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Guideline: **Guideline on the establishment of the voluntary output Label "SOLERGY" for solar thermal collectors in accordance with the delegated regulations (EU) no. 811/2013 and 812/2013 for the purpose of issuing by DIN CERTCO**

Version: 12.02.2016
Author: Stefan Abrecht

Important note:
The following elaboration shows how a voluntary energy output label for solar collectors, the so-called collector output label "SOLERGY", has been designed. The Solar Keymark certificate (data sheet 1 and 2) of a collector is the basic requirement. "SOLERGY" differs fundamentally from the product efficiency labels for conventional space heaters laid down by the EU, since it does **not** relate to primary energy efficiency and consumption, but to the heat that can be generated from solar collectors at a particular temperature level with virtually no primary energy use, and to how effectively the irradiation is used. The presented methodology shall give the EU Commission an indication, how solar collectors could be incorporated into a revision of the Regulations. Until then, the solar thermal industry can follow the example of the European manufacturers of circulation pumps, who managed to successfully implement a label for circulation pumps in a voluntary commitment through its association Europump in 2005, which has been even politically accepted. (Source: Wikipedia)

The idea and the mathematical methodology for the presented collector output label was developed by the author Stefan Abrecht - Solar Experience GmbH. The visual representation of the labels shown and the designation of the output classes were developed together with an industry initiative of collector manufacturers based on first drafts of the author and were also prepared for the market launch of the label. A second revision was carried out following the remarks of EU-Commission officers to prevent legal problems with the EU efficiency label and to show the output classes for each climate region too. This label is issued and registered exclusively by DIN CERTCO (www.dincertco.de) within a specified certification program. A liability in any form is excluded by the author Stefan Abrecht and Solar-Experience GmbH.

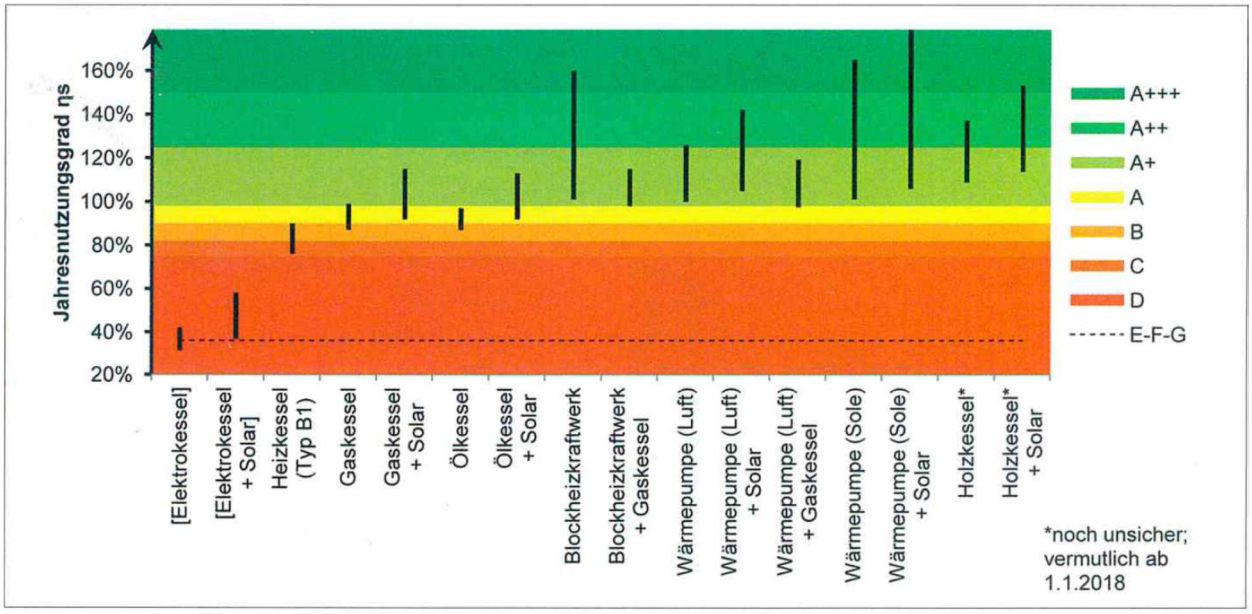
1. Background

In the EU regulations on product labeling only "primary energy consuming equipment" is taken into account so far. As basis for the classification of heat generators for space heating a so-called seasonal space heating energy efficiency (annual efficiency) is defined based on the ratio "provided useful heat" to "primary energy consumption".

