Werner Weiss • Irene Bergmann • Gerhard Faninger

Solar Heat Worldwide

Markets and Contribution to the Energy Supply 2004

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Edition 2006

Solar Heat Worldwide

Markets and Contribution to the Energy Supply 2004

Werner Weiss* • Irene Bergmann* • Gerhard Faninger**

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

**University of Klagenfurt
A-9020 Klagenfurt, Austria

IEA Solar Heating & Cooling Programme, March 2006

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Supported by the Austrian Ministry for Transport, Innovation and Technology

bmvit

Design, Grafics & Typesetting, Imageprocesing: STEINHUBER INFODESIGN, Graz, Austria

Table of Contents

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 was to document the solar thermal capacity previously installed in the important markets worldwide, and to ascertain the contribution of solar plants to the supply of energy and the CO_2 emissions avoided as a result of operating these plants. The collectors documented are unglazed collectors, glazed flat-plate and vacuum tube collectors with water as the energy carrier as well as glazed and unglazed air collectors.

The data were collected within the framework of a questionnaire survey of the national delegates of the Executive Committee of the SHC Programme and other national experts active in the field of solar thermal energy. Since some of the 41 countries included in this report have very detailed statistics and others could only provide estimates from experts, the data was checked for its plausibility on the basis of various publications.

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

The 41 countries included in this report represent 3.74 billion people which is about 57% of the world´s population. The installed capacity in these countries is estimated to represent 85 - 90% of the solar thermal market worldwide.

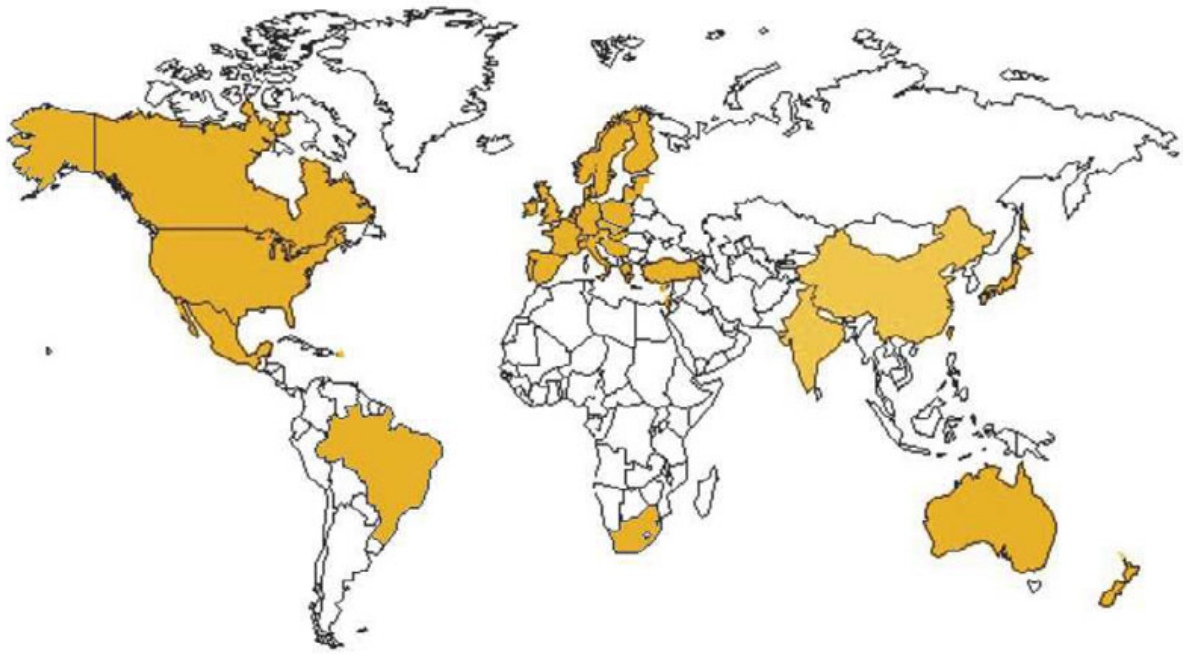


Figure 1: Countries represented in this report (yellow)

2 Summary

Installed capacity

The installed capacity in the 41 countries equaled 98.4 GW_{th} corresponding to 141 million square meters[1] at the end of year 2004. Of this, 74.3 GW_{th} were accounted for by flat-plate and evacuated tube collectors and 23.1 GW_{th} for unglazed plastic collectors. Air collector capacity was installed to an extent of 1.1 GW_{th}.

If one observes the use of solar thermal energy it becomes clear that it greatly varies in the different countries respective economic regions. In North America (USA and Canada) swimming pool heating is dominant with an installed capacity of 18.8 GW_{th} of unglazed plastic collectors while in China and Taiwan (44.4 GW_{th}), Europe (10.8 GW_{th}) and Japan (5.4 GW_{th}) plants with flat-plate and evacuated tube collectors mainly used to prepare hot water and for space heating are dominant.

Flat-plate and evacuated tube collectors

Focusing on the total capacity of flat-plate and evacuated tube collectors installed at the end of the year 2004, China (43.4 GW_{th}), Japan (5.5 GW_{th}), Turkey (5.1 GW_{th}), Germany (4.0 GW_{th}) and Greece (2.1 GW_{th}) are the leading countries. As can be seen from the figures, China is by far the biggest market, representing 44% of the world market.

Focusing on the market penetration—installed capacity per 100,000 inhabitants—then Cyprus (63 MW_{th}), Israel (52 MW_{th}), Greece, Austria and Barbados (19 MW_{th}) are the leading countries. They are followed by Turkey, Australia, Germany, Taiwan and Japan, with an installed capacity between 7 and 4 MW_{th} per 100,000 inhabitants.

Unglazed plastic collectors

With regard to the heating of swimming pools with unglazed plastic collectors, the USA leads with 18.4 GW_{th} ahead of Australia with 2.2 GW_{th}, Germany 0.5 GW_{th}, and Canada as well as Austria with 0.4 GW_{th}.

The market penetration gives a slightly different picture: Australia leads with 11 MW_{th} ahead of the USA with 6 MW_{th} and Austria with 5 MW_{th} per 100,000 inhabitants. In fourth to sixth place there are Switzerland, Canada, and the Netherlands with an installed capacity between 2 and 1.3 MW_{th} per 100,000 inhabitants.

Market development

The most dynamic markets for flat-plate and evacuated tube collectors worldwide are in China, Australia and New Zealand as well as in Europe. The average annual growth rate between 1999 and 2004 was 25% in China and Taiwan, 19% in Australia and New Zealand and 13% in Europe.

The worldwide market of unglazed collectors for swimming pool heating recorded an increase between 1999 and 2002 a slight decrease in 2003. In 2004, the installed capacity again achieved an increase.

1 Making the installed capacity of solar thermal collectors comparable with that of other energy sources, solar thermal experts from 7 countries 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, that was held in September 2004 in Gleisdorf, Austria. The represented associations from Austria, Canada, Germany, the Netherlands, Sweden and the USA 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.

Contribution of solar collectors to the supply of energy

The annual collector yield of all solar thermal systems[2] installed by the end of 2004 in the 41 recorded countries is 58,117 GWh (209,220 TJ). This corresponds to an oil equivalent of 9.3 billion liter and an annual avoidance of 25.4 million tons of CO_2.

Preview 2005

Based on the data available for the year 2005 at the date of publishing this report the total installed capacity worldwide can be estimated with 115 GW_{th}, corresponding to 164 million square meters of collector area.
Compared with other forms of renewable energy, solar heating's contribution meeting global energy demand is second only to wind power, and much bigger than photovoltaics' contribution. This fact is often underestimated.

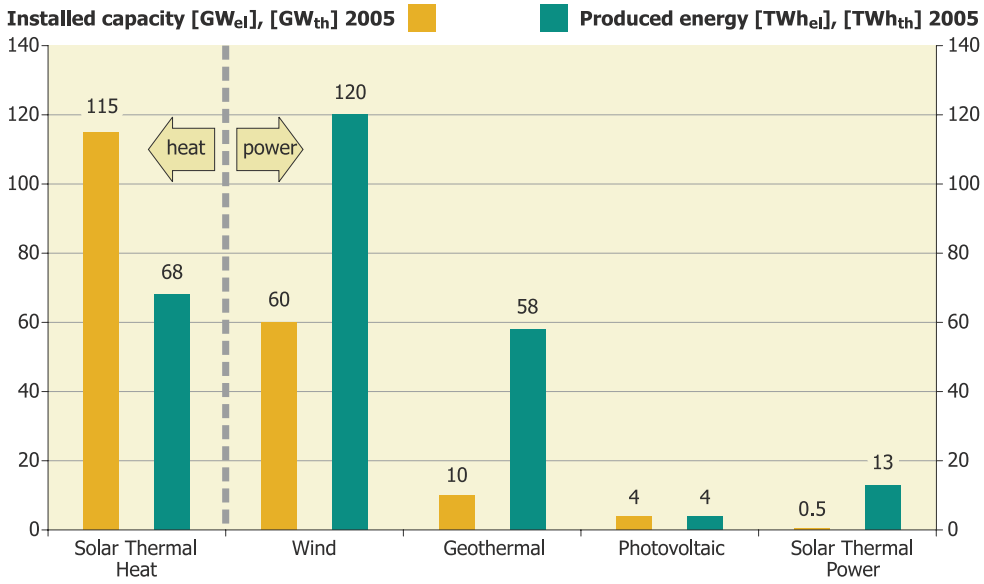


Figure 2: Cumulative capacity (GW) 2005 and annually energy generated (TWh).
Sources: Fawer, M.: Sarasin Sustainability Report 2005 and IEA SHC, 2006

2 All water based systems excl. air based systems. Since the database of the applications of air collectors is insufficient, the contribution of air collectors to the energy supply and CO_2 reduction was not calculated.

3 Total capacity installed by the year 2004

Since the beginning of the 1990s, the solar thermal market has undergone a favorable development. At the end of 2004, a total of 141 million square meters of collector area, corresponding to an installed capacity 98.4 GW_{th} were installed in the 41 recorded countries. These 41 countries represent 3.74 billion people which is about 57% of the world's population. The installed capacity in these countries represent approximately 85 - 90% of the solar thermal market worldwide.

As shown in Table 1, the installed capacity is divided in 34 GW_{th} glazed flat plate collectors (48.83 million square meters) and 40.3 GW_{th} evacuated tube collectors (57.57 million square meters), 23.1 GW_{th} unglazed collectors (33.02 million square meters) and 1.1 GW_{th} glazed and unglazed air collectors (1.16 million square meters).

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated tube	unglazed	glazed	
Australia	2,207.80	1,115.80	0.70			3,324.30
Austria	411.06	1,502.93	24.36			1,938.35
Barbados		52.22				52.22
Belgium	18.20	31.67	2.10			51.97
Brazil		1,586.20				1,586.20
Canada	421.43	53.47	0.84	56.95		532.68
China		4,340.00	39,060.00			43,400.00
Cyprus		513.80				513.80
Czech Republic		32.55	2.45			35.00
Denmark	15.31	214.60	0.39		10.50	240.79
Estonia		0.40				0.40
Finland		5.60	0.27			5.87
France*	70.00	484.40	0.04			554.44
Germany	542.50	3,464.30	526.40			4,533.20
Greece		2,095.94				2,095.94
Hungary	20.79	2.97	1.93			25.69
India		700.00				700.00
Ireland		2.17	1.26		1.96	5.39
Israel		3,353.00				3,353.00
Italy	9.80	288.40	23.80			322.00
Japan		5,300.04	108.16			5,408.20
Lativa		1.16				1.16
Lithuania		1.16				1.16
Luxembourg		8.05				8.05
Malta		10.50	0.25			10.75
Mexico	269.91	179.94				449.85
Netherlands	204.40	203.70				408.10
New Zealand	1.68	58.46	0.75			60.89
Norway	1.05	7.70			1.02	9.77
Poland	1.30	60.73	4.34	2.10	1.75	70.21
Portugal		192.01				192.01
Slovak Republic		39.73				39.73
Slovenia		70.61	0.61			71.23
South Africa	357.00	172.20	0.02			529.22
Spain	7.43	466.32	16.55			490.30
Sweden	27.07	135.45	8.09			170.61
Switzerland**	147.60	221.26	16.58	582.40		967.83
Taiwan		923.14	74.85			997.99
Turkey		5,096.00				5,096.00
United Kingdom	5.07	80.47	37.78			123.31
United States	18,377.47	1,114.58	386.94		159.37	20,038.35
TOTAL	23,116.85	34,183.61	40,299.46	641.45	174.60	98,415.97

* France: incl. Oversea Departments

** Unglazd air collectors in Switzerland:this is a very simple site-built system for hay drying purposes.

Table 1: Cumulative capacity installed at the end of 2004 [MW_{th}]

