Poland		198	4			201
Portugal		47	1			48
Romania	0	5	6			11
Russia		1	0			1
Senegal**		1	1	0	0	2
Slovakia	0	5	1			6
Slovenia		1	0			1
South Africa	42	20	50			112
Spain	2	136	5	1	1	145
Sweden	0	1				1
Switzerland	3	24	3			30
Taiwan		25				25
Tunisia		44				44
Turkey		665	655	0		1,320
United Kingdom	0	4	1	1		5
United States	487	108	4	3	0	603
Uruguay		7				7
Zimbabwe		0	10			10
All other countries (5% of world market excluding China)	72	195	112	1	0	380
TOTAL	1,448	8,492	16,163	14	7	26,123

Note: If no data is given: no reliable database for this collector type is available.
* 0% growth assumed
** estimation

Table 9: *Newly installed capacity in 2019 [MW_{th}/a]*

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²] excl. concentrators
	unglazed	FPC	ETC	unglazed	glazed	
Albania		21,986	2,284			24,270
Argentina	34,496	23,451	39,786	20	158	97,911
Australia	380,000	157,000	17,400			554,400
Austria	460	90,040	310		770	91,580
Barbados*		12,300				12,300
Belgium		23,500	4,300			27,800
Botswana		2,531	68			2,599
Brazil	662,451	627,773	30,761			1,320,985
Bulgaria		23,500	450			23,950
Burkina Faso*		100	310			410
Canada	1,165	609	1,629	10,000	4,100	17,503
Cape Verde**		150				150
Chile		25,183				25,183
China		6,557,000	19,903,000	700		26,460,700
Croatia		18,786	1,241			20,027
Cyprus		69,945	0			69,945
Czech Republic		15,675	7,125			22,800
Denmark		194,000		0		194,000
Estonia		855	570			1,425
Finland		2,565	855			3,420
France (mainland)	1,000	42,500	2,265	900		46,665
France (overseas)		75,364				
Germany		441,000	70,000			511,000
Ghana**		500	200			700
Greece		361,000	500			361,500
Hungary		11,400	4,750			16,150
India		272,156	1,542,460		100	1,814,716
Ireland		12,389				12,389
Israel		360,000				360,000
Italy		132,000	19,600			151,600
Japan		58,257	635		1,492	60,384
Korea, South		3,552	16,918	400	200	21,070
Latvia		22,900	250			23,150
Lebanon		21,608	19,239			40,847
Lesotho		65	140			205
Lithuania		750	1,250			2,000
Luxembourg		3,247	0			3,247
Northern Macedonia		4,924	10,850			15,774
Malta		521	130			651
Mexico	118,300	146,400	143,500			408,200
Mozambique**		280	570			850
Namibia		4,155	8			
Netherlands	2,620	42,950	24,820			70,390
Nigeria*		393	3,515		800	4,708
Norway		1,350	73			1,423
Palestinian Territories		45,568	0			45,568
Poland		282,160	5,030			287,190
Portugal		67,739	1,240			68,979
Romania	0	6,840	9,120			15,960
Russia		1,186	100			1,286
Senegal**		1,500	1,000	0	0	2,500
Slovakia	0	7,600	1,520			9,120
Slovenia		1,200	200			1,400
South Africa	60,324	28,160	71,763			160,247
Spain	2,900	193,650	7,600	1,300	1,000	206,450
Sweden	522	1,126				1,648
Switzerland	3,996	34,294	4,484			42,774
Taiwan		36,000				36,000
Tunisia		62,812				62,812
Turkey		950,000	935,000	100		1,885,100
United Kingdom	0	5,149	1,428	1,000		7,577
United States	696,420	154,050	6,400	4,500	500	861,870
Uruguay		10,418				10,418
Zimbabwe		10	13,869			13,879
All other countries (5% of world market excluding China)	103,403	278,720	159,343	959	480	542,904
TOTAL	2,068,057	12,131,391	23,089,859	19,879	9,600	37,318,786

Note: If no data is given: no reliable database for this collector type is available.
* 0% growth assumed
** estimation

Table 10: *Newly installed collector area in 2019 [m²/a]*

New installations in 2019 are divided into flat plate collectors: 8.5 GW_{th} (12 million m^2), evacuated tube collectors: 16 GW_{th} (23 million m^2), unglazed water collectors: 1.4 GW_{th} (2.1 million m^2), and glazed and unglazed air collectors: 0.02 GW_{th} (0.029 million m^2).

With a share of 61.9 %, evacuated tube collectors remain the most important solar thermal collector technology worldwide (**Figure 32**). In a global context, this breakdown is mainly driven by the dominance of the Chinese market, where around 75 % of all newly installed collectors in 2019 were evacuated tube collectors. Nevertheless, it is notable that the share of evacuated tube collectors decreased from about 82 % in 2011 to 61.9 % in 2019 while in the same time frame flat plate collectors increased their share from 14.7 % to 32.5 %.

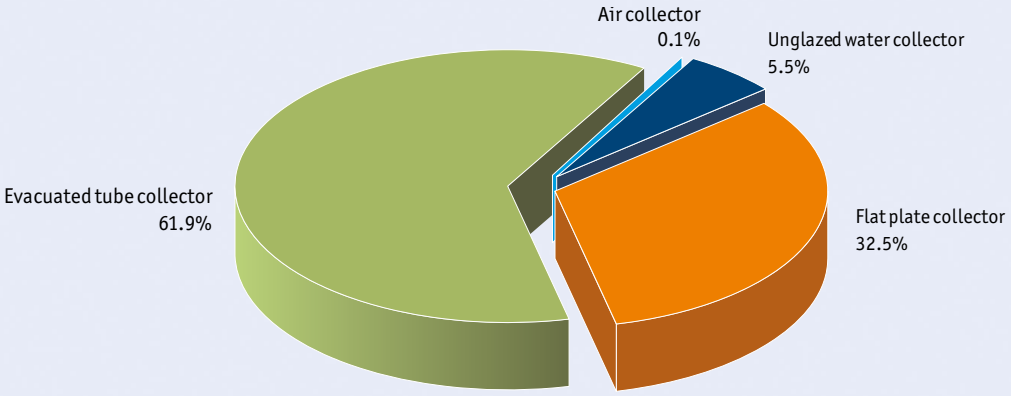


Figure 32: *Distribution of the newly installed capacity by collector type in 2019 - WORLD*

In Europe, the situation is almost the opposite of China, with 73.6 % of all solar thermal collectors installed in 2019 being flat plate collectors (**Figure 33**). In the medium-term perspective, the share of flat plate collectors decreased in Europe from 81.5 % in 2011 to 74.3 % in 2019. While driven mainly by the markets in Turkey, Poland, Switzerland and Germany, evacuated tube collectors increased their share in Europe between 2011 and 2018 from 15.6 % to 26.6 %. In 2019, the share of evacuated tube collectors decreased compared to the year 2018 from 26.6 % in 2018 to 26 % in 2019.

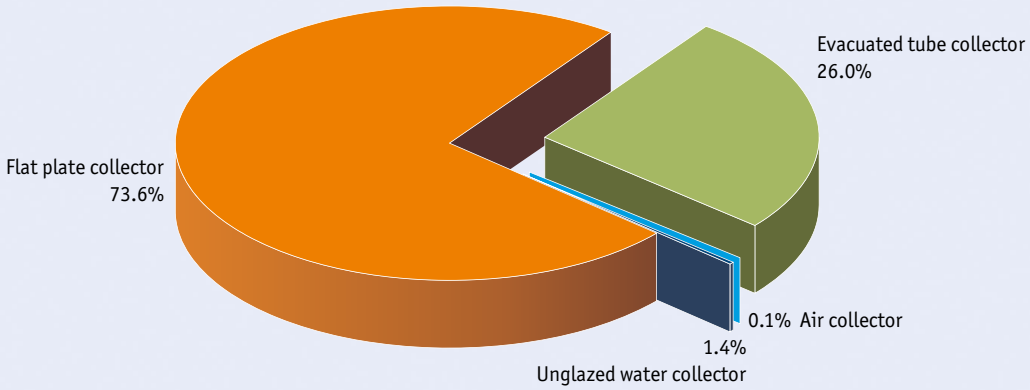


Figure 33: *Distribution of the newly installed capacity by collector type in 2019 – EUROPE*

Europe:EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey

Figure 34 shows the newly installed capacity of glazed and unglazed water collectors for the 10 leading markets in 2019 in total numbers. China remained the market leader in absolute terms, followed by Turkey and India. Brazil and the United States rank four and five in absolute numbers and are ahead of Australia and Germany. Mexico, Greece and Israel are within the top 10 countries, ranking eighth to tenth.

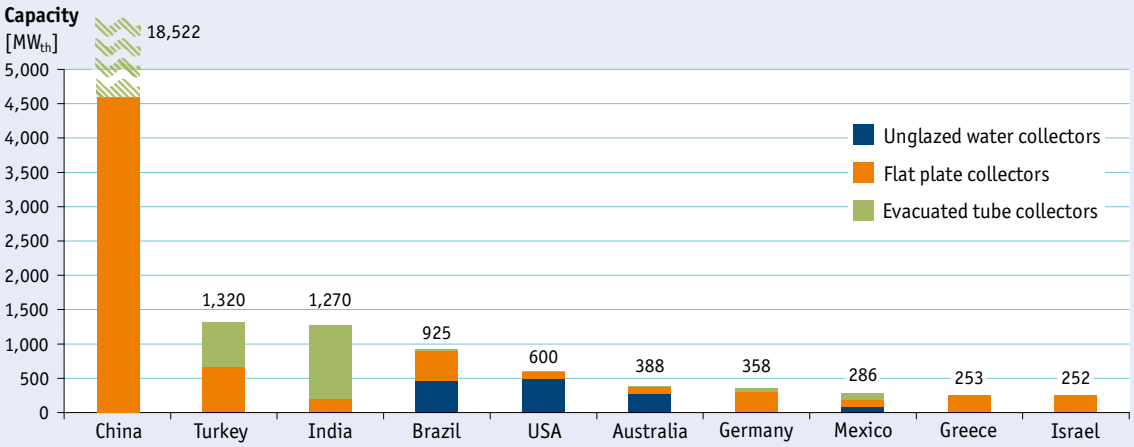


Figure 34: *Top 10 markets for glazed and unglazed water collectors in 2019 (absolute figures in MW_{th})*

In terms of newly installed solar thermal capacity per 1,000 inhabitants in 2019, the top 10 countries are shown in **Figure 35**. Compared to 2018, Cyprus overtook Israel and takes the first position. Denmark ranks fifth due to a couple of large-scale systems installed in 2019, and Turkey overtook Australia. France (overseas), which is documented separately for the first time, ranks sixth. In Latvia, a large-scale district heating system was installed in 2019 and therefore ranks tenth for the first time. China ranks ninth in 2019 after taking the fifth position in 2018.

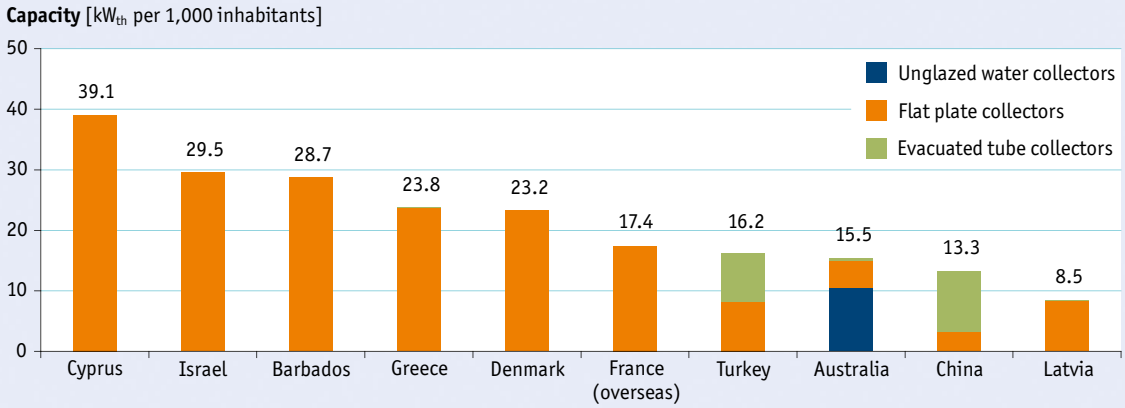


Figure 35: *Top 10 markets for glazed and unglazed water collectors in 2019 (in kW_{th} per 1,000 inhabitants)*

5.6 Newly installed capacity of glazed water collectors

In 2019, glazed water collectors accounted for 94% of the total newly installed capacity. China was the most influential market in the global context (**Figure 36**).

In terms of newly installed glazed water collector capacity per 1,000 inhabitants, Cyprus is the leader ahead of Israel and Barbados. In this respect, China ranks in 8th place (**Figure 37**).

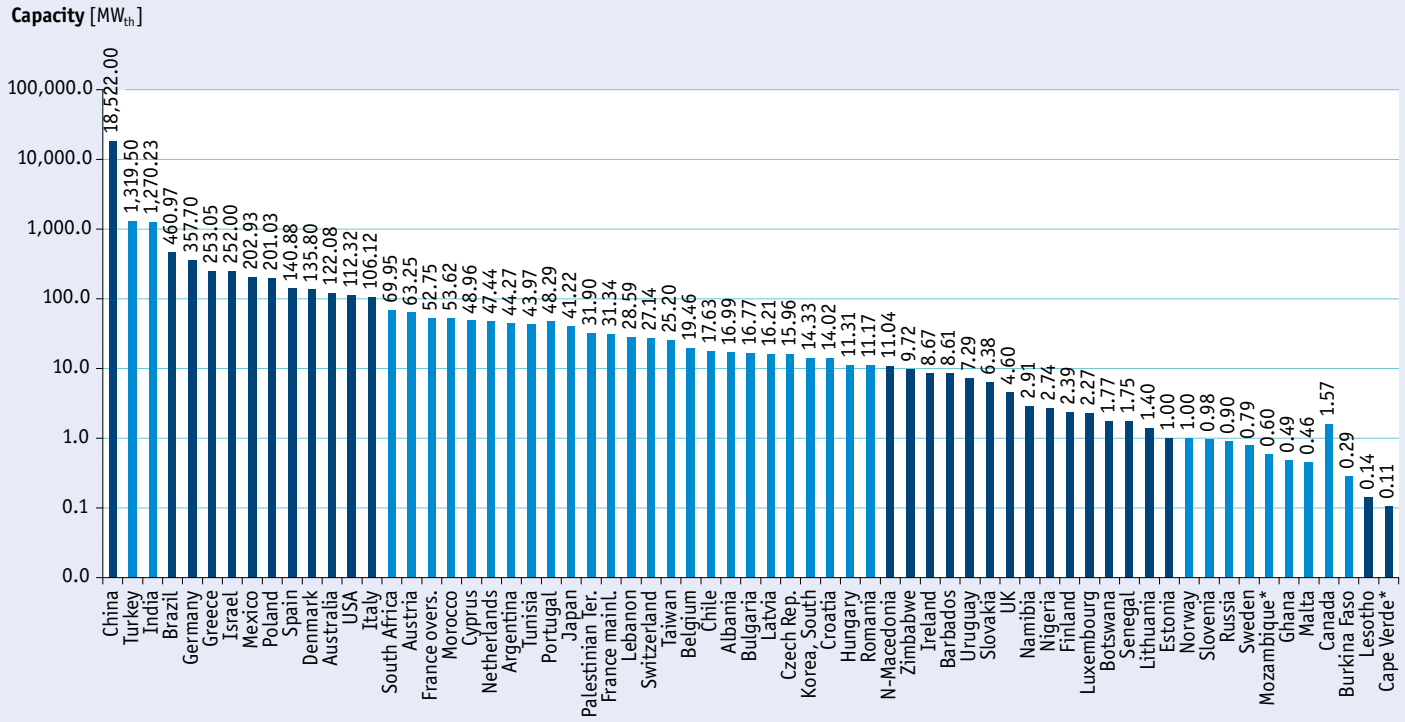


Figure 36: *Newly installed capacity of glazed water collectors in 2019*

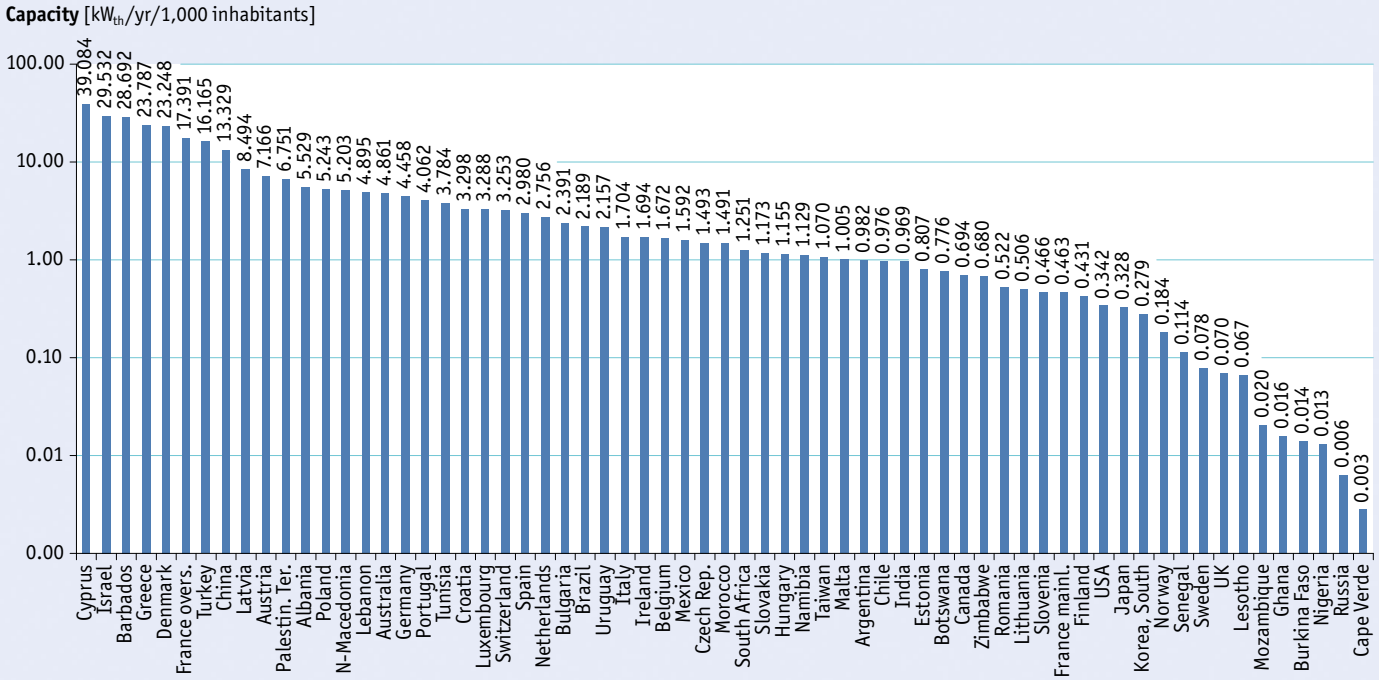


Figure 37: *Newly installed capacity of glazed water collectors in 2019 in kW_{th} per 1,000 inhabitants*

The following figures show the solar thermal market penetration per capita of the newly installed capacity in 2019 worldwide and in Europe.