The primary energy is either the GCV of fossil fuels used (e.g. for oil or gas boilers) or electricity as final energy (e.g. for heat pumps), multiplied by a factor for primary energy of 2.5. For example a low-temperature heat pump with a COP of 4.5 has an energy efficiency of 4.5 / 2.5 = 180 % and thus achieves an A+++ (from 09/2019).

In principle collectors could also be considered as heat pumps, but collectors need only about 1 kWh of electricity for an output of 100 kWh heat (COP_{coll} = 100). This means a primary energy consumption of 2.5 kWh and thus an energy efficiency of 100 / 2.5 = 4.000 %. Hence, solar collectors would have blown the scale and were probably not explicitly included in the classification of energy efficiency classes.
(Remark: Even if the embodied energy for production is taken into account this does not change the fact as the amount energy used is only about 4% of the delivered heat during lifetime.)

Meanwhile, the EU is about to introduce the labelling requirement for wood boilers as well. In fact, for these products the primary energy consideration should have led to a large expansion of the scale of the annual efficiency too. With a boiler efficiency of 80 % and a primary energy factor of 0.2 the efficiency results in 0.8 / 02 = 400 %. However, first publications show that the wood boiler shall have only about to 140 % annual efficiency. So it is clear that the EU has left the actual reference basis of primary energy already. Nevertheless, it does not show methodically how a primary energy-free heat generator has to be handled properly.



Erwartete Einstufung von Heizgeräten in die Energieverbrauchskennzeichnung nach Verordnung 2013/811/EU als Verbundanlage ab 26.9.2015. Bild: UBA

Figure 1: Classification of heaters as package and product label (*source: magazine IKZ-Fachplaner Juli 2013*)

On the other hand, this means that products that use few (wood boiler) or very few (solar collectors) primary energy can be labelled as well. Due to the fact that the classification shown on the energy labels is perceived as a quality mark by manufacturers and consumers, collectors should be labelled too in order to achieve the targets set in the regulation no. 811/2013 to save energy at equivalent functionality and to make consumers buy energy efficient products.

By being excluded from the product labelling scheme, solar collectors could be perceived as no independent energy efficient products. Furthermore, this could be judged as misleading for consumers when assessing heat generators. Without product labelling the CO_2- free contribution of solar thermal energy to the "Energiewende" for heat is neglected completely and its role would only be that of being added to the main products of the package label (boiler, heat pump or heaters with cogeneration) so they are better off. In close accordance to the classification of heat pumps an exact, clear and market oriented labelling scheme for solar collectors is possible and makes sense.

2. Mathematical basis and denomination of the classes

Important note:
Due to the fact, that the EU-classification scale (A+++ to G and the colour gradient from green to red of the arrows leading to the right) is legally protected and may not be used in voluntary labels, a different scale has to be used. The EU scale compares different types of heaters only according to their efficiency related to primary energy consumption. But practically it is not possible to distinguish between them by type of heater. Only products, which use ambient heat or cogeneration are able to reach classes higher than A.
The collector output label SOLERGY has been designed to show the consumer the differentiation related to specific energy output and to primary energy relevance. It has been developed using a scale based on the letter A. The relative classification of the scale has been adapted the way that flat plate collectors of the comfort and premium class, which actually dominate the market, are technologically comparable to the best conventional heat generators, determined by the EU to be heat pumps. Additionally, they are superior from the ecological perspective, which makes it imperative to label them with A++ or A+++ especially from the point of view of the consumer.
Both upper classes (AA and AAA) contain collectors with extra high specific energy output. They can provide heat also under difficult conditions like high solar fractions, smaller areas and higher temperatures as they have special technical

features e.g. double glazing, vacuum isolation and reflectors. The marking of the lowest class A- shows that these products are close to the limit where such products make sense related to heat production. Reasons for such a low class are outdated technologies (e.g. non selective absorber) or not enough solar active area (e.g. vacuum tubes with big spacing). A proof for this fact is, that powerful PV modules can reach this class as well but deliver more high-grade electricity.

