Franz Mauthner | Werner Weiss | Monika Spörk-Dür

Solar Heat Worldwide

Markets and Contribution to the Energy Supply 2014

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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SOLAR HEATING & COOLING PROGRAMME
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1 Background

This report was prepared within the framework of the Solar Heating and Cooling Programme (SHC) of the International Energy Agency (IEA). The goal of the report is to document the solar thermal capacity installed in the important markets worldwide, and to 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 collectors documented 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.

The data were collected from a survey of the national delegates of the IEA SHC Programme's Executive Committee and other national experts active in the field of solar thermal energy. As some of the 61 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.

Starting with the collector area, respectively the capacity installed, the contributions of solar thermal systems towards the supply of energy and the reduction of CO_2 were ascertained.

The 61 countries included in this report represent 4.5 billion people, or about 63 % of the world's population. The installed capacity in these countries is estimated to represent 95 % of the solar thermal market worldwide.

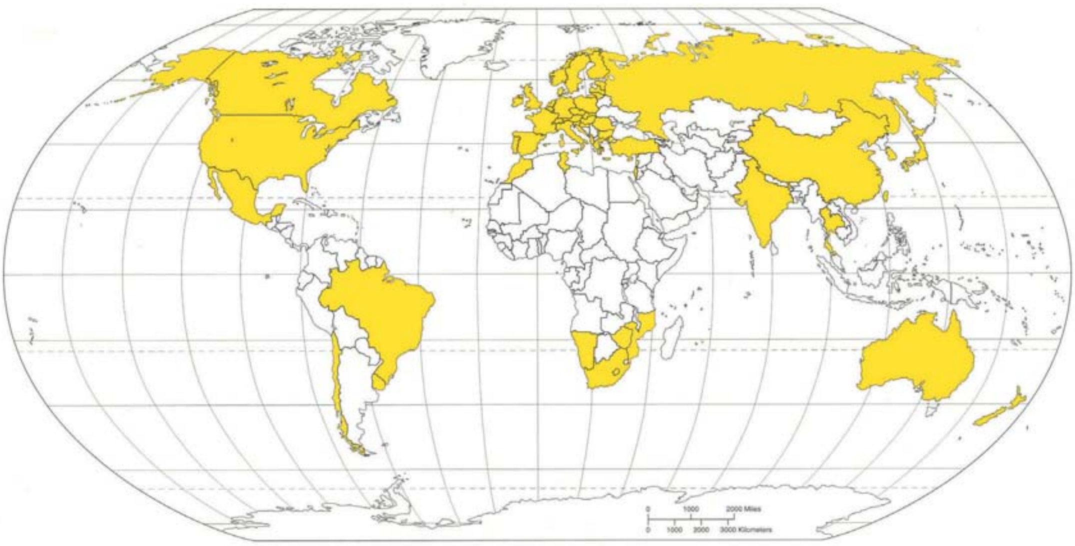

Figure 1: From countries shown in yellow detailed market data are available.
The market data from all other countries are estimated.

2 Summary

This report comprises solar thermal market data from 61 countries covering an estimated 95 % of the worldwide market. The remaining 5 % of the market were extrapolated and are labeled as *"all other countries"* in the following sections.

Total installed capacity in operation worldwide by the end of 2014

By the end of 2014, an installed capacity of 410.2 GW_{th}, corresponding to a total of 586 million square meters[1] of collector area was in operation worldwide.

The vast majority of the total capacity in operation was installed in China (289.5 GW_{th}) and Europe (47.5 GW_{th}), which together accounted for 82.1 % of the total installed capacity. The remaining installed capacity was shared between the United States and Canada (18.0 GW_{th}), Asia w/o China (10.7 GW_{th}), Latin America (10.0 GW_{th}), the MENA[2] countries Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (6.6 GW_{th}), Australia and New Zealand (6.2 GW_{th}), and Sub-Sahara African countries Lesotho, Mauritius, Mozambique, Namibia, South Africa and Zimbabwe (1.3 GW_{th}). The market volume of *"all other countries"* is estimated to amount for 5 % of the total installations (20.5 GW_{th}).

The breakdown of the cumulated capacity in operation in 2014 by collector type is 22.1 % glazed flat-plate collectors, 71.1 % evacuated tube collectors, 6.3 % unglazed water collectors, and 0.4 % glazed and unglazed air collectors.

The leading countries in cumulated unglazed and glazed water collector capacity in operation in 2014 per 1,000 inhabitants were Austria (419 kW_{th}/1,000 inhabitants), Cyprus (412 kW_{th}/1,000 inhabitants), Israel (400 kW_{th}/1,000 inhabitants), Barbados (318 kW_{th}/1,000 inhabitants), Greece (278 kW_{th}/1,000 inhabitants), the Palestinian territories (275 kW_{th}/1,000 inhabitants), Australia (260 kW_{th}/1,000 inhabitants), China (213 kW_{th}/1,000 inhabitants), Turkey (162 kW_{th}/1,000 inhabitants) and Germany (158 kW_{th}/1,000 inhabitants).

New installed capacity worldwide in 2014

In the year 2014, a total capacity of 46.7 GW_{th}, corresponding to 66.7 million square meters of solar collectors, was installed worldwide.

The main markets were in China (36.7 GW_{th}) and Europe (3.4 GW_{th}), which together accounted for 85.9 % of the overall new collector installations in 2014. The rest of the market was shared between Latin America (1.3 GW_{th}), Asia w/o China (1.0 GW_{th}), the United States and Canada (0.8 GW_{th}), the MENA region represented by Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (0.5 GW_{th}), Australia (0.5 GW_{th}), and the Sub-Sahara African countries Lesotho, Mauritius, Mozambique, South Africa and Zimbabwe (0.1 GW_{th}). The market volume of "all other countries" is estimated to amount for 5 % of the new installations (2.3 GW_{th}).

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1 To compare the installed capacity of solar thermal collectors with other energy sources, solar thermal experts agreed upon a methodology to convert installed collector area into solar thermal capacity at a joint meeting of the IEA SHC Programme and major solar thermal trade associations held September 2004 in Gleisdorf, Austria. The represented associations from Austria, Canada, Germany, the Netherlands, Sweden and 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.

2 Middle East and North Africa

Compared to the year 2013 the new collector installations worldwide decreased by 15.2 %. By contrast, the world market growth in the period 2012/2013 amounted to 1.9 % and in the period 2011/2012 to 6.7 %. This indicates a trend change. This is the first time a shrinking world market has been observed. Based on data already available for 2015 this trend seems to continue.

From the top 10 markets in 2014 positive market development was reported in Brazil (+4.5 %), India (+7.0 %), the United States (+0.9 %), Mexico (+18.2 %) and Greece (+19.1 %). The other major solar thermal markets within the top 10 countries, namely China (–17.6 %), Turkey (–0.8 %), Germany (–9.8 %), Australia (–21.1 %) and Israel (–13.4 %) suffered market declines.

Latin America shows the most steady and dynamic upward trend of all economic regions. The dominant Brazilian, but also the large Mexican market as well as the evolving markets such as Chile are responsible for the positive growth rates for the sixth year in a row. In 2014 these markets grew by 8.1 %.

The breakdown of the new installed capacity in 2014 by collector type is 18.5 % glazed flat-plate collectors, 77.9 % evacuated tube collectors, 3.5 % unglazed water collectors and 0.2 % glazed and unglazed air collectors.

In terms of new installed solar thermal capacity per 1,000 inhabitants in 2014, Israel took the lead once again, ahead of China and Palestinian territories (West Bank and Gaza Strip). Due to outstanding achievements in the field of solar district heating in the last couple of years Denmark is ranked fourth in this respect, even ahead of mature solar thermal markets such as Greece, Turkey and Austria.

Contribution to the energy supply and CO_2 reduction

The annual collector yield of all water-based solar thermal systems in operation by the end of 2014 in the 61 recorded countries was 335 TWh (= 1,208 PJ). This corresponds to a final energy savings equivalent of 36.1 million tons of oil and 116.4 million tons of CO_2. The calculated number of different types of solar thermal systems in operation was around 101 million.

In 2014, 94 % of the energy provided by solar thermal systems worldwide was used for heating domestic hot water, mainly by small-scale systems in single-family houses (68 %) and larger applications attached to multi-family houses, hotels, schools, etc. (27 %). 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.

Distribution of systems 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 (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).

For unglazed and glazed water collectors, the evacuated tube collector dominated with a 71 % share of the cumulated capacity in operation and a 78 % share of the new installed capacity. In China, vacuum tube collectors played an important role, and since this was by far the largest market, the worldwide figures tend towards a higher share of this type of solar thermal collector.

Unglazed water collectors accounted for 6 % of the cumulated water collectors installed worldwide and the share tended to decrease. In 2014, the share of unglazed water collectors was 3 % of the new installed capacity.

Worldwide, more than three quarters of all solar thermal systems installed are thermosiphon systems and the rest are pumped solar heating systems. Similar to the distribution by type of solar thermal collector in total numbers the Chinese market influenced the overall figures most, and in 2014 90 % of the new installed systems were estimated to be thermosiphon systems while pumped systems only accounted for 10 %.

In general, thermosiphon systems are more common in warm climates such as in Africa, South America, southern Europe and the MENA region. 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.

The calculated number of water-based solar thermal systems in operation was approximately 101 million by the end of 2014. The breakdown is 6 % used for swimming pool heating, 63 % used for domestic hot water preparation in single-family houses and 28 % 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 1 % and delivered heat to other applications such as district heating networks, industrial processes or thermally driven solar cooling applications.

Compared to the cumulated installed capacity, the share of swimming pool heating was less for new installations (6 % of total capacity and 4 % of new installed capacity). A similar trend can be seen for domestic hot water systems in single-family homes: 63 % of total capacity in operation and 43 % of new installations in 2014 make this kind of systems the most common application worldwide, but with a decreasing tendency.

By contrast, the share of large-scale domestic hot water applications grew (28 % of total capacity and 50 % of new installed capacity). It can be assumed that this market segment took over some of the market shares from both swimming pool heating and domestic hot water systems in single-family homes.

The share of solar combi-systems as well as other applications, such as solar district heating, solar process heat or solar cooling remained at a low level of 3 – 4 % and no real trend can be identified in a global context.

Levelized cost of solar thermal generated heat

Lowest levelized costs for solar thermal generated heat range between ~1 €-ct/kWh for pool heating systems (Australia, Brazil), 2 – 5 €-ct/kWh for small thermosiphon domestic hot water systems (Brazil, India, Israel, Turkey), 7 – 8 €-ct/kWh for small pumped domestic hot water systems (Australia, China) and 2 – 6 €-ct/kWh for large pumped domestic hot water and/or space heating systems (Brazil, China, India, South Africa).

Highest levelized costs for solar thermal generated heat range between ~2 €-ct/kWh for pool heating systems (Canada, Israel), 7 – 12 €-ct/kWh for small thermosiphon domestic hot water systems (Australia, China, South Africa), 12 – 20 €-ct/kWh for small pumped domestic hot water systems (Australia, Austria, Canada, Denmark, France), 8 – 14 €-ct/kWh for large pumped domestic hot water systems (Austria, Canada, Denmark, France) and 11 – 19 €-ct/kWh for small combined hot water and space heating systems (Austria, China, Denmark, South Africa).

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 730,000 worldwide in 2014.[3]

The worldwide turnover of the solar thermal industry in 2014 is estimated at € 21 billion (US$ 24 billion).

Development of global solar thermal capacity in operation and energy yields 2000 – 2015

Global solar thermal capacity of unglazed and glazed water collectors in operation grew from 62 GW_{th} (89 million square meters) in 2000 to 435 GW_{th} (622 million square meters) in 2015. The corresponding annual solar thermal energy yields amounted to 51 TWh in 2000 and to 357 TWh in 2014 (Figure 2).

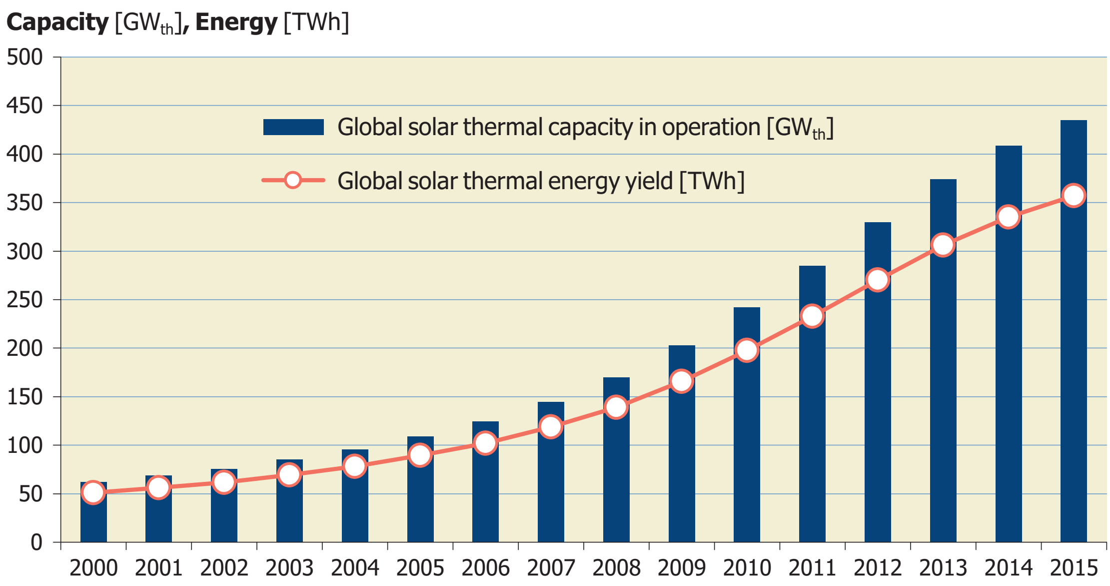


Figure 2: Global solar thermal capacity in operation and annual energy yields 2000 – 2015

2.1 Preview 2015

The estimated total capacity of solar thermal collectors in operation worldwide by the end of 2015 is 435 GW_{th}, or 622 million square meters of collector area. This corresponds to an annual collector yield of 357 TWh, which is equivalent to savings of 38.4 million tons of oil and 123.8 million tons of CO_2.

The preview for 2015 is based on the latest market data from Australia, Austria, Brazil, China, Germany, Israel, Mexico, Turkey and the United States, which represented 87 % of the cumulated installed capacity in operation in the year 2015. The other countries were estimated according to their trend over the past two years.

Compared with other forms of renewable energy, solar heating's contribution in meeting global energy demand is, besides the traditional renewable energies like biomass and hydropower, second only to wind power (Figure 3). In terms of cumulated installed capacity in operation solar thermal is almost equal with wind power by end of 2015.

3 Background information on the methodology used can be found in the Annex, chapter 9.4

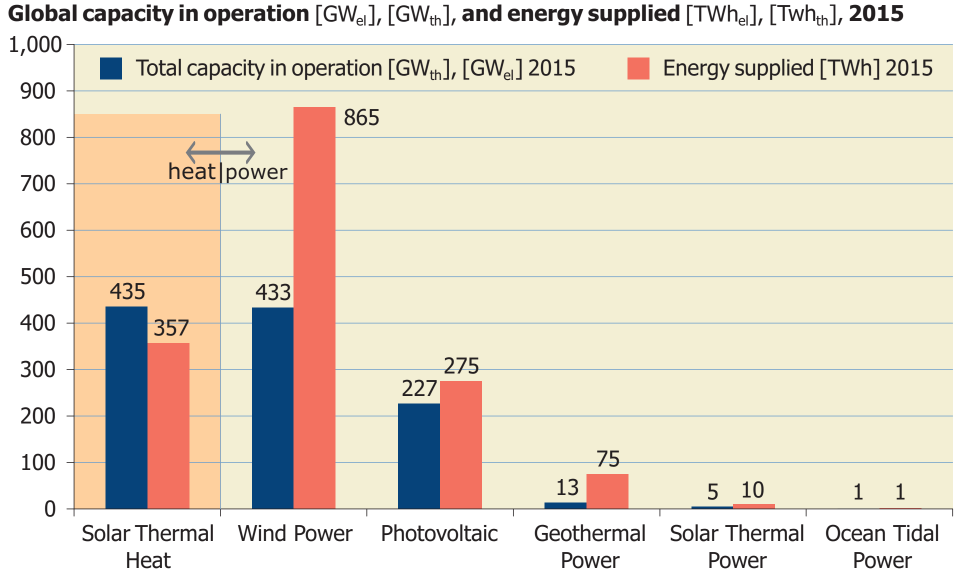


Figure 3: Global capacity in operation [GW_{el}], [GW_{th}] 2014 and annual energy yields [TWh_{el}], [TWh_{th}] *(Sources: AEE INTEC, Global Wind Energy Council (GWEC), European PV Industry Association (EPIA), REN21 - Global Status Reports 2015)*

The development of global installed capacity of solar thermal heat, wind and photovoltaic between 2010 and 2015 is shown in Figure 4. It can be highlighted that all mentioned renewable technologies show positive growth rates in terms of cumulated installed capacities, but as a general trend the growth rates flatten out. Moreover, it can be seen that solar thermal was the leading renewable energy technology in terms of cumulated installed capacity in operation for many years and that wind energy caught up in recent years to a level equal to solar thermal in 2015.

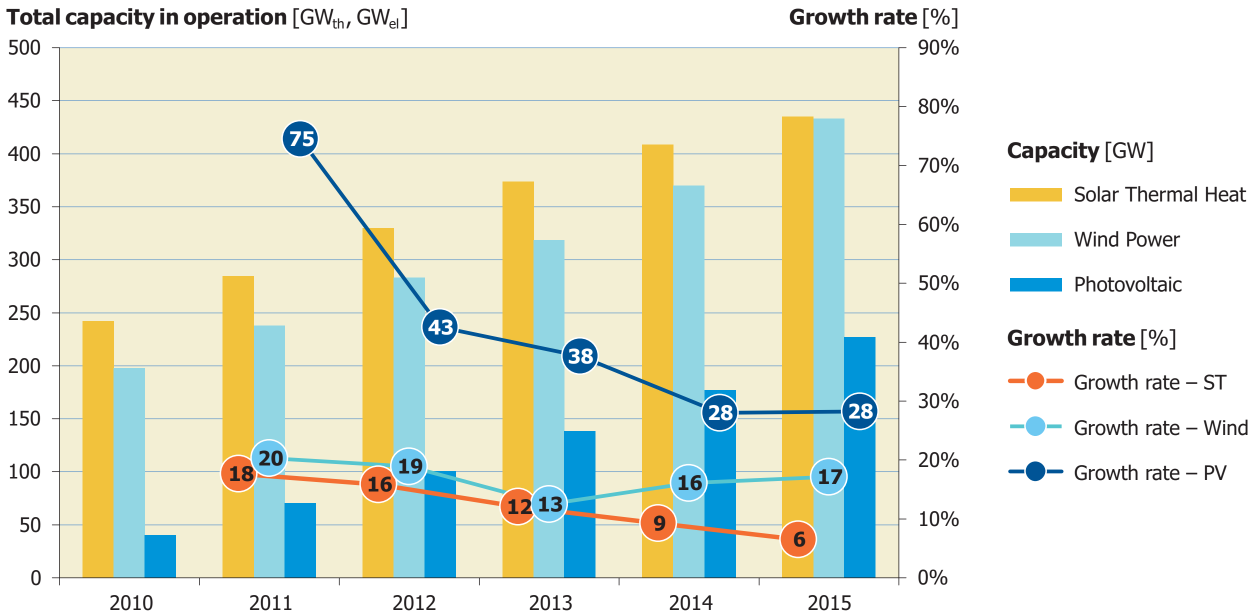


Figure 4: Global solar thermal heat, wind power and photovoltaic capacity in operation and market growth rates between 2010 and 2015 *(Sources: AEE INTEC, Global Wind Energy Council (GWEC), European PV Industry Association (EPIA), REN21 - Global Status Reports 2011-2015)*

3 Total capacity in operation in 2014

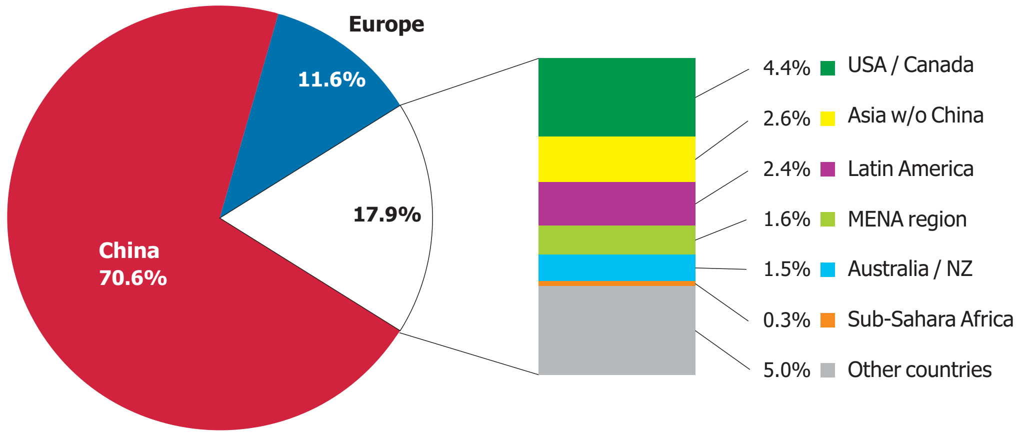
This report aims to give the actual collector area in operation and not the cumulated collector area that has ever been installed in a country. To determine the collector area (and respective capacity) in operation, either official country reports on the lifetime were used or, if such reports were not 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 considered to be less than 10 years.

The analysis further distinguishes between different types of solar thermal collectors, such as unglazed water collectors, glazed water collectors including flat plate collectors (FPC) and evacuated tube collectors (ETC) as well as unglazed and glazed air collectors.

3.1 General market overview of the total installed capacity in operation

By the end of 2014, an installed capacity of 410.2 GW_{th} corresponding to a total of 586.1 million square meters of collector area was in operation worldwide.

The vast majority of the total capacity in operation was installed in China (289.5 GW_{th}) and Europe (47.5 GW_{th}), which together accounted for 82.1 % of the total installed capacity. The remaining installed capacity was shared between the United States and Canada (18.0 GW_{th}), Asia w/o China (10.7 GW_{th}), Latin America (10.0 GW_{th}), the MENA countries Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (6.6 GW_{th}), Australia and New Zealand (6.2 GW_{th}), and Sub-Sahara African countries Lesotho, Mauritius, Mozambique, Namibia, South Africa and Zimbabwe (1.3 GW_{th}). The market volume of *"all other countries"* is estimated to amount for 5 % of the total installations (20.5 GW_{th}).



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

Figure 5: Share of the total installed capacity in operation (glazed and unglazed water and air collectors) by economic region in 2014

Country	Water Collectors [MW_{th}]			Air Collectors [MW_{th}]		TOTAL [MW_{th}]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		112.9	1.0			114
Australia	3,500.0	2,258.9	96.6	210.0	6.2	6,072
Austria	351.9	3,202.2	59.2		2.3	3,616
Barbados*		92.2				92
Belgium	31.5	293.3	52.5			377
Brazil	2,506.2	5,187.9	18.0			7,712
Bulgaria		89.1	2.1			91
Canada	555.8	47.1	29.9	275.7	24.5	933
Chile	38.8	93.9	29.1			162
China		22,085.0	267,435.0			289,520
Croatia		113.4	3.6			117
Cyprus	1.5	464.8	16.9			483
Czech Republic	376.6	276.6	77.9			731
Denmark	14.4	649.4	6.4	2.3	12.6	685
Estonia		4.2	3.2			7
Finland	8.3	25.0	5.9			39
France (mainland) +	74.0	1,647.4	43.3	3.6	0.8	1,769
Germany	391.8	11,013.8	1,374.1		19.8	12,800
Greece		2,987.2	13.2			3,000
Hungary	10.7	133.5	44.2	1.5	1.3	191
India ++		2,458.0	2,758.3		6.4	5,223
Ireland		139.0	71.1			210
Israel	24.6	3,144.7				3,169
Italy	30.7	2,397.8	376.1			2,805
Japan		2,561.4	50.3		363.1	2,975
Jordan***	4.2	687.7	190.5			882
Korea, South		1,242.3	13.3			1,256
Latvia		4.6	1.5			6
Lebanon		183.6	239.1			423
Lesotho #		0.2	0.1			0.3
Lithuania		3.4	3.9			7
Luxembourg		31.1	4.7			36
Macedonia		25.1	4.1			29
Malta		28.0	7.0			35
Mauritius***		86.8				87
Mexico	680.4	730.9	560.7	0.5	6.1	1,979
Morocco***		315.7				316
Mozambique			0.8			0.8
Namibia**		14.5	0.9			15
Netherlands	76.9	356.7	17.2			451
New Zealand*	4.9	100.1	6.8			112
Norway	1.3	25.8	2.7	0.1	2.9	33
Palestinian Territories		1,244.3	5.6			1,250
Poland		919.4	301.4			1,221
Portugal	1.5	642.0	18.1			662
Romania		61.5	38.6	0.6		101
Russia		11.8	1.1		0.0	13
Slovakia	0.4	91.9	14.8			107
Slovenia		119.0	15.1			134
South Africa	673.9	358.1	122.8			1,155
Spain	99.3	2,183.4	132.6			2,415
Sweden	119.2	179.7	49.1			348
Switzerland	145.8	823.1	70.3	504.0		1,543
Taiwan	1.4	1,037.2	85.6			1,124
Thailand***		107.0				107
Tunisia		494.1	49.1			543
Turkey		10,288.7	2,441.5	3.2		12,733
United Kingdom		436.6	116.1	15.1		568
United States	14,935.2	1,963.9	96.5	73.4	29.1	17,098
Uruguay		32.4				32
Zimbabwe		15.0	2.4			17
All other countries (5%)	1,298.0	4,543.4	14,588.5	57.4	25.0	20,512
TOTAL	25,959	90,868	291,770	1,148	500	410,244

Note: If no data is given no reliable database for this collector type is available.

* Total capacity in operation refers to the year 2009. ** Total capacity in operation refers to the year 2012.

*** Total capacity in operation is based on estimations for new installations in 2014.

\# New included countries compared to the 2015 edition of this report

\+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered.

++ The figures for India refer to fiscal year April 2014 to March 2015.

Table 1: Total capacity in operation by the end of 2014 [MW_{th}]

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Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania	0	161,265	1,432	0	0	162,697
Australia	5,000,000	3,227,000	138,000	300,000	8,800	8,673,800
Austria	502,651	4,574,575	84,572	0	3,308	5,165,106
Barbados*	0	131,700	0	0	0	131,700
Belgium	45,000	419,033	75,000	0	0	539,033
Brazil	3,580,239	7,411,321	25,773	0	0	11,017,333
Bulgaria	0	127,280	3,020	0	0	130,300
Canada	794,065	67,336	42,755	393,907	34,947	1,333,010
Chile	55,490	134,101	41,618	0	0	231,209
China	0	31,550,000	382,050,000	0	0	413,600,000
Croatia	0	162,017	5,075	0	0	167,092
Cyprus	2,213	664,034	24,200	0	0	690,447
Czech Republic	538,000	395,214	111,298	0	0	1,044,512
Denmark	20,500	927,644	9,197	3,300	18,000	978,641
Estonia	0	5,930	4,590	0	0	10,520
Finland	11,800	35,651	8,372	0	0	55,823
France (mainland) +	105,700	2,353,400	61,800	5,100	1,100	2,527,100
Germany	559,700	15,734,000	1,963,000	0	28,300	18,285,000
Greece	0	4,267,450	18,850	0	0	4,286,300
Hungary	15,300	190,700	63,100	2,200	1,850	273,150
India ++	0	3,511,470	3,940,430	0	9,200	7,461,100
Ireland	0	198,578	101,605	0	0	300,183
Israel	35,200	4,492,434	0	0	0	4,527,634
Italy	43,800	3,425,404	537,240	0	0	4,006,444
Japan	0	3,659,155	71,828	0	518,714	4,249,697
Jordan***	5,940	982,482	272,084	0	0	1,260,506
Korea, South	0	1,774,678	18,935	0	0	1,793,613
Latvia	0	6,512	2,110	0	0	8,622
Lebanon	0	262,300	341,600	0	0	603,900
Lesotho #	0	250	150	0	0	400
Lithuania	0	4,900	5,500	0	0	10,400
Luxembourg	0	44,450	6,750	0	0	51,200
Macedonia	0	35,820	5,900	0	0	41,720
Malta	0	39,981	9,995	0	0	49,976
Mauritius***	0	123,993	0	0	0	123,993
Mexico	972,053	1,044,082	800,942	752	8,773	2,826,602
Morocco***	0	451,000	0	0	0	451,000
Mozambique	0	0	1,143	0	0	1,143
Namibia**	0	20,700	1,300	0	0	22,000
Netherlands	109,822	509,511	24,500	0	0	643,833
New Zealand*	7,025	142,975	9,644	0	0	159,645
Norway	1,849	36,794	3,862	200	4,106	46,812
Palestinian Territories	0	1,777,625	8,000	0	0	1,785,625
Poland	0	1,313,400	430,600	0	0	1,744,000
Portugal	2,130	917,201	25,850	0	0	945,181
Romania	0	87,900	55,150	800	0	143,850
Russia	0	16,830	1,634	0	50	18,514
Slovakia	500	131,300	21,150	0	0	152,950
Slovenia	0	170,000	21,500	0	0	191,500
South Africa	962,725	511,613	175,430	0	0	1,649,768
Spain	141,824	3,119,167	189,442	0	0	3,450,433
Sweden	170,328	256,651	70,199	0	0	497,178
Switzerland	208,310	1,175,880	100,450	720,000	0	2,204,640
Taiwan	1,984	1,481,756	122,249	0	0	1,605,989
Thailand***	0	152,862	0	0	0	152,862
Tunisia	0	705,831	70,104	0	0	775,935
Turkey	0	14,698,112	3,487,789	4,570	0	18,190,471
United Kingdom	0	623,784	165,816	21,600	0	811,200
United States	21,335,963	2,805,546	137,822	104,900	41,500	24,425,731
Uruguay	0	46,241	0	0	0	46,241
Zimbabwe	0	21,426	3,397	0	0	24,823
All other countries (5%)	1,854,216	6,490,539	20,840,724	81,965	35,718	29,303,162
TOTAL	37,084,327	129,810,786	416,814,475	1,639,294	714,367	586,063,249

Note: If no data is given no reliable database for this collector type is available.

