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WERNER WEISS | MONIKA SPÖRK-DÜR

SOLAR HEAT WORLDWIDE

Global Market Development and Trends in 2019 | Detailed Market Figures 2018

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

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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Global Market Development and Trends in 2019
Detailed Market Data 2018

2020 EDITION

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SOLAR HEATING & COOLING PROGRAMME
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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.

In this edition of Solar Heat Worldwide for the second time also hybrid Photovoltaic-Thermal (PVT) collectors are included, as PVT collectors got more market relevance in recent years. PVT collectors convert in a single device solar radiation in electricity and heat and could thus 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 and other 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 68 countries included in this report represent 4.95 billion people, or about 67 % of the world's population. The installed capacity in these countries is estimated to represent 95 % of the solar thermal market worldwide.

The 2019 edition and all past issues of the report can be downloaded from the following website:
http://www.iea-shc.org/solar-heat-worldwide.

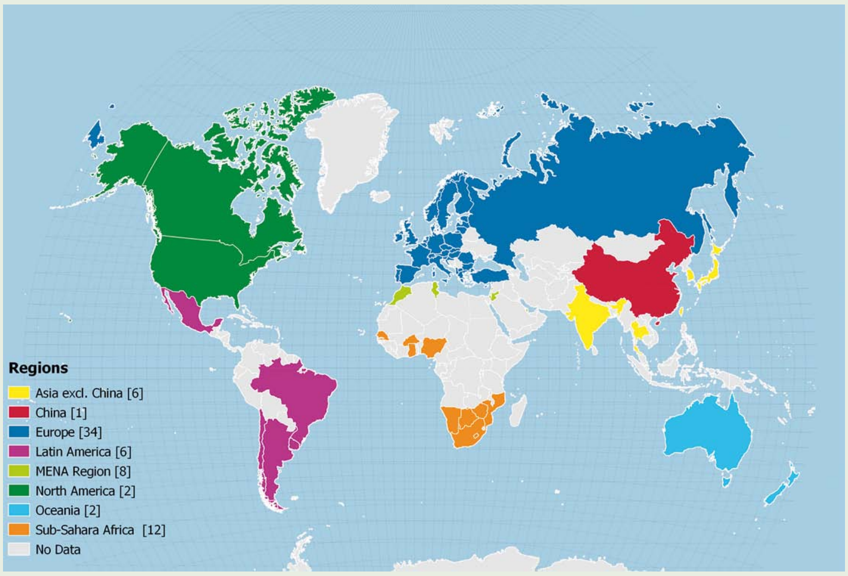


Figure 1: *Countries shown in color have detailed market data. Countries shown in grey have estimated market data. (Source: Natural Earth v.4.1.0, 2020/ AEE INTEC)*

2 Summary

This report is split into two parts. The first part (Chapters 3 – 4) gives an overall overview of the global solar thermal market development in 2019. In addition, general trends are described and detailed 2019 data on successful applications, such as solar assisted district heating, solar heat for industrial processes and hybrid photovoltaic-thermal systems, are documented. Chapter 4.1 in this year's edition deals with thermosiphon systems, which have found widespread use worldwide, especially in social housing programs.

The second part (Chapters 5 – 8) presents detailed market figures for the year 2018 from the 68 surveyed countries. In addition to the installed collector areas, this includes the distribution of the collectors across various systems and applications, as well as the solar yields and avoided emissions.

Global solar thermal market developments in 2019

The cumulated solar thermal capacity in operation at the end of 2019 was 479 GW_{th} (684 million square meters). The corresponding annual solar thermal energy yield amounted to 389 TWh, which correlates to savings of 41.9 million tons of oil and 135.1 million tons of CO_2. This corresponds to 3.5 times the annual $CO_2$2 emissions of Switzerland[1].

The market for new installations once again varied by country, with shrinking markets in large markets like China, USA, Germany and Australia, stable markets in Mexico and Turkey, and growing markets in Denmark, Cyprus, South Africa and Greece. Driven by the decline in new collector installations of about 8% in China, the worldwide market shrank approximately 6% in 2019 compared to 2018.

As the past few years have shown, the solar thermal market is experiencing challenging times. This is especially evident in the large markets in China and Europe, where the traditional mass markets for small-scale solar water heating systems for single-family houses and apartment buildings are under market pressure from heat pumps and photovoltaic systems. However, what is often overlooked is the fact that around 60% of the solar thermal systems installed worldwide are still small-scale thermosiphon systems. Some countries such as Greece, South Africa and some countries in Latin America, have strong markets in this area due to government support programs.

An area with consistent growth is in the number of megawatt-scale systems for district heating and industrial applications. In Denmark, the market grew at about 170% in 2019 because of the installation of a couple of large-scale plants this year.

By the end of 2019, about 400 large-scale solar thermal systems (>350 kW_{th}; 500 m^2) connected to district heating networks and in residential buildings were in operation. The total installed capacity of these systems equaled 1,615 MW_{th} (2.3 million m^2), excluding concentrating systems that added 162,784 m^2. Denmark remains the leading European country for large-scale district heating systems, adding 35% of the newly installed collector area worldwide (excluding parabolic trough collectors). And outside of Europe, China added 97% of the installed collector area for large-scale systems in 2019.

1 Statista Research Department, 11.3.2020 (https://de.statista.com/themen/5533/treibhausgasemissionen-in-der-schweiz/)

Twenty-three large-scale solar thermal systems with about 228,900 m² (160 MW_{th}) were installed in Europe in 2019. Of these installations, 15 were in Denmark (191,300 m²) including five extensions of existing systems, six in Germany (14,700 m²), one in Latvia (21,700 m²) and one in Austria (1,200 m²).

Outside Europe, 218 MW_{th} (311,700 m²) were installed, excluding one concentrating system installed in Mexico and four concentrating systems in China that would add 5,300 m² to the total above.

In China, 47 systems for district heating and large buildings were installed in 2019 (307,000 m²) including four systems with parabolic trough collectors (adding up to 3,876 m²). The largest district heating system installed in China in 2019 was in Zhongba, with a collector area of 35,000 m².

Worldwide interest in solar thermal systems for industrial processes has grown steadily over the past several years. A number of promising projects implemented a range from small-scale demonstration plants to very large systems in the 100 MW_{th} sector. At least 800 solar process heat systems, totaling 1 million m² collector area (700 MW_{th}), were in operation at the end of 2019.

The world's largest solar process heat plant Miraah in Oman was enlarged by roughly 200 MW_{th} in 2019 and now has an installed capacity of 300 MW_{th}. The solar produced steam is used for enhanced oil recovery.

In addition to the more traditional industrial sectors like the food, beverage and mining industry, in which solar thermal systems are used, there are two new applications, in which a number of systems have been built. One application developed in recent years is to supply solar heat to greenhouses for flower and vegetable cultivation. The second application relates to the heating of gas pressure control systems, an interesting application implemented in several systems in Germany.

Photovoltaic Thermal (PVT) collectors and systems are included for the second time in the Solar Heat Worldwide report. This market developed very well in 2019 and saw significant global growth of +9%. This trend was also seen in the European market with a growth rate of 14%, which corresponds to an increase of the yearly new installed capacity of 40.8 MW_{th} and 13,3 MW_{peak}[2]. By the end of 2019, the total installed PVT collector area was 1,166,888 m² (606 MW_{th}, 208 MW_{peak}), and 58% of this collector area was in Europe.

Market status worldwide in 2018

By the end of 2018, an installed capacity of 483 GW_{th}, corresponding to a total of 690 million m² of collector area was in operation in the recorded 68 countries. These figures include unglazed water collectors, flat plate collectors, evacuated tube collectors, and unglazed and glazed air collectors.

The vast majority of the total capacity in operation was installed in China (337.6 GW_{th}) and Europe (56.8 GW_{th}), which together accounted for 81.7% of the total. The remaining installed capacity was shared between the United States and Canada (18.6 GW_{th}), Asia excluding China (14.7 GW_{th}), Latin America (14.8 GW_{th}), the MENA[3] countries (7.1 GW_{th}),

2 Megawatt peak describes the maximum possible power of a photovoltaic generator under standard test conditions

3 Middle East and North Africa (Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia)

Australia and New Zealand (6.6 GW_{th}), and Sub-Sahara African countries[4] (1.7 GW_{th}). The market volume in the 68 documented countries is estimated to represent 95% of the solar thermal market worldwide.
With a global share of about 70%, evacuated tube collectors were the predominant solar thermal collector technology followed by flat plate collectors with about 23%, unglazed water collectors with about 6% and glazed and unglazed air collectors with 0.2%.

The top 10 markets in 2018 in terms of total installations were China, the United States, Turkey, Germany, Brazil, India, Australia, Austria, Israel and Italy.

The leading countries for cumulated glazed and unglazed water collector capacity in operation in 2018 per 1,000 inhabitants were Barbados (565 kW_{th}/1,000 inhabitants), Cyprus (446 kW_{th}/1,000 inhabitants), Austria (408 kW_{th}/1,000 inhabitants), Israel (398 kW_{th}/1,000 inhabitants), Greece (309 kW_{th}/1,000 inhabitants), the Palestinian Territories (271 kW_{th}/1,000 inhabitants), Australia (261 kW_{th}/1,000 inhabitants), China (244 kW_{th}/1,000 inhabitants), Turkey (217 kW_{th}/1,000 inhabitants) and Denmark (202 kW_{th}/1,000 inhabitants).

Newly installed capacity worldwide in 2018

In 2018 a capacity of 33.5 GW_{th}, corresponding to 47.9 million m^2 of solar collectors, were installed worldwide. The main markets in 2018 were China (24.8 GW_{th}) and Europe (2.9 GW_{th}), which together accounted for about 83% of the overall new collector installations. The rest of the market was shared between Latin America (1.2 GW_{th}), Asia excluding China (1.4 GW_{th}), the United States and Canada (0.6 GW_{th}), the MENA countries (0.4 GW_{th}), Australia (0.4 GW_{th}), and the Sub-Sahara African countries (0.1 GW_{th}). The market volume of “all other countries” is estimated to be 5% of the new installations (1.7 GW_{th}).

Remarkable market growth was reported from Denmark (170%), Cyprus (24%), South Africa (20%), Greece (10%), Tunisia (7%) and Brazil (6%).

With a share of 71.3% of the newly installed capacity in 2018, evacuated tube collectors are still by far the most important solar thermal collector technology worldwide. In a global context, this breakdown is mainly driven by the dominance of the Chinese market where around 83% of all newly installed collectors in 2018 were evacuated tube collectors.

Nevertheless, it is notable that the share of evacuated tube collectors on the worldwide scale decreased from about 82% in 2011 to 71.3% in 2018, and in the same time frame flat plate collectors increased their share from 14.7% to 24.2%.

In Europe, the situation is almost the opposite of that in China with 71.9% of all solar thermal systems installed in 2018 being flat plate collectors. In the medium-term perspective, the share of flat plate collectors, however, has decreased in Europe from 81.5% in 2011 to 71.9% in 2018 due to growth of the evacuated tube collector markets in Turkey, Poland, Switzerland and Germany. Overall, the share of evacuated tube collectors in Europe has increased between 2011 and 2018 from 15.6% to 26.6%.

4 Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa and Zimbabwe

In terms of newly installed solar thermal capacity per 1,000 inhabitants in 2018, the top 10 ranking of countries over the past few years has remained the same, except for Austria slipping from eighth to ninth place. Israel is the leader followed by Cyprus, Barbados, Greece, China, Australia, Turkey, Denmark, Austria and the Palestinian Territories.

Distribution by system type and application

The thermal use of the sun's energy varies greatly 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, other such as industrial processes heat, solar district heating and solar thermal cooling).

Worldwide, 58% of all solar thermal systems installed are thermosiphon systems, and the rest are pumped solar heating systems.

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 most often equipped with flat plate collectors, while in China the typical thermosiphon system for domestic hot water preparation is equipped with evacuated tubes.

The calculated number of water-based solar thermal systems in operation was approximately 105 million by the end of 2018. The breakdown is 53% used for domestic hot water preparation in single-family houses and 37% attached to larger domestic hot water systems for multifamily houses, hotels, hospitals, schools, etc., and 6% used for swimming pool heating. Around 2% of the global installed capacity is used in solar combi-systems that supply heat for both domestic hot water and space heating. The remaining systems accounted for around 2% and delivered heat to other applications, including district heating networks, industrial processes and thermally driven solar cooling applications.

Compared to the cumulated installed capacity, the share of swimming pool heating was less for new installations (6% of the total capacity and 3% of newly installed capacity). A similar trend can be seen for several years now for domestic hot water systems in single-family homes – 53% of total capacity in operation and 33% of new installations in 2018 makes this type of system still the most common application worldwide, but it is showing a decreasing trend.

By contrast, the share of large-scale domestic hot water applications shows an increasing trend – 37% of total capacity and 60% of newly installed capacity.

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 650,000 worldwide in 2018.[5]

The worldwide turnover of the solar thermal industry in 2018 is estimated at € 15.4 billion (US$ 16.9 billion).

5 Background information on the methodology used can be found in the Appendix, Chapter 8.5.

3 Worldwide solar thermal capacity in 2019

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 479 GW_{th} (684 million m^2) in 2019. The corresponding annual solar thermal energy yields amounted to 51 TWh in 2000 and 389 TWh in 2019 (Figure 2).

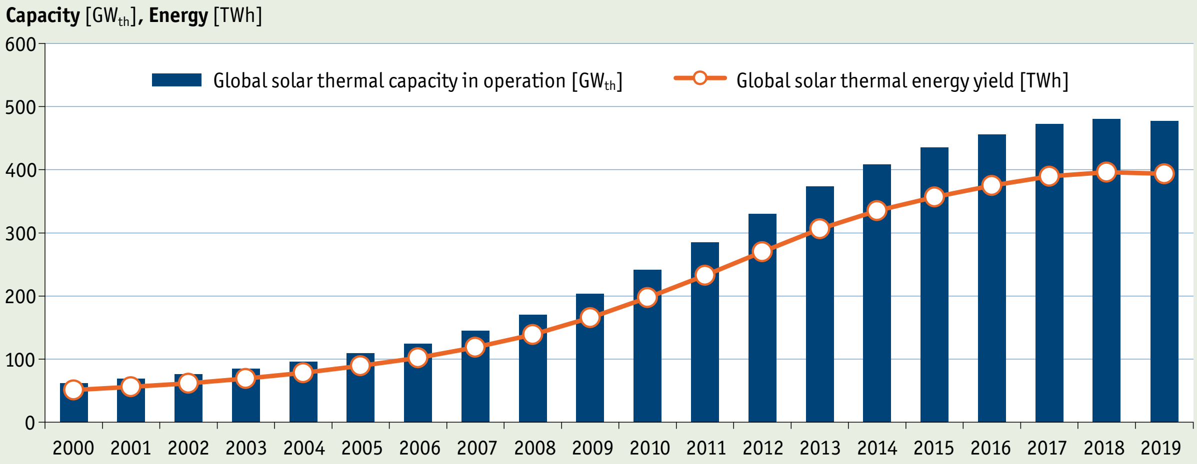


Figure 2: *Global solar thermal capacity in operation and annual energy yields 2000 – 2019*

Environmental effects and contribution to climate goals

The global solar thermal energy yields of all installed solar thermal systems in 2019 corresponds to a savings of 41.9 million tons of oil and 135.1 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 2019 was 479 GW_{th}[6], which trailed behind wind power's installed capacity of 651 GW_{el} and photovoltaics 627 GW_{el} of installed capacity (Figure 3). Geothermal energy and concentrated solar power (CSP) lag behind these three technologies in terms of 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 389 TWh of heat, whereas wind turbines supplied 1567 TWh and photovoltaic systems 751 TWh of electricity.

6 The figures for 2019 are based on the latest market data from Australia, Austria, Brazil, China, Cyprus, Denmark, Germany, India, Mexico, Poland, Spain, South Africa, Turkey and the United States, which represented about 89 % of the cumulated installed capacity in operation in the year 2018.

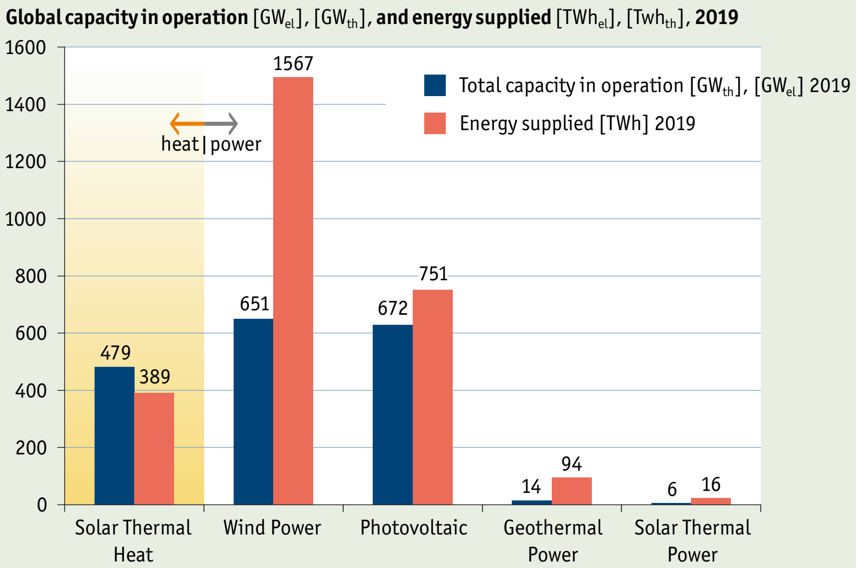


Figure 3: *Global capacity in operation [GW_{el}], [GW_{th}] 2019 and annual energy yields [TWh_{el}], [TWh_{th}].*
*(Sources: AEE INTEC, Global Wind Energy Council (GWEC), European PV Industry Association (EPIA Solar Power Europe), REN21 - Global Status Report 2020, **https://www.statista.com/statistics/476281/global-capacity-of-geothermal-energy/**, **http://helioscsp.com/concentrated-solar-power-had-a-global-total-installed-capacity-of-6451-mw-in-2019/**)*

The development of global installed capacity of solar thermal heat, wind and photovoltaics between 2010 and 2019 is shown in **Figure 4**.

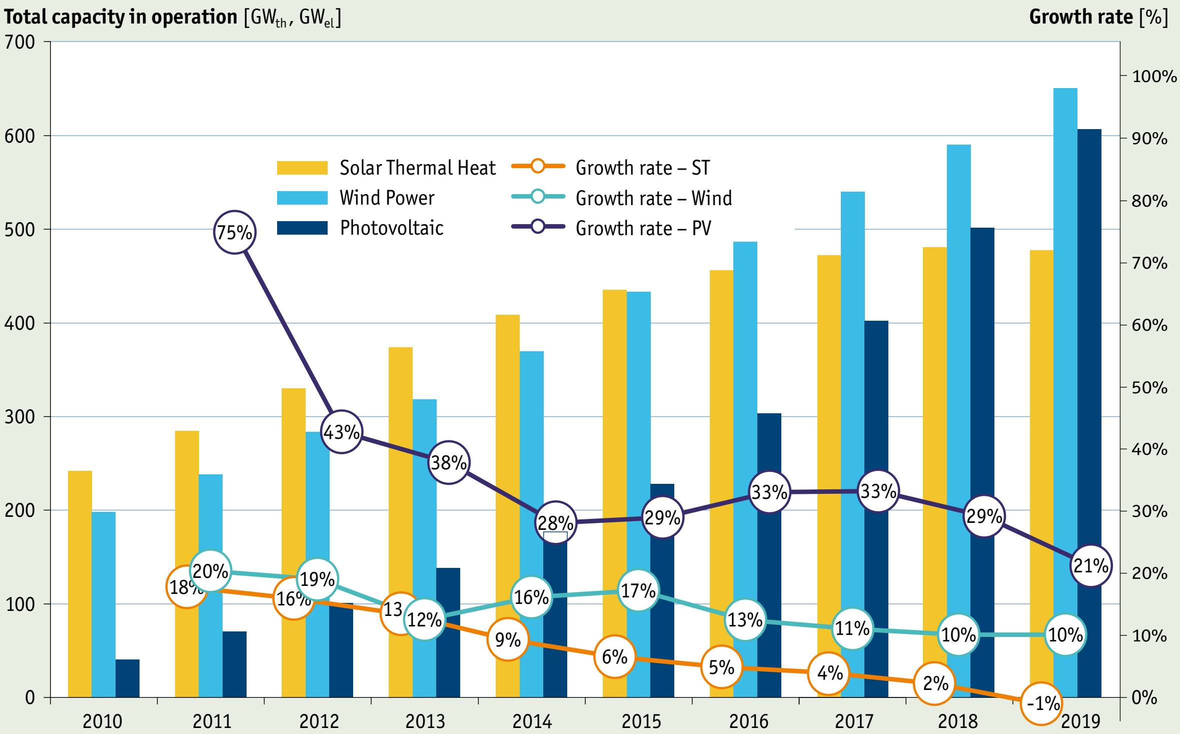
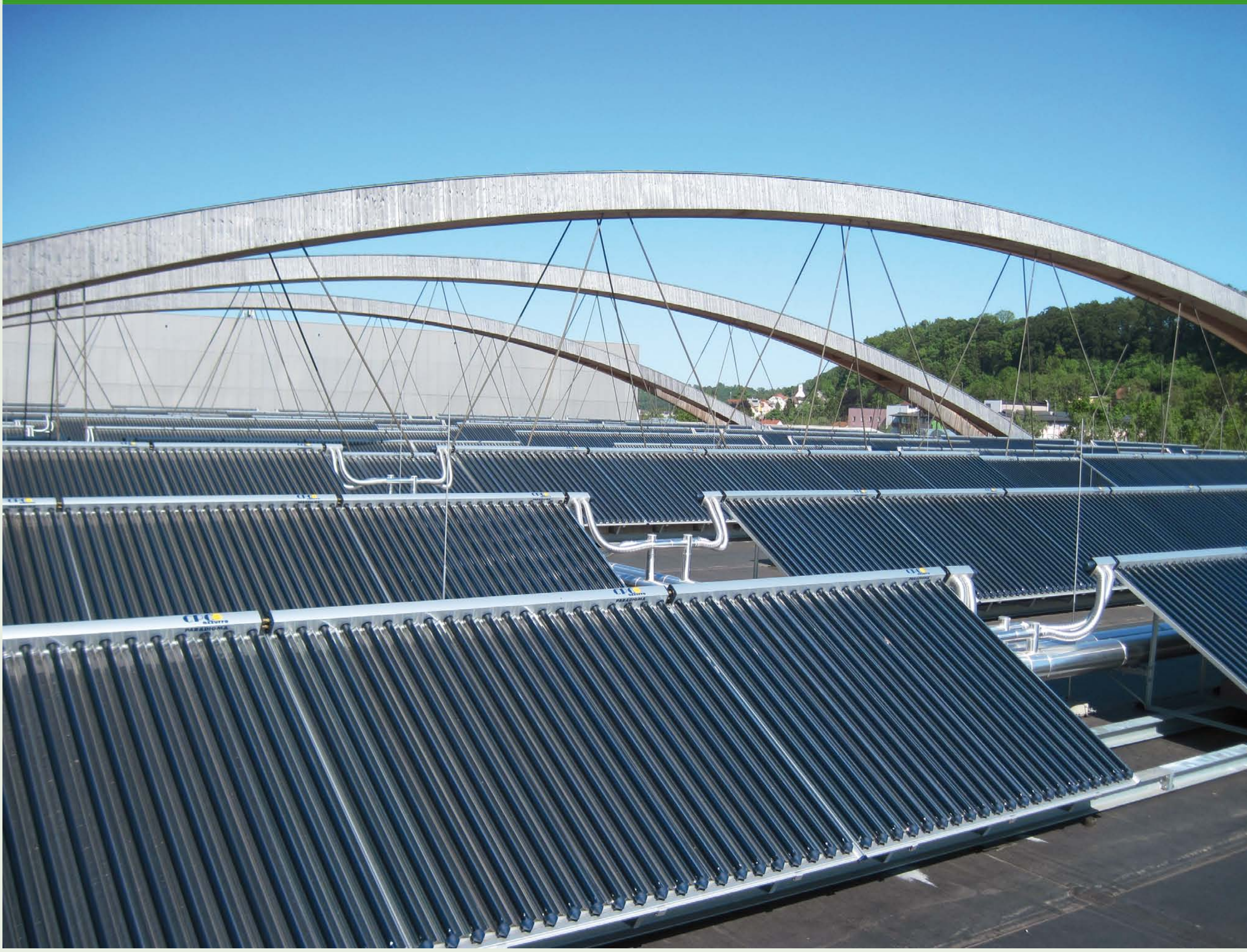


Figure 4: *Global capacity in operation and market growth rates between 2010 and 2019*
(Sources: AEE INTEC, Global Wind Energy Council (GWEC), European PV Industry Association (EPIA Solar Power Europe), REN21 - Global Status Reports 2011-2020)



Vacuum tube collector system with a capacity of 2.5 MW_{th} (3.600 m^2) on the exhibition hall in Wels, Austria *Photo: Paradigma and MEA Solar GmbH*

Despite the downward trend in annual growth rates, photovoltaics continued to grow impressively by 25% in 2019. The market development of wind energy has been fairly stable for three years, with annual growth of around 10%. Unfortunately, heating technologies, especially solar thermal technology, could not keep up with this trend.

In addition to the low attention given by energy policies to the heating sector in general and the fact that solar thermal system prices have hardly fallen for years, the decline is certainly compounded by the global discussion on the electrification of the heat sector (**Figure 4**).

4 Solar thermal market development and trends in 2019

Except for a few countries, solar thermal has been going through very challenging times worldwide for several years. This is reflected in the annual shrinking of the collector capacity as shown above in Figure 5.

This is mainly due to declines in the Chinese market, which is by far the largest market worldwide. In 2019 the Chinese market declined by around 8%. In addition to China, traditionally strong European markets such as in Germany, France and Poland also experienced market slumps in 2019.

Nonetheless, there was an opposite trend in some countries, but their increased market shares, could not compensate for the losses in the larger markets. Positive market growth was recorded in Denmark (170%), Cyprus (24%), South Africa (20%), Greece (10%), Tunisia (7%), Brazil (6%) and India (2%).

As in previous years, interest in solar-supported district heating systems on a megawatt-scale and in applications for solar heating and cooling in the commercial and industrial sectors continues. A number of new installations for these applications were installed all over the globe in 2019, 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.

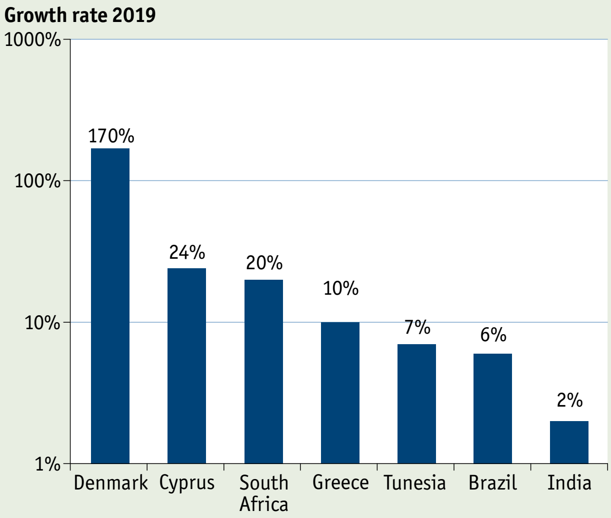


Figure 5: *Growth rates of the most successful countries 2019*

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, multifamily houses, hotels and public buildings represent about 60% of the worldwide annual installations.

In large parts of Europe, but also in China, these applications are coming under increasing pressure 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 5 above, apart from Denmark, in 2019 only those countries where markets were dominated by thermosiphon systems there was significant growth.

Pumped solar thermal systems for water heating and space heating like shown above are increasingly competing with PV systems and heat pumps.
Photo: Werner Weiss, AEE INTEC

China, which traditionally has the most thermosiphon systems, has seen a decline in this market sector for several years. In 2019, however, small thermosiphon systems made a comeback with a total of 8.45 million m² of collector area installed, mainly in rural areas.

Notable success has been achieved particularly in those countries that have linked state social housing programs with the installation of solar water heating systems. Also, Greece and some MENA countries are very successful with the installation of thermosyphon systems.

In the section below are examples of successful strategies for installing thermosiphon solar water heating systems.

4.1.1 Greece was able to record growth rates in times of economic crisis

Greece, with 309 kW_{th} / 1,000 inhabitants, is one of the leading countries in installed capacity per capita and has had a well-established market for decades that was even able to record growth rates in times of economic crisis. A large number of the country's solar thermal systems were installed in the early 1980s. That was the foundation for building a strong solar industry in the country.

In 2019, a capacity of 253 MW_{th}, corresponding to 361,500 m² of solar collectors was installed in Greece. This means an increase in new collector installations by 10% compared to the year 2018. The Greek solar thermal market mostly consists of

Greek thermosiphon systems *Photo: SOLE S.A.*

individual thermosiphon type solar water heaters. A typical system is composed of 150 – 300 liters hot water storage in combination with 2 – 4 m^2 highly selective flat plate collectors with antifreeze protection.

The success in Greece can be attributed to several factors. First, the country has a favorable climate so that a system typically covers 80 – 90% of the yearly hot water needs of a family. Second, and a major reason for the country's long-term success, is local manufacturing. The solar thermal industry began in the mid 1970s and expanded rapidly to where it is today, producing affordable systems with a demonstrated 25-year lifespan for both the domestic and export markets.

Last but not least, government support programs have significantly supported the installation of solar water heaters. For example, the installation of a solar thermal system to cover at least 60% of hot water demand is mandatory for every new building according to the Energy Efficiency Building Regulation Code. And, the installation of a solar thermal system for hot water production is funded up to 70% by the „Saving Energy at Home I and II" programs. Finally, the roof installation of a residential photovoltaic system is only allowed if a solar thermal system for hot water production is already installed.

4.1.2 Market success in southern Africa

South Africa and Namibia are two countries that saw market growth in 2019. With a market growth of 20%, South Africa ranked third among the most successful countries in the world after Denmark and Cyprus in 2019.