In regulation 811/2013 the instruction for the assessment of heat pumps (= categories heaters without low-temperature heat pumps) and low-temperature heat pumps are described in detail. For each type there is a separate classification scheme. For heaters without low-temperature heat pumps (normal heat pump) the A+++ level starts already at 150 % (see table 1, yellow array), for low-temperature heat pumps it starts only at 175 % (see table 1 blue array).

	Output classes "SOLERGY"	B	A---	A--	A-	A	A+	A++	A+++	AA	AAA
	Energy efficiency classes ErP	G	F	E	D	C	B	A	A^{+}	A^{++}	A^{+++}
Heaters without low-temperature heat pump	seasonal space heating efficiency	0%	30%	34%	36%	75%	82%	90%	98%	125%	150%
	relative efficiency A+++ =100%	0%	20%	23%	24%	50%	55%	60%	65%	83%	100%
Collectors for higher temperatures (75 °C)	Annual efficiency η_a at 75 °C annual output/irradiation	0%	9%	10%	11%	23%	25%	27%	29%	37%	45%
	relative efficiency AAA =100%	0%	20%	22%	24%	51%	56%	60%	64%	82%	100%
Low-temperature heat pump	seasonal space heating efficiency	0%	55%	59%	61%	100%	107%	115%	123%	150%	175%
	relative efficiency A+++ =100%	0%	31%	34%	35%	57%	61%	66%	70%	86%	100%
Collectors for medium temperatures (50 °C)	Annual efficiency η_a at50 °C annual output/irradiation	0%	16%	17%	18%	30%	32%	34%	37%	45%	52%
	relative efficiency AAA =100%	0%	31%	33%	35%	58%	62%	65%	71%	87%	100%

Table 1: Classification scheme for energy efficiency of conventional heaters and output classes for solar collectors

The different classification schemes are related to the higher exergy provision of the normal heat pump, which can achieve higher flow temperatures. Accordingly, two scales are introduced for collectors too which depend on whether higher temperatures (75 °C) or medium temperatures (50 °C) are provided.

Since unrealistic simplifications are used in the Regulation 811/2013 for the calculation of the package label when solar devices are included and assessed (e.g. for space heating a fictive collector efficiency at an irradiance of 1000 W/m² and a temperature difference of 40 K are used), an annual efficiency η_a has been introduced in the collector output label in order to achieve a simple and understandable labelling for the consumer. The annual efficiency is calculated using the reference annual output of a collector module at a defined temperature (50 °C or 75 °C) divided by the gross area and the specific annual solar irradiation. Using the generally accepted data sets of tests according to the valid collector standard EN ISO 9806 (resp. old test reports acc. the EN 12975-2) the annual collector output is calculated physically correct for constant collector temperatures by a worldwide accepted and validated calculation method. The calculation is done with an excel program (ScenoCalc in the current version) which is available free of charge. Two sheets are used for the Solar Keymark certification (data sheet 1 and 2)
(Source: http://www.sp.se/en/index/services/solar/ScenoCalc/Sidor/default.aspx)

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Summary of EN 12975 Test Results, annex to Solar KEYMARK Certificate		Licence Number	CERTNO-01C
		Issued	2014-10-14

Company holding the	Acompany	Country	Acountry
Brand (optional)	Abrand	Website	www.
Street, street number	Astreet, 1	E-mail	info@
Postal Code / City, province	A1111-1 Acity, Aprovince	Tel/Fax	99 123 456 789 /-790

