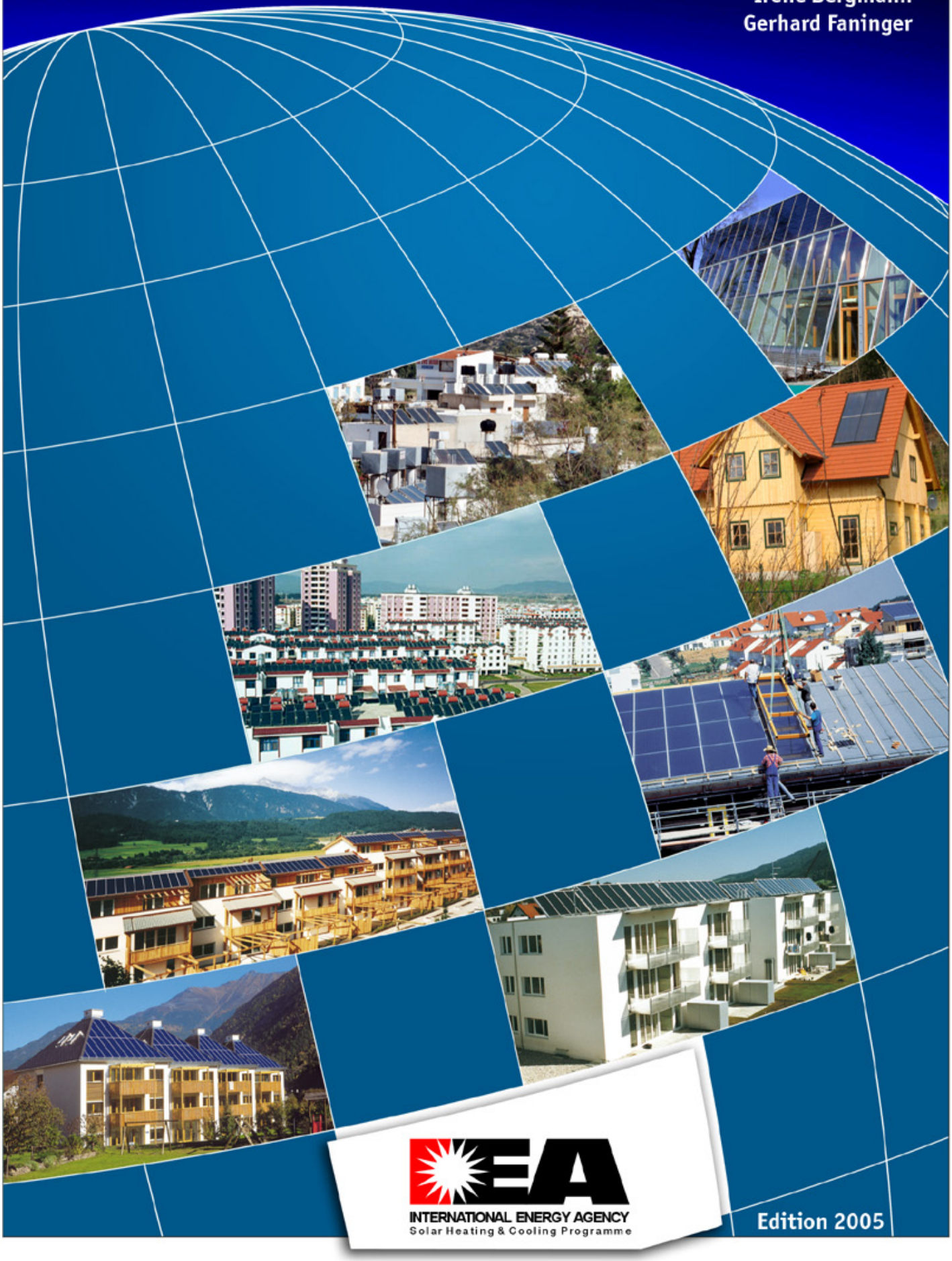
SOLAR HEATING WORLDWIDE

Markets and Contribution to the Energy Supply

Werner Weiss
Irene Bergmann
Gerhard Faninger



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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 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 35 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, and if necessary, corrected. 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 35 countries included in this report represent 3.7 billion people which is about 57% of the world´s population. The collector area installed in these countries is estimated to represent 85-90% of the solar thermal market worldwide.

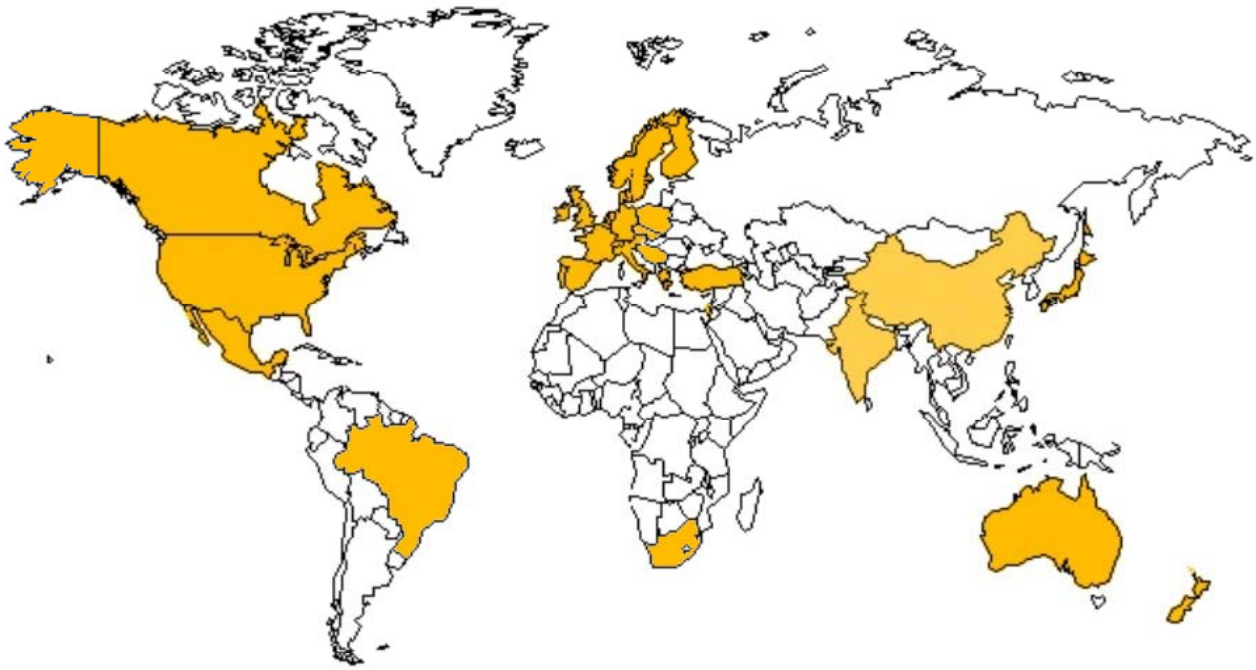


Figure 1: Countries represented in this report (yellow)

2 Summary

Installed capacity

The installed capacity in the 35 countries equaled 92.7 GW_{th} corresponding to 132 million square meters[1] at the end of year 2003. Of this, 69.5 GW_{th} were accounted for by flat-plate and evacuated tube collectors, which are used to prepare hot water and for space heating and 22 GW_{th} for unglazed plastic collectors, which are used mainly to heat swimming pools. Air collector capacity was installed to an extent of 1.2 GW_{th}. These are used for drying agricultural products and to a lesser extent for space heating of houses and production halls.

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 17.9 GW_{th} of unglazed plastic collectors while in China (35.5 GW_{th}), Europe (10.1 GW_{th}) and Japan (8.9 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 by the year 2003, Cyprus, Israel, Greece, Austria and Barbados are the lead countries with 59 MW_{th}, 52 MW_{th}, 21 MW_{th} and 18 MW_{th} per 100.000 inhabitants respectively. They are followed by Turkey, Japan, Australia, Germany and Denmark with an installed capacity between 9 and 4 MW_{th} per 100.000 inhabitants.

Unglazed plastic collectors

With regard to the heating of swimming pools with unglazed plastic collectors, Australia leads with 10 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 0.7 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 2003 was 27% China, 23% in Australia and New Zealand and 11% in Europe.

The worldwide market of unglazed collectors for swimming pool heating recorded a decrease in 2003 after an increase between 1999 and 2002.

[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 2003 in the 35 recorded countries is 55,233 GWh (198,837 TJ). This corresponds to an **oil equivalent** of 8.8 billion liter and an **annual avoidance of 24.1 million tons of CO_2.**

Preview 2004

Based on the data available for the year 2004 at the date of publishing this report the total installed capacity worldwide of flat-plate and evacuated tube collectors can be estimated with 81 GW_{th} (115 million square meters) and the installed capacity of unglazed plastic collectors is estimated with 23 GW_{th} (33 million square meters).

[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 2003

Since the beginning of the 1990s, the solar thermal market has undergone a favorable development. At the end of 2003, a total of 132 million square meters of collector area, corresponding to an installed capacity 92 GW_{th} were installed in the 35 recorded countries. These 35 countries represent 3.7 billion people which is about 57% of the world's population. The collector area installed in these countries represent approximately 85 - 90% of the solar thermal market worldwide.

As shown in Table 1 and Table 2, this collector area is divided in 53.58 million square meters (37 GW_{th}) of glazed flat plate collectors and 45.69 million square meters (32 GW_{th}) of evacuated tube collectors (mainly used for hot water preparation and space heating), 31.5 million square meters (22 GW_{th}) of unglazed collectors for swimming pool heating and 1.68 million square meters (1 GW_{th}) of glazed and unglazed air collectors for space heating and drying applications.

Table 1: Total capacity installed by the year 2003 [MW]

Country	Water collectors			AIR COLLECTOR		TOTAL
	unglazed	glazed	evacuated tube	unglazed	glazed	
Australia	1.936,90	1.010,80				**2.948**
Austria	416,38	1.446,30	22,55			**1.885**
Barbados		50,31				**50**
Belgium	17,66	25,44	1,95			**45**
Brazil		1.563,10				**1.563**
Canada	396,19	52,65	0,70	45,61		**495**
China	420,00	4.760,00	30.800,00			**35.980**
Cyprus		473,90				**474**
Czech Republic		22,35	2,17			**25**
Denmark	15,31	206,20	0,39			**222**
Finland		10,50	0,11	49,00		**60**
France métropole	78,05	401,88	0,04			**480**
France DOM TOM		60,45				**60**
Germany	500,50	2.991,80	473,90		28,00	**3.994**
Greece		2.273,60				**2.274**
Hungary	20,58	1,22	1,79	1,75	26,04	**51**
India		560,00				**560**
Ireland		2,94	0,71		0,14	**4**
Israel		3.304,00				**3.304**
Italy	8,40	255,50	16,10			**280**
Japan		8.654,55	223,21			**8.878**
Mexico	279,65	110,05				**390**
Netherlands	122,92	187,25	2,23	3,36		**316**
New Zealand	1,68	53,33	0,32			**55**
Norway	0,91	6,62	0,14	287,00	0,84	**296**
Poland	0,81	45,63	3,03	2,10	1,40	**53**
Portugal	0,70	180,75	0,35			**182**
Slovenia		69,35	0,40			**70**
South Africa	98,35	106,47	0,01			**205**
Spain	4,28	398,37	12,14			**415**
Sweden	29,23	160,52	3,65			**193**
Switzerland	146,62	204,72	16,63	581,00		**949**
Turkey		6.650,00				**6.650**
United Kingdom	69,30	123,90	18,71			**212**
United States	17.492,48	1.082,00	386,81		159,24	**19.121**
TOTAL	**22.057**	**37.506**	**31.988**	**970**	**216**	**92.737**

Total installed capacity of solar thermal collectors in operation in the year 2003, MW

Table 2: Total collector area in operation by the year 2003 [m^2]

Country	Water collectors			Air Collectors		TOTAL
	unglazed	glazed	evacuated tube	unglazed	glazed	
Australia	2.767.000	1.444.000				**4.211.000**
Austria	594.823	2.066.145	32.209			**2.693.177**
Barbados		71.870				**71.870**
Belgium	25.232	36.348	2.783			**64.363**
Brazil		2.233.000				**2.233.000**
Canada	565.988	75.220	1.000	65.156		**707.364**
China	600.000	6.800.000	44.000.000			**51.400.000**
Cyprus		677.000				**677.000**
Czech Republic		31.930	3.100			**35.030**
Denmark	21.870	294.570	550			**316.990**
Finland		15.000	150	70.000		**85.150**
France métropole	111.500	574.113	60			**685.673**
France DOM TOM		86.350				**86.350**
Germany	715.000	4.274.000	677.000		40.000	**5.706.000**
Greece		3.248.000				**3.248.000**
Hungary	29.400	1.740	2.560	2.500	37.200	**73.400**
India		800.000				**800.000**
Ireland		4.199	1.011		200	**5.410**
Israel		4.720.000				**4.720.000**
Italy	12.000	365.000	23.000			**400.000**
Japan		12.363.636	318.869			**12.682.505**
Mexico	399.493	157.210				**556.703**
Netherlands	175.599	267.504	3.190	4.794		**451.087**
New Zealand	2.400	76.183	460			**79.043**
Norway	1.299	9.450	200	410.000	1.200	**422.149**
Poland	1.150	65.185	4.334	3.000	2.000	**75.669**
Portugal	1.000	258.210	500			**259.710**
Slovenia		99.076	575			**99.651**
South Africa	140.500	152.099	20			**292.619**
Spain	6.112	569106	17.343			**592.561**
Sweden	41.756	229.316	5.214			**276.286**
Switzerland	209.450	292.460	23.760	830.000		**1.355.670**
Turkey		9.500.000				**9.500.000**
United Kingdom	99.000	177.000	26.730			**302.730**
United States	24.989.264	1.545.711	552.580		227.487	**27.315.042**
TOTAL	**31.509.836**	**53.580.631**	**45.697.198**	**1.385.450**	**308.087**	**132.481.202**