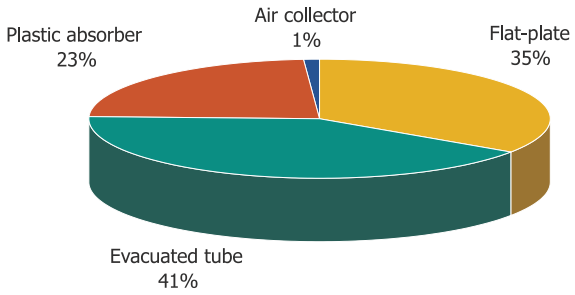


Figure 3: Distribution of the worldwide installed capacity by collector type

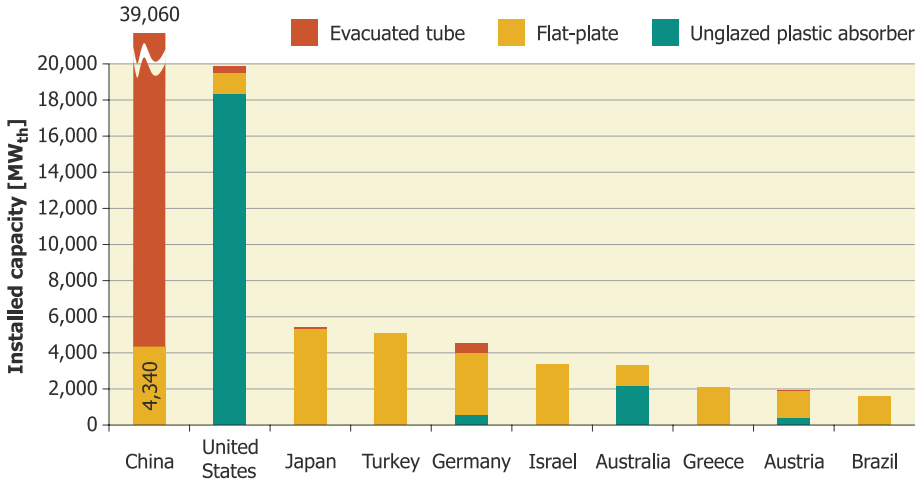
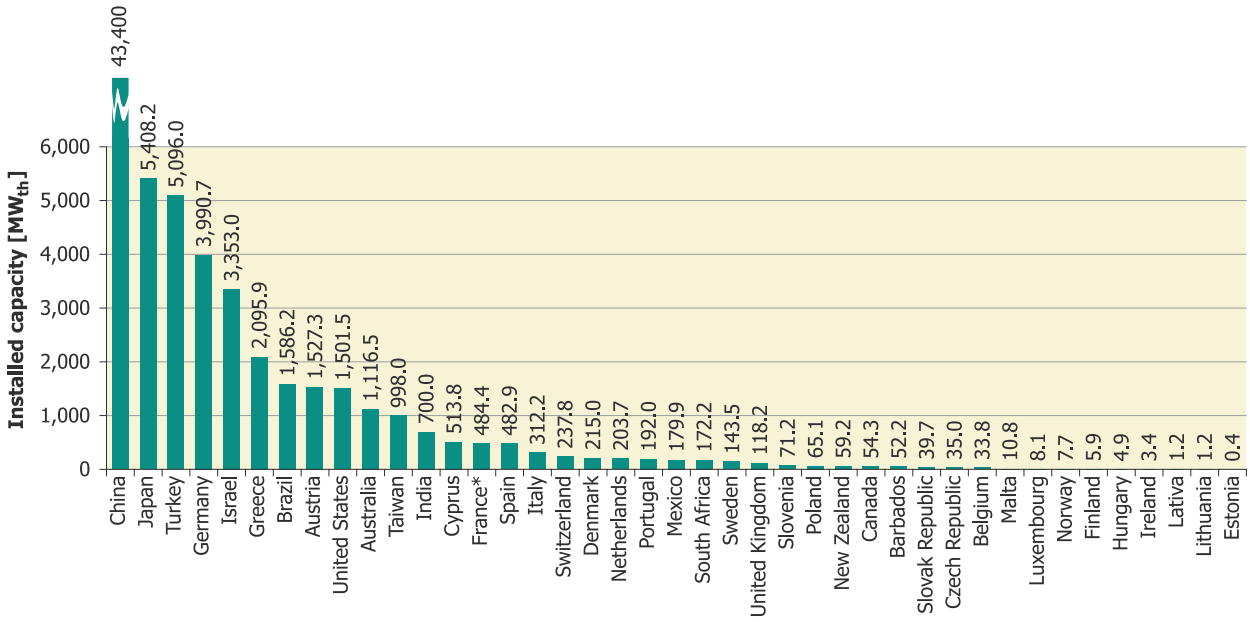


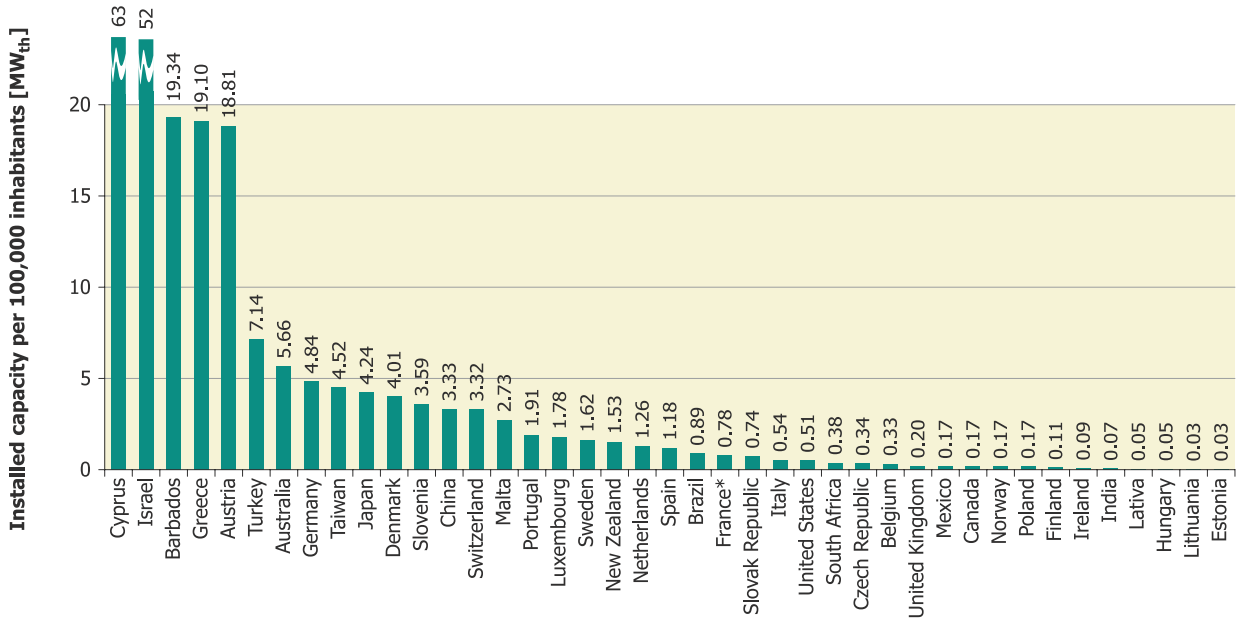
Figure 4: Total installed capacity of water collectors of the 10 leading countries at the end of 2004

3.1 Cumulative installed capacity of glazed flat-plate and evacuated tube collectors at the end of 2004



* France: incl. Oversea Departments

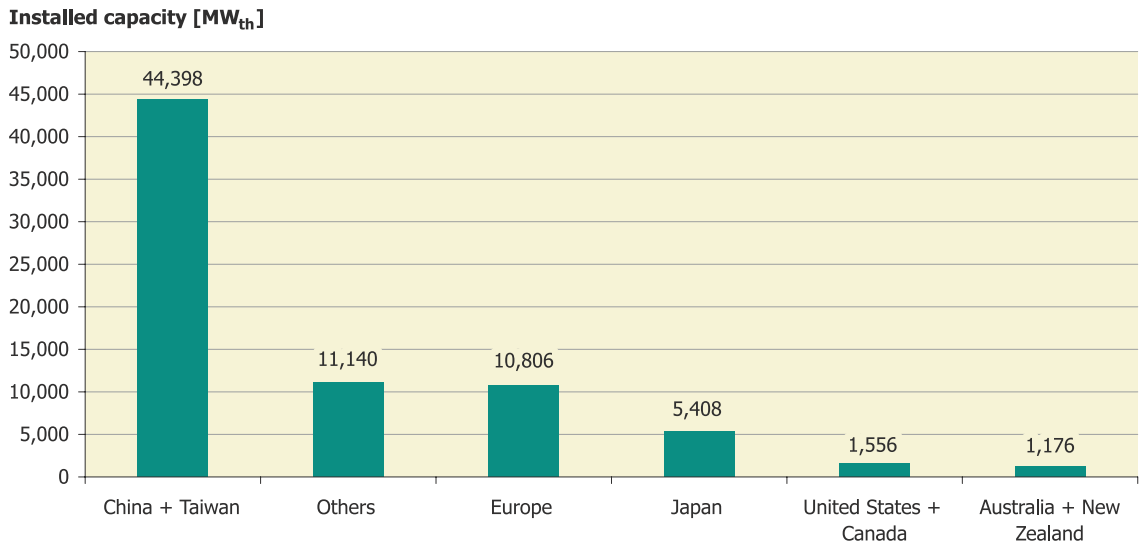
Figure 5: Cumulative installed capacity of glazed flat plate and evacuated tube collectors in operation at the end of 2004



* France: incl. Oversea Departments

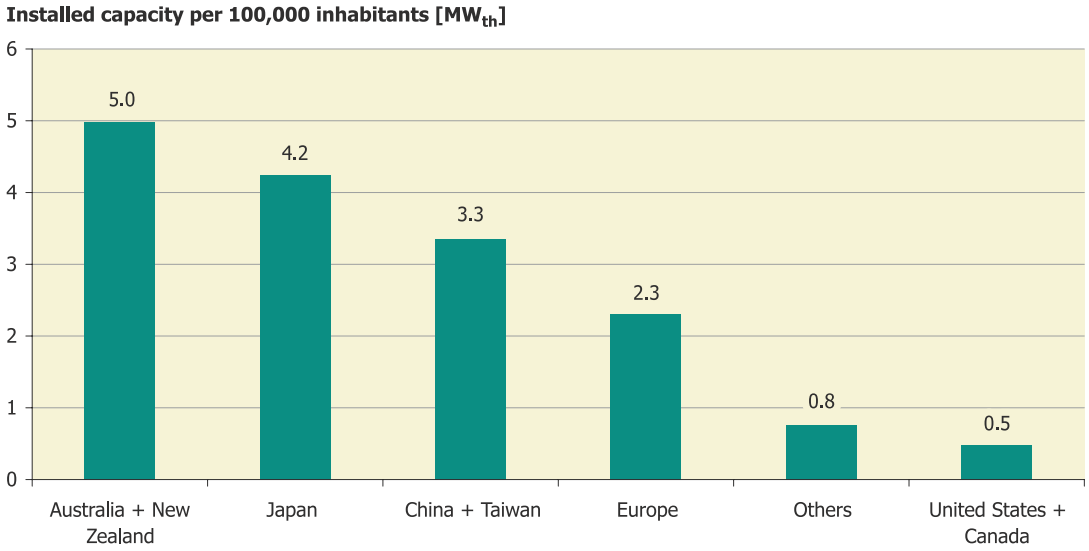
Figure 6: Cumulative installed capacity of glazed flat plate and evacuated tube collectors in operation at the end of 2004 per 100,000 inhabitants

3.2 Cumulative installed capacity of glazed flat plate and evacuated tube collectors in operation at the end of 2004 by economic region



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

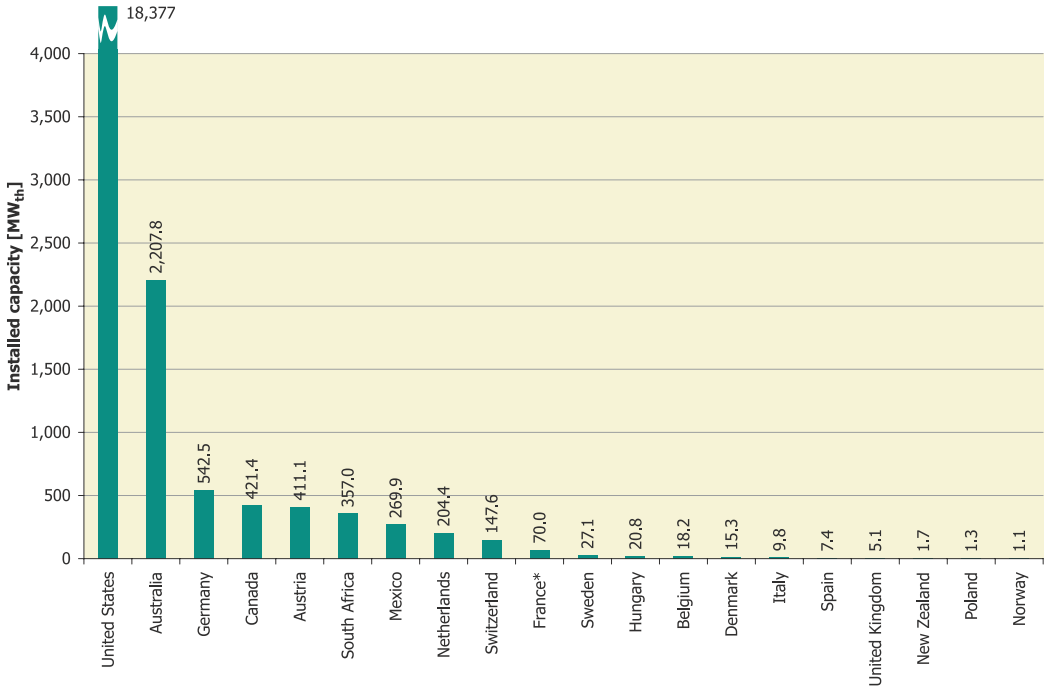
Figure 7: Cumulative installed capacity of glazed flat plate and evacuated tube collectors in operation by economic region at the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

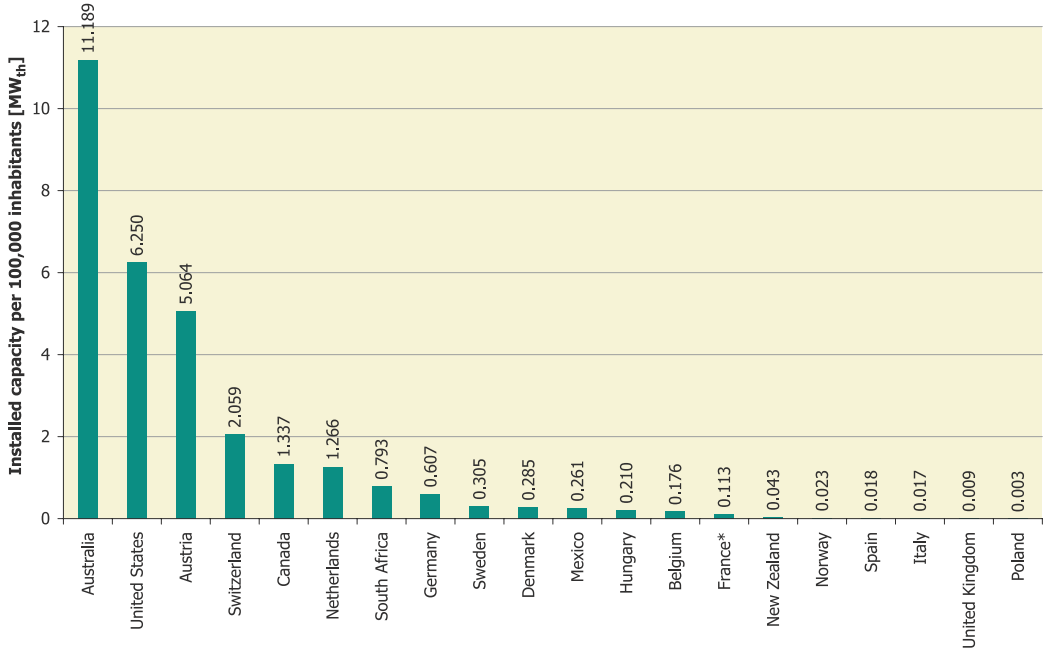
Figure 8: Cumulative installed capacity of glazed flat plate and evacuated tube collectors in operation by economic region at the end of 2004 per 100,000 inhabitants

