Proposal for Simplified Method for Solar Thermal

Position Paper from Solar Heating & Cooling stakeholders on a simplified method for calculating the solar thermal contribution in a package in the scope of the review of the energy labelling and ecodesign regulations for space and water heaters

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1. Introduction

Soon after the Lot1 & Lot2 regulations came into force, in September 2015, it has become evident that the implementation of the package label faced difficult hurdles in the different European markets. This has been reported to Solar Heat Europe/ESTIF by its members and partners, has also been identified by European projects such as Labelpack A+, EEPLIANT and ECOTEST and is also reported by VHK in its studies for the review of Lot1 & Lot2.

Solar systems, to the exception of solar water heaters, do not require a product label and are reflected in the ErP for space and water heaters as components of a package. The current calculation procedures for solar devices are complex for manufacturers, authorities and installers, requiring for each new combinations (no. collectors, water store, etc.) the use of software tools (some available online) that provide the factors required for the package label calculation. Such complexity has been detrimental for solar thermal systems, being potentially one of the factors (though clearly not the only one), affecting sales of solar thermal systems in Europe.

Furthermore, it considers solar thermal as an additional heater while, in all cases where a solar thermal system is installed, it becomes immediately the primary energy source, as the heat generated is essentially free (besides being also carbon free). In practice, this means that solar thermal energy is used first, and a backup system is used to supply the rest. Hence, the solar device is the preferential heater and the backup system the secondary heater, contrary to what could be assumed considering the current Lot1 & Lot2 regulations.

It is important that a new calculation takes into account the advantages of solar thermal systems. Among the numerous advantages of this technology, we can point out that it:

- Is the only 100% CO_2-free technology in Lot1 and Lot2;
- Can supply most of water heating and a considerable part of space heating needs;
- Is available on site, where thermal energy is needed;
- Has very low lifecycle costs;
- Has very high recyclability of materials;
- Has the large majority of sales in Europe supplied by European manufactured systems, by European SMEs.

With this proposal we aim to arrive to a simplified calculation method that is fair for solar thermal systems and not hampering its deployment in the market.

2. Simplified approach

Solar Heat Europe supports the principal for a simplified method for the calculation of the contribution of solar thermal systems in the context of Lot1 & Lot2. In this sense, the proposal included by the VHK experts in their reports on task 6 (for both Lots) is a good starting point for the discussion on a simplified approach.

The proposal presented was based on granting higher efficiency as a function of installed m^2 of collectors. The main advantage would be the simplicity of its application by installers. In addition it would facilitate the possibility of calculating a package label in the case of a retrofit, i.e., when a new solar thermal system is combined with an existing heater.

As pointed out at the Stakeholders Consultation Meeting, this method has clear advantages, though it could be improved by using the solar thermal yield, rather than the collector area, as a basis for the calculation. It was also referred that other factors affecting the performance of solar thermal systems could also be taken into account.

In this sense, Solar Heat Europe gathered a group of experts in order to come to a joint proposal that would respect the following principles:

- Using solar thermal yield as a basis for the calculation;
- Using easily available data;
- Simple utilization by installers;
- Using methods that take into account factors affecting the performance of the solar thermal system, such as seasonality and solar fraction.

2.1. Solar Enhancement Factor / Solar Device Efficiency

In brief, it has been identified by experts that the improvement a solar thermal system brings to a non-solar heat generator (usually referred in solar systems as a back-up heater, such as a boiler, a heat pump or an electric heater) can be identified as a function, which we propose to designate the **"Solar Enhancement Factor"** or **"Solar Device Efficiency"**. This factor is explained in more detail below.

The first question refers to how a solar device can improve the efficiency of a boiler in a package.

The definitions for the efficiencies are given in the regulation 811 and 812

(21) 'seasonal space heating energy efficiency' (η_s) means the ratio between the space heating demand for a designated heating season, supplied by a space heater, a combination heater, a package of space heater, temperature control and solar device or a package of combination heater, temperature control and solar device, and the annual energy consumption required to meet this demand, expressed in %;

(14) 'water heating energy efficiency' (η_{wh}) means the ratio between the useful energy provided by a water heater or a package of water heater and solar device and the energy required for its generation, expressed in %;

In the context of the ErP the "energy required" is interpreted as the primary energy equivalent, i.e. the energy required multiplied by its primary energy factor.