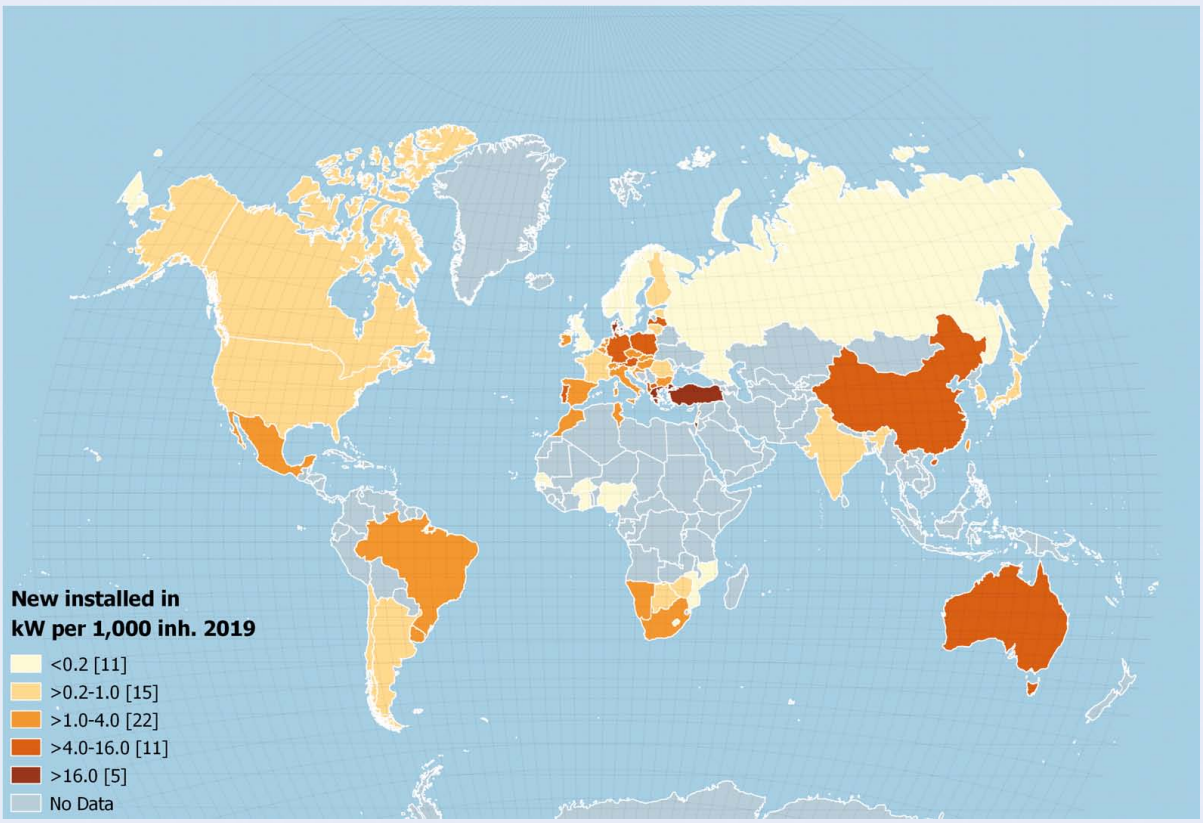


Figure 38: *Newly installed capacity in 2019 in kW_{th} per 1,000 inhabitants – WORLD (Source: Natural Earth v.4.1.0, 2020/AEE INTEC).*

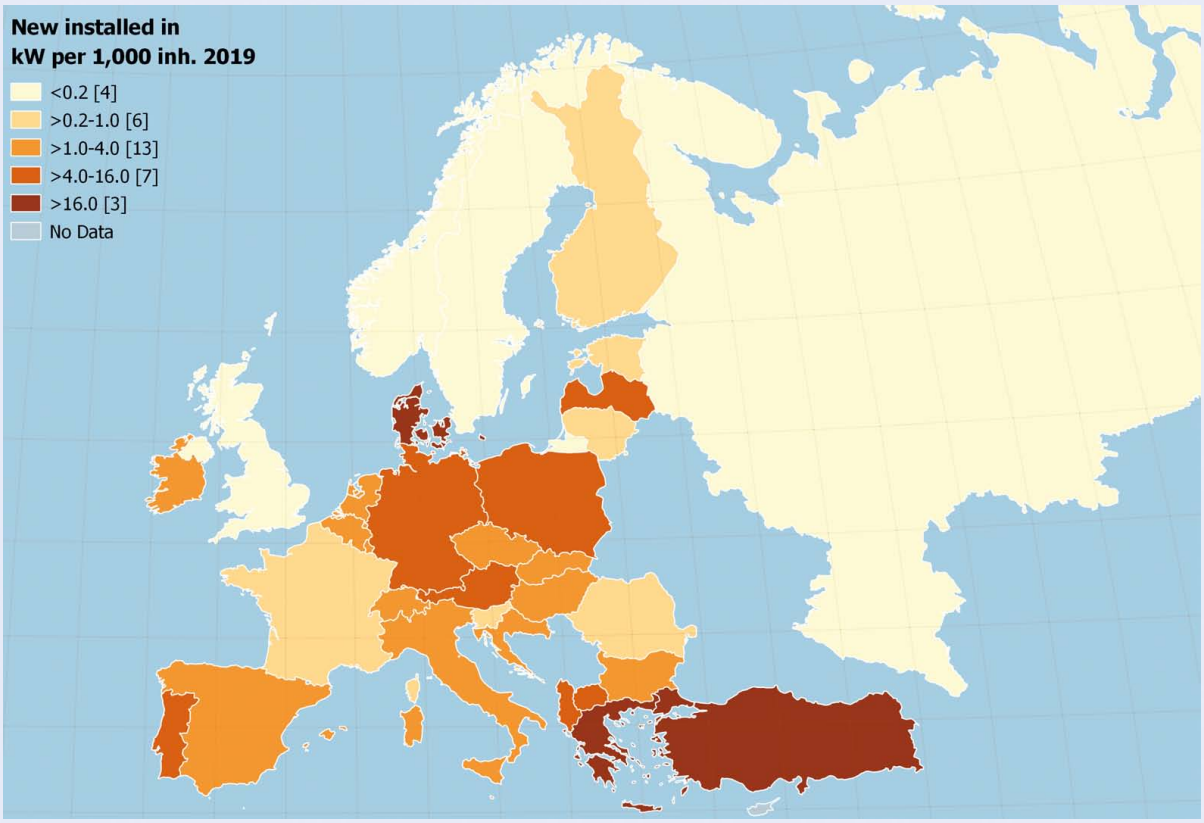


Figure 39: *New Installed capacity in 2019 in kW_{th} per 1,000 inhabitants – EUROPE (Source: Natural Earth v.4.1.0, 2020/AEE INTEC)*

5.7 Market development of glazed water collectors between 2000 and 2019

The worldwide market of glazed water collectors was characterized by a steady upward trend between 2000 and 2011 and then leveled off in 2012 and 2013 at around 50 GW_{th}. In 2014, a significant market decline of -15.6% was reported for the first time since 2000. This trend continued with slightly recovering markets in 2017 and 2018, but in 2019 saw a 16% decline.

The newly installed glazed water collector capacity in 2019 amounted to 24.6 GW_{th} (**Figure 40**).

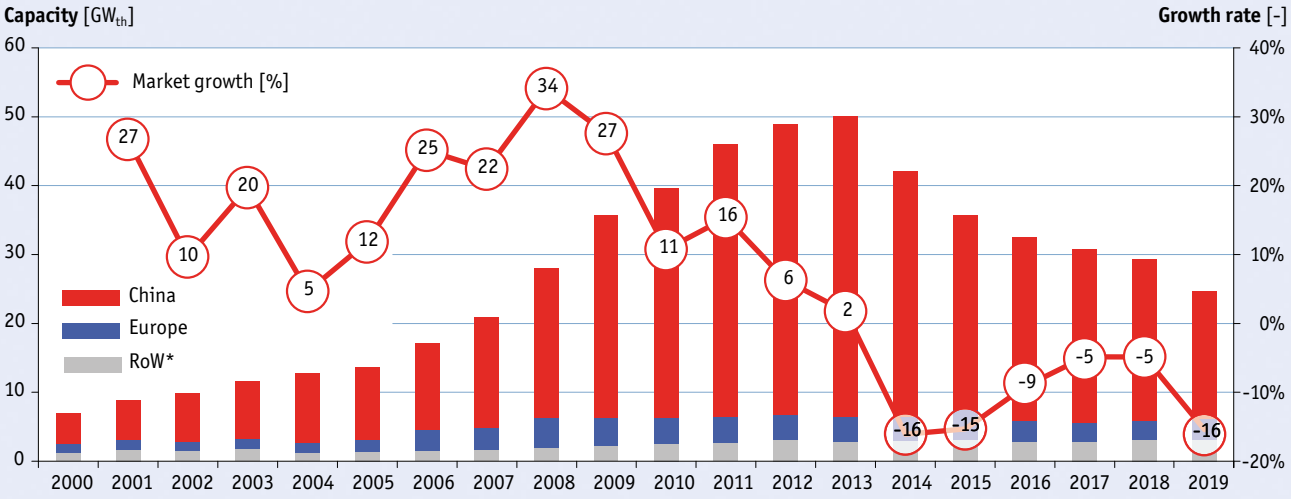


Figure 40: *Global market development of glazed water collectors from 2000 to 2019*

In 2000, the Chinese market was about three times as large as the European market, and by 2019, the Chinese market exceeded the European market by about six-fold (**Figure 41**).

Figure 41 also shows that after years of very high growth rates in China, this trend has changed in the past years. Compared to the years before, the Chinese market began to experience low growth rates in 2012 and 2013 and then shrank significantly in 2014 and 2015. However, this downward trend became less dramatic from 2016 to 2018 but increased again from 2018 to 2019.

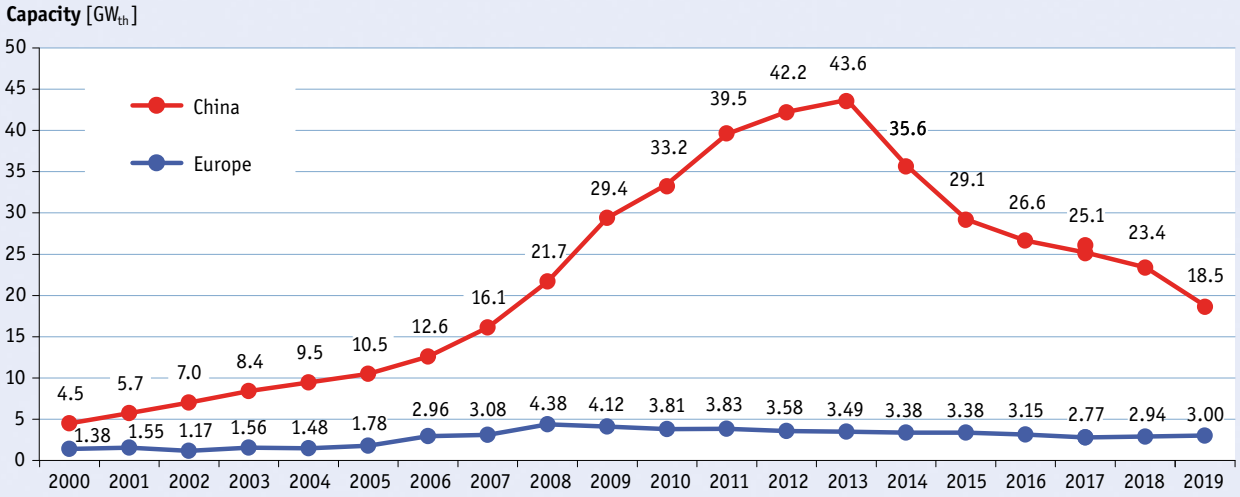
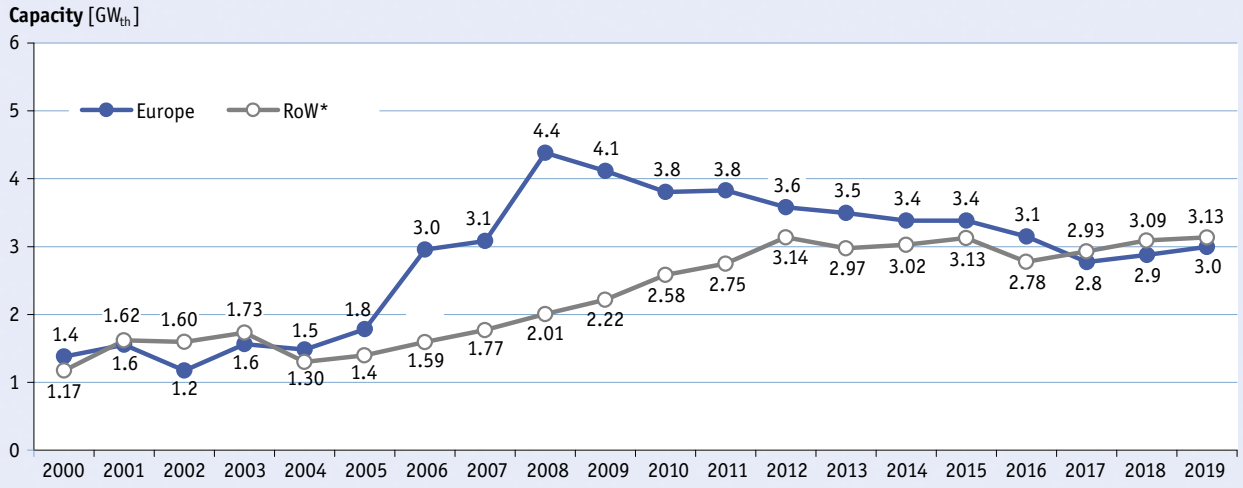


Figure 41: *Market development of glazed water collectors in China and Europe 2000 – 2019*

The European market peaked at 4.4 GW_{th} installed capacity in 2008 and has decreased steadily down to 2.8 GW_{th} in 2017 and now shows a slight recovery with 3.0 GW_{th} in 2019. In the "remaining markets worldwide" (RoW), an upward trend could be observed between 2002 and 2012 and a falling trend from 2013 to 2016. Since 2016, a slight upward trend is noticeable (**Figure 42**).



