Converting
Installed Solar Collector Area & Power Capacity
into
Estimated Annual Solar Collector Energy Output

The proposed method

Proposed method to calculate the annual production of solar thermal energy in kWh:

As a function of the installed solar collector area:

Un-glazed collectors:	***0,29 * H0 * Aa***
Glazed collectors in DHW systems:	***0,44 * H0 * Aa***
Glazed collectors in combi-systems:	***0,33 * H0 * Aa***

As a function of the installed collector nominal thermal power:

Un-glazed collectors:	***0.42 * H0 * Pnom***
Glazed collectors in DHW systems:	***0.63 * H0 * Pnom***
Glazed collectors in combi-systems:	***0.47 * H0 * Pnom***

Being:
H0: Annual global solar irradiation on horizontal the given location in kWh/m²
Aa : Collector aperture area in m²
Pnom : Nominal thermal power output of collector in kW

The need for energy production estimates

The renewable heating and cooling (RHC) sector offers a huge potential that has been underestimated and even neglected in the past. One of the reasons is that the production of heat, for individual consumption, in a decentralised manner has not been properly considered as an important player in a country's energy mix. This was in part due to the lack of generally accepted methods for calculating and monitoring the production of renewable heat.

In order to have a concrete perception of the importance of the energy from renewable heating and cooling sources, namely solar thermal energy, it is important to have an adequate method that can provide a reliable basis for comparing the energy produced using different energy sources.

It is extremely valuable to give effective tools to Governments with which to estimate the energy production potential of solar thermal energy. This can be done either by accessing statistically both the energy produced on the basis of the installed solar thermal capacity in a country or region, or on the potential increase deriving from new policy frameworks.. It is clear that, already today, solar thermal is one of the most cost –effective renewable technologies while still showing a large potential for economies of scale, cost reductions and technological progress. Furthermore, it can make a huge contribution to job creation at local level (more than 50% of the turnover is inherently local, as it is related to distribution, system design, installation and maintenance).

Taking this into account, one of the previous challenges for the solar thermal sector was the calculation of the installed solar thermal capacity in operation in terms of kWth, with the data available: square metres of solar collector area. This challenge was overcome in 2004, when the sector, based on different studies, agreed on a conversion factor of 0,7kWth/m².

The next step was to arrive at an estimation of the annual energy produced by solar thermal collectors.

A simple but effective and reliable method

This document explains how very simple expressions can be used for a general conversion of installed collector capacity (in m² or in kW) into an estimated annual solar collector output. One of the main advantages of these expressions is that they use data already easily accessible , such as the:

a) Annual global solar irradiation on horizontal in a given location (for instance, the capital city of a country) - this data is normally available from national sources or can be obtained with different software;
b) Area of installed solar collectors in square meters (calculated on the basis of the collector aperture area, the most commonly used measure) or the installed collector nominal thermal power – this data is normally available from national statistics or from solar trade associations.

Using such data, and applying the proposed factors, we can estimate the energy produced by solar thermal systems with:

- Unglazed collectors;
- Glazed collectors used for domestic hot water production;
- Glazed collectors used for combined space heating and domestic hot water (combi-systems)

It should be noted that the results are so far only valid for collectors with a liquid heat transfer fluid.

The simple and general expressions put forward give only an estimate of the annual solar energy output. The level of uncertainty introduced by using these simple and practical expressions is not negligible, therefore they should only be used when no other detailed methods exists. The equation could, for example, be used by countries which have no detailed method or procedure for determining the annual energy output of solar thermal systems. In such cases, the use of this method is clearly more reliable and consistent when applied for comparisons between different countries .

A step forward for Solar Thermal Energy Statistics

The international energy statistics deem the energy input to the energy balance of countries as primary energy. Primary energy is the energy commodity directly extracted from natural resources. Examples are coal, crude oil and natural gas. In connection with solar thermal energy, IEA and Eurostat consider as primary energy the first usable form of energy. This is defined as: **"Solar thermal production is the heat available to the heat transfer medium minus the optical and collector losses".**

This document provides a definition that can be used in relation to the information that is known in the solar thermal field. For solar photovoltaic, wind and hydropower, the first usable form of energy is considered to be the electricity that is produced (primary energy production). For nuclear energy the steam going to the turbine is regarded as primary energy (where a turbine efficiency of 33% is assumed).

Solar thermal heat production

For the development of this method, it was considered that:

The solar thermal production as primary energy is defined as the solar thermal heat delivered by the solar collector.

The radiation falling on the collector is not considered as useful energy in the energy balance. The energy delivered by the collector is considered as the primary energy production for solar thermal while the energy actually supplied by the storage unit is what is normally considered as useful heat output. The energy saved by a solar thermal system is the energy that would have been used by a comparable conventional reference heating system.