Total collector area in operation in the year 2003

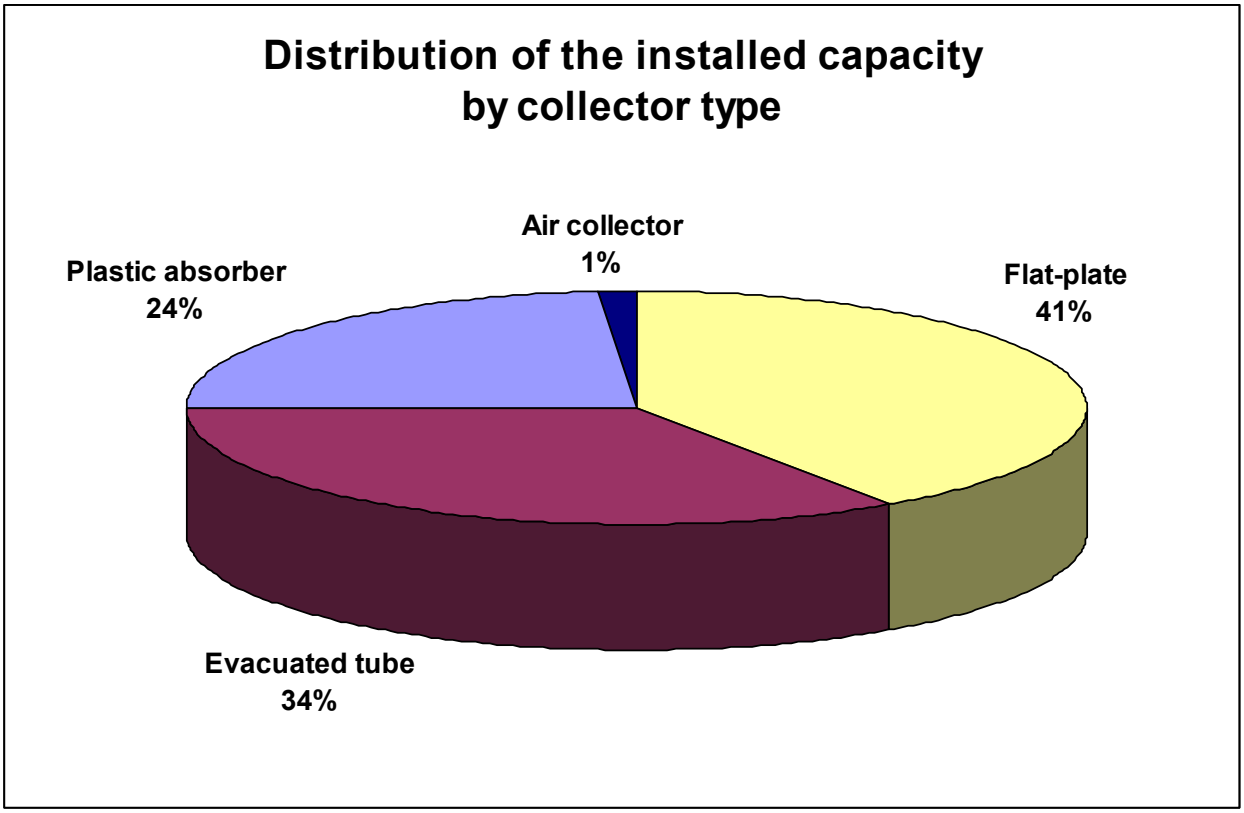


Figure 2: Distribution of the worldwide installed capacity by collector type

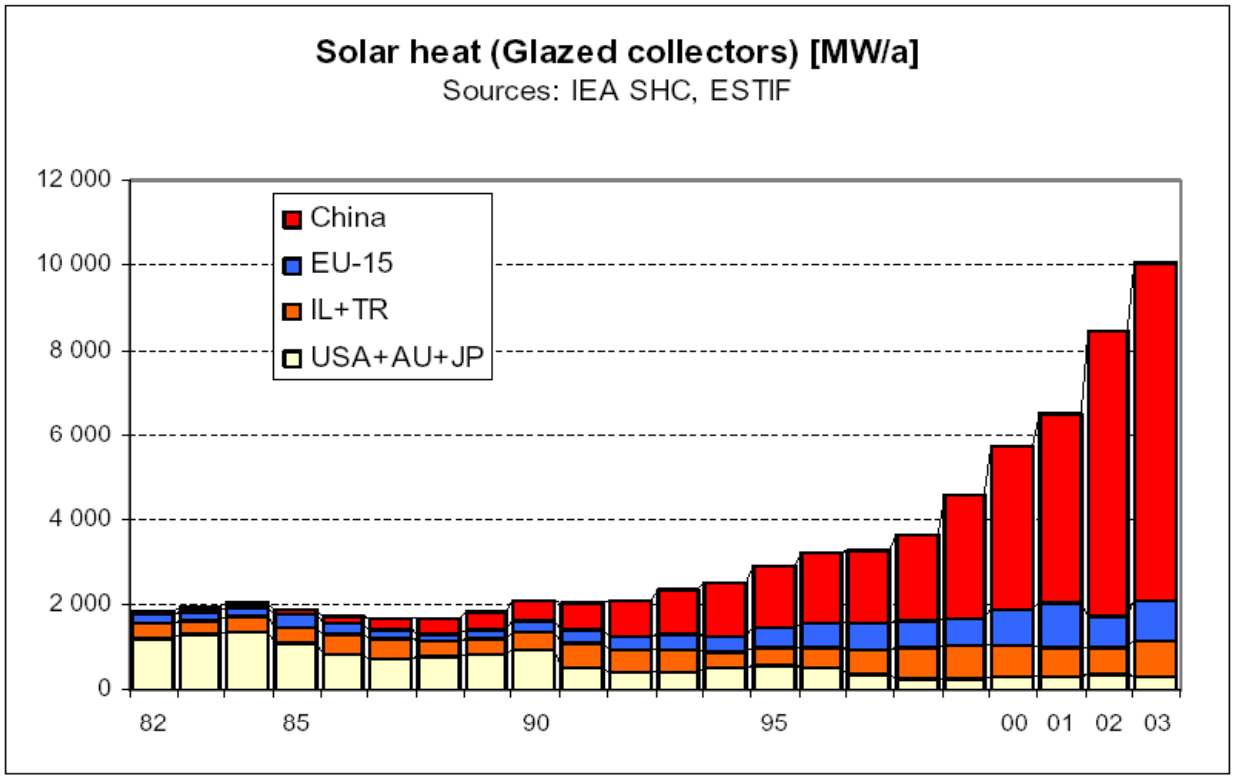


Figure 3: Solar thermal collectors installed in different economic regions (Source: J.O. Dalenbäck)

3.1 Installed capacity of glazed flat-plate and evacuated tube collectors by the year 2003

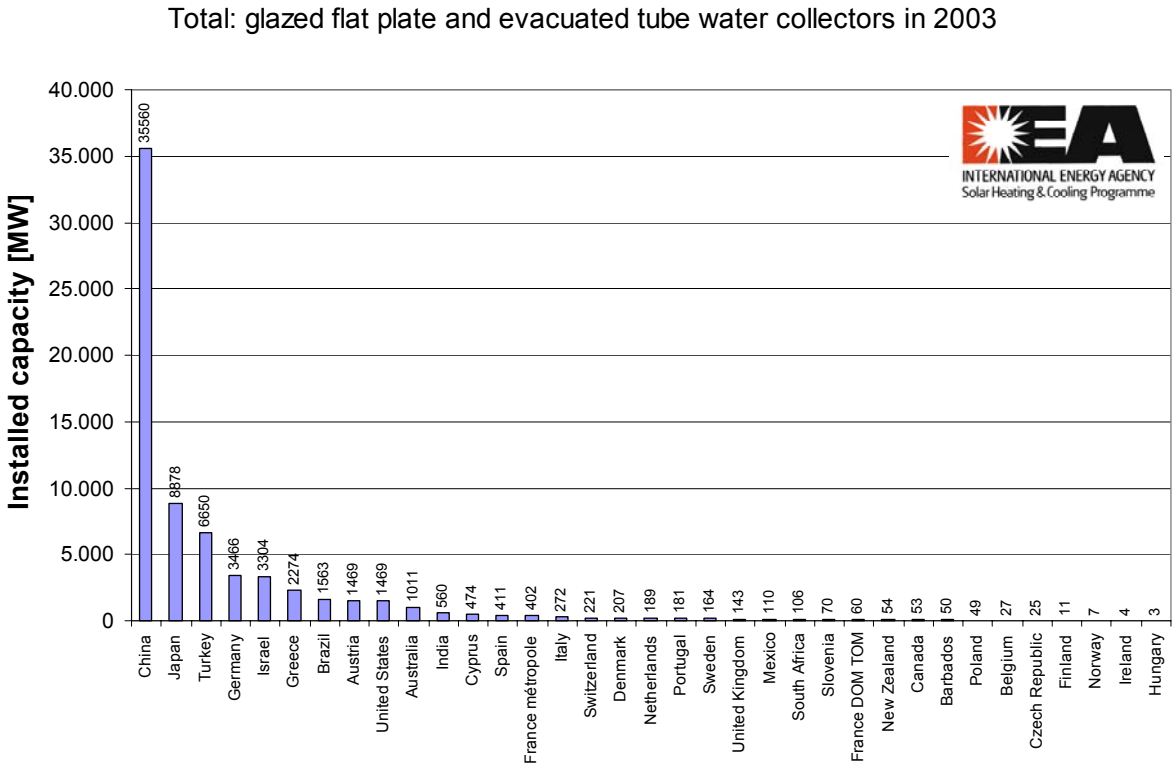


Figure 4: Glazed flat plate and evacuated tube collectors in operation in the year 2003

