SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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ESTIF European Solar Thermal Industry Federation

Simple method for Converting Installed Solar Collector Area to Annual Collector Output

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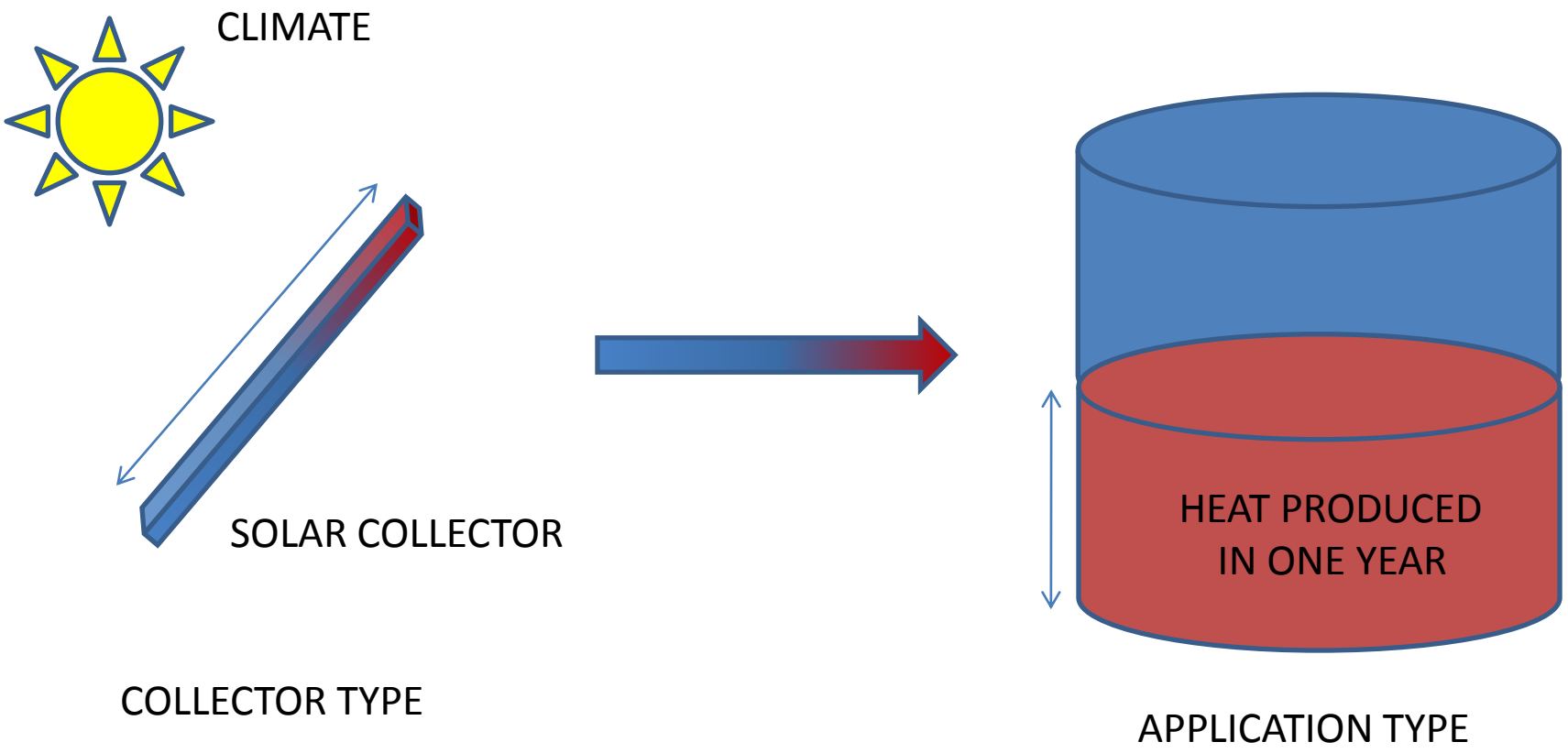
Collector size → Annual energy production