Europe: EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
Rest of World (RoW): Asia (India, Japan, South Korea, Taiwan, Thailand), Australia, Canada, United States
Latin America (Argentina, Brazil, Chile, Mexico, Uruguay) [PM17]
MENA countries (Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia)
Sub-Sahara Africa (Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe),
"All other countries" see figures for 2019 in **Tables 4** and **5**

Figure 42: *Market development of glazed water collectors in Europe and the rest of the world (RoW, excluding China) from 2000 to 2019*

Rest of the World (RoW) includes all economic regions other than China and Europe. Of these regions, Asia (excluding China), Latin America and the MENA countries hold the largest market shares (see **Figure 43**).

"Asia excl. China" is mainly influenced by the large Indian market, which dropped in 2013 but recovered significantly in 2014 and 2015. After a drop again in 2016, it shows an upward trend. Other markets covered within this economic region are Japan and South Korea.

Latin America showed the most steady and dynamic upward trend of all the economic regions until 2014. The dominant Brazilian market and the large Mexican market and the evolving markets, for example, in Chile, are responsible for the positive growth rates that have lasted for six years in a row. Since 2015, the market in this region is about stable, with a slight decrease in 2017 and 2018 but recovering again in 2019.

Glazed water collector markets in the MENA countries were characterized by steady growth from 2000 to 2013. The market decline since 2014, shown in **Figure 43**, is explained by the fact that from 2015 on, there was no data for the two major markets – Morocco and Jordan. The sales numbers in the most important market, Israel, slightly decreased in 2019.

The market volume for glazed water collectors in Australia was similar to the volume in Latin America and the MENA countries in 2009 and continued to shrink more or less through 2015. In 2019, the market showed a 7% decrease.

Sub-Sahara African markets showed a stable market in 2019. In the United States and Canada, the decreasing trend continued with about a -4% decline in 2019.

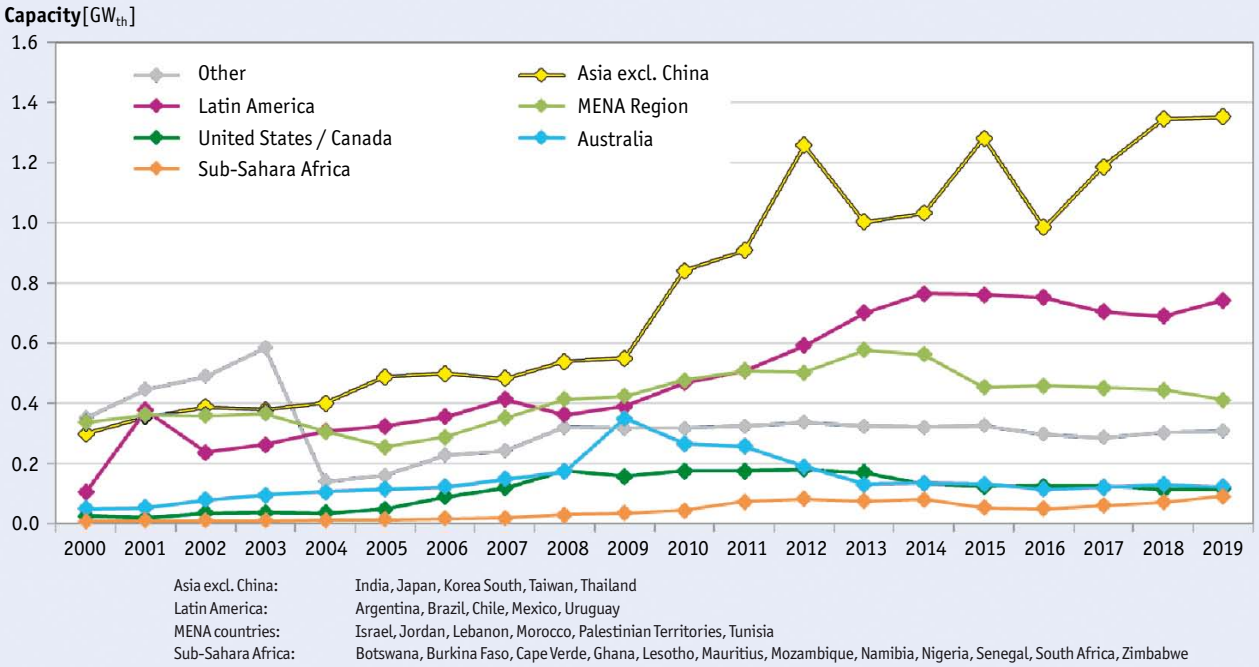


Figure 43: *Market development of glazed water collectors in Latin America, United States / Canada, Sub-Sahara Africa, Asia, the MENA region and Australia (excluding China and Europe) from 2000 to 2019*

In relative figures, the annual global market volume for glazed water collectors grew from 1.2 kW_{th} per 1,000 inhabitants in 2000 to 7.0 kW_{th} per 1,000 inhabitants in 2013 and dropped down to 3.2 kW_{th} per 1,000 inhabitants in 2019 (**Figure 44**).

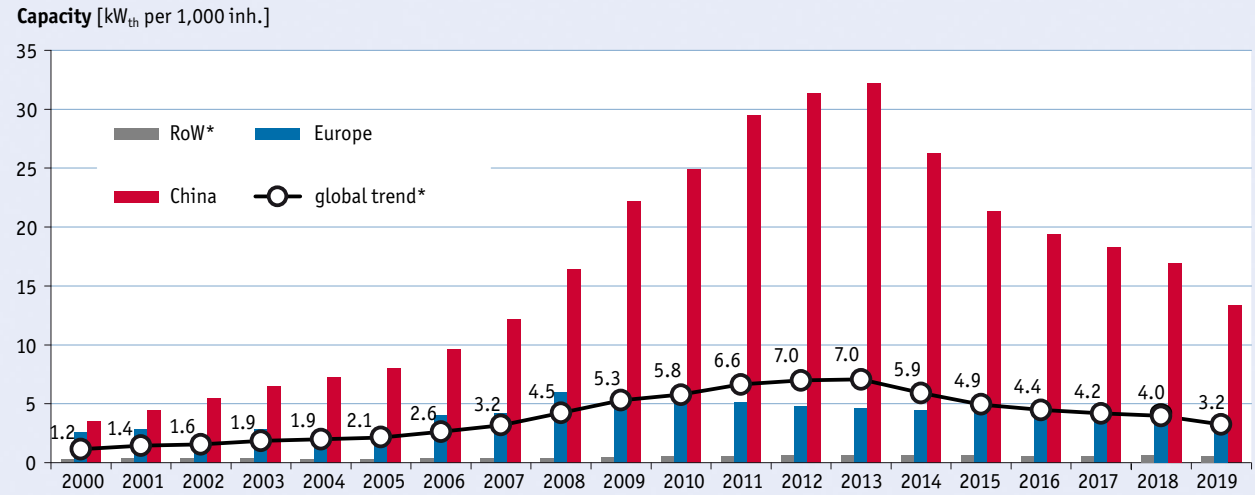


Figure 44: *Annual installed capacity of glazed water collectors in kW_{th} per 1,000 inhabitants from 2000 to 2019*

The fact that China suffered major market declines from 2014 to 2016 is also reflected in the market penetration of glazed water collector installations per capita. The annually installed capacity rose from 3.5 kW_{th} per 1,000 inhabitants in 2000 and peaked at 32.2 kW_{th} per 1,000 inhabitants in 2013 and fell to 13.3 kW_{th} per 1,000 inhabitants in 2019.

In Europe, market penetration peaked in 2008 with 5.9 kW_{th} per 1,000 inhabitants. The downward trend between 2009 and 2013 seems to have stabilized from 2014 on and lies at 3.9 kW_{th} per 1,000 inhabitants in 2019.

5.8 Market development of unglazed water collectors between 2000 and 2019

With a newly installed capacity of 1.5 GW_{th} in 2019, unglazed water collectors accounted for 5.5 % of the total installed solar thermal capacity (**Figure 32**). Compared to 2018, the market decreased slightly by 2.3 %.

The most important markets for unglazed water collectors in 2019 were the United States (488 MW_{th}), Brazil (464 MW_{th}) and Australia (266 MW_{th}). Mexico reported 83 MW_{th} installed unglazed water collector area and South Africa 42 MW_{th}. The capacity in these countries accounted for 93 % of the recorded unglazed water collector installations worldwide. Switzerland (2.8 MW_{th}), Spain (2 MW_{th}) and the Netherlands (1.8 MW_{th}) also reported unglazed water collector installations in 2019.

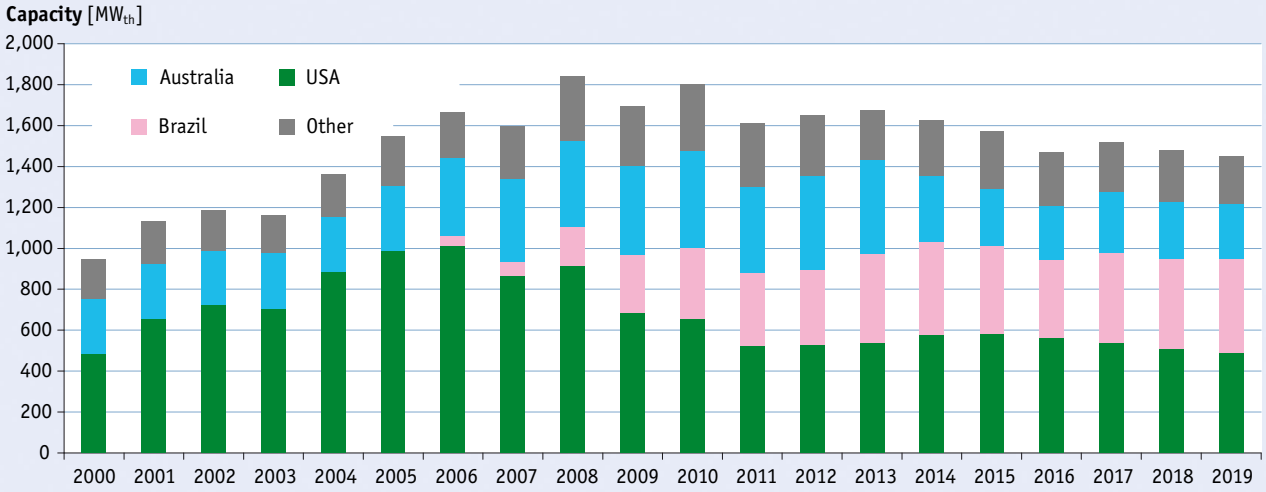


Figure 45: *Global market development of unglazed water collectors from 2000 to 2019*

The unglazed water collector market in the United States peaked in 2006 (1.01 GW_{th}) and has almost halved since then (0.49 GW_{th} in 2019). Nevertheless, the annual global market volume for unglazed water collectors has remained at a nearly constant level because of the Brazilian market, which entered in 2007 and peaked in 2014 at 0.45 GW_{th}. Australia has faced a market decline since 2010 and is now the third largest market for unglazed water collectors behind that of the United States and Brazil.

6 Contribution to the energy supply and CO_2 reduction in 2019

In this section, the total installed glazed and unglazed water collectors' contribution to the thermal energy supply and CO_2 reduction is shown.

The annual collector yield of all water-based solar thermal systems for the simulated applications (swimming pool, DHW for single-family houses, DHW for multi-family houses and solar combi-systems) in operation at the end of 2019 in the 68 recorded countries was 389 TWh (= 1,399 PJ). This corresponds to a final energy savings equivalent of 41.8 million tons of oil and 132.2 million tons of CO_2. The calculated number of solar thermal systems in operation was around 104 million (**Table 11**). The CO_2 emissions saved by the thermal solar systems in operation in 2019 correspond to 3.8 times the total CO_2 emissions in Switzerland[25] (**https://de.statista.com/themen/5533/treibhausgasemissionen-in-der-schweiz/**).

The most dominant application for solar thermal systems is domestic hot water heating (see **section 7.3**), which accounted for the highest savings in terms of oil equivalent and CO_2. In 2019, 94% of the energy produced by solar thermal systems was primarily used for heating domestic hot water, mainly by small-scale systems in single-family houses (58%) and larger applications attached to multi-family houses, hotels, schools, etc. (36%). Swimming pool heating held a 4% share of the contribution to the energy supply and CO_2 reduction and the remaining 2% was met by solar combi-systems.

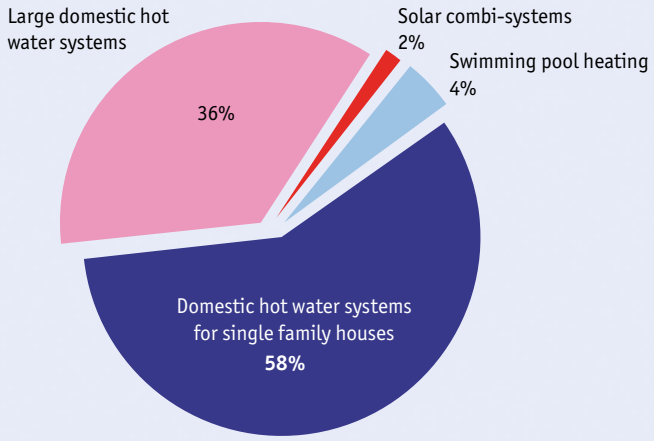


Figure 46: *Share of energy savings and CO_2 reduction by type of application of glazed and unglazed water collectors in operation in 2019*

The basis for these calculations is the total glazed and unglazed water collector area in operation in each country, as shown in **Table 8**. The 1.1 GW_{th} contribution of the total installed air collector capacity in operation in 2019 was not taken into consideration – with only a share of around 0.2% of the total installed collector capacity; these collectors were omitted from the calculation.

The results are based on calculations using the simulation tool, T-SOL expert 4.5, for each country. For the simulations, different types of collectors and applications and characteristic climatic conditions were considered for each country. A more detailed description of the methodology can be found in the appendix (see **Chapter 8**).

Table 11 summarizes the calculated annual collector yields and the corresponding oil equivalents and CO_2 reductions of all water-based solar thermal systems in 2019.

25 Statista Research Department, 8 September 2020

Country	Total collector area [m²]	Total capacity [MW_{th}]	Calculated number of systems	Collector yield [GWh/a]	Collector yield [TJ/a]	Energy savings [t_{oe}/a]	CO_2 reduction [t_{CO2e}/a]
Albania	282,317	198	61,110	199	717	21,421	67,797
Argentina	186,715	131	26,462	115	415	12,404	39,259
Australia	9,338,000	6,537	1,174,053	5,775	20,790	620,706	1,964,535
Austria	5,044,954	3,531	502,238	2,040	7,343	219,232	693,868
Barbados	247,368	173	57,290	217	783	23,377	73,988
Belgium	716,035	501	124,609	285	1,025	30,594	96,831
Botswana	16,128	11	2,634	15	54	1,625	5,143
Brazil	17,358,986	12,151	5,197,755	11,327	40,777	1,217,415	3,853,117
Bulgaria	158,347	111	27,557	78	281	8,385	26,538
Burkina Faso	4,271	3	270	4	14	428	1,354
Canada	886,850	621	33,822	427	1,537	45,874	145,191
Chile	379,566	266	117,450	268	965	28,822	91,222
China	494,919,000	346,443	68,066,210	271,200	976,320	29,148,753	92,255,803
Croatia	254,146	178	44,228	128	460	13,730	43,455
Cyprus	838,450	587	366,477	745	2,683	80,100	253,517
Czech Republic	1,117,146	782	88,581	377	1,357	40,525	128,262
Denmark	1,865,873	1,306	111,551	779	2,803	83,691	264,883
Estonia	18,925	13	3,293	8	27	816	2,584
Finland	70,743	50	12,308	29	103	3,080	9,750
France (mainland)+	3,302,150	2,312	722,246	1,600	5,760	171,971	544,288
Germany	19,798,100	13,859	2,325,056	8,061	29,021	866,436	2,742,271
Ghana	4,081	3	214	4	13	395	1,251
Greece	4,867,500	3,407	1,299,476	3,390	12,205	364,388	1,153,288
Hungary	343,078	240	46,953	158	568	16,957	53,669
India	14,903,617	10,433	7,004,178	12,853	46,270	1,381,411	4,372,167
Ireland	408,320	286	94,499	171	615	18,375	58,156
Israel	4,847,434	3,393	1,552,148	4,475	16,109	480,932	1,522,148
Italy	4,837,014	3,386	841,771	2,951	10,624	317,175	1,003,858
Japan	3,439,901	2,408	833,470	1,991	7,167	213,977	677,238
Jordan*	1,260,506	882	223,109	1,194	4,297	128,286	406,026
Korea, South	1,911,626	1,338	437,953	992	3,571	106,620	337,454
Latvia	38,532	27	6,706	16	59	1,756	5,559
Lebanon	694,039	486	115,842	583	2,098	62,635	198,240
Lesotho	2,457	2	701	2	8	233	737
Lithuania	20,650	14	3,594	9	31	929	2,939
Luxembourg	67,810	47	11,801	29	103	3,083	9,759
Northern Macedonia	112,511	79	25,439	69	250	7,450	23,579
Malta	73,509	51	29,404	64	230	6,857	21,703
Mauritius**	132,793	93	88,529	113	408	12,183	38,558
Mexico	4,732,417	3,313	559,101	2,707	9,746	290,979	920,948
Morocco	825,000	578	111,403	700	2,522	75,285	238,276
Mozambique	3,909	3	596	3	12	348	1,100
Namibia	50,557	35	6,244	46	166	4,957	15,688
Netherlands	694,848	486	154,143	278	1,000	29,870	94,537
New Zealand***	159,645	112	32,703	99	355	10,593	33,526
Nigeria	8,740	6	3,341	8	28	824	2,607
Norway	43,994	31	2,192	16	58	1,741	5,509
Palestine	1,836,982	1,286	630,758	1,714	6,171	184,228	583,080
Poland	2,845,490	1,992	358,057	1,162	4,183	124,890	395,276
Portugal	1,164,032	815	211,010	899	3,235	96,592	305,713
Romania	219,250	153	38,155	121	436	13,014	41,189
Russia	26,330	18	1,565	11	39	1,166	3,690
Senegal	7,324	5	1,825	7	26	768	2,429
Slovakia	177,120	124	21,678	83	298	8,888	28,129
Slovenia	148,500	104	23,332	62	225	6,711	21,239
South Africa	2,332,975	1,633	662,283	1,802	6,486	193,632	612,845
Spain	4,514,973	3,160	531,187	3,149	11,335	338,406	1,071,056
Sweden	552,585	387	41,955	202	727	21,707	68,703
Switzerland	1,714,020	1,200	207,380	677	2,437	72,750	230,255
Taiwan	1,779,055	1,245	351,134	1,082	3,896	116,323	368,161
Thailand****	157,536	110	36,001	132	476	14,212	44,982
Tunisia	1,096,827	768	322,717	984	3,544	105,799	334,853
Turkey	25,822,636	18,076	5,965,029	23,166	83,398	2,489,924	7,880,608
United Kingdom	1,460,160	1,022	233,750	520	1,871	55,856	176,783
United States	25,769,393	18,039	432,926	11,461	41,260	1,231,843	3,898,783
Uruguay	86,419	60	17,802	49	175	5,217	16,510
Zimbabwe	73,518	51	29,867	63	225	6,731	21,304
All other countries (5% of world market excluding China)	9,690,869	6,784	1,372,694	5,534	19,921	594,745	1,882,369
TOTAL	682,764,552	477,935	104,041,819	389,475	1,402,110	41,861,021	132,490,130