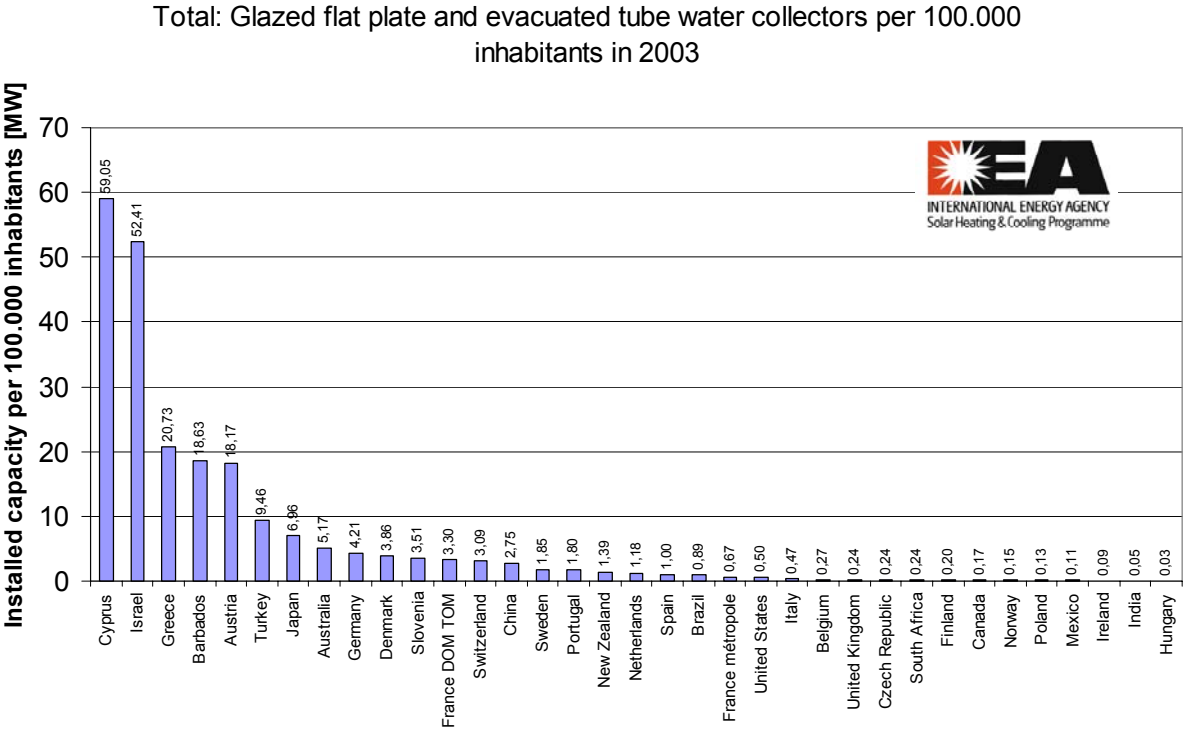
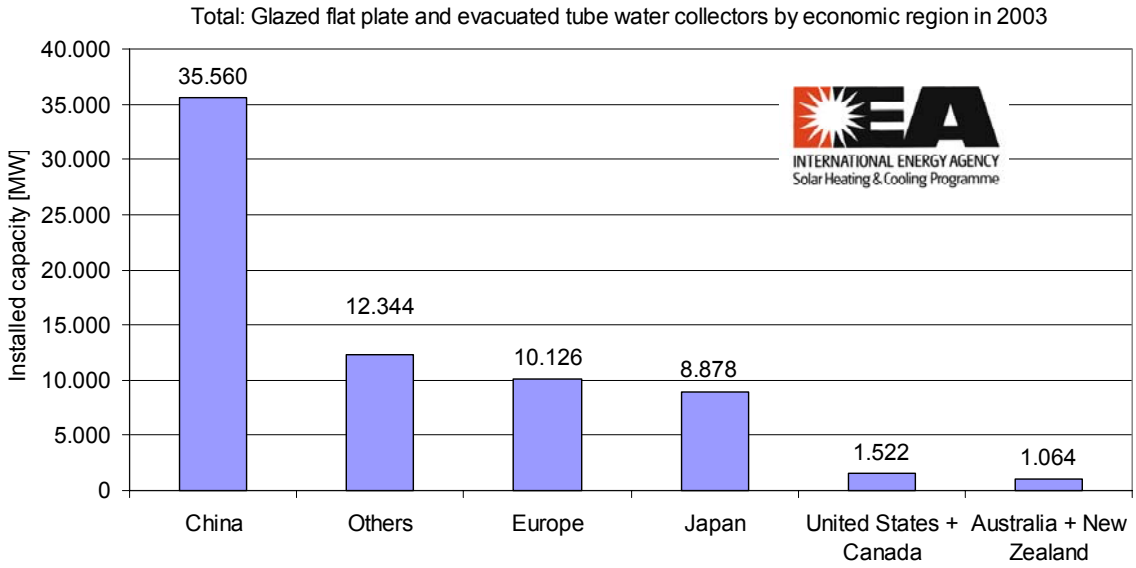


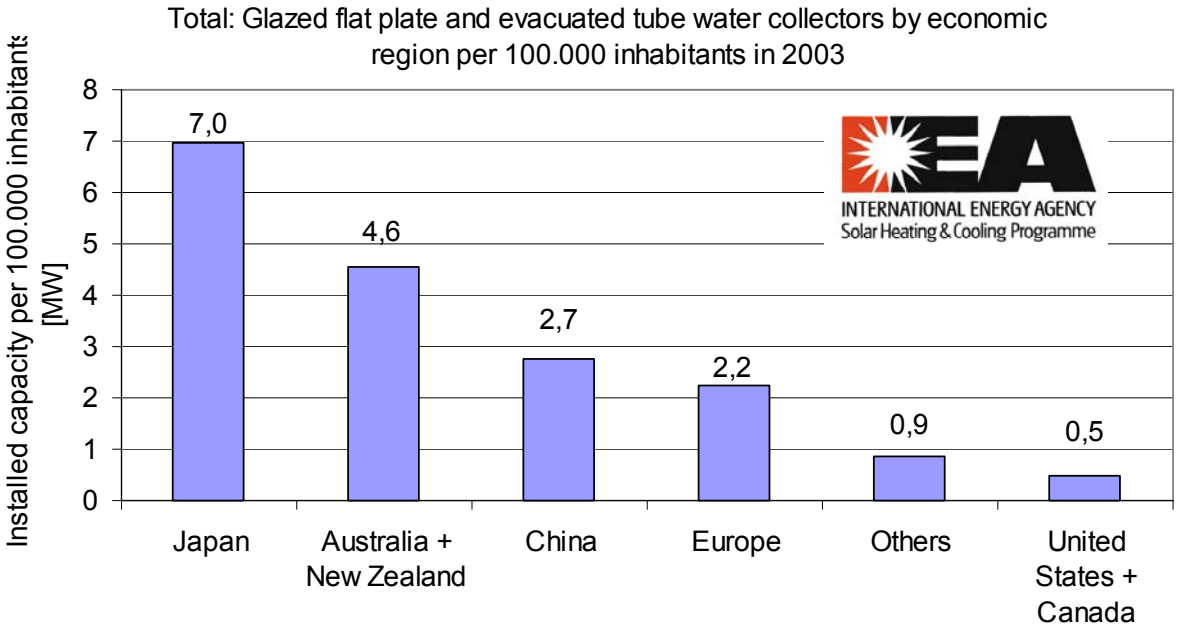
Figure 5: Glazed flat plate and evacuated tube collectors in operation in the year 2003 per 100.000 inhabitants

3.2 Glazed flat plate and evacuated tube collectors in operation in 2003 by economic region



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 6: Glazed flat plate and evacuated tube collectors in operation by economic region in the year 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 7: Glazed flat plate and evacuated tube collectors in operation by economic region in the year 2003 per 100.000 inhabitants

3.3 Unglazed collectors in operation by the year 2003

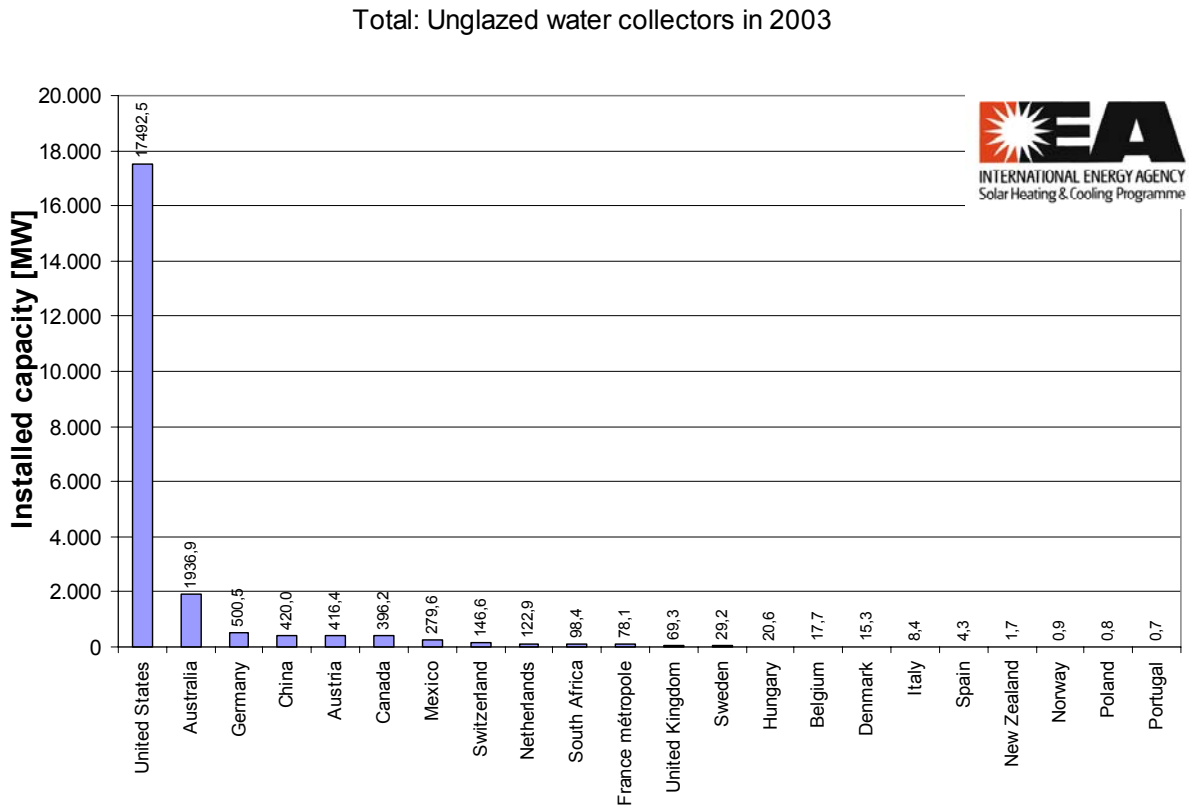


Figure 8: Unglazed collectors in operation in the year 2003

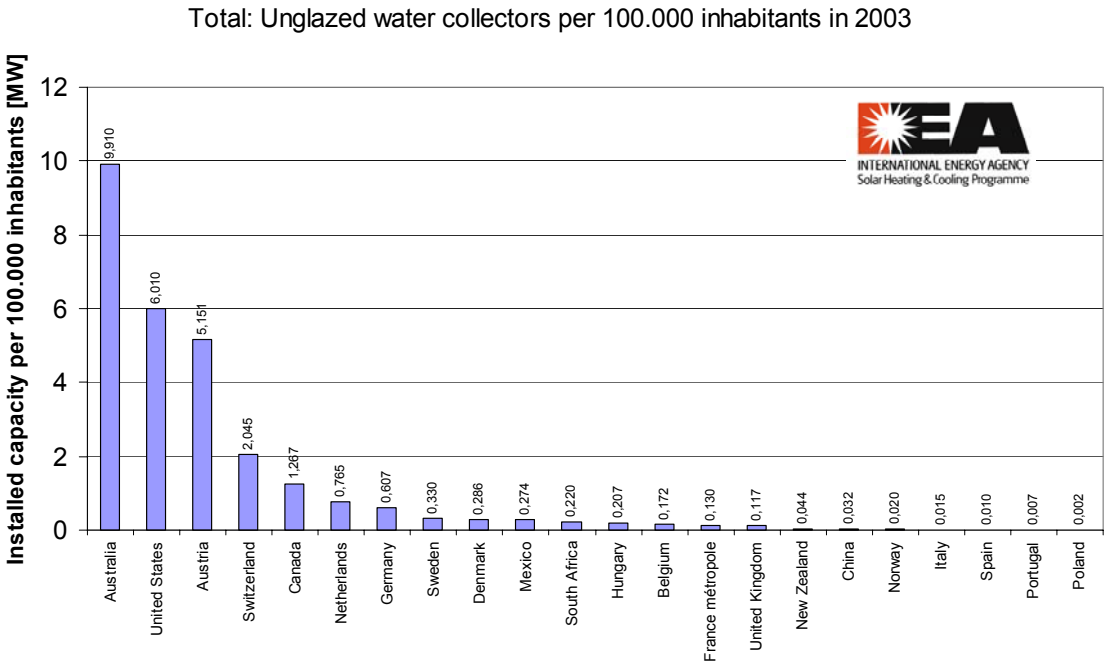
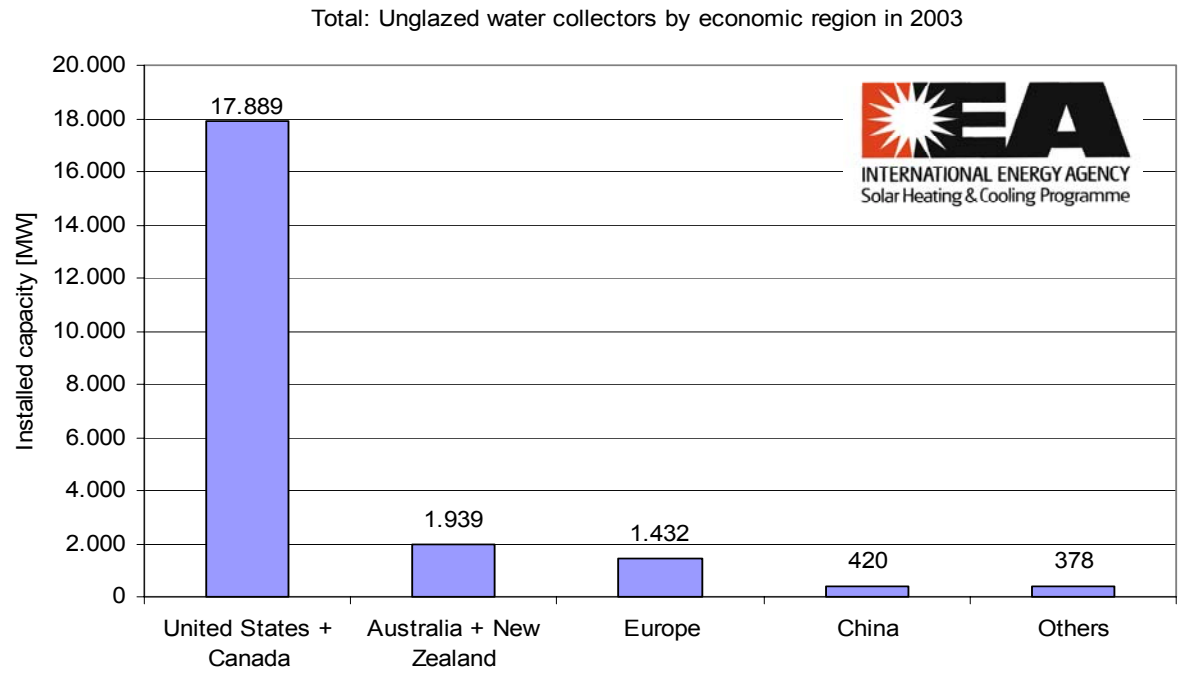