South Africa's One-million solar water heaters program

The One-million solar water heaters program started in 2010 as a rebate scheme to replace existing electric water heaters with solar water heaters to reduce power demand from the national grid. Through the rebate program 400,000 units were installed up to now. In 2015 the Department of Energy (DOE) took over the program and changed the focus to providing solar water heaters to state-subsidized and unelectrified homes. The new program's objective was to quickly install systems, but this was hampered by a lack of qualified installers and resistance by the electricity industry and municipalities who feared a negative impact on their revenue from decreased electricity sales. As a result, 87,000 solar water heaters are waiting to be installed, which should happen in 2020.

In addition to the One-million solar water heater program, there are numerous other projects and programs supporting the installation of thermal solar systems, which ultimately lead to market growth.

In the South African context, it is also noteworthy that around 6,800 PV2heat systems for water heating were installed in 2018 and 2019. A photovoltaic module directly supplies the DC heating element in the hot water tank without using a battery or grid connection with this type of system. This system concept probably will compete with thermosiphon systems in future.

4.1.3 Solar urban development concept in Namibia

The Government of Namibia has been pursuing an ambitious housing program for several years, which will see the construction of a total of 185,000 new residential buildings by 2030.
Since electric power is in short supply in southern Africa, the low power plant capacity leads to power outages and pressure on the electric grid increases with each newly built house. This growing demand can be countered by the installation of thermal solar systems.

Comparative measurements from a number of pilot solar water heating plants in the capital city of Windhoek show that 40 – 50% of household electricity demand is for domestic hot water. Therefore, households with a thermal solar system can save around 1,000 kWh of electricity per year. Motivated by these results, a solar urban development concept was launched in 2019 in Okahandja, about 60 km north of Windhoek. The first construction phase will be a new settlement with around 10,000 apartments. In addition to other requirements, each of the residential buildings must be equipped with a solar water heating system. Projects such as this one is key to the implementation of the Namibian National Energy Policy (NREP 2017).

10,000 apartments in Osona Village, Namibia are being equipped with thermosyphon systems. Photo: Werner Weiss, AEE INTEC

Around 400,000 thermosiphon systems were built in Brazil as part of the Minha Casa, Minha Vida social housing program. *Photo: TUMA*

4.1.4 Solar water heaters for social housing programs in Brazil

Brazil has a long tradition of solar thermal systems in social housing. The development of solar domestic water heating (SDWH) for large housing programs in Brazil started in the mid-1990s. As in Namibia, extensive measurements were taken in Brazil early in the 2000s that helped families save on average 44 % of their electricity consumption and 58 % of electricity costs. Thus, demonstrating that SDWH can have important social benefits beyond its role as an energy conservation tool.

In 2000, the federal government published a new law that required electricity distribution utilities to invest 0.5 % of their net revenue in electricity conservation programs. The law created new opportunities for solar water heating systems and in 2005, Light, a utility company in the state of Rio de Janeiro, implemented the first large project in the country, with a total of 2,340 solar water heating units installed on low-income houses. Other projects followed, but the largest impulse came with a national housing initiative called Minha Casa, Minha Vida (My House, My Life).

The My House, My Life (MHML) program was created in 2009 by the Brazilian federal government to increase housing access for low-income families and to support economic activity during the international financial crisis. The program was managed by a State-owned bank. Starting in 2010, it supported, on an optional basis, the installation of solar water heating systems for low income families in the south, south-east and center-west regions of the country. The decision to install the systems was given to developers, which were paid an extra R$2,500 (€ 1,025) for each system in multi-story buildings and R$1,800 (€ 738) for single-story buildings. This extra payment had to cover all costs incurred installing the system, including the plumbing inside the house. In 2011, solar water heating systems became a mandatory item for all single-family houses within the program, independent of location, with costs included in the total value paid by the government for the houses. The program shrank significantly in 2015 during the country's recession. A political crisis ensued and 2016 brought an abrupt change in government, with a consequent policy change. In early 2017, SDWH was made optional for houses in the north and north-east regions but remained mandatory for other regions. Later in the same year, photovoltaic systems were added as an option, directly competing with SDWH. By the end of 2017, 384,232 SDWH systems were contracted within the program.

Despite a slight market decline between 2015 and 2018, there was a 6% growth in the market in 2019 placing Brazil in the top 7 countries in terms of market growth.

The experience in Brazil shows that massive deployment can be achieved, and solar water heating systems offer a cost-effective opportunity for sustainability and job creation. However, an essential question remains: How to make mass deployment programs, which are political by nature, more stable and less risky to the industry?

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. In the past three years, the concentration of newly installed systems has shifted outside of Europe, predominately to China.

By the end of 2019, about 400 large-scale solar thermal systems (>350 kW_{th}, 500 m²) were in operation (**Figure 6**). The total installed collector area of these systems equaled 2.3 million m² (1,615 MW_{th}), excluding concentrating solar thermal systems and PVT collectors that add up to 162,784 m².

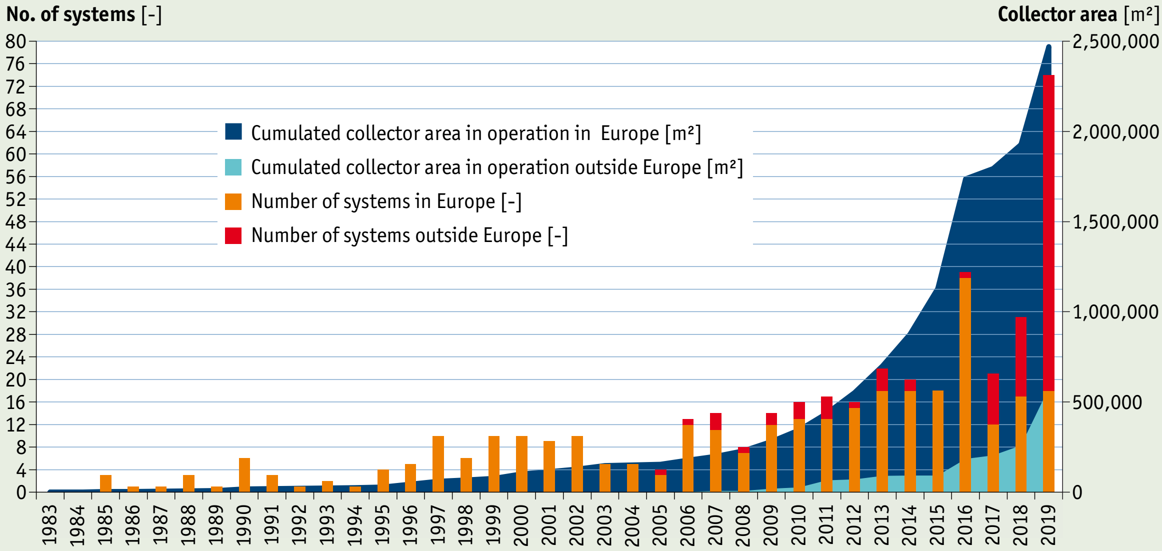


Figure 6: *Large-scale systems for solar district heating and large residential, commercial and public buildings worldwide – annual achievements and cumulated area in operation in 2019*
(Data source: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 55, AT, Bärbel Epp - solarthermalworld.org, DE)

The largest sub-sector of the systems described above is solar assisted district heating. Denmark is the leader by far not only in Europe but worldwide, in the number of systems and installed capacity.

The first solar assisted district heating system in Denmark was installed in the small town of Saltum in 1988. It has a collector area of 1,005 m² (0.7 MW_{th}). By the end of 2019 a total number of 123 systems with 1,554,973 m² collector area with an installed capacity of 1,089 MW_{th} (including extensions of existing systems) was installed in Denmark[7].

Most of the Danish installations are ground mounted flat plate collector fields hydraulically connected to load-balancing storages in close distance to the district heating main distribution line.

In 2019, fifteen solar district heating systems with collector areas between 2,300 m² (Lendemarke) and 25,300 m² (Sæby, stage 2) were built in Denmark.

The largest plants in operation in Denmark were installed in 2016 in Silkeborg (110 MW_{th}), 2011 in Vojens (50 MW_{th}; 69,991 m²), 2009 in Gram (31.4 MW_{th}; 44,836 m²) and 2014 in Dronninglund (26.3 MW_{th}; 37,500 m²). These systems are equipped with seasonal pit heat storages for solar fractions of around 50%.

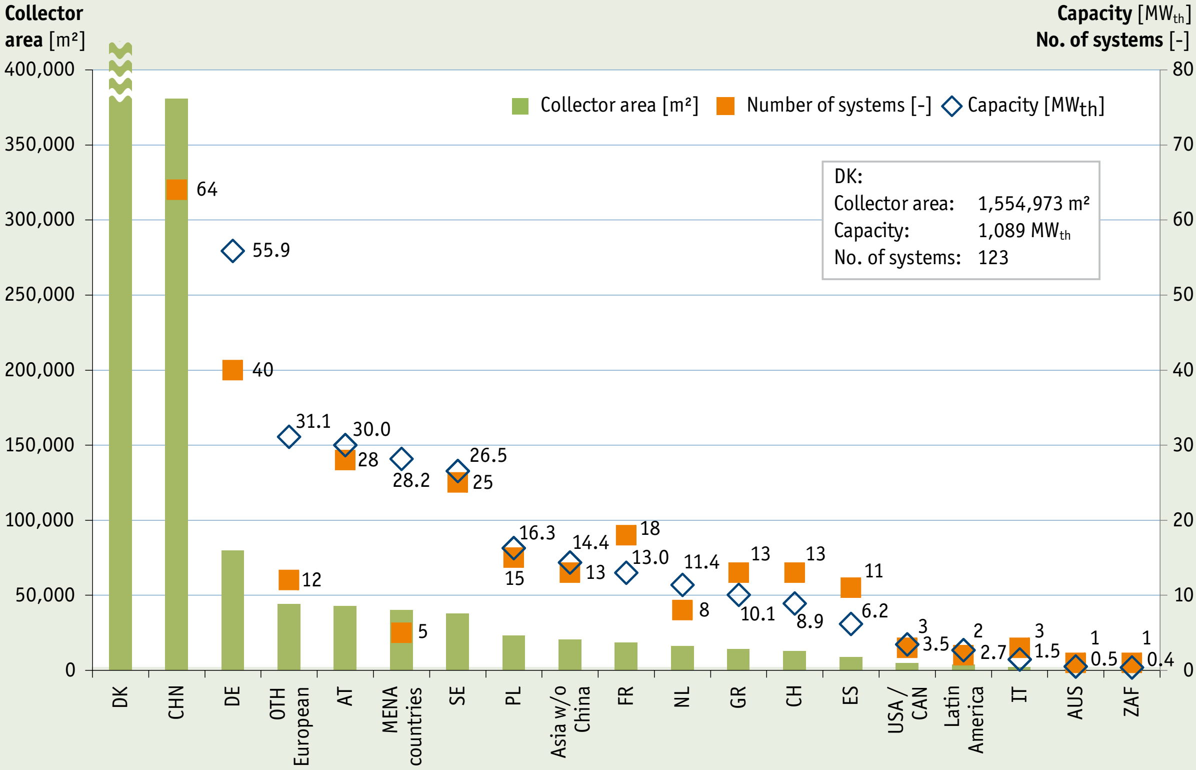


Figure 7: *Large-scale systems for solar district heating and residential buildings – capacities and collector area installed and number of systems in 2019 (concentrating systems and PVT collectors, which are excluded in the figure above, add up to 162,784 m²). (Data source: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 45, AT, Bärbel Epp - Solrico, DE)*

7 Daniel Trier, PlanEnergi, Arcon Sunmark Reference List http://arcon-sunmark.com/brochures, Jan-Olof Dalenbäck SDH – www.solar-district-heating.eu

The Zhongba solar district heating system in Tibet, China with 35,000 m² collector area (24 MW_{th}). Photo: Sunrain

In addition to Denmark (123 systems) and China (64 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 (40 large-scale systems, some of these with seasonal storage), Austria (28 systems), Sweden (25 systems) and France (18 systems). Regions outside Europe with large-scale installations for buildings and district heating are the MENA countries Jordan, Kuwait, Dubai and Saudi Arabia, Asia excluding China (Cambodia, India, Japan, Kyrgyszistan, Russia, Thailand and Turkey), the USA and Canada, Latin America (Brazil, Mexico), Australia and South Africa.

4.2.1 Large-scale systems connected to district heating in 2019

In 2019, 22 large-scale solar thermal systems connected to district heating (>500 m²) were added in Europe. Of these installations, 15 in Denmark[8] (66,800 m²), six in Germany (14,700 m²) and one in Latvia (21,700 m²). Out of Europe, three SDH systems were installed in China (57,386 m²).

The largest system installed in 2019 was in Zhongba, Tibet with a collector area of about 35,000 m² (24 MW_{th}). In addition, two other solar district heating systems were installed in Tibet. In all of China in 2019, the solar district heating systems installed totaled 57,386 m² collector area (40 MW_{th}).

In Europe, the large-scale systems for solar district heating installed in 2019 added 227,700 m² collector area (159 MW_{th}).

Denmark installed three systems ranking two to four (Ringe 31,224 m², Sæby stage 2 25,313 m² and Hadsten 24,517 m²).

The largest solar district installation in Europe, besides the Danish systems, was installed in Latvia. It marks the launch of a milestone project on solar district heating in Eastern Europe. The public utility that serves the Latvian town of Salaspils, near Riga, installed 21,672 m² of collector area (15 MW_{th}) to provide heat for its district heating network. The solar field is connected to an 8,000 m³ water storage tank, from which thermal energy is injected into the network. The project also includes a wood-chip boiler with 3 MW_{th} of capacity.

8 This includes five extensions of already existing systems in Grenaa, Jelling, Sæby, Karup and Nykøbing Sj.

Germany's largest solar district heating system in Ludwigsburg with a capacity of 10 MW_{th} was put into operation in early 2020.

Photo: Arcon / Sunmark

In 2019, six large-scale systems for solar heating networks were brought online in Germany, namely in Liggeringen, Gutleutmatten, Moosach, Potsdam, Halle / Saale and Erfurt.

4.3 Solar heat for industrial processes

The worldwide interest in solar thermal systems for industrial processes has grown steadily the past years. A number of promising projects implemented in the last couple of years range from small-scale demonstration plants to very large systems in the 100 MW_{th} sector.

A variety of industrial processes demand vast amounts of heat, which makes the industrial 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 from air collectors, flat plate and evacuated tube collectors for temperatures up to 100 °C to 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 2020, system designers and collector manufacturers reported 800 plants with an overall installed collector area of 1 million m² for solar process heat worldwide[9].

For 301 of these systems more detailed information on the collector area and installed capacity as well as type of application and type of collector can be found in the SHIP (Solar Heat for Industrial Processes) database, an online portal operated by AEE INTEC in Austria[10].

9 https://www.solarthermalworld.org/news/industrial-sector-sees-record-breaking-capacity-additions-2019

10 http://ship-plants.info/

The world's largest solar process heat plant Miraah in Oman was significantly enlarged in 2019 and now has an installed capacity of 300 MW_{th}.

Photo: GlassPoint Solar, Inc.

Please note that in this year's edition, only systems with a collector area larger than 50 m^2 are included in the evaluation. Subsequently, this excludes systems included in previous editions of the Solar Heat Worldwide report. A definition of the SHIP systems considered in this report can be found in Appendix, **chapter 8.6**.

Figures 8 – **12** show the analysis of the systems where detailed information was available, thus the overall number of systems analyzed is smaller than 800. The total collector area of the 301 documented systems >50 m^2 is 905,000 m^2_{gross} with a thermal capacity of 441 MW_{th}.

All the charts below are dominated by the world's largest solar process heat application Miraah in Oman, which was first commissioned in late 2017 and continues to be expanded. Currently, the thermal capacity in operation is 300 MW_{th}, which accounts for 68% of the total installed thermal capacity of all 301 documented solar process heat applications worldwide. When completed, the Miraah plant should have a total capacity of 1 GW_{th} and produce 6,000 tons of steam per day to be used in oil production.

The second largest system is installed at a copper mine in Chile with a thermal capacity of 27.5 MW_{th} and is used for the copper winning process.

Linear concentrating Fresnel collector system in Austria. *Photo: Ecotherm*

Figure 8 shows the distribution of the 301 systems in terms of size. The two systems mentioned above exceed 21 MW_{th} of thermal capacity (30,000 m²), 41 systems have installed capacities between 0.7 MW_{th} and 21 MW_{th} (1,000 – 29,999 m²) of thermal capacity, 59 systems have installed capacities between 0.35 and 0.7 MW_{th} (500 – 9,999 m²) and 199 systems are below 0.35 MW_{th} (<500 m²).

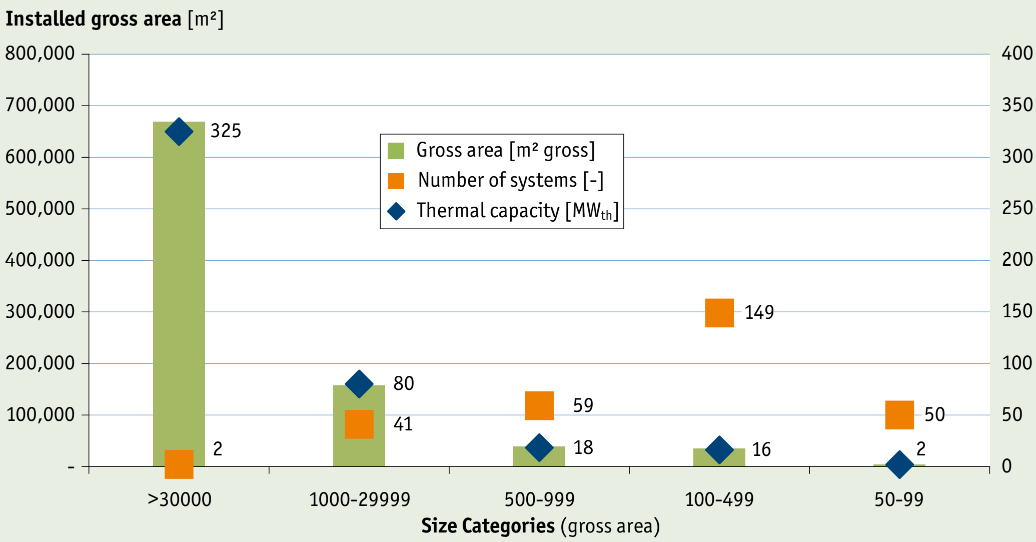


Figure 8: *Solar process heat applications in operation worldwide end of March 2020 by capacity and collector area. (Source: IEA SHC Task49 / IV SHIP database)*

Solar thermal and biogas systems supply the Goess brewery in Austria. Photo: Brauunion

Figure 9 shows the analyzed process heat 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 Miraah it would only be third in this category.

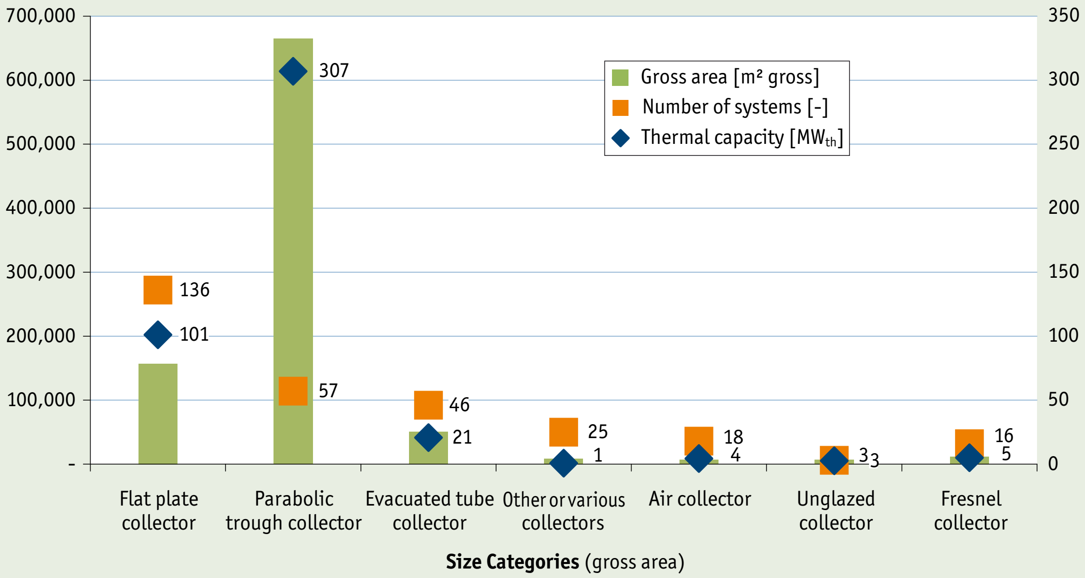


Figure 9: *Solar process heat applications in operation worldwide end of March 2020 by collector type. (Source: IEA SHC Task49/IV SHIP database)*

Figure 10 shows the industry sectors of the 301 detailed analyzed systems. The main sectors are mining, food and textile. The combined food and beverage sector accounts for 46% of all installed systems, however, they tend to be small to medium-sized so only represent 9% of the installed thermal capacity. Another promising sector is the textile industry with 25 installations and 26 MW_{th} (6%) of installed thermal capacity. The mining industry, which includes the two largest systems, is the dominant sector in terms of installed thermal capacity. The 13 systems account for 75% of the total installed thermal capacity. Noteworthy is the combined metal processing, machinery and automotive industry sector, which uses small systems (on average 329 m² collector area), includes 29 plants and 1% of the total installed thermal capacity.

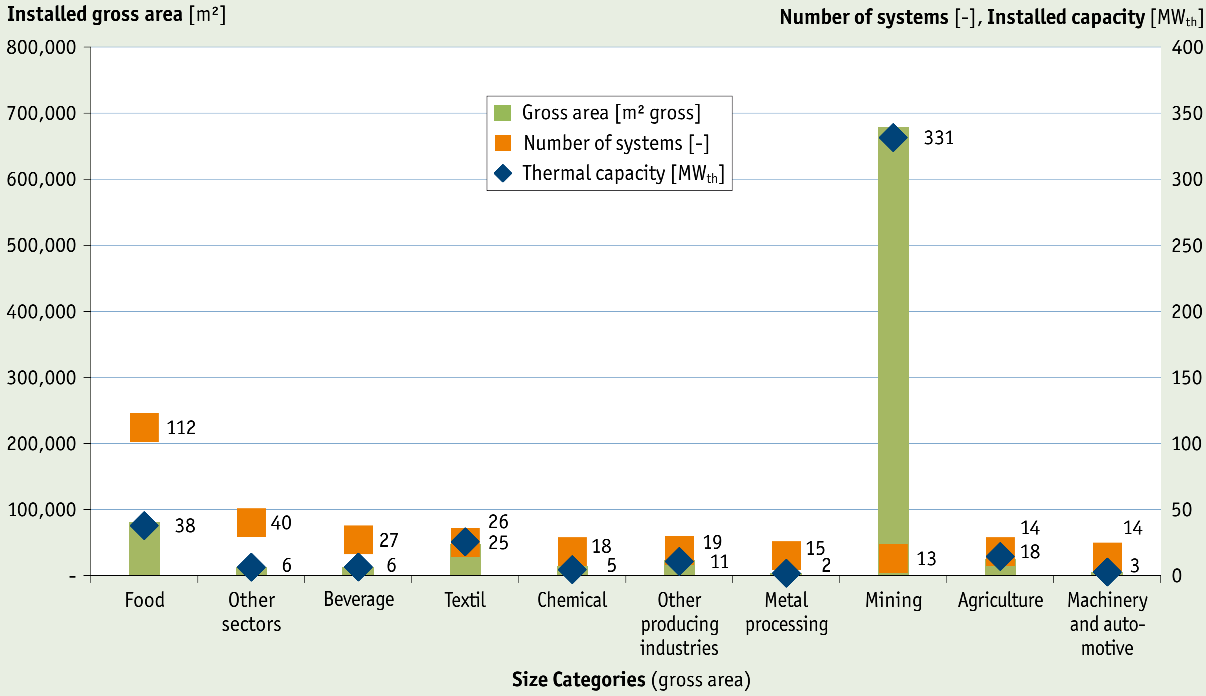


Figure 10: *Solar process heat applications in operation worldwide end of March 2020 by industry sector. (Source: IEA SHC Task49 / IV SHIP database)*

High vacuum flat plat collectors at a rubber factory in Ras Al Kaimah, United Arab Emirates *Photo: TVP Solar*

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

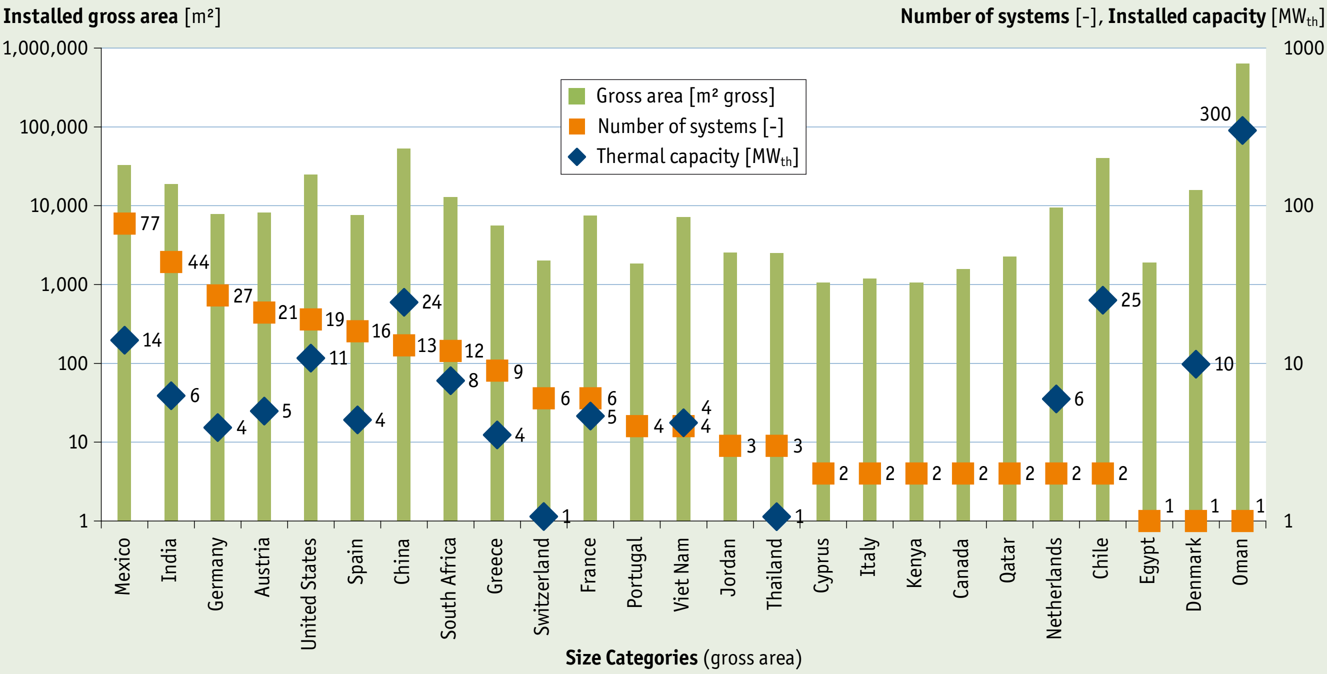
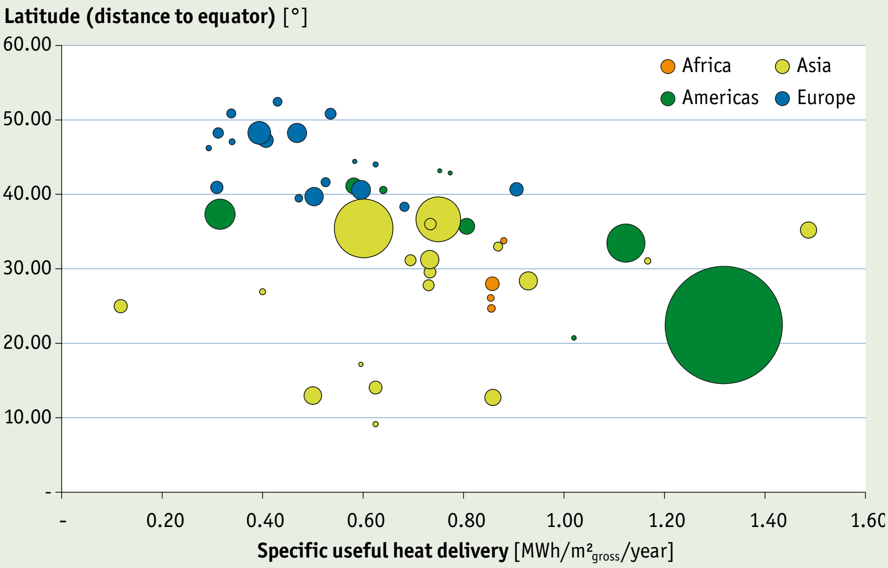


Figure 11: *Solar process heat applications in operation worldwide end of March 2020 by country. (Only countries with at least 0.7 MW_{th} (1,000 m² gross area) are shown, which is 281 of 301 systems, accounting for >99 % of installed thermal capacity). (Source: IEA SHC Task49 / IV SHIP database)*



Looking at the specific useful heat delivery in respect to latitude, Figure 13 illustrates the range. Specific heat delivery depends on the solar radiation, ambient temperature, process integration and process temperature level. Therefore, it has a wide range between 0.2 and about 1.5 for all countries.

Figure 12: *Specific useful heat delivery and latitude of selected installed systems (represents 50 of 301 systems) (Source: IEA SHC Task49 / IV SHIP database)*

Collector system with 6.5 MW_{th} for heating a greenhouse in Heerhugowaard, Netherlands. The application works as a drain-back system, which means that the collector fluid is water and not glycol. *Photo: G2 Energy*

4.3.1 Interesting new applications

In addition to the more traditional industrial sectors that use thermal solar systems highlighted above, there are two interesting niche sectors worth noting. The first is the recent development occurring in horticulture. Solar thermal plants are being used to heat greenhouses for flower or vegetable cultivation. The second is using solar thermal plants to heat natural gas at gas pressure regulation stations during pipeline transportation, an interesting niche application being used in several systems in Germany.