3.3 Cumulative installed capacity of unglazed water collectors in operation at the end of 2004



* France: incl. Oversea Departments

Figure 9: Cumulative installed capacity of unglazed water collectors in operation at the end of 2004



* France: incl. Oversea Departments

Figure 10: Cumulative installed capacity of unglazed water collectors in operation at end of 2004 per 100,000 inhabitants

3.4 Cumulative installed capacity of unglazed water collectors in operation by economic region at the end of 2004

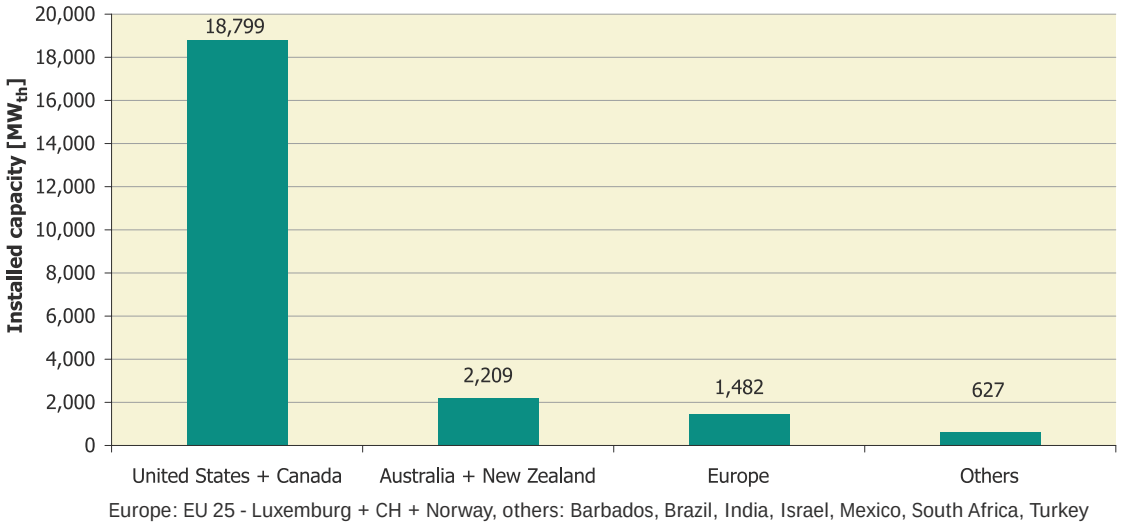


Figure 11: Cumulative installed capacity of unglazed collectors in operation by economic region at the end of 2004

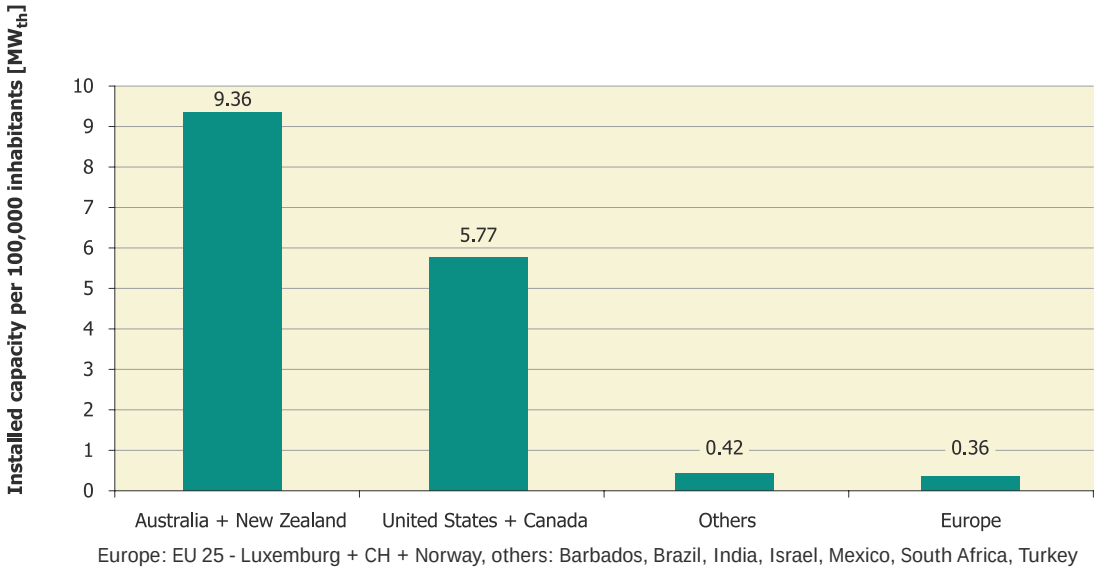


Figure 12: Cumulative installed capacity of unglazed collectors in operation by economic region at the end of 2004 per 100,000 inhabitants

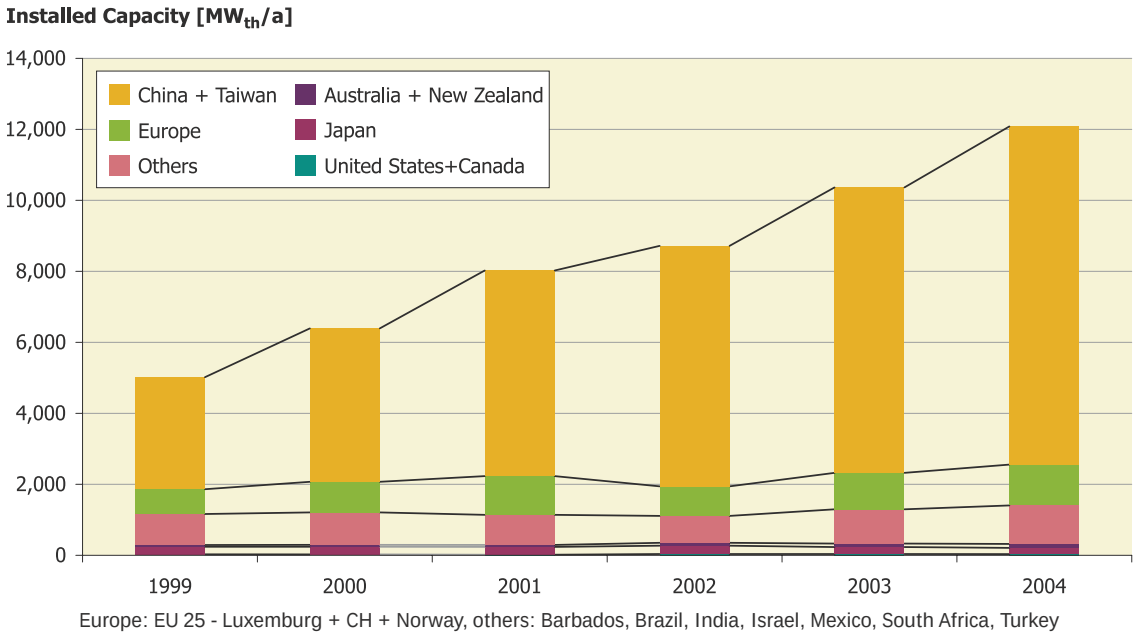
4 Market development 1999 to 2004

Analyzing the market development from 1999 to 2004 in the area of hot water preparation and spacing heating, it can be seen that the market of flat plate and evacuated tube collectors grew significantly during this time period.

The most dynamic markets for flat-plate and evacuated tube collectors worldwide are in China, Australia and New Zealand as well as in Europe. The average annual growth rate between 1999 and 2004 was 25% in China and Taiwan, 19% in Australia and New Zealand and 13% in Europe. The market for flat-plate and evacuated tube collectors is constantly low in Canada and the USA (see also chapter 6.1, Annual installed Capacity, Table 5 to Table 10).

The worldwide market of unglazed collectors for swimming pool heating recorded an increase between 1999 and 2002 and a decrease in 2003. In 2004 the installed capacity again achieved an increase.

4.1 Market development of glazed flat plate and evacuated tube collectors by economic region

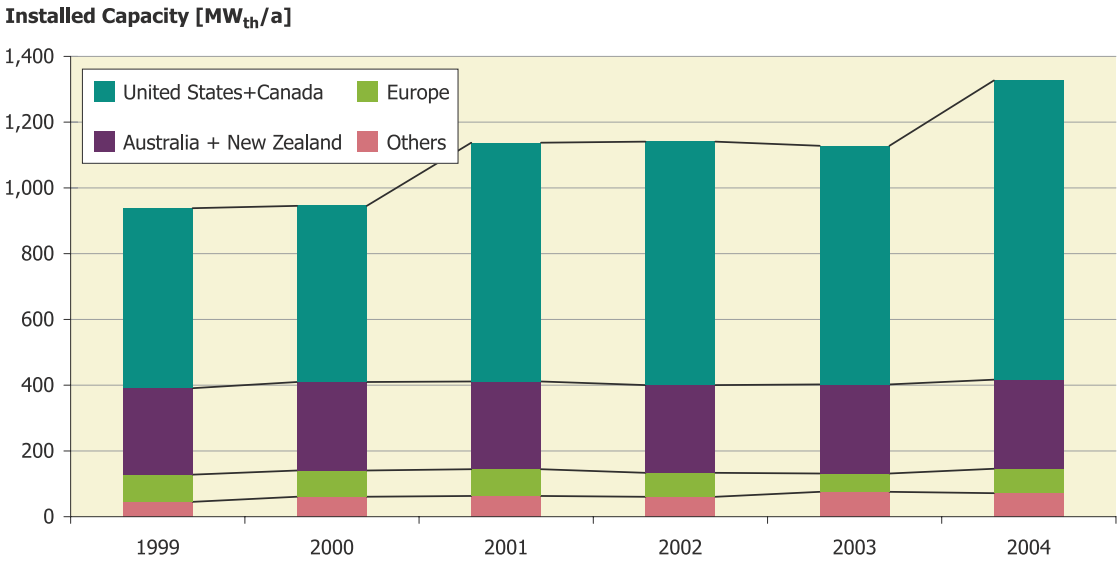


Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 13: Annual installed capacity of flat plate and evacuated tube collectors

It should be mentioned here, that the Chinese market is dominated by evacuated tube collectors, whereas in all other markets the flat-plate collectors are predominant (see Table 1). Other large markets for evacuated tube collectors are Germany, Japan and Taiwan.

4.2 Market development of unglazed plastic collectors by economic region



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 14: Annual installed capacity of unglazed water collectors

5 Contribution to the energy supply and CO_2 reduction

In this section, the contribution of the installed water collectors to the energy supply and CO_2 reduction is shown. The data for air collector applications was insufficient, therefore, the contribution of air collectors to the energy supply and CO_2 reduction was not calculated.

As shown in Table 1, a flat plate and evacuated tube collector capacity of 74.3 GW_{th} and unglazed plastic collector capacity of 23.1 GW_{th} was installed by the end of the year 2004 in the recorded countries. The annual yield of these collectors is calculated to be 58,117 GWh (209,220 TJ). This corresponds to a calculated oil equivalent of 9.3 billion liter and an annual CO_2 reduction of 25.4 million tons of CO_2.

Basis for calculation

In order to ascertain the energy yield of thermal solar plants, the oil equivalent saved and the CO_2 emissions avoided, the following procedure was used:

- Only water collectors were used for the calculations (unglazed, flat plate and evacuated tube collectors). Air collector plants were not considered.
- For each country, the overall collector area installed (water collectors) was allocated to the four plant types:

  Collector area for:
  - swimming pool heating
  - domestic hot water systems for single family houses
  - domestic hot water systems for multi-family houses and district heating
  - solar combisystems for domestic hot water and space heating
- Reference plants were defined for each country for each type of plant.
- The number of plants for each country was ascertained from the share of collector area for each plant type and the collector area per reference system.

Reference collectors and a reference climate were determined for each country apart from the reference plants. On the basis of these reference conditions simulations were performed with the simulation program T-Sol[3] and in this way the solar yields, energy savings and CO_2 emissions were ascertained. The reference conditions, which formed the basis for the simulation, can be found in the appendix.

Results

The annual collector yield per square meter of collector area lies, depending on the application (domestic hot water preparation, space heating ...), the local climatic conditions and the plant dimensioning (high or low solar fraction), between 250 kWh/m² for solar combisystems for hot water preparation and space heating at high latitudes and 600 kWh/m² for plants used to prepare hot water low latitudes.

The energy savings were ascertained from the energy equivalent of the fuel used and the rate of efficiency of the auxiliary heating system. For the auxiliary heating system oil was taken as the fuel for all plants and the energy equivalent per liter of oil 36,700 kJ respectively 10.2 kWh was used in all countries.

3 T-Sol, version 4.03, dynamic simulation program to design and optimize thermal solar plants, Valentin Energiesoftware, www.valentin.de

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 reoport, the energy savings and the CO_2 emissions avoided relate to oil. This represents a simplification since gas, coal, biomass or electricity can be used as the energy source for the auxiliary heating system instead of oil.
The CO_2 emissions avoided by solar plants were ascertained from the energy savings (oil equivalent) 2.73 kg CO_2 per liter oil was used as the emission factor[4].