Collector Type (flat plate glazed/un-glazed; evacuate tubular)	Flat plate collector - glazed
Thermal / photo voltaic hybid collector? (PVT collector)	Yes
Integration in the roof possible ? (manufacturers declaration)	Yes

Collector name	Aperture area (Aa)	Gross length	Gross width	Gross height	Gross area (AG)	Power output per collector module G = 1000 W/m², Tm-Ta 0 K	10 K	30 K	50 K	70 K
	m²	mm	mm	mm	m²	W	W	W	W	W
Acol size A	1,00	1.050	1.050	50	1,10	700	669	597	513	417
Acol size B	2,00	2.100	1.050	50	2,20	1.400	1.337	1.193	1.025	833

Performance test method	Glazed liquid heating collector - steady state - outdoor			
Performance parameters related to aperture	η0	a1	a2	
Units	-	W/(m²K)	W/(m²K²)	
Test results - Flow rate and fluid see note 1	0,700	3,000	0,015	

Bi-directional incidence angle	Yes	KΘ values are obligatory for 50°.								
Incidence angle modifiers KΘ(ΘT) transversal direction	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
	KΘ(ΘT)	1,00	0,99	0,98	0,97	0,94	0,90	0,81	0,52	0,00
Incidence angle modifiers KΘ(ΘL) longitudinal direction	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
	KΘ(ΘL)	1,00	0,99	0,98	0,97	0,94	0,90	0,81	0,52	0,00

Stagnation temperature - Weather conditions see note 2	Tstg	176	°C
Effective thermal capacity	ceff = C/Ag	10	kJ/(m²K)
Max. intende operation temperature - see note 3	Tmax,op	100	°C
Max. operation pressure - see note 3	pmax,op	100	kPa

Pressure drop table - for a collector family, the values shall be for the module with highest ΔP per m² aperture area

Flow rate	kg/(s m²)	0,003	0,007	0,010	0,013	0,017	0,020	0,023	0,027	0,030	0,033
Pressure drop, ΔP	Pa	11	44	100	178	278	400	544	711	900	1111

Optional weather data	Location		Link
Testing Laboratory	Atestlab		
Website	www.Atestlab.Adomaine		
Test report id. number	A0	Date of test report	2014.10.14

During the test GDIF/GTOT was always between 0,1 and 0,2

Comments of testing laboratory:

Example comment.

Thermal performance parameters are given for the PV-module working with max. electrical power output ('MPP mode')

Note 1	Flow rate	0,020	kg/(s m²)	Fluid	Water
Note 2	Irradiance, G = 1000 W/m²; Ambient temperature , Ta=30 °C				
Note 3	Given by manufacturer				

Datasheet version: 4.06, 2014-01-15

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Figure 2: Solar Keymark data sheet 1

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Annual collector output based on EN 12975 Test Results, annex to Solar KEYMARK Certificate	Licence Number	CERTNO-01C
	Issued	14.10.2014

Annual collector output kWh/module

Collector name	Location and collector temperature (Tm) Athens 25°C	Athens 50°C	Athens 75°C	Davos 25°C	Davos 50°C	Davos 75°C	Stockholm 25°C	Stockholm 50°C	Stockholm 75°C	Würzburg 25°C	Würzburg 50°C	Würzburg 75°C
Acol size A	1.119	812	533	859	599	374	632	419	253	687	453	269
Acol size B	2.238	1.625	1.067	1.719	1.198	748	1.265	838	505	1.374	906	537

Collector mounting: Fixed or tracking	Fixed; slope = latitude - 15° (rounded to nearest 5°)

Overview of locations

Location	Latitude °	Gtot kWh/m²	Ta °C	Collector orientation or tracking mode
Athens	38	1.765	18,5	South, 25°
Davos	47	1.714	3,2	South, 30°
Stockholm	59	1.166	7,5	South, 45°
Würzburg	50	1.244	9,0	South, 35°

Gtot	Annual total irradiation on collector plane	kWh/m²
Ta	Mean annual ambient air temperature	°C
Tm	Constant collector operating temperature (mean of in- and outlet temperatures)	°C

The calculation of the annual collector performance is performed with the official Solar Keymark spreadsheet tool ScenoCalc. The collector output is calculated hour by hour according to the efficiency parameters from the Keymark test using constant collector operating temperature (Tm). A detailed description of the calculations is available at http://www.sp.se/en/index/services/solar/ScenoCalc/Sidor/default.aspx.