Solar heated greenhouses

Country	Site	Commis-sioned	Installed capacity [KW_{th}]	Collector size [m²]	Storage tank [m³]
Ethiopia	Arerti	2020	2,919	4,170	1,400
Guatemala	Chimaltenango	2020	1,523	2,175	300
Netherlands	Heerhugowaard	2019	6,510	9,300	1300
USA	Oregon	2019	721	1,030	n/a
Austria	Vienna	2018	88	126	20
Uganda	Kampala	2017	3,230	4,614	900
South Africa	Krugersdorp	2015	6,395	9,135	2100
Denmark	Østervang Varpelev	2015	9,878	14,112	4,800
Germany	Bohlingen	2015	672	960	n/a
Ethiopia	Addis Ababa	2014	1,949	2,784	400
Namibia	Okahandja	2014	2,598	3,712	1,900
Kenya	Naivasha	2013	336	480	150
Morocco	Aït Melloul	2013	705	1007	150

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

Solar heated gas pressure control systems

Solar thermal heating of gas pressure control systems in Großseelheim, Germany
Photo: EnerSolve GmbH

Natural gas is largely imported over long distances with high pressure in order to optimize the use of existing pipelines. Along the way, the gas needs to be decompressed in various stages until it can be fed into local gas grids situated close to final consumers. This central task of controlling the gas pressure level is done by gas pressure regulation and metering stations. There, the gas flow needs to be heated up prior to the process of decompression to avoid the gas from falling below the freezing point of water[11]. The heat demand is in most cases well balanced throughout the entire year and shows a favorable temperature level for the efficient utilization of solar thermal systems.
Several systems with collector areas between 135 m² and 440 m² are installed in Germany. The worldwide potential for such systems is relatively large. In Germany alone, there are 5,000 gas pressure regulation stations with suitable capacity.

4.4 PVT – Photovoltaic-Thermal Systems

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

The PVT market is gaining momentum in several European countries. In recent years, a growing number of specialized PVT technology suppliers have entered European markets.

4.4.1 General market overview

Photovoltaic-Thermal (PVT) collectors were included for the first time in the Solar Heat Worldwide report in 2019 and included data from a 2018 market survey carried out by IEA SHC Task 60 PVT Systems. By the end of 2018 more than 1 million m² of PVT collectors were installed in over 25 countries.

SHC Task 60 PVT Systems[12] carried out this survey again in 2019 with responses from 31 PVT collector manufactures and PVT system suppliers in 12 different countries. In 2019, the total installed PVT collector area was 1,166,888 m² (606 MW_{th},

11 Wimmer, L. et.al. (2019): Monitoring of renewable process heat plants within the gas sector.

12 http://task60.iea-shc.org/

208 MW_{peak}). The vast majority of this collector area was installed in Europe (675,427 m²) followed by Asia excluding China (281,104 m²) and China (133,942 m²), which together accounted for 567 MW_{th}, 194 MW_{peak} of the total installed capacity. The remaining installed collector area was shared between the MENA countries Egypt and Israel (57,509 m²), Sub-Sahara African countries (8,767 m²), USA (5,400 m²), Australia (547 m²) and Latin America (408 m²).

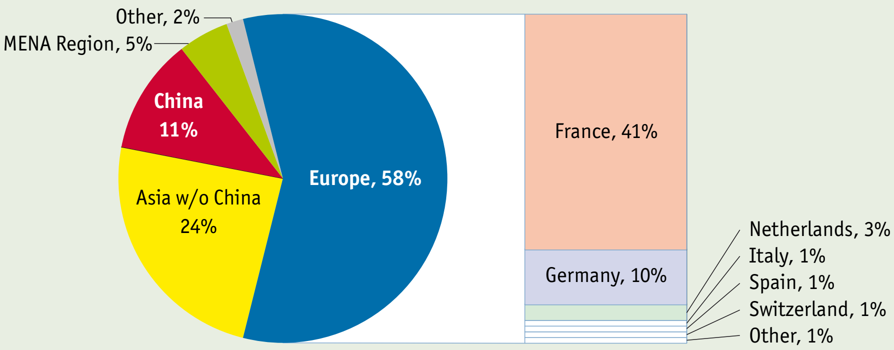


Figure 13: *Distribution of the total installed collector area by economic region in 2019. (Source: IEA SHC Task 60 survey, AEE INTEC)*

In the European market, France is the leader with an installed collector area of 484,587 m² followed by Germany with 112,326 m² and the Netherlands with 32,127 m². In Italy, Spain and Switzerland, collector areas range between 10,000 m² and 15,000 m². In the remaining European countries, collector areas of less than 10,000 m² were reported.

Table 2 shows the cumulated installed collector area by PVT collector type at the end of 2019.

Country	Water Collectors [m²]			Air Collectors [m²]	Concentators [m²]	TOTAL [m²]
	uncovered	covered	evacuated tube			
Australia	523	0	0	24	0	547
Austria	595	922	0	0	0	1,517
Belgium	712	0	16	290	15	1,033
Brazil	26	0	0	0	0	26
Chile	213	101	0	0	10	325
China	133,721	50	0	0	171	133,942
Denmark	85	0	0	0	0	85
Ecuador	0	4	0	0	0	4
Egypt	0	0	0	0	21	21
France	12,619	68	0	471,900	0	484,587
Germany	110,622	1,452	0	87	165	112,326
Ghana	8,000	0	0	0	0	8,000
Hungary	525	53	0	0	0	578
India	0	7	0	0	255	262
Israel	57,488	0	0	0	0	57,488
Italy	13,331	2,170	0	0	0	15,501
Korea, South	280,814	0	0	0	0	280,814
Luxembourg	635	0	0	145	0	780
Macedonia	260	74	0	0	0	334
Maldives	0	0	0	0	21	21
Netherlands	30,353	0	0	0	1,773	32,127
Norway	267	0	0	0	0	267
Pakistan	0	7	0	0	0	7
Paraguey	0	0	0	0	51	51
Portugal	335	0	0	0	0	335
South Africa	0	0	16	0	751	767
Spain	1,552	11,350	0	0	0	12,902
Sweden	0	0	0	0	31	31
Switzerland	7,720	36	0	3,530	0	11,286
United Kingdom	851	312	229	348	0	1,740
United States	5,400	0	0	0	0	5,400
Uruguay	0	2	0	0	0	2
Other	529	3,240	16	0	0	3,785
TOTAL	667,178	19,846	277	476,324	3,263	1,166,888

Table 2: *Total installed PVT collector area worldwide. (Source: IEA SHC Task 60 survey, AEE INTEC)*

4.4.2 Market development of PVT collectors between 2017 and 2019

Based on the market data from 31 PVT manufacturers, the market for PVT collectors was characterized by a significant global growth of +9% on average in 2018 and 2019. This trend was also observed in the European market with a slightly higher growth rate of +14%, which corresponds to an increase of the yearly new installed capacity of 40.8 MW_{th} and 13,3 MW_{peak}.

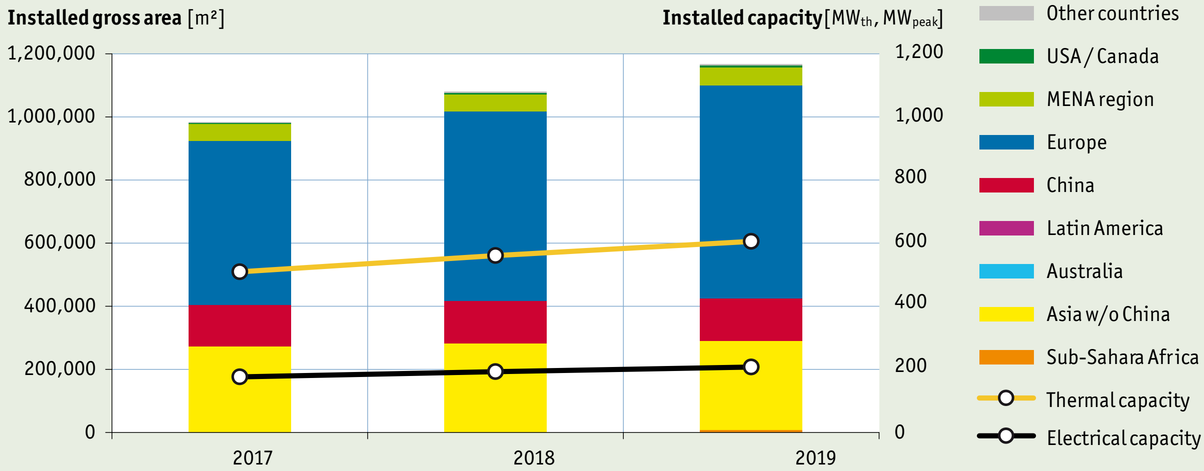


Figure 14: *Global market development of PVT collectors from 2017 to 2019 (Source: IEA SHC Task 60 survey, AEE INTEC)*

The following figure shows the total installed collector area and the distribution by PVT technologies by country in 2019 in Europe.

By the end of 2019, the total cumulative thermal capacity of PVT collectors was 606 MW_{th} and the PV power was 208 MW_{peak} installed worldwide. With a global share of 55% of installed thermal capacity, uncovered PVT water collectors were the dominating PVT technology produced, followed by PVT air collectors with 43% and covered PVT water collectors with 2%. Evacuated tube collectors and concentrators play only a minor role in the total numbers.

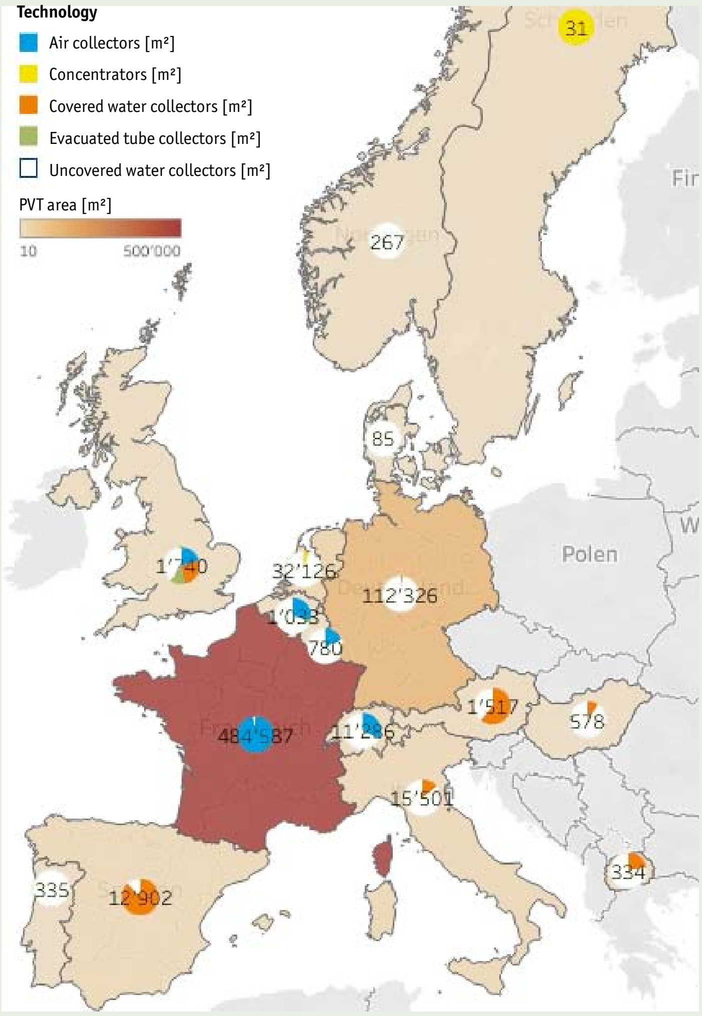


Figure 15: *Total installed collector area and PVT technology in Europe at the end of 2019. (Source: IEA SHC Task 60 survey, AEE INTEC)*

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	262	97	0	0	0	0	13	4	0	0	275	101
Austria	298	110	484	143	0	0	0	0	0	0	782	253
Belgium	357	132	0	0	7	2	158	49	8	2	529	184
Brazil	13	5	0	0	0	0	0	0	0	0	13	5
Chile	107	39	53	16	0	0	0	0	5	1	165	56
China	66,964	24,700	26	8	0	0	0	0	88	18	67,079	24,726
Denmark	43	16	0	0	0	0	0	0	0	0	43	16
Ecuador	0	0	2	1	0	0	0	0	0	0	2	1
Egypt	0	0	0	0	0	0	0	0	11	2	11	2
France	6,319	2,331	36	10	0	0	257,159	80,223	0	0	263,514	82,564
Germany	55,397	20,434	763	225	0	0	47	15	85	17	56,292	20,690
Ghana	4,006	1,478	0	0	0	0	0	0	0	0	4,006	1,478
Hungary	263	97	28	8	0	0	0	0	0	0	291	105
India	0	0	4	1	0	0	0	0	132	27	136	28
Israel	28,789	10,619	0	0	0	0	0	0	0	0	28,789	10,619
Italy	6,676	2,462	1,140	336	0	0	0	0	0	0	7,816	2,798
Korea, South	140,625	51,871	0	0	0	0	0	0	0	0	140,625	51,871
Luxembourg	318	117	0	0	0	0	79	25	0	0	397	142
Macedonia	130	48	39	11	0	0	0	0	0	0	169	59
Maldives	0	0	0	0	0	0	0	0	11	2	11	2
Netherlands	15,200	5,607	0	0	0	0	0	0	919	185	16,119	5,792
Norway	134	49	0	0	0	0	0	0	0	0	134	49
Pakistan	0	0	4	1	0	0	0	0	0	0	4	1
Paraguey	0	0	0	0	0	0	0	0	27	5	27	5
Portugal	168	62	0	0	0	0	0	0	0	0	168	62
South Africa	0	0	0	0	7	2	0	0	389	78	396	80
Spain	777	287	5,962	1,756	0	0	0	0	0	0	6,739	2,043
Sweden	0	0	0	0	0	0	0	0	16	3	16	3
Switzerland	3,866	1,426	19	6	0	0	1,924	600	0	0	5,809	2,032
UK	426	157	164	48	97	25	190	59	0	0	877	290
USA	2,704	997	0	0	0	0	0	0	0	0	2,704	997
Uruguay	0	0	1	0	0	0	0	0	0	0	1	0
Other	265	98	1,702	501	7	2	0	0	0	0	1,974	601
Total	334,107	123,238	10,425	3,071	118	30	259,570	80,975	1,691	341	605,910	207,655

Table 3: *Total installed thermal and electrical PVT collector capacity in 2019. (Source: IEA SHC Task 60 survey, AEE INTEC)*

4.4.3 Distribution by type of application

In 2019, suppliers of PVT technology commissioned at least 2,800 new PVT systems worldwide. The cumulated number of PVT systems in operation at the end of 2019 was 25,823. The break down is 86% for solar air(pre)heating and cooling of buildings followed by 7% for domestic hot water preparation for single family houses and 4% for solar combi-systems that supply both domestic hot water and space heating. Around 1% of the total installed capacity provided heat and electricity to large domestic hot water systems for multifamily houses, hotels, hospitals, schools, etc. The remaining systems account for around 2% and deliver heat and electricity to other applications, including swimming pool heating, district heating applications and solar heat for industrial applications.

Table 4 shows PVT systems by application.

PVT Applications	Number of installations [#]	Total collector area [m²]
Swimming pool heating	102	9,449
Domestic hot water systems SFH	1,767	60,588
Large domestic hot water systems	214	133,831
Solar combi systems for SFH	1,087	26,903
Large solar combi systems	265	57,024
Solar air systems	22,317	485,510
Solar district heating systems	20	11,082
Solar heat for industrial applications	51	21,624
Not classifiable		360,877
TOTAL		1,166,888

Table 4: *PVT systems by application. (Source: IEA SHC Task 60 survey, AEE INTEC)*

As shown in **Figure 16** 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 PVT collectors are the most common technology.

By the end of 2019, 3,296 systems with uncovered PVT collectors were in operation, corresponding to a gross area of 667,178 m². Out of these systems, 54% were used for domestic hot water preparation in single and multifamily houses, hotels, and hospitals. Around 33% of the systems supplied heat and electricity to households and to electric heating elements for domestic hot water and space heating (combi-systems).

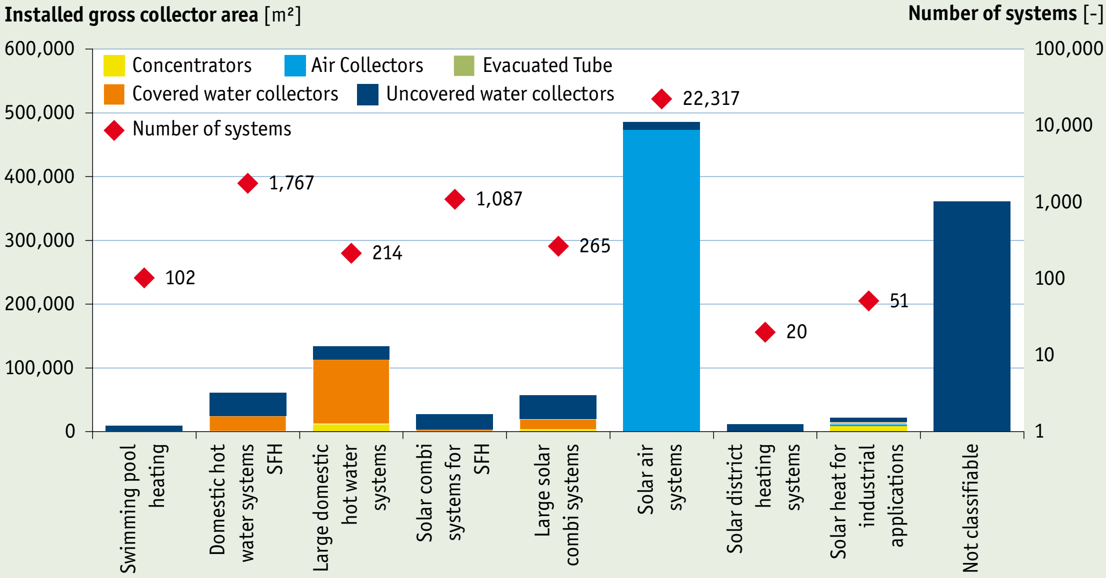
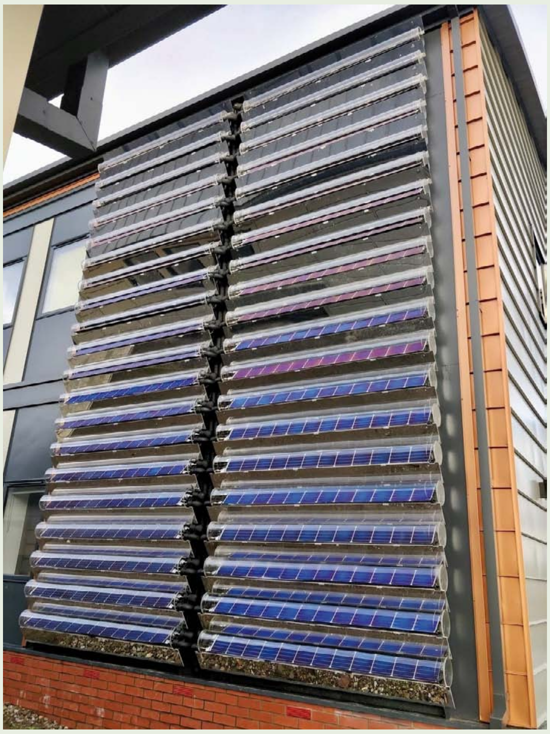


Figure 16: *PVT systems in operation worldwide by application, collector type and collector area at the end of 2019. (Source: IEA SHC Task 60 survey, AEE INTEC)*



Energy-positive office building in the UK with evacuated tube PVT collectors on the south facing façade.

Photo: Naked Energy

4.5 Solar air conditioning and cooling

4.5.1 Small and medium size applications

The global market for cooling and refrigeration will keep growing, particularly in emerging countries, and by 2050 37% of the total electricity demand growth will be due to the electricity demand of air conditioning[13]. Thus, there is huge 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[14]. A major argument for using solar thermally driven systems is that they consume less conventional energy (up to factor five[15]) 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. Nowadays, 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 capacity of the Indian national electricity supply[16]. In other countries, like the USA, the peak load through air conditioning reaches >70% in 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, Germany recently 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 minimum required performance[17].

Solar thermal cooling is still a small niche market with less than 2,000 systems deployed globally as of 2019. However, 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 capacity lower than 20 kW are getting more compact (and thus cheaper in upfront costs) and focused the mass markets. The sector of medium to large scale projects, 350 kW – 2,000 kW, is dominated by engineered systems. Still 70% of the small and medium capacity (< 350 kW) solar cooling systems worldwide are installed in Europe. According to a survey carried out in early 2019 by SOLRICO for REN21[18] in 2018 just a small number of new solar cooling systems in the small and medium range were installed, 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., HyCool[19], sol.e.h.2[20], Zeosol[21], etc.) as well as commercial solar thermal cooling projects are running, for example in China, Spain, USA, Egypt, Greece, Austria, Africa, and Thailand.

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13 https://www.iea.org/futureofcooling/
14 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
15 http://task53.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task53-C3-Final-Report.pdf
16 Low energy cooling and ventilation in indian residences, https://doi.org/10.1080/23744731.2018.1522144
17 https://www.bafa.de/DE/Energie/Energieeffizienz/Klima_Kaeltetechnik/klima_kaeltetechnik_node.html
18 Not published internal communication
19 Jakob, Uli; Kiedaisch, Falko (2019) Analysis of a solar hybrid cooling system for industrial applications, SWC 2019-SHC 2019, paper ID 12143.
20 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.
21 Roumpedakis, Tryfon; et al. (2019) Performance results of a solar adsorption cooling and heating unit, SWC 2019-SHC 2019, paper ID 11465

One megawatt of cooling capacity using solar thermal energy at a hospital in Managua, Nicaragua *Photo: SOLID Solar Energy Systems GmbH*

4.5.2 Solar Cooling with a cooling capacity larger than 350 kW

Solar cooling using thermal absorption chillers with a cooling capacity larger than 350kW/100RT has improved significantly in performance, and at the same time, decreased in costs. 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 scale make solar cooling applications for large office buildings, hotels, hospitals and commercial/industrial applications cost competitive.

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 that during peak demand solar cooling saves money by avoiding the need to purchase electricity at its highest cost. Solar thermal energy also is an easy way of storing the solar heat and shifting it for cooling demands in the evenings and nights, while keeping remaining energy for morning cooling.

The electricity needed by a solar cooling system, for example 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 40 in systems with optimized variable speed driven auxiliaries. Thus, the electric demand for air conditioning in a building is cut down 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, which is 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 m^2) 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, the completion of several new plants is expected. Two solar thermal cooling and process heat systems will be commissioned for a chemical industry and a food production site both located in Barcelona, Spain. One more system with 650 kW for industrial cooling and heating will be commissioned in Graz, Austria, and in Singapore, the Land Transport Authority has awarded the installation of an Environment Control System for 4-in 1 Rail & Bus Depot, which will include the world's largest solar thermal cooling system comprised of a 6,500 m^2 solar collector field and a 1,794 kW absorption chiller.

Country	Site	Commis-sioned	Installed capacity [kW_{th}]	Collector size [m^2]	Collector type	Cooling capacity [kW_{cold}]
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 2018*

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

4.6 Solar air heating systems

Solar air heating systems have been used mainly in North America, Australia and Japan, and to a lesser extent in other countries, in residential buildings, schools, municipalities, and military and commercial buildings.

Storage of the heat is possible, but most solar air systems do not include storage to minimize costs. Solar air heating systems in North America are typically designed to cover between 20 to 30% of the annual space heating demand of a building.

The heating of large production halls using unglazed air collectors has also become more widespread, especially in North America. These unglazed air collectors are often perforated wall cladding systems that use fans to draw air through thousands of tiny holes of the air collector. The collector (absorber), when exposed to direct sunlight, transfers heat to the air as it passes into the building.

Medicinal herb drying with air collectors in Cuba. *Photo: CONA Solar, Austria*

Working on similar principles, a glazed air collector heating system consists of a metal case in which dark air ducts, covered by glass, absorb heat from sunlight. Fans draw fresh air into the ducts, which emerges heated and proceeds through the ventilation system or directly into the building.

Solar air heaters are also common in agricultural applications primarily for drying agricultural goods, timber, coffee and herbs as well as for wood chip drying.

The following table shows the Top 10 countries using solar air collectors.

Country	Air Collectors [m²]		TOTAL [m²]
	unglazed	glazed	
Canada	423,227	50,114	473,341
Australia	370,000	12,800	382,800
Japan		281,669	281,669
United States	121,882	69,500	191,382
Denmark	4,300	18,000	22,300
India		12,150	12,150
France	9,658	1,100	10,758
China	7,000	3,000	10,000
Mexico	752	8,773	9,525
Hungary	3,418	2,300	5,718

Table 6: *Top 10 countries using air collectors*[22]

By the end of 2018, a total of 1,084 MW_{th} (1,548,143 m²) of glazed and unglazed air collectors were installed worldwide. The annual worldwide market in 2018 was in the range of 30 MW_{th} (43,280 m²).

22 Total installed air collector area in operation in 2018

5 Detailed global market data and country statistics 2018

The following chapters of the report show detailed solar thermal market figures for the year 2018 and country figures for 68 countries.

Background of the presented data

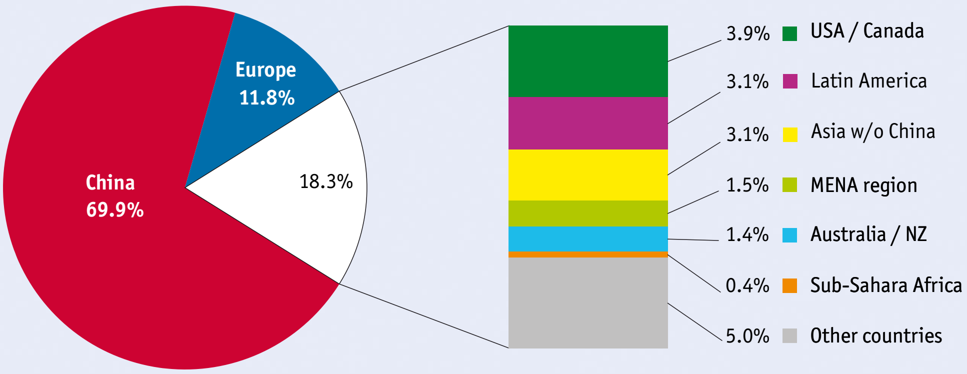
The following chapters of the report show figures of the actual collector area in operation in 2018 and not the cumulated collector area installed in a country, meaning that system lifetimes are considered. To determine the collector area and respective capacity in operation, either official country 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. According to the CSTIF approach, the operation lifetime is 10 years. For Germany, a lifetime of 20 years is used.

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 2018, an installed capacity of 483 GW_{th}, corresponding to a total of 690 million m^2 of collector area was in operation worldwide.

The vast majority of the total capacity in operation was installed in China (337.6 GW_{th}) and Europe (56.8 GW_{th}), which together accounted for 81.7 % of the total installed capacity. The remaining installed capacity was shared between the United States and Canada (18.6 GW_{th}), Latin America (14.8 GW_{th}), Asia excluding China (14.7 GW_{th}), the MENA countries Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (7.1 GW_{th}), Australia and New Zealand (6.6 GW_{th}), and Sub-Sahara African countries Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa and Zimbabwe (1.7 GW_{th}). The market volume of "*all other countries*" is estimated to amount to 5 % of the total installations (24.1 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 2018

Country	Water Collectors [MW_{th}]			Air Collectors [MW_{th}]		TOTAL [MW_{th}] excl. concentrators
	unglazed	FPC	ETC	unglazed	glazed	
Albania		175.0	5.6			181
Argentina	13.0	14.6	34.6			62
Australia	3,889.2	2,414.3	147.7	259.0	9.0	6,719
Austria	236.8	3,286.0	60.2		3.3	3,586
Barbados		165.6				166
Belgium	31.5	382.3	69.5			483
Botswana		7.9	1.6			9
Brazil	4,198.8	6,968.5	91.0			11,258
Bulgaria		96.4	3.4			100
Burkina Faso		2.2	0.5			3
Canada	553.1	49.4	34.9	296.3	35.1	969
Cape Verde		1.5				2
Chile	45.9	164.2	38.0		0.2	248
China		32,165.0	305,452.0	4.9	2.1	337,624
Croatia		152.3	8.4			161
Cyprus	1.5	533.2	16.5			551
Czech Republic	350.0	331.0	100.0			781
Denmark	14.4	1,154.4	6.4	3.0	12.6	1,191
Estonia		6.8	5.5			12
Finland	8.3	25.6	14.0			48
France (mainland)+	69.8	1,749.8	131.4	6.8	0.8	1,958
Germany	364.1	12,044.2	1,468.3		14.6	13,891
Ghana		1.7	0.6			2
Greece		3,283.7	15.4			3,299
Hungary	12.8	163.6	52.6	2.4	1.6	233
India	0.0	3,060.0	6,397.5	0.0	8.5	9,466
Ireland		148.3	85.1			233
Israel	27.3	3,323.9				3,351
Italy	30.7	2,829.7	444.3			3,305
Japan		2,523.6	56.8		197.2	2,778
Jordan*	4.2	687.7	190.5			882
Korea, South		1,194.3	129.5			1,324
Latvia		8.5	2.3			11
Lebanon		247.0	335.9			583
Lesotho		1.1	0.5			2
Lithuania		5.5	7.6			13
Luxembourg		39.5	6.2			46
Northern Macedonia		42.2	25.5			68
Malta		40.8	10.2			51
Mauritius**		93.0				93
Mexico	993.1	1,129.7	904.1	0.5	6.1	3,034
Morocco*		315.7				316
Mozambique	0.1	0.4	1.6			2
Namibia	1.1	30.4	1.0			32
Netherlands	61.3	366.0	32.6			460
New Zealand***	4.9	100.1	6.8			112
Nigeria		0.8	2.6	0.0	0.6	4.0
Norway	1.3	26.6	2.9	0.1	2.9	34
Palestinian Territories		1,248.2	5.8			1,254
Poland		1,447.4	343.4			1,791
Portugal	1.5	748.5	20.5			770
Romania	0.2	75.6	67.4	0.6		144
Russia	0.1	14.9	2.6	0.0	0.0	18
Senegal		1.2	2.2	0.0	0.8	4.2
Slovakia	0.7	101.1	18.7			121
Slovenia		87.2	16.4			104
South Africa	863.9	452.1	205.1	0.0	0.0	1,521
Spain	109.2	2,751.2	157.2	2.3	0.9	3,021
Sweden	119.3	204.4	50.8			374
Switzerland	131.1	958.6	95.9			1,186
Taiwan	1.4	1,125.5	93.3			1,220
Thailand****		110.3				110
Tunisia		674.7	49.1			724
Turkey		12,499.3	5,097.0	7.0		17,603
United Kingdom	366.2	426.2	217.5	16.5		1,026
United States	15,734.9	2,079.9	119.7	85.3	48.7	18,069
Uruguay		53.2				53
Zimbabwe		15.3	26.5			42
All other countries (5%)	1,486.4	5,612.0	16,999.5	36.0	18.2	24,152
TOTAL	29,728	112,241	339,990	721	363	483,043

Note: If no data is given: no reliable database for this collector type is available
* 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 territories of France (DOM) are not considered

Table 7: *Total capacity in operation in 2018 [MW_{th}]*

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL (excl. concentrators) [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
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	233,700	75,100	3,418	2,300	332,818
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		1,706,196	184,959			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*		451,000				451,000
Mozambique	144	641	2,351			3,136
Namibia	1,560	43,457	1,377			46,393
Netherlands	87,600	522,800	46,600			657,000
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		124,500	23,400			147,900
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%)	2,123,422	8,017,193	24,285,024	51,477	25,930	34,503,046
TOTAL	42,468,435	160,343,867	485,700,484	1,029,536	518,608	690,060,930

Note: If no data is given: no reliable database for this collector type is available
* Total collector area in operation refers to the year 2014
** Total collector area in operation refers to the year 2015
*** Total collector area in operation refers to the year 2009
**** Total collector area in operation refers to the year 2016
+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered

Table 8: *Total installed collector area in operation in 2018 [m²]*

The total installed capacity in operation in 2018 was divided into flat plate collectors (FPC): 112.2 GW_{th} (160.3 million m^2), evacuated tube collectors (ETC): 340 GW_{th} (485.7 million m^2), unglazed water collectors: 29.7 GW_{th} (42.5 million m^2), and glazed and unglazed air collectors: 1.1 GW_{th} (1.6 million m^2).