For both cases the efficiency is therefore the ratio of the total net heat benefit ($Q_{load,tot}$) for water and space heating to the total primary energy ($E_{PE,tot}$) required by the boiler.

$$\eta = \frac{Q_{load,tot}}{E_{PE,tot}} \quad (1)$$

While the terms can be split up in load shares provided by non-solar heat generators and the solar device:

$$Q_{load,tot} = Q_{nonsol} + Q_{sol} \quad (2)$$

The primary energy use is

$$E_{PE,tot} = E_{backup} + E_{sol} \quad (3)$$

Which is

$$E_{PE,tot} = E_{backup} \quad (3)^*$$

as solar energy is generated with approximated zero use of primary energy. With

$$\eta_{backup} = \frac{Q_{nonsol}}{E_{backup}} \quad (4)$$

The efficiency is then

$$\eta = \frac{Q_{nonsol} + Q_{sol}}{E_{backup}} = \eta_{backup} + \frac{Q_{sol}}{E_{backup}} \qquad (1)^*$$

And further

$$\eta = \eta_{backup} + \eta_{backup} \cdot \frac{Q_{sol}}{Q_{nonsol}} = \eta_{backup} \cdot (1 + \frac{Q_{sol}}{Q_{nonsol}}) \qquad (1)^{**}$$

Introducing the solar device efficiency η_{sol}

$$\eta_{sol} = (1 + \frac{Q_{sol}}{Q_{nonsol}}) \qquad (5)$$

The equation results in:

$$\eta = \eta_{boiler} \cdot \eta_{\eta sol} \qquad (1)^{***}$$

The solar device efficiency η_{solar} is based on heat loads for space or water heating. Thus, it can be calculated for each specific solar thermal system both for water heaters and combination heaters.

In brief, the conclusion reached is that the package calculations can be limited to one multiplication - ***see formula (1)**** - to combine a backup heater and a solar system.

2.2. Using gross thermal yield as a basis

Considering that solar thermal systems have different efficiencies in capturing thermal energy from the available solar radiation. Therefore, the capacity of a solar thermal collector to capture energy per m² can vary considerably between different models, geographic locations and modes of operation.

In contrast to the collector area, the GTY includes information about the thermal performance of a collector. This means that high performance collectors have better GTY than low performance collectors. As such, the GTY it is an interesting basis for a simplified approach, in order to value those collectors with better performance and to give a better indication of the energy provided.

The GTY is therefore a fair term for analysis of the contribution of solar thermal systems to the efficiency of a space and/or water heating system.

2.3. Using easily available data

Gross thermal Yield of the Solar Collector

To ensure that the method is easy to use, it is essential that the required data is broadly available, of easy access and presented in a clear way.

In this regard, the GTY is a great option, both for new systems (recently placed in the market) or for older products (collectors).

The GTY is used for more than 20 years to compare the performance of collectors in an unambiguous way and has been adopted in the CEN Solar Keymark certification scheme as Scenocalc. The GTY is not yet explicitly defined in the European collector standard. Computing the GTY would however not require new theories, but only using the available performance formulas with defined climate profiles for a certain location, e.g. Athens, Helsinki or Strasbourg.

The GTY information is easily available in Solar Keymark certificates, which are publicly available (for free) in the Solar Keymark database, currently for the four locations Athens, Würzburg, Davos and Stockholm. It would be possible to add the ErP locations Helsinki and Strasbourg as well and to make the necessary tables for each collector model available.

Furthermore, for new or recent products, this information shall be available in the product fiche that the manufacturers have to upload into EPREL.