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Datasheet version: 4.06, 2014-01-15
ScenoCalc version: Ver. 4.06 (Jan. 2014)

Figure 3: Solar Keymark data sheet 2

Within the Solar Keymark certification, the collector output is determined with this program for 4 locations in Europe and with the corresponding tilts facing south. The Solar Keymark data sheet has 2 pages. The dimensions and all collector parameters are listed on page 1. The results of the annual collector output for the 4 locations are listed on page 2. The relevant annual efficiency, which is used for the classification under average climate conditions later, is determined for the location Würzburg. The climate of the location Würzburg is very similar to that of the location Strasbourg, which is used in Regulation 811/2013 and thus can be used equivalent. The annual efficiency for collectors at medium or higher working temperature is called $\eta_a(\text{xy °C})$. It is calculated according the equation:

$$\eta_a(\text{xy °C}) = \frac{\text{Annual Collector Output [kWh per module] (xy °C)}}{\text{Gross area (AG)} \cdot \ Annual\ total\ irradiation\ (Gtot)}$$

The value of the annual efficiency is calculated in %, rounded to the nearest integer.

<u>Example (ScenoCalc default - flat plate collector):</u>

$$\eta_a(50\ °\text{C}) = \frac{453\ \text{kWh}}{1{,}1\ \text{m}^2 \cdot \ 1244\ kWh/m^2} = 33\ \%$$

Result with table 1 of annex: Energy output class A+

$$\eta_a(75\ °\text{C}) = \frac{269\ \text{kWh}}{1{,}1\ \text{m}^2 \cdot \ 1244\ kWh/m^2} = 20\ \%$$

Result with table 2 of annex: Energy output class B

3. Classification

At first, solar collectors for medium temperatures (50 °C) are investigated. As a benchmark for the energy output of an AAA class collector efficiency was fixed to 52 % (see table 1, green array). The conversion factor for the other classes is determined by the ratio of this value to the A+++ value of the low-temperature heat pump. The adjustment can be seen by the fact that the relative characteristic curves of low-temperature heat pump and solar collectors at 50 °C are the same (figure 4, yellow course in accordance with blue).
The output classes for higher temperatures (75 °C) are based on the classification of the heaters without low-temperature heat pump. Again the annual efficiencies are adjusted so that the characteristic curve matches the respective curve for heaters (Figure 4, red curve in accordance with green).
Basically output classes for low temperatures (25 °C) can be determined too. Possibly, the same classification as for medium temperatures could be applied. But currently there is a low market relevance for applications at 25 °C, therefore, this item does not need to be discussed in more detail now.
The standardized efficiency classes shown (= relative efficiency with A +++ = 100 %) also point out how the EU has designed the classification. It is clearly visible that intended technological leaps (different slope of the graphical curve in Fig. 4) are represented by a strong change in the relative efficiency. Correctly, the first leap is applied during the transition from category D (A-) to C (A), because the worse classes E (A--) to G (B) will be excluded from 2019 on. Products which do not have reached the class D (A-) by then must be taken off the market in accordance with the EU Regulation 811. If a product has made the leap to class C (A), it can be shifted to class A+ (A+++) by steady minor improvements. Then there is a second technological leap to A++ (AA). This can be achieved almost only by new improved technology. Getting to A+++ (AAA) is only possible by again significantly increased technological efforts. An analysis of the market for solar collectors shows that today virtually no collectors are available in the 3 lowest classes. Therefore, the rule of the EU Regulations for 2019 to skip these classes is already implemented in this guideline as there is no need to introduce them. Hence, for the SOLERGY label remain 7 classes ranging from A- to AAA. They reflect the available various technological stages of solar collectors on the market in a differentiated and proper manner.