With a global share of 70.4%, evacuated tube collectors were the predominant solar thermal collector technology, followed by flat plate collectors with 22.6% and unglazed water collectors with 6.1% (**Figure 18**). Air collectors play only a minor role in the total numbers.

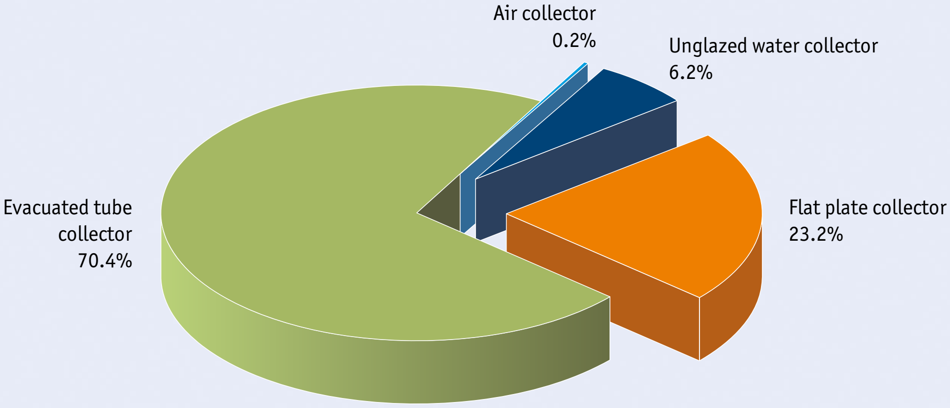


Figure 18: *Distribution of the total installed capacity in operation by collector type in 2018 – WORLD*

By contrast in Europe, the second largest market to China, flat plate collectors were the dominant collector type (**Figure 19**). Compared to 2017, the share of evacuated tube collectors decreased in Europe by 0.6% and the share of unglazed water collectors increased by 3.4%.

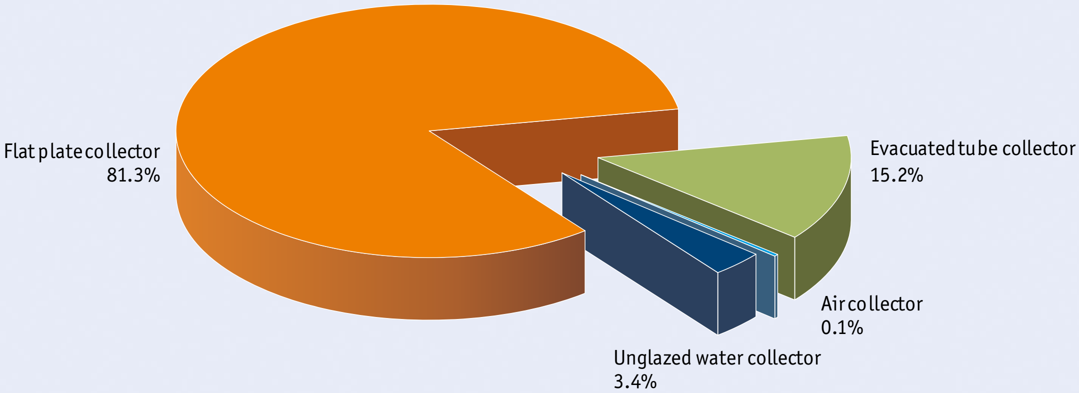


Figure 19: *Distribution of the total installed capacity in operation by collector type in 2018 – EUROPE*

Figure 20 shows the cumulated installed capacity of glazed and unglazed water collectors in operation for the 10 leading markets in 2018 in total numbers.

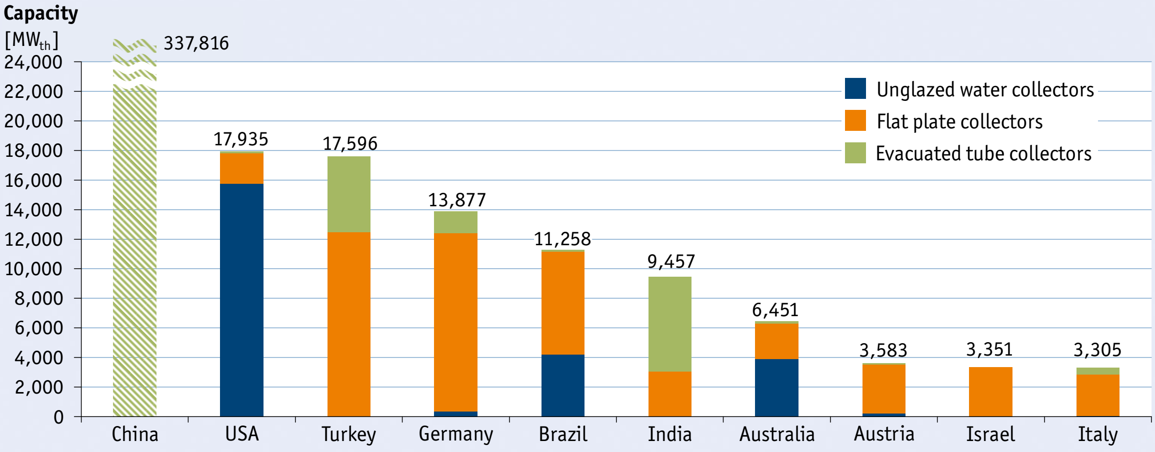


Figure 20: *Top 10 countries of cumulated water collector installations in 2018 (absolute figures in MW_{th})*

Compared to the year 2017, Italy replaced Greece in the top 10 country ranking. Turkey moved past Germany to the third position in 2015 and has held that position since and in 2015 India overtook Australia for the number six position. Both countries show how the market is shifting from historically dominated OECD countries to non-OECD countries.

China remained the world leader in total capacity, and its market is dominated by evacuated tube collectors. The United States held its second 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 Italy, flat plate collectors were the most dominant collector technology. In Turkey, a strong trend towards evacuated tube collector technology can be seen over the past few years.

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 2018 per 1,000 inhabitants were Barbados (565 kW_{th}/1,000 inhabitants), Cyprus (446 kW_{th}/1,000 inhabitants), Austria (408 kW_{th}/1,000 inhabitants), Israel (398 kW_{th}/1,000 inhabitants), Greece (309 kW_{th}/1,000 inhabitants), the Palestinian territories (271 kW_{th}/1,000 inhabitants), Australia (261 kW_{th}/1,000 inhabitants), China (244 kW_{th}/1,000 inhabitants), Turkey (217 kW_{th}/1,000 inhabitants), and Denmark (202 kW_{th}/1,000 inhabitants).

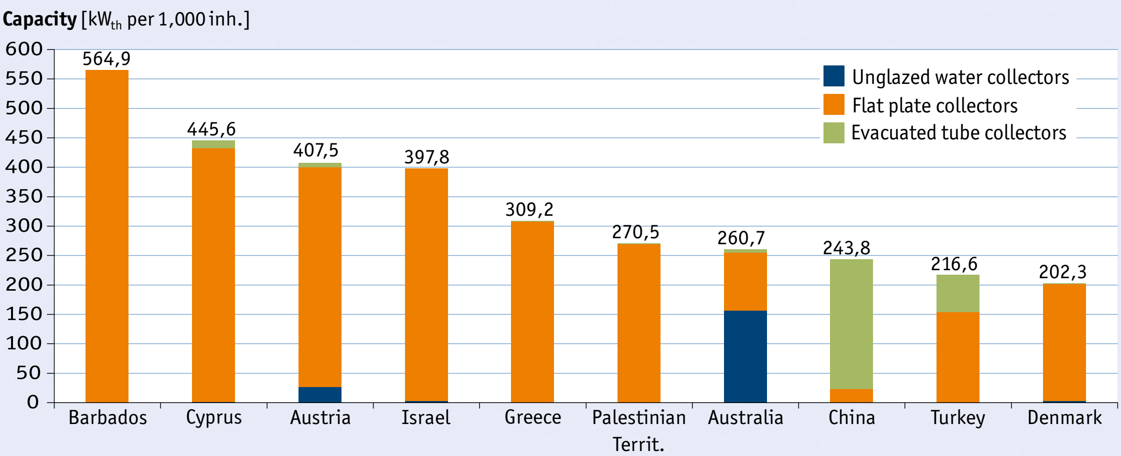


Figure 21: *Top 10 countries of cumulated water collector installations per 1,000 inhabitants in 2018 (relative figures in kW_{th})*

5.2 Total capacity of glazed water collectors in operation

With 337.6 GW_{th}, China was once again by far the leader in terms of total installed capacity of glazed water collectors in 2018. With >10 GW_{th} of installed capacity, Turkey and Germany were next. Several countries, namely India, Brazil, Austria, Israel, Greece, Italy, Spain, Japan, Australia, the United States, Mexico, France, Poland, South Korea, the Palestinian Territories, Taiwan, Denmark and Switzerland had more than 1 GW_{th} of water collectors installed by the end of 2018 (**Figure 22**).

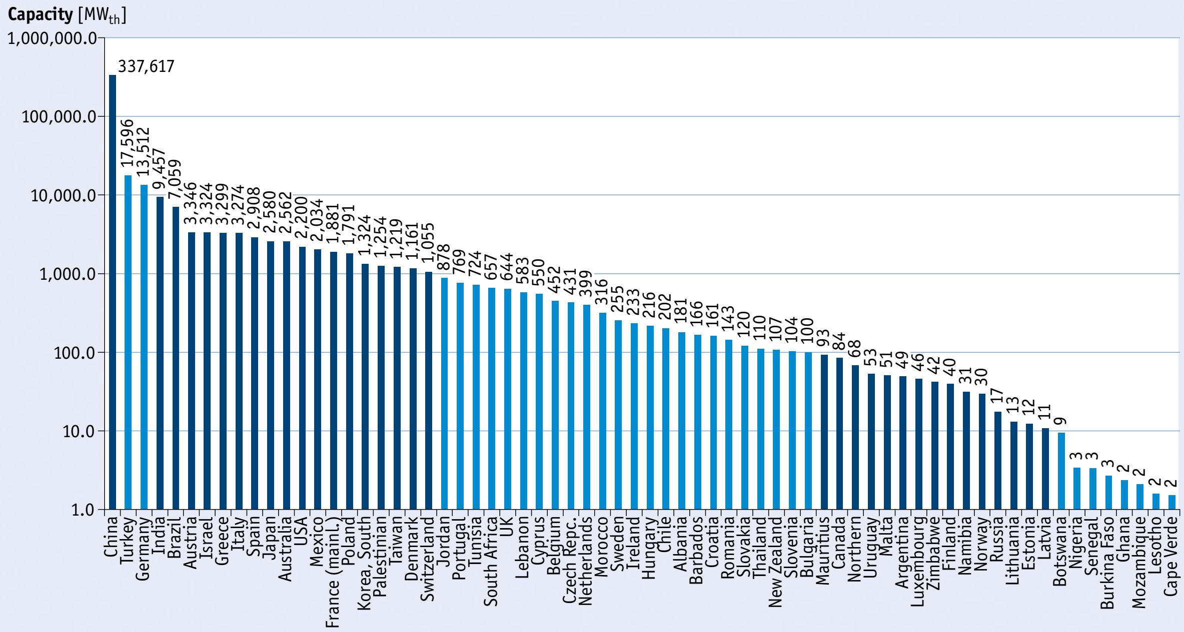


Figure 22: *Total capacity of glazed water collectors in operation by the end of 2018*

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 seventh 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**).

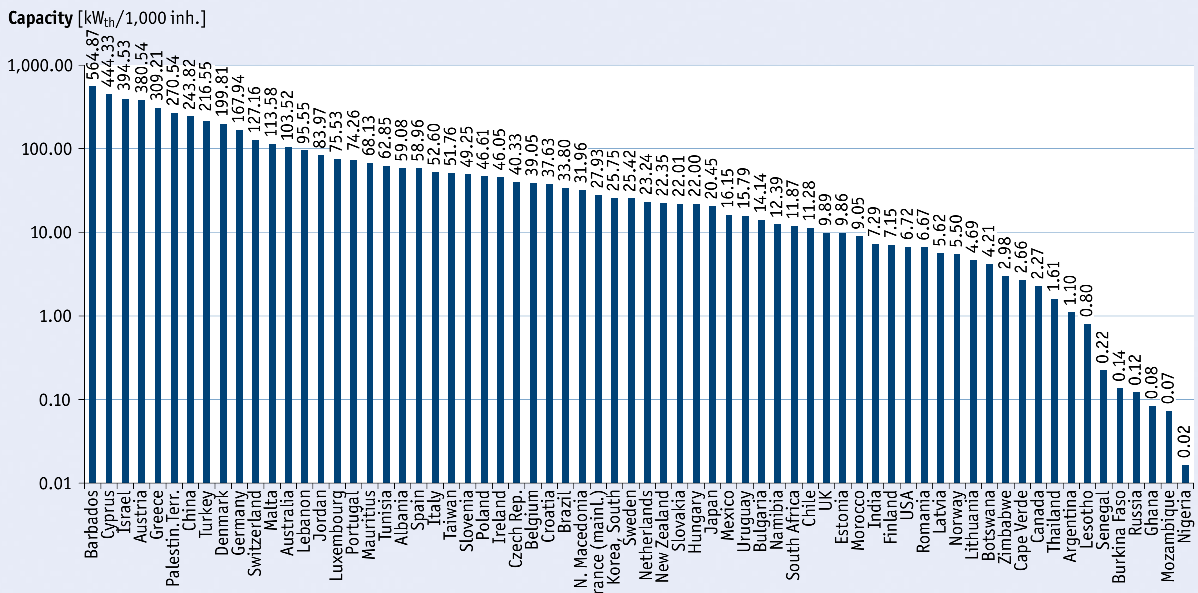


Figure 23: *Total Capacity of glazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2018*

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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 mostly in the middle or in the last third of the ranking.

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.

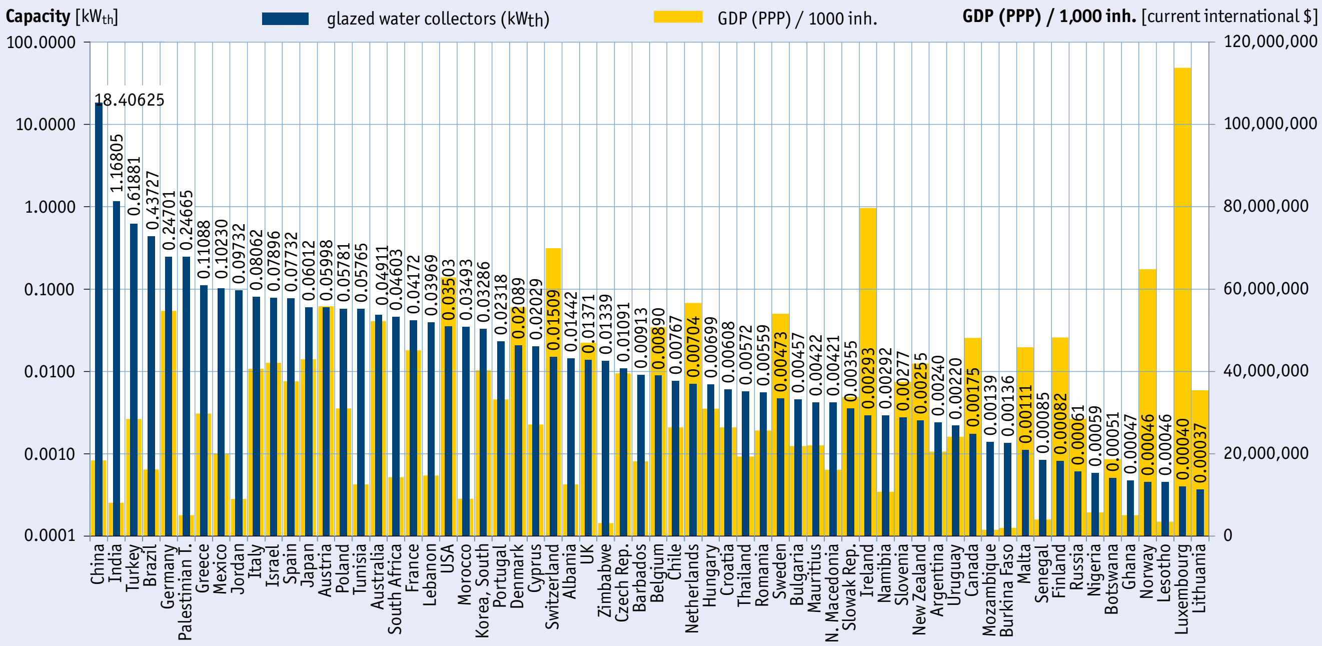


Figure 24: *Cumulated capacity of glazed water collectors per GDP / 1,000 inhabitants in 2018*[23]

23 Source of GDP: UN Data

Figure 25 and Figure 26 show the solar thermal market penetration per capita worldwide and in Europe.

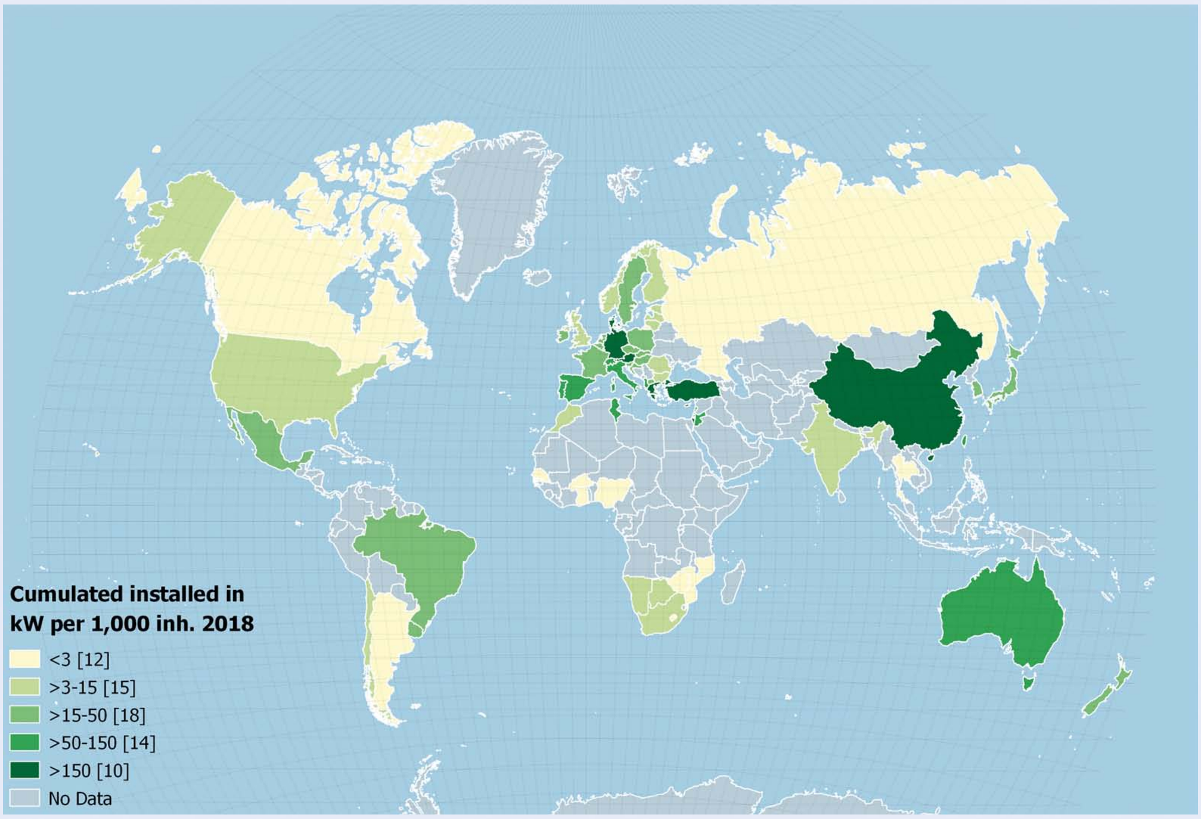


Figure 25: *Solar thermal market penetration per capita in kW_{th} per 1,000 inhabitants – WORLD*

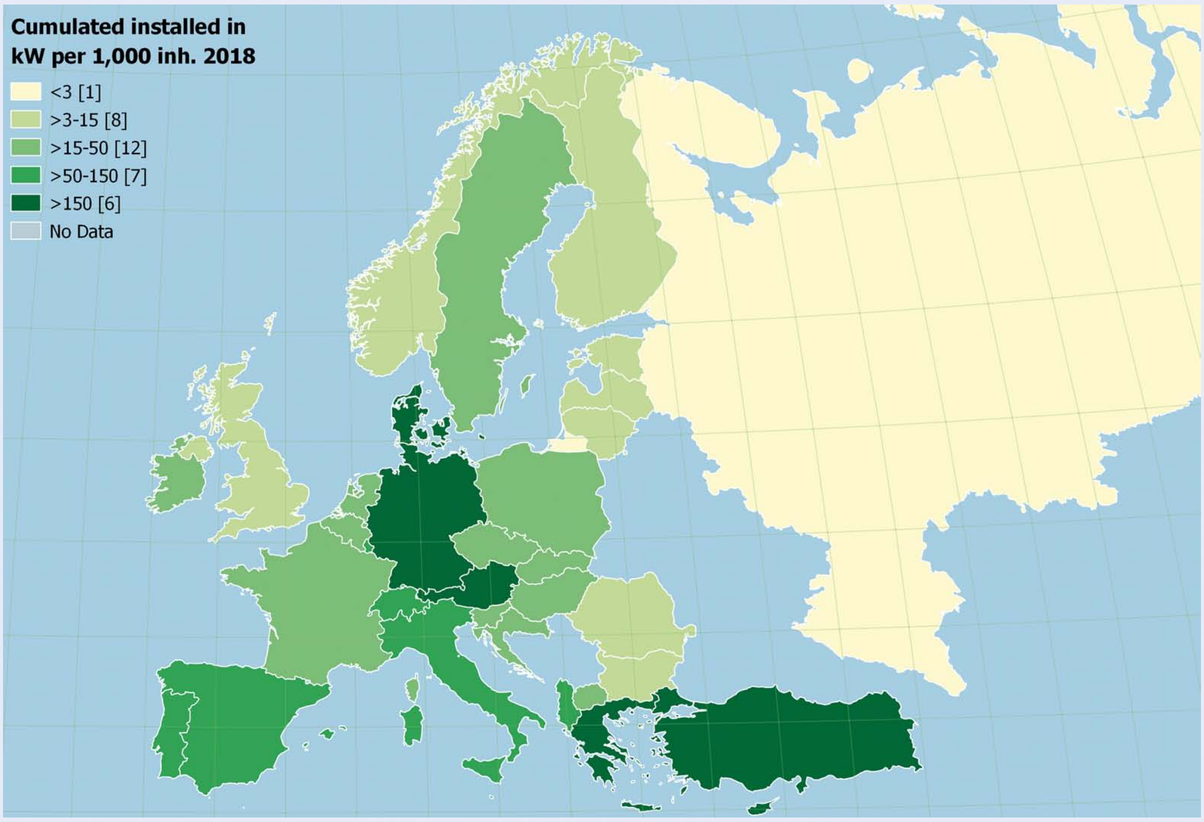


Figure 26: *Solar thermal market penetration per capita in kW_{th} per 1,000 inhabitants – EUROPE*

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

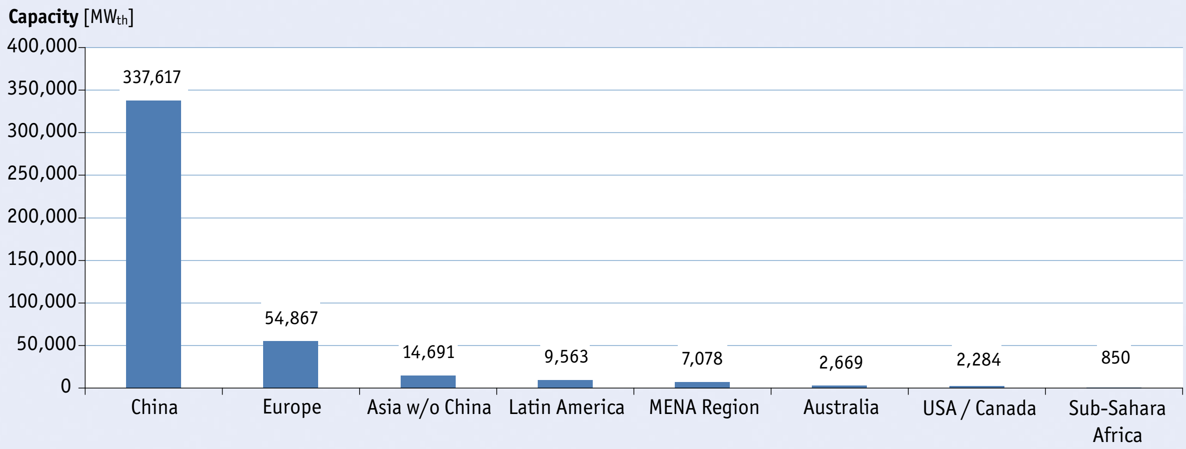
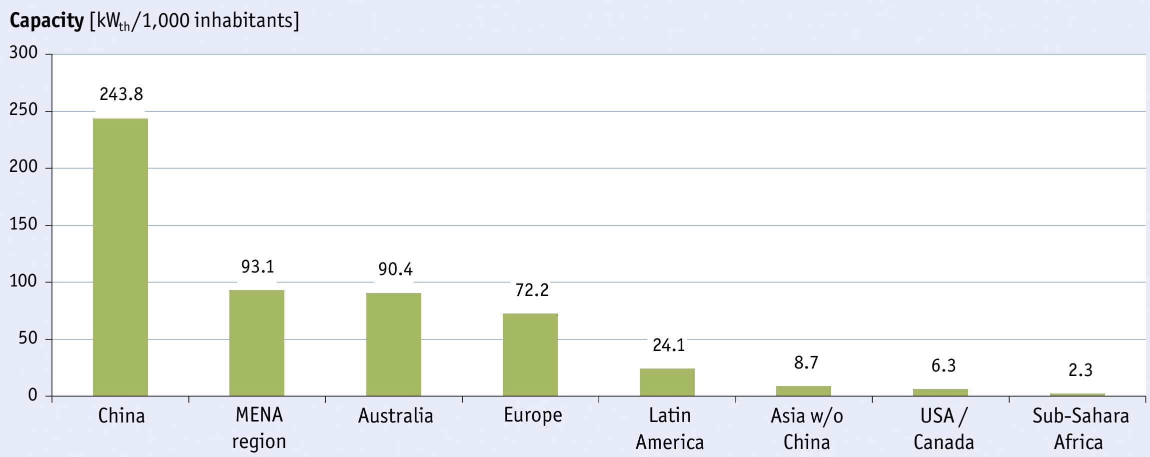


Figure 27: *Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region in 2018*

In terms of market penetration per capita by economic region, China again takes the lead. It is remarkable that 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 penetrations.



Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia excluding 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 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 2018*

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 share of unglazed water collectors in the total installed collector capacity was reduced from 21%[24] in 2005 to just 6% in 2018. **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 2018.