Annex to Solar Keymark Certificate								Licence Number			[redacted]	
Supplementary Information								Issued			[redacted]	
Annual collector output in kWh/collector at mean fluid temperature Tm, based on EN 12975 Test Results												
Standard Locations	Athens			Davos			Stockholm			Würzburg		
Collector name ϑ_m	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
[redacted]	2,565	2,323	1,977	2,225	1,931	1,580	1,613	1,381	1,108	1,734	1,491	1,199
[redacted]	1,840	1,667	1,418	1,596	1,385	1,134	1,158	991	795	1,244	1,070	860

3. Simple utilization by installers

To express the variability of solar thermal energy generation and to consider interaction with other appliances, a simple function will not be enough. Therefore, a table is required to reflect variations depending on the different climatic conditions and the load profiles. Both have an important impact on the performance of a solar thermal system with a back-up heater.

Thus, the table would have as entries:

- Gross thermal yield of the solar thermal collector
- Climatic region
- Load profile

Such tables would differentiate between water heating service (Lot2) or space heating (Lot1).

To further ease the use of these tables, the GTY is replaced by the number of collectors or packages of different collector sizes. These tables would then be published by the solar thermal manufacturers, using the corresponding yield for different numbers of collectors or packages. The calculation behind the tables can be done by the manufacturer or his testing laboratory and is not visible anymore to the installer.

Regarding the output of the table, ESTIF/SHE is investigating two options: Label class or Solar Enhancement Factor.

Having directly the label class as output would require additional simplifications regarding the back-up heater (which can be estimated based on the demand load), while being easier to use by the installer.

The use of the Solar Enhancement Factor (SEF) would provide a clear indication of the contribution of the solar thermal system and allow the final result to be a function of the SEF and the performance of the backup heater. It would require, nonetheless, additional calculations by the installer.

These two options and the process required for installers can be exemplified as follows:

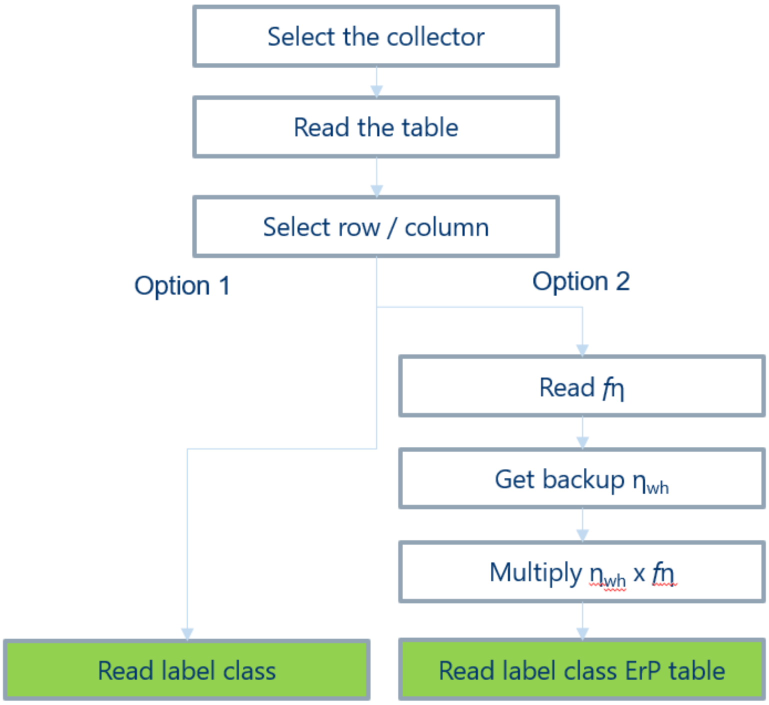

Figure 1: Options regarding label identification process by the installer

Example of tables:

		Number of collector modules:									
Climate:↓	Profile:↓	1	2	3	4	5	6	7	8	9	10
Average	M	x	x	x	x	x	x	x	x	x	x
	L	x	x	x	x	x	x	x	x	x	x
	XL	x	x	x	x	x	x	x	x	x	x
	XXL	x	x	x	x	x	x	x	x	x	x
Colder	M	x	x	x	x	x	x	x	x	x	x
	L	x	x	x	x	x	x	x	x	x	x
	XL	x	x	x	x	x	x	x	x	x	x
	XXL	x	x	x	x	x	x	x	x	x	x
Warmer	M	x	x	x	x	x	x	x	x	x	x
	L	x	x	x	x	x	x	x	x	x	x
	XL	x	x	x	x	x	x	x	x	x	x
	XXL	x	x	x	x	x	x	x	x	x	x

Table 1: Options for table to be provided by the manufacturer summarising the solar thermal impact for a given collector type.