* Total capacity in operation refers to the year 2009. ** Total capacity in operation refers to the year 2012.

**** Total capacity in operation is based on estimations for new installations in 2014.

New included countries compared to the 2015 edition of this report

+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered.

++ The figures for India refer to fiscal year April 2014 to March 2015.

Table 2: Total installed collector area in operation by the end of 2014 [m²]

The total installed capacity in operation in 2014 was divided into flat plate collectors (FPC): 90.9 GW_{th} (129.8 million square meters), evacuated tube collectors (ETC): 291.8 GW_{th} (416.8 million square meters), unglazed water collectors 26.0 GW_{th} (37.1 million square meters), and glazed and unglazed air collectors: 1.6 GW_{th} (2.4 million square meters).

With a global share of 71.1 %, evacuated tube collectors were the predominant solar thermal collector technology, followed by flat plate collectors with 22.1 % and unglazed water collectors with 6.3 %. Air collectors only play a minor role in the total numbers (Figure 6).

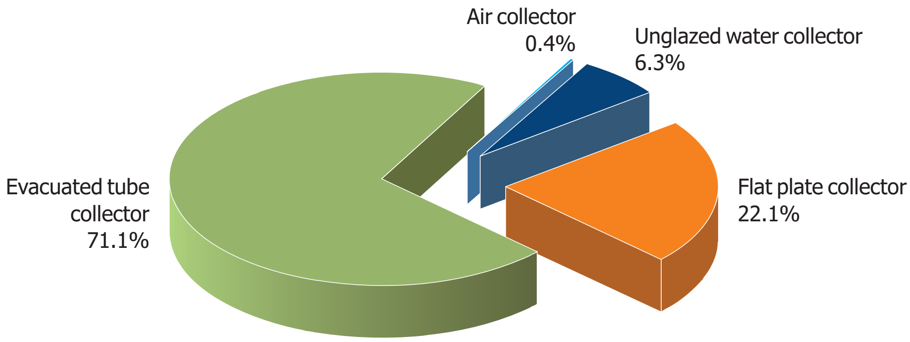


Figure 6: Distribution of the total installed capacity in operation by collector type in 2014 – WORLD

By contrast in Europe, the second largest marketplace for solar thermal collectors to China, flat plate collectors were much more widespread (Figure 7).

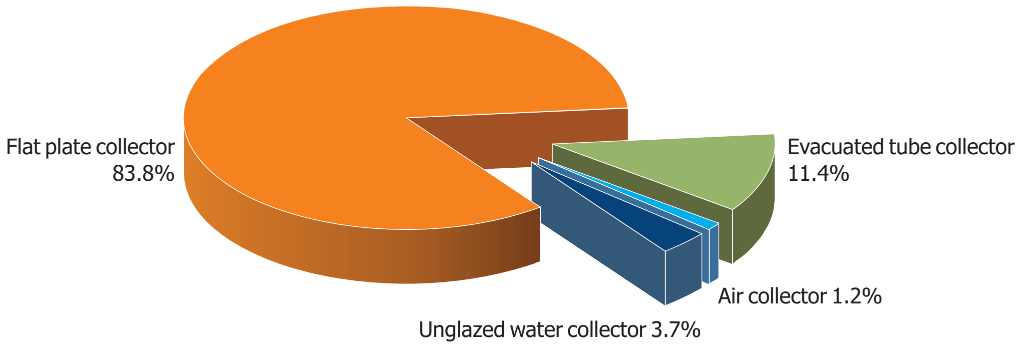


Figure 7: Distribution of the total installed capacity in operation by collector type in 2014 – EUROPE

Figure 8 shows the cumulated installed capacity of glazed and unglazed water collectors in operation for the 10 leading markets in 2014 in total numbers.

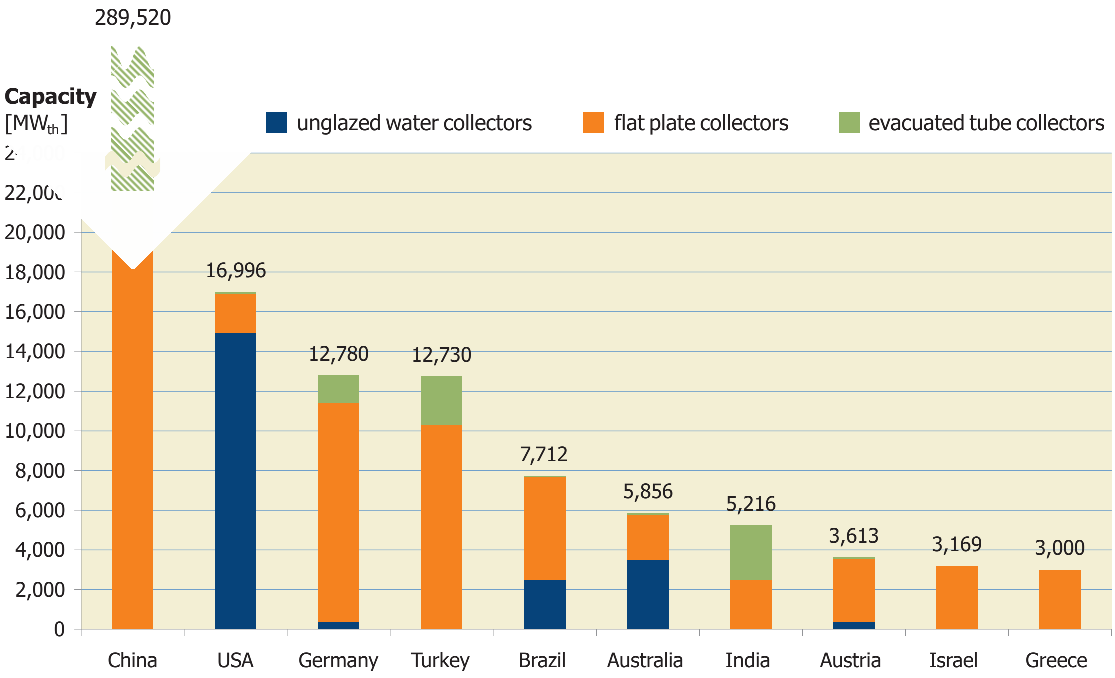


Figure 8: Top 10 countries of cumulated water collector installations (absolute figures in MW$_{th}$)

China, as the world leader in total capacity, was dominated by evacuated tube collectors, whereas the United States held the second position due to its high installation of unglazed water collectors. Only in Australia, and to some extent in Brazil, unglazed water collectors also played an important role. In the large European markets Germany, Austria and Greece flat plate collectors were the most important collector technology. A strong trend towards evacuated tube collector technology can be seen in Turkey and Israel over the past several years.

The leading countries in cumulated unglazed and glazed water collector capacity in operation in 2014 per 1,000 inhabitants were Austria (419 kW$_{th}$/1,000 inhabitants), Cyprus (412 kW$_{th}$/1,000 inhabitants), Israel (400 kW$_{th}$/1,000 inhabitants), Barbados (318 kW$_{th}$/1,000 inhabitants), Greece (278 kW$_{th}$/1,000 inhabitants), the Palestinian territories (275 kW$_{th}$/1,000 inhabitants), Australia (260 kW$_{th}$/1,000 inhabitants), China (213 kW$_{th}$/1,000 inhabitants), Turkey (162 kW$_{th}$/1,000 inhabitants) and Germany (158 kW$_{th}$/1,000 inhabitants).

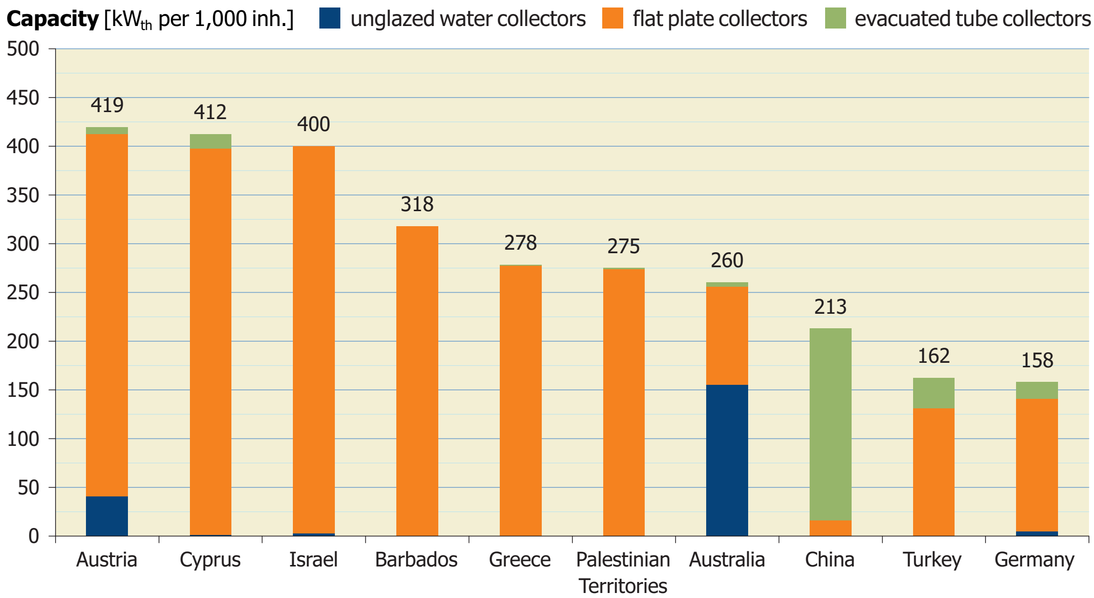


Figure 9: Top 10 countries of cumulated water collector installations (relative figures in kW$_{th}$ per 1,000 inhabitants)

3.2 Total capacity of glazed water collectors in operation

With 289.5 GW_{th}, China was by far the leader in terms of total installed capacity of glazed water collectors in 2014. With >10 GW_{th} of installed capacity, Turkey and Germany were next. Several countries, namely India, Brazil, Austria, Israel, Greece, Italy, Japan, Australia, Spain, the United States, France, Mexico, South Korea, the Palestinian Territories, Poland and Taiwan had more than 1 GW_{th} of water collectors installed by the end of 2014 (Figure 10).

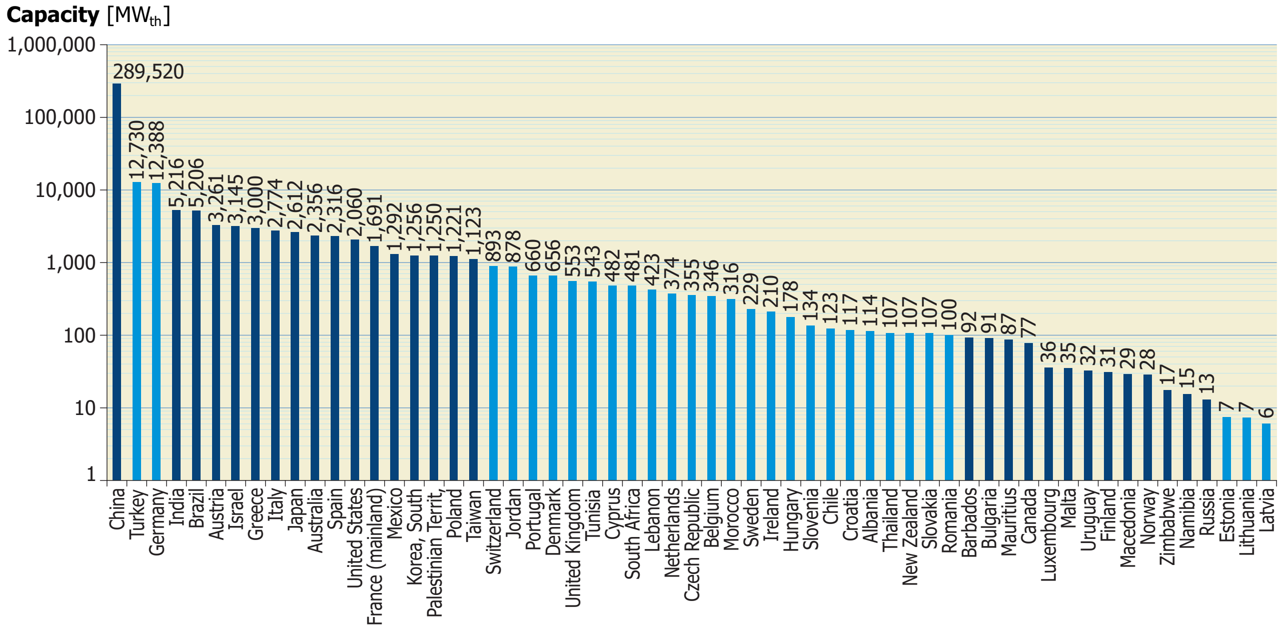


Figure 10: Total capacity of glazed water collectors in operation by the end of 2014

In terms of total installed capacity of glazed water collectors in operation per 1,000 inhabitants, there was a continued dominance by five countries: Cyprus ahead of Israel, Austria, Barbados and Greece. Remarkably, China with its 1.36 billion inhabitants exceeds solar thermal per capacity levels of large European markets such as Turkey, Germany or Denmark (Figure 11).

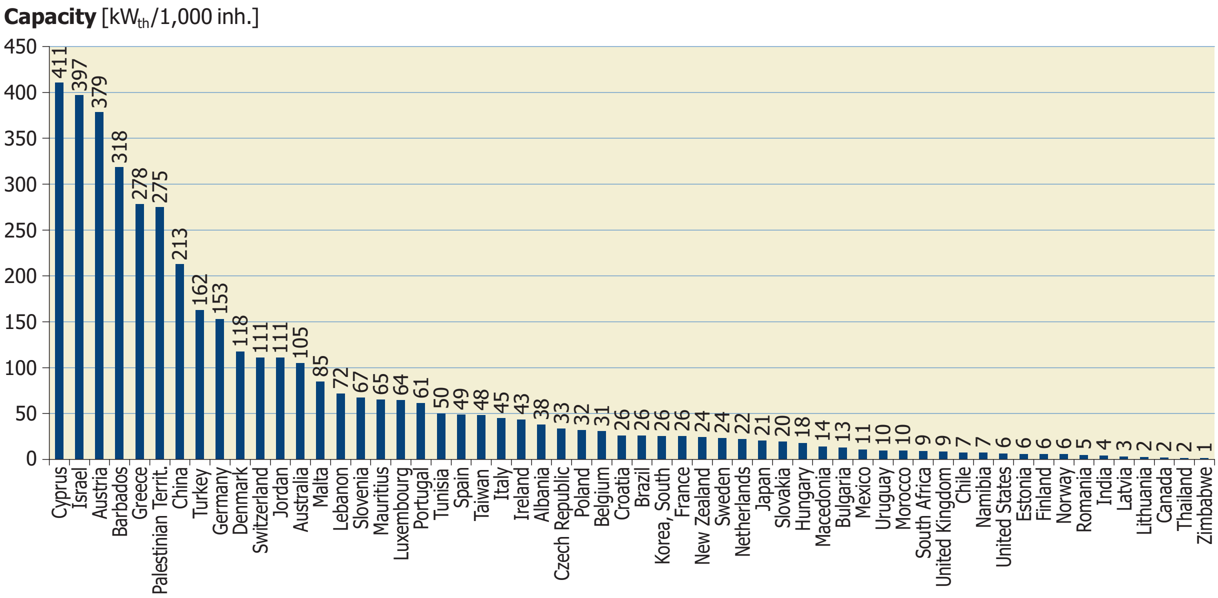


Figure 11: Total capacity of glazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2014

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

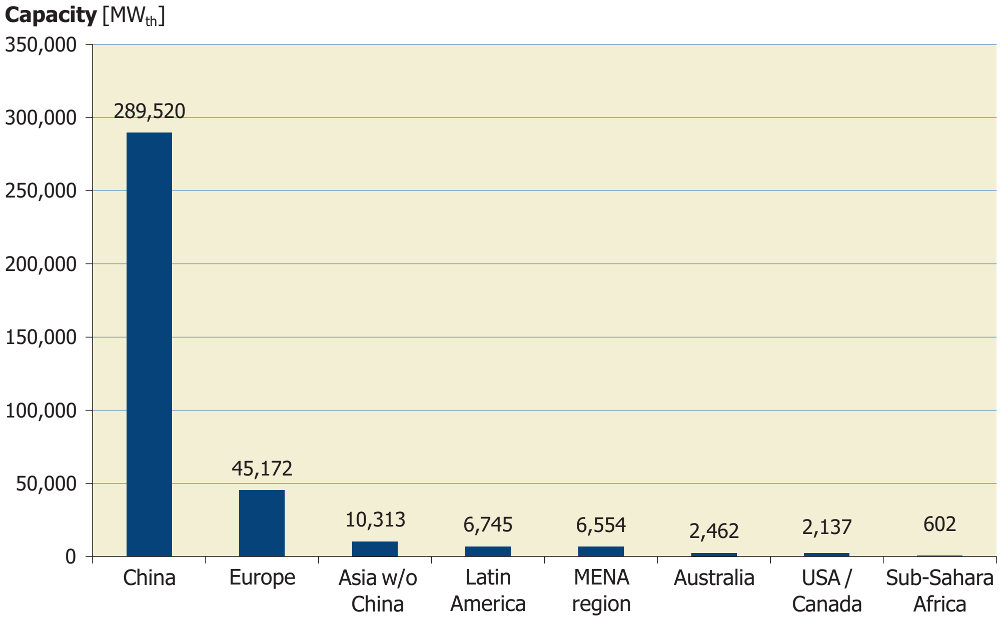


Figure 12: Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region in 2014

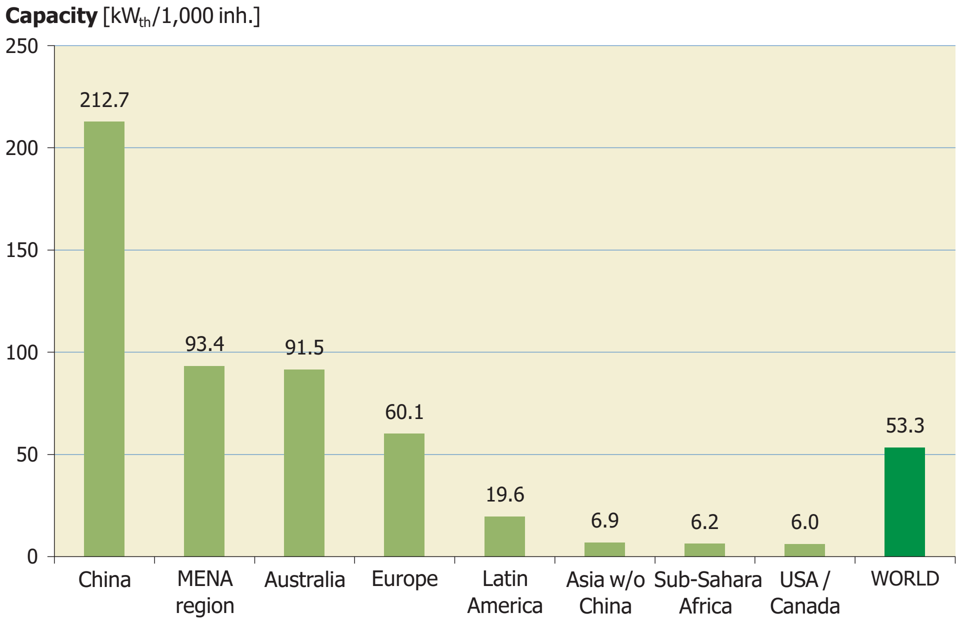


Figure 13: Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region and in kW$_{th}$ per 1,000 inhabitants in 2014

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

3.4 Total capacity of unglazed water collectors in operation

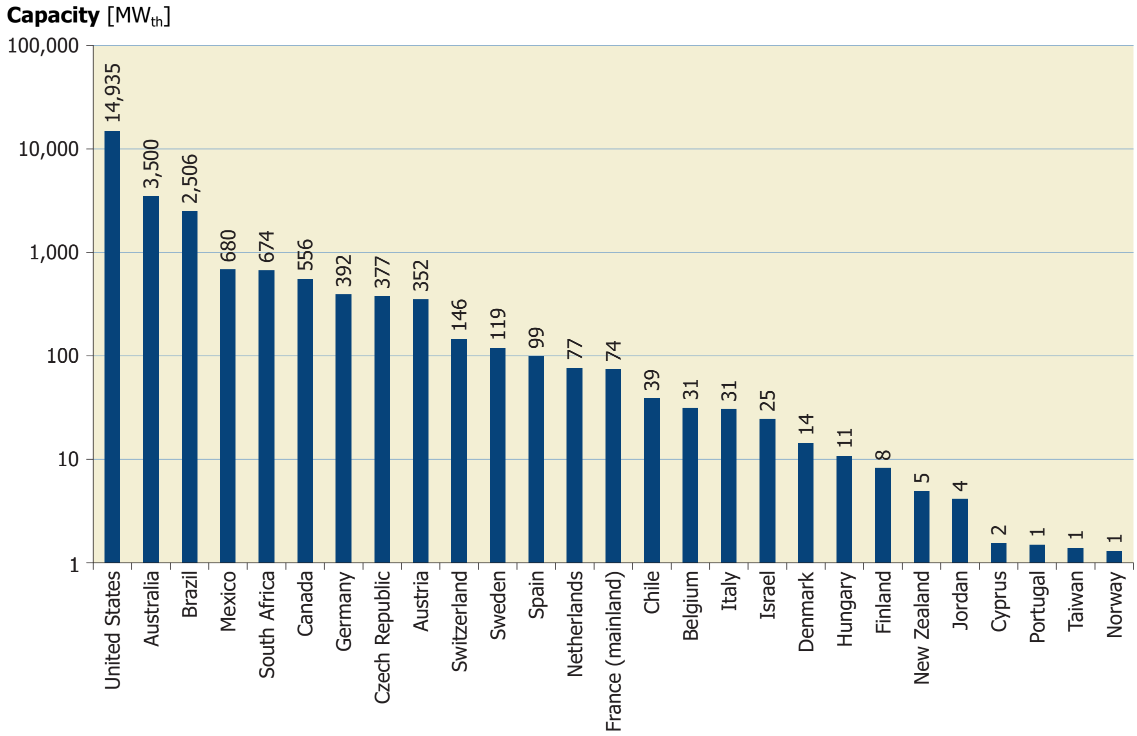


Figure 14: Total capacity of unglazed water collectors in operation in 2014

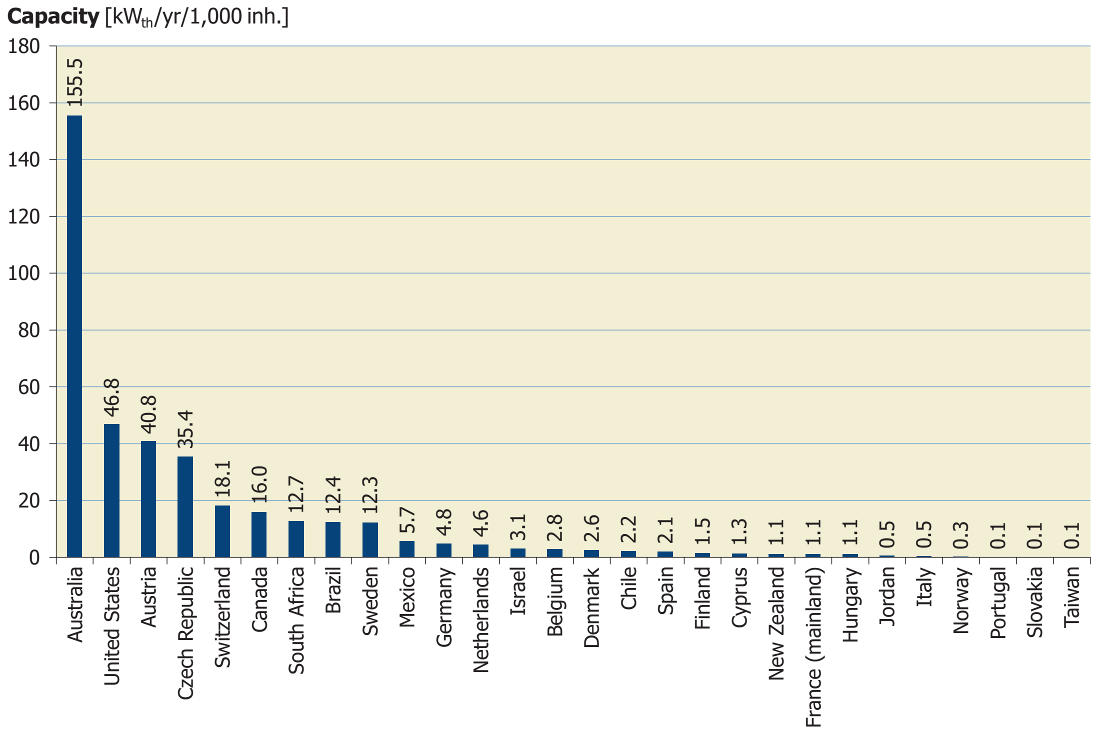


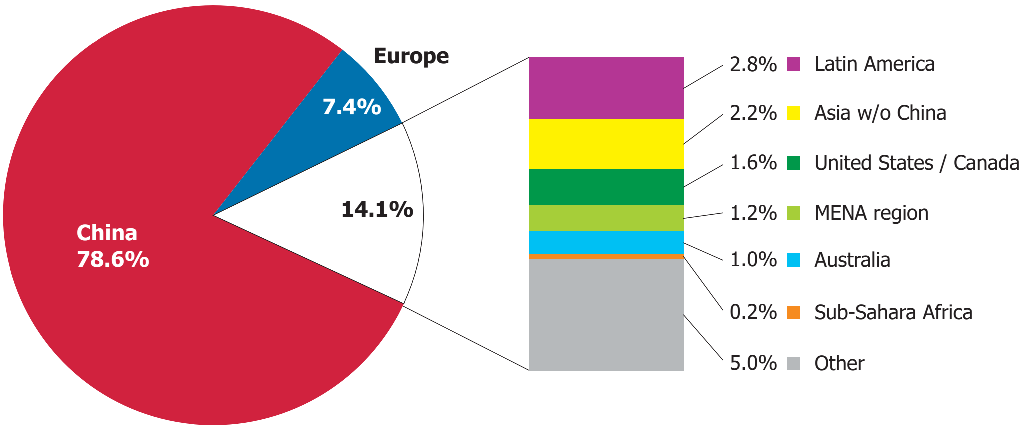
Figure 15: Total capacity of unglazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2014

4 New installed capacity in 2014 and market development

4.1 General market overview of new installed capacity

In the year 2014, a total capacity of 46.7 GW_{th}, corresponding to 66.7 million square meters of solar collectors, was installed worldwide. This means a decrease in new collector installations of 15.2 % compared to the year 2013 (Figure 17). By contrast, the market growth in the period 2012/2013 amounted to 1.9 % and in the period 2011/2012 to 6.7 %. This indicates a trend change. This is the first time a shrinking world market has been observed. Based on data already available for 2015 this trend seems to continue.

The main markets were in China (36.7 GW_{th}) and Europe (3.4 GW_{th}), which together accounted for 85.9 % of the overall new collector installations in 2014. The rest of the market was shared between Latin America (1.3 GW_{th}), Asia w/o China (1.0 GW_{th}), the United States and Canada (0.8 GW_{th}), the MENA region represented by Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (0.5 GW_{th}), Australia (0.5 GW_{th}), and the Sub-Sahara African countries Lesotho, Mauritius, Mozambique, South Africa and Zimbabwe (0.1 GW_{th}). The market volume of "all other countries" is estimated to amount for 5 % of the new installations (2.3 GW_{th}).