Input

Collector

- **Size** in m² OR Capacity in kW
- **Type**
  - Un-glazed ⟷
  - Glazed ⟷

Application

- Pool heating
- Domestic hot water
- Combined space heating and domestic hot water

Climate

- Global horizontal radiation

Output

To satisfy Eurostat and IEA definitions on primary energy, which is for solar thermal defined as:

- *"Solar thermal production is the heat available to the heat transfer medium minus the optical and collector losses".*

Annual solar collector heat production =
what comes out of the collectors


Equations (1)

Un-glazed Collectors for pool heating:

$$Q_{\text{un-glazed collector}} = 0.29 * H_0 * A_a$$

kWh; H_0: kWh/m²; A_a: m²

Q: Annual collector output
H_0: Annual global horizontal solar irradiation
A_a: Collector aperture area

Equations (2)

Glazed Collectors in DHW :

$$Q_{glazed\ collector,DHW} = 0.44 * H_0 * A_a$$

kWh — kWh/m² — m²

Q: Annual collector output
H_0: Annual global horizontal solar irradiation
A_a: Collector aperture area

Glazed collectors: Glazed flat plate and evacuated tubular collectors
DHW: Domestic hot water systems

Equations (3)

Glazed Collectors in Combi-systems :

$$Q_{glazed\ collector,Combi} = 0.33 * H_0 * A_a$$

kWh; H_0: kWh/m²; A_a: m²

Q: Annual collector output
H_0: Annual global horizontal solar irradiation
A_a: Collector aperture area

Glazed collectors: Glazed flat plate and evacuated tubular collectors
Combi-systems: Systems for combined space heating and domestic hot water system

Equations (4)

Weighted average (all collector types and applications) :

$$Q_{weigheted\ average} = 0.42 * H_0 * A_a$$

kWh; H_0: kWh/m²; A_a: m²

Q: Annual collector output
H_0: Annual global horizontal solar irradiation
A_a: Collector aperture area

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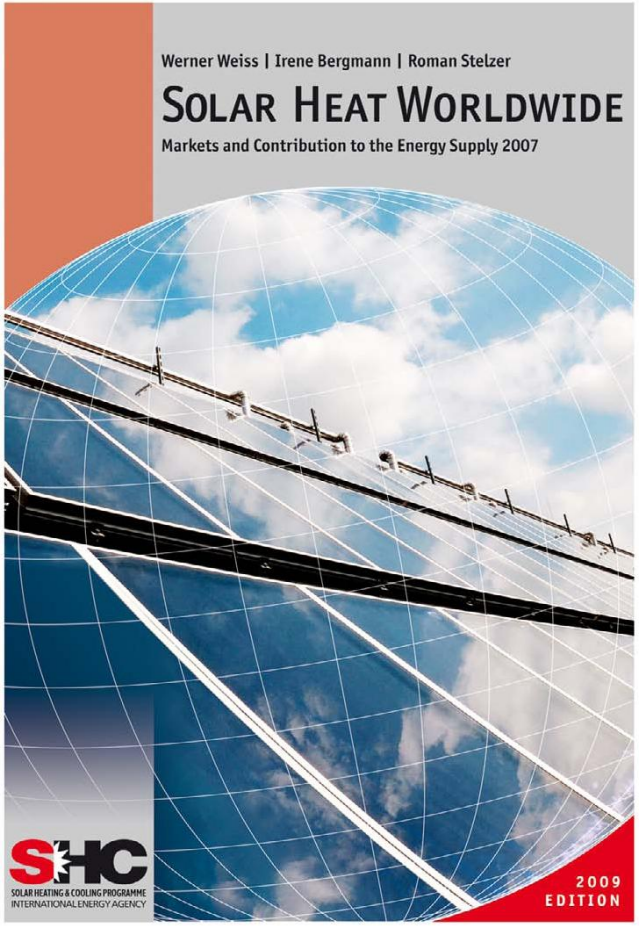
References / validation