* Total capacity in operation refers to the year 2014
** Total capacity in operation refers to the year 2015
*** Total capacity in operation refers to the year 2009
**** Total capacity in operation refers to the year 2016
\+ The figures for France relate to mainland France only, overseas departments and regions are not considered.

Table 11: *Calculated annual collector yield and corresponding oil equivalent and CO_2 reduction of glazed and unglazed water collectors in operation by the end of 2019*

7 Distribution of systems by type and application in 2019

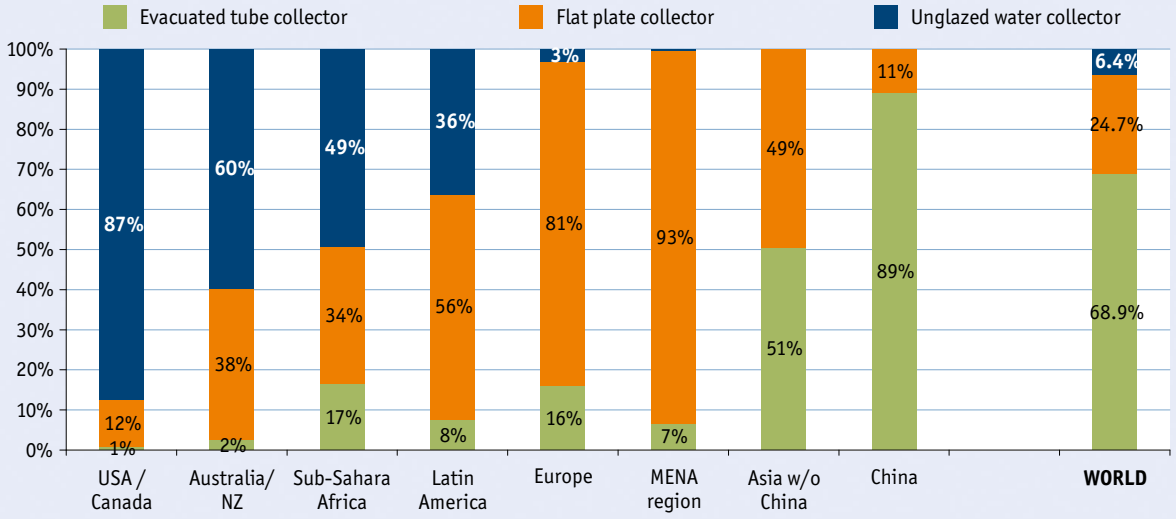
The use of solar thermal energy varies greatly from region to region and can be roughly distinguished by the type of solar thermal collector used (unglazed water collectors, evacuated tube collectors, flat plate collectors, glazed and unglazed air collectors, concentrating collectors), the type of system operation (pumped solar thermal systems, thermosiphon systems), and the main type of application (swimming pool heating, domestic hot water preparation, space heating, others such as heating of industrial processes, solar district heating or solar thermal cooling).

In **Chapters 7.1** to **7.3**, the distribution of these system types and applications are shown by economic regions for both the cumulated capacity in operation in 2019 and the newly installed capacity in 2019[26].

7.1 Distribution by type of solar thermal collector

In terms of the total water collector capacity worldwide in 2019, evacuated tube collectors dominated with 69% of the cumulated capacity in operation (**Figure 47**) and a share of 62% of the newly installed capacity (**Figure 48**). Worldwide flat plate collectors accounted for about 25% of the cumulated capacity in operation (**Figure 49**) and a 32.5% share of the newly installed capacity (**Figure 50**). Unglazed water collectors accounted for 6.4% of the cumulated water collectors installed worldwide and for about 5.5% of the newly installed capacity.

In China, evacuated tube collectors are dominant. In North America, Australia and Sub-Sahara-Africa (mainly driven by South Africa) unglazed water collectors are the collector type with the largest share. In the other regions, flat plate collectors are dominant.

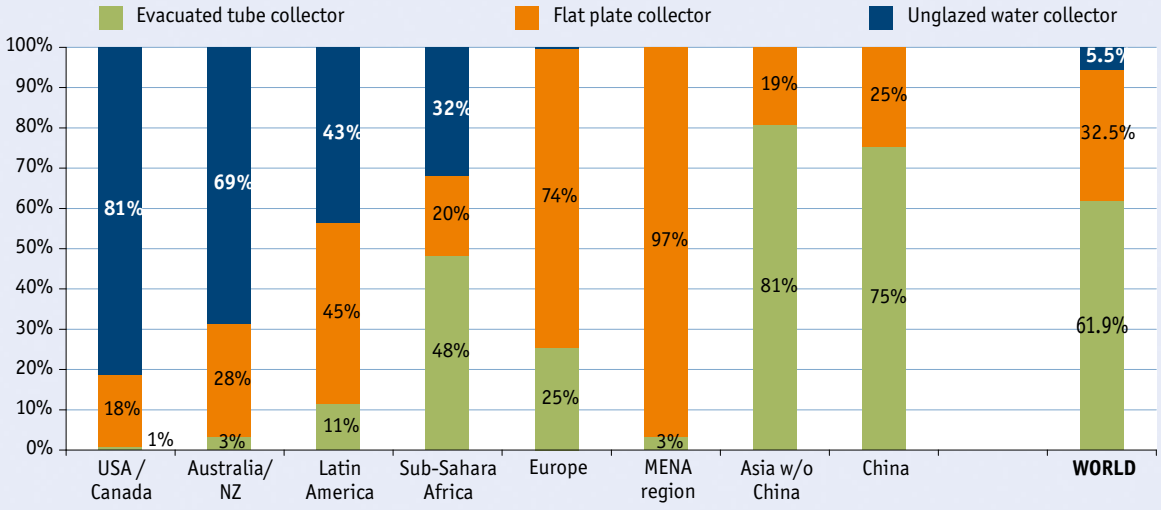


Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w/o China:	India, Japan, South Korea, Taiwan Thailand
Latin America:	Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia

Figure 47: *Distribution by type of solar thermal collector for the total installed water collector capacity in operation by the end of 2019*

26 It is important to note that statistical information summarized in **Chapters 7.1** to **7.3** is sometimes only based on rough expert estimations by country representatives, and therefore, figures may deviate from those published in previous editions of this report, particularly in reference to the cumulated installed capacity in operation by system type and application.

The distribution of the newly installed collector area is shown below. Evacuated tube collectors are dominant in China, Asia (excluding China), driven by development in India, and with an increasing share in Sub-Sahara Africa. Unglazed collectors are dominant in North America and Australia. Flat plate collectors are dominant in Latin America, Europe and the MENA region.



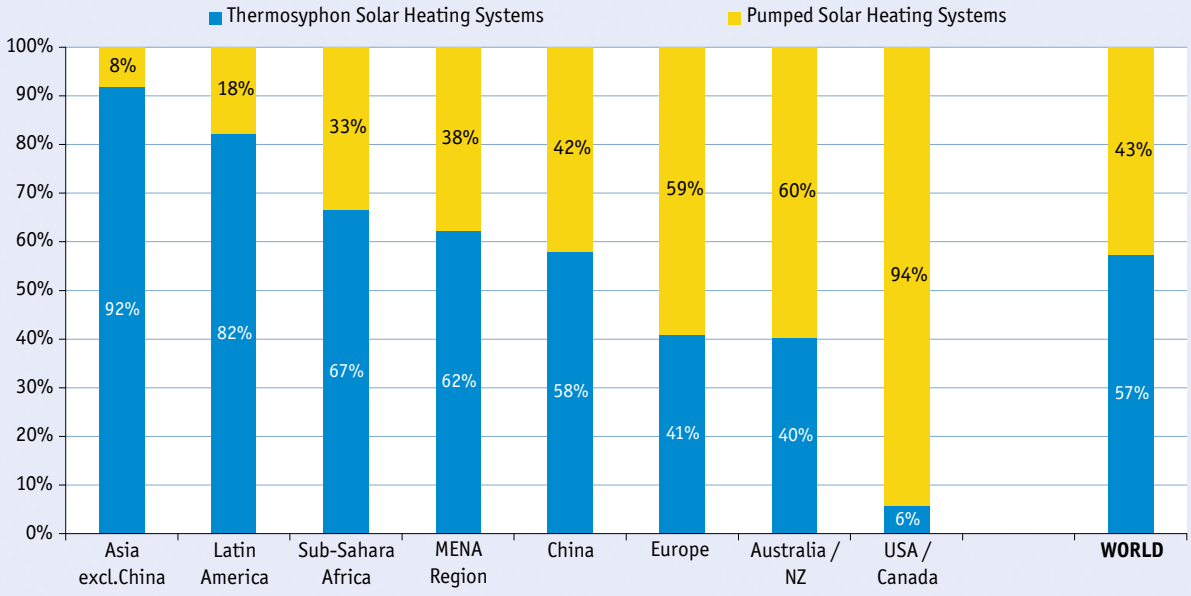
Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w / o China:	India, Japan, South Korea, Taiwan Thailand
Latin America:	Argentina, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Figure 48: *Distribution by type of solar thermal collector for newly installed water collector capacity in 2019*

7.2 Distribution by type of system

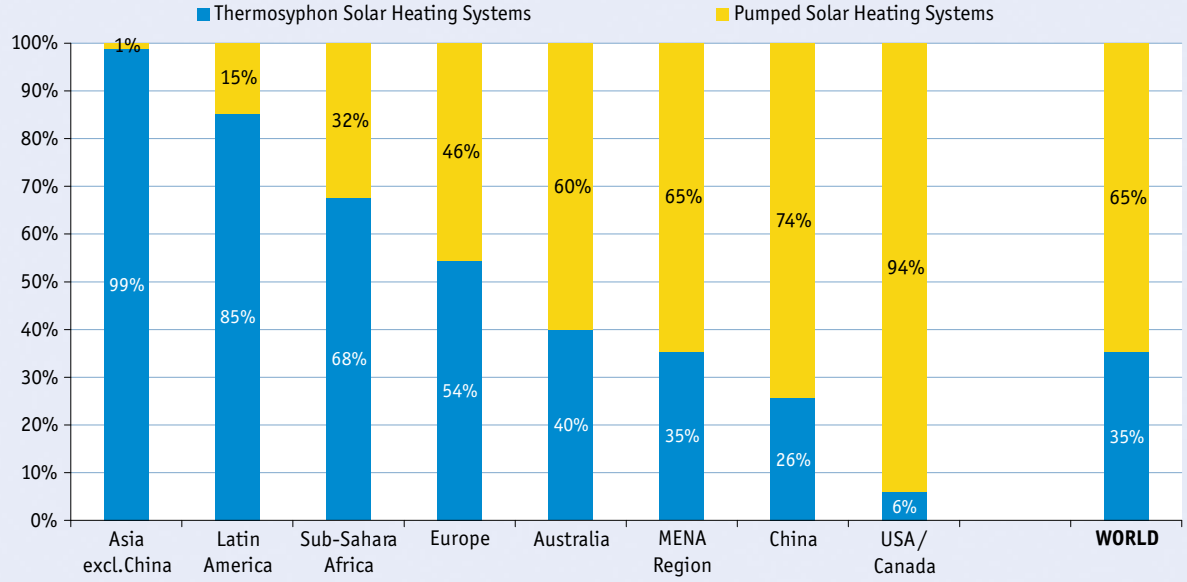
Worldwide, about 57% of all solar thermal systems installed are thermosiphon systems and the rest are pumped solar heating systems (**Figure 49**). Similar to the distribution by type of solar thermal collector in total numbers, the Chinese market influenced the overall figures the most. By the end of 2019, 26% of all newly installed systems in China were thermosiphon systems, while pumped systems accounted for 74%. The number of thermosiphon systems has been decreasing for several years in China (**Figure 50**).

In general, thermosiphon systems are more common in warm climates, such as in Africa, South America, southern Europe and the MENA countries. In these regions, thermosiphon systems are more often equipped with flat plate collectors, while in China, the typical thermosiphon system for domestic hot water preparation is equipped with evacuated tubes.



Sub-Sahara Africa: Botswana, Burkina Faso, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w/o China: India, Japan, South Korea, Taiwan Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe: EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Figure 49: *Distribution by type of system for the total installed glazed water collector capacity in operation by the end of 2019*



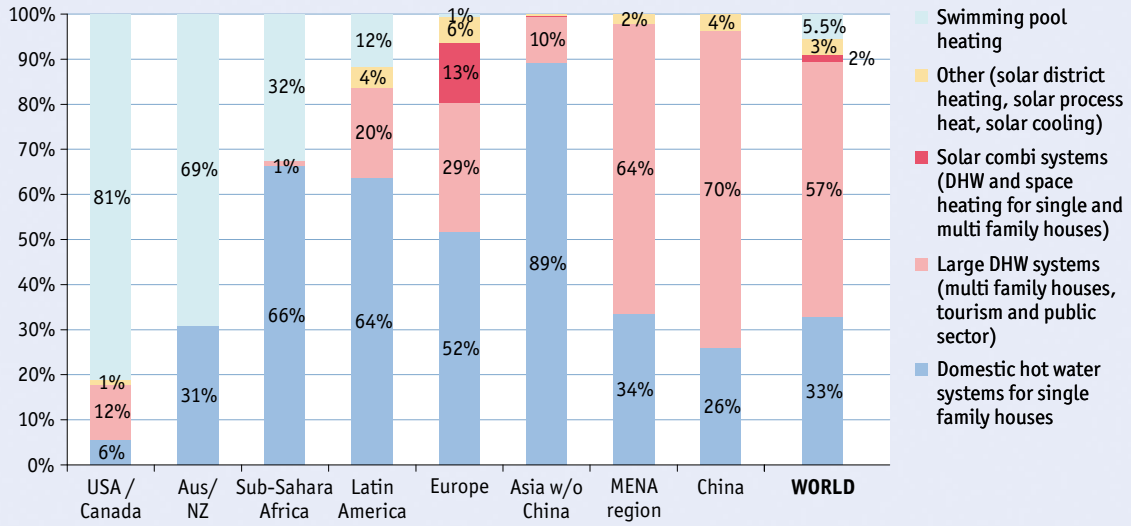
Sub-Sahara Africa: Botswana, Burkina Faso, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Senegal, South Africa, Zimbabwe
Asia w/o China: India, Japan, South Korea, Taiwan Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe: EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Figure 50: *Distribution by type of system for the newly installed glazed water collector capacity in 2019*

7.3 Distribution by type of application

The newly installed water-based solar thermal collector area amounted to 37.2 million m², which corresponds to 26.1 GW of thermal peak capacity (**Table 9**).