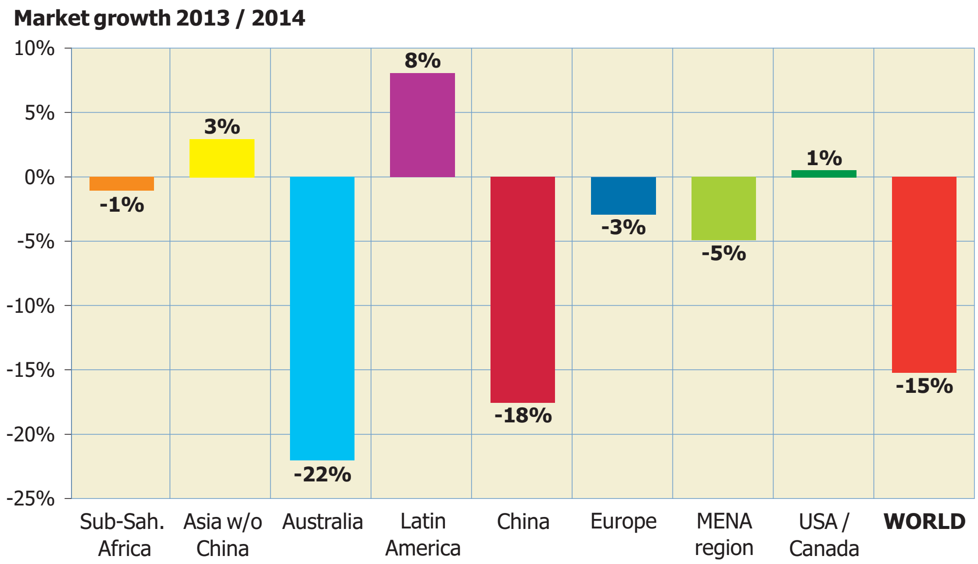


Sub-Sahara Africa:	Lesotho, Mauritius, Mozambique, South Africa, Zimbabwe
Asia w/o China:	India, Japan, Korea South, Taiwan, Thailand
Latin America:	Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Macedonia, Norway, Russia, Switzerland, Turkey
MENA region:	Israel, Jordan, Lebanon, Morocco, Palestinian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

Figure 16: Share of new installed capacity (glazed and unglazed water and air collectors) by economic regions in 2014

From the top 10 markets in 2014 positive market development was reported from Brazil (+4.5 %), India (+7.0 %), the United States (+0.9 %), Mexico (+18.2 %) and Greece (+19.1 %). The other major solar thermal markets within the top 10 countries, namely China (–17.6 %), Turkey (–0.8 %), Germany (–9.8 %), Australia (–21.1 %) and Israel (–13.4 %) suffered market declines.

In terms of economic regions, there was positive market growth in the period 2013/2014 in Asia (w/o China), Latin America and the United States and Canada. In Sub-Sahara Africa, Australia, China, Europe and the MENA region solar thermal system installations dropped (Figure 17).



Sub-Sahara Africa:	South Africa, Zimbabwe
Asia w/o China:	India, Japan, Korea South, Taiwan, Thailand
Latin America:	Brazil, Chile, Mexico, Uruguay
Europe:	EU 28, Albania, Macedonia, Norway, Russia, Switzerland, Turkey
MENA region:	Israel, Jordan, Lebanon, Palestinian Territories, Tunisia

Figure 17: Market growth of new installed capacity (glazed and unglazed water collectors) 2013/2014 by economic region and worldwide

In China, the growth rates between 2000 and 2011 were on average around 23 % and since then have been leveling off (+17.6 % in 2010/2011, +7.6 % in 2011/2012, +2.5 % in 2012/2013). In the period 2013/2014 the Chinese market dropped by −17.6 %, which means the first negative growth rate in China since official recording began in 1997. According to the Chinese Solar thermal industry federation (CSTIF), this trend also continued in the period 2014/2015 where the market further declined by 17.0 %.

In the other Asian countries covered in this report, the dominant Indian market showed a positive growth of 7.0 % whereas Japan (−13.4 %), South Korea (−33.9 %) and Taiwan (−3.3 %) reported negative growth.

Major European markets such as Austria, Germany and Italy have been suffering from significant market declines for several years now. In the period 2013/2014 only three countries of the top 10 European countries, namely Greece (+19.1 %), Spain (+9.9 %) and Denmark (+72.3 %) reported a positive growth rate. A decrease of −3.4 % was reported for all of Europe.

In Latin America, the dominant Brazilian market (+4.5 %) but also the large Mexican market (+18.2 %) as well as evolving markets such as Chile (+55 %) were responsible for the positive trend in this part of the world lasting for the fourth year in a row (+7.8 % in the period 2013/2014).

Both the MENA region and Sub-Sahara Africa showed decreasing market characteristics in the period 2012/2013. Main drivers in this economic regions were South Africa (+0.1 %) and Israel (−13.4 %) as well as Palestinian Territories (+30.0 %) respectively.

The market for water collectors in the United States and Canada significantly decreased in the period 2010/2011 (−15.7 %), recovered in 2011/2012 (+1.3 %), dropped again in 2012/2013 (−4.6 %) and leveled-off in 2013/2014 (+0.5 %).

In Australia, the market for water collectors declined for the fifth year in a row, −5.4 % in the period 2009/2010, −10.4 % in the period 2010/2011, −4.8 % in the period 2011/2012, −9.1 % in the period 2012/2013 and −22.0 % in the period 2013/2014.

Country	Water Collectors [MW_{th}]			Air Collectors [MW_{th}]		TOTAL [MW_{th}]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		14.3	0.3			15
Australia	322.0	121.1	13.4	24.5	0.7	482
Austria	0.9	105.4	2.0		0.3	109
Belgium		29.8	6.7			36
Brazil	450.7	546.8	11.1			1,009
Bulgaria		3.6	0.4			4
Canada	16.6	2.5	2.4	15.2	3.7	40
Chile	11.6	37.3	15.4			64
China		3,780.0	32,900.0	1.6	1.4	36,683
Croatia		13.3	1.8			15
Cyprus		13.2	0.4			14
Czech Republic	24.5	19.0	7.8			51
Denmark		125.4				125
Estonia		0.7	0.7			1.4
Finland		2.1	0.7			3
France (mainland) +		105.4	0.0	0.6		106
Germany	14.0	570.4	59.6			644
Greece		189.0	0.4			189
Hungary	0.7	8.1	3.2	0.1	0.1	12
India ++		165.2	660.8		0.7	827
Ireland		10.3	7.5			18
Israel	1.5	273.0				275
Italy		165.4	22.6			188
Japan		87.3	1.9		4.5	94
Jordan*		38.2	9.6			48
Korea, South		9.2	13.3			22
Latvia		1.4	0.3			2
Lebanon		11.4	18.6			30
Lesotho #		0.2	0.1			0.3
Lithuania		0.6	1.0			2
Luxembourg		3.5	0.7			4
Macedonia		4.0	3.3			7
Malta		0.9	0.2			1.1
Mauritius*		6.2				6
Mexico	81.8	71.1	71.1			224
Morocco*		25.2	0.0			25
Mozambique			0.5			1
Netherlands	1.8	15.5	2.4			20
Norway		2.4	0.4	0.1	0.1	3
Palestinian Territories		110.3	0.7			111
Poland		145.7	36.4			182
Portugal		35.0	0.6			36
Romania	0.1	4.3	8.6			13
Russia		0.1	0.1			0.2
Slovakia	0.4	3.2	0.6			4
Slovenia		2.5	0.7			3
South Africa	32.1	55.1	13.1			100
Spain	2.7	164.7	11.1	0.4		179
Sweden	0.2	3.5	1.2			5
Switzerland	3.1	69.1	10.1			82
Taiwan		75.0	6.8			82
Thailand*		11.4				11
Tunisia		48.7				49
Turkey		745.5	586.8	1.8		1,334
United Kingdom		20.7	4.9	1.1		27
United States	578.7	122.1	6.3	7.7	9.6	724
Uruguay #		3.8				4
Zimbabwe		0.5	0.8			1.3
All other countries (5%)	81.2	431.5	1,817.3	2.8	1.1	2,334
TOTAL	1,625	8,631	36,347	56	22	46,680

Note: If no data is given no reliable database for this collector type is available.
No data from Barbados, Namibia and New Zealand

* Country market data for new installations in 2014 estimated by AEE INTEC (0% growth rate assumed)
\# New included countries compared to the 2015 edition of this report
\+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered.
++ The figures for India refer to fiscal year April 2014 to March 2015.

Table 3: New installed capacity in 2014 [MW_{th}/a]

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania	0	20,450	362	0	0	20,812
Australia	460,000	173,000	19,200	35,000	1,000	688,200
Austria	1,340	150,530	2,910	0	390	155,170
Belgium	0	42,500	9,500	0	0	52,000
Brazil	643,888	781,118	15,864	0	0	1,440,870
Bulgaria	0	5,100	500	0	0	5,600
Canada	23,661	3,553	3,498	21,753	5,223	57,688
Chile	16,542	53,302	22,056	0	0	91,900
China	0	5,400,000	47,000,000	2,300	2,000	52,404,300
Croatia	0	18,952	2,575	0	0	21,527
Cyprus	0	18,834	633	0	0	19,467
Czech Republic	35,000	27,095	11,148	0	0	73,243
Denmark	0	179,186	0	0	0	179,186
Estonia	0	1,000	1,000	0	0	2,000
Finland	0	3,000	1,000	0	0	4,000
France (mainland) +	0	150,500	0	800	0	151,300
Germany	20,000	814,800	85,200	0	0	920,000
Greece	0	270,000	600	0	0	270,600
Hungary	1,000	11,500	4,500	200	200	17,400
India ++	0	236,000	944,000	0	1,000	1,181,000
Ireland	0	14,760	10,674	0	0	25,434
Israel	2,200	390,000	0	0	0	392,200
Italy	0	236,280	32,220	0	0	268,500
Japan	0	124,773	2,760	0	6,495	134,028
Jordan*	0	54,531	13,705	0	0	68,236
Korea, South	0	13,108	18,935	0	0	32,043
Latvia	0	1,940	420	0	0	2,360
Lebanon	0	16,300	26,600	0	0	42,900
Lesotho #	0	250	150	0	0	400
Lithuania	0	800	1,400	0	0	2,200
Luxembourg	0	5,000	1,000	0	0	6,000
Macedonia	0	5,672	4,723	0	0	10,395
Malta	0	1,216	304	0	0	1,520
Mauritius*	0	8,880	0	0	0	8,880
Mexico	116,800	101,600	101,600	0	0	320,000
Morocco*	0	36,000	0	0	0	36,000
Mozambique	0	0	727	0	0	727
Netherlands	2,621	22,104	3,471	0	0	28,196
Norway	0	3,415	585	200	202	4,402
Palestinian Territories	0	157,625	1,000	0	0	158,625
Poland	0	208,100	52,000	0	0	260,100
Portugal	0	50,065	902	0	0	50,967
Romania	170	6,200	12,300	0	0	18,670
Russia	0	75	177	0	0	251
Slovakia	500	4,600	900	0	0	6,000
Slovenia	0	3,500	1,000	0	0	4,500
South Africa	45,844	78,667	18,646	0	0	143,157
Spain	3,839	235,355	15,900	500	0	255,594
Sweden	320	5,024	1,649	0	0	6,993
Switzerland	4,487	98,744	14,403	0	0	117,634
Taiwan	0	107,179	9,682	0	0	116,861
Thailand*	0	16,251	0	0	0	16,251
Tunisia	0	69,555	0	0	0	69,555
Turkey	0	1,065,063	838,280	2,500	0	1,905,843
United Kingdom	0	29,508	7,044	1,600	0	38,152
United States	826,651	174,375	8,990	11,000	13,700	1,034,716
Uruguay #	0	5,441	0	0	0	5,441
Zimbabwe	0	670	1,175	0	0	1,845
All other countries (5%)	116,045	616,476	2,596,204	3,992	1,590	3,334,307
TOTAL	2,320,908	12,329,522	51,924,071	79,845	31,800	66,686,147

Note: If no data is given no reliable database for this collector type is available.
No data from Barbados, Namibia and New Zealand

* Country market data for new installations in 2014 estimated by AEE INTEC (0% growth rate assumed)

\# New included countries compared to the 2015 edition of this report

\+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered.

++ The figures for India refer to fiscal year April 2014 to March 2015.

Table 4: New installed collector area in 2014 [m²/a]

New installations in 2014 are divided into flat plate collectors: 8.6 GW_{th} (12.3 million square meters), evacuated tube collectors: 36.3 GW_{th} (51.9 million square meters), unglazed water collectors: 1.6 GW_{th} (2.3 million square meters,) and glazed and unglazed air collectors: 0.08 GW_{th} (0.11 million square meters).

With a share of 77.9 %, evacuated tube collectors are by far the most important solar thermal collector technology worldwide (Figure 18). In a global context, this breakdown is mainly driven by the dominance of the Chinese market where around 90 % of all new installed collectors in 2014 were evacuated tube collectors.

By contrast, in Europe the situation is almost the opposite with 75.6 % of all solar thermal systems installed in 2014 being flat plate collectors (Figure 19).

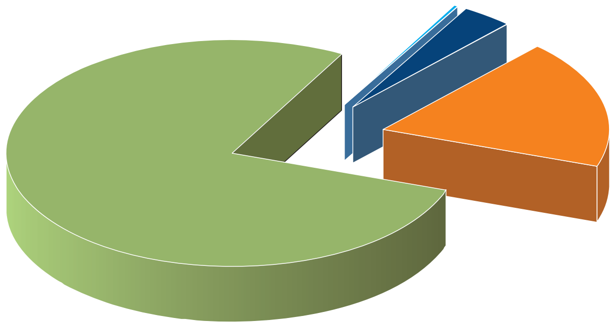


Figure 18: Distribution of the new installed capacity by collector type in 2014 – WORLD

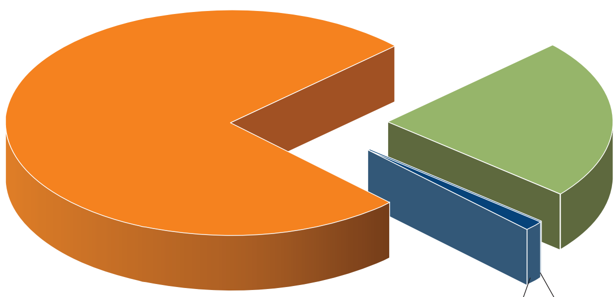


Figure 19: Distribution of the new installed capacity by collector type in 2014 – EUROPE

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

Figure 20 shows the new installed capacity of glazed and unglazed water collectors for the 10 leading markets in 2014 in total numbers. Compared to the new installed capacity in 2013, China remained the market leader in absolute terms followed by Turkey.

In 2014, Germany faced a significant market decline for the third year in a row and hence fell behind the United States. Italy and Poland have been replaced by Mexico and Greece within the Top 10 ranking in 2014 compared to 2013.

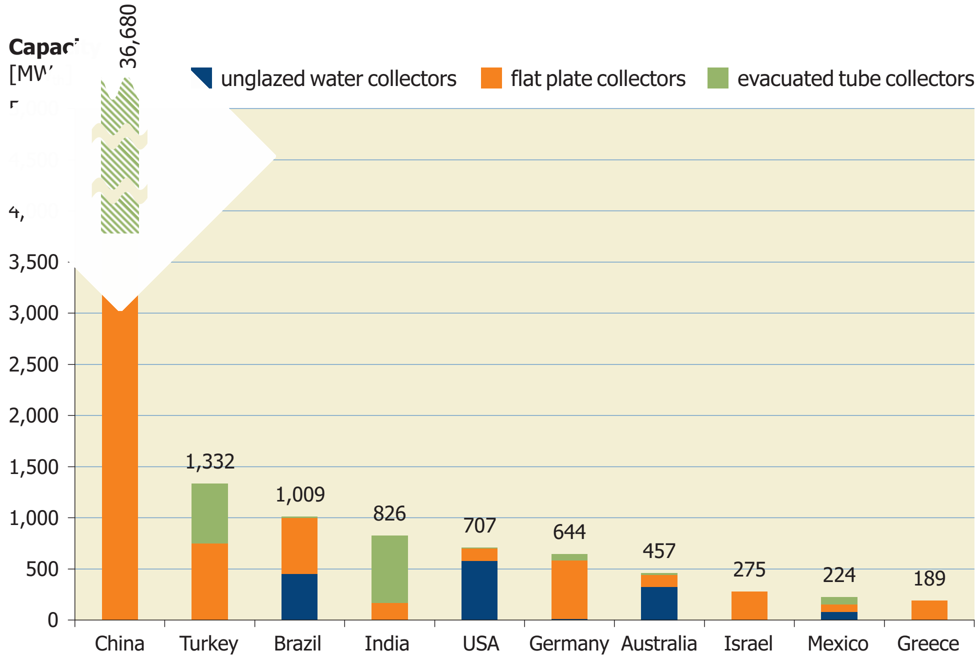


Figure 20: Top 10 markets for glazed and unglazed water collectors in 2014 (absolute figures in MW_{th})

In terms of new installed solar thermal capacity per 1,000 inhabitants in 2014 Israel took over the lead again, ahead of China and Palestinian territories (West Bank and Gaza Strip). Due to outstanding achievements in the field of solar district heating (see Chapter 7.2) over the last couple of years Denmark is ranked fourth in this analysis, even ahead of mature solar thermal markets such as Greece, Turkey and Austria.

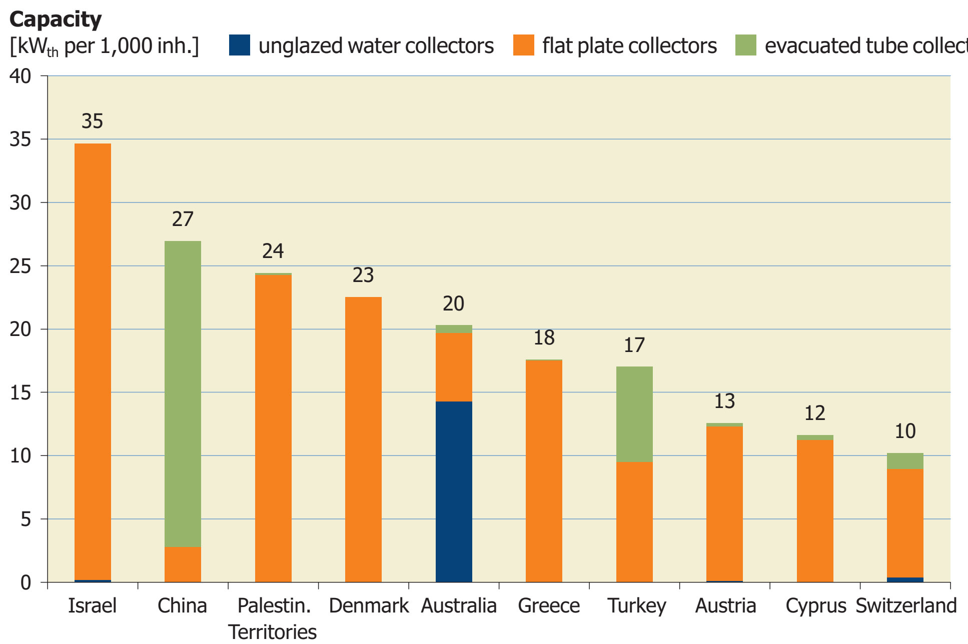


Figure 21: Top 10 markets for glazed and unglazed water collectors in 2014
(relative figures in kW_{th} per 1,000 inhabitants)

4.2 New installed capacity of glazed water collectors

In 2014 glazed water collectors accounted for 96.4 % of the total new installed capacity and with a market share of 81.6 % China was the most influencing market in the global context (Figure 22).

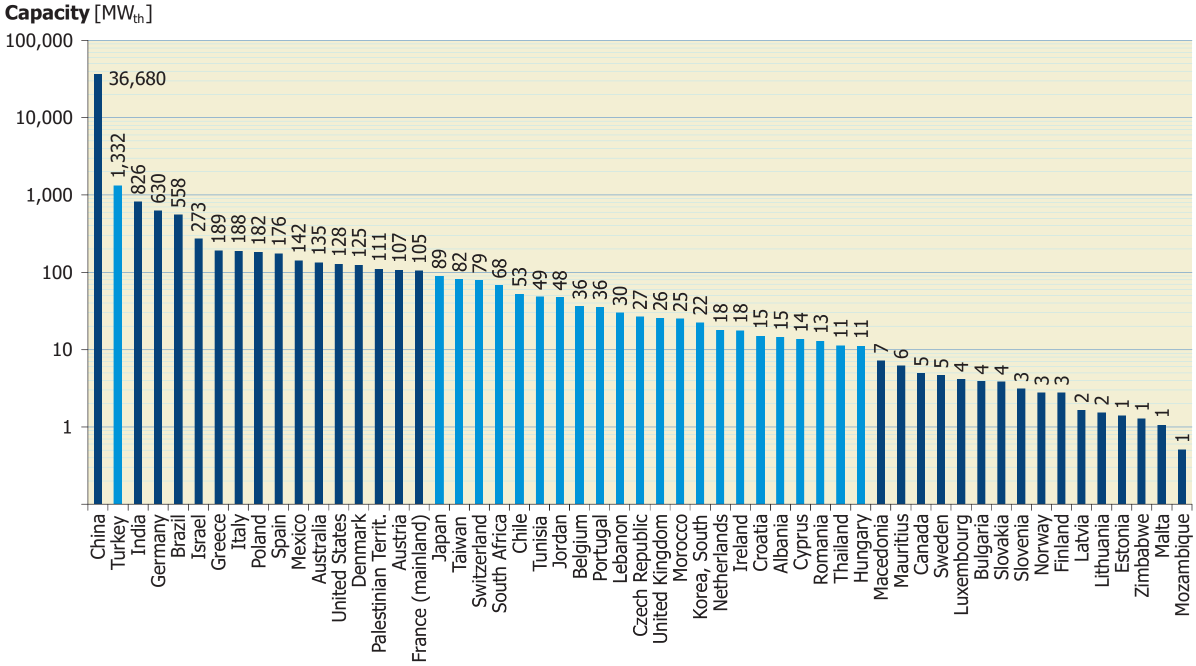


Figure 22: New installed capacity of glazed water collectors in 2014

In terms of new installed glazed water collector capacity per 1,000 inhabitants, Israel is the leader ahead of China and the Palestinian territories (Figure 23).

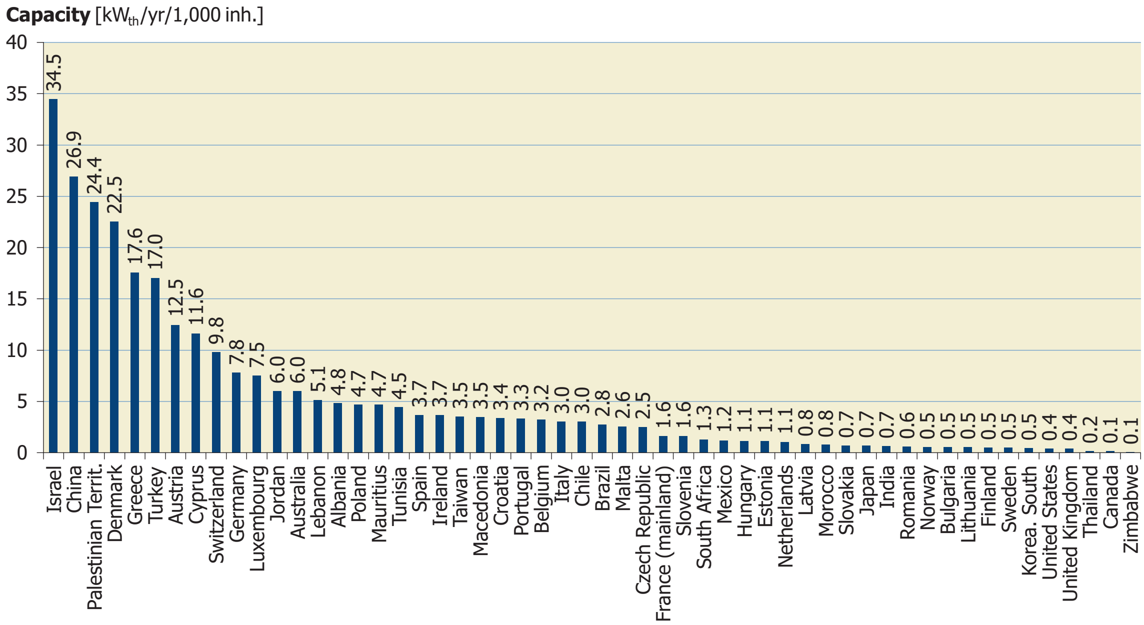
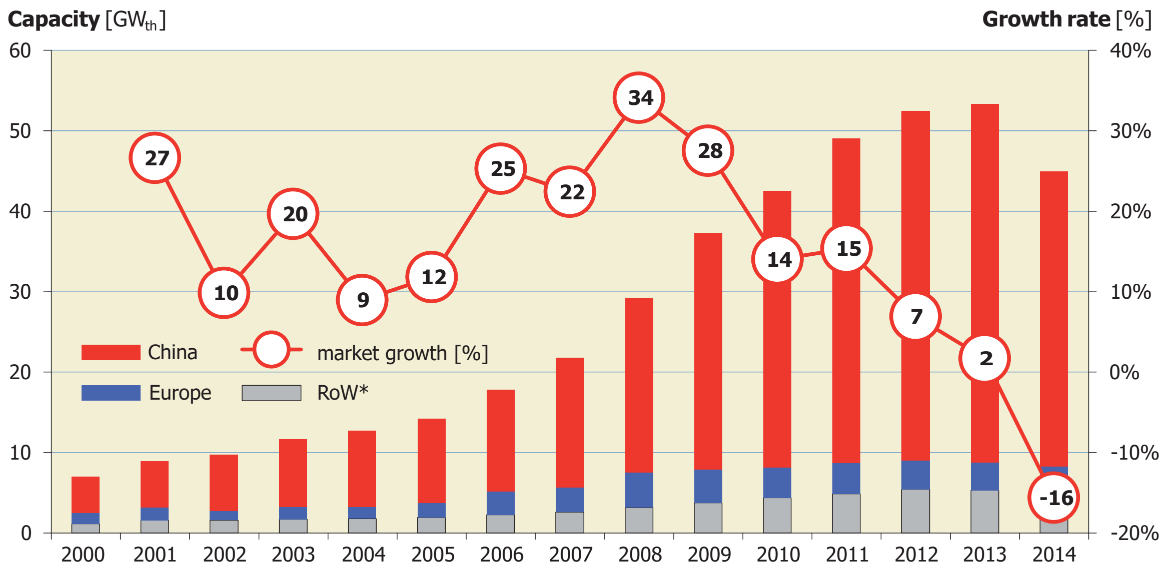


Figure 23: New installed capacity of glazed water collectors in 2014 in kW_{th} per 1,000 inhabitants

4.3 Market development of glazed water collectors between 2000 and 2014

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. The new installed glazed water collector capacity in 2014 amounted to 45 GW_{th} (Figure 24).



Rest of World (RoW): Asia (India, Japan, Korea South, Taiwan, Thailand), Australia, Canada, Latin America (Brazil, Chile, Mexico, Uruguay), MENA region (Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia), Sub-Sahara Africa (Mauritius, Mozambique, Namibia, South Africa, Zimbabwe), USA

Figure 24: Global market development of glazed water collectors from 2000 to 2014

In 2000 the Chinese market was about three times as large as the European market while in 2014 the Chinese market volume exceeded it eleven-fold (Figure 25).

It can be also seen in Figure 25 that after years of very high growth rates in China this trend has changed in the past three years. The Chinese market started to stagnate in 2012 and 2013 and shrank in 2014. According to the Chinese Solar Thermal Industry Federation (CSTIF) this trend continued in the period 2014/2015 where the market further declined by 17.0 %.