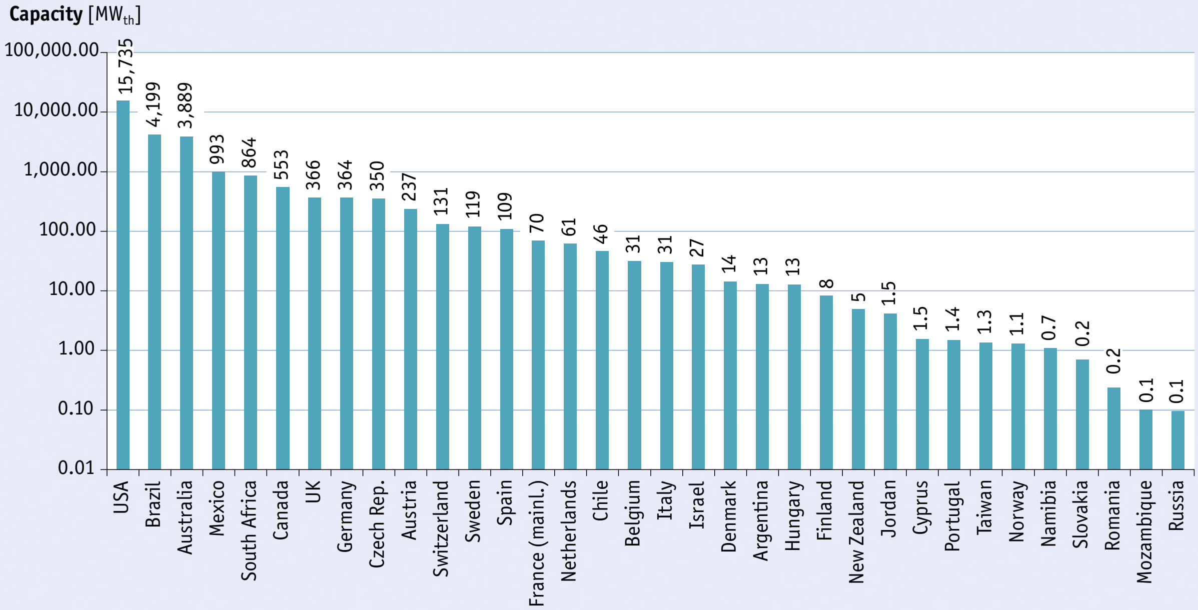


Figure 29: Total capacity of unglazed water collectors in operation in 2018

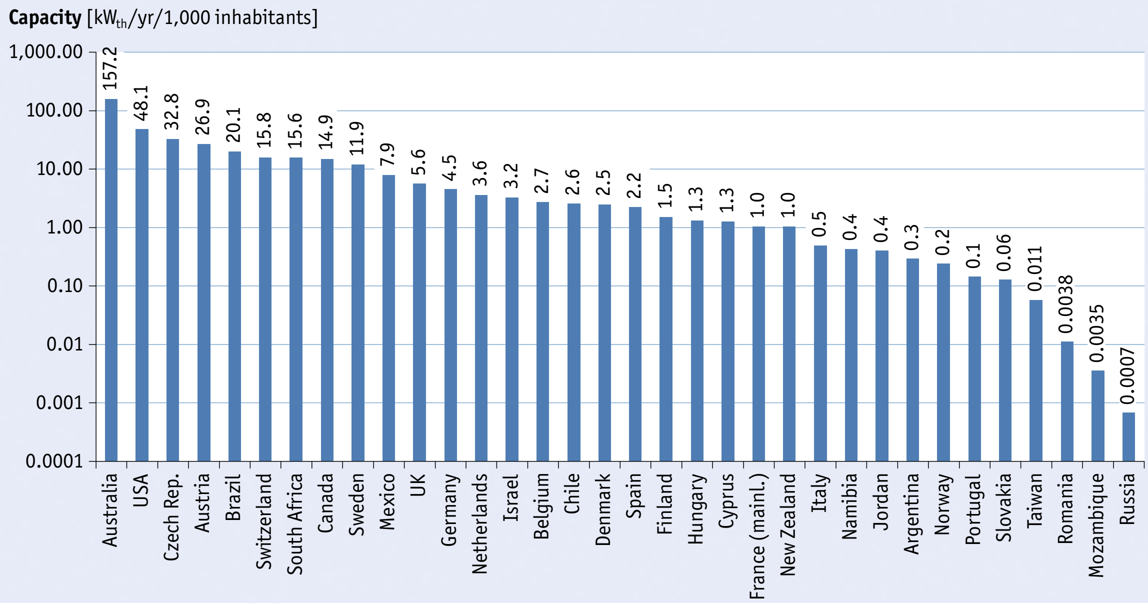
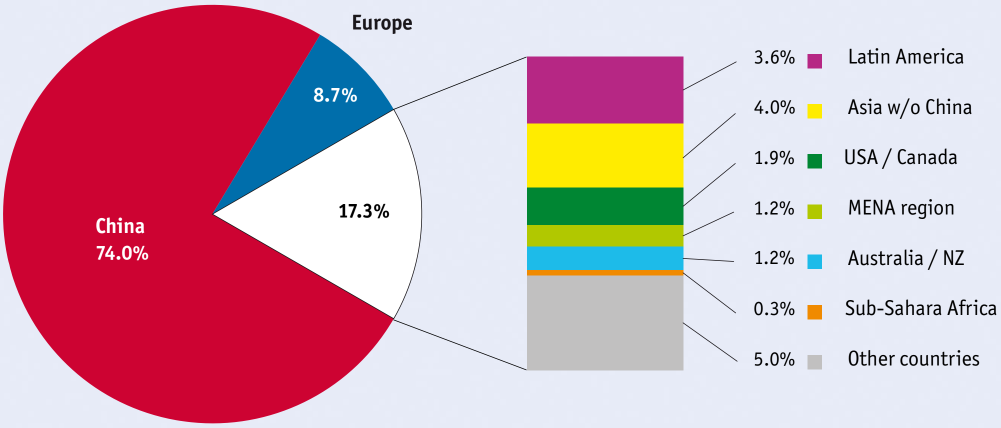


Figure 30: Total capacity of unglazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2018

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

5.5 Newly installed capacity in 2018 and market development

In 2018, a total capacity of 33.5 GW_{th}, corresponding to 47.9 million m^2 of new solar collectors was installed worldwide. The main markets were in China (24.8 GW_{th}) and Europe (2.9 GW_{th}), which together accounted for 82.7 % of the overall new collector installations in 2018. The rest of the market was shared between Latin America (1.2 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 5 % of the new installations (1.7 GW_{th}).



Sub-Sahara Africa:	Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia excluding 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 2018*

Of the top 10 markets in 2018, positive market development was reported from India (17 %) Mexico (4 %) and Greece (4 %). Other countries with impressive market growth were Poland (179 %) and Denmark (128 %). Cyprus showed a 5 % increase compared to 2017.

Country	Water Collectors [MW$_{th}$]			Air Collectors [MW$_{th}$]		TOTAL [MW$_{th}$]
	unglazed	FPC	ETC	unglazed	glazed	excl. concentrators
Albania		16.1	1.9			18.1
Argentina	6.5	7.3	17.3			31.1
Australia	280.0	115.5	12.7	3.5	0.7	412.4
Austria	0.4	68.0	0.8		0.5	69.6
Barbados*		8.6				8.6
Belgium		17.5	3.4			20.9
Botswana**		0.6	0.3			0.9
Brazil	439.1	416.1	19.9			875.1
Bulgaria		3.2	0.3			3.5
Burkina Faso**		0.1	0.2			0.3
Canada	0.7	0.2	0.2	9.5	0.8	11.4
Cape Verde**		0.3				0.3
Chile		14.9	0.3			15.2
China		4,186.0	20,615.0	2.1	0.7	24,803.8
Croatia		13.2	0.4			13.6
Cyprus		39.6	0.0			39.6
Czech Republic	21.0	11.6	5.3			37.8
Denmark		50.3		0.0		50.3
Estonia		0.6	0.4			1.1
Finland		1.9	0.6			2.5
France (mainland)+	0.8	40.0	1.3	0.7		42.9
Germany		353.5	48.0			401.5
Ghana**		0.5	0.2			0.7
Greece		230.0	0.4			230.3
Hungary	0.4	7.7	1.4	0.5	0.1	10.0
India		149.1	1,102.7		0.2	1,252.0
Ireland		5.3	3.3			8.6
Israel	0.7	290.5				291.2
Italy		110.5	15.1			125.6
Japan		52.2	0.8		2.1	55.1
Korea, South		6.3	8.0			14.3
Latvia		0.9	0.2			1.1
Lebanon		10.8	20.5			31.3
Lesotho		0.0	0.1			0.1
Lithuania		0.5	0.9			1.4
Luxembourg		2.4	0.0			2.4
Northern Macedonia		3.6	8.0			11.6
Malta		0.3	0.1			0.4
Mexico	83.6	106.1	94.2			283.9
Mozambique**		0.2	0.4			0.6
Namibia		2.8	0.0			
Netherlands	1.8	22.0	4.8			28.6
Nigeria		0.3	2.5		0.6	3.3
Norway		0.9	0.1			1.0
Palestinian Territories		31.4	0.0			31.4
Poland		210.0	7.0			217.0
Portugal		32.2	0.7			32.9
Romania	0.0	5.0	6.7			11.8
Russia		0.4	0.3			0.7
Senegal**		1.2	0.9	0.0		2.1
Slovakia	0.0	5.6	1.1			6.7
Slovenia		1.0	0.1			1.2
South Africa	45.7	28.7	19.3			93.7
Spain	2.7	134.4	6.8			143.9
Sweden	0.0	1.2	0.1			1.3
Switzerland	3.9	37.4	3.6			44.9
Taiwan		25.2				25.2
Tunisia		44.7				44.7
Turkey		663.6	652.4	0.3		1,316.3
United Kingdom	9.1	4.6	1.3	0.4		15.4
United States	511.1	106.8	5.6	3.5	2.8	629.8
Uruguay		4.6				4.6
Zimbabwe		0.0	12.5			12.5
Other (5%)	74.1	405.6	1,195.3	1.1	0.4	1,676.5
TOTAL	1,481.6	8,111.7	23,905.5	21.5	8.8	33,529.2

Note: If no data is given: no reliable database for this collector type is available.
* Country market data for new installations in 2018 estimated by AEE INTEC
+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered

Table 9: *Newly installed capacity in 2018 [MW$_{th}$/ a]*

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	29,450,000.0	3,000.0	1,000.0	35,434,000.0
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	57,185.0	1,840.0	1,005.0		61,230.0
Germany		505,000.0	68,500.0			573,500.0
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
Japan		74,582.0	1,147.0		2,996.0	78,725.0
Korea, South		9,007.0	11,463.0			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
Northern Macedonia		5,200.0	11,364.0			16,564.0
Malta		486.6	121.6			608.2
Mexico	119,400.0	151,640.0	134,500.0			405,540.0
Mozambique**		280.0	570.0			850.0
Namibia		3,937.0	21.3			
Netherlands	2,620.0	31,400.0	6,800.0			40,820.0
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
Portugal		46,000.0	1,000.0			47,000.0
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		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
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	6,556.8	1,879.2	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
Other (5%)	105,832.0	579,408.1	1,707,535.7	1,537.0	627.2	2,394,940.0
TOTAL	2,116,640.0	11,588,162.3	34,150,714.4	30,740.0	12,543.2	47,898,799.9

Note: If no data is given: no reliable database for this collector type is available.
* Country market data for new installations in 2018 estimated by AEE INTEC
\+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered

Table 10: *Newly installed collector area in 2018 [m²/a]*

New installations in 2018 are divided into flat plate collectors: 8.1 GW_{th} (11.6 million m²), evacuated tube collectors: 23.9 GW_{th} (34.1 million square meters), unglazed water collectors: 1.4 GW_{th} (2.1 million m²), and glazed and unglazed air collectors: 0.03 GW_{th} (0.04 million m²).

With a share of 71.3%, evacuated tube collectors remain by far 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 83% of all newly installed collectors in 2018 were evacuated tube collectors. Nevertheless, it is notable that the share of evacuated tube collectors decreased from about 82% in 2011 to 71.3% in 2018 while in the same time frame flat plate collectors increased their share from 14.7% to 24.2%.

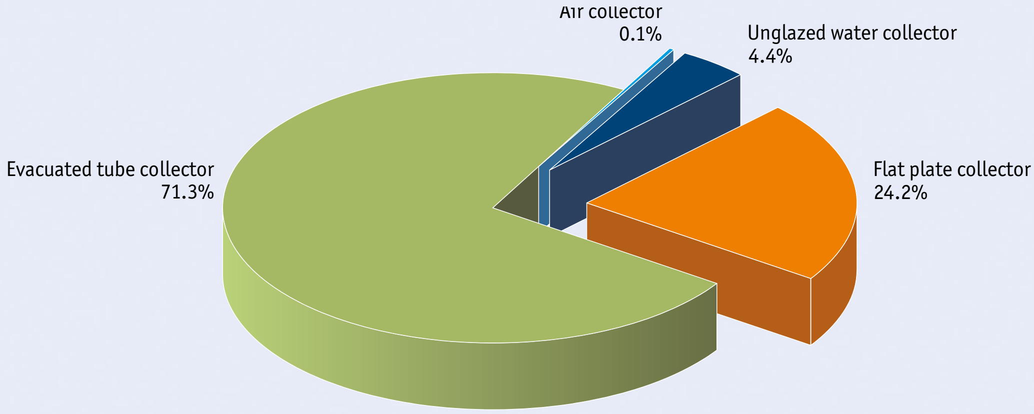
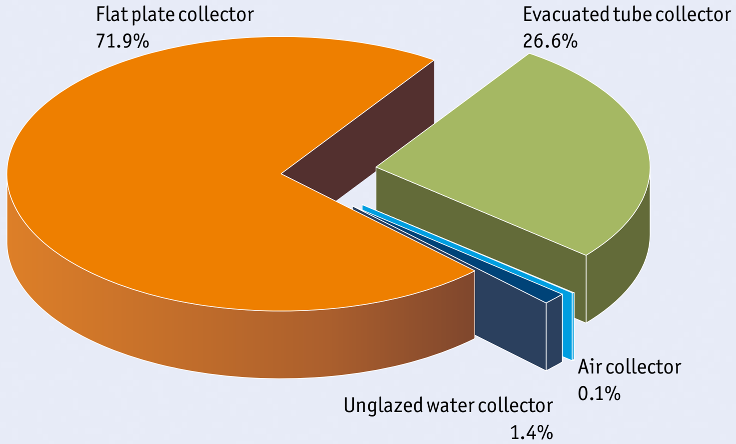


Figure 32: *Distribution of the newly installed capacity by collector type in 2018 – WORLD*

In Europe, the situation is almost the opposite compared to China with 71.9% of all solar thermal collectors installed in 2018 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 71.9% in 2018. While driven mainly by the markets in Turkey, Poland, Switzerland and Germany, evacuated tube collectors increased their share in Europe between 2011 and 2017 from 15.6% to 26.6%. In the year 2018 the share of evacuated tube collectors decreased compared to the year 2017 from 28% in 2017 to 26.6% in 2018.



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

Figure 33: *Distribution of the newly installed capacity by collector type in 2018 – EUROPE*

Figure 34 shows the newly installed capacity of glazed and unglazed water collectors for the 10 leading markets in 2018 in total numbers. China remained the market leader in absolute terms followed by Turkey and India. Australia overtook Germany because Germany faced a market decline for the fifth year in a row.

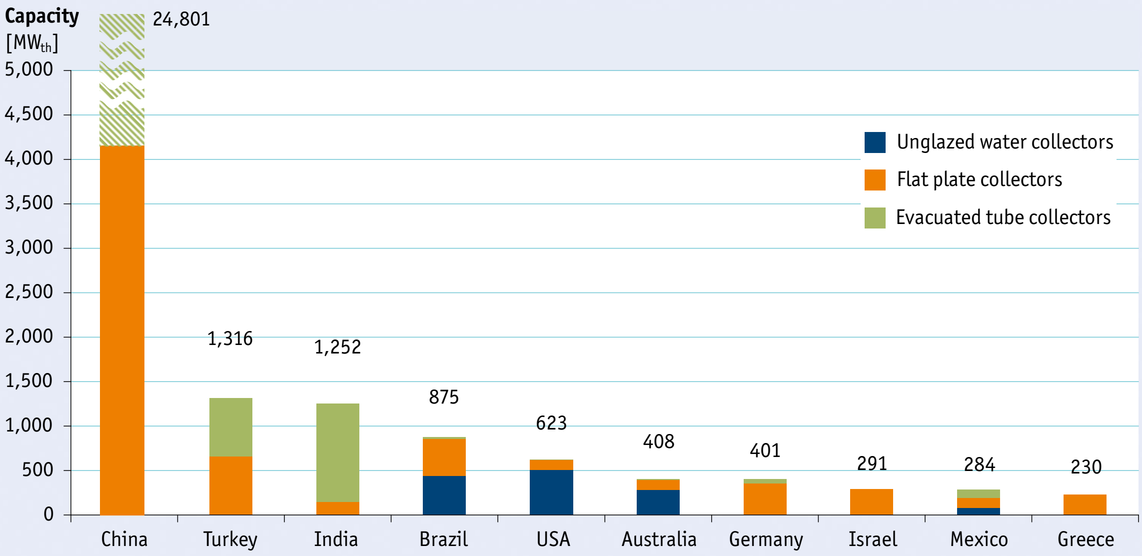


Figure 34: *Top 10 markets for glazed and unglazed water collectors in 2018 (absolute figures in MW_{th})*

In terms of newly installed solar thermal capacity per 1,000 inhabitants in 2018, the top 10 countries are shown in **Figure 35**. Compared to 2017, the ranking remained almost the same in 2018 with Israel, Cyprus and Barbados at the top three positions. Denmark is new to the top 10 in 8th place, putting Austria and the Palestinian Territories in 9th and 10th place. Switzerland fell out of the top 10 ranking.

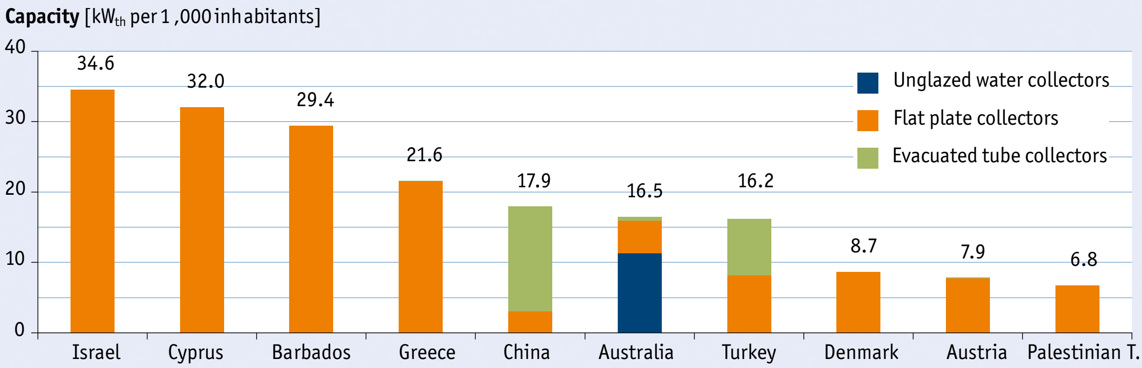


Figure 35: *Top 10 markets for glazed and unglazed water collectors in 2018 (in kW_{th} per 1,000 inhabitants)*

5.6 Newly installed capacity of glazed water collectors

In 2018, glazed water collectors accounted for 95.7% of the total newly installed capacity. China was the most influential market in the global context (Figure 36).

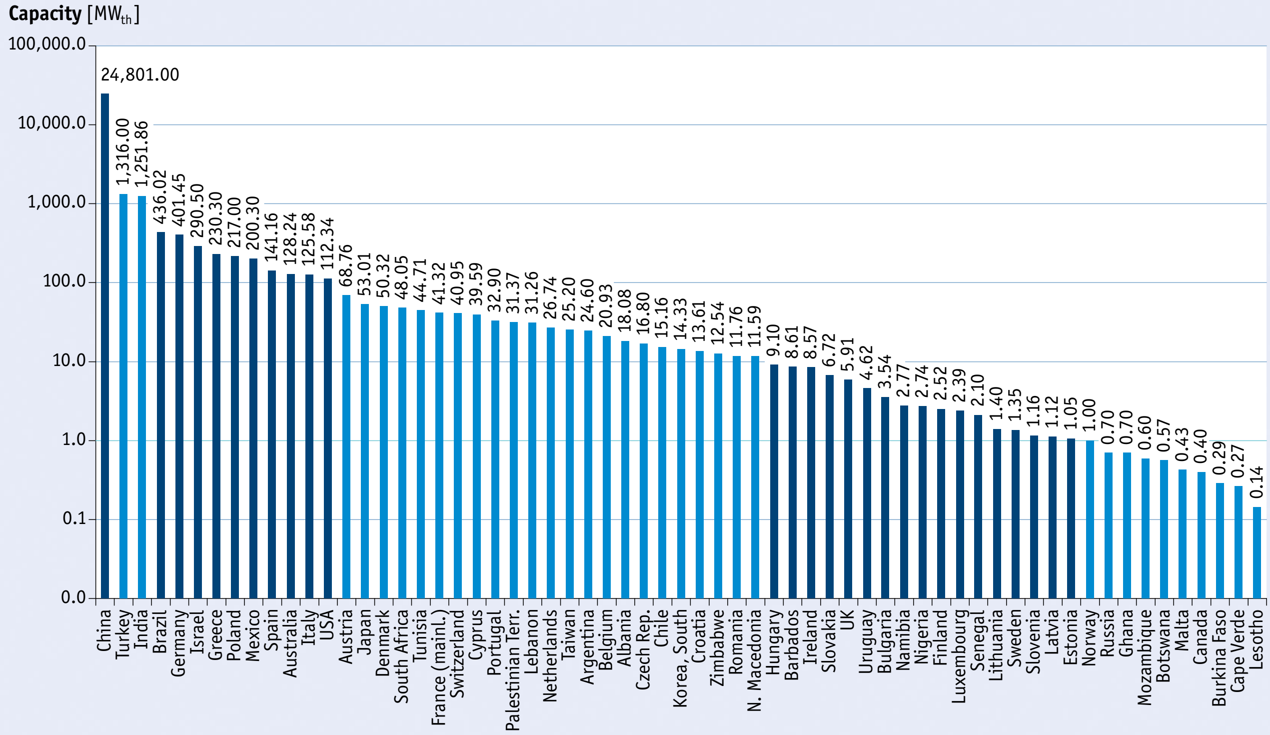


Figure 36: *Newly installed capacity of glazed water collectors in 2018*

In terms of newly installed glazed water collector capacity per 1,000 inhabitants, Israel is the leader ahead of Cyprus and Barbados. In this respect, China ranks in 5th place (Figure 37).

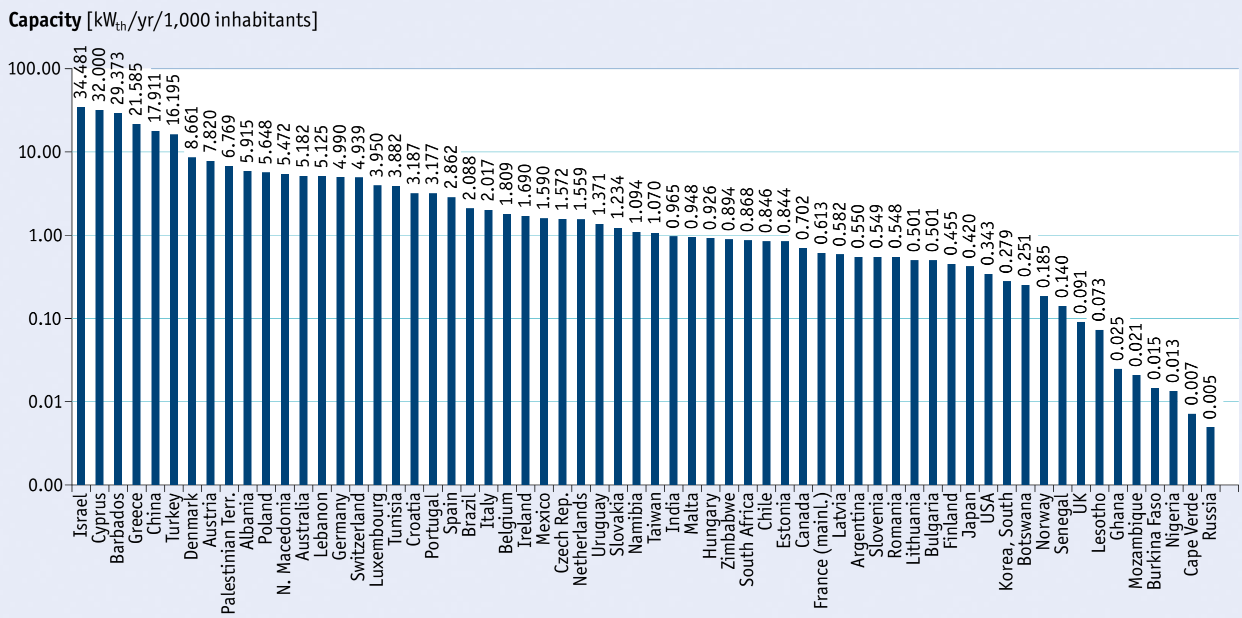


Figure 37: *Newly installed capacity of glazed water collectors in 2018 in kW_{th} per 1,000 inhabitants*

The following figures show the solar thermal market penetration per capita of the newly installed capacity in 2018 world-wide and in Europe.

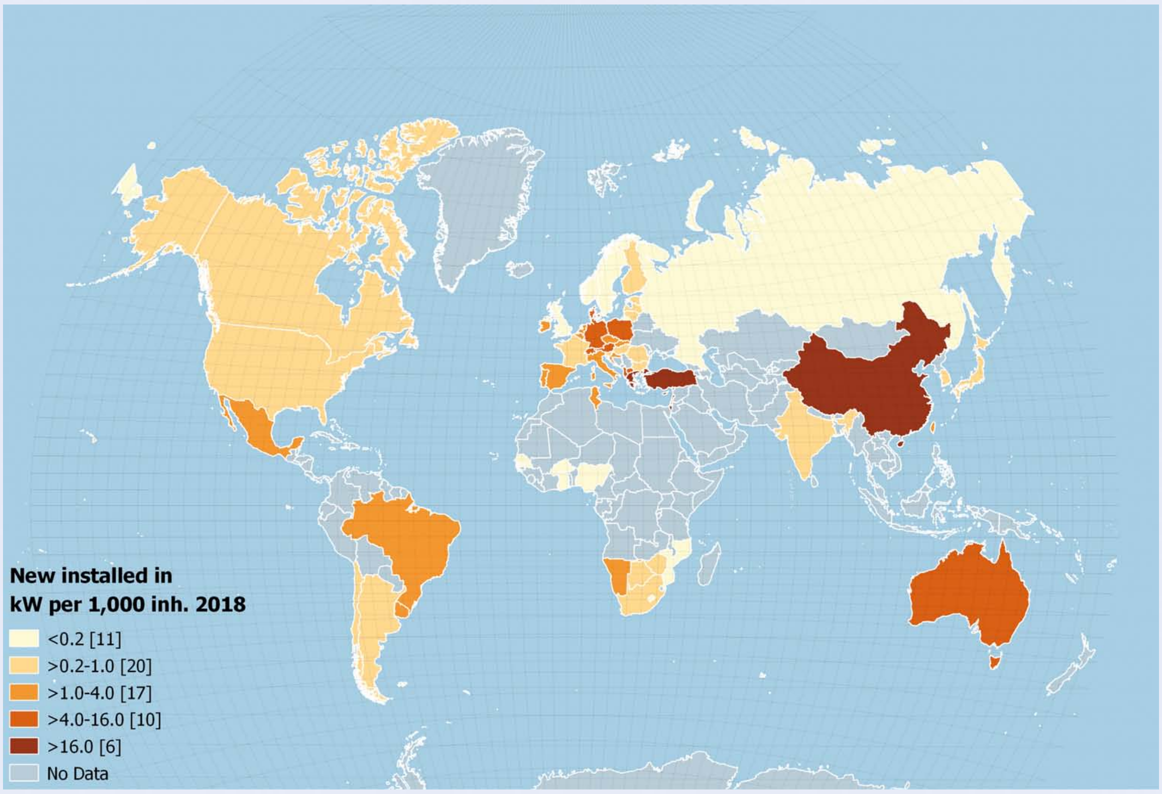


Figure 38: *Newly installed capacity in 2018 in kW_{th} per 1,000 inhabitants – WORLD (Source: Natural Earth v.4.1.0, 2020/ AEE INTEC)*

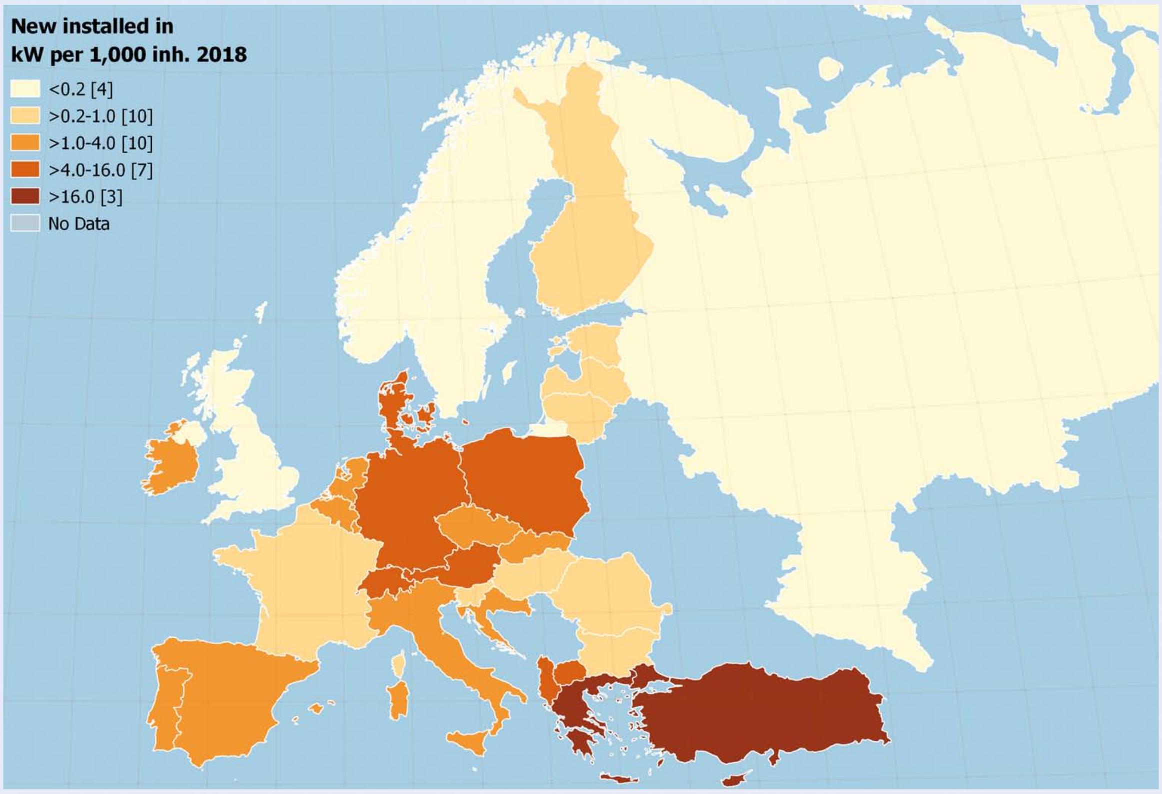


Figure 39: *New Installed capacity in 2018 in kW_{th} per 1,000 inhabitants – EUROPE (Source: Natural Earth v.4.1.0, 2020/ AEE INTEC)*

5.7 Market development of glazed water collectors between 2000 and 2018

The worldwide market of glazed water collectors was characterized by a steady upwards trend between 2000 and 2011 and showed a leveling trend in 2012 and 2013 at around 53 GW_{th}. In 2014, a significant market decline of –15.6 % was reported for the first time since the year 2000. This trend continued in 2015, 2016 and 2017, but in 2018 the markets seem to have recovered slightly as the decline slowed down and some of the top ten markets reported growth.