The largest share of the collector area installed in 2019 is large domestic hot water systems for multi-family houses, tourism and the public sector. Domestic hot water systems in single-family houses accounted for about 33 % of installations in 2019. The share of swimming pool heating was 5.5 %. The share for other applications, such as solar district heating and solar process heat, is about 3 % globally (**Figure 51**).



Sub-Sahara Africa:	Botswana, Burkina Faso, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w/o China:	India, Japan, South Korea, Taiwan Thailand
Latin America:	Barbados, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Figure 51: *Distribution of solar thermal systems by application for the newly installed water collector capacity by economic region in 2019*

8 Appendix

8.1 Methodological approach for the energy calculation

To obtain the energy yield of solar thermal systems, the oil equivalent saved and the CO_2 emissions avoided, the following procedure was used:

- Only water collectors were used in the calculations (unglazed water collectors, flat-plate collectors and evacuated tube collectors). Air collectors were not included.
- For each country, the cumulated water collector area was allocated to the following applications (based on available country market data):
  - Solar thermal systems for swimming pool heating
  - Solar domestic hot water systems for single-family houses,
  - Solar domestic hot water systems for multi-family houses, tourism sector and public sector (to simplify the analysis, solar district heating systems, solar process heat and solar cooling applications were also allocated here), and
  - Solar combi-systems for domestic hot water and space heating for single- and multi-family houses.
- Reference systems were defined for each country and each type of application (pumped or thermosiphon solar thermal system).
- The number of systems per country was determined from the share of collector area for each application and the collector area defined for the reference system.

Apart from the reference applications and systems mentioned above, reference collectors and reference climates were determined. Based on these boundary conditions, simulations were performed using T-Sol [T-Sol, Version 4.5 Expert, Valentin Energiesoftware, **www.valentin-software.com**] and gross solar yields for each country and each system were obtained. The gross solar yields refer to the solar collector heat output and do not include heat losses through transmission piping or storage heat losses[27].

The amount of final energy saved is calculated from the gross solar yields considering a utilization rate of the auxiliary heating system of 0.8. Final energy savings are expressed in tons of oil equivalent (toe): 1 toe = 11,630 kWh.

Finally, the CO_2 emissions avoided by the different solar thermal applications are quoted as kilograms carbon dioxide equivalent ($kgCO_2e$) per tons of oil equivalent: 1 toe = 3.165 t CO_2e[28]. The emission factor only accounts for direct emissions.

To obtain an exact statement about the CO_2 emissions avoided, the substituted energy medium would have to be ascertained for each country. Since this could only be done in a very detailed survey, which goes beyond the scope of this report, the energy savings and the CO_2 emissions avoided, therefore, relate to fuel oil. It is obvious that not all solar thermal systems just replace systems running on oil. This represents a simplification since gas, coal, biomass or electricity can be used as an energy source for the auxiliary heating system instead of oil.

27 Using gross solar yields for the energy calculations is based on a definition for Renewable Heat by EUROSTAT and IEA SHC. In editions of this report prior to 2011 solar yields calculated included heat losses through transmission piping and hence energy savings considered were about 5 to 15 % less depending on the system, the application and the climate.

28 Source: Carbon trust, Conversion factors Energy and carbon conversion, updated 2016

The following tables describe the key data of the reference systems in the different countries, the location of the reference climate used and the share of the total collector area in use for the respective application[29]. Furthermore, a hydraulic scheme is shown for each reference system.

8.1.1 Reference systems for swimming pool heating

Table 12 refers to the total capacity of water collectors in operation used for swimming pool heating as reported from each country by the end of 2019.

Country*	Reference climate	Horizontal irradiation [kWh/m²·a]	Total collector area (swimming pool) [m²]	Collector area per system [m²]	Total number of systems	Specific solar yield (swimming pool) [kWh/m²·a]
Argentina	Buenos Aires	1748	52,262	200	261	470
Australia	Sydney	1674	5,696,180	35	162748	466
Austria	Graz	1126	282,517	200	1413	283
Belgium	Brussels	971	45,110	200	226	261
Brazil	Brasília	1793	6,648,492	32	207765	375
Canada	Montreal	1351	764,283	25	30571	386
Chile	Santiago de Chile	1753	65,665	15	4378	471
Cyprus	Nicosia	1886	2,021	200	10	507
Czech Republic	Praha	998	502,515	200	2513	303
Finland	Helsinki	948	11,814	200	59	256
France	Paris	1112	92,460	200	462	328
Germany	Würzburg	1091	494,600	30	16487	314
Hungary	Budapest	1199	19,142	10	1914	344
Israel	Jerusalem	2198	38,779	200	194	568
Italy	Bologna	1419	43,533	200	218	442
Jordan	Amman	2145	6,661	200	33	578
Northern Macedonia	Skopje	1381	2,250	20	113	371
Mexico	Mexico City	1706	1,538,036	200	7690	311
Netherlands	Amsterdam	999	82,276	40	2057	272
New Zealand	Wellington	1401	7,024	200	35	378
Norway	Oslo	971	1,839	200	9	316
Portugal	Lisbon	1686	2,363	200	12	421
Romania	Bucharest	1324	439	200	2	356
Russia	Moscow	996	284	200	1	268
Slovakia	Bratislava	1214	1,063	200	5	327
Slovenia	Ljubjana	1115	1,485	200	7	300
South Africa	Johannesburg	2075	1,294,473	40	32362	505
Spain	Madrid	1644	158,024	200	790	472
Sweden	Gothenburg	934	170,749	200	854	295
Switzerland	Zürich	1094	159,404	200	797	277
Taiwan	Taipei	1372	3,558	175	20	319
United Kingdom	London	943	522,737	200	2614	254
United States	LA, Indianapolis	1646	22,548,219	200	112741	387
All other countries (5% of world market excluding China)		1457	2,172,490	200	10862	392
	TOTAL		43,432,747		600,224	
	AVG	1393		154		370

* Countries not listed in this table did not report any share of collectors used for swimming pool heating.

Table 12: *Solar thermal systems for swimming pool heating in 2019*

Figure 52 shows the hydraulic scheme of the swimming pool reference system used for the simulations of the solar energy yields.

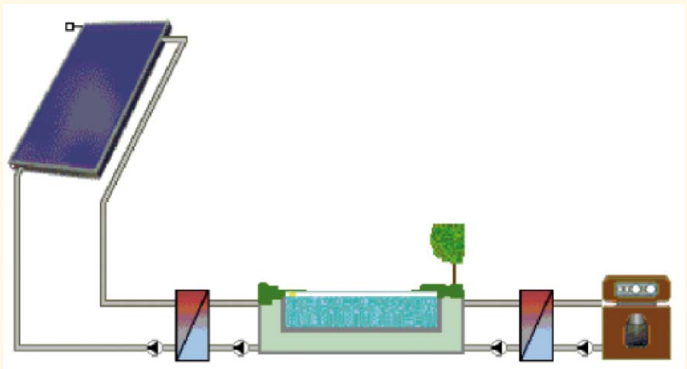


Figure 52: *Hydraulic scheme of the swimming pool reference system*

29 For some countries no specific estimations are available concerning shares by type of application. In these cases shares given in previous reports were used for the calculation.

8.1.2 Reference systems for domestic hot water preparation in single-family houses

The information in **Table 13** refers to the total capacity of water collectors in operation used for domestic hot water heating in single-family houses at the end of 2019 as reported by each country.

Country	Reference climate	Horizontal irradiation [kWh/m²·a]	Total coll. area (DHW-SFH) [m²]	Coll. area per system [m²]	Total number of systems	Specific solar yield (DHW-SFH) [kWh/m²·a]	Type of system
Albania	Tirana	1604.3	177,013	3	59,004.3	713	TS
Argentina	Buenos Aires	1748	103,676	4	25,919.0	777	PS
Australia	Sydney	1674	3,333,937	3.5	952,553.3	844	PS
Austria	Graz	1126	2,235,167	6	372,527.9	451	PS
Barbados	Grantley Adams	2016.3	227,579	4	56,894.6	882	TS
Belgium	Brussels	971.1	436,220	4	109,055.0	423	PDS / PS
Botswana	Gaborone	2161	9,677	4	2,419.2	961	TS
Brazil	Brasília	1792.5	9,127,199	2	4,563,599.4	809	TS
Bulgaria	Sofia	1187.5	102,954	4	25,738.4	524	PS
Burkina Faso	Ouagadougou	2212	591	4	147.7	983	TS
Canada	Montreal	1351.4	13,160	6	2,193.3	556	PS
Chile	Santiago de Chile	1752.7	225,315	2	112,657.7	771	PS
China	Shanghai	1281.9	252,903,609	4	63,225,902.3	592	TS
Croatia	Zagreb	1212	165,240	4	41,310.0	539	PS
Cyprus	Nicosia	1885.5	726,856	2	363,428.2	912	TS
Czech Republic	Praha	998.4	315,247	4.7	67,073.9	385	PS
Denmark	Copenhagen	989.4	292,942	4	73,235.5	454	PS
Estonia	Tallin	960.2	12,305	4	3,076.2	432	PS
Finland	Helsinki	948	38,165	4	9,541.2	441	PS
France	Paris	1112.4	2,212,175	3.2	691,304.8	496	PS
Germany	Würzburg	1091.3	8,744,697	5.6	1,561,553.1	424	PS
Ghana	Accra	2146	359	4	89.8	954	TS
Greece	Athens	1584.6	3,164,739	2.5	1,265,895.6	772	TS
Hungary	Budapest	1198.7	193,743	5	38,748.5	473	PS
India	Neu-Delhi	1960.5	14,636,921	2	7,318,460.3	882	TS
Ireland	Dublin	948.7	367,488	4	91,872.0	423	PS
Israel	Jerusalem	2198	901,623	3	300,540.9	1,024	TS
Italy	Bologna	1419	3,116,613	4	779,153.3	661	PS
Japan	Tokyo	1175.2	3,283,759	4	820,939.7	586	TS
Jordan	Amman	2145.4	1,003,076	4.6	218,060.0	986	TS
Korea, South	Seoul	1161.1	1,747,191	4	436,797.6	525	PS
Latvia	Riga	991.2	25,053	4	6,263.2	462	PS
Lebanon	Beirut	1934.5	436,988	4	109,246.9	860	TS
Lesotho	Maseru	2050	1,140	2	569.8	911	TS
Lithuania	Vilnius	1001.2	13,426	4	3,356.5	450	PS
Luxembourg	Luxembourg	1037.4	44,089	4	11,022.1	450	PS
Northern Macedonia	Skopje	1380.8	100,135	4	25,033.7	627	PS
Malta	Luqa	1901.9	73,509	2.5	29,403.6	868	PS
Mauritius	Port Louis	1920	132,793	1.5	88,528.7	854	TS
Mexico	Mexico City	1706.3	2,236,067	4	559,016.8	718	PS
Morocco	Rabat	2000	429,688	4	107,421.9	889	TS
Mozambique	Maputo	1910	2,252	4	562.9	849	TS
Namibia	Windhoek	2363	22,750	4	5,687.6	1,032	TS
Netherlands	Amsterdam	999	423,410	2.8	151,217.7	433	PDS / PS
New Zealand	Wellington	1401.2	131,287	4	32,821.7	647	PS
Nigeria	Abuja	2007	6,249	4	1,562.3	892	TS
Norway	Oslo	971.1	1,528	6	254.7	430	PS
Palestine	Jerusalem	2198	956,761	1.5	637,841.0	977	TS
Poland	Warsaw	1024.2	1,991,843	6	331,973.8	397	PS
Portugal	Lisbon	1686.4	823,632	4	205,907.9	804	PS
Romania	Bucharest	1324.3	142,266	4	35,566.6	594	PS
Russia	Moscow	996	4,003	4	1,000.8	443	PS
Senegal	Dakar	2197.3	7,104	4	1,776.1	977	TS
Slovakia	Bratislava	1213.8	114,468	6	19,078.1	481	PS
Slovenia	Ljubjana	1114.6	135,135	6	22,522.5	424	PS
South Africa	Johannesburg	2075.1	1,014,082	1.9	533,727.6	1,009	TS
Spain	Madrid	1643.5	1,834,505	4	458,626.2	766	PS
Sweden	Gothenburg	933.9	40,050	4	10,012.5	383	PS
Switzerland	Zürich	1093.8	1,041,392	5.7	182,700.4	426	PS
Taiwan	Taipei	1372.2	1,681,783	4.8	350,371.5	616	TS
Thailand	Bangkok	1764.8	143,985	4	35,996.3	854	TS
Tunisia	Tunis	1808.2	1,062,716	3.3	322,035.1	902	TS
Turkey	Antalya	1795.2	23,756,825	4	5,939,206.3	910	TS
United Kingdom	London	942.6	937,423	4	234,355.7	415	PS
United States	LA, Indianapolis	1646.05	966,352	6	161,058.7	646	PS
Uruguay	Montevideo	1534.2	71,209	4	17,802.3	682	TS
Zimbabwe	Harare	2017.1	58,814	2	29,407.2	854	TS
All other countries (5% of world market excl. China)		1433	4,217,947	4	1,054,486.8	637	
	TOTAL		354,901,892		95,307,115.6		
	AVG	1522		4		680	

PS: pumped system
PDS: pumped drain back system
TS: thermosiphon system

Table 13: Solar thermal systems for domestic hot water heating in single-family houses by the end of 2019

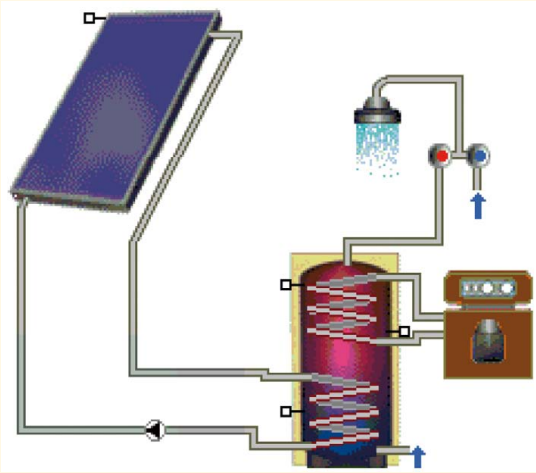


Figure 53:
Hydraulic scheme of the domestic hot water pumped reference system for single-family houses

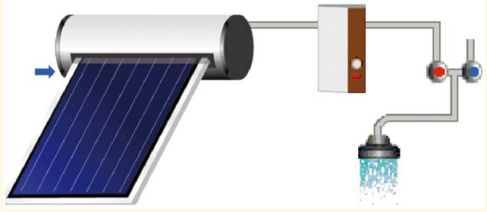


Figure 54:
Hydraulic scheme of the domestic hot water thermosiphon reference system for single-family houses

Figure 53 shows the hydraulic scheme used for the energy calculation for all pumped solar thermal systems and **Figure 54** refers to the thermosiphon systems.

For the Chinese thermosiphon systems, the reference system above was used, but instead of a flat plate collector, as shown in Figure 54 a representative Chinese vacuum tube collector was used for the simulation.

8.1.3 Reference systems for domestic hot water preparation in multifamily houses

The information in **Table 14** refers to the total capacity of water collectors in operation used for domestic hot water heating in multifamily houses at the end of 2019 as reported by each country.

Figure 55 shows the hydraulic scheme of the domestic hot water reference system for multifamily houses used for the simulations of the solar energy yields. As opposed to small-scale domestic hot water systems, all large-scale systems are assumed to be pumped solar thermal systems.