Country	total collector area** [m²]	total capacity [MW_{th}]	calculated number of systems	collector yield [GWh/a]	collector yield [TJ/a]	energy savings oil equivalent [l/a]	CO_2 reduction [t/a]
Australia	4,749,000	3,324	396,178	1,830	6,589	322,379,728	879,712
Austria	2,769,072	1,938	306,068	957	3,446	137,050,763	373,973
Barbados	74,601	52	18,650	61	219	10,854,388	29,598
Belgium	74,249	52	12,192	23	83	3,355,632	9,155
Brazil	2,266,000	1,586	566,500	995	3,583	177,314,500	483,791
Canada	679,626	476	15,373	165	595	27,068,707	73,856
China	62,000,000	43,400	15,500,000	26,490	95,362	4,185,000,000	11,423,500
Cyprus	734,000	514	180,124	460	1,658	78,969,298	215,324
Czech Republic	50,000	35	8,260	16	57	2,305,200	6,256
Denmark	328,990	230	67,143	109	394	15,489,020	42,259
Estonia	570	0	143	0	1	24,225	66
Finland	8,380	6	1,999	3	10	350,693	957
France*	792,062	554	166,849	275	989	40,484,079	110,453
Germany	6,476,000	4,533	830,140	2,238	8,058	326,966,367	892,071
Greece	2,994,200	2,096	1,174,924	1,694	6,100	274,383,697	750,913
Hungary	36,700	26	1,305	11	41	1,889,179	5,154
India	1,000,000	700	250,000	437	1,571	68,750,000	187,750
Ireland	4,894	3	1,224	2	6	212,889	580
Israel	4,790,000	3,353	1,197,500	3,511	12,640	560,430,000	1,528,010
Italy	460,000	322	111,570	194	699	30,707,987	83,775
Japan	7,726,000	5,408	1,870,207	3,667	13,201	551,026,819	1,503,348
Lativa	1,650	1	413	1	2	76,313	209
Lithuania	1,650	1	413	1	2	77,138	210
Luxembourg	11,500	8	2,875	4	14	552,000	1,509
Malta	15,360	11	3,840	5	17	1,754,880	4,788
Mexico	642,644	450	23,624	286	1,028	53,768,047	146,704
Netherlands	583,000	408	134,331	140	505	20,730,353	56,750
New Zealand	86,990	61	20,187	26	94	4,123,960	11,255
Norway	12,500	9	1,812	4	14	518,698	1,415
Poland	94,800	66	15,365	30	109	4,427,842	12,070
Portugal	274,300	192	65,421	172	620	28,133,950	76,760
Slovak Republic	56,750	40	9,458	23	82	3,405,000	9,288
Slovenia	101,751	71	16,660	37	132	5,390,483	14,700
South Africa	756,030	529	64,058	203	733	34,655,873	94,512
Spain	700,433	490	164,575	424	1,527	64,013,897	174,667
Sweden	243,735	171	17,965	74	265	9,948,712	27,166
Switzerland	550,620	385	50,094	151	544	41,603,450	60,303
Taiwan	1,425,700	998	356,425	715	2,574	126,530,875	345,732
Turkey	7,280,000	5,096	1,652,560	4,340	15,623	689,656,240	1,883,645
United Kingdom	176,160	123	42,266	57	206	8,239,427	22,484
United States	28,398,544	19,879	488,771	8,285	29,828	1,422,522,247	3,881,329
Total	139,428,460	97,600	25,807,457	58,117	209,220	9,335,142,555	25,426,001

* France: incl. Oversea Departments

** Unglazed, Glazed Flat Plate and Evacuated Tube Water Collectors

Table 2: Calculated collector yield and corresponding oil equivalent as well as CO_2-reduction of all solar thermal systems (systems for hot water, space heating and swimming pool heating) at the end of 2004

4 It is obvious that not all solar thermal systems worldwide just replace oil. But to investigate the energy mix substituted in all reported countries would be beyond the scope of this report.

Country	total collector area** [m²]	total capacity [MW_{th}]	number of systems	collector yield [GWh/a]	collector yield [TeraJ /a]	energy savings oil equivalent [l/a]	CO_2 reduction [t/a]
Australia	1,595,000	1,117	380,408	668	2,406	116,690,041	318,499
Austria	2,181,848	1,527	303,131	824	2,967	115,314,667	314,667
Barbados	74,601	52	18,650	61	219	10,854,388	29,598
Belgium	48,249	34	12,062	19	67	2,618,714	7,144
Brazil	2,266,000	1,586	566,500	995	3,583	177,314,500	483,791
Canada	77,588	54	12,362	35	128	5,003,412	13,652
China	62,000,000	43,400	15,500,000	26,490	95,362	4,185,000,000	11,423,500
Cyprus	734,000	514	180,124	460	1,658	78,969,298	215,324
Czech Republic	50,000	35	8,260	16	57	2,305,200	6,256
Denmark	307,120	215	67,034	106	382	14,921,417	40,711
Estonia	570	0	143	0.2	1	24,225	66
Finland	8,380	6	1,999	3	10	350,693	957
France*	692,062	484	166,349	255	919	37,079,729	101,164
Germany	5,701,000	3,991	826,265	2,072	7,458	298,125,129	813,380
Greece	2,994,200	2,096	1,174,924	1,694	6,100	274,383,697	750,913
Hungary	7,000	5	1,156	3	10	425,860	1,162
India	1,000,000	700	250,000	437	1,571	68,750,000	187,750
Ireland	4,894	3	1,224	2	6	212,889	580
Israel	4,790,000	3,353	1,197,500	3,511	12,640	560,430,000	1,528,010
Italy	446,000	312	111,500	191	688	30,183,050	82,343
Japan	7,726,000	5,408	1,870,207	3,667	13,201	551,026,819	1,503,348
Lativa	1,650	1	413	1	2	76,313	209
Lithuania	1,650	1	413	1	2	77,138	210
Luxembourg	11,500	8	2,875	4	14	552,000	1,509
Malta	15,360	11	3,840	5	17	1,754,880	4,788
Mexico	257,058	180	21,696	174	626	33,830,724	92,306
Netherlands	291,000	204	132,871	96	346	13,461,305	36,917
New Zealand	84,590	59	20,175	25	92	4,031,695	11,003
Norway	11,000	8	1,804	4	13	484,948	1,323
Poland	92,950	65	15,355	30	108	4,363,240	11,894
Portugal	274,300	192	65,421	172	620	28,133,950	76,760
Slovac Republic	56,750	40	9,458	23	82	3,405,000	9,288
Slovenia	101,751	71	16,660	37	132	5,390,483	14,700
South Africa	246,030	172	61,508	108	387	18,636,773	50,805
Spain	689,821	483	164,522	421	1,516	63,457,944	173,150
Sweden	205,058	144	17,772	68	246	9,148,253	24,982
Switzerland	339,770	238	49,040	115	413	35,576,830	43,860
Taiwan	1,425,700	998	356,425	715	2,574	126,530,875	345,732
Turkey	7,280,000	5,096	1,652,560	4,340	15,623	689,656,240	1,883,645
United Kingdom	168,920	118	42,230	56	203	8,053,261	21,976
United States	2,145,021	1,502	357,504	1,230	4,427	205,028,277	559,457
Total	106,404,390	74,483	25,642,337	49,132	176,876	7,781,633,857	21,187,332

* France: incl. Oversea Departments

** Flat-plate and vaccum tube collectors.

Table 3: Calculated collector yield and corresponding oil equivalent as well as CO_2-reduction of solar thermal systems for hot water preparation and space heating with flat plate and evacuated tube collectors at the end of 2004

Country	total collector area** [m²]	total capacity [MW_{th}]	calculated number of systems	collector yield [GWh/a]	collector yield [TeraJ/a]	energy savings oil equivalent [l/a]	CO_2 reduction [t/a]
Australia	3,154,000	2,208	15,770	1,162	4,182.4	205,689,687	561,213
Austria	587,224	411	2,936	133	479.1	21,736,096	59,306
Barbados							
Belgium	26,000	18	130	4	15.7	736,918	2,011
Brazil							
Canada	602,038	421	3,010	130	467.3	22,065,295	60,204
China							
Cyprus							
Czech Republic							
Denmark	21,870	15	109	3	12.1	567,603	1,549
Estonia							
Finland							
France*	100,000	70	500	20	70.8	3,404,350	9,289
Germany	775,000	543	3,875	167	599.7	28,841,238	78,692
Greece							
Hungary	29,700	21	149	8	30.5	1,463,319	3,993
India							
Ireland							
Israel							
Italy	14,000	10	70	3	10.6	524,937	1,432
Japan							
Lativa							
Lithuania							
Luxembourg							
Malta							
Mexico	385,586	270	1,928	112	402.7	19,937,323	54,398
Netherlands	292,000	204	1,460	44	158.7	7,269,048	19,833
New Zealand	2,400	2	12	1	1.9	92,266	252
Norway	1,500	1	8	0.2	0.8	33,750	92
Poland	1,850	1	9	0.4	1.4	64,602	176
Portugal							
Slovak Republic							
Slovenia							
South Africa	510,000	357	2,550	96	345.1	16,019,100	43,707
Spain	10,612	7	53	3	11.4	555,952	1,517
Sweden	38,677	27	193	5	18.6	800,459	2,184
Switzerland	210,850	148	1,054	37	131.6	6,026,620	16,443
Taiwan							
Turkey							
United Kingdom	7,240	5	36	1	3.9	186,166	508
United States	26,253,522	18,377	131,268	7,056	25,400.3	1,217,493,970	3,321,871
Total	33,024,070	23,117	165,120	8,985		1,553,508,698	4,238,669

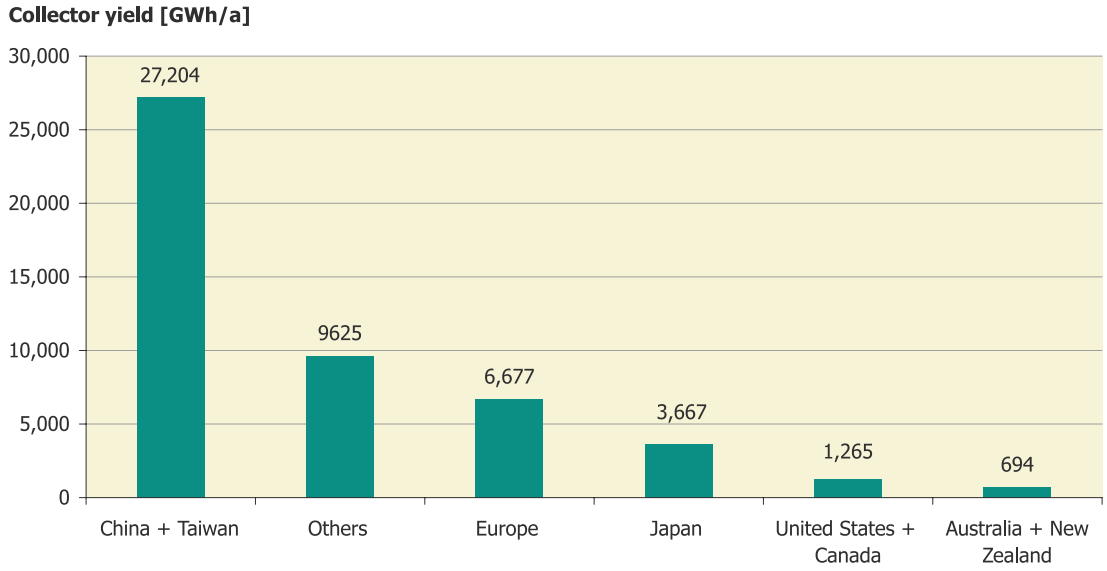
* France: incl. Oversea Departments

** Unglazed Water Collectors

Table 4: Calculated collector yield and corresponding oil equivalent as well as CO_2-reduction of solar thermal systems for swimming pool heating with unglazed collectors at the end of 2004

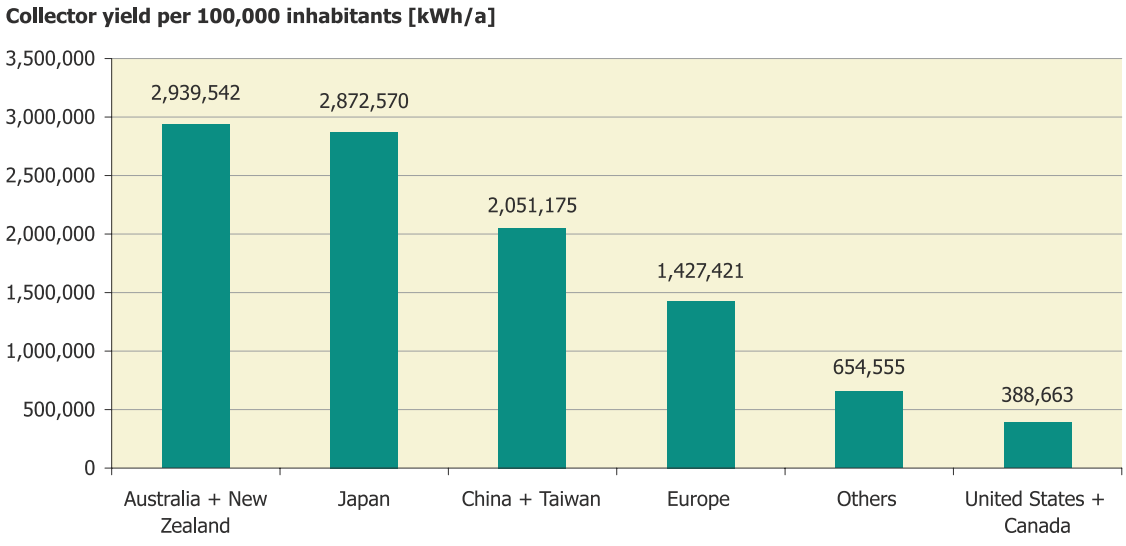
5.1 Collector yield by economic region at the end of 2004

5.1.1 Collector yield of glazed flat plate and evacuated tube collectors by economic region at the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 15: Annual collector yield of glazed flat plate and evacuated tube collectors in operation by economic region at the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 16: Annual collector yield of glazed flat plate and evacuated tube collectors in operation by economic region at the end of 2004 per 100,000 inhabitants

5.1.2 Collector yield of unglazed collectors by economic region at the end of 2004

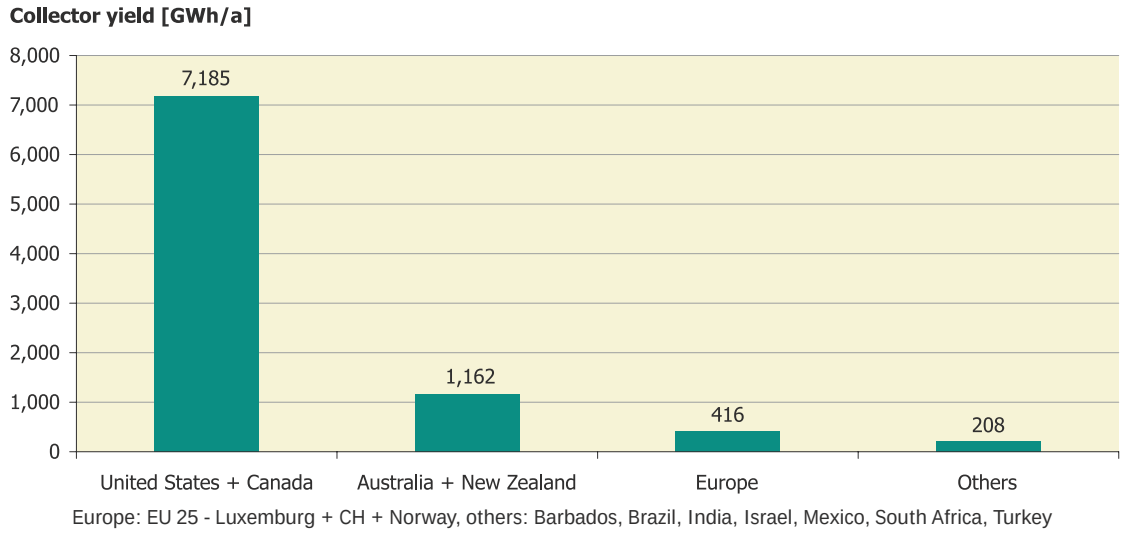


Figure 17: Annual collector yield of unglazed collectors in operation by economic region at the end of 2004