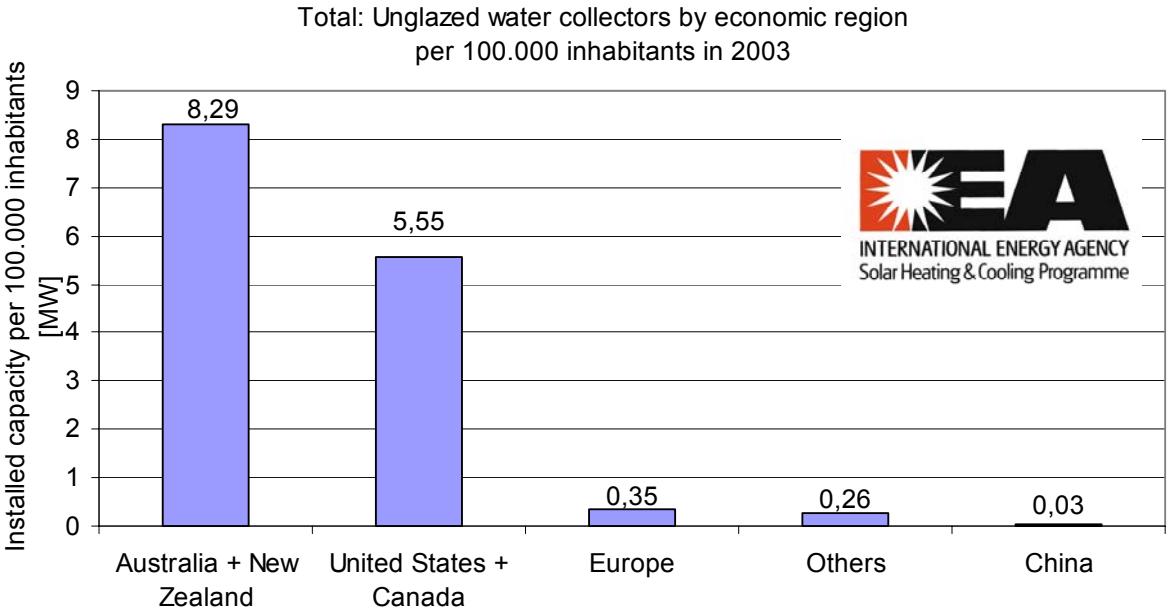
Figure 9: Unglazed collectors in operation in different countries in the year 2003 per 100.000 inhabitants

3.4 Unglazed collectors in operation by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 10: Unglazed collectors in operation by economic region in the year 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 11: Unglazed collectors in operation by economic region in the year 2003 per 100.000 inhabitants

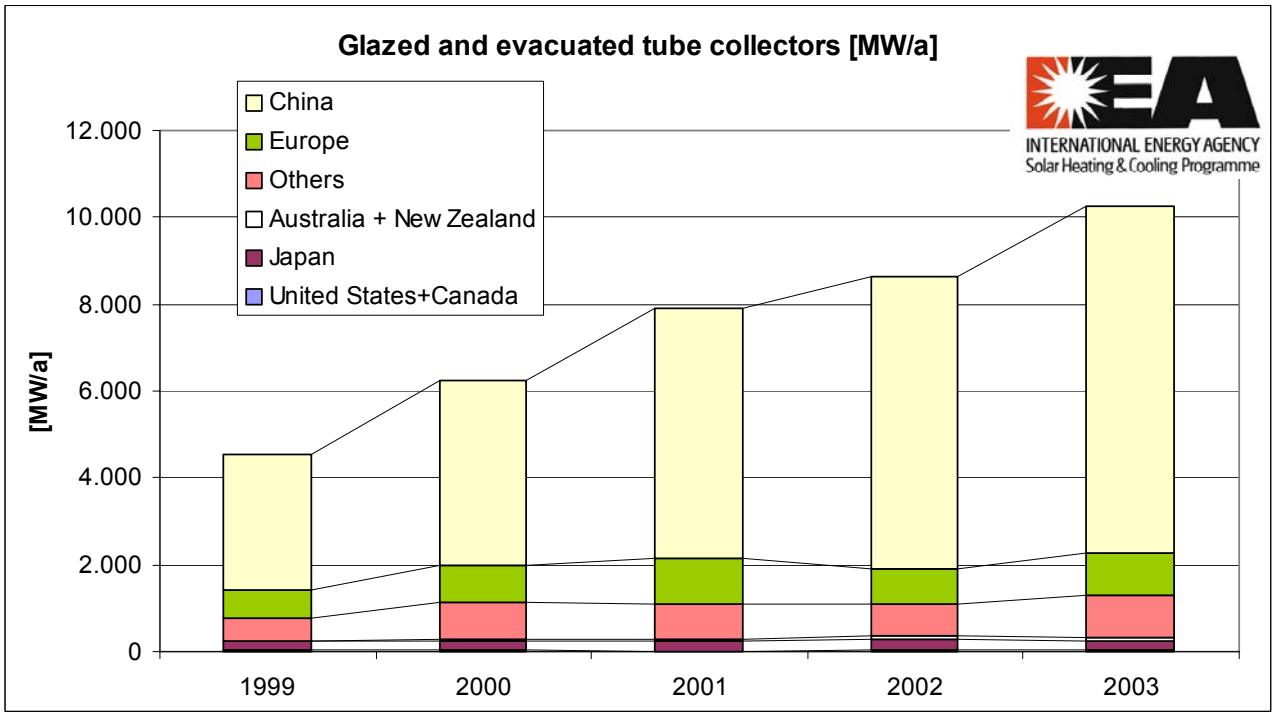
4 Market development

Analyzing the market development from 1999 to 2003 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 2003 was 27% in China, 23% in Australia and New Zealand and 11% in Europe.

The worldwide market of unglazed collectors for swimming pool heating recorded after an increase between 1999 and 2002 a decrease in 2003.

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

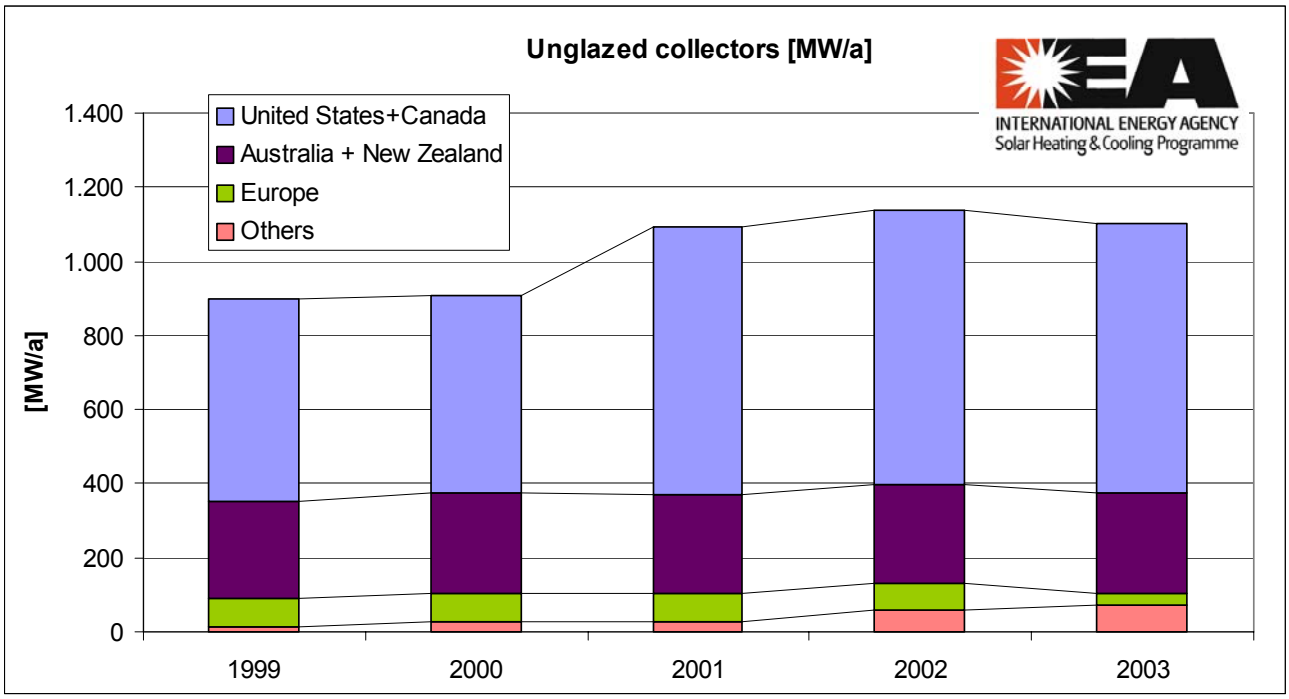


Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 12: 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 and 2).

4.2 Market development of unglazed plastic collectors by economic region



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 13: Annual installed capacity of unglazed 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 69.5 GW_{th} and unglazed plastic collector capacity of 22 GW_{th} was installed by the end of the year 2003 in the recorded countries. The annual yield of these collectors is calculated to be 55,233 GWh (198,837 TJ). This corresponds to a calculated oil equivalent of 8.8 billion liter and an annual CO_2 reduction of 24 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.

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

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.

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.

Table 3: 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) in 2003

Country	total collector area* [m²]	calculated number of systems	collector yield [GWh/a]	collector yield [TJ/a]	energy savings - oil equivalent [l/a]	CO2 reduction [t/a]
Australia	4.211.000	358.229	1.624	5.848	286.094.184	780.698
Austria	2.693.177	294.505	927	3.338	132.919.229	362.699
Barbados	71.870	17.967	59	211	10.457.028	28.514
Belgium	64.363	9.909	19	70	2.838.986	7.746
Brazil	2.233.000	558.250	981	3.531	174.732.250	476.746
Canada	642.208	14.974	157	565	25.659.220	70.011
China	51.400.000	12.703.000	21.826	78.575	3.450.390.000	9.418.268
Cyprus	677.000	166.136	425	1.529	72.836.805	198.603
Czech Republic	35.030	5.787	11	40	1.615.023	4.383
Denmark	316.990	64.524	105	379	14.906.000	40.669
Finland	15.150	3.613	5	17	634.009	1.730
France metropole	685.673	138.570	234	841	34.559.249	94.288
France DOM TOM	86.350	21.588	70	253	12.563.925	34.259
Germany	5.666.000	721.140	1.953	7.030	285.513.387	778.974
Greece	3.248.000	812.000	1.892	6.811	302.876.000	827.347
Hungary	33.700	857	10	36	1.710.138	4.666
India	800.000	200.000	349	1.257	55.000.000	150.200
Ireland	5.210	1.303	2	6	226.635	617
Israel	4.720.000	1.180.000	3.460	12.455	552.240.000	1.505.680
Italy	400.000	97.060	169	608	26.707.846	72.862
Japan	12.682.505	3.070.012	6.019	21.670	904.530.207	2.467.800
Mexico	556.703	15.266	222	800	41.346.409	112.812
Netherlands	446.293	124.477	116	418	16.893.336	46.268
New Zealand	79.043	18.291	24	85	3.745.194	10.221
Norway	10.949	1.589	3	12	454.659	1.241
Poland	70.669	11.490	23	81	3.303.505	9.005
Portugal	259.710	61.707	163	586	26.577.479	72.513
Slovenia	99.651	16.316	40	144	5.995.389	16.366
South Africa	292.619	38.732	93	335	15.936.119	43.453
Spain	592.561	139.899	360	1.295	54.268.759	148.077
Sweden	276.286	20.535	84	302	11.327.269	30.930
Switzerland	525.670	46.688	143	515	39.097.548	57.154
Turkey	9.500.000	2.156.500	5.663	20.387	899.963.500	2.458.054
United Kingdom	302.730	51.428	83	298	12.258.464	33.451
United States	27.087.555	474.661	7.919	28.508	1.359.426.271	3.709.173
Total	**130.787.665**	**23.617.004**	**55.233**	**198.837**	**8.839.604.025**	**24.075.477**