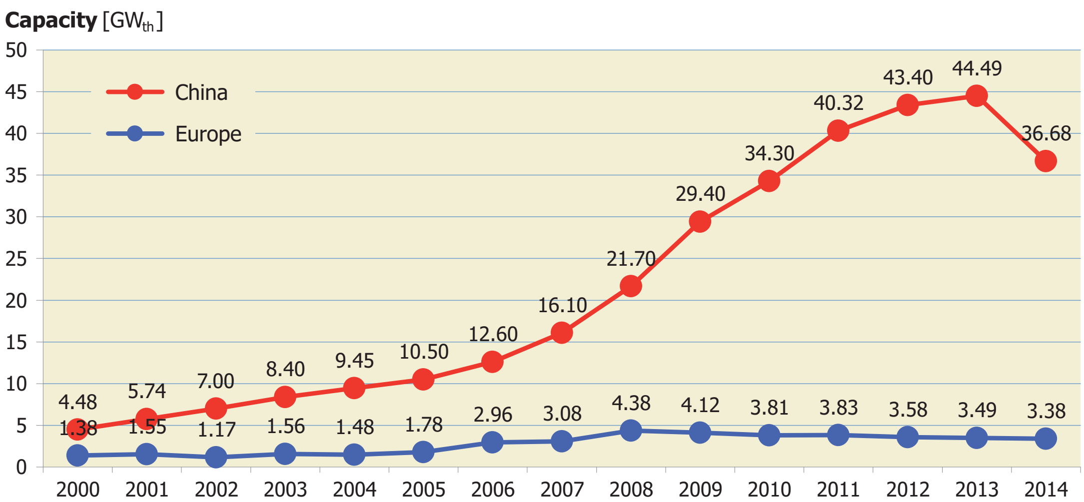
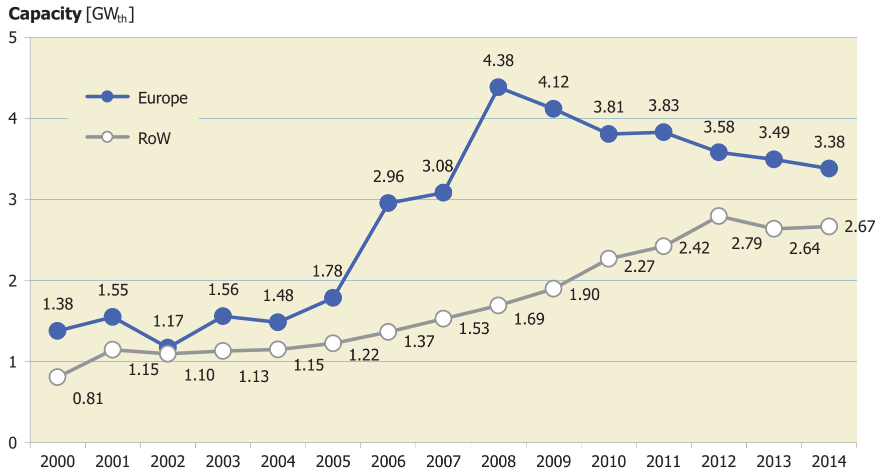


Figure 25: Market development of glazed water collectors in China and Europe

The European market peaked at 4.4 GW_{th} installed capacity in 2008 and has decreased steadily down to 3.4 GW_{th} in 2014. In the remaining markets worldwide (RoW) an upwards trend could be observed between 2002 and 2012 with a stagnating tendency in 2013 and 2014 (Figure 26).



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

Rest of World (RoW): Asia (India, Japan, Korea South, Taiwan, Thailand), Australia, Canada, Latin America (Brazil, Chile, Mexico, Uruguay), MENA region (Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia), Sub-Sahara Africa (Mauritius, Mozambique, Namibia, South Africa, Zimbabwe), USA

Figure 26: Market development of glazed water collectors in Europe and the rest of the world (RoW, w/o China) from 2000 to 2014

RoW includes all economic regions other than China and Europe. Of these regions, Asia (w/o China), the MENA region and Latin America hold the largest market shares (see Figure 27).

"Asia excl. China" is mainly influenced by the large Indian market, which dropped significantly in 2013 and recovered in 2014. Other markets covered within this economic region (Japan, South Korea, Thailand) reported a market decrease in 2014. In sum this led to a slight market increase of 2.9 % of in the period 2013/2014 compared to a market decrease of –20.3 % in the preceding period.

Latin America shows the most steady and dynamic upward trend of all economic regions. The dominant Brazilian, but also the large Mexican market as well as evolving markets such as Chile are responsible for the positive growth rates lasting the sixth year in a row (+8.1 % in 2014).

Glazed water collector markets in the MENA region are characterized by steady growth in the long-run, but with annual fluctuations. In 2013, the MENA region recovered from a market decline in 2012. In 2014, the market decreased again by –4.6 % mainly due to decreasing sales numbers in the most important market, Israel.

The market volume for glazed water collectors in Australia was similar to the volume in Latin America and the MENA region in 2009 and continued to shrink through 2013. In 2014, a slight increase of 3.2 % was reported.

Sub-Sahara African markets, most notably South Africa, showed a slight increase in 2014 (+3.5 %) after a decrease of 10.2 % in 2013. By contrast, United States and Canada showed a decreasing trend the second year in a row (–21.4 % in 2014).

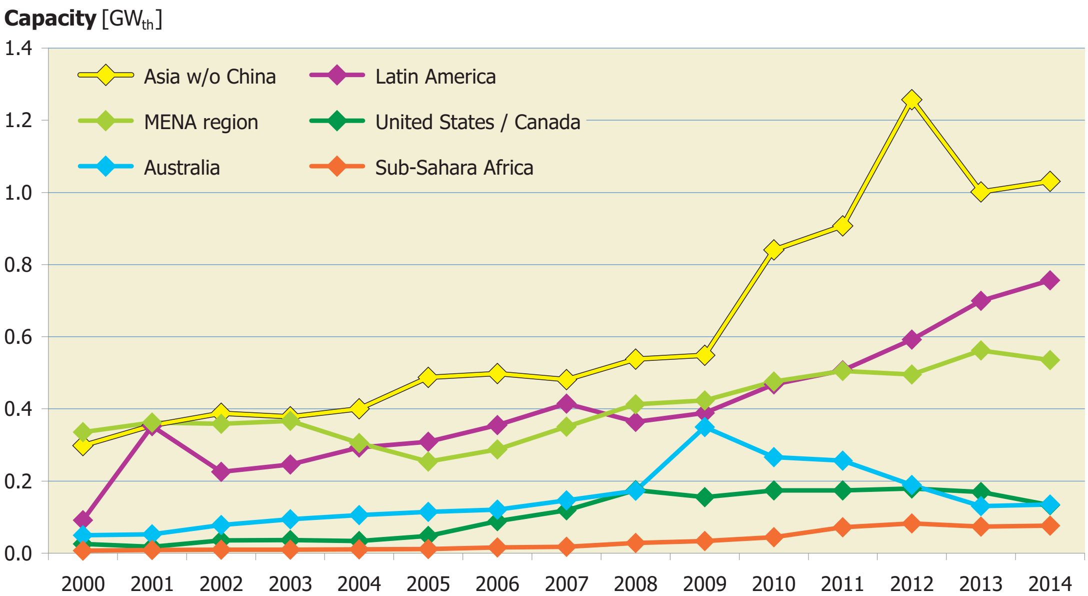


Figure 27: Market development of glazed water collectors in Rest of World (w/o China and Europe) from 2000 to 2014

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 6.3 kW_{th} per 1,000 inhabitants in 2014 (Figure 28).

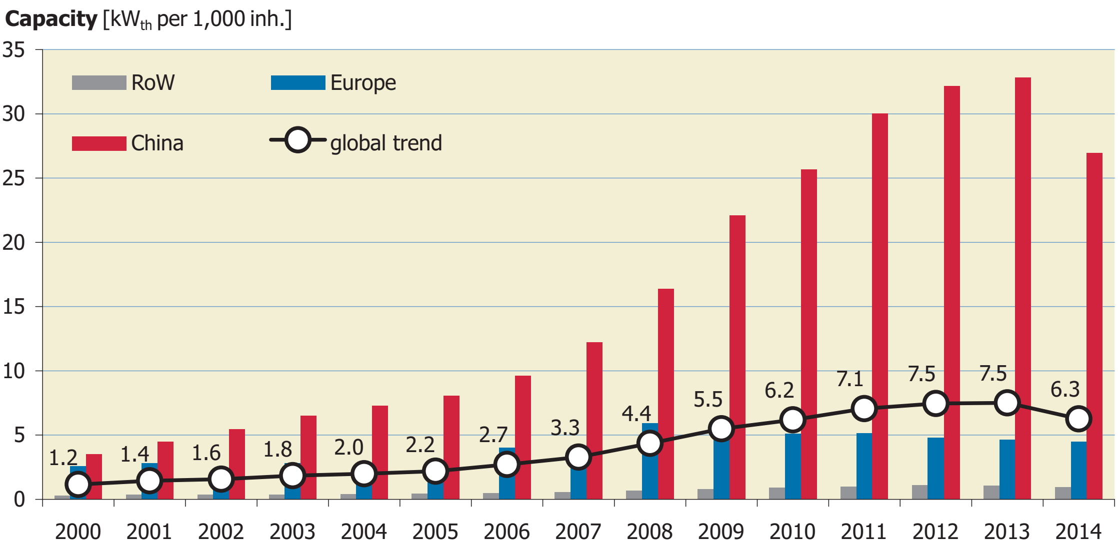


Figure 28: Annual installed capacity of glazed water collectors in kW_{th} per 1,000 inhabitants from 2000 to 2014

Although China suffered from a major market decline in 2014, it is important to note that China had the second highest market penetration in terms of glazed water collector installations per capita compared to all other countries covered in this report. 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 (2014: 26.9 kW_{th} per 1,000 inhabitants). Worldwide, only Israel showed a higher market penetration of 34.5 kW_{th} per 1,000 inhabitants in 2014 as can be seen in Figure 23.

In Europe, the market penetration peaked in 2008 with 5.9 kW_{th} per 1,000 inhabitants and since then a steady downward trend in per capita installations can be observed leading to a value of 4.5 kW_{th} per 1,000 inhabitants in 2014.

4.4 Market development of unglazed water collectors between 2000 and 2014

With a new installed capacity of 1.6 GW_{th} in 2014, unglazed water collectors accounted for 3.5 % of the total installed solar thermal capacity (Figure 18). Compared to the year 2013 the market decreased by −2.9 %.

The most important markets for unglazed water collectors in 2014 were the United States (579 MW_{th}), Brazil (451 MW_{th}), Australia (322 MW_{th}), Mexico (82 MW_{th}) and South Africa (32 MW_{th}) which accounted for 90 % of the recorded unglazed water collector installations worldwide. Another 4 % were installed in the Czech Republic (25 MW_{th}), Canada (17 MW_{th}), Germany (14 MW_{th}) and Chile (12 MW_{th}).

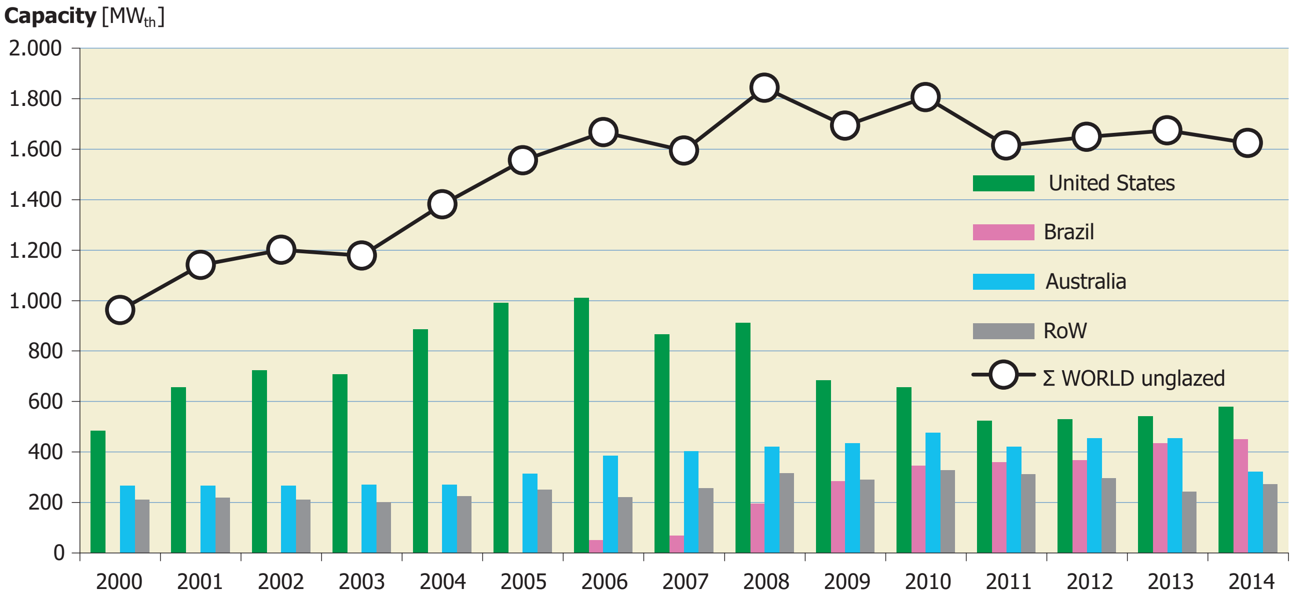


Figure 29: Global market development of unglazed water collectors from 2000 to 2014

The unglazed water collector market in the United States peaked in 2006 (1.01 GW_{th}) and has almost halved since then (0.58 GW_{th} in 2014). Nevertheless, the annual global market volume for unglazed water collectors has remained at a constant level because of the Brazilian market, which entered in 2007 and has grown steeply since then. Australia faced a significant market decrease of −29.2 % in 2014 and is now the third largest market for unglazed water collectors behind that of the United States and Brazil.

5 Contribution to the energy supply and CO_2 reduction

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 basis for these calculations is the total glazed and unglazed water collector area in operation in each country as shown in Table 1. The contribution of the total installed air collector capacity in operation in 2014 of 1.6 GW_{th} was not taken into consideration – with a share of around 0.4 % 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 (www.valentin-software.com) 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 9).

The annual collector yield of all water-based solar thermal systems in operation by the end of 2014 in the 61 recorded countries was 335 TWh (= 1,208 PJ). This corresponds to a final energy savings equivalent of 36.1 million tons of oil and 116.4 million tons of CO_2. The calculated number of different types of solar thermal systems in operation was around 101 million (Table 5).

The most important field of application for solar thermal systems is domestic hot water heating (see section 6.3), and therefore, this type of application also accounted for the highest savings in terms of oil equivalent and CO_2. In 2014, 94 % of the energy provided by solar thermal systems worldwide was used for heating domestic hot water, mainly by small-scale systems in single-family houses (68 %) and larger applications attached to multi-family houses, hotels, schools, etc. (27 %). Swimming pool heating held a share of 4 % in the contribution to the energy supply and CO_2 reduction and the remaining 2 % were met by solar combi-systems.

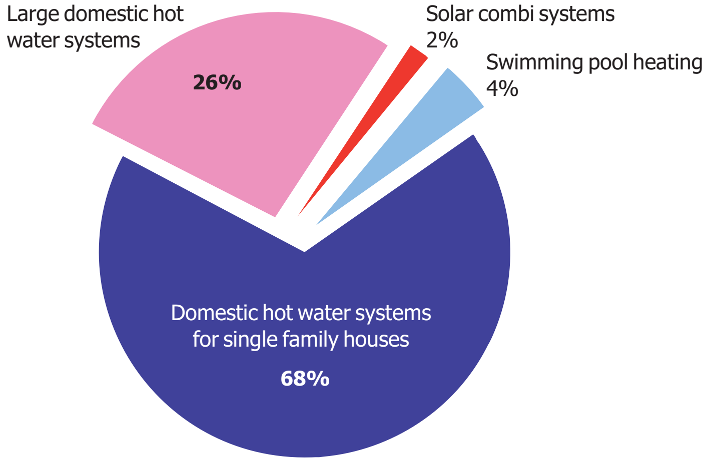


Figure 30: Share of energy savings and CO_2 reduction by type of application of glazed and unglazed water collectors in operation in 2014

Table 5 summarizes the calculated annual collector yields and the corresponding oil equivalents and CO_2 reductions of all water-based solar thermal systems (systems for hot water, space heating and swimming pool heating) in operation by the end of 2014.

Country	Total collector area [m²]	Total capacity [MW_{th}]	Calculated number of systems	Collector yield [GWh/a]	Energy savings [t_{oe}/a]	CO_2 reduction [t_{CO2e}/a]
Albania	162,697	114	29,687	115	12,327	39,790
Australia	8,365,000	5,856	1,062,217	5,199	558,804	1,803,820
Austria	5,161,798	3,613	513,871	2,087	224,309	724,070
Barbados*	131,700	92	32,925	116	12,492	40,323
Belgium	539,033	377	93,806	214	23,031	74,344
Brazil	11,017,333	7,712	3,298,890	7,189	772,664	2,494,159
Bulgaria	130,300	91	22,676	64	6,900	22,273
Canada	904,156	633	15,144	368	39,544	127,648
Chile	231,209	162	31,190	164	17,655	56,991
China	413,600,000	289,520	70,105,200	231,838	24,918,150	80,435,787
Croatia	167,092	117	29,079	84	9,027	29,138
Cyprus	690,447	483	301,787	614	65,961	212,922
Czech Republic	1,044,512	731	72,531	348	37,389	120,691
Denmark	957,341	670	87,705	405	43,508	140,445
Estonia	10,520	7	1,831	4	454	1,465
Finland	55,823	39	9,715	23	2,431	7,848
France (mainland) +	2,520,900	1,765	526,468	1,188	127,687	412,173
Germany	18,256,700	12,780	2,144,037	7,434	798,979	2,579,104
Greece	4,286,300	3,000	1,144,313	2,986	320,900	1,035,865
Hungary	269,100	188	38,697	121	13,053	42,135
India ++	7,451,900	5,216	3,282,003	6,435	691,605	2,232,502
Ireland	300,183	210	69,472	126	13,508	43,605
Israel	4,527,634	3,169	1,449,748	4,182	449,451	1,450,827
Italy	4,006,444	2,805	697,229	2,445	262,738	848,117
Japan	3,730,983	2,612	909,073	2,164	232,602	750,838
Jordan***	1,260,506	882	223,109	1,194	128,286	414,108
Korea, South	1,793,613	1,256	410,916	927	99,657	321,693
Latvia	8,622	6	1,500	4	393	1,269
Lebanon	603,900	423	66,731	500	53,752	173,512
Lesotho #	400	0	200	0	39	126
Lithuania	10,400	7	1,810	4	468	1,510
Luxembourg	51,200	36	8,910	22	2,328	7,515
Macedonia	41,720	29	9,516	26	2,774	8,954
Malta	49,976	35	13,342	40	4,311	13,916
Mauritius***	123,993	87	82,662	106	11,375	36,719
Mexico	2,817,077	1,972	332,818	1,612	173,212	559,127
Morocco***	451,000	316	60,900	383	41,146	132,821
Mozambique	1,143	1	286	1	104	337
Namibia**	22,000	15	2,717	20	2,157	6,963
Netherlands	643,833	451	153,240	257	27,619	89,153
New Zealand*	159,645	112	32,703	99	10,592	34,191
Norway	42,506	30	2,118	16	1,682	5,428
Palestinian Territ.	1,785,625	1,250	613,124	1,666	179,038	577,933
Poland	1,744,000	1,221	219,453	712	76,545	247,087
Portugal	945,181	662	182,666	735	79,049	255,171
Romania	143,050	100	24,895	79	8,491	27,408
Russia	18,464	13	841	8	826	2,667
Slovakia	152,950	107	18,720	71	7,675	24,774
Slovenia	191,500	134	28,961	80	8,563	27,642
South Africa	1,650,050	1,155	693,004	1,178	126,614	408,709
Spain	3,450,433	2,415	413,879	2,409	258,953	835,901
Sweden	497,178	348	37,748	182	19,530	63,044
Switzerland	1,484,640	1,039	179,627	586	63,018	203,423
Taiwan	1,605,989	1,124	317,038	977	104,995	338,923
Thailand***	152,862	107	34,933	128	13,790	44,514
Tunisia	775,935	543	229,641	697	74,922	241,847
Turkey	18,185,901	12,730	4,200,943	16,316	1,753,651	5,660,785
United Kingdom	789,600	553	137,412	307	32,975	106,443
United States	24,279,331	16,996	486,396	10,925	1,174,273	3,790,555
Uruguay	46,241	32	11,560	32	3,387	10,935
Zimbabwe	24,823	17	6,206	21	2,279	7,356
All other countries (5%)	29,185,494	20,430	6,011,466	17,233	1,852,183	5,978,848
TOTAL	583,709,885	408,597	101,221,287	335,463	36,055,821	116,388,189

Note: If no data is given no reliable database for this collector type is available.

* Total capacity in operation refers to the year 2009. ** Total capacity in operation refers to the year 2012.

*** Total capacity in operation is based on estimations for new installations in 2014.

\# New included countries compared to the 2015 edition of this report

\+ The figures for France relate to mainland France only, overseas territories of France (DOM) are not considered.

++ The figures for India refer to fiscal year April 2014 to March 2015.

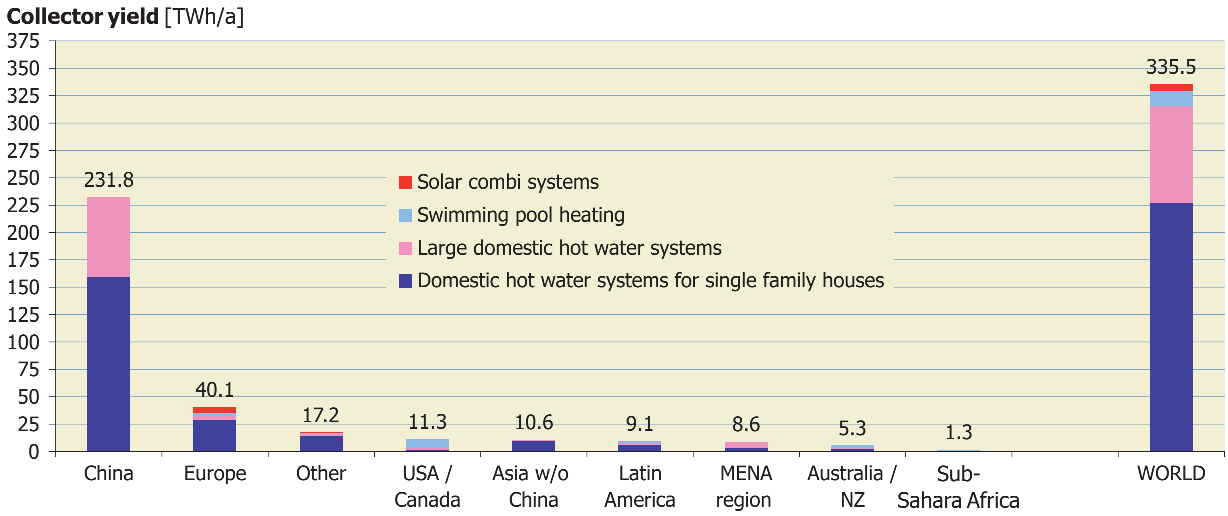
Table 5: Calculated annual collector yield and corresponding oil equivalent and CO_2 reduction of glazed and unglazed water collectors in operation by the end of 2014

In Chapters 5.1 to 5.3, the annual collector yield, energy savings and CO_2 savings by economic regions and world-wide are graphed.

5.1 Annual collector yield by economic region

In 2014, gross solar thermal collector yields amounted to 335.5 TWh worldwide (Table 5) and the major share, 68 %, was contributed by domestic hot water applications for single-family houses (Figure 30).

China accounted for 69 % of the thermal energy gains (232 TWh), Europe for 12 % (40 TWh) and the Rest of the World for 19 % (64 TWh) (Figure 31).



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

Figure 31: Annual collector yield of unglazed and glazed water collectors in operation in 2014

5.2 Annual energy savings by economic region

Considering a utilization ratio of 0.8 for the reference oil boiler, which is assumed to be partially replaced by the solar thermal system (see methodology Chapter 9.1), the annual final energy savings amounted to 419.3 TWh or 36.1 million tons of oil equivalent in 2014[4]

The breakdown shows that China accounted for 24.9 million tons oil equivalent, Europe for 4.3 million tons oil equivalent, and the Rest of World for 6.8 million tons oil equivalent (Figure 32).

4 1 toe = 1.163 x 10^4 kWh (Defra/DECC 2013)

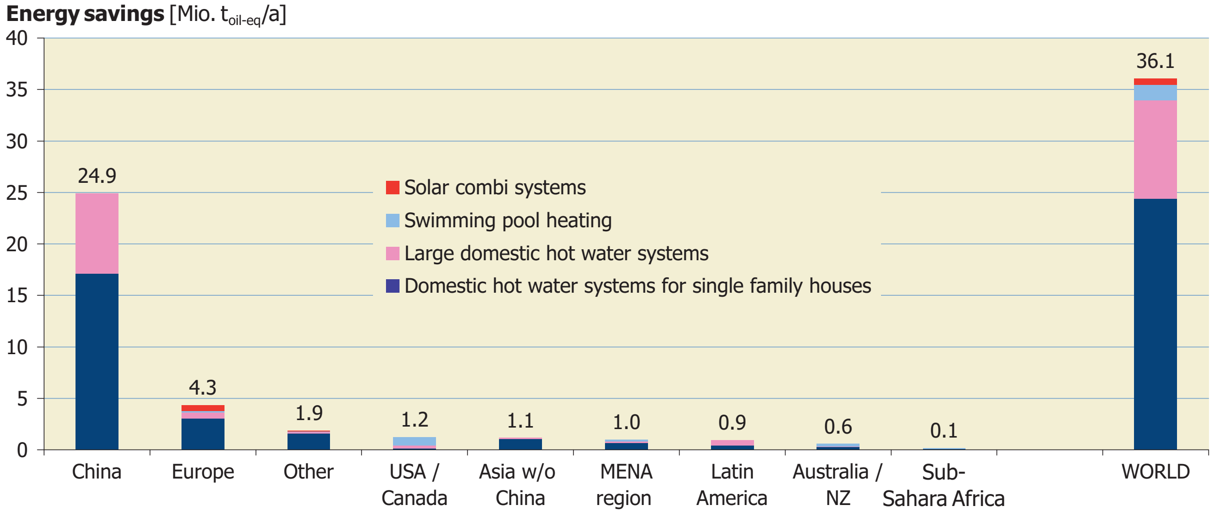


Figure 32: Annual energy savings in oil equivalent by unglazed and glazed water collectors in operation in 2014

5.3 Annual contribution to CO_2 reduction by economic region

36.1 million tons of oil equivalents correspond to an annual CO_2 emission reduction of 116.4 million tons[5] Here, the breakdown was China 80.4 million tons of CO_2e, Europe 13.9 million tons of CO_2e, and the Rest of World 22.0 million tons of CO_2e (see Figure 33).

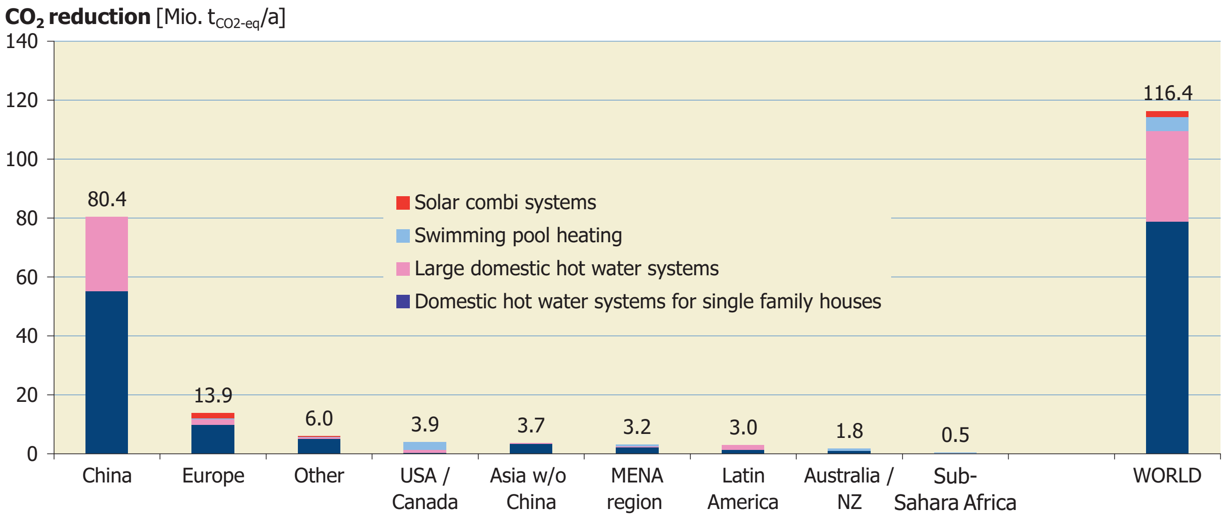


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Figure 33: Contribution to CO_2 reduction by unglazed and glazed water collectors in operation in 2014

5 1 toe (fuel oil) = 3,228 tCO_2e (Defra/DECC 2013)

6 Distribution of systems by system type and application

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 6.1 to 6.3, the share of these system types and applications are shown by different economic regions for both the cumulated capacity in operation in 2014 and the new installed capacity in 2014[6]

6.1 Distribution by type of solar thermal collector

In terms of the total water collector area, evacuated tube collectors dominated with a share of 71 % of the cumulated capacity in operation (Figure 34) and a share of 78 % of the new installed capacity (Figure 35). Especially in China, vacuum tube collectors played an important role and this was by far the largest market supported by the high growth rates in previous years. The worldwide figures trend towards a higher share of this type of solar thermal collector. Unglazed water collectors accounted for 6 % of the cumulated water collectors installed worldwide and for 3 % of the new installed capacity.