In the table above, the 'x' might represent a label class (option 1 above) or the Solar Enhancement Factor (option 2).

In the case of option 2, the table can be complemented by a calculation for the package efficiency and the reference table from the regulations (space heating or water heating, depending on the case), for installer's (or other user) convenience.

Back-up efficiency	95%	1)
Solar Enhancement Factor	121%	2)
Package efficiency	**115%**	3) = 1)*2)

Device	G		F		E		D		C		B		A		A +		A ++		A +++	
Seasonal Space Heating - Heaters (general)	<	30%	<=	34%	<=	36%	<=	75%	<=	82%	<=	90%	<=	98%	<=	125%	<	150%	=>	150%
Seasonal Space Heating - Low temperature heat pumps	<	55%	<=	59%	<=	61%	<=	100%	<=	107%	<=	115%	<=	123%	<=	150%	<	175%	=>	175%

Table 2: Additional fields for Option 2, to facilitate calculation and identification of label class.

4. Calculation method

As indicated before, the Solar Enhancement Factor (or Solar Device Efficiency) should be determined solely with the specifications of the collector, in particular the gross thermal yield. This implies that several assumptions have to be made for other elements, such as the water store, pump or control.

Taking the collector as a basis, there are several options in terms of reference methods. These can be grouped into two main streams:

- **GTY methods**
- **EN 15316-4-3, method 2**

4.1. GTY methods

The GTY is a globally recognized tool for the determination collector yields. With appropriate assumptions about the other elements the Q_{nonsol} and Q_{sol} of a solar device can be determined directly for given loads.

There are two different approaches under development based on the GTY. Both methods are not yet implemented in a standard or in the Solar Keymark certification scheme. It would however be possible to implement both methods within very short time (2-3 months) in the Solar Keymark datasheets and as amendment to the EN 12975 standard in less than one year.

The currently used ScenoCalc tool would have to be adapted to provide the necessary data for Helsinki and Strasburg as well to fit the transition to a Package Label class.

The simplification of the calculation requires several assumptions to reduce the number of variables in the calculation. Several of these assumptions are still being discussed but are also expressed in the different methods.

4.2. EN 15316-4-3, method 2

This standard in the EPBD series of standards is currently applied for water heating (=SOLCAL). The method is not yet adapted to the current collector standards and it is evident that the version in force (as in the transitional method) is underrating solar thermal in a catastrophic manner. The revised method of 2017, while better than the previous, still raises some questions.

As for the GTY method, appropriate assumptions about the other elements are needed to determine the Q_{nonsol} and Q_{sol} of a solar device based on the collector specifications.

Following intense discussions, the preferred options to develop further a simple but reliable calculation method are the GTY methods.

4.3. Heat Demand

While for other parameters it is possible to apply an assumption that will simplify the calculations, there is one aspect that needs special attention, in particular taking into account the characteristics of the methods proposed: the heat demand.

- ***Water heating***

For DHW, the current load profiles (M, L, XL, XXL) as defined in the ErP are used. This is reflected in the output table presented above (Table1).

- ***Space heating***

In the case of space heating, no heat demand patterns are available from the regulation. It is therefore necessary to make reasonable assumptions there. Several options are currently being assessed, including the ErP Heat Pump approach (defining a P_{rated} and maximum operation hours hrs_{max}) and a current project (in the scope of the Solar Keymark Network) that aims to compose space heating demand sequences.

5. References

Information from the VHK reports used:

• *Task 6: Installer label (page 48):*

4.5 Installer label

According to stakeholders in the solar thermal industry the current energy label, with its single equation and 4 input parameters (Asol, Vsol, fsol, ηcol) is too complicated for the installer. Therefore, it is proposed for an Average climate to give 1 percentage point of efficiency for every m² of collector surface.