Country	Total collector area** [m²]	Total capacity [MW$_{th}$]	Calculated number of systems	Collector yield [GW$_{th}$/a]	Collector yield [TJ/a]	Energy savings - oil equivalent [t/a]	CO_2 reduction [t/a]
Albania	50,176	35.1	6,724	6.9	24.9	1,153.16	3,745
Australia	5,753,000	4,027.1	433,358	2,192.3	7,892.3	323,918.09	1,052,261
Austria	3,601,431	2,521.0	360,154	1,204.5	4,336.0	152,306.53	494,756
Barbados	82,794	58.0	20,698	67.5	242.9	10,119.03	32,848
Belgium	194,946	136.5	36,774	64.7	233.1	7,824.17	25,412
Brazil	3,685,291	2,579.7	897,449	1,598.0	5,753.0	238,859.04	775,847
Bulgaria	27,600	19.3	6,900	12.0	43.2	2,074.97	6,734
Canada	752,422	526.7	17,112	183.1	659.3	25,187.30	81,813
China	114,140,000	79,898.0	27,484,912	49,217.2	177,181.8	6,596,378.88	21,467,451
Cyprus	795,710	557.0	195,267	499.1	1,796.9	71,911.17	233,427
Czech Republic	127,810	89.5	18,674	40.1	144.4	4,794.89	15,509
Denmark	418,630	293.0	86,815	140.6	506.2	16,680.50	54,178
Estonia	1,470	1.0	368	0.5	1.7	52.48	171
Finland	17,385	12.2	4,030	5.4	19.6	602.18	1,956
France*	1,554,000	1,087.8	331,274	516.4	1,858.9	76,849.96	249,321
Germany	9,398,077	6,578.7	1,246,190	3,457.0	12,445.1	420,310.09	1,365,272
Greece	3,573,000	2,501.1	1,374,890	1,883.1	6,779.0	331,672.27	1,078,740
Hungary	46,700	32.7	7,266	15.9	57.3	2,511.43	8,162
India	2,150,000	1,505.0	537,500	1,928.6	6,942.8	271,351.50	881,500
Ireland	35,567	24.9	8,892	11.8	42.3	1,299.62	4,215
Israel	4,961,100	3,472.8	1,177,572	3,643.9	13,117.9	492,169.12	1,597,153
Italy	1,002,650	701.9	241,981	424.3	1,527.5	56,449.91	183,336
Japan	6,951,638	4,866.1	1,682,760	3,316.5	11,939.2	418,423.96	1,359,003
Jordan	847,532	593.3	207,984	594.7	2,140.9	103,247.20	335,330
Latvia	5,350	3.7	1,338	1.8	6.5	207.85	677
Lithuania	3,450	2.4	863	1.1	4.1	135.48	439
Luxembourg	18,900	13.2	4,725	6.5	23.5	762.05	2,481
Macedonia	19,270	13.5	4,198	7.2	25.9	1,250.80	4,061
Malta	29,360	20.6	7,340	9.2	33.0	2,817.68	9,153
Mexico	911,473	638.0	39,801	435.8	1,568.9	69,380.28	225,359
Namibia	6,169	4.3	1,542	3.1	11.0	598.52	1,932
Netherlands	673,033	471.1	94,693	162.9	586.3	18,809.35	61,072
New Zealand	119,177	83.4	26,972	35.4	127.4	4,723.21	15,346
Norway	12,970	9.1	1,873	4.1	14.7	451.53	1,467
Poland	235,897	165.1	28,737	76.5	275.4	9,794.75	31,795
Portugal	282,109	197.5	67,144	176.9	637.0	24,275.33	78,848
Korea	69,600	48.7	17,400	32.2	115.9	5,086.37	16,530
Slovak Republic	98,215	68.8	16,369	39.3	141.6	4,950.04	16,075
Slovenia	116,965	81.9	19,151	42.2	151.8	5,205.04	16,898
South Africa	876,290	613.4	65,063	226.5	815.4	32,345.38	105,018
Spain	1,212,764	848.9	288,544	739.4	2,661.9	93,614.35	304,089
Sweden	332,000	232.4	22,240	124.6	448.6	11,976.46	38,887
Switzerland	671,310	469.9	60,690	195.9	705.4	23,663.94	76,853
Taiwan	1,255,340	878.7	313,835	629.6	2,266.4	93,585.60	304,420
Thailand	70,000	49.0	17,500	47.7	171.7	9,937.20	31,483
Tunisia	218,000	152.6	54,500	145.4	523.5	27,010.20	87,800
Turkey	10,150,000	7,105.0	2,304,050	6,050.5	21,781.9	807,693.56	2,626,236
United Kingdom	304,920	213.4	76,230	101.6	365.6	12,211.13	39,670
United States	30,116,580	21,081.6	551,066	8,848.3	31,854.1	1,275,575.53	4,143,322
TOTAL	207,978,070	145,585	40,471,410	89,168	321,004	12,162,209	39,548,052