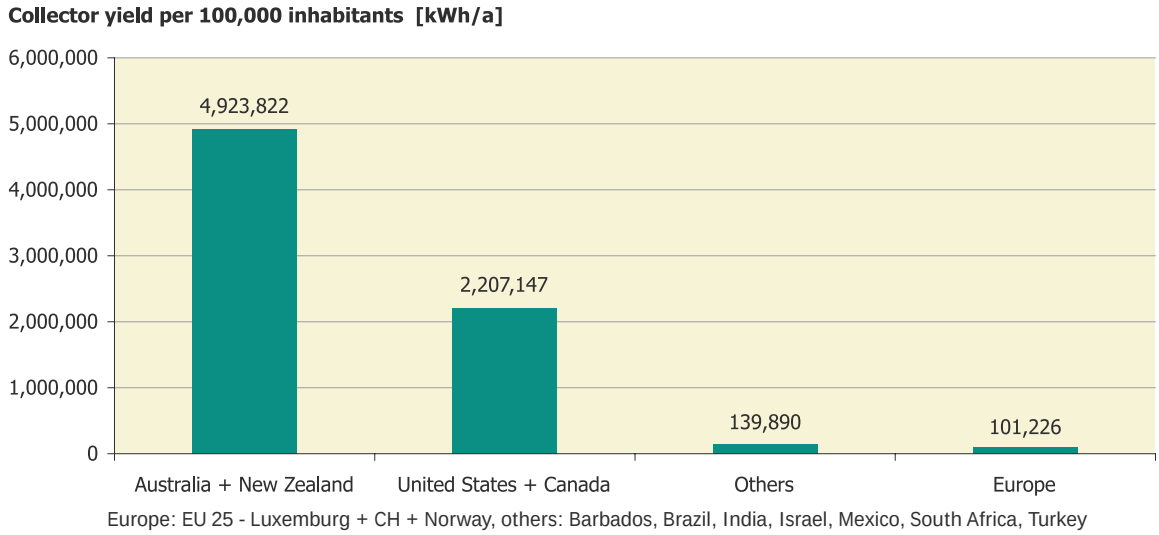
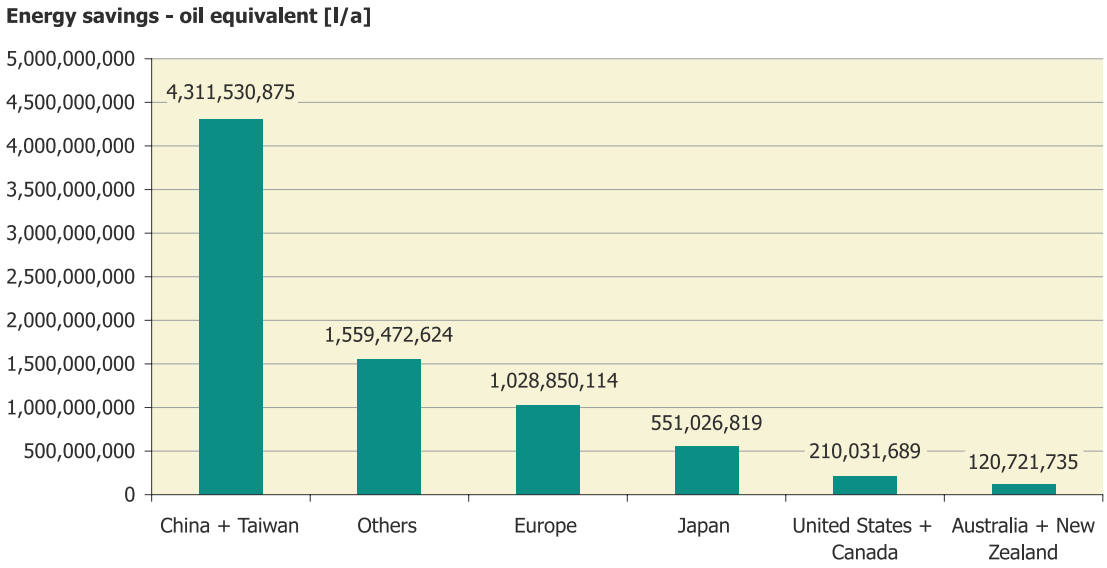


Figure 18: Annual collector yield of unglazed collectors in operation by economic region at the end of 2004 per 100,000 inhabitants

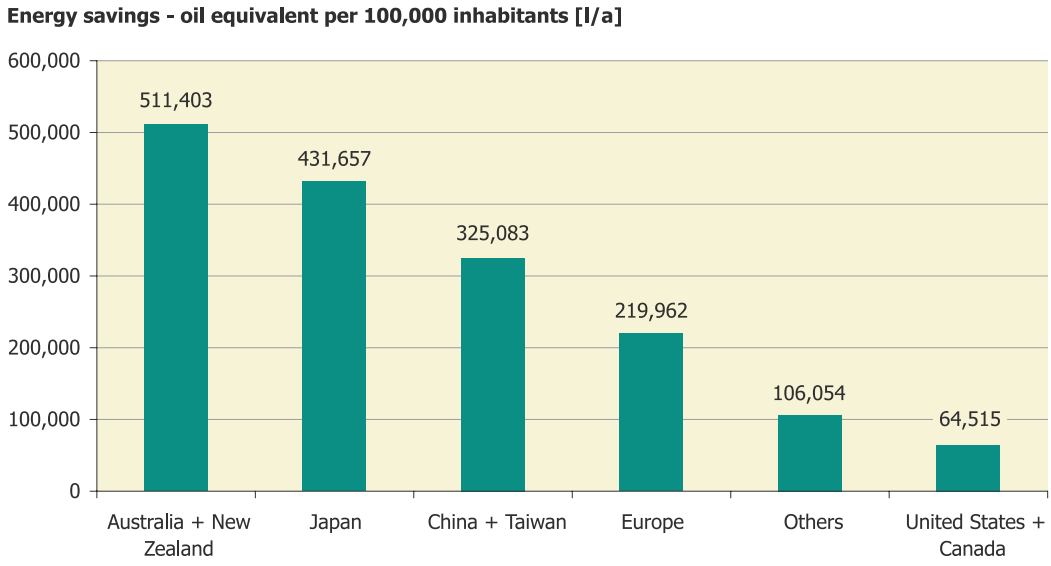
5.2 Energy savings by economic region at the end of 2004

5.2.1 Energy savings in oil equivalent—glazed flat plate and evacuated tube collectors by economic region at the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 19: Annual energy savings in oil equivalent—glazed flat plate and evacuated tube collectors by economic region at the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 20: Annual energy savings in oil equivalent—glazed flat plate and evacuated tube collectors operation by economic region at the end of 2004 per 100,000 inhabitants

5.2.2 Energy savings in oil equivalent—unglazed collectors by economic region at the end of 2004

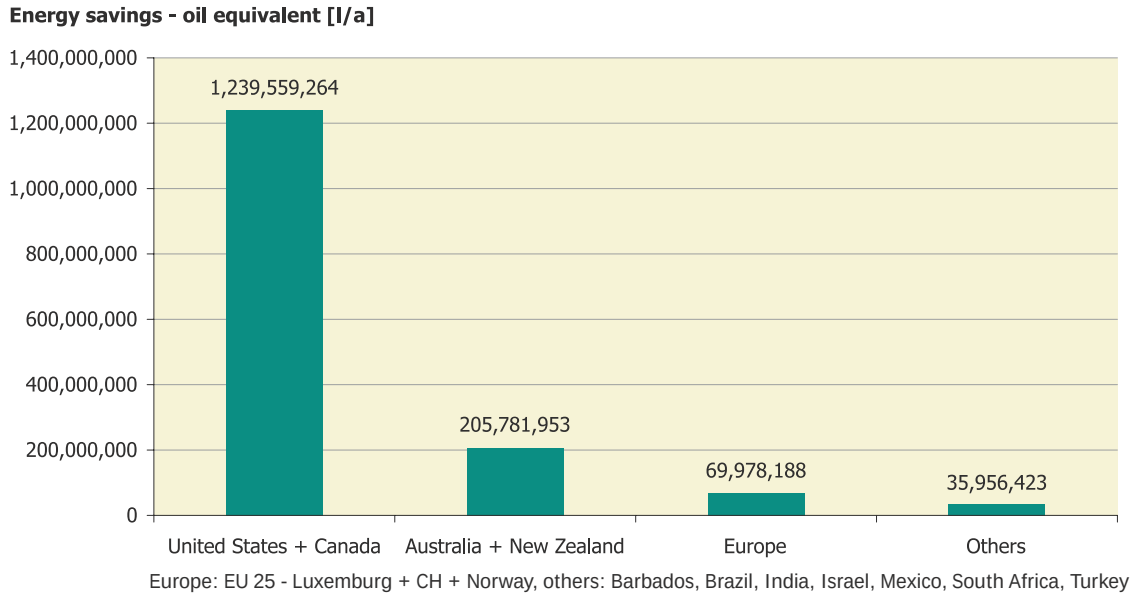


Figure 21: Annual energy savings in oil equivalent—unglazed collectors by economic region at the end of 2004

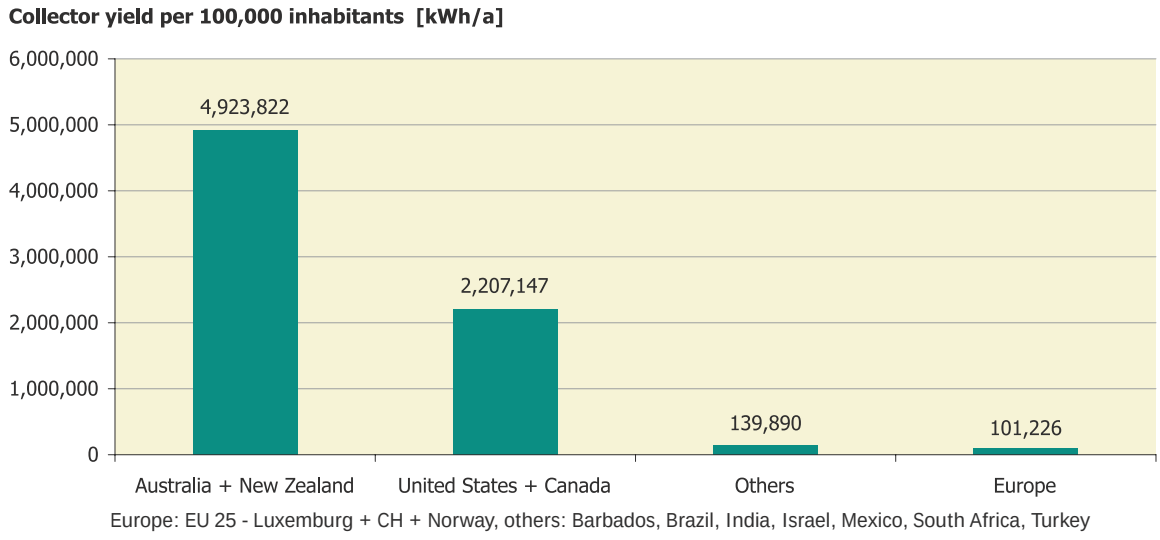
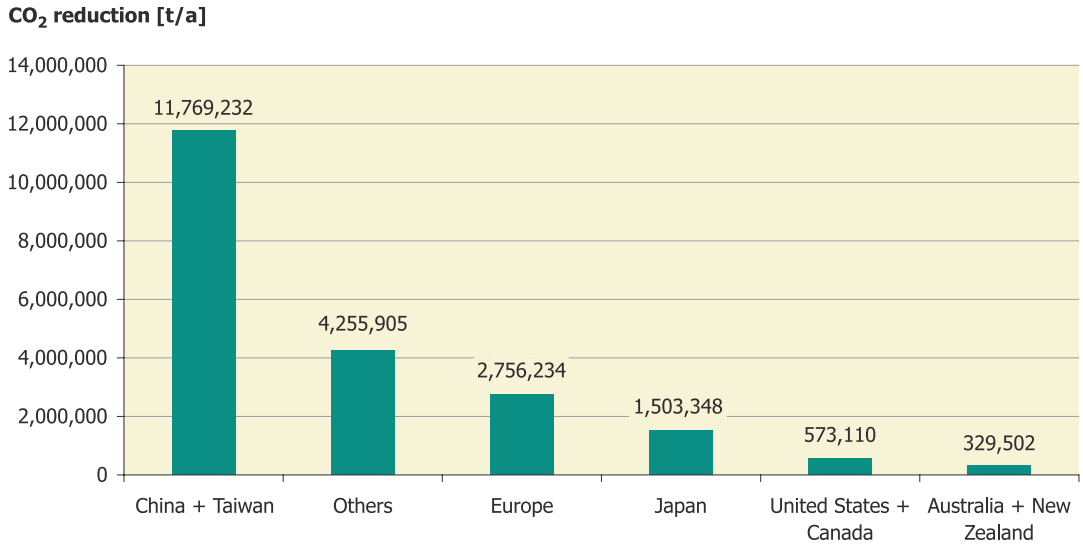


Figure 22: Annual energy savings by economic region at the end of 2004 per 100,000 inhabitants in oil equivalent—unglazed collectors