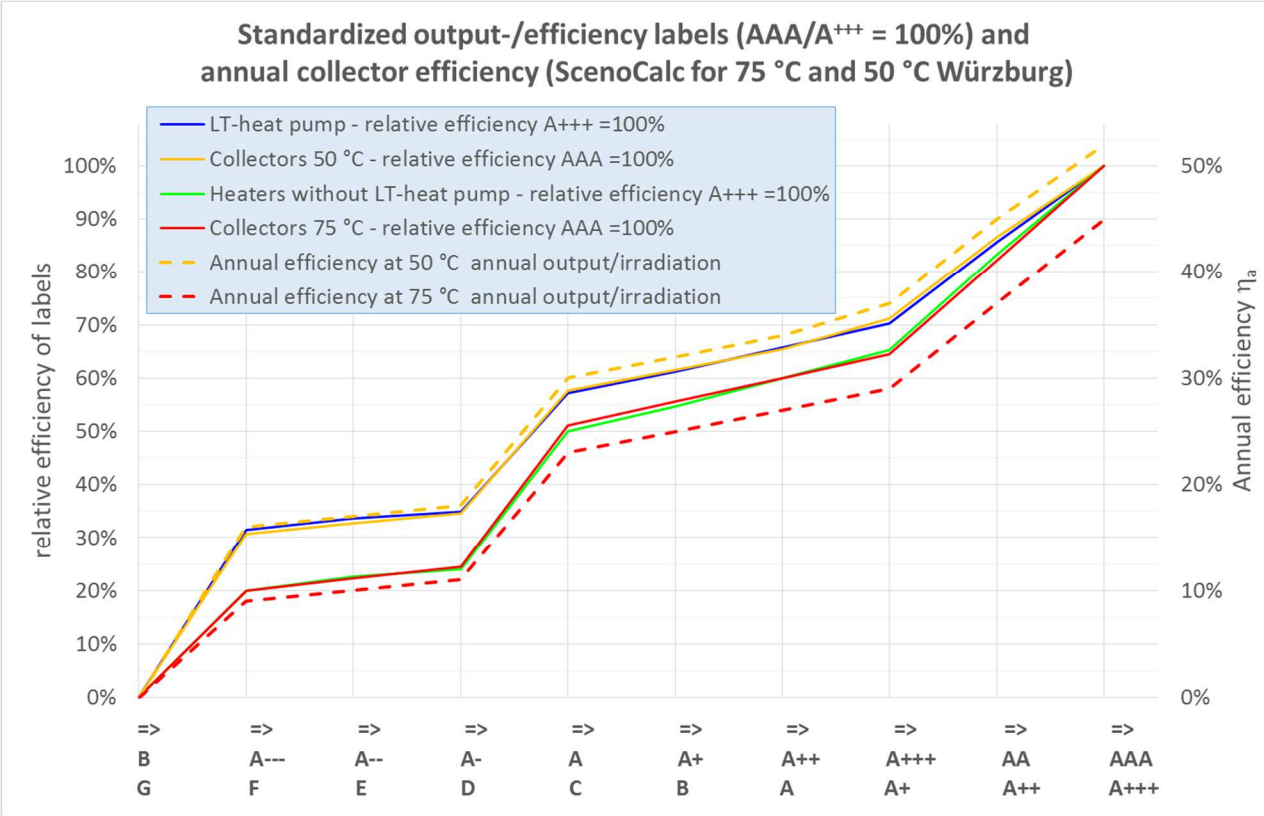


Figure 4: Standardized efficiency / output classes

Subsequently, a possible labelling scheme for solar collectors is presented in accordance to Regulation 811/2013 and 812/2013. As previously described, output classes can be determined for solar collectors for both higher temperatures as well as for medium temperatures. It is up to the manufacturer to determine whether the collector is only suitable for medium or higher temperature (e.g. district heating, process heat). Accordingly he can select the appropriate label. Unlike EU Regulations for space heating, it makes sense to use the highest class AAA for solar collectors right from the beginning since the classes B to A-- are not required as explained before. Nowadays, collectors deliver so much energy per m² that these classes practically do not occur.