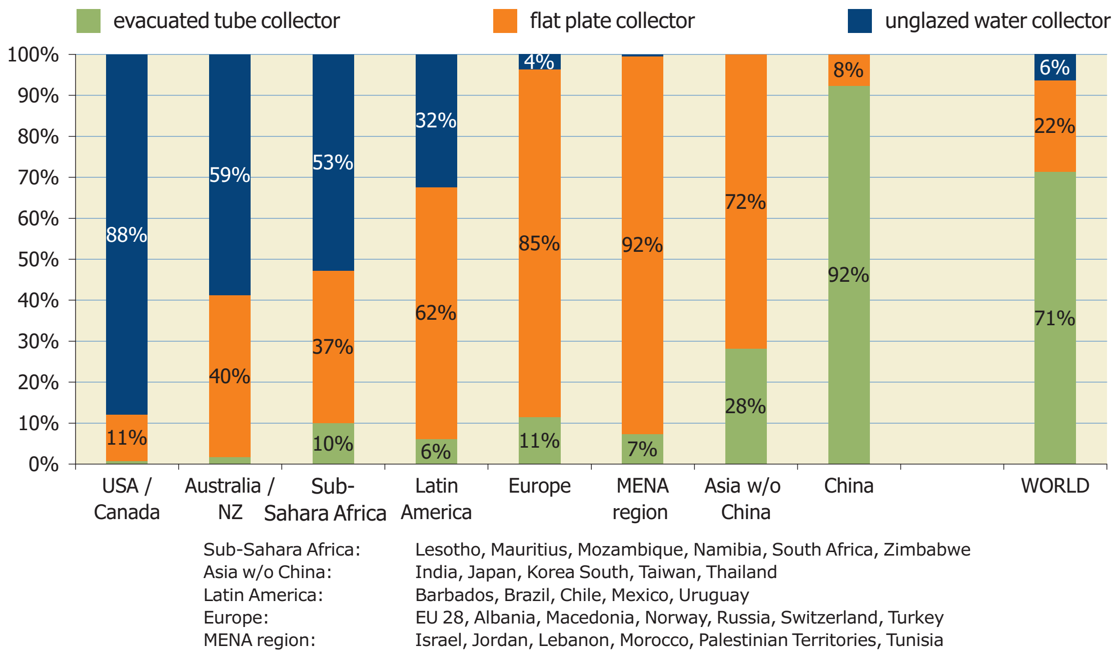
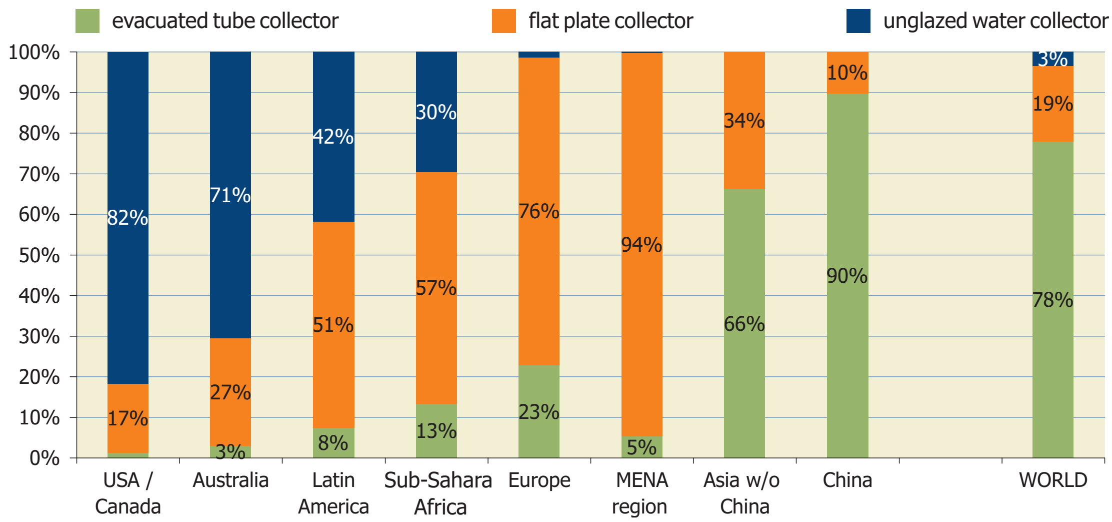


Figure 34: Distribution by type of solar thermal collector for the total installed water collector capacity in operation by the end of 2014

6 It has to be considered that statistical information summarized in Chapters 6.1 to 6.4 is sometimes based on rough expert estimations by country representatives only and hence especially the share by type of system and application of the cumulated installed capacity in operation may deviate from figures published in previous editions of this report..



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Asia w/o China: India, Japan, Korea South, Taiwan, Thailand
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MENA region: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Figure 35: Distribution by type of solar thermal collector for the new installed water collector capacity in 2014

6.2 Distribution by type of system

Worldwide, more than three quarters of all solar thermal systems installed are thermosiphon systems and the rest are pumped solar heating systems (Figure 36). Similar to the distribution by type of solar thermal collector in total numbers, the Chinese market influenced the overall figures the most. In 2014, 90 % of the new installed systems were estimated to be thermosiphon systems while pumped systems only accounted for 10 % (Figure 37).

In general, thermosiphon systems are more common in warm climates such as in Africa, South America, southern Europe and the MENA region. 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.

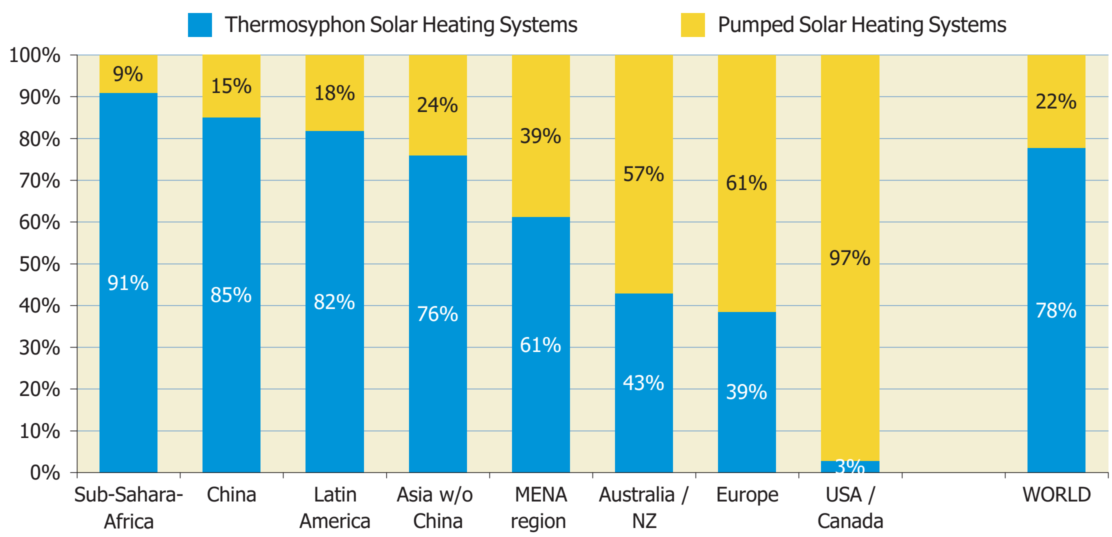

Figure 36: Distribution by type of system for the total installed glazed water collector capacity in operation by the end of 2014

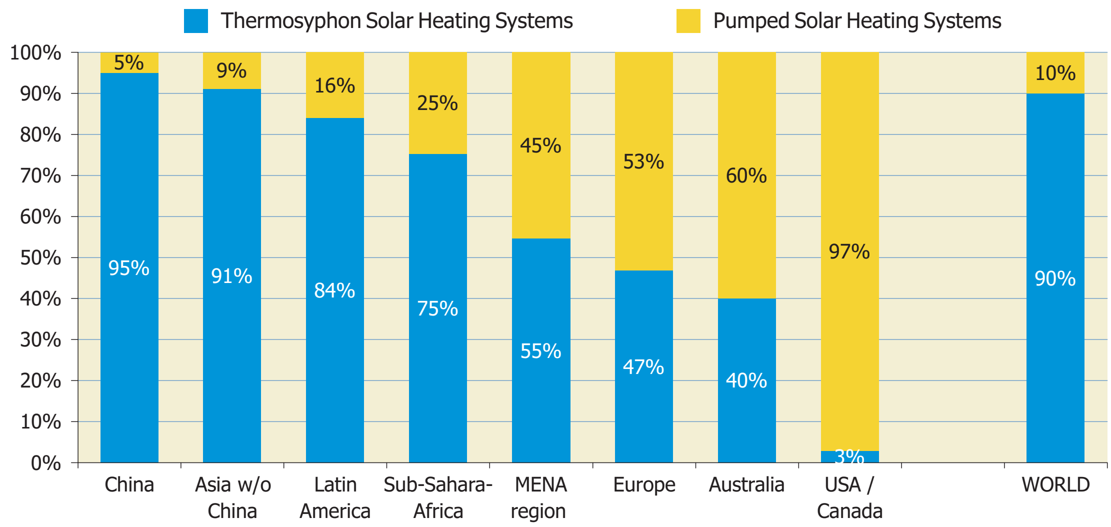

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Figure 37: Distribution by type of system for the new installed glazed water collector capacity in 2014

6.3 Distribution by kind of application

By the end of 2014, 584 million square meters of water-based solar thermal collectors corresponding to a thermal peak capacity of 409 GW_{th} were in operation worldwide (Table 5). Out of these, 6 % were used for swimming pool heating, 63 % were used for domestic hot water preparation in single-family houses and 28 % 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 1 % and delivered heat to other applications such as district heating networks, industrial processes or thermally driven solar cooling applications (Figure 38). Considering typical solar thermal system sizes for the mentioned applications in the different countries covered in this report the number of systems in operation worldwide is calculated to be around 101 million.

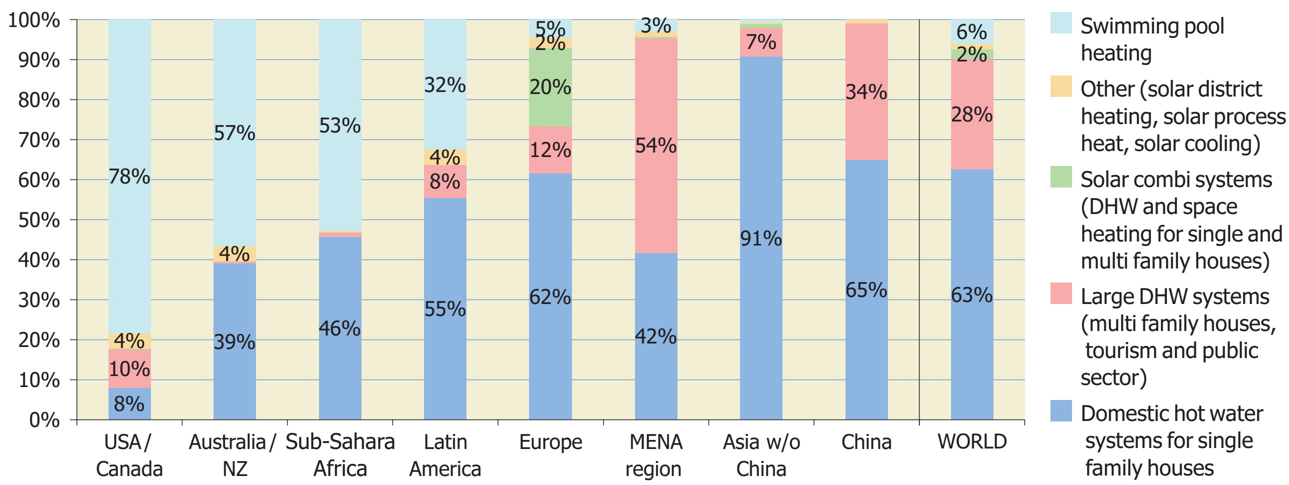

Figure 38: Distribution of solar thermal systems by application for the total installed water collector capacity by economic region in operation by the end of 2014

The new installed water-based solar thermal collector area amounted to 67 million square meters, which corresponds to 47 GW of thermal peak capacity (Table 3).
Compared to the cumulated installed capacity, the share of swimming pool heating was less for new installations (6 % of total capacity and 4 % of new installed capacity). A similar trend can be seen for domestic hot water systems in single-family homes: 63 % of total capacity in operation and 43 % of new installations in 2014 make this kind of systems the most common application worldwide but with a decreasing tendency.

By contrast, the share of large-scale domestic hot water applications basically tends to increase (28 % of total capacity and 50 % of new installed capacity). It can be assumed that this market segment took over some of the market shares from both swimming pool heating and domestic hot water systems in single-family homes.

The share of solar combi-systems as well as other applications, such as solar district heating, solar process heat or solar cooling remained at a low level of 3 – 4 % and no real trend can be identified in a global context (Figure 39).

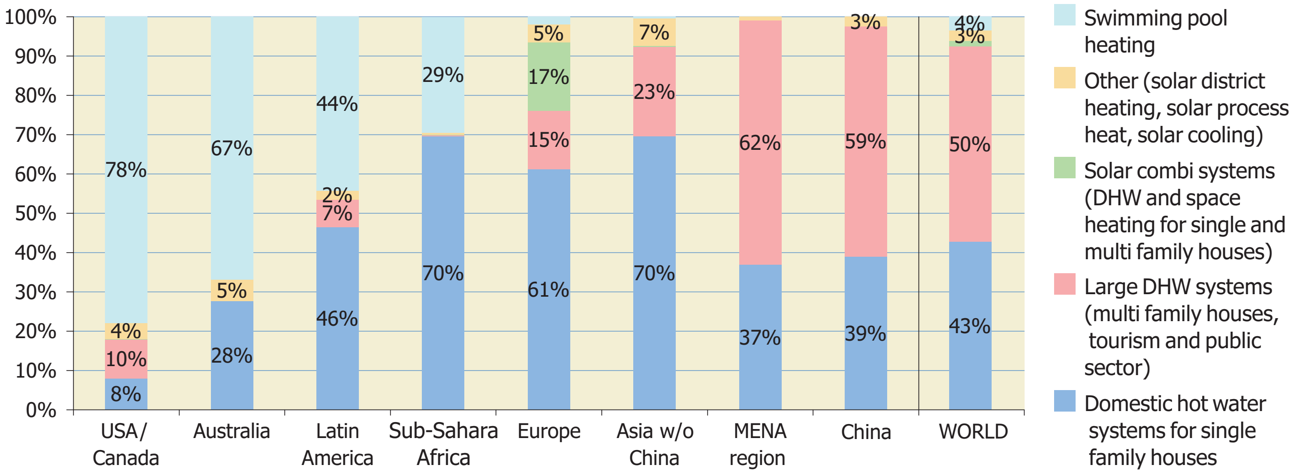

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Figure 39: Distribution of solar thermal systems by application for the new installed water collector capacity by economic region in 2014

7 Exceptional markets and applications for solar thermal systems

7.1 Overview of global megawatt-scale solar thermal applications

Megawatt-scale solar supported district heating systems and solar heating and cooling applications in the commercial and industrial sector have gained increasing interest all over the world in recent years, and several ambitious projects have been successfully implemented.

Two of the largest solar thermal systems worldwide are located in Denmark and supply heat to **district heating** networks. In May 2014 a 26 MW_{th} (37,573 m²) installation was inaugurated in the Danish town of Dronninglund. The ground-mounted flat plate collector field is hydraulically connected to seasonal pit heat storage with a volume of 61,700 m³ and is designed to cover around 50 % of the annual district heating demand of the 1,350 costumers connected in future[7]; [8]. Two even larger solar district heating application with seasonal storage were commissioned in Gram and the city of Vojens in 2015. The system in Vojens is now the world's largest solar thermal system with a thermal capacity of 37 MW_{th} (52,491 m²). It is connected to a huge seasonal pit heat storage with a volume of 203,000 m³. Together with an already existing 13 MW_{th} (17,500 m²) installation at Vojens district heating, a total solar thermal capacity of 50 MW_{th} (69,991 m²) will deliver 55 – 60 % of the thermal energy demand of 2,000 households[9]; [10].

In Riyadh, Saudi Arabia another large-scale solar district heating plant was commissioned in July 2011. The solar thermal plant with a total capacity of 25.4 MW_{th} (36.305 m²) is connected to a heating network for the supply of space heating and domestic hot water at a university campus[11].

Another successful solar supported heating network was implemented in Alberta, Canada. The Drake Landing Solar Community uses a 1.6 MW_{th} (2.293 m²) centralized solar thermal plant connected to a seasonal borehole thermal energy storage to supply more than 90 % of the energy needed for space heating of 52 energy efficient single-family homes[12]; [13].

Also in China large-scale district heating systems got more attention in recent years. The currently largest solar district heating system in China was installed in 2013 at the Hebei University of Economics and Business in Shijiazhuang and supplies heat for space heating and hot water for the students appartments. A vacuum collector filed of 8.1 MW_{th} (11,592m²) is connected to 20,000 m³ heat storage. The overall storage comprises of 228 steel tanks, which are integrated in a building.

The two **largest solar cooling applications worldwide** are in Singapore and the USA. The largest solar cooling application is located in Arizona, USA and was commissioned in May 2014. The installation covers a roof-mounted solar thermal collector field with a capacity of 3.4 MW_{th} (4,865 m²) that supplies heat to a single-effect lithium bromide absorption chiller with a cooling capacity of 1.75 MW[14]; [15]. In Singapore a solar cooling system was installed in August 2011 with a total capacity of 2.73 MW_{th} (3,900 m²) started operation at the United World College in Singapore. The roof mounted solar thermal collector field is hydraulically connected to a 1.76 MW_{th} absorption chiller and supplies hot water and cooling to approximately 2,900 students who live and study at the newly created 76,000 m² campus[16].

7 http://www.solarthermalworld.org/content/denmark-dronninglund-inaugurates-26-mwth-solar-district-heating-plant
8 http://www.solarthermalworld.org/content/denmark-23-mwth-cover-55-heat-demand-1500-households
9 http://www.solarthermalworld.org/content/denmark-37-mw-field-203000-m3-storage-underway
10 http://www.arcon.dk/NY_Referencer.aspx
11 http://www.solarthermalworld.org/content/saudi-arabia-womens-university-solar-district-heating
12 http://www.solarthermalworld.org/content/canada-district-heating-90-solar-fraction
13 http://www.dlsc.ca/
14 http://www.solarthermalworld.org/content/usa-largest-solar-cooling-system-worldwide
15 http://www.solid.at/en/references/solar-cooling
16 http://www.solarthermalworld.org/content/singapore-second-largest-solar-cooling-installation-worldwide

The world's largest solar **process heat application** was commissioned in Chile in June 2013. The installation with a thermal peak capacity of 27.5 MW covers a total of 39,300 m² of flat plate collector area connected to 4,000 m³ thermal energy storage. The solar thermal system is designed to cover 85 % of the process heat demand needed to refine copper at the Gaby copper mine of state-owned mining company Codelco[17].

Solar heat for industrial applications is getting more attention in general. As examples for this trend one system from the USA and one from China are described in the following:
Probably the largest solar process heat application in the USA was installed in April 2012 in North Carolina. The 5.5 MW_{th} (7,804 m²) solar thermal system equipped with flat plate collectors supplies hot water to a turkey processing plant, lessening the use of propane gas[18].

The largest solar process heat applications installed in China are connected to dyeing and weaving mill factories. A system with a thermal peak capacity of 9.1 MW_{th} (13,000 m²) was constructed in the province of Zhejiang.

More examples of solar process heat applications can be found at http://ship-plants.info/.

7.2 Large-scale solar district heating and cooling applications in Europe

In the Scandinavian countries of Denmark and Sweden, but also in Austria, Germany, Spain and Greece large-scale solar thermal applications connected to local or district heating grids have been in use since the early 1980s.

By the end of 2015, 235 large-scale solar thermal systems >350 kW_{th} (500 m²) connected to heating networks and 17 systems connected to cooling networks were in operation in Europe (Figure 40). The total installed capacity of these systems equaled 745 MW_{th} (1,063,791 m²). In 2015, 20 large-scale solar thermal systems were added compared to 15 new installations in 2014. Of these installations, 17 were installed in Denmark and one each in Sweden, Austria and Italy.

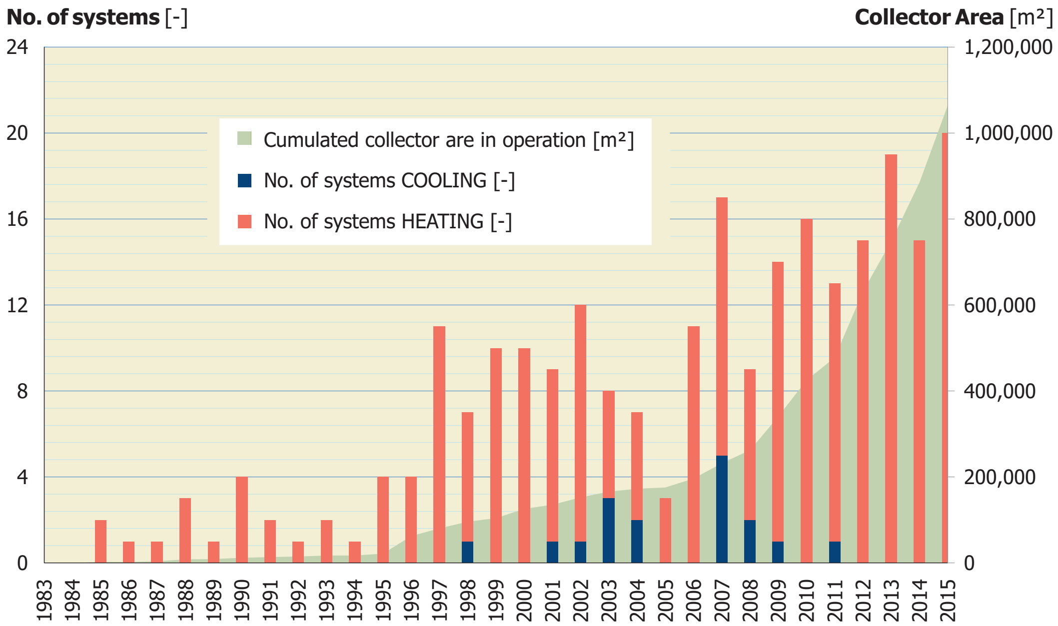


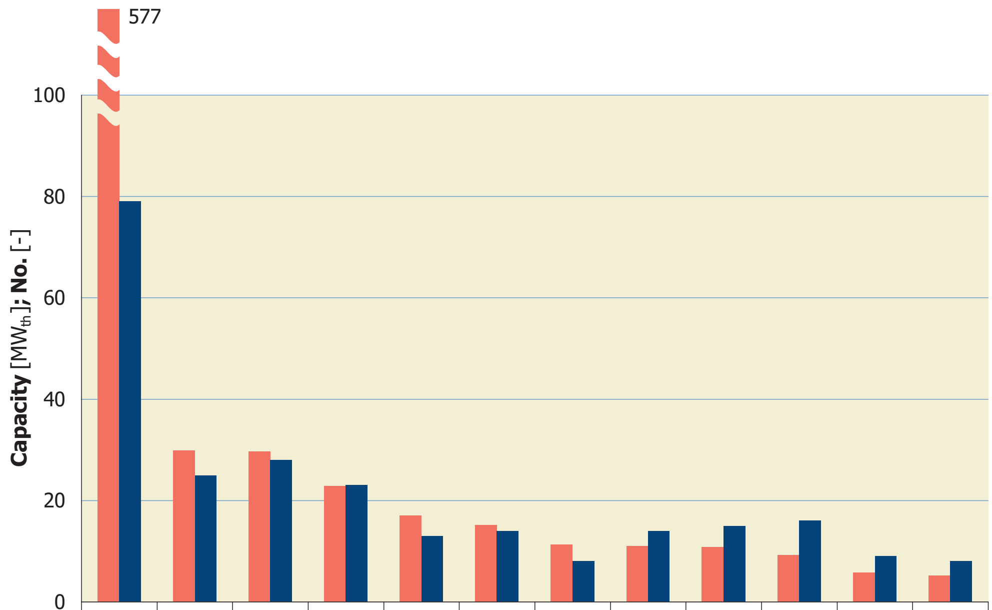
Figure 40: Solar district heating and cooling in Europe – annual achievements and cumulated area in operation in 2015 *(Data source: Jan-Olof Dalenbäck – Chalmers University of Technology, SE)*

17 http://www.solarthermalworld.org/content/chile-president-inaugurates-solar-field-275-mwth
18 http://solarthermalworld.org/content/usa-contractor-runs-7804-m²-collector-system-prestage-foods-factory

Denmark by far holds the leading position in Europe with both large-scale systems installed as well as capacity installed (Figure 41). In 2015, 71 solar district heating plants with a total installed capacity of 577 MW$_{th}$ (823,838 m²) were in operation in Denmark. The average system size of these plants calculates to 7.3 MW$_{th}$ (10,428 m²). 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. The largest plants in operation are located in Vojens (49 MW$_{th}$; 69,991 m²), Gram (31.4 MW$_{th}$; 44,836 m²) and Dronninglund (26.3 MW$_{th}$; 37,500 m²) and are equipped with seasonal pit heat storages for solar fractions of around 50 %. The installations in Vojens and Gram have been enlarged in 2014 and 2015 respectively, which indicates a high level of customer satisfaction[19].

In Europe and worldwide, Denmark is the only example for a mature and commercial solar district heating market. In several other countries smaller niche markets exist, such as in Austria where 28 systems > 500 m² are installed to feed into district heating networks, smaller micro grids in urban quarters or local biomass heating networks. In Germany, several remarkable demonstration plants with seasonal storage were built and also from other countries such as Sweden (23 plants), Spain (16 plants), France (15 plants), Greece, Poland (14 plants) and Switzerland (9 plants) interesting achievements are reported.

Large-scale solar cooling applications were built in southern European countries with high cooling loads. In Italy (5 plants) and Spain (5 plants) several best practice examples exist.



	DK	DE	AT	SE	OTH	PL	NL	GR	FR	ES	CH	IT
Capacity [MW$_{th}$]	577	30	30	23	17	15	11	11	11	9	6	5
No. of systems [-]	79	25	28	23	13	14	8	14	15	16	9	8

Figure 41: Solar district heating and cooling in Europe – capacities installed and No. of systems in 2015
(Data source: Jan-Olof Dalenbäck – Chalmers University of Technology, SE)

19 The market for solar assisted district heating networks in Denmark has been booming for several years and is driven by high taxes for fossil fuels and a thermal energy supply system that is characterized by decentralization on the one hand and a high share of wind energy for electricity production on the other hand. This together with the liberalized market mechanisms for electricity in Europe and low solar thermal system prices for large-scale systems make solar thermal heat in Denmark even competitive against natural gas driven combined heat and power systems in many cases. Actual levelized costs for solar thermal generated heat in Denmark amount to 30 – 40 €/MWh. More information about the (Danish) Solar District Heating success story in Europe can be found here: http://www.solar-district-heating.eu/. A database of techno-economic benchmark figures and monitoring data of several Danish best practice examples can be accessed here: http://www.solvarmedata.dk/index.asp?secid=228

7.3 Market for solar air conditioning and cooling applications

Solar cooling applications convert the energy from the sun into cold by means of driving a thermal cooling machine.

By the end of 2014, an estimated 1,200 solar cooling systems were installed worldwide. More recent global data are not available because worldwide there are more and more market players active, especially in Asia and Middle East, making reliable data collection difficult. The last figures showed a positive trend between 2004 and 2014, but the growth rates tended to slowly decline from 36 % in 2008/2009 to 14 % in 2013/2014.

Approximately 75 % of the installed solar cooling installations worldwide are installed in Europe, most notably in Spain, Germany and Italy. However, the share of applications from outside of Europe trended up. The majority of all systems is equipped with flat plate or evacuated tube collectors. By contrast, some thermal cooling machines driven by concentrated solar thermal energy (with concentrating solar thermal collectors such as parabolic troughs or Fresnel collectors) were reported from India, Australia and Turkey[20].

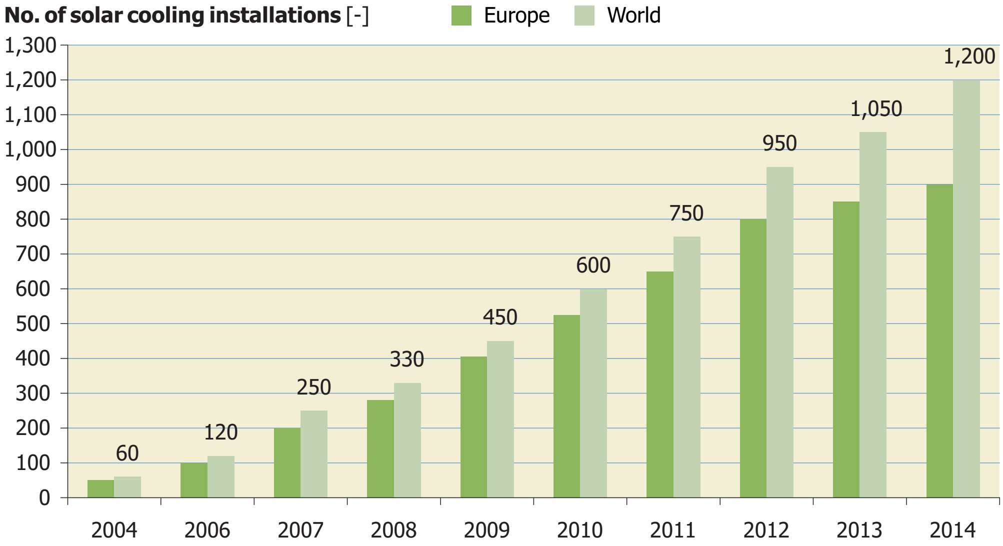


Figure 42: Market development 2004 – 2014 of small to large-scale solar air conditioning and cooling systems (Source: Solem Consulting, Tecsol)

The overall number of systems installed to date indicates that solar cooling remains a niche market, but one that is developing. Since 2007, system costs have been reduced by about 50 % due to the further standardization of the solar cooling kits.