The newly installed glazed water collector capacity in 2018 amounted to 32 GW_{th} (**Figure 40**).

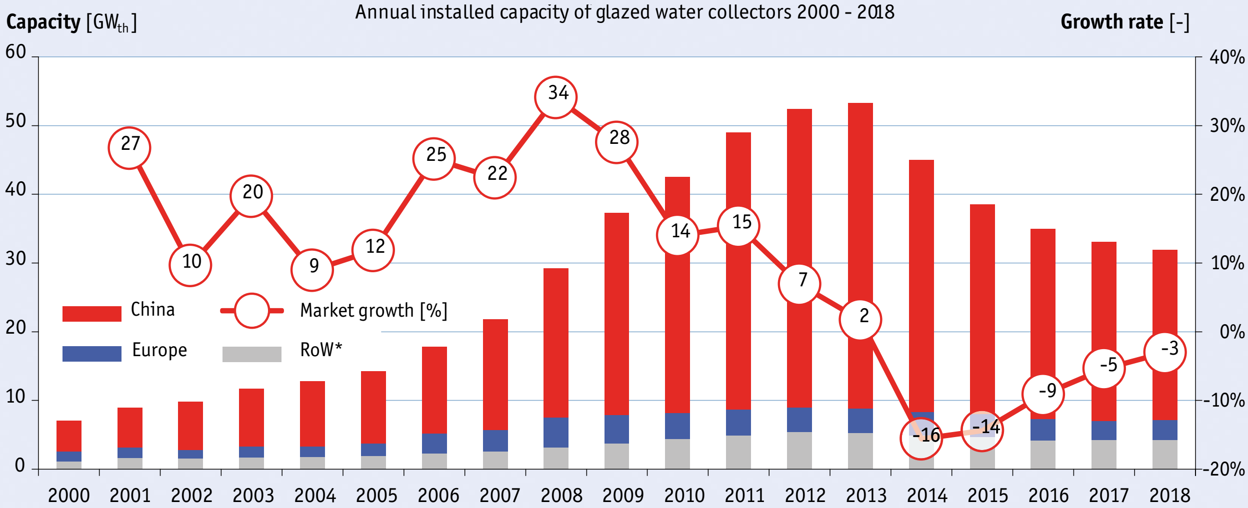


Figure 40: *Global market development of glazed water collectors from 2000 to 2018*

In 2000, the Chinese market was about three times as large as the European market while in 2018, the Chinese market exceeded the European market more than eight-fold (**Figure 41**).

It can also be seen in **Figure 41** 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. The downwards trend, however, became less dramatic from 2016 on.

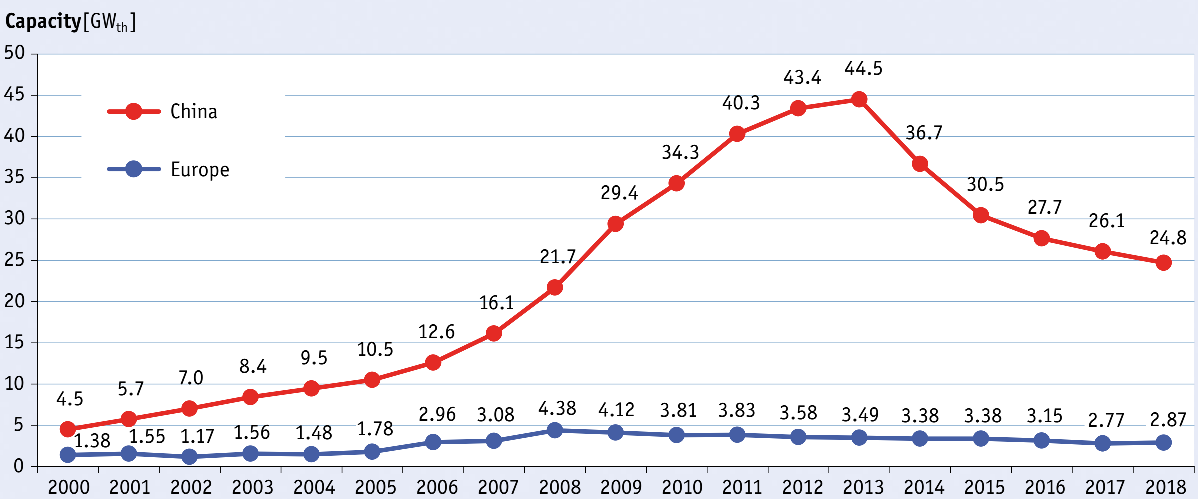
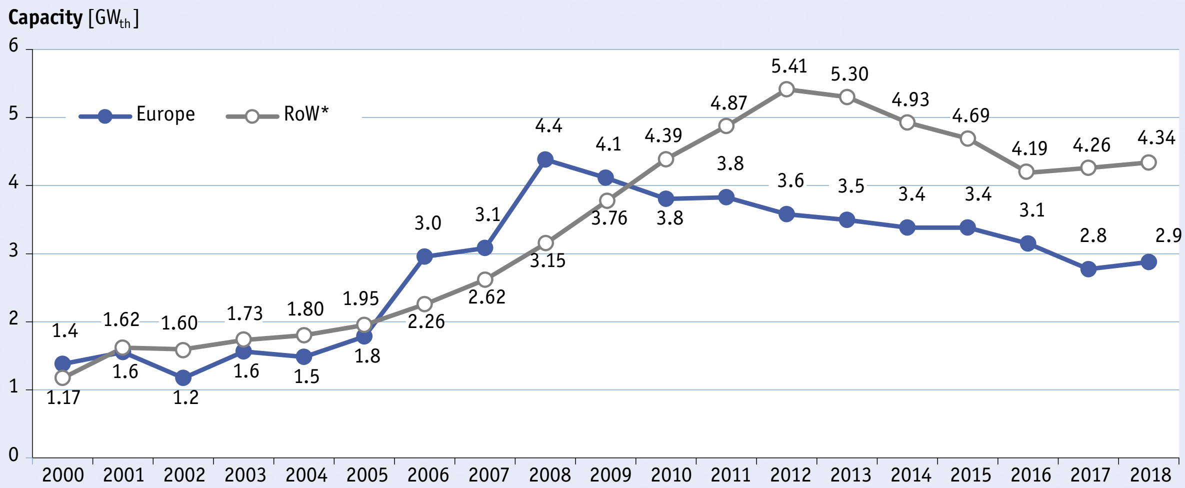


Figure 41: *Market development of glazed water collectors in China and Europe 2000 – 2018*

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 2.9 GW_{th} in 2018. In the “remaining markets worldwide” (RoW), an upward trend could be observed between 2002 and 2012 and a falling trend in the years 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, Korea South, Taiwan, Thailand), Australia, Canada, United States
	Latin America (Argentina, Brazil, Chile, Mexico, Uruguay)
	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 2018 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 2018*

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

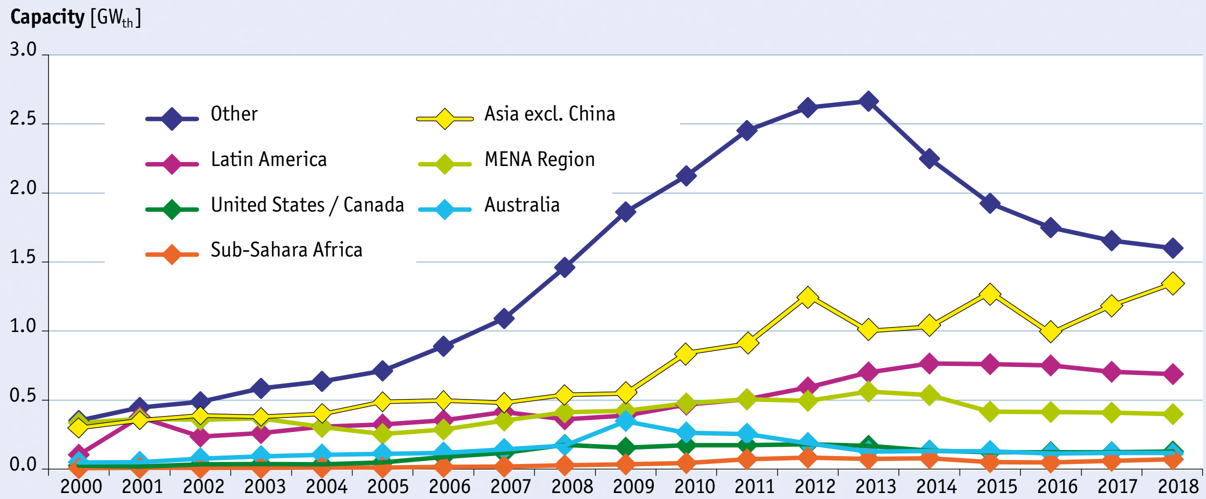
“Asia excl. China” is mainly influenced by the large Indian market, which dropped in 2013 but recovered significantly in 2014 and 2015. After a drop again in 2016, it has shown an increasing trend. Other markets covered within this economic region (Japan, South Korea) also reported market increases in 2018.

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

Glazed water collector markets in the MENA countries were characterized by steady growth from 2000 to 2013. The market decline since 2014, which is shown in **Figure 43**, is explained by the fact that from 2015 on no data were received from two major markets – Morocco and Jordan. The sales numbers in the most important market, Israel, slightly decreased in 2018.

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 2018, the market showed a slight decrease by 2 %.

Sub-Sahara African markets showed a stable market in 2018. In the United States and Canada, the decreasing trend continued with about a –7 % decline in 2018.



Asia excl. China:	India, Japan, Korea South, Taiwan, Thailand
Latin America	Argentina, Brazil, Chile, Mexico, Uruguay
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

Figure 43: *Market development of glazed water collectors in the Latin America, United States / Canada, Sub-Sahara Africa, Asia, the MENA Region and Australia (excluding China and Europe) from 2000 to 2018*

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 7.5 kW$_{th}$ per 1,000 inhabitants in 2013 and dropped down to 4.3 kW$_{th}$ per 1,000 inhabitants in 2018 (**Figure 44**).

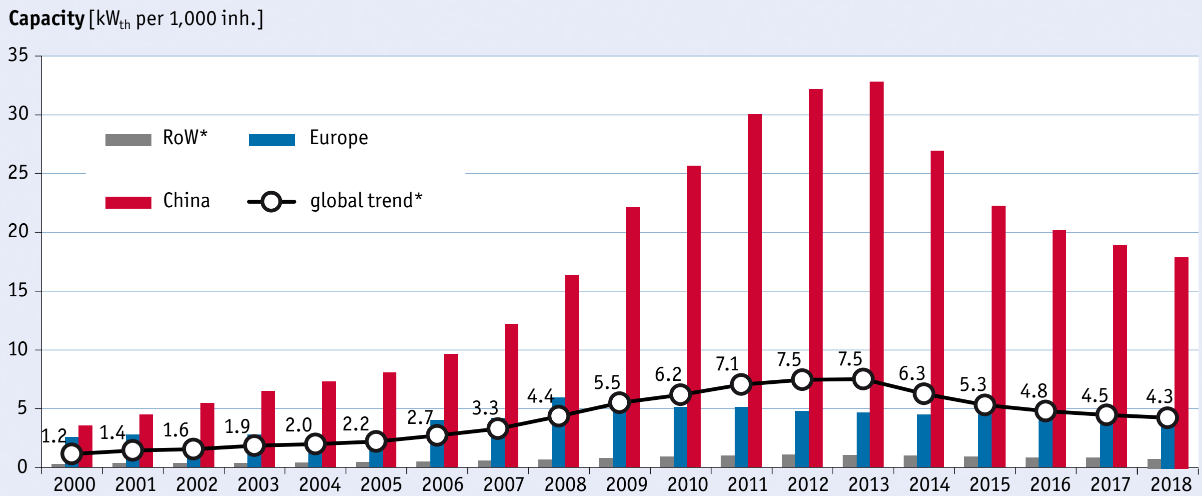


Figure 44: *Annual installed capacity of glazed water collectors in kW$_{th}$ per 1,000 inhabitants from 2000 to 2017*

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 32.8 kW$_{th}$ per 1,000 inhabitants in 2013 and fell down to 17.9 kW$_{th}$ per 1,000 inhabitants in 2018.

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 3.8 kW$_{th}$ per 1,000 inhabitants in 2018.

5.8 Market development of unglazed water collectors between 2000 and 2018

With a newly installed capacity of 1.5 GW_{th} in 2018, unglazed water collectors accounted for 4.4% of the total installed solar thermal capacity (**Figure 32**). Compared to 2017, the market decreased slightly by 2.5%.

The most important markets for unglazed water collectors in 2018 were the United States (512 MW_{th}), Brazil (439 MW_{th}), Australia (280 MW_{th}), Mexico (84 MW_{th}) and South Africa (46 MW_{th}), which accounted for 92% of the recorded unglazed water collector installations worldwide. Another 3% were installed in the Czech Republic (21 MW_{th}), the United Kingdom (9 MW_{th}), Switzerland (4 MW_{th}), Spain (3 MW_{th}) and Canada (1 MW_{th}).

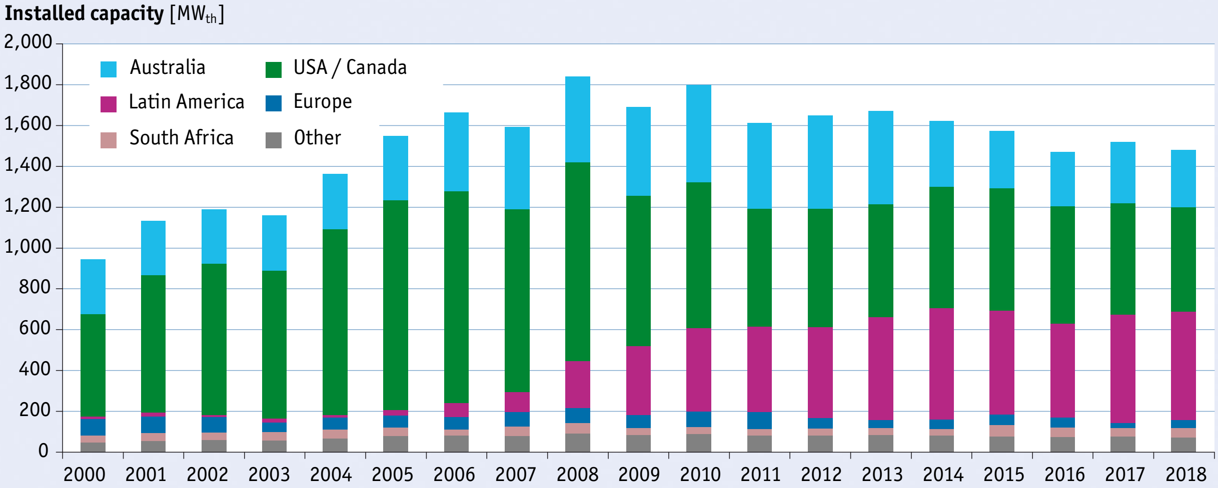


Figure 45: *Global market development of unglazed water collectors from 2000 to 2018*

The unglazed water collector market in the United States peaked in 2006 (1.01 GW_{th}) and has almost halved since then (0.51 GW_{th} in 2018). 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 with 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 2018

In this section, the contribution of the total installed glazed and unglazed water collectors in operation 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 by the end of 2018 in the 68 recorded countries was 392 TWh (= 1,413 PJ). This corresponds to a final energy savings equivalent of 42.1 million tons of oil and 133.5 million tons of CO_2. The calculated number of different types of solar thermal systems in operation was around 105 million (**Table 11**). The CO_2 emissions saved by the thermal solar systems in operation in 2018 correspond to 3.5 times the total CO_2 emissions in Switzerland[25].

The most dominant application for solar thermal systems is domestic hot water heating (see section 7.3), therefore, this type of application accounted for the highest savings in terms of oil equivalent and CO_2. In 2018, 94% of the energy provided by solar thermal systems worldwide was mainly used for heating domestic hot water, mainly by small-scale systems in single-family houses (59%) and larger applications attached to multi-family houses, hotels, schools, etc. (36%). Swimming pool heating held a share of 4% in the contribution to the energy supply and CO_2 reduction and the remaining 2% was met by solar combi-systems.

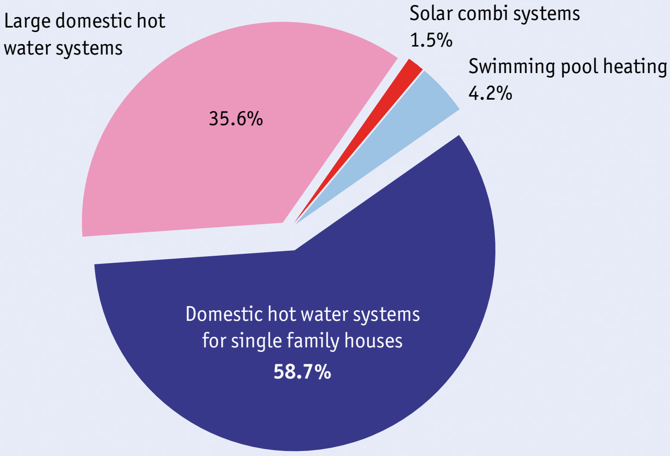


Figure 46: *Share of energy savings and CO_2 reduction by type of application of glazed and unglazed water collectors in operation in 2018*

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 contribution of the total installed air collector capacity in operation in 2018 of 1.1 GW_{th} was not taken into consideration – with 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 as well as the characteristic climatic conditions were considered for each country. A more detailed description of the methodology can be found in the appendix (see **Chapter 8**).

25 Statista Research Department, 11.3.2020, https://de.statista.com/themen/5533/treibhausgasemissionen-in-der-schweiz/

Table 11 summarizes the calculated annual collector yields and the corresponding oil equivalents and CO_2 reductions of all water-based solar thermal systems by the end of 2018.

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	258,047	181	55,857	182	656	19,579	61,969
Australia	9,216,000	6,451	1,158,715	5,700	20,519	612,597	1,938,868
Austria	5,118,625	3,583	509,573	2,070	7,450	222,433	704,001
Barbados	236,544	166	54,800	208	749	22,354	70,752
Belgium	690,517	483	120,169	275	988	29,504	93,380
Botswana	13,529	9	2,210	13	46	1,363	4,314
Brazil	16,083,201	11,258	4,815,750	10,494	37,780	1,127,942	3,569,935
Bulgaria	142,600	100	24,816	70	253	7,551	23,898
Burkina Faso	3,861	3	244	4	13	387	1,224
Canada	910,564	637	34,727	438	1,578	47,101	149,073
Chile	354,383	248	109,658	250	901	26,910	85,170
China	482,310,000	337,617	67,330,476	264,683	952,859	28,448,322	90,038,940
Croatia	229,567	161	39,951	115	415	12,402	39,252
Cyprus	787,462	551	344,191	700	2,520	75,229	238,100
Czech Republic	1,115,712	781	88,450	377	1,356	40,469	128,086
Denmark	1,678,775	1,175	100,366	701	2,522	75,299	238,322
Estonia	17,520	12	3,049	7	25	756	2,392
Finland	68,323	48	11,887	28	100	2,975	9,416
France (mainland)+	2,787,047	1,951	609,591	1,350	4,862	145,148	459,394
Germany	19,823,590	13,877	2,328,050	8,072	29,058	867,552	2,745,801
Ghana	3,381	2	177	3	11	328	1,037
Greece	4,713,000	3,299	1,258,229	3,283	11,818	352,822	1,116,682
Hungary	327,100	229	44,760	150	541	16,166	51,166
India	13,510,701	9,457	6,349,557	11,651	41,945	1,252,302	3,963,537
Ireland	333,407	233	77,161	140	503	15,004	47,486
Israel	4,787,434	3,351	1,532,936	4,419	15,909	474,979	1,503,308
Italy	4,720,914	3,305	821,566	2,880	10,369	309,562	979,763
Japan	3,686,355	2,580	899,533	2,140	7,704	230,008	727,976
Jordan*	1,260,506	882	223,109	1,194	4,297	128,286	406,026
Korea, South	1,891,155	1,324	433,263	981	3,533	105,479	333,840
Latvia	15,432	11	2,686	7	24	703	2,226
Lebanon	832,665	583	194,200	712	2,563	76,530	242,218
Lesotho	2,252	2	643	2	7	213	675
Lithuania	18,700	13	3,254	8	28	841	2,662
Luxembourg	65,363	46	11,375	28	100	2,972	9,407
Macedonia	96,737	68	22,172	60	214	6,401	20,259
Malta	72,858	51	29,143	63	228	6,796	21,511
Mauritius**	132,793	93	88,529	113	408	12,183	38,558
Mexico	4,324,217	3,027	510,875	2,474	8,905	265,880	841,511
Morocco*	451,000	316	60,900	383	1,378	41,156	130,257
Mozambique	3,136	2	478	3	9	279	883
Namibia	46,393	32	5,730	42	152	4,549	14,396
Netherlands	657,000	460	156,265	264	949	28,337	89,686
New Zealand***	159,645	112	32,703	99	355	10,593	33,526
Nigeria	4,832	3	1,847	4	15	455	1,441
Norway	44,093	31	2,197	16	58	1,744	5,521
Palestine	1,791,414	1,254	615,112	1,672	6,018	179,658	568,616
Poland	2,558,300	1,791	321,919	1,045	3,761	112,285	355,381
Portugal	1,100,682	770	199,526	850	3,059	91,335	289,075
Romania	204,690	143	35,622	113	407	12,150	38,453
Russia	25,044	18	1,386	10	37	1,118	3,539
Senegal	4,824	3	1,202	5	17	506	1,600
Slovakia	172,200	121	21,076	80	289	8,641	27,348
Slovenia	147,900	104	23,454	62	224	6,675	21,127
South Africa	2,173,059	1,521	509,474	1,567	5,642	168,459	533,174
Spain	4,310,823	3,018	507,168	3,006	10,822	323,105	1,022,627
Sweden	534,986	374	40,619	196	704	21,016	66,515
Switzerland	1,693,790	1,186	204,932	669	2,408	71,892	227,537
Taiwan	1,743,055	1,220	344,029	1,060	3,817	113,969	360,711
Thailand****	157,536	110	36,001	132	476	14,212	44,982
Tunisia	1,034,015	724	304,236	928	3,341	99,740	315,677
Turkey	25,137,636	17,596	5,806,794	22,552	81,186	2,423,873	7,671,558
United Kingdom	1,442,719	1,010	232,372	514	1,852	55,289	174,989
United States	25,620,816	17,935	430,430	11,395	41,022	1,224,740	3,876,304
Uruguay	76,000	53	19,000	52	186	5,568	17,621
Zimbabwe	59,639	42	27,024	51	183	5,468	17,306
Other (5%)	34,424,296	24,097	4,875,938	19,620	70,634	2,108,821	6,674,417
TOTAL	688,420,362	481,894	105,063,133	392,433	1,412,759	42,178,959	133,496,404

* 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 territories of France (DOM) are not considered

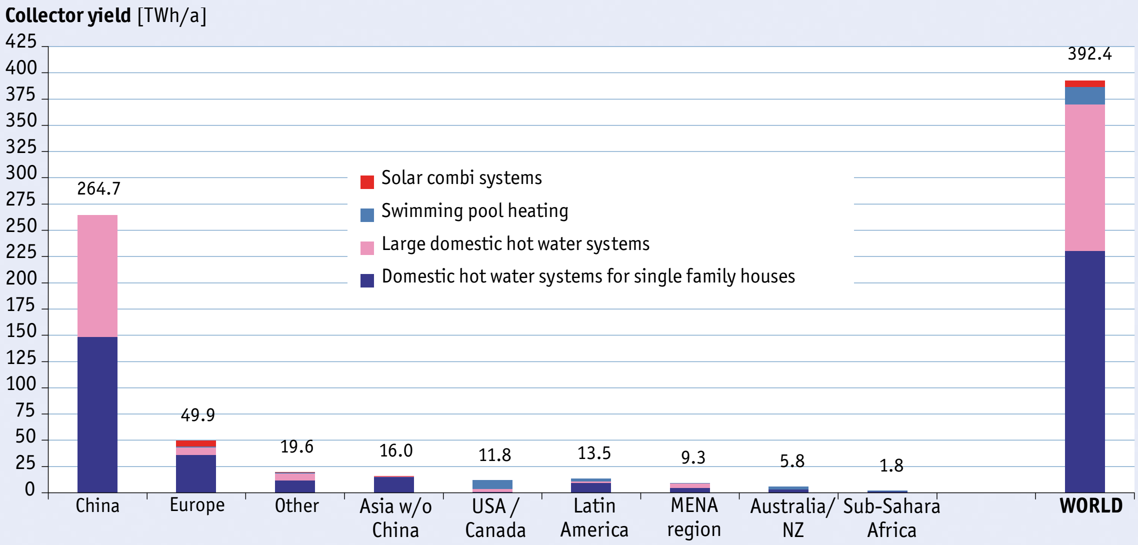
Table 11: *Calculated annual collector yield and corresponding oil equivalent and CO_2 reduction of glazed and unglazed water collectors in operation by the end of 2018*

In **Chapters 6.1** to **6.3**, the annual collector yield, energy savings and CO_2 savings by economic regions and worldwide are graphed.

6.1 Annual collector yield by economic region

In 2018, gross solar thermal collector yields amounted to 392 TWh worldwide (**Table 11**) and the major share, 59%, was contributed by domestic hot water applications for single-family houses (**Figure 46**).

China accounted for 67% of the thermal energy gains (265 TWh), Europe for 12.5% (50 TWh) and the Rest of the World for 19.8% (78 TWh) (**Figure 47**).



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

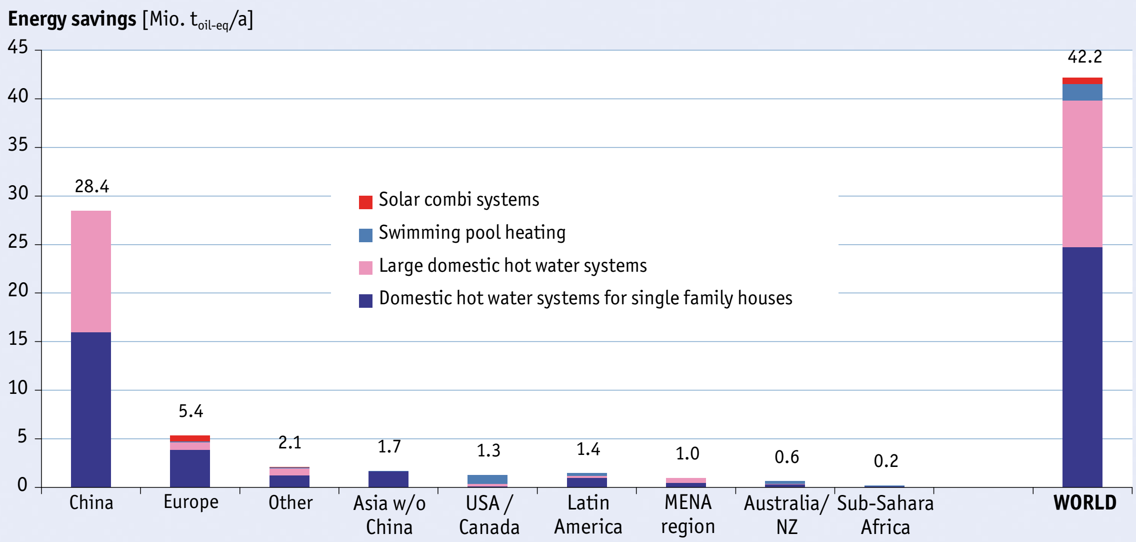
Figure 47: *Annual collector yield of unglazed and glazed water collectors in operation in 2018*

6.2 Annual energy savings by economic region

The annual final energy savings amounted to 491 TWh or 42.2 million tons of oil equivalent in 2018. This is calculated using a utilization ratio of 0.8 for the reference oil boiler, which is assumed to be partially replaced by a solar thermal system (see methodology **Chapter 8.1**)[26].

The breakdown shows that China accounted for 28.4 million tons oil equivalent, Europe for 5.4 million tons oil equivalent, and the Rest of World for 8.4 million tons oil equivalent (**Figure 48**).