With the new energy label class limits proposed in Chapter 2, this could mean e.g. for a 15 m² collector surface a jump of 2 classes, e.g. from D to B or —with a high efficiency boiler— even from C to A. Once the starting level is B, the jump will be 1 class.

The condition is that the solar tank should be at least 50 litres per m² of collector surface and the tank energy label rating should be at least 'C'.

Table 16. NEWly proposed Energy label classes for all central space heaters except low-temperature heat pumps

Label class	seasonal efficiency	class widths	Examples of typical appliances
A+++	$\eta_s \geq 180$		WHP(+), mCHP(H_2), GHP(H_2)
A++	$150 \leq \eta_s < 180$	30	AHP(+), WHP(0), GHP(+)
A+	$130 \leq \eta_s < 150$	20	AHP(0), WHP(-), HYB(+), mCHP(+)
A	$110 \leq \eta_s < 130$	20	SOL(+), HYB(0), mCHP(0),
B	$98 \leq \eta_s < 110$	12	SOL(0), HYB(-), mCHP(-), Condens(H2)
C	$93 \leq \eta_s < 98$	5	Condens(-/0/+)
D	$87 \leq \eta_s < 93$	6	Condens(-/0/+)
E	$76 \leq \eta_s < 87$	11	Non-condens(0/+)
F	$43 \leq \eta_s < 76$	39	EL(+), ATO(+)
G	$\eta_s < 43$		EL(0), ATO(0/-)

*=GSHP=brine/water source heat pump, mCHP=micro-cogeneration, GHP=gas-fired heat pump, ASHP=air-source heat pump, HYB=hybrid ASHP & Condens, SOL=Solar assist & Condens, Condens=condensing gas/oil boiler, Non-condens=non-condensing gas/oil boiler (e.g. B1), EL=Electric resistance boiler, ATO=atmospheric or otherwise non-condensing (banned but e.g. to use for label of existing).

(H2)=e-hydrogen ready or operating, (+)=good, (0)=average, (-)=bad.

• *Task 6: Solar contribution (page 38):*

For the solar contribution to efficiency of a package the expression is

Solar efficiency contribution (in %)= ('III' x Asol +'IV' x Vsol) x fsol x (ηcol/100) x S

Where

- 'III' is 294/(11 x Prated), where Prated (presumably in kW) relates to the preferential heater;
- Asol is solar collector surface in m²;
- 'IV' is 115/(11 x Prated), where Prated relates to the preferential heater;
- Vsol is the solar tank volume in m³;
- fsol is a factor that depends on the preferential heater (0.9 if fuel boiler, 0.7 if mCHP, 0.45 if heat pump);
- ηcol is the collector efficiency at a temperature difference between the solar
- collector and the surrounding air of 40 K and a global solar irradiance of 1 000 W/m²;
- S is tank (standby loss) Energy Label rating, with A+=0.95; A=0.91; B=0.86; C=0.83; D-G=0.81.

• *Task 3: Solar potential (page 37):*

In order to establish how much of this solar irradiance could be useful, the EU monthly averages can be weighed against the heating load. This is shown in Table 6 and results in 2259 Wh/m².d.

Table 6. Average EU28 global solar irradiance over the heating season, weighted for population and for heating load

		Jan	Feb	Mar	Apr	Oct	Nov	Dec	AVERAGE
Space heating load	% of total	20%	20%	13%	6%	6%	16%	19%	
Global solar irradiance G, monthly EU averages weighted for population	Wh/m²	1608	2446	3478	4562	3040	1853	1281	2259

The values in the table are given for a horizontal plane. The solar flux for a vertical plane would be 70% higher with South orientation, whereas the East/West orientation gives 35-40% less sun and the North orientation gives 70% less. Overall, assuming that on average there is no preference in orientation, the solar influx for windows should be 20% less than 2259 Wh/m².d, i.e. around 1800 Wh/m².d.