A recent UNEP study on the Arab region (22 countries) indicates that solar thermal cooling potential of around one MW cooling capacity is economically feasible in the UAE, Kuwait, Qatar and Saudi Arabia[21]. In the UAE, solar thermal cooling is currently economically viable with lower net present cost than the reference case over 20 years.

20 Jakob U. (2013): Status and Perspective of Solar Cooling outside of Australia; Australian Solar Cooling 2013 Conference, Sydney 2013

21 UNEP (2015): Assessment on the Commercial Viability of Solar Cooling Technologies and Applications in the Arab Region

7.4 Best practice examples of worldwide installed solar process heat applications

A variety of industrial processes demand vast amounts of thermal energy, 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 at or below 100°C to concentrating solar thermal collectors such as parabolic troughs, Fresnel collectors or Scheffler dishes for temperatures up to 400°C.

Solar Heat for Industrial Processes (SHIP) is still a niche market, but a number of promising projects have been implemented in the last couple of years ranging from small-scale demonstration plants to very large systems, such as the world's second largest solar thermal plant in Chile, which delivers heat for the leaching process at a copper mine (see section 7.1).

By April 2016, 188 SHIP applications are reported to be in operation globally with a cumulated installed capacity of around 106 MW_{th} (154,500 m²). Of these installations, 21 systems exceed 0.7 MW_{th} (1,000 m) of thermal peak capacity, 35 systems have installed capacities of between 0.35 and 0.7 MW_{th} (500 – 1,000 m²) and 132 systems are below 0.35 MW_{th}.

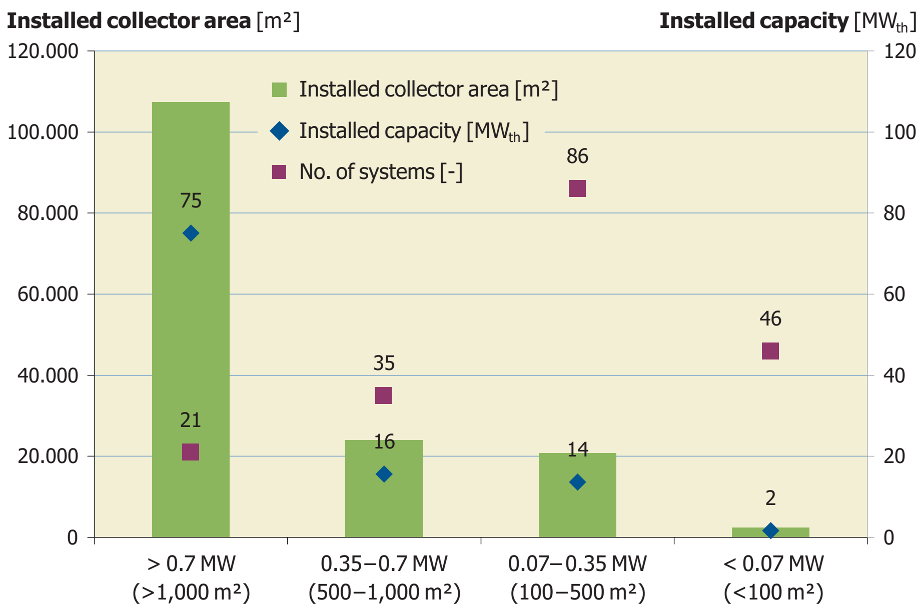


Figure 43: Global solar process heat applications in operation by April 2016 *(Source: IEA SHC Task49/IV SHIP database)*

Further information on the mentioned solar process heat applications in operation are collected in an online database that was created within the framework of IEA SHC Task 49/IV on "Solar Heat Integration in Industrial Processes"[22].

The SHIP database can be accessed by private users and the intent is to continuously add new and existing SHIP applications in order to spread knowledge about the possibilities offered by this technology. The database can be found at http://ship-plants.info/.

22 http://task49.iea-shc.org/

7.5 Market for Solar Air Heating Systems

Solar air heating is a solar thermal technology in which the energy from the sun heats air. In colder climates, space heating is usually the largest use of building energy and it is the air in the buildings that is heated. Space heating consumes much more energy than hot water in most residential buildings. Solar air heating systems can be building integrated and are designed typically to cover between 20 and 30 % of the annual space heating demand of a building.

The air is generally taken off the top of the wall (since hot air rises) and the heated or pre-heated fresh air is then connected to fans and ducted into the building via the ventilation system.

Solar air heaters are also common in agricultural applications primarily for drying.

Solar air heating systems have been used mainly in North America for the past 30 years by schools, municipalities, military, agricultural, commercial and industrial entities as well as in residential buildings. Wall mounted systems are common and take advantage of the lower winter sun angles and eliminate any snow accumulation typical of roof mounted systems. Storage of the heat is possible, but most solar air systems do not include storage to minimize costs.

Solar space heating with air collectors is not common in Europe, likely due to the lack of a European test standard for air collectors, but in North America building integrated solar air collectors are the most popular form of solar thermal systems in the commercial, industrial and institutional markets due to their low cost and architectural integration into buildings.

8 Solar thermal system cost and levelized costs of heat

In this chapter, economic performance indicators for major solar thermal markets worldwide are analyzed. In total, technical and economic benchmark figures for solar thermal systems from 11 countries including Australia, Austria, Brazil, Canada, China, Denmark, India, Israel, South Africa, Turkey and France were collected from a comprehensive questionnaire. Solar thermal experts, solar trade associations, technology providers and installation companies from these countries were asked to provide cost information about solar thermal applications most commonly applied in their countries, including small domestic hot water systems for single-family houses (DHW-SFH), large domestic hot water systems for multi-family houses (DHW-MFH), small combined hot water and space heating systems (COMBI-SFH) and swimming pool heating systems with unglazed water collectors (POOL HEATING).

Lowest LCOH for the different solar thermal applications investigated range between ~1 €-ct/kWh for pool heating systems (Australia, Brazil), 2 – 5 €-ct/kWh for small thermosiphon DHW systems (Brazil, India, Israel, Turkey), 7 – 8 €-ct/kWh for small pumped domestic hot water systems (Australia, China) and 2 – 6 €-ct/kWh for large pumped domestic hot water and/or space heating systems (Brazil, China, India, South Africa).

Highest LCOH for the different solar thermal applications investigated range between ~2 €-ct/kWh for pool heating systems (Canada, Israel), 7 – 12 €-ct/kWh for small thermosiphon DHW systems (Australia, China, South Africa), 12 – 20 €-ct/kWh for small pumped domestic hot water systems (Australia, Austria, Canada, Denmark, France), 8 – 14 €-ct/kWh for large pumped domestic hot water systems (Austria, Canada, Denmark, France) and 11 – 19 €-ct/kWh for small combined hot water and space heating systems (Austria, China, Denmark, South Africa).

In Chapters 8.1 to 8.4 the results are summarized in bar charts that show both the range of investment costs as well as the range of the corresponding **L**evelized **C**ost **o**f solar thermal generated **H**eat (LCOH) for each solar thermal application available in the respective country. Cost data are expressed as specific values in Euro per square meter gross collector area [€/m²$_{gross}$] and refer to end-user (customer) prices w/o value added tax and subsidies. Levelized costs of solar thermal generated heat (LCOH) are expressed as Euro-cents per kWh thermal end energy provided by the solar thermal system (cf. Chapter 9.1). The methodology applied for the LCOH calculation as well as all relevant techno-economic benchmark figures and assumptions are documented in Chapter 9.3.

8.1 Small domestic hot water systems

The majority of solar thermal systems installed worldwide are for domestic hot water preparation (Chapter 6.3). Small domestic hot water systems for single-family homes as investigated in this chapter may differ by type of system (pumped systems, PS, or thermosiphon systems, TS) and/or by type of collector technology used (flat plate collector, FPC, or evacuated tube collector, ETC). Pumped systems are common in central and northern Europe as well as in North America and Australia whereas thermosiphon systems are more common in warm climates, such as in Africa, Latin America, southern Europe and the MENA region (Chapter 6.2). In Australia, both types of systems are about evenly present. In China, evacuated tube collectors in combination with thermosiphon systems are dominant, but the share of pumped systems with either flat plate or evacuated tube collectors is increasing. Other countries analyzed in this chapter are dominated by systems with flat plate collectors.

In Figure 44, **specific solar thermal system costs** (w/o VAT and subsidies, including installation cost) in €/m²$_{gross}$ are highlighted for **small pumped DHW systems** in different countries within a typical price range (boxplots). The corresponding **levelized costs of solar thermal generated heat (LCOH)** in €-ct/kWh[23] are shown as grey bars (green diamond equal the average value).

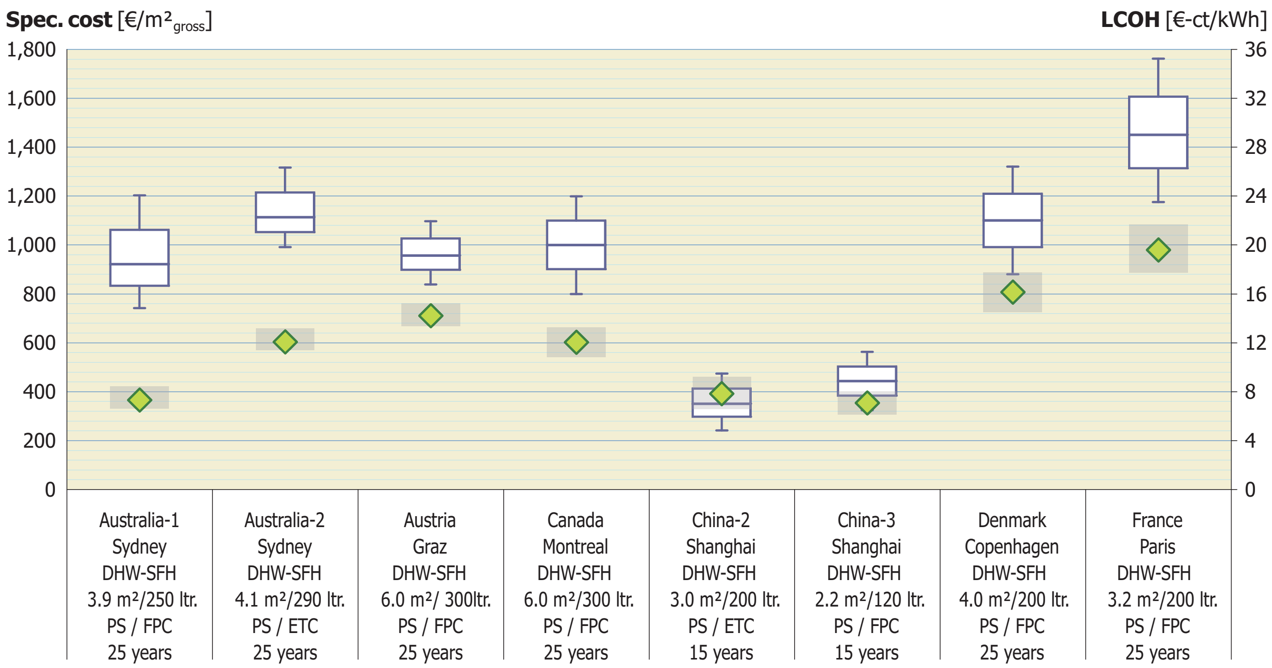


Figure 44: Specific Investment costs and levelized costs of solar thermal generated heat for small *pumped* domestic hot water systems

The pumped solar water heating systems for single-family homes presented above have a collector area in the range between 2.2 m² (China) and 6 m² (Austria and Canada) and corresponding hot water storages between 120 liter and 300 liter. Flat plate collectors as well as evacuated tube collectors are used for this type of system.

Based on long-term experiences, service lifetime of the systems of between 15 years (China) and 25 years (all other countries) were taken as a basis for the calculation of LCOH.
Depending on the conditions above as well as the end consumer cost and the respective climatic conditions the LCOH for small pumped hot water systems is between 7 – 19 €-ct/kWh. The lowest cost for solar heat is in Australia and China. In central and northern Europe and Canada the cost of solar heat is about twice as high. By far the highest cost of solar heat is in France. The type of collector used seems not to have a significant influence on the cost of solar heat.

23 Respective currency exchange rates by January 2016 (https://www.oanda.com/currency/converter/)

In Figure 45, **specific solar thermal system costs** (w/o VAT and subsidies, including installation cost) in €/m²$_{gross}$ are highlighted for **small thermosiphon DHW systems** in different countries within a typical price range (boxplots). The corresponding **levelized costs of solar thermal generated heat (LCOH)** in €-ct/kWh[24] are shown as grey bars (green diamond equal the average value).

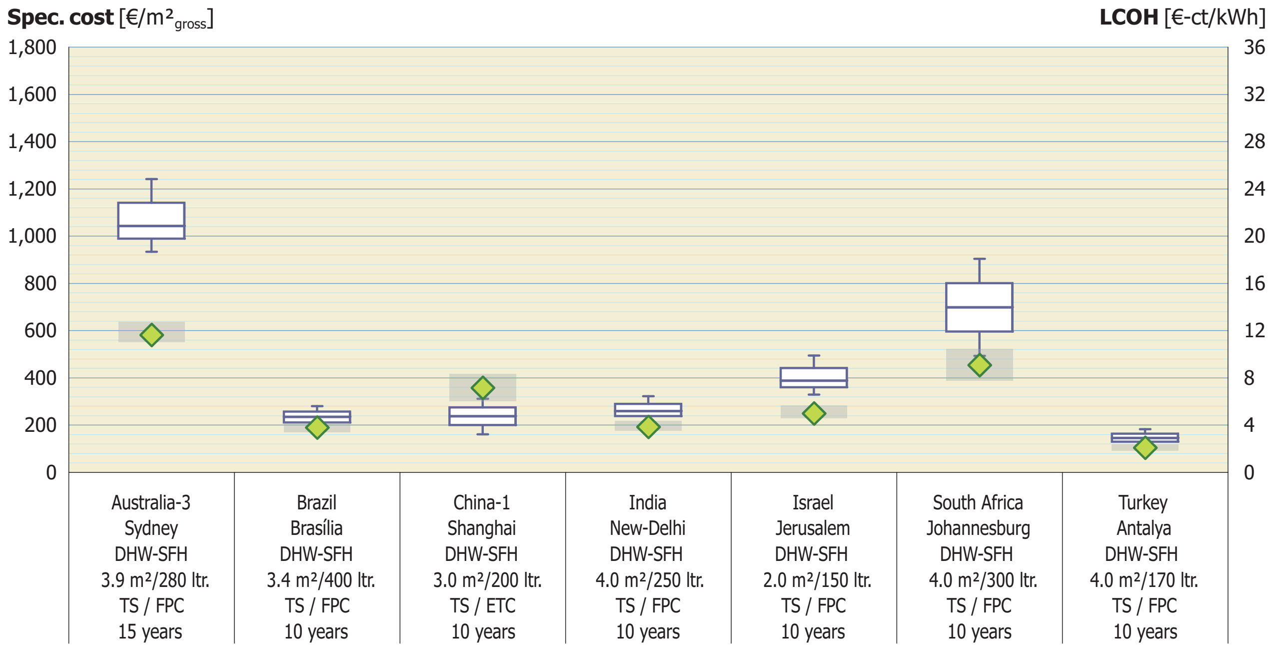


Figure 45: Specific Investment costs and levelized costs of solar thermal generated heat for small thermosiphon domestic hot water systems

The thermosiphon solar water heating systems for single-family homes presented above have a collector area in the range between 2 m² (Israel) and 4 m² (India, South Africa, Turkey) and corresponding hot water storages between 150 liter and 400 liter. Flat-plate as well as evacuated tube collectors are also used for thermosiphon systems.

Service lifetimes of these systems are between 10 and 15 years depending on the system quality. Depending on the conditions above as well as the end consumer cost and the respective climatic conditions the LCOH for thermosiphon hot water systems are between 2.1 €-ct/kWh (Turkey) and 11.6 €-ct/kWh (Australia).

24 Respective currency exchange rates by January 2016 (https://www.oanda.com/currency/converter/)

8.2 Large domestic hot water systems

In Figure 46, **specific solar thermal system costs** (w/o VAT and subsidies, including installation cost) in €/m²$_{gross}$ are highlighted for **large pumped DHW systems** and for different countries within a typical price range (boxplots). The corresponding **levelized costs of solar thermal generated heat (LCOH)** in €-ct/kWh[25] are shown as grey bars (green diamond equal the average value).

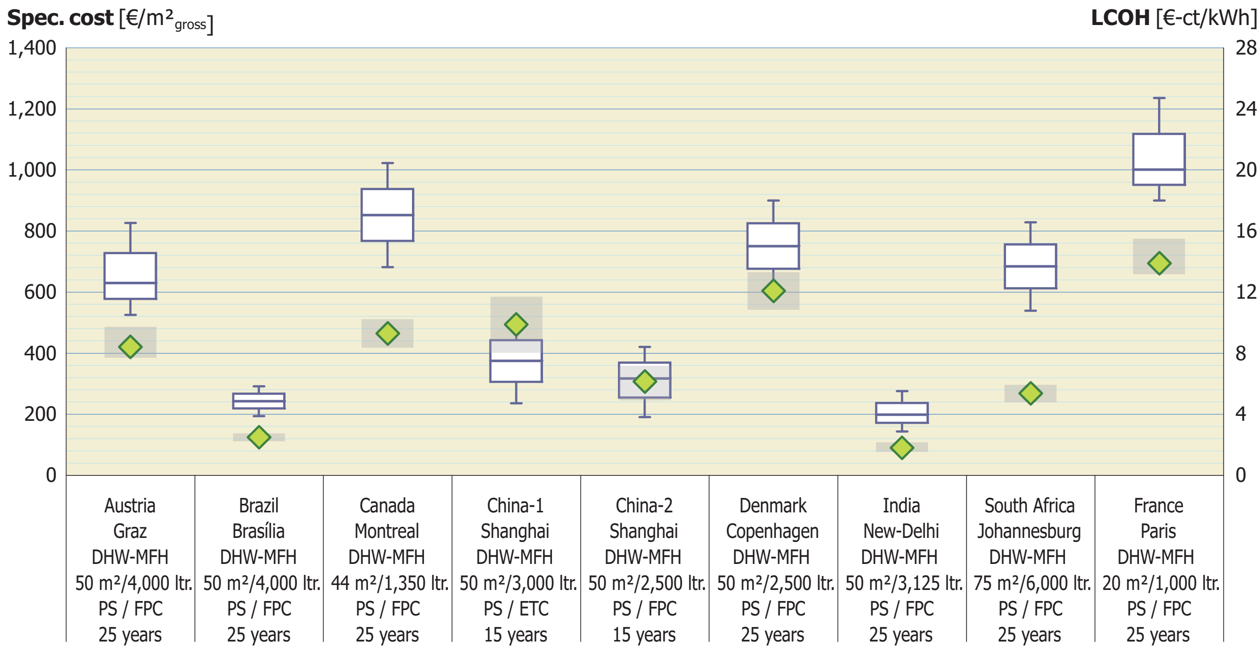


Figure 46: Specific Investment costs and levelized costs of solar thermal generated heat for large *pumped* domestic hot water systems

Larger pumped solar water heating systems for multi-family homes, hotels or hospitals presented above have a collector area in the range between 20 m² (France) and 75 m² (South Africa) and corresponding hot water storages between 1,000 liter and 6,000 liter. Flat plate collectors as well as evacuated tube collectors are used for this type of systems.

Based on long-term experiences the service lifetime of the systems is between 15 years (China) and 25 years (all other countries) and served as a basis for the calculation of LCOH. Depending on the conditions above as well as the end consumer cost and the respective climatic conditions the LCOH for larger pumped hot water systems are in the range between 2 – 14 €-ct/kWh. The lowest cost for solar heat is achieved in India and Brazil. In Denmark and France, the highest cost of solar heat is 12 €-ct/kWh and 14 €-ct/kWh, respectively.

25 Respective currency exchange rates by January 2016 (https://www.oanda.com/currency/converter/)

8.3 Combined hot water and space heating systems

In Figure 47, **specific solar thermal system costs** (w/o VAT and subsidies, including installation cost) in €/m²$_{gross}$ are highlighted for **small combined hot water and space heating systems** in different countries within a typical price range (boxplots). The corresponding **levelized costs of solar thermal generated heat (LCOH)** in €-ct/kWh[26] are shown as grey bars (green diamond equal the average value).

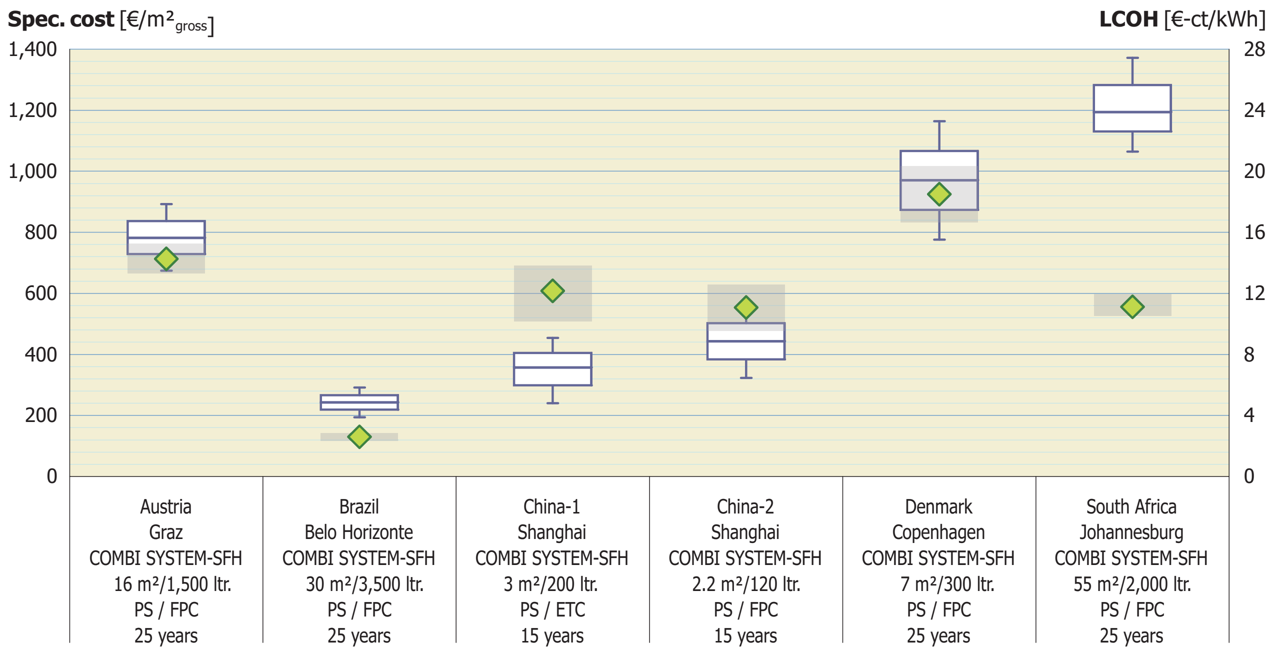


Figure 47: Specific Investment costs and levelized costs of solar thermal generated heat for small combined hot water and space heating systems

The investigated Solar Combi-systems (used in single-family homes for hot water preparation but also for space heating in winter time) have collector areas in the range between 2.2 m² (China) and 55 m² (South Africa) and corresponding hot water storages between 120 liter and 2,000 liter. Flat plate collectors are used predominantly for these applications.

Depending on the collector size of the systems and the climatic conditions the corresponding solar fraction of these systems has quite a broad variation. The service lifetime of the systems is between 15 years (China) and 25 years (all other countries[27]).

Depending on the conditions above as well as the end consumer cost and the respective climatic conditions the LCOH for solar combi-systems is between 3 – 18 €-ct/kWh.

26 Respective currency exchange rates by January 2016 (https://www.oanda.com/currency/converter/)

27 System investigated in South Africa is imported from Europe

8.4 Swimming pool heating systems

In Figure 48, **specific solar thermal system costs** (w/o VAT and subsidies, including installation cost) in €/m²$_{gross}$ are highlighted for **swimming pool heating systems with unglazed water collectors** in different countries within a typical price range (boxplots). The corresponding **levelized costs of solar thermal generated heat (LCOH)** in €-ct/kWh[28] are shown as grey bars (green diamond equal the average value).

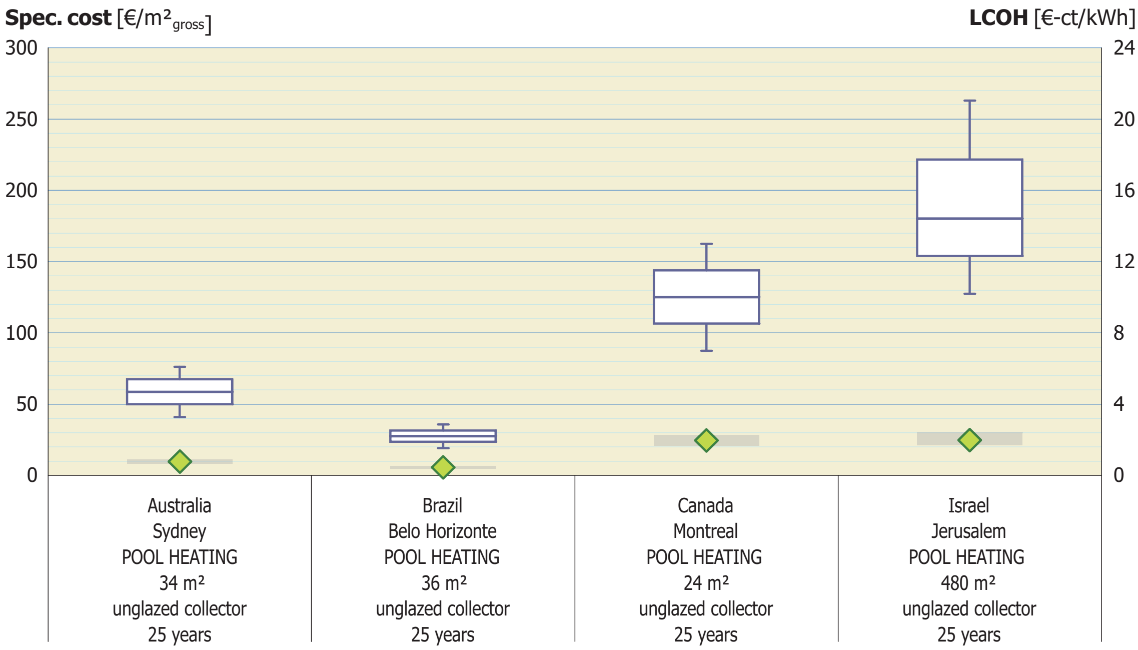


Figure 48: Specific Investment costs and levelized costs of solar thermal generated heat for swimming pool heating systems

Swimming pool heating is the most economical solar water heating system. The LCOH has a range of 1 – 2 €-ct/kWh.

28 Respective currency exchange rates by January 2016 (https://www.oanda.com/currency/converter/)

9 Appendix

9.1 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 ($kgCO_2e$) per tons of oil equivalent: 1 toe = 3.228 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. Furthermore, a hydraulic scheme is shown for each reference system.

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: Defra /DECC 2013

9.1.1 Reference systems for swimming pool heating

The information in Table 6 refers to the total capacity of water collectors in operation used for swimming pool heating as reported from each country by the end of 2014.