26 1 toe = 1.163 x 104 kWh (Source: IEA **www.iea.org**, 2020), for the simulated applications



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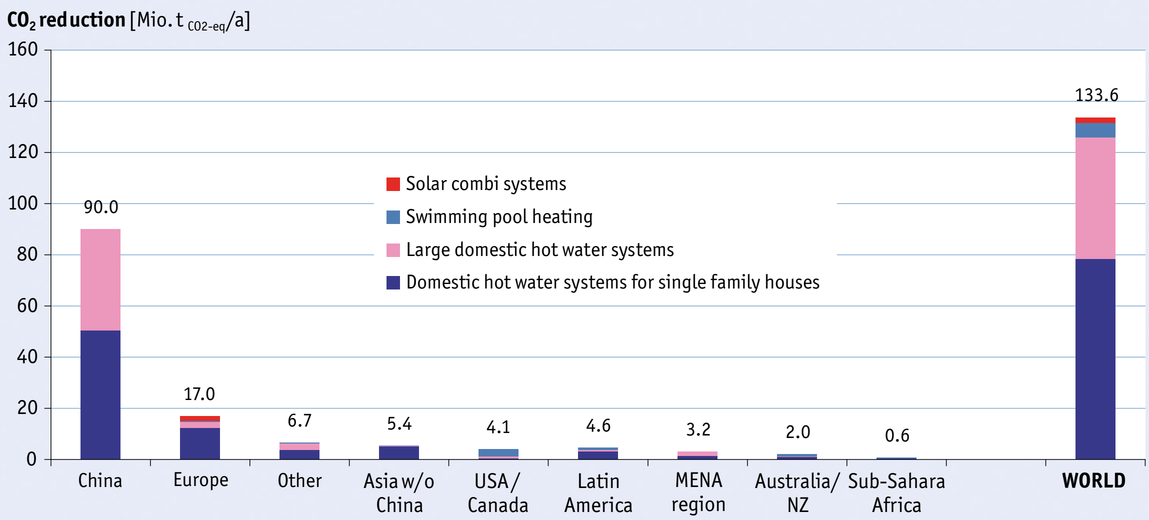
Asia w / o China:	India, Japan, South Korea, Taiwan Thailand
Latin America:	Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia

Figure 48: *Annual energy savings in oil equivalent by unglazed and glazed water collectors in operation in 2018*

6.3 Annual contribution to CO_2 reduction by economic region

42.2 million tons of oil equivalent correspond to an annual CO_2 emission reduction of 133.6 million tons[27]. The breakdown shows that China accounted for 90 million tons of CO_2 equivalent, Europe 17 million tons of CO_2 equivalent, and the Rest of World 26.6 million tons of CO_2 equivalent (see **Figure 49**).



See Fig. 48 for allocation data

Figure 49: *Contribution to CO_2 reduction by unglazed and glazed water collectors in operation in 2018*

27 1 toe (fuel oil) = 3,165 t C02e (Source: Carbon trust updated conversion factors, 2016)

7 Distribution of systems by type and application in 2018

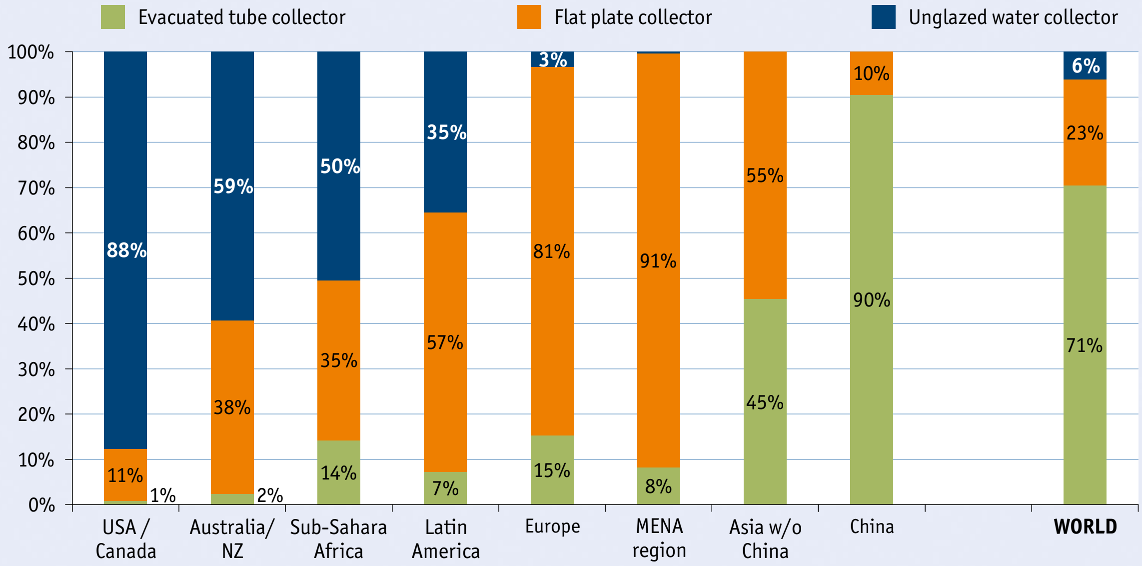
The use of solar thermal energy varies greatly from region to region and can be roughly distinguished by the type of solar thermal collector used (unglazed water collectors, evacuated tube collectors, flat plate collectors, glazed and unglazed air collectors, concentrating collectors), the type of system 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 different economic regions for both the cumulated capacity in operation in 2018 and the newly installed capacity in 2018[28].

7.1 Distribution by type of solar thermal collector

In terms of the total water collector capacity worldwide in 2018, evacuated tube collectors dominated with a share of 70.5% of the cumulated capacity in operation (**Figure 50**) and a share of 71.4% of the newly installed capacity (**Figure 51**). Worldwide flat plate collectors accounted for about 23% of the cumulated capacity in operation (**Figure 50**) and a 24% share of the newly installed capacity (**Figure 51**). Unglazed water collectors accounted for 6% of the cumulated water collectors installed worldwide and for about 4% 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.

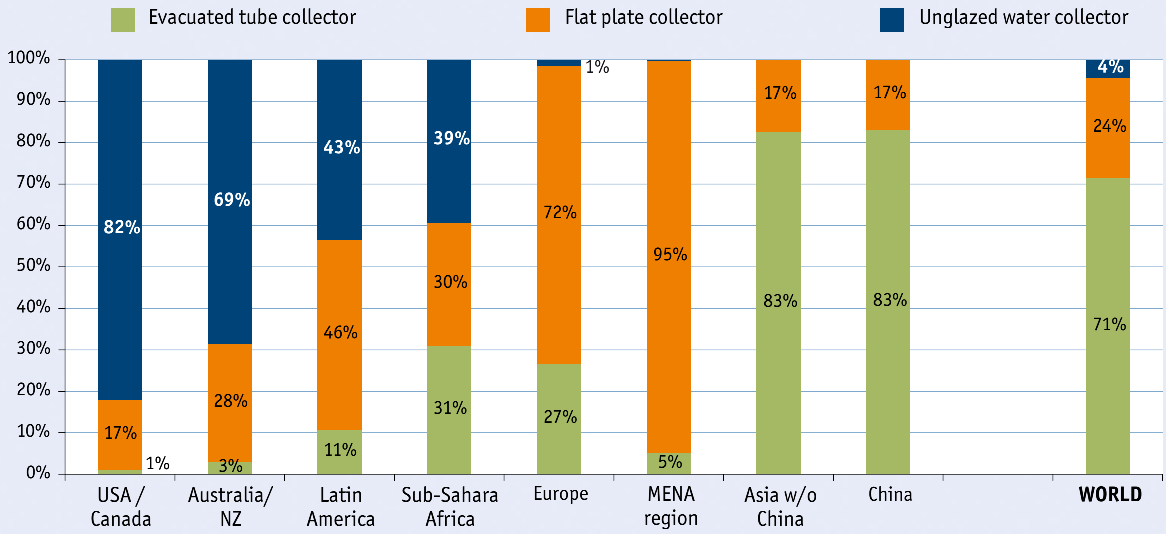


Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w / o China: India, Japan, South Korea, Taiwan Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe: EU 28, Albania, Northern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

Figure 50: *Distribution by type of solar thermal collector for the total installed water collector capacity in operation by the end of 2018*

28 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.

With respect to newly installed collector area, the distribution is shown below. Evacuated tube collectors are dominant in China and Asia excluding China (driven by the development in India), but also increasing their 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
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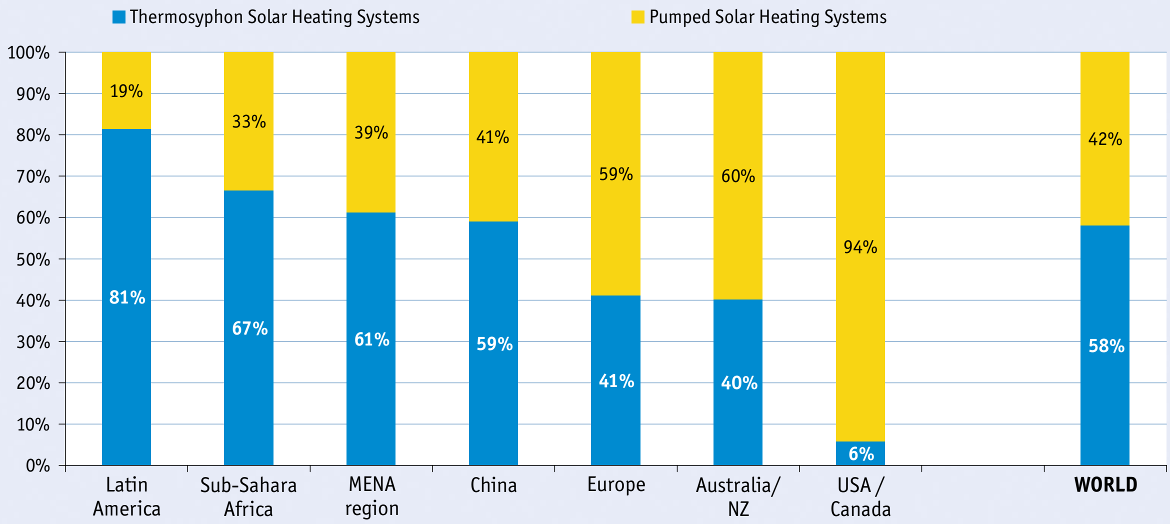
Latin America:	Argentina, Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries:	Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia

Figure 51: *Distribution by type of solar thermal collector for the newly installed water collector capacity in 2018*

7.2 Distribution by type of system

Worldwide, about 60 % of all solar thermal systems installed are thermosiphon systems and the rest are pumped solar heating systems (**Figure 52**). 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 2018, 59 % of all newly installed systems in China were thermosiphon systems while pumped systems accounted for 41 %. The number of thermosiphon systems has been decreasing for several years, and in 2018, pumped systems accounted for 73 % of new installed systems in China (**Figure 53**).

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.



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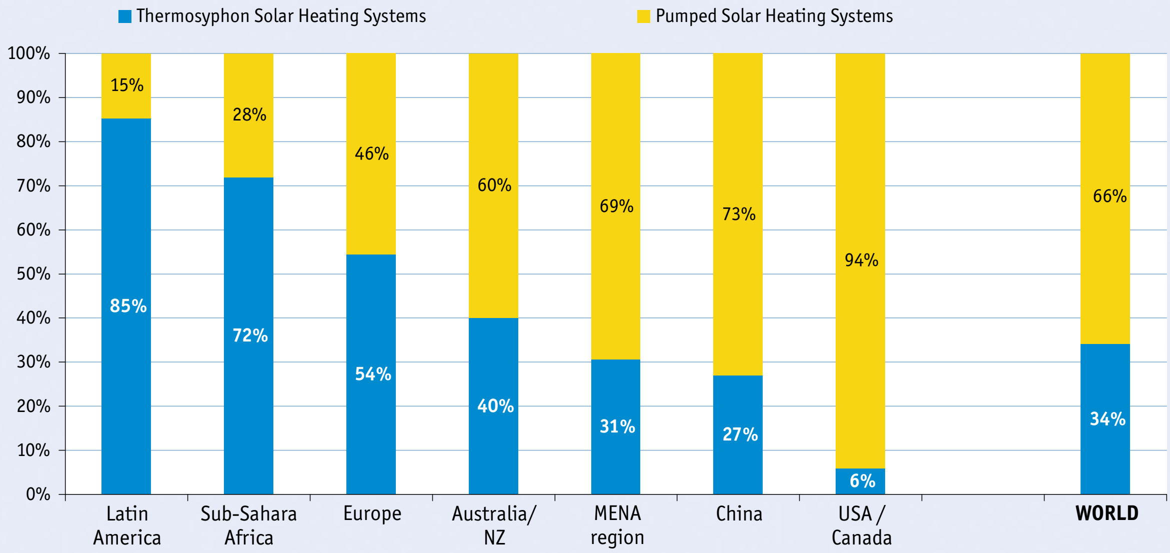
Europe: EU 28, Albania, Northern Macedonia, Norway, Russia, Switzerland, Turkey
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia

Figure 52: *Distribution by type of system for the total installed glazed water collector capacity in operation by the end of 2018*



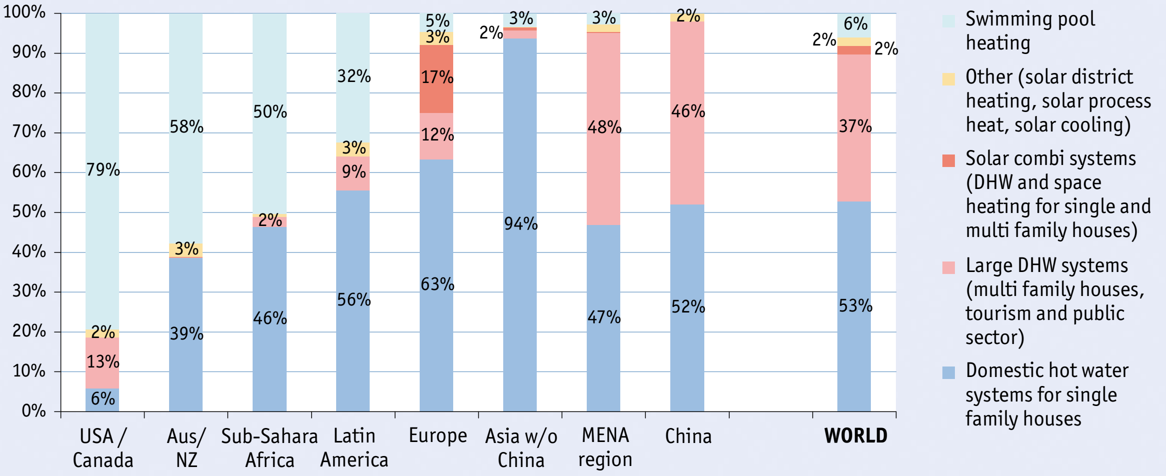
See Fig. 52 for allocation data

Figure 53: *Distribution by type of system for the newly installed glazed water collector capacity in 2018*

7.3 Distribution by type of application

By the end of 2018, 689 million m^2 of water-based solar thermal collectors, corresponding to a thermal peak capacity of 482 GW_{th}, were in operation worldwide (Table 7). Out of these, 6 % were used for swimming pool heating, 53 % were used for domestic hot water preparation in single-family houses, and 37 % were attached to larger domestic hot water systems for multifamily houses, hotels, hospitals, schools, etc.

Around 2 % of the worldwide installed capacity supplied heat for both domestic hot water and space heating (solar combi-systems). The remaining systems accounted for around 2 % and delivered heat to other applications, such as district heating networks, industrial processes or thermally driven solar cooling applications (Figure 54). Considering typical solar thermal system sizes for the above mentioned applications in the different countries covered in this report, the number of systems in operation worldwide is calculated to be around 105 million.



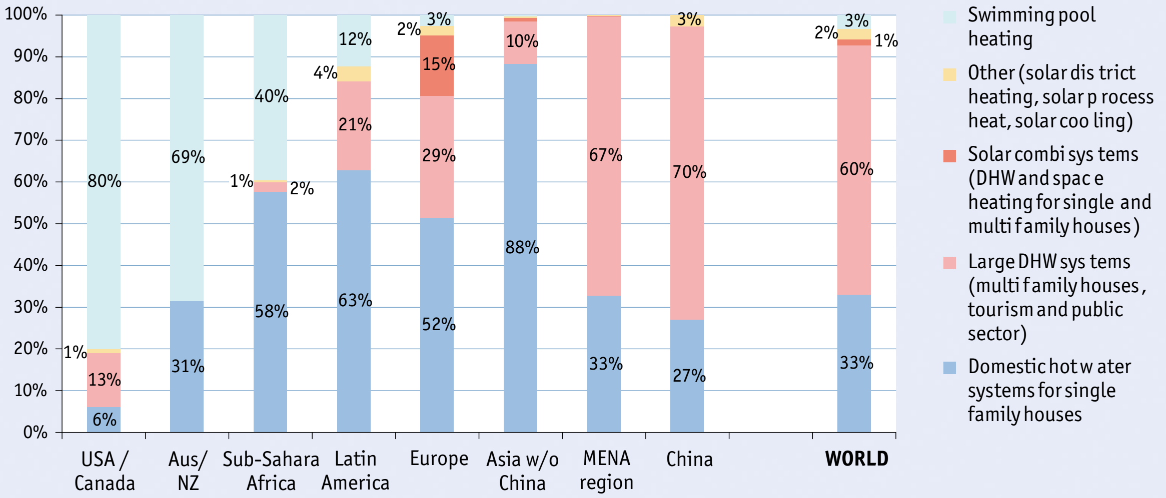
Sub-Sahara Africa: Botswana, Burkina Faso, Ghana, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Asia w / o China: India, Japan, South Korea, Taiwan, Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe: EU 28, Albania, Northern Macedonia,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

Figure 54: *Distribution of solar thermal systems by application for the total installed water collector capacity by economic region in operation by the end of 2018*

The newly installed water-based solar thermal collector area amounted to 47.9 million m², which corresponds to 33.5 GW of thermal peak capacity (Table 9).

Compared to the cumulated installed capacity, the share of swimming pool heating was less for new installations (6% of total capacity and 3% of newly installed capacity). Domestic hot water systems in single-family houses accounted for about 53% of total capacity in operation and 33% of new installations in 2018.

The share of applications such as solar district heating and solar process heat is at about 2% globally (Figure 55).



Allocations like above except Latin America: Barbados, Brazil, Chile, Mexico, Uruguay

Figure 55: *Distribution of solar thermal systems by application for the newly installed water collector capacity by economic region in 2018*

8 Appendix

8.1 Methodological approach for the energy calculation

In order 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 multifamily houses including the tourism sector as well as the 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 for 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. On the basis of these boundary conditions, simulations were performed with the simulation program 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[29].

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 (kg CO_2e) per tons of oil equivalent: 1 toe = 3.165 t CO_2e[30]. The emission factor only account 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.

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[31]. Furthermore, a hydraulic scheme is shown for each reference system.

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29 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.

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

31 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.

8.1.1 Reference systems for swimming pool heating

The information in 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 2018.

Country*	Reference climate	Horizontal irradiation [kWh/m²·a]	Total collector area (DHW-SFH) [m²]	Collector area per system [m²]	Total number of systems	Specific solar yield (DHW-SFH) [kWh/m²·a]
Australia	Sydney	1674	5,400,576	35	154302	466
Austria	Graz	1126	580,239	200	2901	283
Belgium	Brussels	971.1	32,203	200	161	261
Brazil	Brasília	1792.5	5,226,465	32	163327	375
Bulgaria	Sofia	1187.5	6,650	200	33	319
Canada	Montreal	1351.4	531,678	25	21267	386
Chile	Santiago de Chile	1752.7	65,561	15	4371	471
Croatia	Zagreb	1212	10,706	200	54	326
Cyprus	Nicosia	1885.5	1,899	200	9	507
Czech Republic	Praha	998.4	578,274	200	2891	303
Estonia	Tallin	960.2	817	200	4	258
Finland	Helsinki	948	3,109	200	16	256
France (mainland)	Paris	1112.4	150,322	200	752	328
Germany	Würzburg	1091.3	607,737	30	20258	314
Greece	Athens	1584.6	219,796	200	1099	426
Hungary	Budapest	1198.7	32,448	10	3245	344
India	Neu-Delhi	1960.5	135,107	16	8444	527
Israel	Jerusalem	2198	191,497	200	957	568
Italy	Bologna	1419	220,165	200	1101	442
Jordan	Amman	2145.4	6,661	200	33	578
Korea, South	Seoul	1161.1	15,237	200	76	312
Latvia	Riga	991.2	720	200	4	267
Lebanon	Beirut	1934.5	833	16.5	50	520
Lithuania	Vilnius	1001.2	872	200	4	269
Luxembourg	Luxembourg	1037.4	3,048	200	15	279
Macedonia	Skopje	1380.8	1,935	20	97	371
Mexico	Mexico City	1706.3	1,544,363	200	7722	311
Morocco	Rabat	2000	18,040	200	90	538
Netherlands	Amsterdam	999	101,835	40	2546	272
New Zealand	Wellington	1401.2	11,175	200	56	378
Norway	Oslo	971.1	1,843	200	9	316
Palestine	Jerusalem	2198	71,657	200	358	591
Portugal	Lisbon	1686.4	5,503	200	28	421
Romania	Bucharest	1324.3	9,546	200	48	356
Russia	Moscow	996	258	200	1	268
Slovakia	Bratislava	1213.8	8,031	200	40	327
Slovenia	Ljubjana	1114.6	1,479	200	7	300
South Africa	Johannesburg	2075.1	1,232,124	40	30803	505
Spain	Madrid	1643.5	215,541	200	1078	472
Sweden	Gothenburg	933.9	153,190	200	766	295
Switzerland	Zürich	1093.8	283,135	200	1416	277
Taiwan	Taipei	1372.2	14,816	175	85	319
Thailand	Bangkok	1764.8	1,269	300	4	475
United Kingdom	London	942.6	523,707	200	2619	254
United States	LA, Indianapolis	1646.05	20,496,653	200	102483	387
Other (5%)		1407	2,038,108	200	10191	392
	TOTAL		40,756,826		545,821	
	AVERAGE	1404		159		374

* 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 2018

Figure 56 shows the hydraulic scheme of the swimming pool reference system as used for the simulations of the solar energy yields.

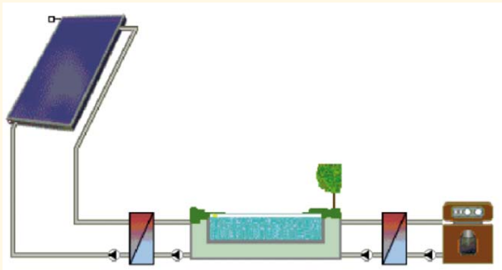


Figure 56: Hydraulic scheme of the swimming pool reference system

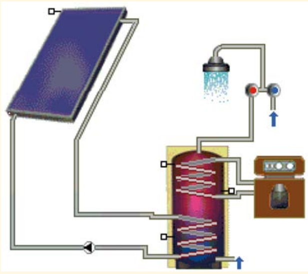
8.1.2 Reference systems for domestic hot water preparation in single-family houses

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 2018 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	161,795	3	53,931.8	713	TS
Australia	Sydney	1674	3,492,864	3.5	997,961.1	844	PS
Austria	Graz	1126	2,130,874	6	355,145.7	451	PS
Barbados	Grantley Adams	2016.3	217,691	4	54,422.9	882	TS
Belgium	Brussels	971.1	427,857	4	106,964.4	423	PDS / PS
Botswana	Gaborone	2161	8,117	4	2,029.4	961	TS
Brazil	Brasília	1792.5	9,251,332	2	4,625,665.9	809	TS
Bulgaria	Sofia	1187.5	88,358	4	22,089.4	524	PS
Burkina Faso	Ouagadougou	2212	534	4	133.5	983	TS
Canada	Montreal	1351.4	40,065	6	6,677.5	556	PS
Chile	Santiago de Chile	1752.7	207,314	2	103,657.1	771	PS
China	Shanghai	1281.9	313,501,500	4	78,375,375.0	592	TS
Croatia	Zagreb	1212	142,244	4	35,561.0	539	PS
Cyprus	Nicosia	1885.5	682,655	2	341,327.3	912	TS
Czech Republic	Praha	998.4	275,804	4.7	58,681.7	385	PS
Denmark	Copenhagen	989.4	263,568	4	65,891.9	454	PS
Estonia	Tallin	960.2	10,856	4	2,713.9	432	PS
Finland	Helsinki	948	42,258	4	10,564.4	441	PS
France (mainl.)	Paris	1112.4	1,817,155	3.2	567,860.8	496	PS
Germany	Würzburg	1091.3	8,662,258	5.6	1,546,831.8	424	PS
Ghana	Accra	2146	298	4	74.4	954	TS
Greece	Athens	1584.6	2,920,265	2.5	1,168,106.0	772	TS
Hungary	Budapest	1198.7	170,092	5	34,018.4	473	PS
India	Neu-Delhi	1960.5	11,821,863	2	5,910,931.7	882	TS
Ireland	Dublin	948.7	300,066	4	75,016.6	423	PS
Israel	Jerusalem	2198	861,738	3	287,246.0	1,024	TS
Italy	Bologna	1419	2,925,169	4	731,292.2	661	PS
Japan	Tokyo	1175.2	3,556,964	4	889,241.0	586	TS
Jordan	Amman	2145.4	1,003,076	4.6	218,060.0	986	TS
Korea, South	Seoul	1161.1	1,714,652	4	428,663.1	525	PS
Latvia	Riga	991.2	9,562	4	2,390.5	462	PS
Lebanon	Beirut	1934.5	769,382	4	192,345.6	860	TS
Lesotho	Maseru	2050	1,044	2	522.2	911	TS
Lithuania	Vilnius	1001.2	11,587	4	2,896.7	450	PS
Luxembourg	Luxembourg	1037.4	40,500	4	10,125.0	450	PS
Macedonia	Skopje	1380.8	87,063	4	21,765.8	627	PS
Malta	Luqa	1901.9	72,858	2.5	29,143.3	868	PS
Mauritius	Port Louis	1920	132,793	1.5	88,528.7	854	TS
Mexico	Mexico City	1706.3	1,945,898	4	486,474.4	718	PS
Morocco	Rabat	2000	225,500	4	56,375.0	889	TS
Mozambique	Maputo	1910	1,807	4	451.6	849	TS
Namibia	Windhoek	2363	20,877	4	5,219.3	1,032	TS
Netherlands	Amsterdam	999	407,012	2.8	145,361.3	433	PDS / PS
New Zealand	Wellington	1401.2	127,716	4	31,929.0	647	PS
Nigeria	Abuja	2007	3,455	4	863.8	892	TS
Norway	Oslo	971.1	1,531	6	255.2	430	PS
Palestine	Jerusalem	2198	895,707	1.5	597,138.0	977	TS
Poland	Warsaw	1024.2	1,790,810	6	298,468.3	397	PS
Portugal	Lisbon	1686.4	764,974	4	191,243.5	804	PS
Romania	Bucharest	1324.3	126,830	4	31,707.5	594	PS
Russia	Moscow	996	3,636	4	909.1	443	PS
Senegal	Dakar	2197.3	4,679	4	1,169.8	977	TS
Slovakia	Bratislava	1213.8	106,698	6	17,783.1	481	PS
Slovenia	Ljubjana	1114.6	136,068	6	22,678.0	424	PS
South Africa	Johannesburg	2075.1	908,773	1.9	478,301.7	1,009	TS
Spain	Madrid	1643.5	1,724,329	4	431,082.3	766	PS
Sweden	Gothenburg	933.9	40,065	4	10,016.3	383	PS
Switzerland	Zürich	1093.8	945,139	5.7	165,813.8	426	PS
Taiwan	Taipei	1372.2	1,636,205	4.8	340,876.1	616	TS
Thailand	Bangkok	1764.8	142,833	4	35,708.3	854	TS
Tunisia	Tunis	1808.2	1,001,857	3.3	303,593.1	902	TS
Turkey	Antalya	1795.2	23,126,625	4	5,781,656.3	910	TS
United Kingdom	London	942.6	919,012	4	229,753.0	415	PS
United States	LA, Indianapolis	1646.05	1,537,249	6	256,208.2	646	PS
Uruguay	Montevideo	1534.2	76,000	4	19,000.0	682	TS
Zimbabwe	Harare	2017.1	53,675	2	26,837.6	854	TS
Other (5%)		1407	21,397,670	4	5,349,417.5	628	TS/PS
	TOTAL		427,896,705		112,740,144.8		
	AVERAGE	1518		4		678	

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

Table 13: *Solar thermal systems for domestic hot water heating in single-family houses by the end of 2018*



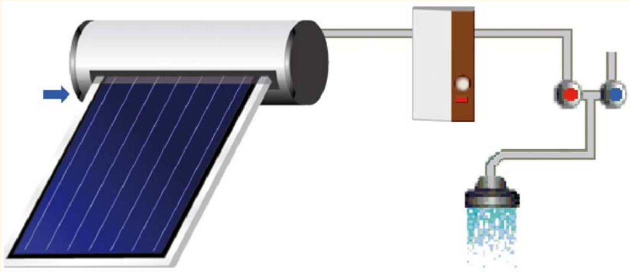


Figure 57 | 58: Hydraulic schemes of the domestic hot water pumped (left) and thermosiphon (right) reference system for single-family houses

Figure 57 shows the hydraulic scheme used for the energy calculation for all pumped solar thermal systems and Figure 58 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 58 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 2018 as reported by each country.