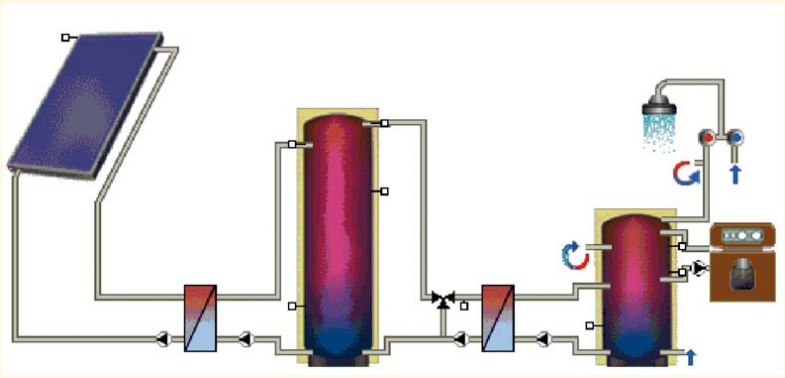


Figure 55: *Hydraulic scheme of the domestic hot water pumped reference system for multifamily houses*

Country	Reference climate	Horizontal irradiation [kWh/m²·a]	Total collector area (DHW-MFH) [m²]	Collector area per system [m²]	Total number of systems	Specific solar yield (DHW-MFH) [kWh/m²·a]
Albania	Tirana	1604.3	105,304	50	2,106	694
Argentina	Buenos Aires	1748	14,062	50	281	730
Australia	Sydney	1674	307,883	50	6,158	725
Austria	Graz	1126	416,847	50	8,337	505
Barbados	Grantley Adams	2016.3	19,789	50	396	842
Belgium	Brussels	971.1	99,188	50	1,984	406
Botswana	Gaborone	2161	6,451	30	215	903
Brazil	Brasília	1792.5	1,583,863	60	26,398	658
Bulgaria	Sofia	1187.5	23,410	50	468	515
Burkina Faso	Ouagadougou	2212	3,680	30	123	924
Canada	Montreal	1351.4	111,259	50	2,225	621
Chile	Santiago de Chile	1752.7	88,586	50	1,772	732
China	Shanghai	1281.9	242,015,391	50	4,840,308	502
Croatia	Zagreb	1212	37,573	50	751	506
Cyprus	Nicosia	1885.5	96,189	50	1,924	750
Czech Republic	Praha	998.4	47,657	42.4	1,124	436
Denmark	Copenhagen	989.4	1,507,625	50	30,153	413
Estonia	Tallin	960.2	2,798	50	56	401
Finland	Helsinki	948	8,639	50	173	396
France	Paris	1112.4	997,515	20	49,876	489
Germany	Würzburg	1091.3	2,363,259	50	47,265	472
Ghana	Accra	2146	3,722	30	124	896
Greece	Athens	1584.6	719,604	50	14,392	642
Hungary	Budapest	1198.7	70,604	50	1,412	522
India	Neu-Delhi	1960.5	266,696	50	5,334	749
Ireland	Dublin	948.7	12,250	50	245	425
Israel	Jerusalem	2198	3,907,032	3	1,302,344	918
Italy	Bologna	1419	708,661	50	14,173	593
Japan	Tokyo	1175.2	7,599	50	152	516
Jordan	Amman	2145.4	250,769	50	5,015	801
Korea, South	Seoul	1161.1	143,431	50	2,869	485
Latvia	Riga	991.2	5,697	50	114	414
Lebanon	Beirut	1934.5	252,883	40	6,322	808
Lesotho	Maseru	2050	1,309	10	131	856
Lithuania	Vilnius	1001.2	3,053	50	61	418
Luxembourg	Luxembourg	1037.4	10,025	50	200	433
Northern Macedonia	Skopje	1380.8	9,001	50	180	577
Mexico	Mexico City	1706.3	958,314	50	19,166	713
Morocco	Rabat	2000	386,719	50	7,734	835
Mozambique	Maputo	1910	1,657	50	33	798
Namibia	Windhoek	2363	27,806	50	556	814
Netherlands	Amsterdam	999	146,387	40	3,660	418
New Zealand	Wellington	1401.2	16,411	50	328	585
Nigeria	Abuja	2007	2,491	1.4	1,779	838
Norway	Oslo	971.1	16,713	50	334	406
Palestine	Jerusalem	2198	861,085	50	17,222	918
Poland	Warsaw	1024.2	711,373	50	14,227	447
Portugal	Lisbon	1686.4	355,524	40	8,888	705
Romania	Bucharest	1324.3	32,349	50	647	553
Russia	Moscow	996	19,437	50	389	416
Senegal	Dakar	2197	220	4.5	49	918
Slovakia	Bratislava	1213.8	26,028	50	521	507
Slovenia	Ljubjana	1114.6	2,970	50	59	477
South Africa	Johannesburg	2075.1	35,905	87	413	867
Spain	Madrid	1643.5	2,155,543	50	43,111	676
Sweden	Gothenburg	933.9	54,224	50	1,084	430
Switzerland	Zürich	1093.8	124,345	20	6,217	457
Taiwan	Taipei	1372.2	94,597	30	3,153	518
Thailand	Bangkok	1764.8	11,820	80	148	737
Tunisia	Tunis	1808.2	35,208	50	704	755
Turkey	Antalya	1795.2	2,065,811	80	25,823	750
United States	LA, Indianapolis	1646.05	2,254,822	50	45,096	688
Zimbabwe	Harare	2017.1	14,704	32	459	842
All other countries (5% of world market excl. China)		1239	3,134,424	50	62,688	518
	TOTAL		269,776,190		6,639,651	
	AVG	1519		46		625

Table 14: *Solar thermal systems for domestic hot water heating in multifamily houses by the end of 2019*

8.1.4 Reference systems for domestic hot water preparation and space heating in single and multi-family houses (solar combi-systems)

The information in Table 15 refers to the total capacity of water collectors in operation used for domestic hot w1.1 GW_{th} water heating in multi-family houses at the end of 2019 as reported by each country.

Country	Reference climate	Horizontal irradiation [kWh/m²·a]	Total collector area (DHW-SFH) [m²]	Collector area per system [m²]	Total number of systems	Spec. solar yield (DHW-SFH) [kWh/m²·a]
Austria	Graz	1126	2,108,459	14	150,604.20	369
Belgium	Brussels	971.1	135,772	12	11,314.36	342
Bulgaria	Sofia	1187.5	32,044	12	2,670.34	418
Canada	Montreal	1351.4	89	12	7.41	476
Croatia	Zagreb	1212	51,430	12	4,285.87	426
Cyprus	Nicosia	1885.5	13,383	12	1,115.24	663
Czech Republic	Praha	998.4	251,634	8.5	29,603.95	351
Denmark	Copenhagen	989.4	65,306	8	8,163.19	348
Estonia	Tallin	960.2	3,830	12	319.15	338
Finland	Helsinki	948	12,094	12	1,007.86	334
Germany	Würzburg	1091.3	8,290,776	11.5	720,937.05	378
Greece	Athens	1584.6	985,016	12	82,084.69	558
Hungary	Budapest	1198.7	71,163	10	7,116.32	422
Ireland	Dublin	948.7	28,582	12	2,381.87	364
Italy	Bologna	1419	970,037	12	80,836.45	499
Japan	Tokyo	1175.2	148,543	12	12,378.57	414
Korea, South	Seoul	1161.1	20,894	12	1,741.20	409
Latvia	Riga	991.2	7,798	12	649.80	349
Lebanon	Beirut	1934.5	4,168	12	347.37	681
Lesotho	Maseru	2050	8	12	0.68	721
Lithuania	Vilnius	1001.2	4,179	12	348.24	352
Luxembourg	Luxembourg	1037.4	13,722	12	1,143.54	365
Northern Macedonia	Skopje	1380.8	1,125	10	112.51	486
Morocco	Rabat	2000	8,594	12	716.15	704
Netherlands	Amsterdam	999	44,569	6	7,428.24	352
New Zealand	Wellington	1401.2	4,923	12	410.27	493
Norway	Oslo	971.1	23,914	15	1,594.29	342
Palestine	Jerusalem	2198	19,135	12	1,594.60	773
Poland	Warsaw	1024.2	142,275	12	11,856.21	365
Romania	Bucharest	1324.3	44,280	12	3,690.00	466
Russia	Moscow	996	2,606	15	173.75	350
Slovakia	Bratislava	1213.8	35,628	12	2,969.00	427
Slovenia	Ljubjana	1114.6	8,910	12	742.50	362
Spain	Madrid	1643.5	366,901	10	36,690.10	619
Sweden	Gothenburg	933.9	287,417	10	28,741.73	389
Switzerland	Zürich	1093.8	388,579	11	35,325.38	385
Thailand	Bangkok	1764.8	1,722	12	143.49	621
All other countries (5% of world market excl. China)		1149	172,472	12	14,372.68	404
	TOTAL		14,771,980		1,265,618.21	
	AVG	1278		12		450

Table 15: Solar combi-system reference for single and multifamily houses and the total collector area in operation in 2019 (Combi-system: System for the supply of domestic hot water and space heating)

Figure 56 shows the hydraulic scheme of domestic hot water reference system for multifamily houses used for the simulations of the solar energy yields.

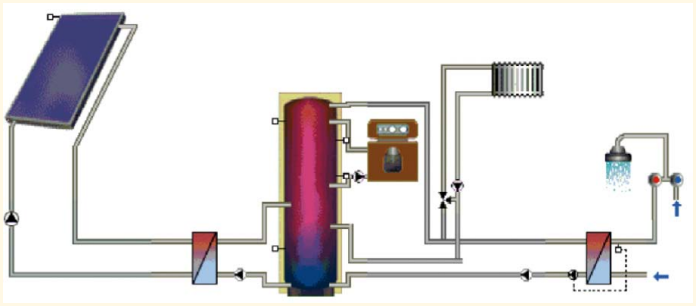


Figure 56: Hydraulic scheme of the solar-combi reference system for single and multi-family houses

8.2 Reference collectors

8.2.1 Data of the reference unglazed water collector for swimming pool heating

$\eta = 0.85$

$a_1 = 20$ [W/m²K]

$a_2 = 0.1$ [W/m² K²]

8.2.2 Data of the reference collector for all other applications except for China

$\eta = 0.8$

$a_1 = 3.69$ [W/m²K]

$a_2 = 0.007$ [W/m² K²]

8.2.3 Data of the Chinese reference vacuum tube collector

$\eta = 0.74$

$a_1 = 2.5$ [W/m²K]

$a_2 = 0.013$ [W/m² K²]

8.3 Methodological approach for the job calculation

The job calculation is based on a comprehensive literature study, information provided by the China National Renewable Energy Centre and IRENA, and data collected from different country market reports. Based on this information, the following assumptions were taken to calculate the number of full-time jobs:

In countries with high labor costs, advanced automated production of flat plate or evacuated tube collectors and heat storages – pumped systems with a total of 133 m² solar collector area have to be installed on average per full-time job. In countries with low labor cost and advanced automated production of evacuated tube collectors and heat storages – thermosiphon systems with a total of 87 m² solar collector area have to be installed per full-time job on average. The same collector area has to be installed per full-time job in countries with mainly manual flat plate collector production and low labor cost. For swimming pool systems with unglazed polymeric collectors or air collectors around 200 m² solar collector area have to be installed per full-time job.

The numbers presented are full-time jobs and consider production, installation and maintenance of solar thermal systems.

8.4 Reference climates

No.	Country	Reference climate	Horizontal irradiation [kWh/m²·a]	Inclined irradiation [kWh/m²·a]	Avg. outside air temp. [°C]
1	Albania	Tirana	1,604	1,835	13.5
2	Argentina	Buenos Aires	1,748	1,971	17.5
3	Australia	Sydney	1,674	1,841	18.1
4	Austria	Graz	1,126	1,280	9.2
5	Barbados	Grantley Adams	2,016	2,048	27.4
6	Belgium	Brussels	971	1,095	10.0
7	Botswana	Gaborone	2,161	2,365	18.0
8	Brazil	Brasília	1,793	1,838	22.0
9	Bulgaria	Sofia	1,188	1,304	10.1
10	Burkina Faso	Ouagadougou	2,212	2,270	25.0
11	Canada	Montreal	1,351	1,568	6.9
12	Cape Verde	Praia	2,096	2,168	23.6
13	Chile	Santiago de Chile	1,753	1,850	14.5
14	China	Shanghai	1,282	1,343	17.1
15	Croatia	Zagreb	1,212	1,352	11.3
16	Cyprus	Nicosia	1,886	2,098	19.9
17	Czech Republic	Praha	998	1,111	7.9
18	Denmark	Copenhagen	989	1,164	8.1
19	Estonia	Tallin	960	1,126	5.3
20	Finland	Helsinki	948	1,134	4.6
21	France	Paris	1,112	1,246	11.0
22	Germany	Würzburg	1,091	1,225	9.5
23	Ghana	Accra	2,146	2,161	23.7
24	Greece	Athens	1,585	1,744	18.5
25	Hungary	Budapest	1,199	1,346	11.0
26	India	Neu-Delhi	1,961	2,275	24.7
27	Ireland	Dublin	949	1,091	9.5
28	Israel	Jerusalem	2,198	2,400	17.3
29	Italy	Bologna	1,419	1,592	14.3
30	Japan	Tokyo	1,175	1,287	16.7
31	Jordan	Amman	2,145	2,341	17.9
32	Korea, South	Seoul	1,161	1,280	12.7
33	Latvia	Riga	991	1,187	6.3
34	Lebanon	Beirut	1,935	2,132	19.9
35	Lesotho	Maseru	2,050	2,290	15.2
36	Lithuania	Vilnius	1,001	1,161	6.2
37	Luxembourg	Luxembourg	1,037	1,158	8.4
38	Northern Macedonia	Skopje	1,381	1,521	12.5
39	Malta	Luqa	1,902	2,115	18.7
40	Mauritius	Port Louis	1,920	2,010	23.3
41	Mexico	Mexico City	1,706	1,759	16.6
42	Morocco	Rabat	2,000	2,250	17.2
43	Mozambique	Maputo	1,910	2,100	22.8
44	Namibia	Windhoek	2,363	2,499	21.0
45	Netherlands	Amsterdam	999	1,131	10.0
46	New Zealand	Wellington	1,401	1,542	13.6
47	Nigeria	Abuja	2,007	2,051	25.7
48	Norway	Oslo	971	1,208	5.8
49	Palestine	Jerusalem	2,198	2,400	17.3
50	Poland	Warsaw	1,024	1,156	8.1
51	Portugal	Lisbon	1,686	1,875	17.4
52	Romania	Bucharest	1,324	1,473	10.6
53	Russia	Moscow	996	1,181	5.9
54	Senegal	Dakar	2,197	2,259	24.9
55	Slovakia	Bratislava	1,214	1,374	10.3
56	Slovenia	Ljubjana	1,115	1,231	9.8
57	South Africa	Johannesburg	2,075	2,232	15.6
58	Spain	Madrid	1,644	1,844	15.5
59	Sweden	Gothenburg	934	1,105	7.2
60	Switzerland	Zürich	1,094	1,218	9.6
61	Taiwan	Taipei	1,372	1,398	20.8
62	Thailand	Bangkok	1,765	1,898	29.1
63	Tunisia	Tunis	1,808	2,038	19.3
64	Turkey	Antalya	1,795	1,958	18.4
65	United Kingdom	London	943	1,062	12.0
66	United States	LA, Indianapolis	1,646	1,816	14.3
67	Uruguay	Montevideo	1,534	1,647	15.9
68	Zimbabwe	Harare	2,017	2,087	18.9

Table 16: *Reference climates for the 68 countries surveyed*

Source: T-Sol expert version 4.5 and Meteonorm version 6.1 and Global Solar Atlas (The Worldbank Group 2016).

8.5 Population data

No	Country	2018	Reg. code
1	Albania	3,072,944	6
2	Argentina	45,089,449	4
3	Australia	25,113,987	3
4	Austria	8,825,644	6
5	Barbados	300,082	4
6	Belgium	11,635,321	6
7	Botswana	2,282,973	1
8	Brazil	210,604,687	4
9	Bulgaria	7,011,475	6
10	Burkina Faso	20,286,336	1
11	Canada	37,350,365	8
12	Cape Verde	574,799	1
13	Chile	18,053,934	4
14	China	1,389,618,778	5
15	Croatia	4,250,505	6
16	Cyprus	1,252,725	6
17	Czech Republic	10,691,502	6
18	Denmark	5,841,245	6
19	Estonia	1,236,253	6
20	Finland	5,556,081	6
21	France	67,625,957	6
21	France (Overseas)	3,033,473	6
22	Germany	80,230,554	6
23	Ghana	30,918,261	1
24	Greece	10,638,236	6
25	Hungary	9,783,707	6
26	India	1,311,158,140	2
27	Ireland	5,120,458	6
28	Israel	8,533,033	7
29	Italy	62,270,612	6
30	Japan	125,555,208	2
31	Jordan	10,669,125	7
32	Korea, South	51,439,350	2
33	Latvia	1,903,750	6
34	Lebanon	5,841,037	7
35	Lesotho	2,146,942	1
36	Lithuania	2,768,295	6

No	Country	2018	Reg. code
37	Luxembourg	617,419	6
38	Malta	453,321	6
39	Mauritius	1,371,242	1
40	Mexico	127,455,990	4
41	Morocco	35,217,358	7
42	Mozambique	29,320,964	1
43	Namibia	2,581,343	1
44	Netherlands	17,210,116	6
45	New Zealand	4,854,803	3
46	Nigeria	208,640,307	1
47	Northern Macedonia	2,122,376	6
48	Norway	5,419,620	6
49	Palestine	4,724,723	7
50	Poland	38,345,891	6
51	Portugal	10,314,630	6
52	Romania	21,388,159	6
53	Russia	142,818,379	6
54	Senegal	15,364,850	1
55	Slovakia	5,442,524	6
56	Slovenia	2,102,381	6
57	South Africa	55,891,953	1
58	Spain	47,274,670	6
59	Sweden	10,108,781	6
60	Switzerland	8,343,256	6
61	Taiwan	23,553,634	2
62	Thailand	69,082,954	2
63	Tunisia	11,620,878	7
64	Turkey	81,628,106	6
65	United Kingdom	65,405,533	6
66	United States	328,239,523	8
67	Uruguay	3,380,460	4
68	Zimbabwe	14,277,179	1
	All other countries	2,619,197,750	9
Σ Solar Thermal World Statistics		**4,992,858,546**	66%

Table 17: *Inhabitants by the end of 2019 of the 68 surveyed countries in alphabetical order*

Data source: International Data Base of the U.S. Census Bureau

http://www.census.gov/population/international/data/idb/informationGateway.php

Region Code / Region		Σ Inhabitants	Share
1	Sub-Sahara Africa	383,657,149	5%
2	Asia excl. China	1,580,789,286	21%
3	Australia	29,968,790	0%
4	Latin America	404,884,602	5%
5	China	1,389,618,778	18%
6	Europe	761,743,899	10%
7	MENA Region	76,606,154	1%
8	United States / Canada	365,589,888	5%
9	Other countries	2,619,197,750	34%
TOTAL		7,612,056,296	100%

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde Ghana, Namibia, Nigeria, Mozambique, Senegal, South Africa, Zimbabwe
Asia excluding China: India, Japan, Korea South, Taiwan, Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe: Albania, EU 28, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA Region: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia**Table 18:**

Table 18: *Inhabitants per economic region by the end of 2019*

Data source: International Data Base of the U.S. Census Bureau

http://www.census.gov/ipc/www/idb/country.php

8.6 Definition of SHIP systems

In November 2019, the IEA Solar Heating and Cooling Programme defined systems, providing solar heat for industrial processes (SHIP systems), as shown below.
This definition only refers to the collection and documentation of SHIP systems as part of the Solar Heat Worldwide report.