Country*	Reference climate	Horizontal irradiation [kWh/m²·a]	Total collector area (swimming pool) [m²]	Collector area per system [m²]	Total number of systems	Specific solar yield (swimming pool) [kWh/m²·a]
Australia	Sydney	1,674	4,821,520	35	137,758	466
Austria	Graz	1,126	585,133	200	2,926	283
Belgium	Brussels	971	25,138	200	126	262
Brazil	Brasília	1,793	3,580,239	32	111,882	375
Bulgaria	Sofia	1,188	6,077	200	30	320
Canada	Montreal	1,351	792,912	200	3,965	386
Chile	Santiago de Chile	1,753	36,993	200	185	473
Croatia	Zagreb	1,212	7,793	200	39	327
Cyprus	Nicosia	1,886	1,665	200	8	508
Czech Republic	Praha	998	604,482	200	3,022	303
Denmark	Copenhagen	989	20,443	200	102	295
Estonia	Tallin	960	491	200	2	259
Finland	Helsinki	948	2,603	200	13	256
France	Paris	1,112	133,756	200	669	328
Germany	Würzburg	1,091	559,700	30	18,657	314
Greece	Athens	1,585	199,896	200	999	427
Hungary	Budapest	1,199	32,292	10	3,229	344
India	Neu-Delhi	1,961	74,519	16	4,657	529
Israel	Jerusalem	2,198	181,105	200	906	568
Italy	Bologna	1,419	186,845	200	934	442
Jordan	Amman	2,145	6,661	200	33	578
Korea, South	Seoul	1,161	14,451	200	72	313
Latvia	Riga	991	402	200	2	267
Lithuania	Vilnius	1,001	485	200	2	270
Luxembourg	Luxembourg	1,037	2,388	200	12	280
Macedonia	Skopje	1,381	417	20	21	372
Malta	Luqa	1,902	2,331	200	12	513
Mexico	Mexico City	1,706	1,006,099	200	5,030	311
Morocco	Rabat	2,000	18,040	200	90	539
Netherlands	Amsterdam	999	109,452	40	2,736	272
New Zealand	Wellington	1,401	11,175	200	56	378
Norway	Oslo	971	1,777	200	9	316
Palestinian Territ.		2,198	71,425	200	357	593
Portugal	Lisbon	1,686	1,890	200	9	421
Romania	Bucharest	1,324	6,671	200	33	357
Russia	Moscow	996	46	200	0	269
Slovakia	Bratislava	1,214	7,133	200	36	327
South Africa	Johannesburg	2,075	962,443	4	240,611	505
Spain	Madrid	1,644	172,522	200	863	472
Sweden	Gothenburg	934	142,364	200	712	295
Switzerland	Zürich	1,094	248,173	200	1,241	277
Taiwan	Taipei	1,372	14,454	175	83	319
Thailand	Bangkok	1,765	1,232	300	4	476
United Kingdom	London	943	36,824	200	184	254
United States	LA, Indianapolis	1,646	18,937,878	200	94,689	387
All other countries (5%)		1,463	1,770,509	200	8,853	394
	TOTAL		35,400,842		645,861	
	AVERAGE	1,401		55		394

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

Table 6: Solar thermal systems for swimming pool heating by end of 2014

Figure 49 shows the hydraulic scheme of the swimming pool reference system as used for the simulations of the solar energy yields.

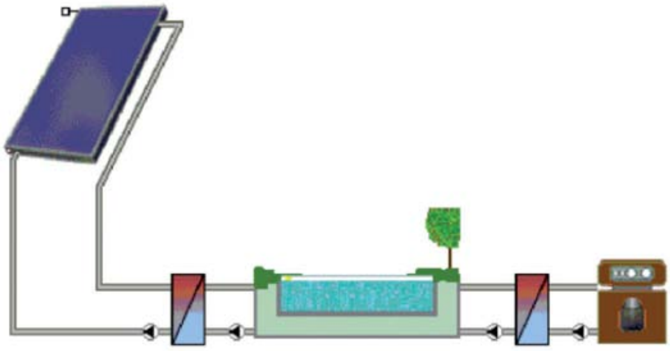


Figure 49: Hydraulic scheme of the swimming pool reference system

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

The information in Table 7 refers to the total capacity of water collectors in operation used for domestic hot water heating in single-family houses at the end of 2014 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	1,604	93,394	3.3	28,301	713	TS
Australia	Sydney	1,674	3,212,434	3.5	917,838	844	PS
Austria	Graz	1,126	2,148,847	6.0	358,141	451	PS
Barbados	Grantley Adams	2,016	131,700	4.0	32,925	882	TS
Belgium	Brussels	971	333,995	4.0	83,499	423	PDS / PS
Brazil	Brasília	1,793	6,337,358	2.0	3,168,679	809	TS
Bulgaria	Sofia	1,188	80,736	4.0	20,184	524	PS
Canada	Montreal	1,351	48,086	6.0	8,014	556	PS
Chile	Santiago de C.	1,753	117,917	4.0	29,479	771	PS
China	Shanghai	1,282	268,840,000	4.0	67,210,000	592	TS
Croatia	Zagreb	1,212	103,533	4.0	25,883	539	PS
Cyprus	Nicosia	1,886	598,552	2.0	299,276	912	TS
Czech Republic	Praha	998	221,130	4.7	47,049	385	PS
Denmark	Copenhagen	989	296,776	4.0	74,194	454	PS
Estonia	Tallin	960	6,518	4.0	1,630	432	PS
Finland	Helsinki	948	34,589	4.0	8,647	441	PS
France	Paris	1,112	1,505,201	3.2	470,375	496	PS
Germany	Würzburg	1,091	7,977,579	5.6	1,424,568	424	PS
Greece	Athens	1,585	2,655,874	2.5	1,062,349	772	TS
Hungary	Budapest	1,199	156,078	5.0	31,216	473	PS
India	Neu-Delhi	1,961	6,520,413	2.0	3,260,206	882	TS
Ireland	Dublin	949	270,164	4.0	67,541	423	PS
Israel	Jerusalem	2,198	814,974	3.0	271,658	1,024	TS
Italy	Bologna	1,419	2,482,469	4.0	620,617	661	PS
Japan	Tokyo	1,175	3,591,071	4.0	897,768	586	TS
Jordan	Amman	2,145	1,003,076	4.6	218,060	986	TS
Korea, South	Seoul	1,161	1,626,214	4.0	406,554	525	PS
Latvia	Riga	991	5,342	4.0	1,336	462	PS
Lebanon	Beirut	1,935	229,482	4.0	57,371	860	TS
Lesotho	Maseru	2,050	400	2.0	200	911	0
Lithuania	Vilnius	1,001	6,444	4.0	1,611	450	PS
Luxembourg	Luxembourg	1,037	31,725	4.0	7,931	450	PS
Macedonia	Skopje	1,381	37,548	4.0	9,387	627	PS
Malta	Luqa	1,902	30,966	2.5	12,386	868	PS
Mauritius	Port Louis	1,920	123,993	1.5	82,662	854	0
Mexico	Mexico City	1,706	1,267,685	4.0	316,921	718	PS
Morocco	Rabat	2,000	225,500	4.0	56,375	889	TS
Mozambique	Maputo	1,910	1,143	4.0	286	849	TS
Namibia	Windhoek	2,363	9,900	4.0	2,475	1,032	TS
Netherlands	Amsterdam	999	399,176	2.8	142,563	433	PDS / PS
New Zealand	Wellington	1,401	127,716	4.0	31,929	647	PS
Norway	Oslo	971	1,476	6.0	246	430	PS
Palestinian Territ.		2,198	892,813	1.5	595,208	977	TS
Poland	Warsaw	1,024	1,220,800	6.0	203,467	397	PS
Portugal	Lisbon	1,686	706,995	4.0	176,749	804	PS
Romania	Bucharest	1,324	88,637	4.0	22,159	594	PS
Russia	Moscow	996	1,922	4.0	481	443	PS
Slovakia	Bratislava	1,214	94,771	6.0	15,795	481	PS
Slovenia	Ljubjana	1,115	158,945	6.0	26,491	424	PS
South Africa	Johannesburg	2,075	673,181	1.5	448,787	1,009	TS
Spain	Madrid	1,644	1,414,678	4.0	353,669	766	PS
Sweden	Gothenburg	934	37,234	4.0	9,308	383	PS
Switzerland	Zürich	1,094	828,433	5.7	145,339	426	PS
Taiwan	Taipei	1,372	1,508,023	4.8	314,172	616	TS
Thailand	Bangkok	1,765	138,595	4.0	34,649	854	TS
Tunisia	Tunis	1,808	756,537	3.3	229,254	902	TS
Turkey	Antalya	1,795	16,731,029	4.0	4,182,757	910	TS
United Kingdom	London	943	489,251	4.0	122,313	415	PS
United States	LA, Indianapolis	1,646	1,942,347	6.0	323,724	646	PS
Uruguay	Montevideo	1,534	46,241	4.0	11,560	682	TS
Zimbabwe	Harare	2,017	24,823	4.0	6,206	854	TS
All other countries (5%)		1,399	23,430,193	4.0	5,857,548	622	TS / PS
	TOTAL		364,892,620		94,847,967		
	AVERAGE	1,466		3.8		622	

PS pumped system
TS thermosiphon system
PDS pumped drain back system

Table 7: Solar thermal systems for domestic hot water heating in single-family houses by the end of 2014

Figure 50 shows the hydraulic scheme used for the energy calculation for all pumped solar thermal systems and Figure 51 refers to the thermosiphon systems.

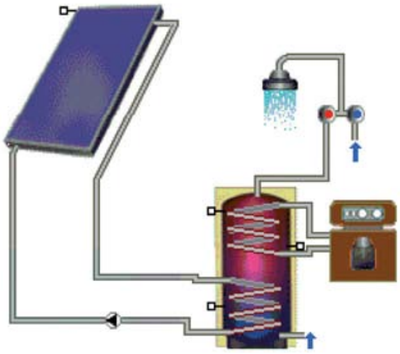


Figure 50: Hydraulic scheme of the domestic hot water pumped reference system for single-family houses

Figure 51: Hydraulic scheme of the domestic hot water thermosiphon reference system for single-family houses

For the Chinese thermosiphon systems the reference system above was used, but instead of a flat plate collector as shown in Figure 51 a representative Chinese vacuum tube collector was used for the simulation.

9.1.3 Reference systems for domestic hot water preparation in multifamily houses

The information in Table 8 refers to the total capacity of water collectors in operation used for domestic hot water heating in multifamily houses at the end of 2014 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	1,604	69,303	50.0	1,386	694
Australia	Sydney	1,674	331,046	50.0	6,621	725
Austria	Graz	1,126	400,787	50.0	8,016	505
Belgium	Brussels	971	75,944	50.0	1,519	405
Brazil	Brasília	1,793	1,099,736	60.0	18,329	658
Bulgaria	Sofia	1,188	18,358	50.0	367	515
Canada	Montreal	1,351	33,124	50.0	662	621
Chile	Santiago de Chile	1,753	76,299	50.0	1,526	733
China	Shanghai	1,282	144,760,000	50.0	2,895,200	502
Croatia	Zagreb	1,212	23,542	50.0	471	506
Cyprus	Nicosia	1,886	79,210	50.0	1,584	750
Czech Republic	Praha	998	35,011	42.4	826	436
Denmark	Copenhagen	989	630,549	50.0	12,611	414
Estonia	Tallin	960	1,482	50.0	30	401
Finland	Helsinki	948	7,865	50.0	157	396
France	Paris	1,112	605,068	20.0	30,253	489
Germany	Würzburg	1,091	2,155,944	50.0	43,119	472
Greece	Athens	1,585	603,897	50.0	12,078	642
Hungary	Budapest	1,199	24,219	50.0	484	522
India	Neu-Delhi	1,961	856,969	50.0	17,139	749
Ireland	Dublin	949	9,005	50.0	180	425
Israel	Jerusalem	2,198	3,531,555	3.0	1,177,185	919
Italy	Bologna	1,419	564,468	50.0	11,289	593
Japan	Tokyo	1,175	5,596	50.0	112	516
Jordan	Amman	2,145	250,769	50.0	5,015	801
Korea, South	Seoul	1,161	133,500	50.0	2,670	458
Latvia	Riga	991	1,215	50.0	24	414
Lebanon	Beirut	1,935	374,418	40.0	9,360	809
Lithuania	Vilnius	1,001	1,465	50.0	29	418
Luxembourg	Luxembourg	1,037	7,214	50.0	144	433
Macedonia	Skopje	1,381	3,338	50.0	67	577
Malta	Luqa	1,902	7,041	50.0	141	794
Mexico	Mexico City	1,706	543,293	50.0	10,866	713
Morocco	Rabat	2,000	202,950	50.0	4,059	835
Namibia	Windhoek	2,363	12,100	50.0	242	814
Netherlands	Amsterdam	999	103,013	40.0	2,575	418
New Zealand	Wellington	1,401	15,965	50.0	319	585
Norway	Oslo	971	16,148	50.0	323	406
Palestinian Territ.		2,198	803,531	50.0	16,071	917
Poland	Warsaw	1,024	436,000	50.0	8,720	447
Portugal	Lisbon	1,686	236,295	40.0	5,907	705
Romania	Bucharest	1,324	20,154	50.0	403	553
Russia	Moscow	996	15,838	50.0	317	416
Slovakia	Bratislava	1,214	21,549	50.0	431	507
Slovenia	Ljubjana	1,115	3,830	50.0	77	477
South Africa	Johannesburg	2,075	14,427	4.0	3,607	867
Spain	Madrid	1,644	1,587,199	50.0	31,744	676
Sweden	Gothenburg	934	50,375	50.0	1,007	430
Switzerland	Zürich	1,094	98,917	20.0	4,946	457
Taiwan	Taipei	1,372	83,511	30.0	2,784	518
Thailand	Bangkok	1,765	11,378	80.0	142	737
Tunisia	Tunis	1,808	19,398	50.0	388	756
Turkey	Antalya	1,795	1,454,872	80.0	18,186	750
United Kingdom	London	943	111,247	50.0	2,225	393
United States	LA, Indianapolis	1,646	3,399,106	50.0	67,982	688
All other countries (5%)		1,259	2,952,642	50.0	59,053	526
	TOTAL		168,991,676		4,500,970	
	AVERAGE	1,416		37.5		526

PS: pumped system

Table 8: Solar thermal systems for domestic hot water heating in multifamily houses by end of 2014

Figure 52 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 systems.

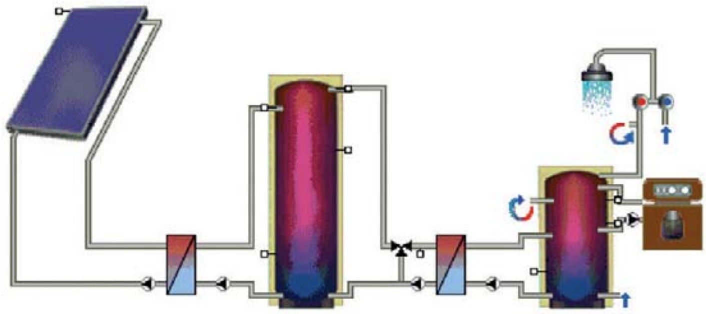


Figure 52: Hydraulic scheme of the domestic hot water pumped reference system for multifamily houses

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

The information in Table 9 refers to the total capacity of water collectors in operation used for domestic hot water heating in multifamily houses at the end of 2014 as reported by each country.

Country	Reference climate	Horizontal irradiation [kWh/m²·a]	Total collector area (Combi system) [m²]	Collector area per system [m²]	Total number of systems	Spec. solar yield (Combi system) [kWh/m²·a]
Austria	Graz	1,126	2,027,032	14.0	144,788	369
Belgium	Brussels	971	103,955	12.0	8,663	342
Bulgaria	Sofia	1,188	25,129	12.0	2,094	418
Canada	Montreal	1,351	30,034	12.0	2,503	476
Croatia	Zagreb	1,212	32,224	12.0	2,685	426
Cyprus	Nicosia	1,886	11,021	12.0	918	663
Czech Republic	Praha	998	183,889	8.5	21,634	351
Denmark	Copenhagen	989	9,573	12.0	798	348
Estonia	Tallin	960	2,029	12.0	169	338
Finland	Helsinki	948	10,766	12.0	897	334
France	Paris	1,112	276,875	11.0	25,170	370
Germany	Würzburg	1,091	7,563,477	11.5	657,694	378
Greece	Athens	1,585	826,633	12.0	68,886	558
Hungary	Budapest	1,199	56,511	15.0	3,767	422
Ireland	Dublin	949	21,013	12.0	1,751	364
Italy	Bologna	1,419	772,662	12.0	64,388	499
Japan	Tokyo	1,175	134,315	12.0	11,193	414
Korea, South	Seoul	1,161	19,448	12.0	1,621	409
Latvia	Riga	991	1,663	12.0	139	349
Lithuania	Vilnius	1,001	2,006	12.0	167	352
Luxembourg	Luxembourg	1,037	9,874	12.0	823	365
Macedonia	Skopje	1,381	417	10.0	42	486
Malta	Luqa	1,902	9,638	12.0	803	669
Morocco	Rabat	2,000	4,510	12.0	376	704
Netherlands	Amsterdam	999	32,192	6.0	5,365	352
New Zealand	Wellington	1,401	4,789	12.0	399	493
Norway	Oslo	971	23,105	15.0	1,540	342
Palestinian Territories		2,198	17,856	12.0	1,488	773
Poland	Warsaw	1,024	87,200	12.0	7,267	365
Romania	Bucharest	1,324	27,588	12.0	2,299	466
Russia	Moscow	996	658	15.0	44	350
Slovakia	Bratislava	1,214	29,497	12.0	2,458	427
Slovenia	Ljubjana	1,115	28,725	12.0	2,394	362
Spain	Madrid	1,644	276,035	10.0	27,603	619
Sweden	Gothenburg	934	267,206	10.0	26,721	389
Switzerland	Zürich	1,094	309,117	11.0	28,102	385
Thailand	Bangkok	1,765	1,657	12.0	138	621
United Kingdom	London	943	152,278	12.0	12,690	332
All other countries (5%)		1,139	1,032,149	12.0	86,012	401
	TOTAL		14,424,747		1,226,490	
	AVERAGE	1,241		11.8		401

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

Table 9: Solar combi system reference for single and multifamily houses and the total collector area in operation in 2014

Figure 53 shows the hydraulic scheme of domestic hot water reference system for multifamily houses as used for the simulations of the solar energy yields.

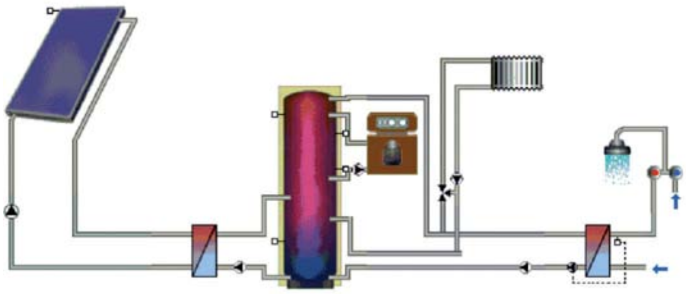


Figure 53: Hydraulic scheme of the solar-combi reference system for single and multifamily houses

9.2 Reference collectors

9.2.1 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]

9.2.2 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]

9.2.3 Data of the Chinese reference vacuum tube collector

$\eta = 0.74$
$a_1 = 2.5$ [W/m²K]
$a_2 = 0.013$ [W/m² K²]

9.3 Methodological approach for the cost calculation

The economic performance of the investigated solar thermal systems in Chapter 8 is quantified using the levelized cost of energy *(LCOE)* approach (e.g., acc. to /[31]/). The idea of this approach is to compare the total costs *(C)* related to an energy supply system with the resulting energy supplied by this system *(E)*. Since both the costs as well as the energy supplied are subject to the time preference of the investors, both terms are discounted at the interest rate r with an economic assessment period of t. LCOE are calculated according to Equation 1:

$$LCOE = \frac{\sum_{t=1}^{t_{ges}} C_t \cdot (1+r)^{-t}}{\sum_{t=1}^{t_{ges}} E_t \cdot (1+r)^{-t}} \qquad \text{(Eq. 1)}$$

The calculation of levelized cost of solar thermal generated heat *LCOH* in this report is derived from Equation 1 and may be expressed as the following:

$$LCOE = \frac{I_0 + \sum_{t=1}^{t_{ges}} A_t \cdot (1+r)^{-t}}{\sum_{t=1}^{t_{ges}} SE \cdot (1+r)^{-t}} \qquad \text{(Eq. 2)}$$

LCOH	levelized cost of solar thermal generated heat [€/kWh]
I_0	specific solar thermal system costs incl. installation (excl. VAT and subsidies) [€/m²$_{gross}$]
A_t	fixed and variable O&M expenditures in the year *t* [€/m²$_{gross}$]
SE	solar energy yield in the year *t* [kWh/m²$_{gross}$]
r	discount (interest) rate [%]
t_{ges}	period of use (solar thermal system life time in years) [a]
t	year within the period of use (1,2,... t_{ges})

All technical and economical parameters of the investigated solar thermal systems are elaborated for both the solar loop and solar energy storage. Conventional heat supply is not considered.

All specific benchmark figures are referred to gross collector area installed (e.g., €/m²$_{gross}$, kWh/m²$_{gross}$).

Cost data refer to end-user (customer) prices w/o value added taxes or subsidies. Solar energy yield SE is referred to as specific annual thermal energy delivered by the solar thermal collector in kWh per m² gross collector area installed (thermal losses in solar loop piping and thermal energy storage not considered).

Calculation of levelized cost of solar thermal generated heat *LCOH* in this report is based on following assumptions for all systems:

Discount (interest) rate r =3 %
Annual O&M expenditures A_t = 0.5 % of specific costs incl. installation I_0 in case of pumped systems
Annual O&M expenditures A_t = 0.25 % of specific costs incl. installation I_0 in case of thermosiphon systems
Period of use (solar thermal system life time) t_{ges} = 25 years for all pumped systems (except China: 15 years) and 10 years for all thermosiphon systems (except Australia: 15 years).

In Table 10, techno-economic benchmark figures of the investigated solar thermal systems are summarized for all countries and all kinds of applications.

31 Branker, K., Pathak, M.J.M., Pearce, J.M., 2011. A review of solar photovoltaic levelized cost of electricity. Renewable and Sustainable Energy Reviews 15, 4470–4482.

Country	Reference climate	Global horizontal irradiation	Kind of system / Kind of collector	Gross coll. area / storage volume	Annual solar energy yield*	Net spec. solar thermal system costs incl. labour		Levelized Cost of Heat	
						MIN	MAX	MIN	MAX
[-]	[-]	kWh/(m²·a)	[-]	m² / liter	kWh/(m²·a)	€/(m²gross)		€-ct/kWh	
Small domestic hot water systems (e.g. in single family homes) - A) Pumped systems (Figure 44)									
Australia-1	Sydney	1,674	PS / FPC	3.9 m²/250 ltr.	844	740	1,200	5.9	9.6
Australia-2	Sydney	1,674	PS / ETC	4.1 m²/290 ltr.	844	990	1,320	10.7	14.3
Austria	Graz	1,126	PS / FPC	6.0 m²/300 ltr.	451	840	1,100	12.5	16.2
Canada	Montreal	1,351	PS / FPC	6.0 m²/300 ltr.	556	800	1,200	9.6	14.5
China-2	Shanghai	1,282	PS / ETC	3.0 m²/200 ltr.	592	240	470	5.4	10.6
China-3	Shanghai	1,282	PS / FPC	2.2 m²/120 ltr.	592	320	560	5.2	9.0
Denmark	Copenhagen	989	PS / FPC	4.0 m²/200 ltr.	454	880	1,320	12.9	19.4
France	Paris	1,112	PS / FPC	3.2 m²/200 ltr.	496	1,180	1,760	15.9	23.8
Small domestic hot water systems (e.g. in single family homes) - B) Thermosiphon systems (Figure 45)									
Australia-3	Sydney	1,674	TS / FPC	3.9 m²/280 ltr.	844	930	1,240	10.4	13.9
Brazil	Brasília	1,793	TS / FPC	3.4 m²/400 ltr.	809	190	280	3.0	4.6
China-1	Shanghai	1,282	TS / ETC	3.0 m²/200 ltr.	592	160	310	4.9	9.5
India	New-Delhi	1,961	TS / FPC	4.0 m²/250 ltr.	882	220	320	3.2	4.8
Israel	Jerusalem	2,198	TS / FPC	2.0 m²/150 ltr.	1,024	330	500	4.2	6.4
South Africa	Johannesburg	2,075	TS / FPC	4.0 m²/300 ltr.	1,009	490	900	6.4	11.8
Turkey	Antalya	1,795	TS / FPC	4.0 m²/170 ltr.	910	110	180	1.6	2.6
Large domestic hot water and/or space heating systems (e.g. in multi family homes, hotels, etc.) (Figure 46)									
Austria	Graz	1,126	PS / FPC	50 m²/4,000 ltr.	505	530	830	7.0	11.1
Brazil	Brasília	1,793	PS / FPC	50 m²/4,000 ltr.	658	190	290	2.0	3.0
Canada	Montreal	1,351	PS / FPC	44 m²/1,350 ltr.	621	680	1,020	7.4	11.1
China-1	Shanghai	1,282	PS / ETC	50 m²/3,000 ltr.	502	240	510	6.2	13.5
China-2	Shanghai	1,282	PS / FPC	50 m²/2,500 ltr.	502	190	420	3.7	8.1
Denmark	Copenhagen	989	PS / FPC	50 m²/2,500 ltr.	414	600	900	9.7	14.5
India	New-Delhi	1,961	PS / FPC	50 m²/3,125 ltr.	749	140	280	1.3	2.5
South Africa	Johannesburg	2,075	PS / FPC	75 m²/6,000 ltr.	867	540	830	4.2	6.5
France	Paris	1,112	PS / FPC	20 m²/1,000 ltr.	489	900	1,240	12.5	17.1
Combined hot water and space heating systems (Figure 47)									
Austria	Graz	1,126	PS / FPC	16 m²/1,500 ltr.	369	670	890	12.4	16.2
Brazil	Belo Horizonte	1,789	PS / FPC	30 m²/3,500 ltr.	631	190	290	2.1	3.1
China-1	Shanghai	1,282	PS / ETC	3 m²/200 ltr.	388	240	450	8.2	15.5
China-2	Shanghai	1,282	PS / FPC	2.2 m²/120 ltr.	388	320	560	8.1	14.1
Denmark	Copenhagen	989	PS / FPC	7 m²/300 ltr.	348	780	1,160	14.8	22.2
South Africa	Johannesburg	2,075	PS / FPC	55 m²/2,000 ltr.	730	1,060	1,370	9.9	12.7
Pool heating systems with unglazed water collectors (Figure 48)									
Australia	Sydney	1,674	PS / unglaz.	34 m² / –	466	40	80	0.5	1.0
Brazil	Belo Horizonte	1,789	PS / unglaz.	36 m² / –	375	20	40	0.3	0.6
Canada	Montreal	1,351	PS / unglaz.	24 m² / –	386	90	160	1.4	2.6
Israel	Jerusalem	2,198	PS / unglaz.	480 m² / –	568	130	260	1.4	2.9

Table 10: Country-specific techno-economic benchmark figures of the investigated solar thermal systems

* Annual solar energy yields in **Table 10** are referred to aperture collector area. For LCOH calculation annual solar energy yields referring to gross collector area were used (conversion factors of 1/1.1 for flat plate collectors and 1/1.5 for evacuated tube collectors were assumed)

9.4 Methodological approach for 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.

9.5 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	Australia	Sydney	1,674	1,841	18.1
3	Austria	Graz	1,126	1,280	9.2
4	Barbados	Grantley Adams	2,016	2,048	27.4
5	Belgium	Brussels	971	1,095	10.0
6	Brazil	Brasília	1,793	1,838	22.0
7	Bulgaria	Sofia	1,188	1,304	10.1
8	Canada	Montreal	1,351	1,568	6.9
9	Chile	Santiago de Chile	1,753	1,850	14.5
10	China	Shanghai	1,282	1,343	17.1
11	Croatia	Zagreb	1,212	1,352	11.3
12	Cyprus	Nicosia	1,886	2,098	19.9
13	Czech Republic	Praha	998	1,111	7.9
14	Denmark	Copenhagen	989	1,164	8.1
15	Estonia	Tallin	960	1,126	5.3
16	Finland	Helsinki	948	1,134	4.6
17	France	Paris	1,112	1,246	11.0
18	Germany	Würzburg	1,091	1,225	9.5
19	Greece	Athens	1,585	1,744	18.5
20	Hungary	Budapest	1,199	1,346	11.0
21	India	Neu-Delhi	1,961	2,275	24.7
22	Ireland	Dublin	949	1,091	9.5
23	Israel	Jerusalem	2,198	2,400	17.3
24	Italy	Bologna	1,419	1,592	14.3
25	Japan	Tokyo	1,175	1,287	16.7
26	Jordan	Amman	2,145	2,341	17.9
27	Korea, South	Seoul	1,161	1,280	12.7
28	Latvia	Riga	991	1,187	6.3
29	Lebanon	Beirut	1,935	2,132	19.9
30	Lesotho	Maseru	2,050	2,290	15.2
31	Lithuania	Vilnius	1,001	1,161	6.2
32	Luxembourg	Luxembourg	1,037	1,158	8.4
33	Macedonia	Skopje	1,381	1,521	12.5
34	Malta	Luqa	1,902	2,115	18.7
35	Mauritius	Port Louis	1,920	2,010	23.3
36	Mexico	Mexico City	1,706	1,759	16.6
37	Morocco	Rabat	2,000	2,250	17.2
38	Mozambique	Maputo	1,910	2,100	22.8
39	Namibia	Windhoek	2,363	2,499	21.0
40	Netherlands	Amsterdam	999	1,131	10.0
41	New Zealand	Wellington	1,401	1,542	13.6
42	Norway	Oslo	971	1,208	5.8
43	Palestinian Territories	Jerusalem	2,198	2,400	17.3
44	Poland	Warsaw	1,024	1,156	8.1
45	Portugal	Lisbon	1,686	1,875	17.4
46	Romania	Bucharest	1,324	1,473	10.6
47	Russia	Moscow	996	1,181	5.9
48	Slovakia	Bratislava	1,214	1,374	10.3
49	Slovenia	Ljubjana	1,115	1,231	9.8
50	South Africa	Johannesburg	2,075	2,232	15.6
51	Spain	Madrid	1,644	1,844	15.5
52	Sweden	Gothenburg	934	1,105	7.2
53	Switzerland	Zürich	1,094	1,218	9.6
54	Taiwan	Taipei	1,372	1,398	20.8
55	Thailand	Bangkok	1,765	1,898	29.1
56	Tunisia	Tunis	1,808	2,038	19.3
57	Turkey	Antalya	1,795	1,958	18.4
58	United Kingdom	London	943	1,062	12.0
59	United States	LA, Indianapolis	1,646	1,816	14.3
60	Uruguay	Montevideo	1,534	1,647	15.9
61	Zimbabwe	Harare	2,017	2,087	18.9

Source: T-Sol expert version 4.5 and Meteonorm version 6.1.