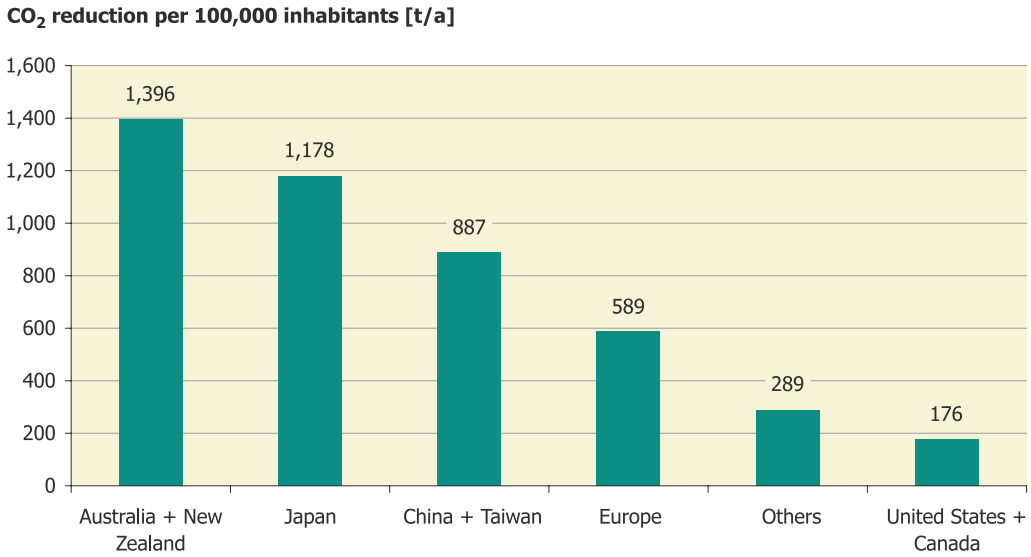
5.3 Contribution to CO_2 reduction by economic region at the end of 2004

5.3.1 Contribution to CO_2 reduction: Flat plate and evacuated tube collectors by economic region at the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 23: Annual contribution to CO_2 reduction—flat plate and evacuated tube collectors by economic region the end of 2004



Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 24: Annual contribution to CO_2 reduction by economic region at the end of 2004 per 100,000 inhabitants—flat plate and evacuated tube collectors

5.3.2 Contribution to CO_2 reduction: Unglazed collectors by economic region at the end of 2004

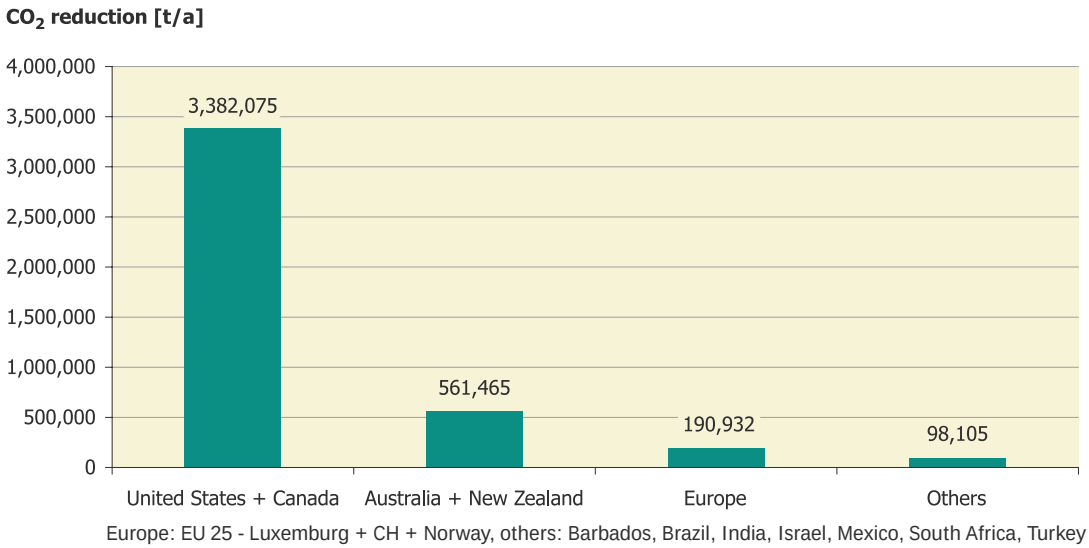


Figure 25: Annual contribution to CO_2 reduction—unglazed collectors by economic region at the end of 2004

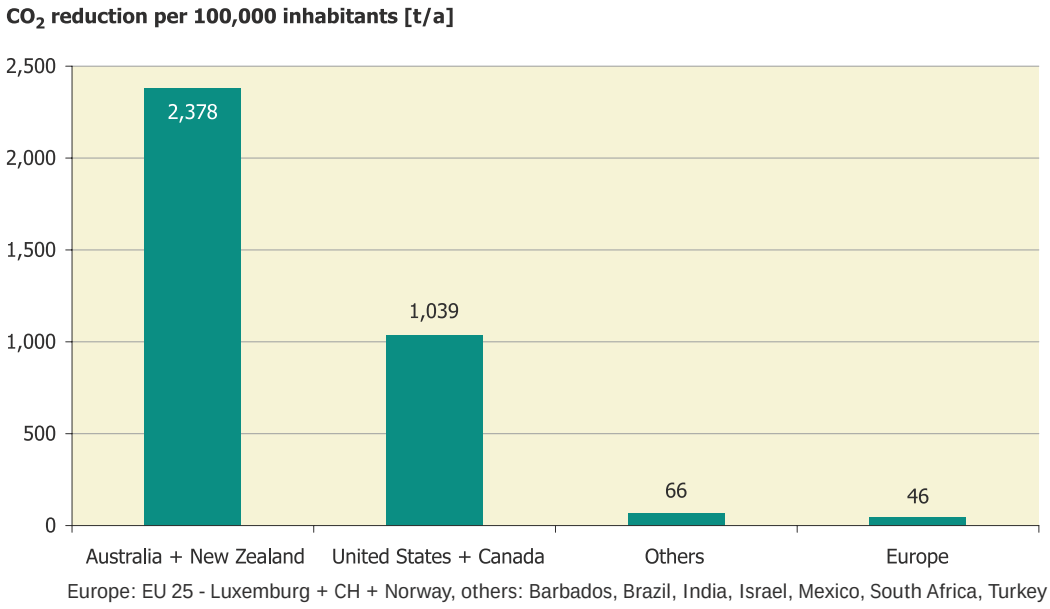


Figure 26: Annual contribution to CO_2 reduction by economic region at the end of 2004 per 100,000 inhabitants—unglazed collectors

6 Appendix

6.1 Annual installed capacity

The following tables show the capacity installed yearly in the recorded countries from 1999 to 2004. It has to be mentioned here, that the number of countries who made data available increased from 21 countries in 1999 to 41 countries in 2004 (including Oversea Departments of France). Therefore the total numbers of the different years can not be compared directly.

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated	unglazed	glazed	
Austria	11.84	97.13	1.68		0.35	111.00
Belgium	0.88	0.91	0.14			1.93
Canada	17.50	0.16	0.02	1.39		19.07
Denmark	0.17	10.71	0.07			10.95
Finland		1.05	0.07	0.35		1.47
France*	4.90	16.10	0.70			21.70
Germany	35.00	252.00	42.00		3.50	332.50
Greece		129.50				129.50
Italy	2.10	31.50	2.10	0.35	0.35	36.40
Japan		208.93	5.80			214.73
Mexico	15.09	3.77				18.87
Netherlands	5.60	19.60		0.21		25.41
New Zealand	2.80	2.80				5.60
Norway	0.07	0.70			0.07	0.84
Portugal	0.35	5.60	0.35			6.30
Spain		15.11				15.11
Sweden	2.05	6.55	0.10		0.06	8.76
Switzerland	12.27	19.92	0.81			32.99
Turkey		525.00				525.00
United Kingdom		2.10	4.20			6.30
United States	530.14	26.92	0.39		0.72	558.17
TOTAL	640.76	1,376.06	58.43	2.30	5.04	2,082.59

* France: incl. Oversea Departments

Table 5: Installed capacity in 1999, MW_{th}/a

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	266.00	49.70				315.70
Austria	10.32	105.38	1.68	2.10	0.39	119.86
Barbados		1.91				1.91
Belgium	0.88	0.98	0.14			2.00
Brazil		45.50				45.50
Canada	18.90	0.44	0.11	2.36		21.81
China		1,498.00	2,772.00			4,270.00
Cyprus		21.00				21.00
Denmark	0.05	9.01	0.04			9.09
Finland		1.40		0.35		1.75
France*	5.25	23.80				29.05
Germany	35.00	357.00	77.00		4.90	473.90
Greece		126.70				126.70
India		49.00				49.00
Ireland		0.24	0.03			0.27
Israel		273.00	0.30			273.30
Italy	2.10	31.50	2.10	0.35	0.35	36.40
Japan		211.13	4.12			215.26
Mexico	25.04	12.34	0.00			37.38
Netherlands	5.25	18.90	0.04	0.21		24.40
New Zealand	3.15	3.15				6.30
Norway	0.07	0.70			0.07	0.84
Portugal	0.35	5.25	0.35			5.95
South Afrika	35.70	7.00				42.70
Spain	0.00	24.97				24.97
Sweden	2.09	12.63	0.61			15.33
Switzerland	10.82	16.99	1.56	6.30		35.68
Taiwan		47.14	3.82			50.96
Turkey		525.00				525.00
United Kingdom	7.00	6.30	0.70			14.00
United States	516.86	24.97	0.98		0.39	543.20
TOTAL	944.82	3,511.03	2,865.57	11.67	6.09	7,339.18

* France: incl. Oversea Departments

Table 6: Installed capacity in 2000, MW_{th}/a

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	266.00	52.50				318.50
Austria	6.35	110.50	1.55			118.40
Barbados		1.91				1.91
Belgium	0.52	2.92	0.21			3.65
Brazil		35.00				35.00
Canada	16.10	0.70	0.12	2.88		19.79
China		2,009.00	3,731.00			5,740.00
Denmark	0.42	18.20	0.11			42.00
Finland		1.05	0.04			18.73
France*	9.80	26.95				1.09
Germany	35.00	525.00	105.00			36.75
Greece		122.50				665.00
India		56.00				122.50
Ireland		0.11	0.08			56.00
Israel		294.00	0.00			0.19
Italy	2.10	27.79	2.63	0.35	0.35	294.00
Japan		217.00	2.80			33.22
Mexico	25.34	11.12				219.80
Netherlands	5.25	21.47				36.46
New Zealand	0.84	1.89	0.01			26.72
Norway	0.07	0.18				2.74
Portugal		4.20				0.24
South Africa	37.80	8.75				4.20
Spain	3.50	36.50	3.50			46.55
Sweden	2.37	15.08	0.30			43.50
Switzerland	8.81	17.86	0.74	6.30		17.75
Taiwan		48.89	3.96			33.71
Turkey		441.00				52.85
United Kingdom	7.00	5.60	5.06			441.00
United States	710.09	17.04	0.26		0.26	727.65
TOTAL	1,137.35	4,130.72	3,857.35	9.53	0.61	9,159.90

* France: incl. Oversea Departments

Table 7: Installed capacity in 2001, MW_{th}/a

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	266.00	78.40				344.40
Austria	7.39	105.70	1.44			114.52
Barbados		1.91				1.91
Belgium	0.53	2.94	0.21			3.68
Brazil		33.60				33.60
Canada	16.66	0.75	0.11	6.76		24.28
China		1,050.00	5,670.00			6,720.00
Cypres		21.00				21.00
Czech Republic**						
Denmark		11.20			3.50	14.70
Estonia**						
Finland		1.05	0.04			1.09
France*	4.90	38.50				43.40
Germany	35.00	332.50	45.50			413.00
Greece		106.40				106.40
Hungary		0.81	0.04			0.84
India		70.00				70.00
Ireland		0.53	0.08			0.61
Israel		280.00				280.00
Italy	2.10	32.20	4.20			38.50
Japan		231.10	3.78			234.87
Lativa**						
Lithuania**						
Luxembourg**						
Malta**						
Mexico	21.38	14.25				35.64
Netherlands	5.25	23.35	0.51			29.11
New Zealand	0.84	2.47	0.07			3.38
Norway	0.14	0.49			0.07	0.70
Poland	0.22	8.63	0.83			9.68
Portugal		3.50				3.50
Slovak Republic**						
Slovenia		0.73	0.15			0.88
South Africa	39.20	9.73	0.01			48.94
Spain	0.21	38.87	3.26			42.35
Sweden	2.75	10.33	0.35			13.43
Switzerland	7.39	17.39	1.11	2.10		27.99
Taiwan		50.70	4.11			54.81
Turkey		350.00				350.00
United Kingdom	7.00	5.60	5.25			17.85
United States	723.81	34.41	0.26		0.26	758.75
TOTAL	1,140.76	2,969.04	5,741.30	8.86	3.83	9,863.80

* France: incl. Oversea Departments

** Data not raised

Table 8: Installed capacity in 2002, MW_{th}/a

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	270.90	93.80				364.70
Austria	6.93	115.64	1.20			123.77
Barbados		1.91				1.91
Belgium	1.31	6.00	0.34			7.64
Brazil		23.10				23.10
Canada	18.34	0.80	0.12	7.27		26.53
China		980.00	7,000.00			7,980.00
Cyprus		21.00				21.00
Czech Republic		4.47	0.43			4.90
Denmark		5.60			3.50	9.10
Estonia		0.11				0.11
Finland		1.05				1.05
France*	4.33	63.97	0.04			68.34
Germany		455.00	49.00			504.00
Greece		112.70				112.70
Hungary		1.01	0.04			1.05
India		70.00				70.00
Ireland		0.83	0.14		0.14	1.11
Israel		280.00				280.00
Italy	2.10	35.00	4.90			42.00
Japan		194.94	1.39			196.34
Lativa		0.28				0.28
Lithuania		0.28				0.28
Luxembourg		1.05				1.05
Malta		1.40	0.06			1.46
Mexico	34.26	18.45				52.71
Netherlands	9.80	19.38				29.18
New Zealand		4.17	0.25			4.41
Norway	0.35	1.05	0.07		0.07	1.54
Poland	0.21	16.74	1.61			18.56
Portugal		6.45				6.45
Slovak Republic		3.50				3.50
Slovenia		0.53	0.25			0.79
South Africa	41.30	9.79	0.01			51.10
Spain	0.57	43.05	5.38			49.00
Sweden	3.11	12.58	0.90			16.59
Switzerland	6.05	18.36	0.42	1.40		26.22
Taiwan		57.63	4.67			62.30
Turkey		560.00				560.00
United Kingdom		8.40	7.00			15.40
United States	707.61	35.85	0.59		0.39	744.43
TOTAL	1,107.16	3,285.87	7,078.81	8.67	4.10	11,484.61