Contribution of thermal collectors to the supply of energy in 2003

*) Unglazed, glazed flat plate and evacuated tube collectors

Table 4: 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 in 2003

Country	total collector area* [m²]	number of systems	collector yield [GWh/a]	collector yield [Tera J /a]	energy savings - oil equivalent [l/a]	CO2 reduction [t/a]
Australia	1.444.000	344.394	605	2.179	105.642.896	288.346
Austria	2.098.354	291.531	793	2.853	110.901.856	302.625
Barbados	71.870	17.967	59	211	10.457.028	28.514
Belgium	39.131	9.783	15	55	2.123.835	5.794
Brazil	2.233.000	558.250	981	3.531	174.732.250	476.746
Canada	76.220	12.144	35	126	4.915.194	13.412
China	50.800.000	12.700.000	21.704	78.135	3.429.000.000	9.359.900
Cyprus	677.000	166.136	425	1.529	72.836.805	198.603
Czech Republic	35.030	5.787	11	40	1.615.023	4.383
Denmark	295.120	64.415	102	367	14.338.397	39.120
Finland	15.150	3.613	5	17	634.009	1.730
France metropole	574.173	138.012	212	762	30.763.399	83.931
France DOM TOM	86.350	21.588	70	253	12.563.925	34.259
Germany	4.951.000	717.565	1.799	6.477	258.905.019	706.375
Greece	3.248.000	812.000	1.892	6.811	302.876.000	827.347
Hungary	4.300	710	2	6	261.600	714
India	800.000	200.000	349	1.257	55.000.000	150.200
Ireland	5.210	1.303	2	6	226.635	617
Israel	4.720.000	1.180.000	3.460	12.455	552.240.000	1.505.680
Italy	388.000	97.000	166	599	26.257.900	71.635
Japan	12.682.505	3.070.012	6.019	21.670	904.530.207	2.467.800
Mexico	157.210	13.269	106	383	20.690.025	56.452
Netherlands	270.694	123.599	89	322	12.521.974	34.341
New Zealand	76.643	18.279	23	83	3.652.928	9.970
Norway	9.650	1.583	3	12	425.432	1.161
Poland	69.519	11.485	22	80	3.263.347	8.896
Portugal	258.710	61.702	162	585	26.534.940	72.397
Slovenia	99.651	16.316	40	144	5.995.389	16.366
South Africa	152.119	38.030	67	240	11.523.014	31.413
Spain	586.449	139.868	358	1.289	53.948.558	147.203
Sweden	234.530	20.326	78	282	10.463.087	28.572
Switzerland	316.220	45.641	107	384	33.110.943	40.820
Turkey	9.500.000	2.156.500	5.663	20.387	899.963.500	2.458.054
United Kingdom	203.730	50.933	68	244	9.712.828	26.505
United States	2.098.291	349.715	1.203	4.331	200.561.648	547.269
Total	**99.277.829**	**23.459.455**	**46.696**	**168.105**	**7.363.189.592**	**20.047.149**

Contribution of thermal collectors to the supply of energy (without Solar systems for swimming pools) in 2003

*)Glazed flat plate and evacuated tube collectors

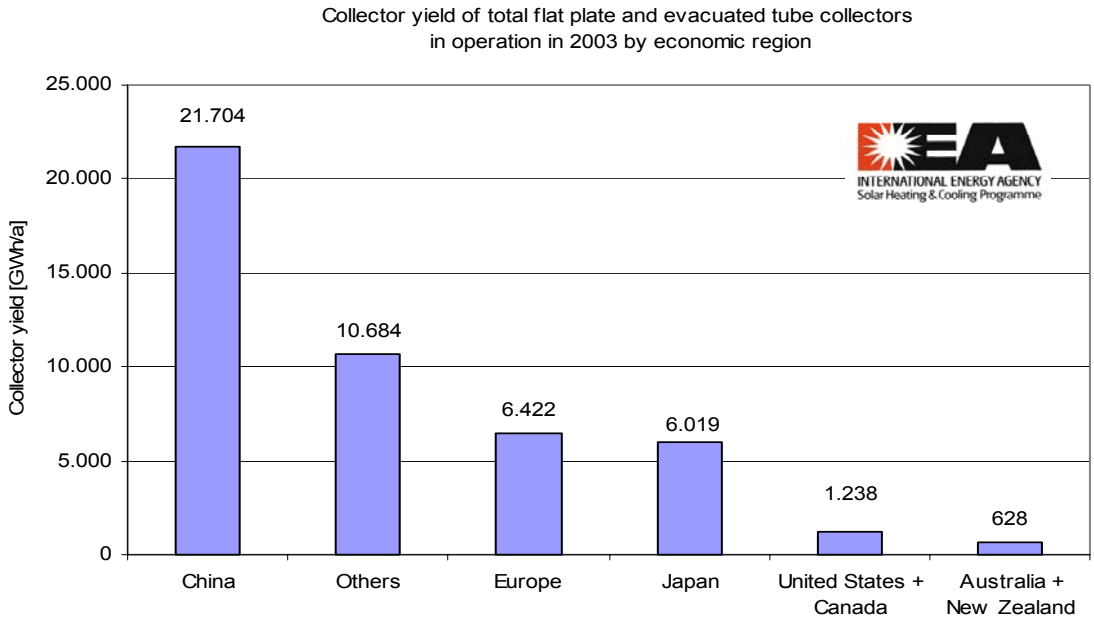
Table 5: Calculated collector yield and corresponding oil equivalent as well as CO_2-reduction of solar thermal systems for swimming pool heating with unglazed collectors in 2003

Country	total collector area [m²]	calculated number of systems	collector yield [GWh/a]	collector yield [Tera J/a]	energy savings - oil equivalent [l/a]	CO2 reduction [t/a]
Australia	2.767.000	13.835	1.019	3.669,2	180.451.289	492.352
Austria	594.823	2.974	135	485,3	22.017.373	60.074
Barbados						
Belgium	25.232	126	4	15,2	715.151	1.951
Brazil						
Canada	565.988	2.830	122	439,3	20.744.026	56.599
China	600.000	3.000	122	439,5	21.390.000	58.368
Cyprus						
Czech Republic						
Denmark	21.870	109	3	12,1	567.603	1.549
Finland						
France métropole	111.500	558	22	78,9	3.795.850	10.357
France DOM TOM						
Germany	715.000	3.575	154	553,3	26.608.368	72.599
Greece						
Hungary	29.400	147	8	30,2	1.448.538	3.952
India						
Ireland						
Israel						
Italy	12.000	60	3	9,1	449.946	1.228
Japan						
Mexico	399.493	1.997	116	417,2	20.656.385	56.360
Netherlands	175.599	878	27	95,5	4.371.362	11.927
New Zealand	2.400	12	1	1,9	92.266	252
Norway	1.299	6	0,19	0,7	29.228	80
Poland	1.150	6	0,24	0,9	40.158	110
Portugal	1.000	5	0,24	0,9	42.539	116
Slovenia						
South Africa	140.500	703	26	95,1	4.413.105	12.041
Spain	6.112	31	2	6,6	320.202	874
Sweden	41.756	209	6	20,1	864.182	2.358
Switzerland	209.450	1.047	36	130,7	5.986.605	16.334
Turkey						
United Kingdom	99.000	495	15	54,0	2.545.637	6.946
United States	24.989.264	124.946	6.716	24.177,1	1.158.864.623	3.161.904
Total	**31.509.836**	**157.549**	**8.537**		**1.476.414.433**	**4.028.328**

Solar systems for swimming pools - calculation results for the reference system in 2003

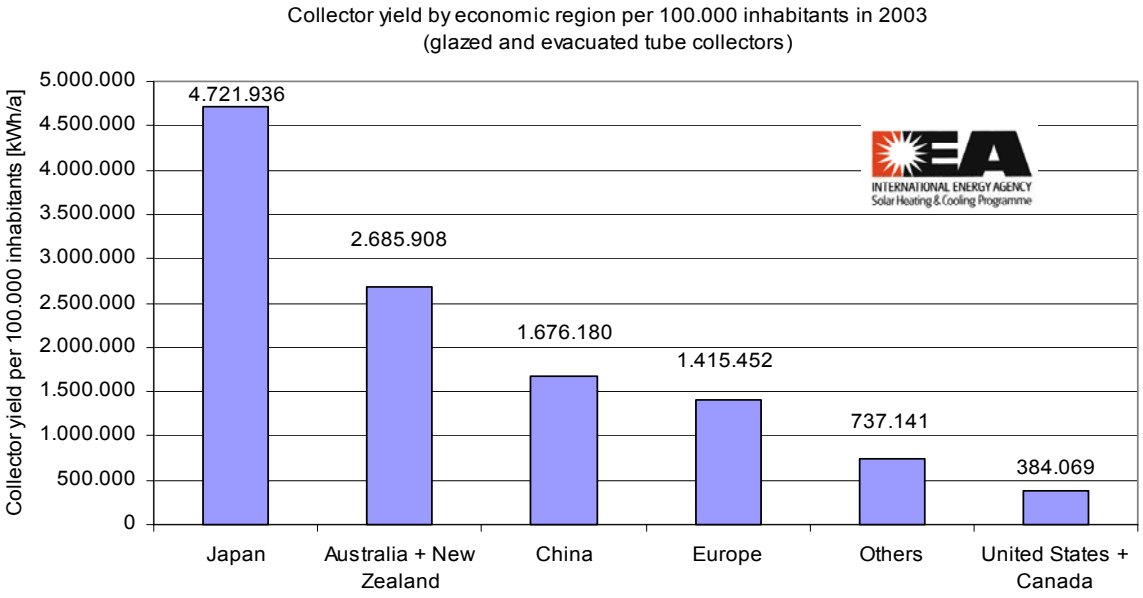
5.1 Collector yield by economic region in 2003

5.1.1 Collector yield of glazed flat plate and evacuated tube collectors by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

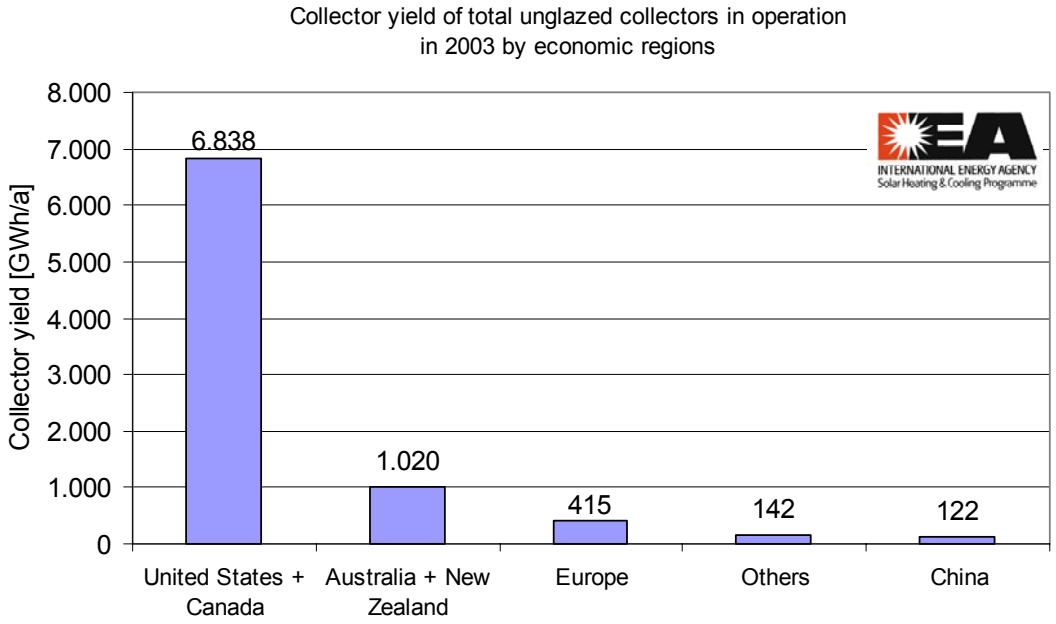
Figure 14: Annual collector yield of glazed flat plate and evacuated tube collectors in operation by economic region in the year 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