Applications considered as SHIP Systems

Industrial Process Applications

All solar thermal systems direct or indirect (via heat storage) connected to an industrial process. Systems that, in addition to the industrial process, also supply the space heating for the production halls, offices or showers, are also taken into account.

Agricultural Applications

Solar thermal systems used for drying for wood chips, crops, fruits, etc and heat for animal breeding.

Greenhouses

Solar thermal systems supplying heat for commercial food and flower production, nurseries and vegetable farming.

Service Sector

Solar thermal systems supplying commercial laundries, car/truck washing, and sewage sludge drying facilities with heat.

Solar cooling of industrial processes

This refers to all cooling processes in industrial plants.

Not considered in this definition:

- Solar air conditioning of office buildings or industry halls
- Tourism sector like hotels (including laundries of hotels)
- Health sector: hospitals, clinics
- Boarding schools
- Military barracks
- Showers or canteens for workers

Minimum size of systems

For the worldwide survey, only installations larger than 50 m² are considered. The minimum size of the plants surveyed was determined since small plants in many countries are not recorded separately. This does not mean that there are not SHIP systems with smaller collector areas. In some countries (e.g., Germany), the number of SHIP plants with collector areas below 50 m² is significantly higher than the realized plants above that limit.

8.7 Methodological adjustments and market data of the previous years

Change in the method for estimating global installed capacity

Global solar thermal capacity is based on the latest market data from the 20 largest solar thermal markets in terms of added capacity. These were the following countries for the year 2020 listed in order of their added capacity: China, Turkey, India, Brazil, United States, Germany, Australia, Mexico, Israel, Greece, Spain, Poland, South Africa, Italy, Netherlands, Cyprus, Austria, Morocco, Tunisia and Portugal, which represent 95 % of the cumulative installed capacity in operation in 2019. The added capacities in the other countries, for which new additions are available until 2019, were projected according to the trend over the past two years. The rest of the world, that means countries without detailed solar thermal market information in 2019 and previous years, were estimated to be 5 % of the global market volume without China in 2020.

Until 2019, the "rest of the world" was considered 5 % of the global market, including China, which overestimated its market share. This methodological change should be noted when comparing data from this year's edition of Solar Heat Worldwide with earlier editions.

Conversion from square meters to capacity

The data presented in **Chapters 5** to **8** were initially collected in square meters. Through an agreement of international experts, the collector areas of these solar thermal applications have been converted and shown in installed capacity.

Making the installed capacity of solar thermal collectors comparable with that of other energy sources, solar thermal experts from seven countries agreed upon a methodology to convert installed collector area into solar thermal capacity.

The methodology was developed during a meeting with IEA SHC Programme officials and major solar thermal trade associations in Gleisdorf, Austria in September 2004. The represented associations from Austria, Canada, Germany, the Netherlands, Sweden and the United States as well as the European Solar Thermal Industry Federation (ESTIF) and the IEA SHC Programme agreed to use a factor of 0.7 kW_{th}/m^2 to derive the nominal capacity from the area of installed collectors.

Data from the previous years

The following tables provide data from the previous years to ensure consistency of the calculations within this report. If necessary, the numbers have been revised compared to the data published in earlier editions of this report due to changes in methodology or the origin of the data for each country.

In **Table 19**, **Table 20** and **Table 21** these [PM20]countries are marked accordingly and in **Chapter 8.8** (References) the respective data source is cited.

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		22,471.0	2,486.0			24,957.0
Argentina	9,318.0	10,393.0	24,748.0			44,459.0
Australia	425,000.0	155,185.0	17,243.0	5,000.0	1,000.0	603,428.0
Austria	630.0	99,770.0	1,060.0		320.0	101,780.0
Barbados*		11,430.0				11,430.0
Belgium		30,200.0	5,200.0			35,400.0
Botswana		1,000.0	1,800.0			2,800.0
Brazil	632,451.0	602,803.0	28,260.0			1,263,514.0
Bulgaria		4,600.0	450.0			5,050.0
Burkina Faso**		1,050.0	180.0			1,230.0
Canada	16,478.0	651.0	1,129.0	6,688.0	8.0	24,954.0
Cape Verde		180.0				180.0
Chile	0.0	29,300.0	11,878.0	0.0	0.0	41,178.0
China+		5,770,000.0	29,865,095.0	1,000.0		35,636,095.0
Croatia		19,300.0	1,400.0			20,700.0
Cyprus		53,718.0	0.0			53,718.0
Czech Republic	0.0	16,500.0	7,500.0			24,000.0
Denmark		31,500.0		0.0		31,500.0
Estonia		900.0	600.0			1,500.0
Finland		2,900.0	700.0			3,600.0
France (mainland)++	5,500.0	45,740.0	2,260.0	800.0		54,300.0
Germany	20,000.0	559,000.0	66,000.0			645,000.0
Ghana*		80.9	26.0			106.9
Greece		316,000.0	500.0			316,500.0
Hungary	500.0	12,000.0	3,000.0	300.0	100.0	15,900.0
India		397,286.0	1,120,963.0		500.0	1,518,749.0
Ireland		11,250.0	9,050.0			20,300.0
Israel	1,000.0	426,000.0				427,000.0
Italy		171,600.0	23,400.0			195,000.0
Japan		70,501.0	969.0		4,269.0	75,739.0
Korea, South		3,266.0	15,801.0			19,067.0
Latvia		1,350.0	250.0			1,600.0
Lebanon		26,842.0	22,957.0			49,799.0
Lesotho		34.0	122.5			156.5
Lithuania		750.0	1,250.0			2,000.0
Luxembourg		3,600.0	0.0			3,600.0
Northern Macedonia		6,886.0	8,225.0			15,111.0
Malta		518.2	129.5			647.7
Mexico	114,900.0	149,200.0	127,100.0			391,200.0
Mozambique		300.0	600.0			900.0
Namibia		4,524.8	12.2			4,536.9
Netherlands	2,620.0	22,220.0	6,160.0			31,000.0
Nigeria	0.0	400.0	67.6	0.0		467.6
Norway		2,241.0	78.0			2,319.0
Palestinian Territories		44,052.0	0.0			44,052.0
Poland		107,200.0	3,900.0			111,100.0
Portugal		45,250.0	850.0			46,100.0
Romania	0.0	7,200.0	9,600.0			16,800.0
Russia		392.5	66.0			458.5
Senegal**		4.4	85.6	0.0	58.3	148.3
Slovakia	0.0	8,000.0	1,600.0			9,600.0
Slovenia		1,300.0	250.0			1,550.0
South Africa	59,825.0	31,953.0	39,405.0			131,183.0
Spain	3,652.0	190,666.0	7,187.0			201,505.0
Sweden	0.0	2,867.0	341.0			3,208.0
Switzerland	4,931.0	57,774.0	6,626.0			69,331.0
Taiwan		88,623.4	5,544.3			94,167.7
Tunisia		63,246.0				63,246.0
Turkey		975,000.0	950,000.0	1,000.0		1,926,000.0
United Kingdom		9,938.0	0.0	500.0		10,438.0
United States	766,210.0	165,800.0	8,596.0	6,000.0	4,000.0	950,606.0
Uruguay		10,551.0				10,551.0
Zimbabwe		0.0	4,665.0			4,665.0
All other countries (5% of world market excluding China)	108,579.7	273,429.4	134,330.0	1,067.8	539.8	517,946.7
TOTAL	2,171,594.7	11,238,587.5	32,551,695.8	22,355.8	10,795.1	45,995,028.9

* 0% growth assumed
** 7% growth assumed
\+ exports excluded
++ The figures for France refer to mainland France only, overseas departments and regions are not considered

Table 19: *Newly installed collector area in 2017 [m²]*

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		23,068.0	2,764.0			25,832.0
Argentina	9,318.0	10,393.0	24,748.0			44,459.0
Australia	400,000.0	165,000.0	18,200.0	5,000.0	1,000.0	589,200.0
Austria	510.0	97,100.0	1,130.0		650.0	99,390.0
Barbados		12,300.0				12,300.0
Belgium		25,000.0	4,900.0			29,900.0
Botswana		807.8	421.2			1,229.0
Brazil	627,321.0	594,482.0	28,397.0			1,250,200.0
Bulgaria		4,600.0	450.0			5,050.0
Burkina Faso		100.0	310.0			410.0
Canada	980.0	230.0	340.0	13,630.0	1,120.0	16,300.0
Cape Verde		380.0				380.0
Chile		21,228.0	427.0			21,655.0
China*		5,980,000.0	27,388,821.0	3,000.0	1,000.0	33,372,821.0
Croatia		18,850.0	592.0			19,442.0
Cyprus		56,552.0	0.0			56,552.0
Czech Republic	30,000.0	16,500.0	7,500.0			54,000.0
Denmark		71,879.0		0.0		71,879.0
Estonia		900.0	600.0			1,500.0
Finland		2,700.0	900.0			3,600.0
France (mainland)	1,200.0	49,500.0	1,840.0	1,005.0		53,545.0
France (overseas)+		97,139.0				97,139.0
Germany		505,000.0	68,500.0			
Ghana		750.0	250.0			1,000.0
Greece		328,500.0	500.0			329,000.0
Hungary	500.0	11,000.0	2,000.0	668.0	100.0	14,268.0
India		213,053.0	1,575,323.0		250.0	1,788,626.0
Ireland		7,540.7	4,698.3			12,239.0
Israel	1,000.0	415,000.0				416,000.0
Italy		157,900.0	21,500.0			179,400.0
Korea, South		3,552.0	16,918.0			20,470.0
Latvia		1,350.0	250.0			1,600.0
Lebanon		15,360.0	29,303.0			44,663.0
Lesotho		65.0	140.0			205.0
Lithuania		750.0	1,250.0			2,000.0
Luxembourg		3,418.0	0.0			3,418.0
Mozambique		280.0	570.0			850.0
Namibia		3,937.0	21.3			3,958.3
Nigeria		392.6	3,515.2		800.0	4,707.8
Norway		1,350.0	73.0			1,423.0
Palestinian Territories		44,820.0	0.0			44,820.0
Poland		300,000.0	10,000.0			310,000.0
Romania	0.0	7,200.0	9,600.0			16,800.0
Russia		624.8	370.4			995.2
Senegal		1,650.0	1,350.0	0.0	0.0	3,000.0
Slovakia	0.0	8,000.0	1,600.0			9,600.0
Slovenia		1,450.0	200.0			1,650.0
South Africa	65,231.0	41,056.0	27,590.0			133,877.0
Spain	3,866.0	191,966.0	9,698.0			205,530.0
Sweden	0.0	1,755.0	167.0			1,922.0
Switzerland	5,640.0	53,429.0	5,078.0			64,147.0
Taiwan		36,000.0				36,000.0
Thailand		0.0	0.0		0.0	0.0
Tunisia		63,873.0				63,873.0
Turkey		948,000.0	932,000.0	400.0		1,880,400.0
United Kingdom	13,022.0	6,557.0	1,879.0	500.0		21,958.0
United States	730,200.0	152,530.0	7,950.0	5,000.0	4,000.0	899,680.0
Uruguay		6,600.0				6,600.0
Zimbabwe		26.9	17,887.4			17,914.3
All other countries (5% of world market excluding China)	105,832.0	272,513.3	157,822.8	1,379.1	574.5	538,121.8
TOTAL	2,116,640.0	11,430,266.7	30,545,277.3	30,582.1	12,490.5	44,135,256.7

* exports excluded
\+ figures for France overseas according to ObservEr2019

Table 20: *Newly installed collector area in 2018 [m²]*

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		250,037	8,010			258,047
Argentina	18,636	20,786	49,496			88,918
Australia	5,556,000	3,449,000	211,000	370,000	12,800	9,598,800
Austria	338,255	4,694,348	86,022		4,678	5,123,303
Barbados		236,544				236,544
Belgium	45,000	546,167	99,350			690,517
Botswana		11,308	2,221			13,529
Brazil	5,998,282	9,954,957	129,962			16,083,201
Bulgaria		137,680	4,920			142,600
Burkina Faso		3,082	779			3,861
Canada	790,124	70,617	49,823	423,227	50,114	1,383,905
Cape Verde		2,163				2,163
Chile	65,550	234,528	54,305		300	354,683
China+		45,950,000	436,360,000	7,000	3,000	482,320,000
Croatia		217,500	12,067			229,567
Cyprus	2,213	761,682	23,567			787,462
Czech Republic	500,000	472,914	142,798			1,115,712
Denmark	20,500	1,649,078	9,197	4,300	18,000	1,701,075
Estonia		9,730	7,790			17,520
Finland	11,800	36,590	19,933			68,323
France (mainland)	99,671	2,499,656	187,720	9,658	1,100	2,797,805
France (overseas)++		250,000				
Germany	520,090	17,206,000	2,097,500		20,800	19,844,390
Ghana		2,494	887			3,381
Greece		4,691,000	22,000			4,713,000
Hungary	18,300	249,850	75,100	3,418	2,300	348,968
India	0	4,371,402	9,139,299	0	12,150	13,522,851
Ireland		211,821	121,586			333,407
Israel	39,000	4,748,434				4,787,434
Italy	43,800	4,042,411	634,703			4,720,914
Japan		3,605,145	81,210		281,669	3,968,024
Jordan*	5,940	982,482	272,084			1,260,506
Korea, South		1,479,231	411,924			1,891,155
Latvia		12,192	3,240			15,432
Lebanon		352,821	479,844			832,665
Lesotho		1,514	738			2,252
Lithuania		7,900	10,800			18,700
Luxembourg		56,463	8,900			65,363
Northern Macedonia		60,319	36,418			96,737
Malta		58,287	14,572			72,858
Mauritius**		132,793				132,793
Mexico	1,418,653	1,613,922	1,291,642	752	8,773	4,333,742
Morocco+++		750,000				750,000
Mozambique	144	641	2,351			3,136
Namibia	1,560	43,457	1,377			46,393
Netherlands	87,560	522,750	46,610			656,920
New Zealand***	7,025	142,975	9,644			159,645
Nigeria		1,080	3,752	0	870	5,702
Norway	1,849	38,041	4,203	200	4,106	48,400
Palestinian Territories		1,783,189	8,225			1,791,414
Poland		2,067,700	490,600			2,558,300
Portugal	2,130	1,069,222	29,330			1,100,682
Romania	340	108,000	96,350	800		205,490
Russia	137	21,220	3,687	2	64	25,110
Senegal		1,741	3,083	0	1,203	6,027
Slovakia	1,000	144,450	26,750			172,200
Slovenia		125,950	23,600			149,550
South Africa	1,234,149	645,845	293,065	0	0	2,173,059
Spain	156,038	3,930,261	224,524	3,250	1,250	4,315,323
Sweden	170,410	291,998	72,578			534,986
Switzerland	187,290	1,369,440	137,060			1,693,790
Taiwan	1,937	1,607,874	133,244			1,743,055
Thailand****		157,536				157,536
Tunisia		963,911	70,104			1,034,015
Turkey		17,856,182	7,281,454	9,970		25,147,606
United Kingdom	523,111	608,843	310,765	23,600		1,466,319
United States	22,478,478	2,971,267	171,071	121,882	69,500	25,812,198
Uruguay		76,000				76,000
Zimbabwe		21,838	37,801			59,639
All other countries (5% of world market excl. China)	2,123,420	5,616,645	1,330,665	51,108	25,772	9,147,611
TOTAL	42,468,393	158,282,905	462,973,300	1,029,167	518,450	665,272,214

* cumulated collector area by end of 2014
** cumulated collector area by end of 2015
*** cumulated collector area by end of 2009
**** cumulated collector area by end of 2016
\+ exports excluded
++ France overseas calculated based on Eurobserver Reports 2015-2019
+++ 2021 revised timeseries according to MDPI Switzerland 2021

Table 21: *Total collector area in operation by the end of 2018 [m²]*

8.8 References to reports and persons who have supplied the data

The production of the report, *Solar Heat Worldwide – Edition 2021*, was kindly supported by national representatives of the recorded countries or other official sources of information as cited below.