* France: incl. Oversea Departments

Table 9: Installed capacity in 2003, MW_{th}/a

Country	Water Collectors			Air Collectors		TOTAL [MW_{th}]
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	270.90	105.00	0.70			376.60
Austria	6.23	126.00	1.82			134.05
Barbados		1.91				1.91
Belgium		10.29				10.29
Brazil		23.10				23.10
Canada	25.24	0.82	0.14	11.34		37.53
China		1,050.00	8,400.00			9,450.00
Cyprus		21.00				21.00
Czech Republic		5.67	0.28			5.95
Denmark		8.40			3.50	11.90
Estonia		0.18				0.18
Finland		0.98	0.16			1.14
France*	4.34	77.50				81.84
Germany		472.50	52.50			525.00
Greece		150.50				150.50
Hungary	0.21	1.75	0.14			2.10
India		140.00				140.00
Ireland		0.84	0.56		0.07	1.47
Israel		49.00				49.00
Italy	1.75	42.00	8.40			52.15
Japan		172.40	3.24			175.64
Lativa		0.35				0.35
Lithuania		0.35				0.35
Luxembourg		1.19				1.19
Malta		2.86	0.09			2.95
Mexico	28.86	19.24				48.11
Netherlands	22.40	18.20				40.60
New Zealand		5.57	0.43			6.00
Norway	0.14	1.05			0.18	1.37
Poland	0.46	15.79	1.89			18.13
Portugal		11.26				11.26
Slovak Republic		3.85				3.85
Slovenia		1.26	0.21			1.47
South Africa	42.70	9.80	0.01			52.51
Spain	3.15	55.44	4.41			63.00
Sweden	6.07	12.25	1.79			20.11
Switzerland	7.82	20.93	0.88	1.40		31.03
Taiwan		72.26	5.86			78.12
Turkey		840.00				840.00
United Kingdom	0.70	8.40	7.00			16.10
United States	884.96	32.58	0.13		0.26	917.93
TOTAL	1,305.93	3,592.46	8,490.64	12.74	4.01	13,405.77

* France: incl. Oversea Departments

Table 10: Installed capacity in 2004, MW_{th}/a

6.2 Reference systems

To make the simulations to determine the energy output of a solar thermal heating system, it was necessary to define reference systems for different applications and countries (regions).
Based on the reference systems, hot water demand, heat load (only for solar combisystems[5]) and weather data, the energy output of the systems and the resulting energy savings in oil equivalent were calculated.
Four major applications and reference systems (see table below) were chosen for the simulations. For these reference systems, the daily hot water demand, the space heating demand (only for solar combisystems) and the weather data (location) were defined. The reference systems are those systems, which are most common in the respective country.
The following tables describe the key data of the reference systems in different countries, the location of the reference climate used and the share of the total collector area[6] in use for the respective application. Furthermore, a hydraulic scheme is shown for each reference system.

6.2.1 Solar thermal systems for swimming pool heating with unglazed plastic absorbers

Country	Reference system	Total coll. area [m²]	Number of systems	Reference climate
Australia	C: 200 m² unglazed plastic absorber	3,154,000	15,770	Sydney
Austria	C: 200 m² unglazed plastic absorber	587,224	2,936	Graz
Belgium	C: 200 m² unglazed plastic absorber	26,000	130	Brussels
Canada	C: 200 m² unglazed plastic absorber	602,038	3,010	Montreal
Denmark	C: 200 m² unglazed plastic absorber	21,870	109	Copenhagen
France	C: 200 m² unglazed plastic absorber	100,000	500	Paris
Germany	C: 200 m² unglazed plastic absorber	775,000	3,875	Würzburg
Hungary	C: 200 m² unglazed plastic absorber	29,700	149	Budapest
Italy	C: 200 m² unglazed plastic absorber	14,000	70	Bologna
Mexico	C: 200 m² unglazed plastic absorber	385,586	1,928	Mexico City
Netherlands	C: 200 m² unglazed plastic absorber	292,000	1,460	Amsterdam
New Zealand	C: 200 m² unglazed plastic absorber	2,400	12	Wellington
Norway	C: 200 m² unglazed plastic absorber	1,500	8	Oslo
Poland	C: 200 m² unglazed plastic absorber	1,850	9	Warsaw
South Africa	C: 200 m² unglazed plastic absorber	510,000	2,550	Johannisburg
Spain	C: 200 m² unglazed plastic absorber	10,612	53	Madrid
Sweden	C: 200 m² unglazed plastic absorber	38,677	193	Gothenburg
Switzerland	C: 200 m² unglazed plastic absorber	210,850	1,054	Zurich
United Kingdom	C: 200 m² unglazed plastic absorber	7,240	36	London
United States	C: 200 m² unglazed plastic absorber	26,253,522	131,268	Denver, Los Angeles
Total		33,024,070	165,120	

C: collector area

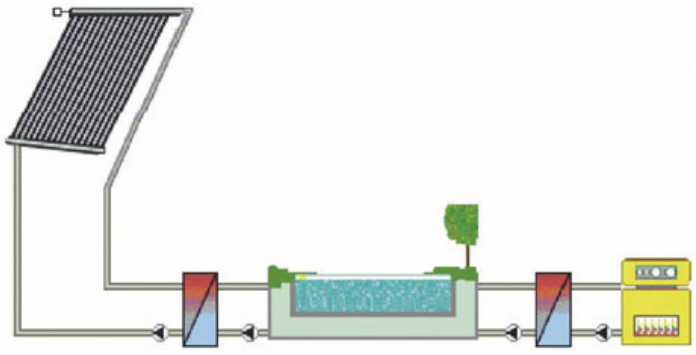


Figure A1: Hydraulic scheme of the swimming pool reference system

5 Solar combisystems are solar heating installations providing space heating as well as domestic hot water for the inhabitants of the building. The primary energy sources are solar energy as well as an auxiliary source such as biomass, gas, oil and electricity.

6 Glazed flat plate and evacuated tube collector

6.2.2 Solar domestic hot water systems for single family houses

Country	reference system	reference climate	% of total market[7]
Australia	C: 4 m² / ST: 300 l / HWD: 170 l/d / TS	Sydney	95
Austria	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Graz	77
Barbados	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Raizet	100
Belgium	C: 4 m² / ST: 200 l / HWD: 150 l/d / PDS	Brussels	100
Brazil	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Rio de Janeiro	100
Canada	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Montreal	95
China	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Shanghai	100
Cyprus	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Cyprus	98
Czech Republic	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Praha	99
Denmark	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Copenhagen	86
Estonia	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Tallin	100
Finland	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Helsinki	95
France	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Paris	95
Germany	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Würzburg	80
Greece	C: 2.5 m² / ST: 150 l / HWD: 150 l/d / TS	Athens	98
Hungary	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Budapest	99
Indien	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Bombay	100
Irland	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Dublin	100
Israel	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Jerusalem	100
Italy	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Bologna	100
Japan	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Tokyo	96
Lativa	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Riga	100
Lithuania	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Vilnius	100
Luxembourg	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Luxembourg	100
Malta	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Valletta	100
Mexico	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Mexico City	28
Netherlands	C: 2 m² / ST: 150 l / HWD: 150 l/d / PDS	Amsterdam	90
New Zealand	C: 4 m² / ST: 300 l / HWD: 150 l/d / TS	Wellington	95
Norway	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Oslo	98
Poland	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Warsaw	99
Portugal	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Lisbon	95
Slovac Republic	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Bratislawa	100
Slovenia	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Ljubliana	98
South Afrika	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Johannisburg	100
Spain	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Madrid	95
Sweden	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Gothenburg	10
Switzerland	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Zurich	80
Taiwan	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Taipei	100
Turkey	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Ankara	90
United Kingdom	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	London	100
United States	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Denver / Los Angeles	100

C collector area
ST hot water storage
HWD hot water demand / day with 60°C
TS thermosiphon system
PS pumped system
PDS pumped, drain back system

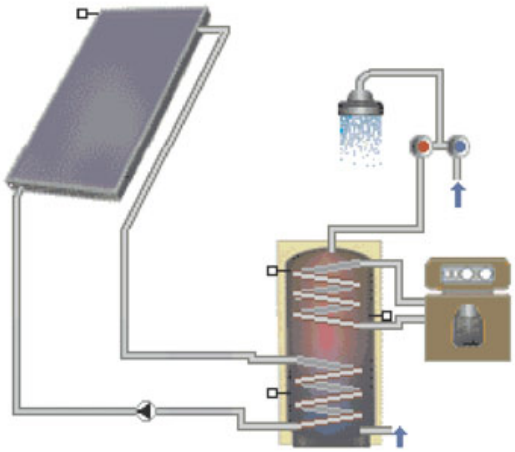


Figure A2: Hydraulic scheme of the DHW reference system

7 percentage of total installed collector area (flat plate and vacuum tube) at the end of 2004 for DHW systems for single family houses

6.2.3 Solar domestic hot water systems for multi-family houses, hotels and district heating

Country	reference system	reference climate	% of total market[8]
Australia	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Sydney	5
Austria	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Graz	3
Canada	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Montreal	5
Cyprus	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Cyprus	2
Czech Republic	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Praha	1
Denmark	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Copenhagen	13
Finland	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Helsinki	5
France metrople	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Paris	1
Germany	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Würzburg	8
Greece	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Athens	2
Hungary	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Budapest	1
Japan	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Tokyo	2
Mexico*	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Mexico City	72
Netherlands	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PDS	Amsterdam	8
New Zealand	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Wellington	5
Norway	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Oslo	1
Poland	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Warsaw	1
Portugal	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Lisbon	5
Slovenia	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Ljubliana	2
Spain	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Madrid	5
Sweden	C: 1000 m² / ST: 50000 l / HWD: 40000 l/d / PS	Gothenburg	25
Switzerland	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Zurich	5
Turkey	C: 50 m² / ST: 2500 l / HWD: 2000 l/d / PS	Ankara	10

* Industry

C collector area
ST hot water storage
HWD hot water demand / day with 60°C
TS thermosiphon system
PS pumped system
PDS pumped, drain back system

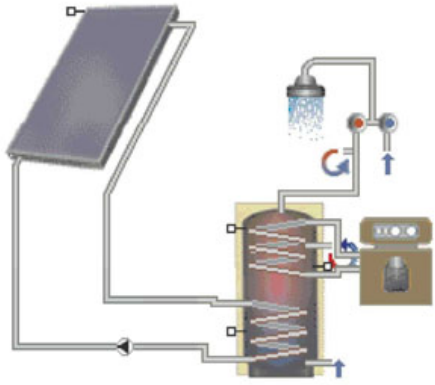


Figure A3: Hydraulic scheme of the DHW system for muli-family houses

8 percentage of total installed collector area (flat plate and vacuum tube) until 2000 for DHW systems for multi-family houses and district heating systems

6.2.4 Solar combisystems for domestic hot water and space heating (one family house with 140 m² gross area)

Country	reference system	reference climate	% of total market[9]
Austria	C: 20 m² / ST: 2000 l / HWD: 160 l/d / SHD: 80 kWh/m² / PS	Graz	20
Denmark	C: 15 m² / ST: 800 l / HWD: 160 l/d / SHD: 80 kWh/m² / PS	Copenhagen	1
France	C: 15 m² / ST: 250 l / HWD: 160 l/d / SHD: 80 kWh/m² / PS	Paris	4
Germany	C: 12 m² / ST: 750 l / HWD: 160 l/d / SHD: 80 kWh/m² / PS	Würzburg	12
Japan	C: 12 m² / ST: 750 l / HWD: 160 l/d / SHD: 80 kWh/m² / PS	Tokyo	2
Netherlands	C: 4 m² / ST 240 l / HWD: 160 l/d / SHD: 80 kWh/m² / PDS	Amsterdam	2
Norway	C: 10 m² / ST: 1500 l / HWD: 160 l/d / SHD: 100 kWh/m² / PS	Oslo	1
Sweden	C: 12 m² / ST: 1000 l / HWD: 160 l/d / SHD: 100 kWh/m² / PS	Gothenburg	65
Switzerland	C: 15 m² / ST: 1000 l / HWD: 160 l/d / SHD: 80 kWh/m² / PS	Zurich	15

C collector area
ST hot water storage
TS thermosiphon system
PS pumped system
PDS pumped, drain back system
HWD hot water demand / day with 60°C
SHD space heat demand [kWh/m² a]

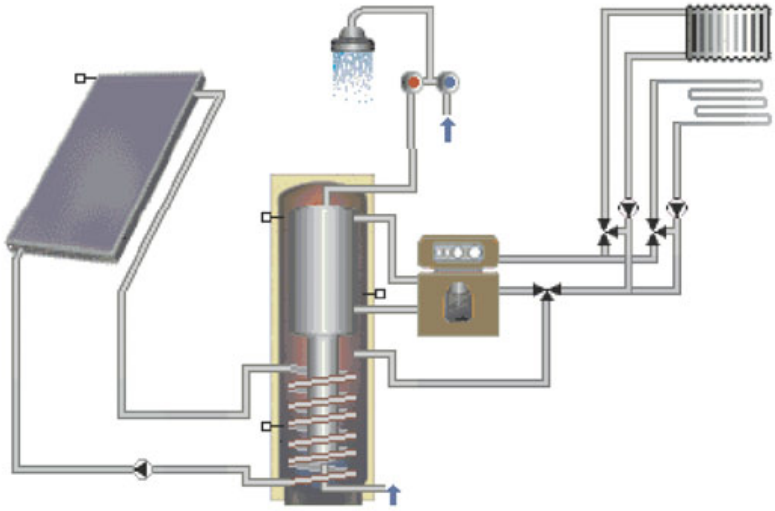


Figure A4: Hydraulic scheme of the solar combi reference system

9 percentage of total installed collector area (flat plate and vacuum tube) until 2000 for solar combi systems

6.3 Reference collector

Data of the reference absorber for swimming pool heating:
η = 0.85
a1 = 20 [W/m²K]
a2 = 0.1 [W/m² K²]

Data of the reference collector for all other applications:
η = 0.8
a1 = 3.69 [W/m²K]
a2 = 0.007 [W/m² K²]

6.4 Reference climates

Country	Used reference climate[10]
Australia	Sydney
Austria	Graz
Barbados	Raizet
Belgium	Brussels
Brazil	Rio de Janeiro
Canada	Montreal
China	Shanghai
Cyprus	Nicosia
Czech Repulic	Praha
Denmark	Copenhagen
pnumEstonia	Tallin
Finland	Helsinki
France metropole	Paris
Germany	Würzburg
Greece	Athens
Hungary	Budapest
India	Bombay
Ireland	Dublin
Israel	Jerusalem
Italy	Bologna
0Japan	Tokyo
Lativa	Riga
Lithuania	Vilnius
Luxembourg	Luxembourg
Malta	Valletta
Mexico	Mexico City
Netherlands	Amsterdam
New Zealand	Wellington
Norway	Oslo
Poland	Warzaw
Portugal	Lisbon
Slovac Republic	Bratislawa
Slovenia	Ljubliana
South Africa	Johannisburg
Spain	Madrid
Sweden	Gothenburg
Switzerland	Zurich
Taiwan	Taipei
Turkey	Ankara
United Kingdom	London
United States	Denver / Los Angeles

10 METEONORM

6.5 Population data

Raised countries in alphabetic order.