Additionally to the output classes of the collector on the labels, the annual output per module is specified in kWh/a explicitly for colder (Stockholm), medium (Würzburg) and warmer (Athens) locations. They are shown on the label explicitly beside the belonging reference locations. The output data are taken directly from Solar Keymark datasheet 2. The climate of the colder location Stockholm is very similar to that of the location of Helsinki referred in the regulations. The warmer location in both cases is Athens. Therefore the weather data files on an hourly basis implemented in the program can be used equivalent to the EU 3 zones for solar irradiation. On the label itself the Solar Keymark logo, the license number of the collector model and the reference to the website www.solarkeymark.org are declared. The collector output label SOLERGY is issued by DIN CERTCO (www.dincertco.de) and delivered as image file. The data of the labels of all participating companies are presented in a registered database published in the internet.

Important:
A label for a certain temperature level can principally only be issued, if the collector at all reference locations achieves at least the lowest class which is granted!

Annex

Classification of solar collectors into output classes according their annual efficiency at average climate (reference location Würzburg) and its labelling requirements.

Table 1

Output classes of solar collectors at medium temperatures (50 °C)

Output class	Annual efficiency η_a in %
AAA	$\eta_a \geq 52$
AA	$45 \leq \eta_a < 52$
A+++	$37 \leq \eta_a < 45$
A++	$34 \leq \eta_a < 37$
A+	$32 \leq \eta_a < 34$
A	$30 \leq \eta_a < 32$
A-	$18 \leq \eta_a < 30$
A--	$17 \leq \eta_a < 18$
A---	$16 \leq \eta_a < 17$
B	$\eta_a < 16$

Table 2

Output classes of solar collectors at higher temperatures (75°C)

Output class	Annual efficiency η_a in %
AAA	$\eta_a \geq 45$
AA	$37 \leq \eta_a < 45$
A+++	$29 \leq \eta_a < 37$
A++	$27 \leq \eta_a < 29$
A+	$25 \leq \eta_a < 27$
A	$23 \leq \eta_a < 25$
A-	$11 \leq \eta_a < 23$
A--	$10 \leq \eta_a < 11$
A---	$9 \leq \eta_a < 10$
B	$\eta_a < 9$