* France: includes Overseas Departments

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

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) at the end of 2007

References / validation

	Unglazed	DHW-SFH	DHW-MFH	Combi-Systems	Weighted average
% of glazed area		95%	3%	2%	100%
% of total area	18%	79%	3%	1%	100%
Mean value of constant, C	**0.26**	**0.39**	**0.38**	**0.29**	**0.36**
Std.dev.	0.04	0.05	0.03	0.05	
Std.dev.%	14%	13%	7%	16%	

Un-glazed collector yield $= 0.26 * H_0$

Glazed collector yield, DHW $= 0.38 * H_0$

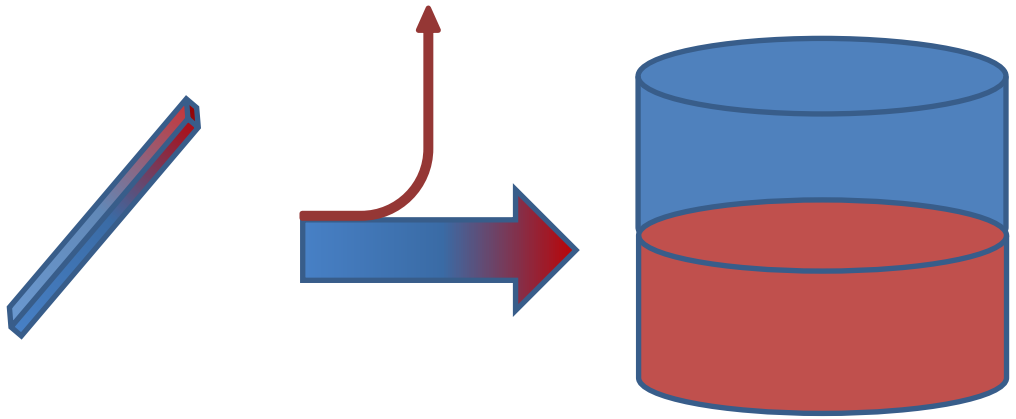
Glazed collector yield, Combi $= 0.29 * H_0$