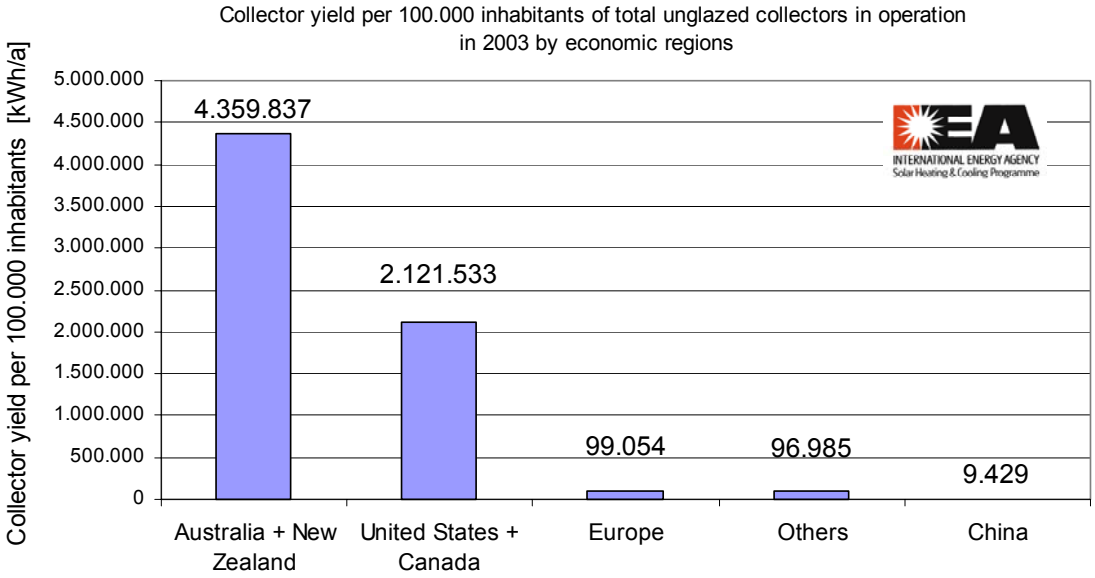
Figure 15: Annual collector yield of glazed flat plate and evacuated tube collectors in operation by economic region in the year 2003 per 100.000 inhabitants

5.1.2 Collector yield of unglazed collectors by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 16: Annual collector yield of unglazed collectors in operation by economic region in the year 2003

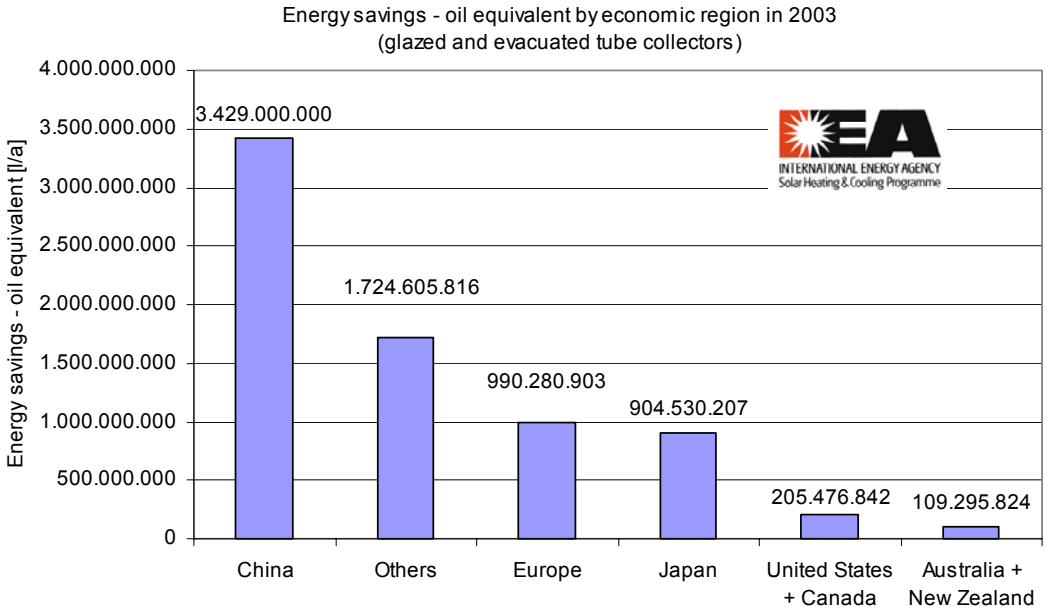


Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 17: Annual collector yield of unglazed collectors in operation by economic region in the year 2003 per 100.000 inhabitants

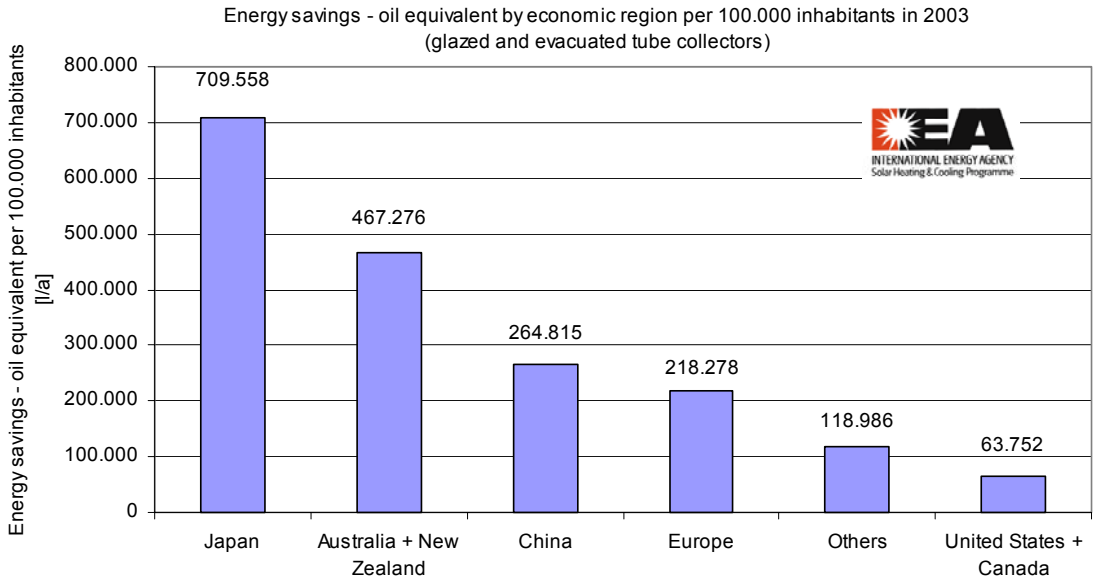
5.2 Energy savings by economic region in 2003

5.2.1 Energy savings in oil equivalent - glazed flat plate and evacuated tube collectors by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

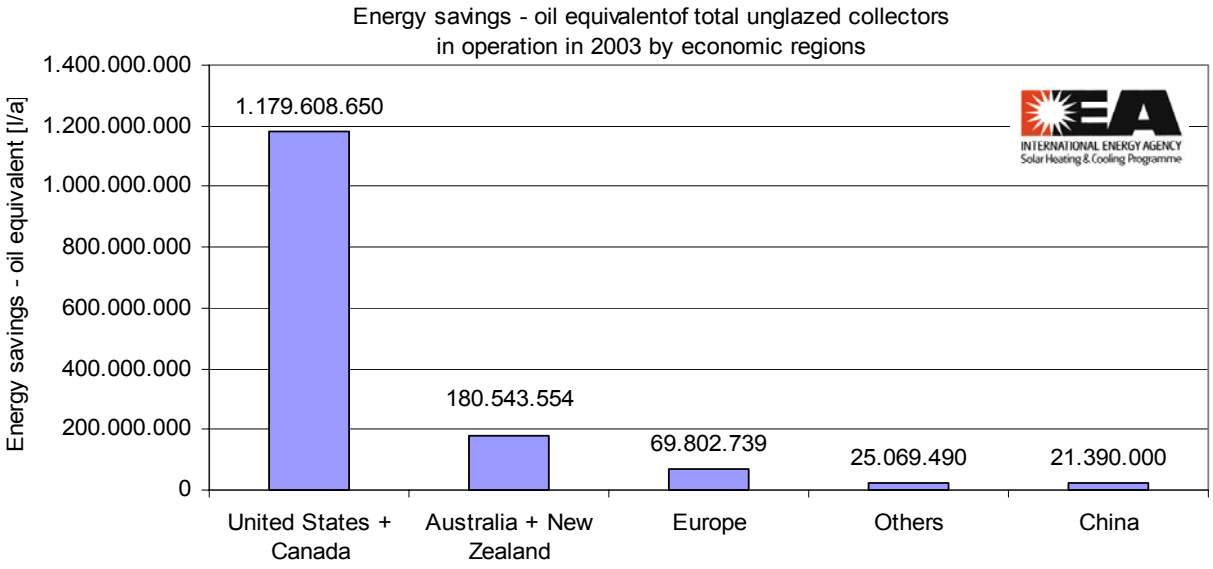
Figure 18: Annual energy savings in oil equivalent - glazed flat plate and evacuated tube collectors by economic region in the year 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

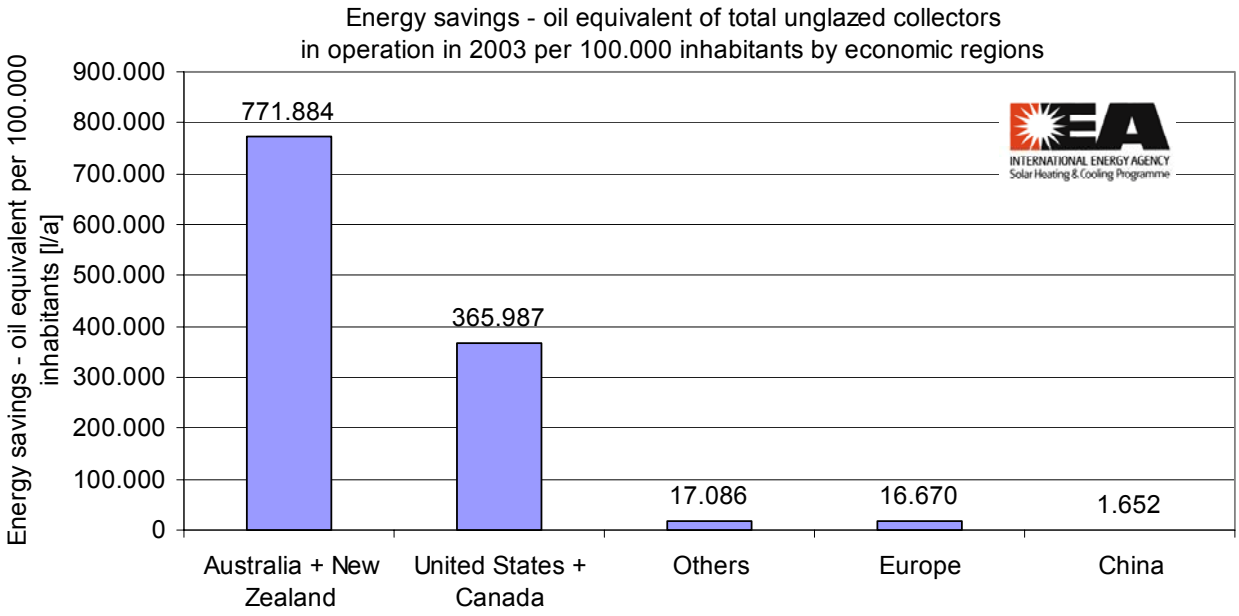
Figure 19: Annual energy savings in oil equivalent - glazed flat plate and evacuated tube collectors operation by economic region in the year 2003 per 100.000 inhabitants

5.2.2 Energy savings in oil equivalent - unglazed collectors by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 20: Annual energy savings in oil equivalent - unglazed collectors by economic region in the year 2003

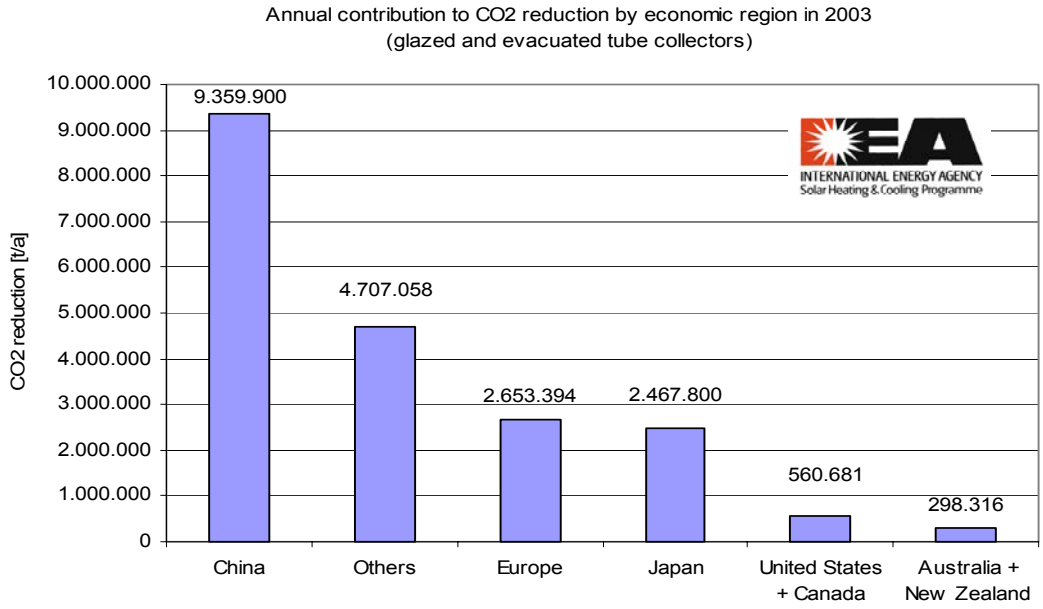


Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 21: Annual energy savings by economic region in the year 2003 per 100.000 inhabitants in oil equivalent - unglazed collectors