	Country	Inhabitants 2003		Country	Inhabitants 2003
1	Australia	19,731,000	22	Lativa	2,307,000
2	Austria	8,118,000	23	Lithuania	3,444,000
3	Barbados	270,000	24	Luxembourg	453,000
4	Belgium	10,318,000	25	Malta	394,000
5	Brazil	178,470,000	26	Mexico	103,457,000
6	Canada	31,510,000	27	Netherlands	16,149,000
7	China	1,304,196,000	28	New Zealand	3,875,000
8	Cyprus	818,200	29	Norway	4,533,000
9	Czech Republic	10,236,000	30	Poland	38,587,000
10	Denmark	5,364,000	31	Portugal	10,062,000
11	Estonia	1,323,000	32	Slovak Republic	5,402,000
12	Finland	5,207,000	33	Slovenia	1,984,000
13	France*	61,977,000	34	South Africa	45,026,000
14	Germany	82,476,000	35	Spain	41,060,000
15	Greece	10,976,000	36	Sweden	8,876,000
16	Hungary	9,877,000	37	Switzerland	7,169,000
17	India	1,065,462,000	38	Taiwan	22,092,000
18	Ireland	3,956,000	39	Turkey	71,325,000
19	Israel	6,433,000	40	United Kingdom	59,251,000
20	Italy	57,423,000	41	United States	294,043,000
21	Japan	127,654,000		TOTAL	3,741,284,200

13	*France	61,977,000
	Guadeloupe	440,000
	Martinique	393,000
	Réunion	756,000
	Polynésie	244,000
	France métropole	60,144,000

Economic Region	Inhabitants in 2003
United States + Canada	325,553,000
Japan	127,654,000
China + Taiwan	1,326,288,000
Europe	467,740,200
Australia + New Zealand	23,606,000
Others	1,470,443,000
Total	3,741,284,200

Europe: EU 25 - Luxemburg + CH + Norway, others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Source for population data:

Statistisches Jahrbuch 2006, http://www.statistik.at/jahrbuch_2006/deutsch/start.shtml

David Ince, Fair Trading Commission Barbados

www.visitcyprus.org.cy/

www.cia.gov/cia/publications/factbook/geos/gp.html#People

martiniquetourism.com/article/view/4

6.6 2004 Data in m²

The presented data in chapter 3 to 5 has been originally collected in square meters. Through an agreement of international experts collector areas of solar thermal applications are shown in installed capacity.

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

Nevertheless solar thermal collectors are traditionally quoted in square meters. Therefore Table 11 and Table 12 give the 2004 data in m².

Country	Water Collectors			Air Collectors		TOTAL [m²]
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	387,000	150,000	1,000			538,000
Austria	8,900	180,000	2,594			191,494
Barbados		2,731				2,731
Belgium		14,700				14,700
Brazil		33,000				33,000
Canada	36,050	1,168	200	16,196		53,614
China		1,500,000	12,000,000			13,500,000
Cyprus		30,000				30,000
Czech Republic		8,100	400			8,500
Denmark		12,000			5,000	17,000
Estonia		250				250
Finland		1,400	230			1,630
France*	6,200	110,715				116,915
Germany	30,000	675,000	75,000			780,000
Greece		215,000				215,000
Hungary	300	2,500	200			3,000
India		200,000				200,000
Ireland		1,194	800		100	2,094
Israel		70,000				70,000
Italy	2,500	60,000	12,000			74,500
Japan		246,286	4,629			250,914
Lativa		500				500
Lithuania		500				500
Luxembourg		1,700				1,700
Malta		4,083	132			4,215
Mexico	41,235	27,490				68,725
Netherlands	32,000	26,000				58,000
New Zealand		7,950	620			8,570
Norway	200	1,500	0		250	1,950
Poland	650	22,550	2,700			25,900
Portugal		16,088				16,088
Slovak Republic		5,500				5,500
Slovenia		1,800	300			2,100
South Africa	61,000	14,000	10			75,010
Spain	4,500	79,200	6,300			90,000
Sweden	8,677	17,498	2,560			28,735
Switzerland**	11,171	29,903	1,257	2,000		44,331
Taiwan	0	103,230	8,370			111,600
Turkey		1,200,000				1,200,000
United Kingdom	1,000	12,000	10,000			23,000
United States	1,264,225	46,544	186		372	1,311,327
TOTAL	1,895,608	5,132,080	12,129,488	18,196	5,722	19,181,093

* France: incl. Oversea Departments

** Unglazd air collectors in Switzerland: this is a very simple site-built system for hay drying purposes.

Table 11: Collector Area installed in 2004, m²/a

Country	Water collectors			Air Collectors		TOTAL [m²]
	unglazed	glazed	evacuated tube	unglazed	glazed	
Australia	3,154,000	1,594,000	1,000			4,749,000
Austria	587,224	2,147,045	34,803			2,769,072
Barbados		74,601				74,601
Belgium	26,000	45,249	3,000			74,249
Brazil		2,266,000				2,266,000
Canada	602,038	76,388	1,200	81,352		760,978
China		6,200,000	55,800,000			62,000,000
Cyprus		734,000				734,000
Czech Republic		46,500	3,500			50,000
Denmark	21,870	306,570	550		15,000	343,990
Estonia		570				570
Finland		8,000	380			8,380
France*	100,000	692,000	62			792,062
Germany	775,000	4,949,000	752,000			6,476,000
Greece		2,994,200				2,994,200
Hungary	29,700	4,240	2,760			36,700
India		1,000,000				1,000,000
Ireland		3,094	1,800		2,800	7,694
Israel		4,790,000				4,790,000
Italy	14,000	412,000	34,000			460,000
Japan		7,571,480	154,520			7,726,000
Lativa		1,650				1,650
Lithuania		1,650				1,650
Luxembourg		11,500				11,500
Malta		15,000	360			15,360
Mexico	385,586	257,058				642,644
Netherlands	292,000	291,000				583,000
New Zealand	2,400	83,520	1,070			86,990
Norway	1,500	11,000			1,450	13,950
Poland	1,850	86,750	6,200	3,000	2,500	100,300
Portugal		274,300				274,300
Slovak Republic		56,750				56,750
Slovenia		100,876	875			101,751
South Africa	510,000	246,000	30			756,030
Spain	10,612	666,178	23,643			700,433
Sweden	38,677	193,498	11,560			243,735
Switzerland**	210,850	316,090	23,680	832,000		1,382,620
Taiwan		1,318,773	106,927			1,425,700
Turkey		7,280,000				7,280,000
United Kingdom	7,240	114,950	53,970			176,160
United States	26,253,522	1,592,256	552,766		227,674	28,626,217
TOTAL	33,024,070	48,833,735	57,570,656	916,352	249,424	140,594,236

* France: incl. Oversea Departments

** Unglazd air collectors in Switzerland: this is a very simple site-built system for hay drying purposes.

Table 12: Cumulative Collector Area installed at the end of 2004, m²

6.7 References to reports and persons that have supplied the data

The following persons and members of the Executive Committee of the IEA Solar Heating and Cooling Programme supplied the data and the reference systems for their respective countries:

Australia	John Ballinger Solar Efficient Architecture, Kangaroo Valley
	Ken Guthrie Sustainability Victoria, Melbourne
Austria	Gerhard Faninger IFF — Klagenfurt University, Klagenfurt
Barbados	David Ince Fair Trading Commission Barbados
Belgium	André De Herde Université Catholique de Louvain, Lauvain-la-Neuve
Brazil	Stefan Krauter Universidade Estadual de Ceará, Departamento de Física, Grupo de Energias Alternativas, Brasil
	Dr Samuel Abreu Universidade Federal de Santa Catarina
Canada	Doug McClenahan CANMET — Natural Resources Canada, Ottawa
China	Chinese Solar Thermal Industry Federation (CSTIF)
	Jiang Xinian Guangzhou Institute of Energy Conservation Chinese Academy of Sciences, Beijing
	Prof. Luguang Yan, Prof. Li Zhongming China Solar Energy Society (CSES)
Cyprus	Christodoulos Pharconides Renewable Energy Systems Engineer, Cyprus Institute of Energy
	Soteris Kalogirou Higher Technical Institute, Nicosia
Czech Republic	Eva Kudrnová Technology Centre AS CR, Prague
Denmark	Jens Windeleff ENS, Copenhagen
Finland	Peter Lund Helsinki University of Technology, Espoo

France	Richard Loyen Association de Professionnels pour le Developpement des Énergies Renouvelables, Castellet
Germany	Gerhard Stry-Hipp Bundesverband Solarindustrie e.V. — Bsi, Berlin
Greece	Vassiliki Drosou Mechanical Energy Engineer, Solar Thermal Systems Section CRES — Centre for Renewable Energy Sources
	Costas Travasaros Greek Solar Industry Association
Hungary	Prof. Istvan Farkas Hungarian Solar Energy Society
India	Amit Kumar Coordinator, OPET India, Energy Environment Technology Division, T E R I
Ireland	Xavier Dubuisson Renewable Energy Information Office, Sustainable Energy Ireland
Israel	Asher Vaturi ICTAF, Tel Aviv University Ministry of National Infrastructures, Solel and Israel Manufacturing Association, Tel Aviv
Italy	Paolo Zampetti ENEA, Rome
	Eng. Giacobbe Braccio ENEA, C.R. Trisaia, Rotondella (Matera)
Japan	Noriaki Yamashita, Takuo Yamaguchi Institute for Sustainable Energy Policies (ISEP) Solar System Development Association(SSDA)
	Kazuki Yoshimura National Institute of Advanced Industrial Science and Technology, Nagoya
Mexico	Dr. Wilfrido Rivera Gomez-Franco Centro de Investigacion en Energia, Universidad Nacional Autonoma de Mexico
	Isaac Pilatowsky and Claudio Estrada Centro de Investigacion en Energia, Temixco, Morelos
	Asociación Nacional de Energía Solar, A.C.
Netherlands	Lex Bosselaar SenterNovem, Utrecht
	CBS: Statistics Netherlands, Rijswijk, www.cbs.nl

New Zealand	Michael Donn, School of Architecture, Wellington
	Brian Cox Solar Industries Association New Zealand
Norway	Fritjof Salvesen KanEnergi AS, 1351 Rud
Poland	Stanislaw Golebiowski, Krystian Kurowski EC BREC / IBMER, Warzawa
Portugal	João Farinha Mendes INETI — Edificio G, Lisbon
Slovenia	Gradbeni Institut ZRMK, Ljubliana
South Africa	Carmen Armstrong Project Officer EDC, UNDP/CEF SWH Project Energy Development Corporation (EDC) of the Central Energy Fund (CEF)
	Dieter Holm Sustainable Energy Society of Southern Africa, Pretoria
Spain	Manuel Romero CIEMAT, Madrid
Sweden	Jan-Olof Dalenbäck Chalmers University of Technology, Göteborg Solar Energy Association — SEAS
Switzerland	Urs Wolfer Bundesamt für Energie, Bern
Turkey	Gulsun Erkul First Secretary (Energy Adviser), Permanent Delegation of Turkey to the OECD
	Mehmet ÇAGLAR Ministery of Energy and Natural Resources of TURKEY
	A. Kutay ULKE Mechanical Engineer, Export Department, EZINC Metal San. ve Tic. A.S.
United States	Drury Crawley U.S. Department of Energy, Washington D.C.

Reports

European Solar Thermal Industry Federation (ESTIF): Solar Thermal Markets in Europe, Trends and Market Statistics 2004, June 2005

European Solar Thermal Industry Federation (ESTIF): Sun in Action II—A solar thermal strategy for Europe, Brussels, April 2003

European Solar Thermal Energy Conference estec 2003—Proceedings
Freiburg, Germany, 2003

Active Solar Thermal Industry Group (ASTIG): Solar Thermal Markets in Europe, Brussels, March, 2002

European Solar Industry Federation (ESIF)/European Commission: Sun in action—The solar thermal market—A strategic plan for action in Europe, Office for Official Publications of the European Communities, Luxembourg, 1996

Faninger, Gerhard: Der Solarmarkt in Österreich 2003, Bundesverband SOLAR in WKO and IFF-Universität Klagenfurt, Klagenfurt, 2004

Faninger, Gerhard: Der Solarmarkt in Österreich 2004, BMVIT and IFF-Universität Klagenfurt, Vienna and Graz Klagenfurt, April 2005

SOFAS: Markterhebung Sonnenenergie 2001, Teilstatistik der Schweizerischen Statistik der erneuerbaren Energien, Bundesamt für Energie, Bern, Mai, 2002

SOFAS: Markterhebung Sonnenenergie 2003, Teilstatistik der Schweizerischen Statistik der erneuerbaren Energien, Bundesamt für Energie, Bern, Mai, 2004

SOFAS: Markterhebung Sonnenenergie 2004, Teilstatistik der Schweizerischen Statistik der erneuerbaren Energien, Bundesamt für Energie, Bern, Mai, 2005

DOE 2004: Renewable Energy Annual 2003. Washington, DC: Energy Information Administration. DOE/EIA-0603(2003). Table 17—Solar Thermal Collector Shipments by Type, Quantity, Value and Average Price, 2002 and 2003.

Solar Thermal Barometer, EurObserv'ER, Oct. 2004

Solar Thermal Barometer, EurObserv'ER, August 2005

Bsi-Statistic Solarthermie 1990 - 2004, BDH survey, Germany

SEI-REIO survey, Ireland

Market Survey of Solar Water Heating in South Africa for the Energy Development Corporation (EDC) of the Central Energy Fund (CEF); by Dieter Holm for SolaSure, 2005-05-23