COUNTRY	CONTACT	SOURCE REMARKS
Albania	**Dr. Eng. Edmond M. HIDO** EEC - Albania-EU Energy Efficiency Centre	EEC - Albania-EU Energy Efficiency Centre
Argentina	**Federico Pescio, Martín Sabre** ENERGÍA SOLAR TÉRMICA – Instituto Nacional de Tecnología Industrial (INTI) Energías RenovablesCentro de Investigación y Desarrollo en Energías Renovables	Censo Nacional de Energía Solar Térmica (baja temperatura) Instituto Nacional de Tecnología Industrial (INTI) Cumulated calculated by AEE INTEC based on newly installed
Australia	**Dr. David Ferrari** Economic Affairs Officer, United Nations Environment and Social Committee for Asia and the Pacific, Bangkok	UN ESCAP, with data from the Clean Energy Regulator and industry surveys / interviews Out of operation systems calculated by UN ESCAP
Austria	**Werner Weiss** AEE - Institute for Sustainable Technologies	Biermayr et al, 2021: Innovative Energietechnologien in Österreich – Marktentwicklung 2020 (Report in German) Out of operation systems calculated by AEE INTEC
Barbados	**James Husbands** Solardynamics Ltd.	Timeline based on Solar Water Heating Techscope Market Readiness Assessment – Reports, UNEP 2015 0% growth assumed
Belgium	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation **AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe, 2020 Unglazed water collectors: AEE INTEC recordings
Botswana	**Karen Gibson** SIAB Solar Industries Association Botswana	Industry survey 2020
Brazil	**Dr. Danielle Johann,** Diretora Executiva ABRASOL Associção Brasileira de Energia Solar Térmica	ABRASOL Out of operation systems calculated based on ABRASOL long time recordings
Bulgaria	**Pedro Dias,** Secretary General Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe, 2020
Burkina Faso	**Kokouvi Edem N'Tsoukpoe** International Institute for Water and Environmental Engineering Ouagadougou, Burkina Faso	Rapport de l'étude de marché du solaire thermique: production d'eau chaude et de séchage de produits agricoles, 2015 Estimation for 2019
Canada	**Reda Djebbar, Ph.D., P.Eng.** Natural Resources Canada (NRC)	J.L Richards Report „Survey of Active Solar Thermal Collectors, Industry and Markets in Canada (2019-2020)" Out of operation systems considered by NRC air collectors provided by John Hollick

Cape Verde	**Antúnio Barbosa**	Country Market Report on solar thermal heating systems, solar drying and solar cooling, September 2015 Estimation for 2019
Chile	**Andrés Véliz Araya** División Energías Renovables Ministerio de Energía / Gobierno de Chile	Minvu Program, Law 20365 (Tax Benefit) www.minenergia.cl/sst/ Data provided by Andrés Véliz Araya
China	**Ruicheng Zheng** China Academy of Building Research CSTIF - Chinese Solar Thermal Industry Federation	CSTIF - Chinese Solar Thermal Industry Federation Exports excluded, out of operation systems calculated by AEE INTEC (11 years lifetime in 2019 considered)
Croatia	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe, 2020
Cyprus	**Panayiotis Kastanias** Cyprus Employers and Industrialists Federation	FPC Cyprus Union of Solar Thermal Industrialists (EBHEK) and the Cyprus Employers & Industrialists Federation (OEB) Cumulated calculated by AEE INTEC based on replacement figures provided by Panayiotis Kastanias
Czech Republic	**Ales Bufka** Ministry of Industry and Trade **Pedro Dias**, Secretary General Solar Heat Europe (lESTIF) – European Solar Thermal Industry Federation **AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Unglazed water collectors: AEE INTEC recordings
Denmark	**Jan-Erik Nielsen, Daniel Trier** Planenergi	Unglazed water collectors: AEE INTEC recordings
Estonia	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020 (estimation)
Finland	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020 (estimation)
France	**Paul Kaaijik,** ADEME - Agence de l'Environnement et de la Maîtrise de l'Énergie **John Hollick** SAHWIA - Solar Air Heating World Industry Association	EurobservER' 2020 Air collectors: John Hollick France overseas: Eurobser'Er 2020 Cumulated France overseas based on EurobservEr reports 2015-2020
Germany	**BSW - Bundesverband Solarwirtschaft e.V.,** data provided by Bärbel Epp Solrico – Solar market research **John Hollick** SAHWIA - Solar Air Heating World Industry Association	BSW - Bundesverband Solarwirtschaft e.V. Air collectors: John Hollick FPC / ETC: BSW solar long time recordings; unglazed water collectors & glazed air collectors: AEE INTEC recordings
Ghana	**Divine Atsu** Koforidua Polytechnic, Dpt. of Energy Systems Engineering	Estimation for 2019
Greece	**Costas Travasoras** EBHE – Greek Solar Industry Association **Vassiliki Drosou** CRES – Center for Renewable Energy Sources	

Hungary	**Pál Varga** MÉGNAP- Hungarian Solar Thermal Industry Federation **John Hollick** SAHWIA - Solar Air Heating World Industry Association	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020Air collectors: John Hollick Glazed water collectors: Solar Heat Europe 2020 cumulated calculated based on newly installed
India	**Jaideep N. Malaviya** Malaviya Solar Energy Consultancy	Malaviya Solar Energy Consultancy (based on market survey) New and cumulated installations based on survey from Malaviya Solar Energy Consultancy; out of operation systems considered, in 2016 recorded data changed from fiscal to calendar year
Ireland	**Mary Holland, Barry Gleeson** Sustainable Energy Authority of Ireland	Grant Scheme Data, BER database; Energy policy statistical support unit of Sustainable Energy Authority of Ireland Cumulated calculated by AEE INTEC based on newly installed collector areas
Israel	**Eli Shilton** ELSOL **Bärbel Epp** Solrico – Solar market research	ELSOL (Eli Shilton), data provided by Bärbel Epp Cumulated collector area calculated by AEE INTEC based on new installation and replacement figures from Eli Shilton (ELSOL)
Italy	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation **AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Cumulated area: Solar Heat Europe 2020 / share FPC-ETC: AEE INTEC unglazed water collectors: AEE INTEC
Japan	**Manami Mizutani** Japan Solar System Development Association	Japan Solar System Development Association Long time series
Jordan	**AEE INTEC**	AEE INTEC New installations: no new collectors for 2019 reported Cumulated installations by end of 2014
Korea, South	**Ki-Young Choi** Korea Energy Management Corporation (KEMCO) **Kyoung-ho Lee** Solar Thermal and Geothermal Research Center New and Renewable Energy Research Division Korea Institute of Energy Research (KIER)	2018 New & Renewable Energy Statistics by the Korea New & Renewable Energy Center, KEA 2019 Time series revised 2020 0 % growth assumed for 2019 newly installed collector area
Latvia	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020
Lebanon	**Tony Gebrayel, Rani Al Achkar** Lebanese Center for Energy Conservation (LCEC)	Lebanese Center for Energy Conservation (LCEC) Cumulated calculated by AEE INTEC
Lesotho	**Puleng Mosothoane** Bethel Business and Community Development Center (BBCDC)	SOLTRAIN Study, data provided by Puleng Mosothoane 0 % growth assumed
Lithuania	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020 (estimation)
Luxembourg	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020 (estimation)

Malta	**Therese Galea** Sustainable Energy and Water Conservation Unit (SEWCU) Ministry for Energy and Health	Sustainable Energy and Water Conservation Unit (SEWCU) based on data provided by the Regulator for Energy and Water Services (REWS)
Mauritius	**Devika Balgobin** Statistician / Environment Statistics Unit Ministry of Environment and Sustainable Development	Statistics Mauritius No new collector area 2019; cumulated collector area by end of 2015
Mexico	**David Garcia** FAMERAC **Bärbel Epp** Solrico – Solar market research	Glazed and unglazed water collectors: FAMERAC - Renewable Energy Industry Association data provided by Bärbel Epp Air collectors: SAHWIA - Solar Air Heating World Industry Association Cumulated installations: calculated by AEE INTEC
Morocco	**Ashraf Kraidy** RECREEE - Regional Center for Renewable Energy and Energy Efficiency	"A New Project for a Much More Diverse Moroccan Strategic Version: The Generalization of Solar Water Heater" by Fatima Zohra Gargab, Amine Allouhi, Tarik Kousksou, Haytham El-Houari, Abdelmajid Jamil; MDPI Switzerland 2021 newly installed and cumulated collector areas according to timeline
Mozambique	**Dr. Fabião Cumbe** ENPCT, E.P. **Geraldo Nhumaio** University Eduardo Mondlane, Maputo **AEE INTEC**	estimation AEE INTEC 0% growth assumed, cumulated installations calculated by AEE INTEC
Namibia	**Fenni Shidhika** Namibia Energy Institute Namibia University of Science and Technology	Namibia Energy Institute-Solar Water Heaters-Survey 2019
Netherlands	**André Meurink, Reinoud Segers, Maria José Linders** Statistics Netherlands (CBS)	Statistics Netherlands (CBS) Newly installed areas: Statistics Netherlands based on survey of sales. Market Shares: Expert estimates Netherlands Enterprise Agency and Holland Solar.
New Zealand		No data available since 2010 Cumulated area in 2009
Nigeria	**Okala Nwoke** National Centre for Energy Research and Development, University of Nigeria, Nsukka	0% growth assumed
Northern Macedonia	**Prof. Dr. Ilja Nasov** National University St. Kiril and Metodij, Faculty for Natural Science, Institute of Physics, Solar Energy Department	Public custom administration and Macedonian Solar Energy Association Cumulated installations calculated by AEE INTEC based on new installation figures
Norway	**Dr. Michaela Meir** Aventasolar	Solvarmeanlegg i Norge 2019 commissioned by The Norwegian Solar Energy Cluster (Solenergiklyngen), provided by Michaela Meir 0% growth assumed, cumulated calculated by AEE INTEC (flat plate collectors: 4% out of operation considered)
Palestinian Territories	**Mohammed Mobayyed** EEU Director Palestinian Energy Authority **Abdallah Azzam** Palestinian Central Bureau of Statics Natural Resource Statistics	Palestinian Energy Authority Cumulated area calculated by AEE INTEC (replacements not considered)

Poland	**Janusz Staroscik - President** Association of Heating Appliances manufacturers and Importers in Poland	
Portugal	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020
Romania	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020
Russia	**Prof. Vitaly Butuzov** Energotechnologies Service Ltd. Krasnodar **Dr. Semen Frid** JIHT RAS - Joint Institute for High Temperatures of Russian Academy of Sciences **Dr. Sophia Kiseleva** Lomonosow Moscow State University	The source of information - Energotechnologies Service Ltd. (ETS)
Senegal	**T. Ababacar** Université Cheikh Anta DIOP	Rapport de Marché du Solaire Thermique: Production d' Eau Chaude et Séchage de Produits Agricoles 0% growth assumed
Slovakia	**Pedro Dias** Secretary General Solar Heat Europe (ESTIF) - European Solar Thermal Industry Federation	Solar Thermal Markets in Europe - Trends and Market Statistics 2019, Solar Heat Europe 2020 Glazed water collectors: Solar Heat Europe 2020
Slovenia	**Ciril Arkar** University of Ljubljana, Faculty of Mechanical Engineering	Eco Fund, Slovenian Environmental Public Fund
South Africa	**Karin Kritzinger** Centre of Renewable and Sustainable Energy Studies University of Stellenbosch	Department of Energy, SESSA, Stellenbosch University, Solco, GIZ, Sanedi, City of Cape Town Metro
Spain	**Pascual Polo** ASIT - Asociación Solar de la Industria Térmica	ASIT (Solar Energy Industry Association of Spain) Out of operation systems calculated by ASIT
Sweden	**Viktor Döhlen** Swedish ExCo for IEA SHC	
Switzerland	**http://www.swissolar.ch/**	SWISSOLAR - Markterhebung Sonnenenergie 2019, Bundesamt für Energie 2020 Out of operation systems calculated by SWISSOLAR
Taiwan	**K.M. Chung** Energy Research Center - National Cheng Kung University	Installers association 0% growth assumed
Thailand	**Charuwan Phipatana-phuttapanta** Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy	GIZ study, Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy (Subsidized systems) no new collector area in 2019; cumulated area by end of 2016
Tunisia	**Abdelkader Baccouche** Agence Nationale pour la Maîtrise de l'Energie (ANME)	ANME (National Agency of Energy Conservation)

Turkey	**A. Kutay Ulke** Bural Heating Corporation Ltd. **John Hollick** SAHWIA - Solar Air Heating World Industry Association **Prof. Bulent Yesilata** GAP Renewable Energy and Energy Efficiency Center, Harran University	Water collectors: A. Kutay Ulke, personal studies Air collectors: SAHWIA New installations: A. Kutay Ulke cumulated installations: calculated by AEE INTEC considering 15 years lifetime
United Kingdom	**Elizabeth Waters** Renewables, Heat and Consumption BEIS - Department for Business, Energy & Industrial Strategy **John Hollick** SAHWIA - Solar Air Heating World Industry Association	UK Solar Trade Association and ESTIF Reports collated in BEIS annual survey Active Solar 2019 survey with efficiency and lifetime, Air collectors provided by John Hollick
United States	**Brad Heavner** California Solar and Storage Association (CALSSA) **Pam Murphey** IEA SHC Technology Program **John Hollick** SAHWIA - Solar Air Heating World Industry Association	Water Collectors and air collectors: IAPMO Solar Heating & Cooling Programs; Air collectors: SAHWIA New installations: CALSSA Totals: calculated by AEE INTEC considering 25 years lifetime
Uruguay	**Martín Scarone** Ministry of Industry, Energy and Mining	Ministry of Industry, Energy and Mining, data provided by Martín Scarone
Zimbabwe	**Samson Mhlanga** National University of Science and Technology, Bulawayo	Dr. Anton Schwarzlmüller Domestic Solar Heating unpublished statistics SOLTRAIN survey 2020 (unpublished sources) cumulated calculated by AEE INTEC

8.9 Additional literature and web sources used

The following reports and statistics were used in this report.

- Bundesamt für Energie (BFE): Markterhebung Sonnenenergie 2019 - Teilstatistik der Schweizerischen Statistik der erneuerbaren Energien; prepared by SWISSOLAR, Thomas Hostettler, Bern, Switzerland July 2020
- Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK), Austria – Innovative Energy Technologies - Market Development 2019; Ed. Peter Biermayr et al, Vienna, Austria June 2020
- Bundesverband Solarwirtschaft e.V. (BSW-Solar): Statistische Zahlen der deutschen Solarwärmebranche (Solarthermie) 2021; accessed April 2021
- ClearSky Advisors Inc.: Survey of Active Solar Thermal Collectors, Industry and Markets in Canada (2019-2020); Prepared by ClearSky Advisors Inc., Dr. Reda Djebbar, Natural Resources Canada, April 2021
- Eurobserv'ER 2020, Solar Thermal and Concentrated Solar Power Barometers
- Global Market Outlook for Solar Power / 2019-2023, Solar Power Europe, 2019
- GWEC / Global Wind Report 2020, Global Wind Energy Council, March 2021
- IEA Global Energy Review 2021
- IEA PVPS Snapshot 2020
- IRENA: Renewable Energy and Jobs: Annual Review 2019
- IRENA Renewable Energy Statistics 2021
- Lehr, U. et.al (2015), Beschäftigung durch erneuerbare Energien in Deutschland: Ausbau und Betrieb, heute und morgen
- Solar Heat Europe (ESTIF): Solar Heat Markets in Europe, Trends and Market Statistics 2019, December 2020
- Weiss, W. (2003) Wirtschaftsfaktor Solarenergie, Wien
- Weiss, W., Biermayr, P. (2006) Potential of Solar Thermal in Europe, published by ESTIF
- Wimmer, L. et al. (2019), Monitoring of renewable process heat plants within the gas sector.

The following online sources were used in this report:

https://www.amee.ma/
http://www.anes.org/anes/index.php
http://www.asit-solar.com/
http://helioscsp.com/concentrated-solar-power-had-a-global-total-installed-capacity-of-6451-mw-in-2019
https://www.solarpowereurope.org/
http://www.giz.de/
http://www.iea-shc.org/
http://www.irena.org/
http://www.olade.org/
http://www.ren21.net/
http://sahwia.org/
http://www.solar-district-heating.eu/
http://www.solarwirtschaft.de/
http://www.solrico.com/
http://www.solarthermalworld.org/
https://www.statista.com/statistics/476281/global-capacity-of-geothermal-energy
http://www.swissolar.ch/

8.10 List of Figures

8.11 List of Tables