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	96,252	50	1,925	694
Australia	Sydney	1674	322,560	50	6,451	725
Austria	Graz	1126	397,435	50	7,949	505
Barbados	Grantley Adams	2016.3	18,853	50	377	842
Belgium	Brussels	971.1	97,287	50	1,946	406
Botswana	Gaborone	2161	5,412	30	180	903
Brazil	Brasília	1792.5	1,605,404	60	26,757	658
Bulgaria	Sofia	1187.5	20,091	50	402	515
Burkina Faso	Ouagadougou	2212	3,327	30	111	924
Canada	Montreal	1351.4	338,730	50	6,775	621
Chile	Santiago de Chile	1752.7	81,508	50	1,630	732
China	Shanghai	1281.9	168,808,500	50	3,376,170	502
Croatia	Zagreb	1212	32,344	50	647	506
Cyprus	Nicosia	1885.5	90,340	50	1,807	750
Czech Republic	Praha	998.4	41,504	42.4	979	436
Denmark	Copenhagen	989.4	1,356,450	50	27,129	413
Estonia	Tallin	960.2	2,468	50	49	401
Finland	Helsinki	948	9,565	50	191	396
France (mainland)	Paris	1112.4	819,570	20	40,979	489
Germany	Würzburg	1091.3	2,340,979	50	46,820	472
Ghana	Accra	2146	3,083	30	103	896
Greece	Athens	1584.6	664,015	50	13,280	642
Hungary	Budapest	1198.7	61,985	50	1,240	522
India	Neu-Delhi	1960.5	1,553,731	50	31,075	749
Ireland	Dublin	948.7	10,002	50	200	425
Israel	Jerusalem	2198	3,734,199	3	1,244,733	918
Italy	Bologna	1419	665,130	50	13,303	593
Japan	Tokyo	1175.2	7,741	50	155	516
Jordan	Amman	2145.4	250,769	50	5,015	801
Korea, South	Seoul	1161.1	140,760	50	2,815	485
Latvia	Riga	991.2	2,174	50	43	414
Lebanon	Beirut	1934.5	58,287	40	1,457	808
Lesotho	Maseru	2050	1,200	10	120	856
Lithuania	Vilnius	1001.2	2,635	50	53	418
Luxembourg	Luxembourg	1037.4	9,209	50	184	433
Macedonia	Skopje	1380.8	5,804	50	116	577
Mexico	Mexico City	1706.3	833,956	50	16,679	713
Morocco	Rabat	2000	202,950	50	4,059	835
Mozambique	Maputo	1910	1,330	50	27	798

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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]
Namibia	Windhoek	2363	25,516	50	510	814
Netherlands	Amsterdam	999	115,304	40	2,883	418
New Zealand	Wellington	1401.2	15,965	50	319	585
Nigeria	Abuja	2007	1,377	1.4	984	838
Norway	Oslo	971.1	16,751	50	335	406
Palestine	Jerusalem	2198	806,136	50	16,123	918
Poland	Warsaw	1024.2	639,575	50	12,792	447
Portugal	Lisbon	1686.4	330,205	40	8,255	705
Romania	Bucharest	1324.3	28,839	50	577	553
Russia	Moscow	996	20,013	50	400	416
Senegal	Dakar	2197.3	145	4.5	32	918
Slovakia	Bratislava	1213.8	24,261	50	485	507
Slovenia	Ljubjana	1114.6	1,479	50	30	477
South Africa	Johannesburg	2075.1	32,161	87	370	867
Spain	Madrid	1643.5	2,026,087	50	40,522	676
Sweden	Gothenburg	933.9	54,206	50	1,084	430
Switzerland	Zürich	1093.8	112,852	20	5,643	457
Taiwan	Taipei	1372.2	92,033	30	3,068	518
Thailand	Bangkok	1764.8	11,726	80	147	737
Tunisia	Tunis	1808.2	32,158	50	643	755
Turkey	Antalya	1795.2	2,011,011	80	25,138	750
United States	LA, Indianapolis	1646.05	3,586,914	50	71,738	688
Zimbabwe	Harare	2017.1	5,964	32	186	842
Other (5%)		1407	10,248,187	50	204,964	525
	TOTAL		204,936,402		5,281,155	
	AVERAGE	1515		46		625

Table 14: *Solar thermal systems for domestic hot water heating in multifamily houses by the end of 2018*

Figure 59 shows the hydraulic scheme of domestic hot water reference system for multifamily houses as 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 ones.

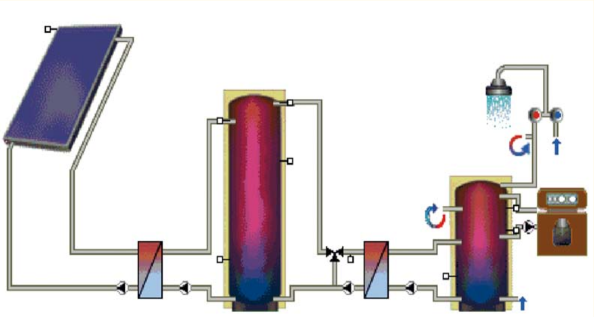

Figure 59: *Hydraulic scheme of the domestic hot water pumped reference system for multifamily houses*

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

The information in **Table 15** (see page 70) refers to the total capacity of water collectors in operation used for domestic hot water heating in multifamily houses at the end of 2018 as reported by each country.

Figure 60 shows the hydraulic scheme of domestic hot water reference system for multifamily houses as used for the simulations of the solar energy yields.

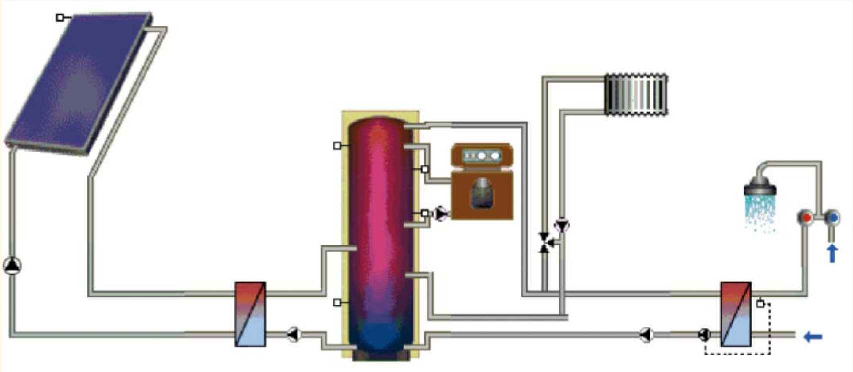

Figure 60: *Hydraulic scheme of the solar-combi reference system for single and multifamily houses*

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	2,010,078	14	143,576.99	369
Belgium	Brussels	971.1	133,169	12	11,097.46	342
Bulgaria	Sofia	1187.5	27,501	12	2,291.76	418
Canada	Montreal	1351.4	91	12	7.59	476
Croatia	Zagreb	1212	44,273	12	3,689.42	426
Cyprus	Nicosia	1885.5	12,569	12	1,047.42	663
Czech Republic	Praha	998.4	220,130	8.5	25,897.64	351
Denmark	Copenhagen	989.4	58,757	8	7,344.64	348
Estonia	Tallin	960.2	3,379	12	281.57	338
Finland	Helsinki	948	13,391	12	1,115.94	334
Germany	Würzburg	1091.3	8,212,616	11.5	714,140.53	378
Greece	Athens	1584.6	908,924	12	75,743.71	558
Hungary	Budapest	1198.7	62,574	10	6,257.42	422
Ireland	Dublin	948.7	23,338	12	1,944.87	364
Italy	Bologna	1419	910,451	12	75,870.89	499
Japan	Tokyo	1175.2	121,650	12	10,137.48	414
Korea, South	Seoul	1161.1	20,505	12	1,708.77	409
Latvia	Riga	991.2	2,976	12	248.01	349
Lebanon	Beirut	1934.5	4,163	12	346.94	681
Lesotho	Maseru	2050	7	12	0.62	721
Lithuania	Vilnius	1001.2	3,606	12	300.53	352
Luxembourg	Luxembourg	1037.4	12,606	12	1,050.46	365
Macedonia	Skopje	1380.8	1,935	10	193.47	486
Morocco	Rabat	2000	4,510	12	375.83	704
Netherlands	Amsterdam	999	32,850	6	5,475.00	352
New Zealand	Wellington	1401.2	4,789	12	399.11	493
Norway	Oslo	971.1	23,968	15	1,597.88	342
Palestine	Jerusalem	2198	17,914	12	1,492.85	773
Poland	Warsaw	1024.2	127,915	12	10,659.58	365
Romania	Bucharest	1324.3	39,475	12	3,289.62	466
Russia	Moscow	996	1,137	15	75.80	350
Slovakia	Bratislava	1213.8	33,210	12	2,767.47	427
Slovenia	Ljubjana	1114.6	8,874	12	739.50	362
Spain	Madrid	1643.5	344,866	10	34,486.58	619
Sweden	Gothenburg	933.9	287,526	10	28,752.55	389
Switzerland	Zürich	1093.8	352,664	11	32,060.34	385
Thailand	Bangkok	1764.8	1,708	12	142.34	621
Other (5%)		1407	741,682	12	61,806.86	403
	TOTAL		14,831,780		1,268,415.47	
	AVERAGE	1278		12		450

Combi-system: system for the supply of domestic hot water and space heating

Table 15: *Solar combi system reference for single and multifamily houses and the total collector area in operation in 2018*

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]

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 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	Malta	Luqa	1,902	2,115	18.7
39	Mauritius	Port Louis	1,920	2,010	23.3
40	Mexico	Mexico City	1,706	1,759	16.6
41	Morocco	Rabat	2,000	2,250	17.2
42	Mozambique	Maputo	1,910	2,100	22.8
43	Namibia	Windhoek	2,363	2,499	21.0
44	Netherlands	Amsterdam	999	1,131	10.0
45	New Zealand	Wellington	1,401	1,542	13.6
46	Nigeria	Abuja	2,007	2,051	25.7
47	Northern Macedonia	Skopje	1,381	1,521	12.5
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).

8.4 Population data

No	Country	2018	Reg. code
1	Albania	3,057,220	6
2	Argentine	44,694,198	4
3	Australia	24,747,894	3
4	Austria	8,793,370	6
5	Barbados	293,131	4
6	Belgium	11,570,762	6
7	Botswana	2,249,104	1
8	Brazil	208,846,892	4
9	Bulgaria	7,057,504	6
10	Burkina Faso	19,742,715	1
11	Canada	37,081,268	8
12	Cape Verde	568,373	1
13	Chile	17,925,262	4
14	China	1,384,688,986	5
15	Croatia	4,270,480	6
16	Cyprus	1,237,088	6
17	Czech Republic	10,686,269	6
18	Denmark	5,809,502	6
19	Estonia	1,244,288	6
20	Finland	5,537,364	6
21	France	67,364,357	6
22	Germany	80,457,737	6
23	Ghana	28,102,471	1
24	Greece	10,669,474	6
25	Hungary	9,825,704	6
26	India	1,296,834,042	2
27	Ireland	5,068,050	6
28	Israel	8,424,904	7
29	Italy	62,246,674	6
30	Japan	126,168,156	2
31	Jordan	10,458,413	7
32	Korea, South	51,418,097	2
33	Latvia	1,923,559	6
34	Lebanon	6,100,075	7
35	Lesotho	1,962,461	1
36	Lithuania	2,793,284	6
37	Luxembourg	605,764	6

No	Country	2018	Reg. code
39	Malta	449,043	6
40	Mauritius	1,364,283	1
41	Mexico	125,959,205	4
42	Morocco	34,871,495	7
43	Mozambique	28,556,701	1
44	Namibia	2,533,224	1
45	Netherlands	17,151,228	6
46	New Zealand	4,779,949	3
47	Nigeria	203,452,505	1
38	Northern Macedonia	2,118,945	6
48	Norway	5,372,191	6
49	Palestine	4,635,207	7
50	Poland	38,420,687	6
51	Portugal	10,355,493	6
52	Romania	21,457,116	6
53	Russia	142,122,776	6
54	Senegal	15,020,945	1
55	Slovakia	5,445,040	6
56	Slovenia	2,102,126	6
57	South Africa	55,380,210	1
58	Spain	49,331,076	6
59	Sweden	10,040,995	6
60	Switzerland	8,292,809	6
61	Taiwan	23,545,963	2
62	Thailand	68,615,858	2
63	Tunisia	11,516,189	7
64	Turkey	81,257,239	6
65	United Kingdom	65,105,246	6
66	United States	327,167,434	8
67	Uruguay	3,369,299	4
68	Zimbabwe	14,030,368	1
	All other countries (5%)	2,471,105,519	9
	Σ Solar Thermal World Statistics	4,954,345,737	67%
	Σ Inhabitants world	7,425,451,256	

Table 17: *Inhabitants by the end of 2018 of the 68 surveyed countries in alphabetical orderData 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	372,963,360	5%
2	Asia w/o China	1,566,582,116	21%
3	Australia / New Zealand	29,527,843	0%
4	Latin America	401,087,987	5%
5	China	1,384,688,986	19%
6	Europe	759,240,460	10%
7	MENA Region	76,006,283	1%
8	United States / Canada	364,248,702	5%
9	Other countries	2,471,105,519	33%
TOTAL		7,424,172,227	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: *Inhabitants per economic region by the end of 2018Data source: International Data Base of the U.S. Census Bureau **http://www.census.gov/ipc/www/idb/country.php***

8.5 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 as well as 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 cost, 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.

8.6 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 which, in addition to the industrial process, also supply the space heating for the production halls or offices or showers, are also taken into account.

Agricultural applications like drying systems for wood chips, crops, fruits and solar heat used for animal breeding.

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

Service Sector: Solar thermal systems supplying commercial laundries, car/truck washing as well as sewage sludge drying facilities with heat.
Solar cooling of industrial processes

Not considered in this definition are:
- 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 m^2 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 no SHIP systems with smaller collector areas. In some countries (e.g. Germany), the number of SHIP plants with collector areas below 50 m^2 is significantly higher than the realized plants above that limit.

8.7 Market data of the previous years

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

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.

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

In the following **Table 19**, **Table 20** and **Table 21** these 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		21,714.0	784.0			22,498.0
Australia	380,000.0	148,200.0	16,470.0	30,000.0	1,000.0	575,670.0
Austria	760.0	109,600.0	1,440.0		130.0	111,930.0
Barbados*		11,430.0				11,430.0
Belgium		39,000.0	7,500.0			46,500.0
Botswana**		2,500.0				2,500.0
Brazil	548,205.0	734,240.0	22,477.0			1,304,922.0
Bulgaria		5,100.0	500.0			5,600.0
Burkina Faso		1,000.0	150.0			1,150.0
Canada	22,008.0	1,303.0	2,367.0	10,438.0	100.0	36,216.0
Cape Verde**		120.0				120.0
Chile	0.0	29,300.0	11,878.0	0.0	0.0	41,178.0
China		5,340,000.0	34,180,000.0	500.0		39,520,500.0
Croatia		19,000.0	2,500.0			21,500.0
Cyprus		62,170.0	0.0			62,170.0
Czech Republic	30,000.0	22,000.0	9,000.0			61,000.0
Denmark		478,297.0		0.0		478,297.0
Estonia		1,000.0	1,000.0			2,000.0
Finland		3,333.0	1,667.0			5,000.0
France (mainland)+	2,000.0	64,530.0	2,580.0	800.0		69,910.0
Germany	22,000.0	677,000.0	67,000.0			766,000.0
Ghana***		75.6	24.3			99.9
Greece		272,000.0	600.0			272,600.0
Hungary	1,000.0	9,000.0	3,000.0	100.0	100.0	13,200.0
India++		150,476.0	1,050,383.0		1,200.0	1,202,059.0
Ireland		13,594.1	10,782.7			24,376.8
Israel	1,000.0	420,000.0				421,000.0
Italy		183,647.0	25,043.0			208,690.0
Japan*		77,315.0	737.0		7,046.0	85,098.0
Korea, South		10,686.4	18,285.6			28,972.0
Latvia		1,500.0	300.0			1,800.0
Lebanon		23,900.0	31,170.0			55,070.0
Lesotho		46.0	151.0			197.0
Lithuania		800.0	1,400.0			2,200.0
Luxembourg		4,200.0	700.0			4,900.0
Northern Macedonia		6,466.0	5,993.0			12,459.0
Malta*		1,597.5	399.4			1,996.9
Mexico	108,300.0	139,100.0	118,800.0			366,200.0
Mozambique*	8.4	12.8	6.6			27.8
Namibia	780.0	5,369.8	30.0			6,179.8
Netherlands	2,620.0	20,137.0	5,179.0			27,936.0
Nigeria	0.0	229.2	78.9	0.0	35.0	343.1
Norway		1,660.0	110.0			1,770.0
Palestinian Territories**		49,000.0	225.0			49,225.0
Poland		111,700.0	3,700.0			115,400.0
Portugal		45,300.0	800.0			46,100.0
Romania	0.0	6,800.0	11,000.0			17,800.0
Russia	22.0	1,820.3	172.0	2.0	14.0	2,030.3
Senegal**	0.0	4.1	80.0	0.0	54.5	138.6
Slovakia	0.0	8,000.0	1,600.0			9,600.0
Slovenia		2,300.0	400.0			2,700.0
South Africa	67,428.0	32,207.3	26,640.0			126,275.3
Spain	3,321.0	201,793.0	7,076.0	1,250.0	1,250.0	214,690.0
Sweden	0.0	2,487.0	336.0			2,823.0
Switzerland	5,654.0	51,150.0	9,895.0			66,699.0
Taiwan		94,370.2	5,783.8			100,154.0
Thailand		2,680.0	0.0		0.0	2,680.0
Tunisia		67,738.0				67,738.0
Turkey		964,000.0	887,000.0	3,000.0		1,854,000.0
United Kingdom		10,920.0	3,010.8	500.0		14,430.8
United States	802,314.0	164,135.0	8,528.0	12,000.0	9,000.0	995,977.0
Uruguay		6,598.0				6,598.0
Zimbabwe		32.0	8,954.0			8,986.0
Other (5%)	105,127.4	575,562.3	1,925,036.2	3,083.7	1,048.9	2,609,858.5
TOTAL	2,102,547.8	11,511,246.7	38,500,723.3	61,673.7	20,978.4	52,197,169.9

* Revised due to new / adapted database 2020
** 0% growth assumed 2016
\+ The figures for France refer to mainland France only, overseas territories are not considered
\++ In 2016 change from fiscal year to calendar year. Data refer to April-Dec. 2016

Table 19: *Newly installed collector area in 2016 [m²]*

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		6,028,000.0	31,232,000.0	1,000.0		37,261,000.0
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		10,631.0	8,435.6			19,066.6
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
Other (5%)	108,579.7	587,927.5	1,777,731.9	1,120.4	539.8	2,475,899.3
TOTAL	2,171,594.7	11,758,550.7	35,554,637.2	22,408.4	10,795.1	49,517,986.1

* Revised to new / adapted database in 2020
** 7 % growth assumed in 2017
*** 0 % growth assumed in 2017
\+ The figures for France refer to mainland France only, overseas territories are not considered

Table 20: *Newly installed collector area in 2017 [m²]*

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL (excl. concentrators) [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		226,969	5,246			232,215
Argentina	9,318	10,393	24,748			44,459
Australia	5,427,000	3,409,000	193,000	365,000	11,800	9,405,800
Austria	378,291	4,704,139	85,727		4,028	5,172,185
Barbados**		225,720				225,720
Belgium	45,000	522,883	94,450			662,333
Botswana		10,500	1,800			12,300
Brazil	5,370,961	9,400,875	101,565			14,873,401
Bulgaria		135,580	4,470			140,050
Burkina Faso		2,982	469			3,450
Canada	806,144	70,714	49,512	412,609	48,994	1,387,973
Cape Verde		1,783				1,783
Chile	65,550	213,300	53,878	0	300	333,028
China		42,818,000	435,062,000	4,000	2,000	477,886,000
Croatia		199,041	11,475			210,516
Cyprus	2,213	742,482	23,567			768,262
Czech Republic	598,000	444,305	136,798			1,179,103
Denmark	20,500	1,610,870	9,197	4,300	18,000	1,662,867
Estonia		8,830	7,190			16,020
Finland	11,800	34,690	19,033			65,523
France (mainland)+	125,780	2,439,996	185,880	8,653	1,100	2,761,409
Germany	545,580	17,001,000	2,079,000		22,400	19,647,980
Ghana		1,744	637			2,381
Greece		4,596,000	22,000			4,618,000
Hungary	17,800	222,700	73,100	2,750	2,200	318,550
India	0	4,158,349	7,563,976	0	11,900	11,734,225
Ireland		233,670	129,881			363,551
Israel	38,000	4,673,434				4,711,434
Italy	43,800	3,917,526	613,203			4,574,529
Japan		3,795,769	110,510		278,673	4,184,952
Jordan***	5,940	982,482	272,084			1,260,506
Korea, South		1,697,189	173,496			1,870,685
Latvia		11,142	2,740			13,882
Lebanon		337,461	450,541			788,002
Lesotho		1,449	598			2,047
Lithuania		7,200	9,550			16,750
Luxembourg		53,745	8,900			62,645
Northern Macedonia		55,119	25,054			80,173
Malta		57,799	14,450			72,249
Mauritius****		132,793				132,793
Mexico	1,299,253	1,462,282	1,157,142	752	8,773	3,928,202
Morocco***		451,000				451,000
Mozambique	144	361	1,781			2,286
Namibia	1,560	39,520	1,355			42,435
Netherlands	95,370	515,090	39,810			650,270
New Zealand++	7,025	142,975	9,644			159,645
Nigeria	0	688	237	0	70	994
Norway	1,849	38,220	4,130	200	4,106	48,505
Palestinian Territories		1,738,369	8,225			1,746,594
Poland		1,768,490	480,600			2,249,090
Portugal	2,130	1,028,905	28,330			1,059,365
Romania	340	102,400	86,750	800		190,290
Russia	137	20,596	3,317	2	64	24,115
Senegal		91	1,733	0	1,203	3,027
Slovakia	1,000	140,550	25,150			166,700
Slovenia		124,500	23,400			147,900
South Africa	1,168,918	604,789	265,475	0	0	2,039,182
Spain	152,172	3,738,295	214,826	1,750	1,250	4,108,293
Sweden	170,410	301,993	72,411			544,814
Switzerland	192,580	1,333,290	132,590			1,658,460
Taiwan	1,937	1,571,874	133,244			1,707,055
Thailand+++		157,536				157,536
Tunisia		900,038	70,104			970,142
Turkey		16,908,182	6,349,454	9,570		23,267,206
United Kingdom*	510,089	624,266	175,453	23,100		1,332,908
United States	22,308,019	2,904,951	163,307	116,975	65,500	25,558,752
Uruguay		69,393				69,393
Zimbabwe		21,811	19,914			41,725
All other countries (5%)	2,074,980	7,677,899	24,057,269	50,024	25,387	33,885,559
TOTAL	41,499,590	153,557,974	481,145,375	1,000,485	507,749	677,711,173

* Revised due to new / adapted database in 2020
** Based on Solar Water Heating Techscope Market Readiness Assessment - Reports UNEP 2015, 0 % growth assumed in 2017
*** cumulated collector area by end of 2014
**** cumulated collector area by end of 2015
\+ The figures for France refer to mainland France only, overseas territories are not considered.
++ cumulated collector area by end of 2009
+++ cumulated collector area by end of 2016

Table 21: *Total collector area in operation by the end of 2017 [m²]*

8.8 References to reports and persons who have supplied the data

The production of the report, *Solar Heat Worldwide – Edition 2020* 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)	EEC - Albania-EU Energy Efficiency Centre
Argentina	**Federico Pescio** ENERGÍA SOLAR TÉRMICA Instituto Nacional de Tecnología Industrial (INTI) Energías Renovables / Centro de Investigación y Desarrollo en Energías Renovables	Censo Nacional de Energía Solar Térmica (baja temperatura) Instituto Nacional de Tecnología Industrial (INTI) 0% growth assumed
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, 2019: Innovative Energietechnologien in Österreich – Marktentwicklung 2018 (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 2018 data provided by James Husbands
Belgium	**Solar Heat Europe / ESTIF** **AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 Unglazed water collectors: AEE INTEC recordings
Botswana	**Karen Gibson** SIAB Solar Industries Association Botswana	Industry survey 2018
Brazil	**Dr. Danielle Johann** Diretora Executiva, ABRASOL, Associação Brasileira de Energia Solar Térmica	ABRASOL Out of operation systems calculated based on ABRASOL long time recordings (provided by Marcelo Mesquita) 2019 data for market estimation provided by Bärbel Epp
Bulgaria	**Solar Heat Europe / ESTIF** **AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 Unglazed water collectors: AEE INTEC recordings
Burkina Faso	**Dr. 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
Canada	**Reda Djebbar, Ph.D., P.Eng.** Natural Resources Canada	Clear Sky Advisors, April 2019 Report - „Survey of Active Solar Thermal Collectors, Industry and Markets in Canada (2018)" Out of operation systems considered by NRC

Cape Verde	**Antúnio Barbosa**	Country Market Report on solar thermal heating systems, solar drying and solar cooling, September 2015 Integrated 2019, new collector area 2018 estimation AEE INTEC
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	**Hu Runqing** Center for Renewable Energy Development - Energy Research Institute (NDRC) **Ruicheng Zheng** China Academy of Building Research	CSTIF - Chinese Solar Thermal Industry Federation Out of operation systems calculated by CSTIF
Croatia	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019
Cyprus	**Panayiotis Kastanias** Cyprus Employers and Industrialists Federation	EBHEK Solar Thermal Market Analysis 2017-2018 New installations 2018: EBHEK Solar Thermal Market Analysis 2017-2018 Cumulated calculated by AEE INTEC based on replacement figures provided by Panayiotis Kastanias
Czech Republic	**Aleš Bufka** Ministry of Industry and Trade	Unglazed water collectors: AEE INTEC recordings
Denmark	**Jan-Erik Nielsen, Daniel Trier** Planenergi	Unglazed water collectors: AEE INTEC recordings
Estonia	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)
Finland	**Ville Maljanen** Solar Energy Statistics Finland **Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)
France (mainland)	**Paul Kaaijk** ADEME - Agence de l'Environnement et de la Maîtrise de l'Énergie **John Hollick** SAHWIA - Solar Air Heating World Industry Association	ObservER' 2019 Air collectors: John Hollick
Germany	**Marco Tepper** 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: recordings AEE INTEC
Ghana	**Divine Atsu** Koforidua Polytechnic Department of Energy Systems Engineering	2018 market estimation provided by Klaus Kucher
Greece	**Costas Travasoras** EBHE – Greek Solar Industry Association **Dr. 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	MÉGNAP- Hungarian Solar Thermal Industry Federation Air collectors: John Hollick New and cumulated installations: Hungarian Solar Thermal Industry Federation (MÉGNAP); provided by Pál Varga (personal estimation)
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** 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 new 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	**Solar Heat Europe / ESTIF** **AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Cumulated area: Solar Heat Europe / ESTIF 2019 / 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 2018 reported Cumulated installations by end of 2014
Korea, South	**Eunhee Jeong** 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, 2019 Shares ETC / FPC 2018 calculated by AEE INTEC according to shares in 2016 and 2017
Latvia	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)
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
Lithuania	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)
Luxembourg	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)

Malta	**Ing. 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) Revised timeline provided by Therese Galea
Mauritius	**Mrs Devika Balgobin** Statistician, Environment Statistics Unit Ministry of Environment and Sustainable Development	Statistics Mauritius No new collector area 2018; 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 Associationdata 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	No new collector area 2018; cumulated collector area by end of 2014
Mozambique	**Fabião Cumbe** ENPCT, E.P. **AEE INTEC**	estimation AEE INTEC Cumulated installations calculated by AEE INTEC based on new installation figures for 2018
Namibia	**Fenni Shidhika** Namibia Energy Institute Namibia University of Science and Technology	Namibia Energy Institute-Solar Water Heaters-Survey 2018
Netherlands	**André Meurink, Dr. Reinoud Segers** 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	**Dr. Okala Nwoke** National Centre for Energy Research and Development, University of Nigeria, Nsukka	National Centre for Energy Research and Development, University of Nigeria 2018 data provided by Okala Nwoke plus 30 % additional installed area assumed by AEE INTEC
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	**Michaela Meir** Aventasolar	Solvarmeanlegg i Norge 2018 commissioned by The Norwegian Solar Energy Cluster (Solenergiklyngen), provided by Michaela Meir calculated by AEE INTEC based on new installed 2018 (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 Starosćik** President, Association of Heating Appliances manufacturers and Importers in Poland	
Portugal	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)

Romania	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)
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 2018 market estimation provided by Klaus Kucher
Slovakia	**Solar Heat Europe / ESTIF**	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF2019 Glazed water collectors: Solar Heat Europe / ESTIF, 2019 (estimation)
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	**Solar Thermal Markets in Europe** Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019	Solar Thermal Markets in Europe - Trends and Market Statistics 2018, Solar Heat Europe / ESTIF 2019
Switzerland	**http://www.swissolar.ch/**	SWISSOLAR - Markterhebung Sonnenenergie 2018, Bundesamt für Energie 2019 Out of operation systems calculated by SWISSOLAR
Taiwan	**K.M. Chung** Energy Research Center - National Cheng Kung University	Installers association 2018 new installations provided by K.M. Chung
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) Data for subsidized systems, provided by Charuwan Phipatana-phuttapanta, single-family houses estimated by AEE INTEC based on GIZ study, no new collector area in 2018; 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 shares provided by Prof. Bulent Yesilata (2016)
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 Solar Heat Europe / ESTIF Reports collated in BEIS annual survey Active Solar 2018 survey with efficiency and lifetime, Air collectors provided by John Hollick Timeline provided by Elizabeth Waters
United States	**Les Nelson** IAPMO Solar Heating & Cooling Programs **John Hollick** SAHWIA - Solar Air Heating World Industry Association	Water Collectors and air collectors: IAPMO Solar Heating & Cooling Programs; Air collectors: SAHWIA New installations: DOE / SEIA / IAPMO; 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 (unpublished sources) cumulated 2018 calculated by AEE INTEC

8.9 Additional literature and web sources used

The following reports and statistics were used in this report.

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- Bundesministerium für Verkehr, Innovation und Technologie (BMVIT): Innovative Energy Technologies in Austria - Market Development 2018; prepared by Peter Biermayr et al, Vienna, Austria June 2019
- Bundesverband Solarwirtschaft e.V. (BSW-Solar): Statistische Zahlen der deutschen Solarwärmebranche (Solarthermie) 2018; accessed December 2019
- ClearSky Advisors Inc.: Survey of Active Solar Thermal Collectors, Industry and Markets in Canada (2018); Prepared by ClearSky Advisors Inc., Dr. Reda Djebbar, Natural Resources Canada, March 2019
- European Solar Thermal Industry Federation (ESTIF): Solar Thermal Markets in Europe, Trends and Market Statistics 2018; Belgium - Brussels; November 2019
- Global Market Outlook for Solar Power / 2019-2023, Solar Power Europe, 2019
- GWEC / Global Wind Report 2019, Global Wind Energy Council, March 2020
- IRENA: Renewable Energy and Jobs: Annual Review 2018
- Lehr, U. et.al (2015), Beschäftigung durch erneuerbare Energien in Deutschland: Ausbau und Betrieb, heute und morgen
- Weiss, W. (2003) Wirtschaftsfaktor Solarenergie, Wien
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- Wimmer, L. et.al. (2019), Monitoring of renewable process heat plants within the gas sector.

The following online sources were used in this report:

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http://www.asit-solar.com/

http://helioscsp.com/concentrated-solar-power-had-a-global-total-installed-capacity-of-6451-mw-in-2019

http://www.solarpowereurope.org/home/

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/

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https://www.statista.com/statistics/476281/global-capacity-of-geothermal-energy

http://www.swissolar.ch/

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8.10 List of Figures

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