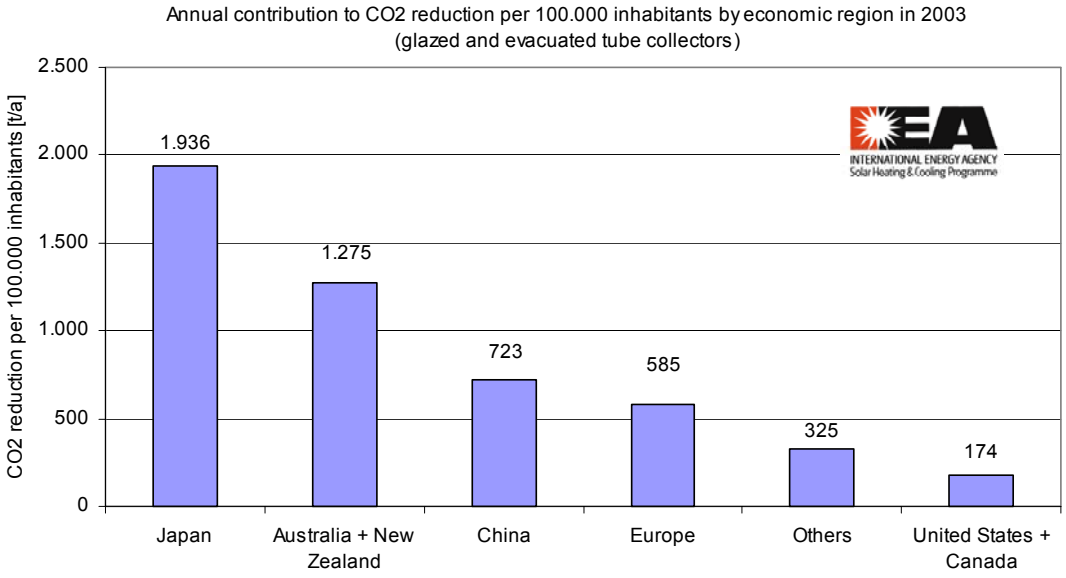
5.3 Contribution to CO_2 reduction by economic region in 2003

5.3.1 Contribution to CO_2 reduction: Flat plate and evacuated tube collectors by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

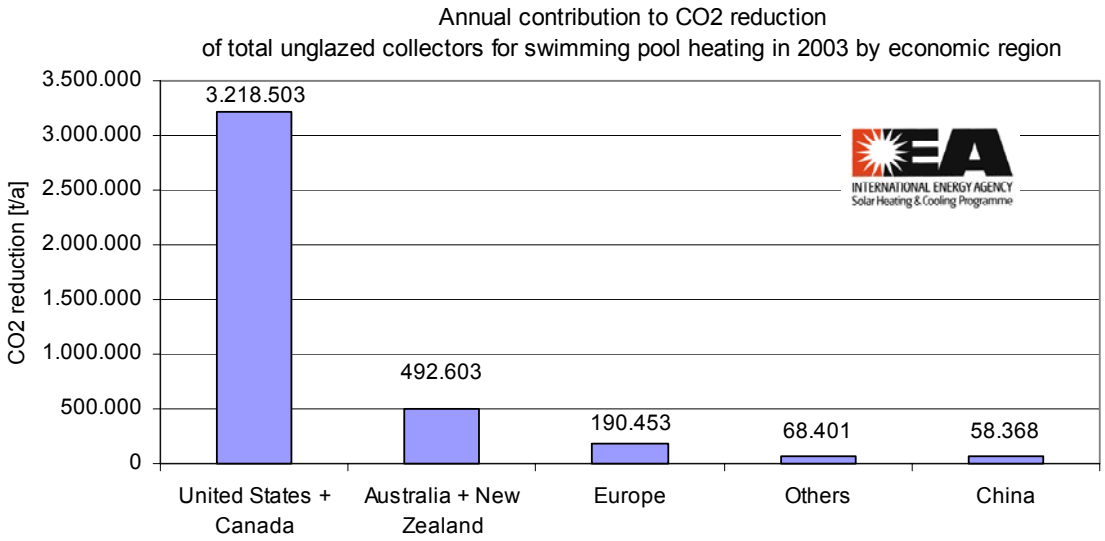
Figure 22: Annual contribution to CO_2 reduction – flat plate and evacuated tube collectors by economic region in the year 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

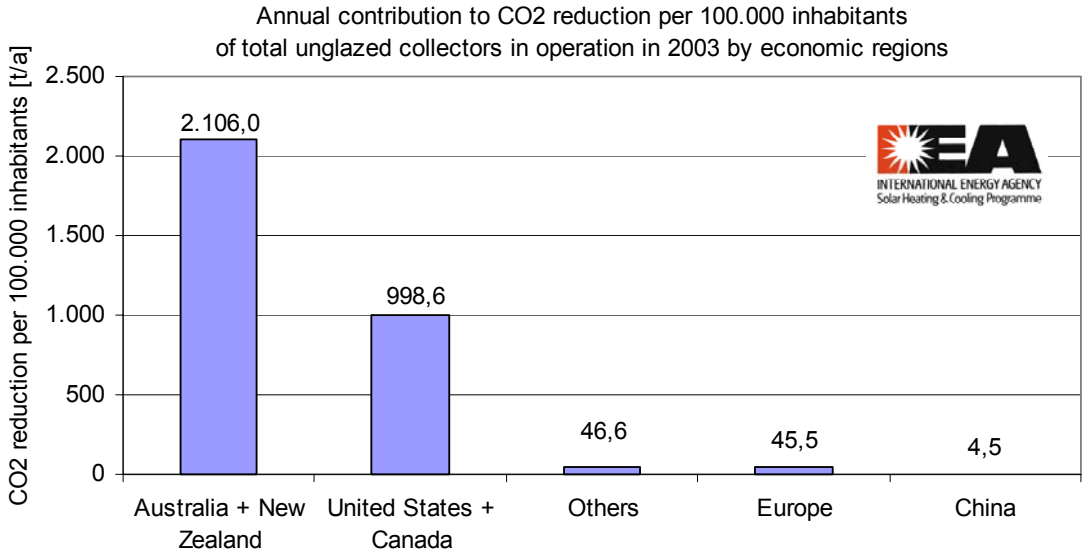
Figure 23: Annual contribution to CO_2 reduction by economic region in the year 2003 per 100.000 inhabitants– flat plate and evacuated tube collectors

5.3.2 Contribution to CO_2 reduction: Unglazed collectors by economic region in 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 24: Annual contribution to CO_2 reduction – unglazed collectors by economic region in the year 2003



Europe: EU 15 - Luxemburg + CH, Norway, Cyprus, Czech Republic, Hungary, Slovenia and Poland
Others: Barbados, Brazil, India, Israel, Mexico, South Africa, Turkey

Figure 25: Annual contribution to CO_2 reduction by economic region in the year 2003 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 2003. It has to be mentioned here, that the number of countries who made data available increased from 21 countries in 1999 to 35 countries in 2003. Therefore the total numbers can not be compared directly.

Table 6: Installed capacity in 1999, MW/yr

Country	Water Collectors			Air Collectors		TOTAL
	unglazed	glazed	evacuated	unglazed	glazed	
Australia						
Austria	11,84	97,13	1,68		0,35	**111,0**
Belgium	0,88	0,91	0,14			**1,9**
Canada	17,50	0,16	0,02	1,39		**19,1**
Denmark	0,17	10,71	0,07			**11,0**
Finland		1,05	0,07	0,35		**1,5**
France	4,90	16,10	0,70			**21,7**
Germany	35,00	252,00	42,00		3,50	**332,5**
Greece		112,78				**112,8**
Italy	2,10	31,50	2,10	0,35	0,35	**36,4**
Japan		208,93	5,80			**214,7**
Mexico	15,09	3,77				**18,9**
Netherlands	5,60	19,60		0,21		**25,4**
New Zealand	2,80	2,80				**5,6**
Norway	0,07	0,70			0,07	**0,8**
Portugal	0,35	5,60	0,35			**6,3**
Spain		15,11				**15,1**
Sweden	2,05	6,55	0,10		0,06	**8,8**
Switzerland	12,27	19,92	0,81			**33,0**
Turkey		525,00				**525,0**
United Kingdom		2,10	4,20			**6,3**
United States	530,14	26,92	0,39		0,72	**558,2**
TOTAL	**640,8**	**1.359,3**	**58,4**	**2,3**	**5,0**	**2.065,9**

Collector Area Installed in 1999, MW/yr

Table 7: Installed capacity in 2000, MW/yr

Country	Water Collectors			Air Collectors		TOTAL
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	266,00	49,70				**315,7**
Austria	10,32	105,38	1,68	2,10	0,39	**119,9**
Belgium	0,88	0,98	0,14			**2,0**
Canada	18,90	0,44	0,11	2,36		**21,8**
China		1.498,00	2.772,00			**4.270,0**
Denmark	0,05	9,01	0,04			**9,1**
Finland		1,40		0,35		**1,8**
France	5,25	23,80				**29,1**
Germany	35,00	357,00	77,00		4,90	**473,9**
Greece		119,00				**119,0**
India		49,00				**49,0**
Ireland		0,24	0,03			**0,3**
Israel		273,00	0,30			**273,3**
Italy	2,10	31,50	2,10	0,35	0,35	**36,4**
Japan		211,13	4,12			**215,3**
Mexico	25,04	12,34	0,00			**37,4**
Netherlands	5,25	18,90	0,04	0,21		**24,4**
New Zealand	3,15	3,15				**6,3**
Norway	0,07	0,70		14,00	0,07	**14,8**
Portugal	0,35	5,25	0,35			**6,0**
Spain	0,00	24,97				**25,0**
Sweden	2,09	12,63	0,61			**15,3**
Switzerland	10,35	17,29	1,09	6,30		**35,0**
Turkey		525,00				**525,0**
United Kingdom	7,00	6,30	0,70			**14,0**
United States	516,86	24,97	0,98		0,39	**543,2**
TOTAL	**908,6**	**3.381,1**	**2.861,3**	**25,7**	**6,1**	**7.182,8**

Collector Area Installed in 2000, MW/yr

Table 8: Installed capacity in 2001, MW/yr

Country	Water Collectors			Air Collectors		TOTAL
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	266,0	52,5				**318,5**
Austria	6,3	110,5	1,6			**118,4**
Belgium	0,5	2,9	0,2			**3,7**
Canada	16,1	0,7	0,1	2,9		**19,8**
China		2.009,0	3.731,0			**5.740,0**
Denmark	0,4	18,2	0,1			**18,7**
Finland		1,1	0,0			**1,1**
France	9,8	27,0				**36,8**
Germany	35,0	525,0	105,0			**665,0**
Greece		122,5				**122,5**
India		56,0				**56,0**
Ireland		0,1	0,1			**0,2**
Israel		294,0				**294,0**
Italy	2,1	27,8	2,6	0,4	0,4	**33,2**
Japan		217,0	2,8			**219,8**
Mexico	25,3	11,1				**36,5**
Netherlands	5,3	21,5				**26,7**
New Zealand	0,8	1,9	0,0			**2,7**
Norway	0,1	0,2				**0,2**
Portugal		4,2				**4,2**
Spain	3,5	36,5	3,5			**43,5**
Sweden	2,4	15,1	0,3			**17,7**
Switzerland	4,2	15,3	0,6	6,3		**26,5**
Turkey		441,0				**441,0**
United Kingdom	7,0	5,6	5,1			**17,7**
United States	710,1	17,0	0,3		0,4	**727,8**
TOTAL	**1.095,0**	**4.033,6**	**3.853,3**	**9,5**	**0,7**	**8.992,1**

Collector Area Installed in 2001, MW/yr

Table 9: Installed capacity in 2002, MW/yr

Country	Water Collectors			Air Collectors		TOTAL
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	266,0	78,4				**344,4**
Austria	7,4	105,7	1,4			**114,5**
Barbados		1,9				**1,9**
Belgium	0,5	2,9	0,2			**3,7**
Brazil		33,6				**33,6**
Canada	16,7	0,8	0,1	6,8		**24,3**
China		1.050,0	5.670,0			**6.720,0**
Cypres		8,4				**8,4**
Czech Republic						**0,0**
Denmark		11,2				**11,2**
Finland		1,1	0,0			**1,1**
France métropole	4,9	18,8				**23,7**
France DOM TOM		28,9				**28,9**
Germany	35,0	332,5	45,5			**413,0**
Greece		92,4				**92,4**
Hungary		0,8	0,04			**0,8**
India		70,0				**70,0**
Ireland		0,5	0,1			**0,6**
Israel		280,0				**280,0**
Italy	2,1	32,2	4,2			**38,5**
Japan		231,1	3,8			**234,9**
Mexico	21,4	14,3				**35,6**
Netherlands	5,3	23,3	0,5			**29,1**
New Zealand	0,8	2,5	0,1			**3,4**
Norway	0,1	0,5		3,5	0,1	**4,2**
Poland	0,2	8,6	0,8			**9,7**
Portugal		3,5				**3,5**
Slovenia		0,7	0,2			**0,9**
South Africa	39,2	9,7	0,0			**48,9**
Spain	0,2	38,9	3,3			**42,3**
Sweden	2,7	10,3	0,4			**13,4**
Switzerland	3,2	15,2	0,3	2,1		**20,8**
Turkey		350,0				**350,0**
United Kingdom	7,0	5,6	5,3			**17,9**
United States	723,8	34,4	0,3		0,3	**758,7**
TOTAL	**1.136,5**	**2.898,8**	**5.736,4**	**12,4**	**0,3**	**9.784,4**