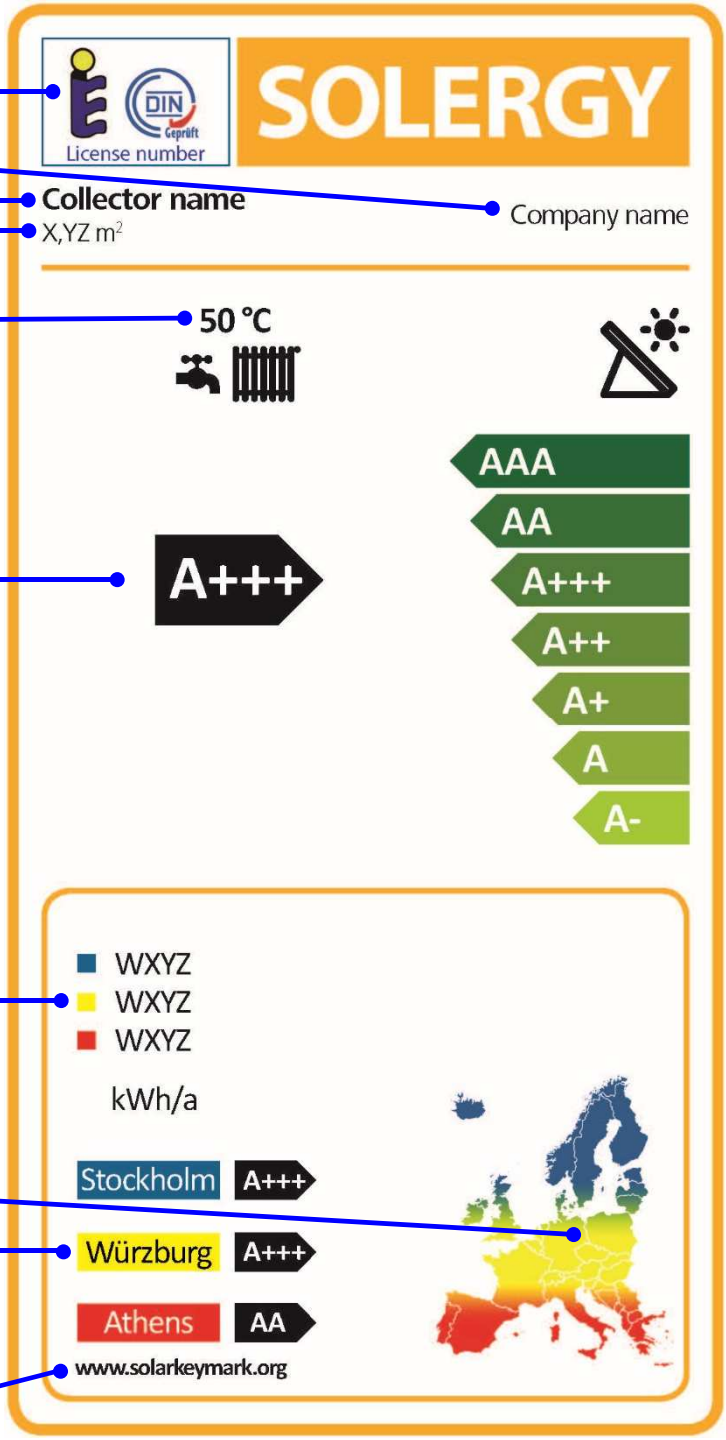
Note:

Output classes A-- to B are listed to have a complete overview but are not necessary as the market situation shows typically products with higher output and none with such low output. Hence these classes are not used for classification and labelling!

Design of the label for medium (50 °C) temperatures

<u>The label shall include the following information:</u>

- Solar Keymark Logo and license number
- Supplier´s name or trade mark
- Supplier´s model identifier
- Gross area of the collector module
- Designation of the heat generator for medium temperatures (50 °C)
  e.g. for water and space heating
- Output classes (AAA to A-) at average climate (Würzburg) for medium temperatures (50 °C), determined by annex table 1
- Annual collector output acc. Solar Keymark data sheet 2 each at average (Würzburg), colder (Stockholm) and warmer (Athens) climate for medium temperatures (50 °C)
- European solar map displaying three indicative global solar irradiance zones
- Reference locations Stockholm, Würzburg, Athens for the 3 zones and related output classes (AAA to A-) for 50 °C
- Website where the data used are to be found: www.solarkeymark.org



Design of the label for medium (50 °C) and higher (75 °C) temperatures

<u>The label shall include the following information:</u>

- Solar Keymark Logo and license number
- Supplier´s name or trade mark
- Supplier´s model identifier
- Gross area of the collector module
- Designation of the heat generator for medium temperatures (50 °C) e.g. for water and space heating and higher temperatures (75 °C) e.g. for process heat
- Output classes (AAA to A-) at average climate (Würzburg) for medium temperatures (50 °C) and higher temperatures (75 °C), determined by annex table 1 and 2
- Annual collector output acc. Solar Keymark data sheet 2 each at average (Würzburg), colder (Stockholm) and warmer (Athens) climate for medium temperatures (50 °C) and higher temperatures (75 °C)
- European solar map displaying three indicative global solar irradiance zones
- Reference locations Stockholm, Würzburg, Athens for the 3 zones and related output classes (AAA to A-) for 50 °C and 75 °C
- Website where the data used are to be found: www.solarkeymark.org