Final energy consumption

The final energy consumption is the energy delivered to the end user. This term is used in the European directive on renewable energy (2009/28/EC) to define the fraction of renewable energy. For solar water systems at the end user (which is the case with most solar systems) the final energy consumption is the solar thermal production - thus the collector output !

Only if the solar heat is centrally produced and distributed over a network, is the final energy the solar heat output and therefore in most cases the final energy is the solar thermal production (the primary energy).

In order to calculate the system output, losses from piping, storage, etc. would need to be deducted. Moreover, to obtain the final savings from the solar thermal system, additional savings in back-up losses (if any such savings exist) shall be added to the system output (additional back-up loss savings could result from stand-by losses from a boiler if it is turned off during all summer months). Furthermore, the efficiency of the boiler to convert fuel (e.g. oil or gas) into heat has to be considered. Due to such additional savings, the final savings of the solar thermal system are much higher than the solar collector energy output. Hence, the solar thermal system's final primary energy savings are in most cases much higher than the collector output, particularly when solar thermal energy replaces electricity.

Status in relation with current statistics
Ccurrently countries are free to use their own figures to perform the conversion from area to energy, providing an EU average of 437 KWh/m². The new method will yield 400 kWh/m2 (from 358 kWh/m² for unglazed collectors to 544 kWh/m² for domestic how water applications).

Only few countries have data for combined hot water and space heating systems (combi-systems) but so far these systems only represent < 2 % of the world market. It is expected that as the solar thermal market grows in a country, more detailed information will be available on the conversion factors for the different applications.

Anyhow, and as mentioned above, this is a simplified method, requiring easily accessible data. Whenever either a country or region is able to use a more accurate and detailed method, it should be used in preference.

The studies behind the method

Several studies were dedicated to the development of a generally accepted method to calculate and monitor the production of solar thermal energy. Some of these studies were carried out within the scope of projects such as Therra (Thermal Energy from Renewables) and K4RES-H (Key issues for Renewable Heat in Europe), supported by the Intelligent Energy Europe Programme, and also within the IEA Solar Heating and Cooling Programme. From these studies and with the cooperation of different experts it was finally possible to arrive to a commonly accepted method.

The analysis was performed on four different applications for solar thermal systems (following the categories
in IEA-SHC Solar Heat Worldwide):

- Unglazed systems - typically for swimming pool heating
- Domestic hot water systems (DHW) in one-family houses
- Domestic hot water systems (DHW) in multi-family houses
- Combined domestic hot water and space heating systems in one- and multi-family houses (Combi-systems)

The data used represented over 98 % of the world market according to IEA-SHC Solar Heat Worldwide statistics. With this the annual Collector Energy output in kWh/m² divided by global irradiation on horizontal in kWh/m² was calculated for a given location. This was then analysed for the four different applications referred above and a possible constant (systematic relation) assessed, identifying the mean value and taking into account the data relevance.

Afterwards, it was important to determine the nominal power capacity and a number of “equivalent full load hours”, following the usual parameters to describe the annual yield from other energy (electricity) producing technologies, such as wind or solar photovoltaic.

Further analysis was carried out on some of the points considered relevant, such as the reference in terms of collector area, the comparison of performance from flat plate collectors with evacuated tube collectors and the analysis of systems output in relation to the collector output: i.e. pipe losses.

Finally it was possible to put all these conclusions together and arrive to very simple and general expressions that can be used for converting installed collector area or installed collector thermal power capacity – grouping collectors (and systems) in only two types.

The proposed method

The annual solar collector output in kWh can be expressed - within reasonable uncertainty - as follows

As a function of the installed solar collector area:

Un-glazed collectors:	***0,29 * H0 * Aa***
Glazed collectors in DHW systems:	***0,44 * H0 * Aa***
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H0: Annual global solar irradiation on horizontal the given location in kWh/m²
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The subscribers

The following organisations, signatories of the Memorandum of Understanding between the IEA Solar Heating and Cooling Programme and Solar Trade Associations, subscribe this proposal.

International Energy Agency - Solar Heating and Cooling Programme (IEA-SHC):
www.iea-shc.org

Austria Solar: www.austriasolar.at
Asociación Solar de la Industria Térmica, Spain (ASIT): www.asit-solar.com
Bundesverband Solarwirtschaft, Germany (BSW): www.solarwirtschaft.de
European Solar Thermal Industry Federation (ESTIF) – www.estif.org
Holland Solar – www.hollandsolar.nl
Solar Energy Association of Sweden (SEAS) – www.solenergiforeningen.se
Solar Energy Industries Association, USA (SEIA) – www.seia.org

Note

Further documentation on this proposal for Converting Installed Collector Area & Power Capacity into Estimated Annual Collector Output can be provided upon request from info@estif.org .