Collector Area Installed in 2002, MW/yr

Table 10: Installed capacity in 2003, MW/yr

Country	Water Collectors			Air Collectors		TOTAL
	unglazed	glazed	evacuated	unglazed	glazed	
Australia	270,9	93,8				**364,7**
Austria	6,9	115,6	1,2			**123,8**
Barbados		1,9				**1,9**
Belgium	1,3	6,0	0,3			**7,6**
Brazil		23,1				**23,1**
Canada	18,3	0,8	0,1	7,3		**26,5**
China		980,0	7.000,0			**7.980,0**
Cypres		10,5				**10,5**
Czech Republic		4,5	0,4			**4,9**
Denmark		5,6				**5,6**
Finland		1,1				**1,1**
France métropole	4,2	27,2	0,0			**31,4**
France DOM TOM		31,5				**31,5**
Germany		455,0	49,0			**504,0**
Greece		88,2				**88,2**
Hungary		1,0	0,0			**1,1**
India		70,0				**70,0**
Ireland		0,6	0,1		0,1	**0,8**
Israel		280,0				**280,0**
Italy	2,1	35,0	4,9			**42,0**
Japan		194,9	1,4			**196,3**
Mexico	34,3	18,4				**52,7**
Netherlands	9,8	19,4				**29,2**
New Zealand		4,2	0,2			**4,4**
Norway	0,4	1,1	0,1	3,5	0,1	**5,0**
Poland	0,2	16,7	1,6			**18,6**
Portugal		6,4				**6,4**
Slovenia		0,5	0,3			**0,8**
South Africa	39,2	1,0	0,0			**40,2**
Spain	0,6	43,1	5,4			**49,0**
Sweden	3,1	12,6	0,9			**16,6**
Switzerland	1,2	15,1	0,1	1,4		**17,9**
Turkey		560,0				**560,0**
United Kingdom		8,4	7,0			**15,4**
United States	707,6	35,8	0,6		0,4	**744,4**
TOTAL	**1.100,1**	**3.169,0**	**7.073,8**	**12,2**	**0,6**	**11.355,7**

Collector Area Installed in 2003, MW/yr

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[4]) 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 - described in section 4 - 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[5] 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 collector area [m²]	Number of systems	Reference climate
Australia	C: 200 m² unglazed plastic absorber	2.380.000	11.900	Sydney
Austria	C: 200 m² unglazed plastic absorber	591.423	2.957	Graz
Belgium	C: 200 m² unglazed plastic absorber	23.362	117	Brussels
Canada	C: 200 m² unglazed plastic absorber	539.794	2.699	Montreal
China	C: 200 m² unglazed plastic absorber	600.000	3.000	Shanghai
Denmark	C: 200 m² unglazed plastic absorber	21.870	109	Copenhagen
France métropole	C: 200 m² unglazed plastic absorber	105.500	528	Paris
Germany	C: 200 m² unglazed plastic absorber	715.000	3.575	Würzburg
Hungary	C: 200 m² unglazed plastic absorber	2.500	13	Budapest
Italy	C: 200 m² unglazed plastic absorber	9.000	45	Bologna
Mexico	C: 200 m² unglazed plastic absorber	350.546	1.753	Mexico City
Netherlands	C: 200 m² unglazed plastic absorber	161.599	808	Amsterdam
New Zealand	C: 200 m² unglazed plastic absorber	2.400	12	Wellington

[4] 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.
[5] Glazed flat plate and evacuated tube collector

Country	Reference system	Total collector area [m²]	Number of systems	Reference climate
Norway	C: 200 m² unglazed plastic absorber	799	4	Oslo
Poland	C: 200 m² unglazed plastic absorber	850	4	Warsaw
Portugal	C: 200 m² unglazed plastic absorber	1.000	5	Lisbon
South Africa	C: 200 m² unglazed plastic absorber	84.500	423	Johannisburg
Spain	C: 200 m² unglazed plastic absorber	5.302	27	Madrid
Sweden	C: 200 m² unglazed plastic absorber	37.314	187	Gothenburg
Switzerland	C: 200 m² unglazed plastic absorber	207.670	1.038	Zurich
United Kingdom	C: 200 m² unglazed plastic absorber	99.000	495	London
United States	C: 200 m² unglazed plastic absorber	23.978.390	119.892	Denver, Los Angeles
Total		**29.917.819**	**149.589**	

C: collector area

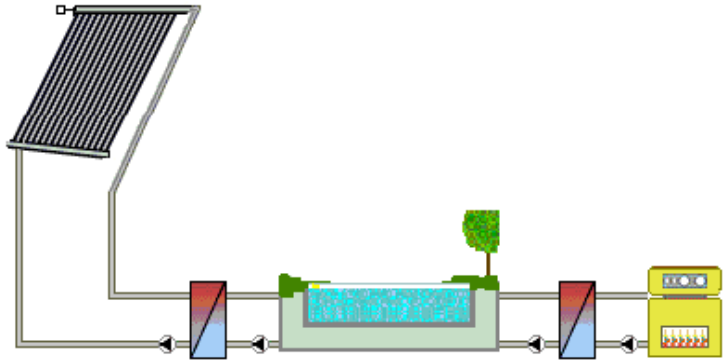


Figure A1: Hydraulic scheme of the swimming pool reference system

6.2.2 Solar domestic hot water systems for single family houses

Country	**reference system**	**reference climate**	**% of total market[6]**
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
Finland	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Helsinki	95
France metropole	C: 4 m² / ST: 200 l / HWD: 150 l/d / PS	Paris	95
France DOM TOM	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Raizet	100
Germany	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Würzburg	80
Greece	C: 4 m² / ST: 200 l / HWD: 150 l/d / TS	Athens	100
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
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
Slovenia	C: 6 m² / ST: 300 l / HWD: 150 l/d / PS	Zagreb	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
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

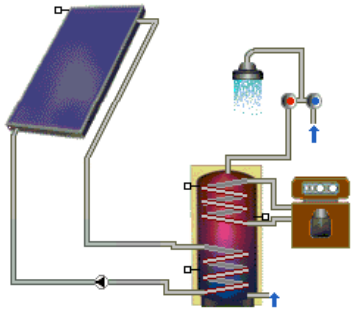


Figure A2: Hydraulic scheme of the DHW reference system

[6] percentage of total installed collector area (flat plate and vacuum tube) by the year 2000 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 [7]
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
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	Zagreb	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

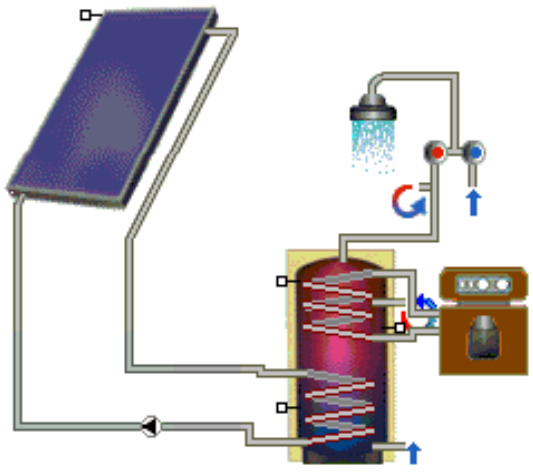


Figure A3: Hydraulic scheme of the DHW system for muli-family houses

[7] 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[8]
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]

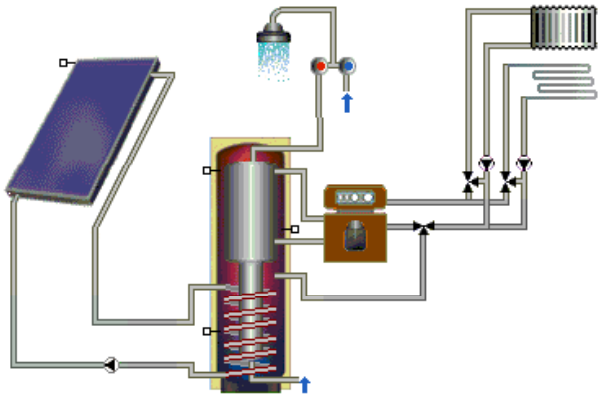


Figure A4: Hydraulic scheme of the solar combi reference system

[8] 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

$\eta = 0.85$
a1 = 20 [W/m²K]
a2 = 0.1 [W/m² K²]

Data of the reference collector for all other applications:

$\eta = 0.8$
a1 = 3.69 [W/m²K]
a2 = 0.007 [W/m² K²]

6.4 Reference climates

Country	Used reference climate[9]
Australia	Sydney
Austria	Graz
Barbados	Raizet
Belgium	Brussels
Brazil	Rio de Janeiro
Canada	Montreal
China	Shanghai
Cyprus	Nicosia
Czech Repulic	Praha
Denmark	Copenhagen
Finland	Helsinki
France metropole	Paris
France DOM TOM	Raizet
Germany	Würzburg
Greece	Athens
Hungary	Budapest
India	Bombay
Ireland	Dublin
Israel	Jerusalem
Italy	Bologna
Japan	Tokyo
Mexico	Mexico City
Netherlands	Amsterdam
New Zealand	Wellington
Norway	Oslo
Poland	Warzaw
Portugal	Lisbon
Slovenia	Ljubliana
South Africa	Johannisburg
Spain	Madrid
Sweden	Gothenburg
Switzerland	Zurich
Turkey	Ankara
United Kingdom	London
United States	Denver Los Angeles

[9] METEONORM

6.5 Population data

Country	Inhabitants 2002
Australia	19.544.000
Austria	8.084.000
Barbados	270.000
Belgium	10.296.000
Brazil	176.257.000
Canada	31.271.000
China	1.294.867.000
Cyprus	802.500
Czech Republic	10.246.000
Denmark	5.351.000
Finland	5.197.000
France métropole	59.850.000
France DOM TOM	1.830.515
Germany	82.414.000
Greece	10.970.000
Hungary	9.923.000
India	1.049.549.000
Ireland	3.911.000
Israel	6.304.000
Italy	57.482.000
Japan	127.478.000
Mexico	101.965.000
Netherlands	16.067.000
New Zealand	3.846.000
Norway	4.514.000
Poland	38.622.000
Portugal	10.049.000
Slovenia	1.986.000
South Africa	44.759.000
Spain	40.977.000
Sweden	8.867.000
Switzerland	7.171.000
Turkey	70.318.000
United Kingdom	59.068.000
United States	291.038.000
Total	3671146017

Economic Region	Inhabitants in 2002
United States + Canada	322.309.000
Japan	127.478.000
China	1.294.867.000
Europe	453.678.015
Australia + New Zealand	23.390.000
Others	1.449.422.000
Total	**3.671.144.015**

Source for population data:
Statistisches Jahrbuch 2005,
www.statistik.at/cgi-bin/jahrbuch_2005.pl?KAPITEL=02&SPRACHE=D
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 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 (installed collector area) and the reference systems for their respective countries:

Australia	John Ballinger Solar Efficient Architecture, Kangaroo Valley
	Ken Guthrie Sustainable Energy Authority 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
Canada	Doug McClenahan CANMET - Natural Resources Canada, Ottawa
China	Jiang Xinian Guangzhou Institute of Energy Conservation Chinese Academy of Sciences, Beijing
Cyprus	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	Aris Aidonis Center for Renewable Energy Sources (CRES), Pikermi
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
Japan	Yoshimura, Kazuki National Institute of Advanced Industrial Science and Technology, Nagoya Solar System Development Association(SSDA)
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 EC BREC / IBMER, Warzawa
Portugal	João Farinha Mendes INETI - Edificio G, Lisbon

Slovenia	Gradbeni Institut ZRMK, Ljubliana
South Africa	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 SOFAS, "Markterhebung Sonnenenergie 2001", August 2003
Turkey	Gulsun Erkul First Secretary (Energy Adviser), Permanent Delegation of Turkey to the OECD Mehmet ÇAĞLAR Ministery of Energy and Natural Resources of TURKEY
United States	Drury Crawley U.S. Department of Energy, EE-41, Washington D.C.

Reports

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

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

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, Oct. 2004

BSI and BDH survey, Germany

SEI-REIO, survey (Ireland)