Weighted average yield, $= 0.36 * H_0$

References / validation

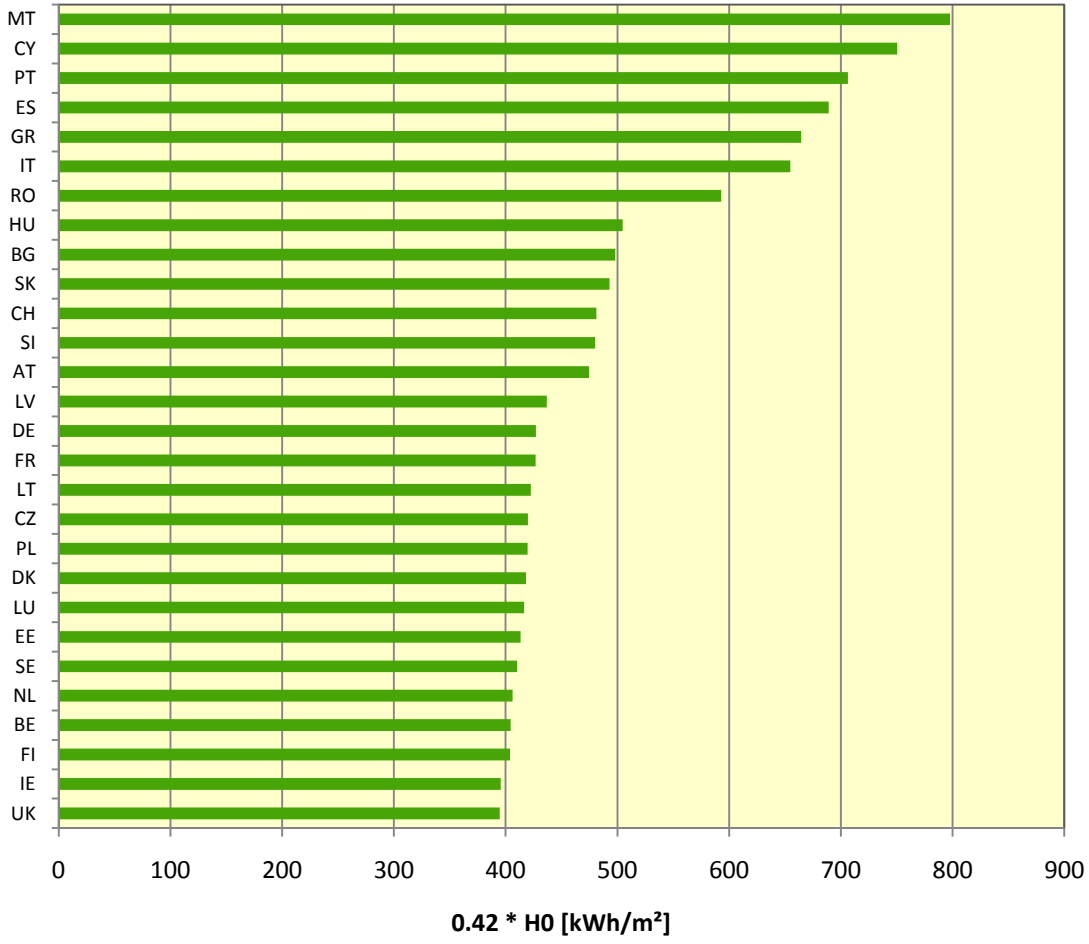
*Converting **Yield** to **Output:***

Take into account pipe losses : 15%



*Un-glazed collector **output***	*= 0.26 + 15 % =*	***0.29*** ** H_0*
*Glazed collector **output**, DHW*	*= 0.38 + 15 % =*	***0.44*** ** H_0*
*Glazed collector **output**, Combi*	*= 0.29 + 15 % =*	***0.33*** ** H_0*
*Weighted average **output***	*= 0.36 + 15 % =*	***0.42*** ** H_0*

Conversion factors, $m^2 \rightarrow kWh$, $c_{weight} \cdot H_0$ for EU-27 + CH



*) based on weighted average
c = 0.42

Conversions established:

m^2 → kW:

- ✓ All collectors and systems: **0.7**

m^2 → kWh:

- ✓ Un-glazed collectors & pool heating systems: **0.29*H_0**
- ✓ Glazed collectors and water heating: **0.44*H_0**
- ✓ Glazed collectors and space & water heating: **0.33*H_0**

- ✓ Weighted average: **0.42*H_0**

kW → kWh

- ✓ Weighted average (all collectors and systems): **0.6**