Table 11: Reference climates for the 61 countries surveyed

9.6 Population data

No	Country	2014	Reg. code
1	Albania	3,020,209	6
2	Australia	22,507,617	3
3	Austria	8,615,828	6
4	Barbados	289,680	4
5	Belgium	11,236,729	6
6	Brazil	202,656,788	4
7	Bulgaria	7,228,183	6
8	Canada	34,834,841	8
9	Chile	17,363,894	4
10	China	1,361,344,333	5
11	Croatia	4,470,534	6
12	Cyprus	1,172,458	6
13	Czech Republic	10,627,448	6
14	Denmark	5,569,077	6
15	Estonia	1,272,468	6
16	Finland	5,454,355	6
17	France	66,259,012	6
18	Germany	80,996,685	6
19	Greece	10,775,557	6
20	Hungary	9,919,128	6
21	India	1,236,344,631	2
22	Ireland	4,832,765	6
23	Israel	7,921,139	7
24	Italy	61,680,122	6
25	Japan	127,103,388	2
26	Jordan	7,930,491	7
27	Korea, South	49,039,986	2
28	Latvia	2,007,730	6
29	Lebanon	5,882,562	7
30	Lesotho	1,942,008	1
31	Lithuania	2,914,462	6
32	Luxembourg	557,989	6
33	Macedonia	2,091,719	6
34	Malta	412,655	6
35	Mauritius	1,331,155	1
36	Mexico	120,286,655	4
37	Morocco	32,987,206	7
38	Mozambique	24,692,144	1
39	Namibia	2,198,406	1
40	Netherlands	16,877,351	6
41	New Zealand	4,401,916	3
42	Norway	5,147,792	6
43	Palestinian Territories	4,547,431	7
44	Poland	38,593,885	6
45	Portugal	10,813,834	6
46	Romania	21,729,871	6
47	Russia	142,470,272	6
48	Slovakia	5,443,583	6
49	Slovenia	1,988,292	6
50	South Africa	53,006,857	1
51	Spain	47,737,941	6
52	Sweden	9,723,809	6
53	Switzerland	8,061,516	6
54	Taiwan	23,359,928	2
55	Thailand	67,741,401	2
56	Tunisia	10,937,521	7
57	Turkey	78,401,967	6
58	United Kingdom	63,742,977	6
59	United States	318,857,056	8
60	Uruguay	3,332,972	4
61	Zimbabwe	13,771,721	1
	All other countries	2,673,175,425	9
	Σ Solar Thermal World Statistics	4,505,547,468	63%
	Σ Inhabitants world	7,178,722,893	100%

Data source: International Data Base of the U.S. Census Bureau http://www.census.gov/ipc/www/idb/country.php

Table 12: Inhabitants by the end of 2014 of the 61 surveyed countries in alphabetical order

Region Code / Region		Σ Inhabitants	Share
1	Sub-Sahara Africa	96,942,291	1.4%
2	Asia excl. China	1,503,982,929	21.0%
3	Australia / New Zealand	26,909,533	0.4%
4	Latin America	343,929,989	4.8%
5	China	1,361,344,333	19.0%
6	Europe	751,848,203	10.5%
7	MENA region	72,329,510	1.0%
8	United States / Canada	353,691,897	4.9%
9	Other countries	2,667,744,208	37.2%
TOTAL		7,178,722,893	100.0%

Data source: International Data Base of the U.S. Census Bureau
http://www.census.gov/ipc/www/idb/country.php

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

Table 13: Inhabitants per economic region by the end of 2014

9.7 Market data of the previous years

The data presented in Chapters 3 through 5 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 in 2014 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 14, Table 15 and Table 16 these countries are highlighted accordingly and in Chapter 9.8 (References) the respective data source is cited.

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL (excl. concentrators) [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		21,060	140			21,200
Australia	650,000	239,400	30,450	35,000	1,000	955,850
Austria	2,410	200,800	5,590		830	209,630
Barbados**						
Belgium		50,500	11,500			62,000
Brazil	525,508	625,855				1,151,363
Bulgaria		7,400	600			8,000
Canada	71,510	6,513	7,812	15,824	12,359	114,018
Chile		20,000				20,000
China		4,850,000	57,150,000			62,000,000
Croatia		18,474				18,474
Cyprus	24	20,646	1,439			22,109
Czech Republic	50,000	37,000	13,000			100,000
Denmark		112,500	500			113,000
Estonia		900	900			1,800
Finland		3,000	1,000			4,000
France (mainland)		240,750	8,750	4,500	1,000	255,000
Germany		1,036,000	114,000			1,150,000
Greece		241,500	1,500			243,000
Hungary	1,500	35,000	15,000	300	250	52,050
India		429,000	1,001,000		2,500	1,432,500
Ireland		18,516	8,148			26,664
Israel*	1,200	360,500				361,700
Italy		283,800	46,200			330,000
Japan		158,741	3,208		7,950	169,899
Jordan		54,531	13,705			68,236
Korea, South		63,774				63,774
Latvia		150	150			300
Lebanon		34,000	10,000			44,000
Lithuania		600	1,200			1,800
Luxembourg		3,250	900			4,150
Macedonia		5,120	453			5,573
Malta		1,499	510			2,009
Mauritius		43,470				43,470
Mexico	109,500	95,250	95,250			300,000
Morocco		36,000				36,000
Mozambique			143			143
Namibia**						
Netherlands*	2,621	26,062	3,000			31,683
New Zealand**						
Norway		15,236	795		1,983	18,014
Palestinian Territorries		115,000	7,000			122,000
Poland		216,000	86,000			302,000
Portugal	182	83,624	7,090			90,896
Romania		8,500	7,000			15,500
Russia		6,097	287			6,384
Slovakia		6,500	1,000			7,500
Slovenia		13,500	3,000			16,500
South Africa	49,068	22,176	50,344			121,588
Spain	3,591	211,060	12,623			227,274
Sweden	910	8,251	3,006			12,167
Switzerland	11,815	125,609	17,287			154,711
Taiwan	5	105,698	11,848			117,551
Thailand		22,660				22,660
Tunisia		74,238	2,180			76,418
Turkey		1,146,298	478,000			1,624,298
United Kingdom		47,893	11,382	5,000		64,275
United States	757,400	229,700	12,000	15,000	14,000	1,028,100
Uruguay*		9,229				9,229
Zimbabwe		802	570			1,372
All other countries (5%)	117,750	623,665	3,118,814	3,980	2,204	3,866,412
TOTAL	2,354,994	12,473,296	62,376,274	79,604	44,076	77,328,244

* revised due to new / adapted database in 2016

** no data for new installations in the respective year available

Table 14: New installed collector area in 2012 (revised 2016) [m²]

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL (excl. concentrators) [m²]
	unglazed	glazed	evacuated tube	unglazed	glazed	
Albania		29,680	284			29,964
Australia	650,000	165,200	21,000	35,000	1,000	872,200
Austria	1,460	175,140	4,040		1,010	181,650
Barbados**						
Belgium		48,500	10,500			59,000
Brazil	621,616	747,282	9,909			1,378,807
Bulgaria		5,100	500			5,600
Canada	21,804	3,125	3,650	23,904	5,584	58,067
Chile		59,300				59,300
China		6,500,000	57,060,000			63,560,000
Croatia		18,400	2,500			20,900
Cyprus	33	17,807	472			18,312
Czech Republic	35,000	32,306	12,225			79,531
Denmark		103,600	400			104,000
Estonia		1,000	1,000			2,000
Finland		3,000	1,000			4,000
France (mainland)		171,273	19,667	500		191,440
Germany		908,000	112,000			1,020,000
Greece		226,700	450			227,150
Hungary	800	10,500	7,500	200	200	19,200
India		330,000	770,000		4,000	1,104,000
Ireland		16,330	10,382			26,712
Israel*	2,800	450,000				452,800
Italy		261,360	35,640			297,000
Japan		142,568	2,847		9,270	154,685
Jordan		54,531	13,705			68,236
Korea, South		48,473				48,473
Latvia		1,500	500			2,000
Lebanon		22,000	35,000			57,000
Lithuania		800	1,400			2,200
Luxembourg		5,000	1,000			6,000
Macedonia		5,120	453			5,573
Malta		1,083	278			1,361
Mauritius		8,880				8,880
Mexico	98,550	85,725	85,725	400	400	270,800
Morocco		36,000				36,000
Mozambique			143			143
Namibia**						
Netherlands*	2,621	25,878	4,000			32,499
New Zealand**						
Norway		3,536	846		1,224	5,606
Palestinian Territorries		115,000	7,000			122,000
Poland		199,100	75,000			274,100
Portugal		54,374	2,860			57,234
Romania		9,000	14,850	800		24,650
Russia		1,555	135			1,690
Slovakia		5,200	1,000			6,200
Slovenia		8,000	2,000			10,000
South Africa	50,010	51,902	41,187			143,099
Spain	3,794	222,552	6,169			232,515
Sweden	351	6,124	2,487			8,962
Switzerland	10,952	107,962	14,012			132,926
Taiwan		110,221	10,616			120,838
Thailand		16,251				16,251
Tunisia		69,070				69,070
Turkey		1,082,308	837,539	500		1,920,347
United Kingdom		32,234	8,566	1,000		41,800
United States	771,400	223,800	11,600	11,300	7,800	1,025,900
Uruguay*		11,657				11,657
Zimbabwe		1,995	1,415			3,410
All other countries (5%)	119,536	687,000	3,119,234	3,874	1,605	3,931,249
TOTAL	2,390,727	13,740,002	62,384,687	77,478	32,093	78,624,987

* revised due to new / adapted database in 2016

** no data for new installations in the respective year available

Table 15: New installed collector area in 2013 (revised 2016) [m²]

Country	Water Collectors [m²]			Air Collectors [m²]		TOTAL (excl. concentrators) [m²]
	unglazed	glazed	evacuated tube	unglazed	glazed	
Albania		140,815	1,070			141,885
Australia*	4,778,225	3,145,000	119,000	265,000	7,800	8,315,025
Austria	531,691	4,442,045	82,362		2,918	5,059,016
Barbados**		131,690				131,690
Belgium	45,000	377,330	65,453			487,783
Brazil	2,936,351	6,663,003	9,909			9,609,263
Bulgaria		123,680	2,520			126,200
Canada	785,857	64,210	39,303	373,154	29,724	1,292,249
Chile		139,309				139,309
China		27,767,614	346,892,386			374,660,000
Croatia		143,065	2,500			145,565
Cyprus	2,180	675,200	23,567			700,947
Czech Republic	503,000	368,119	100,150			971,269
Denmark	20,515	755,378	9,197	3,264	18,000	806,354
Estonia		4,930	3,590			8,520
Finland	11,779	33,051	7,372			52,202
France (mainland)*	105,699	2,202,904	61,796	5,053	1,117	2,376,569
Germany	562,176	15,055,000	1,897,000		29,491	17,543,667
Greece		4,160,100	18,250			4,178,350
Hungary	14,300	179,200	58,600	2,000	1,650	255,750
India		3,253,010	2,978,190		8,200	6,239,400
Ireland		185,952	91,667			277,619
Israel*	34,750	4,429,434				4,464,184
Italy	43,766	3,144,110	505,020			3,692,896
Japan		3,996,621	77,775		512,219	4,586,615
Jordan	5,940	927,951	258,379			1,192,270
Korea, South		1,762,570				1,762,570
Latvia		4,350	1,690			6,040
Lebanon		246,000	315,000			561,000
Lithuania		4,100	4,100			8,200
Luxembourg		40,050	5,750			45,800
Macedonia*		30,140	1,177			31,317
Malta		38,758	9,690			48,448
Mauritius		115,113				115,113
Mexico	855,253	942,482	699,342	752	8,773	2,506,602
Morocco		415,000				415,000
Mozambique			416			416
Namibia**		20,699	1,307			22,006
Netherlands*	114,473	497,736	21,000			633,209
New Zealand**	7,025	142,975	9,644			159,645
Norway	1,926	34,236	3,414		4,067	43,643
Palestine		1,620,000	7,000			1,627,000
Poland		1,106,400	378,600			1,485,000
Portugal	2,128	877,551	24,950			904,629
Romania		85,700	42,850	800		129,350
Russia		16,756	1,457			18,213
Slovakia		129,950	20,250			150,200
Slovenia		165,550	21,250			186,800
South Africa	916,881	432,946	156,784			1,506,611
Spain	137,985	2,883,812	173,542			3,195,339
Sweden*	170,008	256,617	68,550			495,175
Switzerland	211,740	1,085,760	87,440	800,000		2,184,940
Taiwan	1,394	1,465,311	78,924			1,545,628
Thailand		136,611				136,611
Tunisia		636,276	70,104			706,380
Turkey*		14,133,049	2,649,509	2,070		16,784,628
United Kingdom		565,025	178,848	20,000		763,873
United States	20,907,216	2,806,716	128,832	103,139	27,800	23,973,703
Uruguay*		40,800				40,800
Zimbabwe		20,756	2,222			22,978
All other countries (5%)	1,774,066	6,066,764	18,866,774	82,907	34,303	26,824,814
TOTAL	35,481,323	121,335,281	377,335,472	1,658,139	686,063	536,496,278

* revised due to new / adapted database in 2016

** no data for new installations in the respective year available

Table 16: Total collector area in operation by the end of 2013 (revised 2016) [m²]

9.8 References to reports and persons that have supplied the data

The production of the report, Solar Heat Worldwide 2014 – Edition 2016 edition 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
Australia	**Dr. David Ferrari** Sustainability Victoria	Sustainability Victoria Out of operation systems calculated by Sustainability Victoria
Austria	**Werner Weiss** AEE - Institute for Sustainable Technologies	Biermayr et al, 2015: Innovative Energietechnologien in Österreich – Marktentwicklung 2014 (Report in German) Out of operation systems calculated by AEE INTEC
Barbados		No data available since 2009 Cumulated area in2009
Belgium	**ESTIF – European Solar Thermal Industry Federation / AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015 Unglazed water collectors: AEE INTEC recordings
Brazil	**Marcelo Mesquita** Depto. Nac. de Aquecimento Solar da ABRAVA	DASOL ABRAVA Out of operation systems calculated based on DASOL ABRAVA long time recordings
Bulgaria	**ESTIF – European Solar Thermal Industry Federation / AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2014 Unglazed water collectors: AEE INTEC recordings
Canada	**Reda Djebbar, Ph.D., P.Eng.** Natural Resources Canada	Clear Sky Advisors, April 2015 Report - „Survey of Active Solar Thermal Collectors, Industry and Markets in Canada (2013/2014)" Out of operation systems considered by NRC
Chile	**Dr. Andreas Häberle, Jose Miguel Cardemil** Fraunhofer Center for Solar Energy Technologies, Chile	Dr. Andreas Häberle, Jose Miguel Cardemil (estimation 2014)
China	**Hu Runqing** Center for Renewable Energy Development - Energy Research Institute (NDRC)	CSTIF - Chinese Solar Thermal Industry Federation Out of operation systems calculated by CSTIF
Croatia	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015
Cyprus	**Soteris Kalogirou, PhD, DSc** Cyprus University of Technology **ESTIF – European Solar Thermal Industry Federation**	Cyprus Institute of Energy Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 New installations, Share FPC-ETC + unglazed: Cyprus Institute of Energy Cumulated installations: ESTIF 2015
Czech Republic	**Ales Bufka** Ministry of Industry and Trade	Ministry of Industry and Trade

Denmark	**ESTIF – European Solar Thermal Industry Federation / AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015 Unglazed water collectors: AEE INTEC recordings
Estonia	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015 (estimation)
Finland	**ESTIF – European Solar Thermal Industry Federation / AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015 (estimation) Unglazed water collectors: AEE INTEC recordings
France (mainland)	**Frédéric Tuillé** Observ'ER - Observatoire des énergies renouvelables **Paul KAAIJK** Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME) **John Hollick** SAHWIA - Solar Air Heating World Industry Association **ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Air collectors: John Hollick Cumulated area: ESTIF 2015 / share FPC-ETC: AEE INTEC / unglazed water&air collectors: AEE INTEC
Germany	**Felix Pag** University of Kassel **Jan Knaack** BSW - Bundesverband Solarwirtschaft e.V. **John Hollick** SAHWIA - Solar Air Heating World Industry Association	ESTIF 2015, Evaluation of MAP (BAFA, KfW), BSW; provided by Felix Pag, University of Kassel Air collectors: SAHWIA FPC/ETC: BSW Solar long time recordings; unglazed water collectors & glazed air collectors: recordings AEE INTEC
Greece	**Vassiliki Drosou, M.Sc. PhD** CRES - Centre for Renewable Energy Sources **Costas Travasoras (EBHE)** **AEE INTEC**	Vassiliki Drosou (CRES), Costas Travasoras (EBHE) Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 New installations: ETC/FPC by ESTIF; Vassiliki DROSOU (CRES), Costas TRAVASAROS (EBHE) Cumulated installations: cumulated area: ESTIF 2015 / share FPC-ETC: AEE INTEC
Hungary	**Pál Varga** MÉGNAP- Hungarian Solar Thermal Industry Federation	MÉGNAP- Hungarian Solar Thermal Industry Federation 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
Ireland	**Mary Holland** Sustainable Energy Authority of Ireland	Energy policy statistical support unit of Sustainable Energy Authority of Ireland Grant scheme data; BER database: Source: Energy policy statistical support unit of Sustainable Energy Authority of Ireland; provided by Mary Holland

Israel	**Dr. Asher Vaturi** ICTAF - Israel Bureau of Statistics **Eli Shilton** ELSOL	Israel Bureau of Statistics, Israel Ministry of water and energy & The Max Stern Yezreel Valley College (Dr. Asher Vaturi) ELSOL (Eli Shilton) Cumulated collector area calculated by AEE INTEC based on new installation and replacement figures from Israel Bureau of Statistics,ICTAF, Tel Aviv University, The Max Stern Yezreel Valley College (Dr. Asher Vaturi) and Eli Shilton (ELSOL)
Italy	**ESTIF – European Solar Thermal Industry Federation / AEE INTEC**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF Cumulated area: ESTIF 2015 / share FPC-ETC: AEE INTEC / unglazed water collectors: AEE INTEC
Japan	**Yamashita Noriaki** ISEP - Institute for Sustainable Energy Policies	ISEP; Solar System Development Association (SSDA) Out of operation systems calculated by ISEP
Jordan	**AEE INTEC**	AEE INTEC New installations: projected by AEE INTEC (0 % growth rate 2013 / 2014) Cumulated installations: calculated by AEE INTEC based on estimation for new installations in 2014
Korea, South	**Eunhee Jeong** Korea Energy Management Corporation (KEMCO)	2014 New & Renewable Energy Statistics by the Korea New & Renewable Energy Center, 2015
Latvia	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015 (estimation)
Lebanon	**Tony Matar** The Lebanese Association for Energy Saving & for Environment (ALMEE)	The Lebanese Association for Energy Saving & for Environment (ALMEE) Out of operation systems considered by ALMEE
Lithuania	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2014 (estimation)
Luxembourg	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2014 (estimation)
Macedonia	**Prof. Dr. Ilja Nasov** National University St.Kiril and Metodij, Faculty for Natural Science, Institute of Physics, Solar Energy Department, Ul.Veljko Vlahovic 18/mezanin, 1000 Skopje, Macedonia	2014 data estimation of Ilya Nasov and other solar experts New installations: estimation of Ilya Nasov and other solar experts Cumulated installations: calculated by AEE INTEC based on new installation figures
Malta	**Ing. Therese Galea** Sustainable Energy and Water Conservation Unit Ministry for energy and Health	Sustainable Energy and Water Conservation Unit (SEWCU) based on data provided by the Regulator for Energy and Water Services (REWS)
Mauritius	**Mrs Devika Balgobin** Statistician, Environment Statistics Unit Ministry of Environment and Sustainable Development	Statistics Mauritius New and cumulated installations 2014 - projected by AEE INTEC (0 % growth rate 2013 / 2014)

Mexico	**David Garcia** FAMERAC **Bärbel Epp** Solrico – Solar market research http://www.solrico.com/	Glazed and unglazed water collectors: FAMERAC - Renewable Energy Industry Association Air collectors: SAHWIA - Solar Air Heating World Industry Association unpublished data provided by Bärbel Epp Cumulated installations: calculated by AEE INTEC based on data from ANES, FAMERAC and solarthermalworld.org
Morocco	**Ashraf Kraidy** RECREEE - Regional Center for Renewable Energy and Energy Efficiency	2014 data projected by AEE INTEC (0 % growth rate 2013 / 2014)
Mozambique	**Fabião Cumbe** ENPCT, E.P. **AEE INTEC**	estimation AEE INTEC (based on SOLTRAIN project experiences) and projects from World Bank funds under EDAP Cumulated installations calculated by AEE INTEC based on new installation figures for 2014
Namibia		No data available since 2011. Cumulated area in 2012
Netherlands	**André Meurink, Reinoud Segers** Statistics Netherlands (CBS)	Statistics Netherlands (CBS) New 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 in2009
Norway	**Peter Bernhard** Asplan Viak AS – KanEnergi **Åse Lekang Sørensen** Norwegian Solar Energy Society	Asplan Viak AS – KanEnergi Norwegian Solar Energy Society
Palestinian Territories	**Ashraf Kraidy** RECREEE - Regional Center for Renewable Energy and Energy Efficiency	Regional Center for Renewable Energy and Energy Efficiency Cumulated area calculated by AEE INTEC (replacements not considered)
Poland	**Aneta Wieçka / Grzegorz Wiśniewski** Institute for Renewable Energy (EC BREC IEO)	EC BREC IEO 2015: Polish solar thermal energy market'2015] [report]
Portugal	**APISOLAR - Associação Portuguesa da Indústria Solar** **ESTIF – European Solar Thermal Industry Federation**	APISOLAR (www.apisolar.pt) „Observatório Solar Térmico 2013" Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 New installations: APISOLAR Cumulated area: ESTIF 2015 / share FPC-ETC + unglazed: APISOLAR (www.apisolar.pt) [Observatório Solar Térmico 2014]
Romania	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015
Russia	**Dr. Semen Frid, Dr. Sophia Kiseleva** Moscow State University **Prof. Vitaly Butuzov** Yuzhgeoteplo corporation, Krasnodar	Joint Institute for High Temperatures of Russian Academy of Sciences (JIHT RAS) Dr. Semen Frid, Sophia Kiseleva - Moscow State University, Vitaly Butuzov - Energytechnologies Ltd. (Krasnodar); the source of information - JIHT RAS.

Slovakia	**ESTIF – European Solar Thermal Industry Federation**	Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015
Slovenia	**University of Ljubljana, Faculty of Mechanical Engineering** **ESTIF – European Solar Thermal Industry Federation**	University of Ljubljana, Faculty of Mechanical Engineering;Eco Fund, Slovenian Environmental Public Fund; provided by Ciril Arkar Solar Thermal Markets in Europe - Trends and Market Statistics 2014, ESTIF 2015 Glazed water collectors: ESTIF, 2015
South Africa	**Prof. Dieter Holm** SOLTRAIN coordinator Southern Africa and SESSA organizer for Gauteng	Dept of Energy, Industry, Eskom, Karin Kritzinger, Wally Weber; provided by Dieter Holm
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	**Prof. Jan-Olof Dalenbäck** Svensk Solenergi / CHALMERS	Svensk solenergi (Solar Energy Association of Sweden)
Switzerland	**http://www.swissolar.ch/**	SWISSOLAR - Markterhebung Sonnenenergie 2014, Bundesamt für Energie 2015 Out of operation systems calculated by SWISSOLAR Replacements for "hay drying applications" estimated by AEE INTEC
Taiwan	**K.M. Chung** Energy Research Center - National Cheng Kung University	Bureau of Energy, Ministry of Economic Affairs, R.O.C. Out of operation systems calculated by Bureau of Energy, Ministry of Economic Affairs, R.O.C.
Thailand	**AEE INTEC**	Projected by AEE INTEC (0 % growth rate 2013 / 2014)
Tunisia	**Abdelkader Baccouche** Agence Nationale pour la Maîtrise de l'Energie (ANME)	ANME (National Agency of Energy Conservation)
Turkey	**A. Kutay Ulke** EZINC Metal San. Tic. A.S. **John Hollick** SAHWIA - Solar Air Heating World Industry Assoc. **Prof. Bulent Yesilata** GAP Renewable Energy and Energy Efficiency Center Harran University	Water collectors: Ezinc Metal San. Tic. A.S. Air collectors: SAHWIA New installations: Ezinc Metal San. Tic. A.S Cumulated installations: calculated by AEE INTEC considering 12 years lifetime
United Kingdom	**Lethbridge Yehuda** Department of Energy and Climate Change **John Hollick** SAHWIA - Solar Air Heating World Industry Association	DECC Digest of UK Energy Statistics 2015 and internal DECC analysis Air collectors provided by John Hollick
United States	**Les Nelson** IAPMO Solar Heating & Cooling Programs **John Hollick** SAHWIA - Solar Air Heating World Industry Assoc.	Water Collectors and air collectors: IAPMO Solar Heating & Cooling Programs; Air collectors: SAHWIA New installed: DOE/SEIA/IAPMO Totals: calculated by AEE INTEC considering 25 years life time
Uruguay	**National Energy Department**	National Energy Department: www.dne.gub.uy - from: http://www.solarthermalworld.org/content/uruguay-battle-market-growth-continues
Zimbabwe	**Dr. Anton Schwarzlmüller**	SOLTRAIN survey (unpublished sources) Cumulated 2014: calculated by AEE INTEC

9.8.1 Additional literature and web sources used

The following reports and statistics were used in this report:

- Bundesamt für Energie (BFE): Markterhebung Sonnenenergie 2013 - Teilstatistik der Schweizerischen Statistik der erneuerbaren Energien; prepared by SWISSOLAR, Thomas Hostettler, Bern, Switzerland July 2014
- Bundesministerium für Verkehr, Innovation und Technologie (BMVIT): Innovative Energy Technologies in Austria - Market Development 2013; prepared by Peter Biermayr et al, Vienna, Austria May 2014
- Bundesverband Solarwirtschaft e.V. (BSW-Solar): Statistische Zahlen der deutschen Solarwärmebranche (Solarthermie) 2014; accessed on April 2015
- ClearSky Advisors Inc.: Survey of Active Solar Thermal Collectors, Industry and Markets in Canada (2013/2014); Prepared by ClearSky Advisors Inc., Dr. Reda Djebbar, Natural Resources Canada, March 2015
- European Solar Thermal Industry Federation (ESTIF): Solar Thermal Markets in Europe, Trends and Market Statistics 2013; Belgium - Brussels; June 2014
- IRENA: Renewable Energy and Jobs: Annual Review 2015,
- Weiss, W. (2003) Wirtschaftsfaktor Solarenergie, Wien
- Weiss, W., Biermayr, P. (2006) Potential of Solar Thermal in Europe, published by ESTIF
- Lehr, U. et.al (2015) Beschäftigung durch erneuerbare Energien in Deutschland: Ausbau und Betrieb, heute und morgen

The following online sources were used in this report:

- http://www.anes.org/anes/index.php
- http://www.aderee.ma/
- http://www.apisolar.pt/
- http://www.asit-solar.com/
- http://www.dasolabrava.org.br/
- http://www.solarpowereurope.org/home/
- http://www.giz.de/
- http://www.iea-shc.org/
- http://www.irena.org/
- http://www.mnre.gov.in/
- http://www.ome.org/
- http://www.olade.org/
- http://www.ren21.net/
- http://sahwia.org/
- http://www.solar-district-heating.eu/
- http://www.solarwirtschaft.de/
- http://www.solrico.com/
- http://www.solarthermalworld.org/
- http://www.swissolar.ch/

9.9 List of Figures

9.10 List of Tables