M7.2 g-value Round Robin testing among three different measurements setup

WP7. Demonstration, T7.2

Authors. Hauer M., Reithmaier N. (BB), De Michele G. (EURAC), Plörer D. (UIBK)

Date: 12/2019

Table of Contents

1 Introduction and objective

Given the measurement infrastructure developments achieved during the FACEcamp project, a Round Robin campaign has been done in order to compare the different setup from a quantitative point of view. The g-value Round Robin activities aimed at benchmarking the different equipment and measurement procedures one against the other.

2 Methodology

2.1 Solar heat gain coefficient (SHGC, g-value)

The solar heat gain coefficient (accord. to EN 410) is defined as sum of transmittance of direct irradiation (shortwave, spectrum airmass 1.5 and parallel beam) and relative secondary heat gains (longwave radiation and convection). In EN 410 the irradiating beam is assumed to be parallel, the method is basically meant to be used for glazing but is generally also used for all transparent materials.
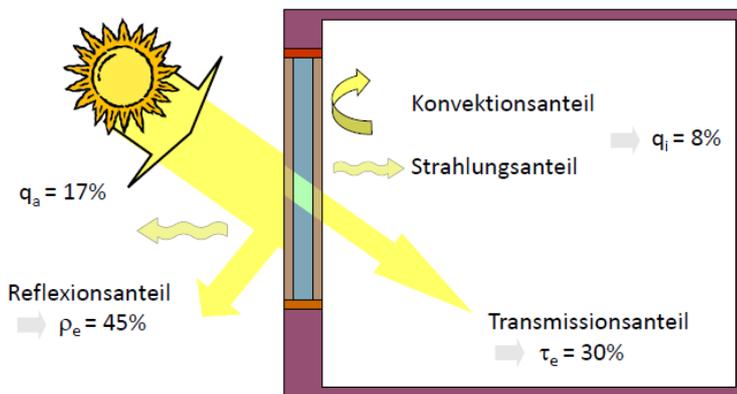
$$g = \tau_e + q_i$$

$g = solar\ heat\ gain\ coefficient$

$\tau_e = Solar\ transmission$

$q_i = secondary\ heatflux$

Figure 1: g-value components

2.2 Samples and measurement plan

Probe #	Probe name	BB	EURAC	UIB
#1	Float glazing (triple pane)	✓	-*	✓
#2	3-pane IGU with low-e coating on #2 and #5	✓	- *	✓
#3	3-pane IGU with sun protecting coating on #5	✓	-*	✓
#4	Okasolar – sun shade raster	✓	✓	✓
#5	2-pane float glazing with in-between shading blinds	✓	-*	✓
#6	2-pane IGU with low-e coating on #3	✓	✓	✓
#7	3-pane IGU with low-e coating on #2 and #5	✓	✓	✓

* Sample dimension do not fit the metering chamber of Eurac system
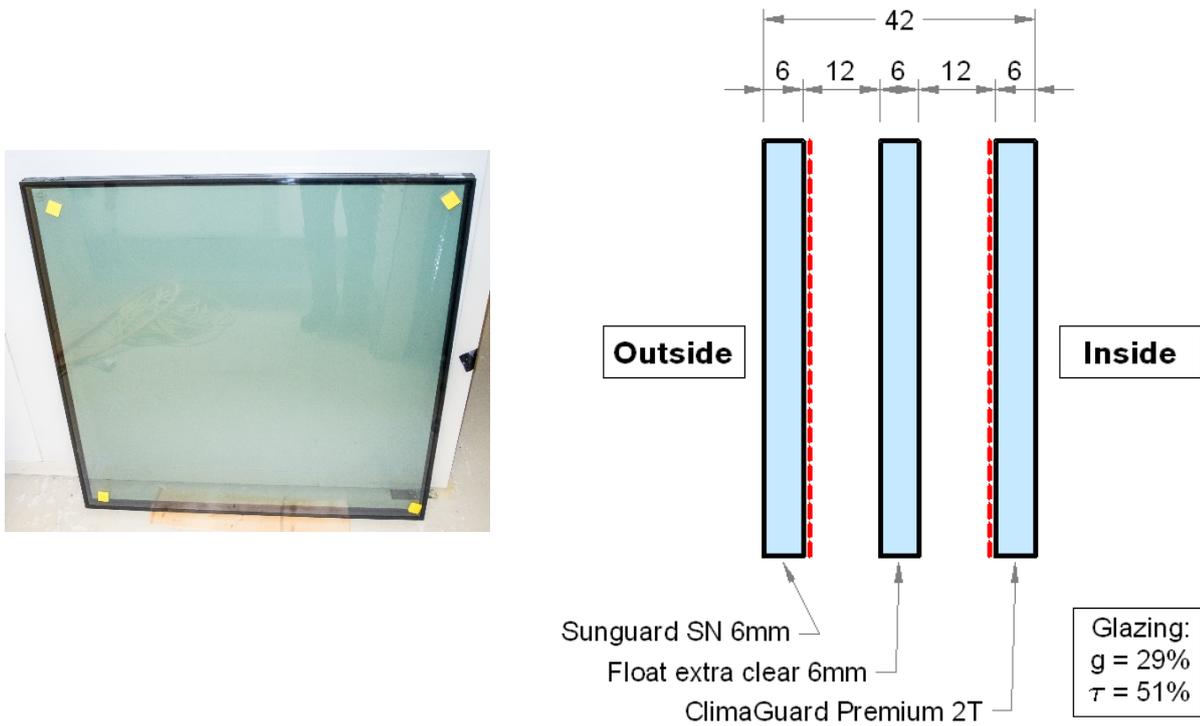
2.2.1 Insulation glazing units (#1 - #3)

Figure 2: top: Probe #3, Dimensions of the IGU sample: 1000mm x 1000mm x 42mm

2.2.2 Hella lamella white at cut off alignment (#5)

2.2.3 Okasolar 3D (#4)

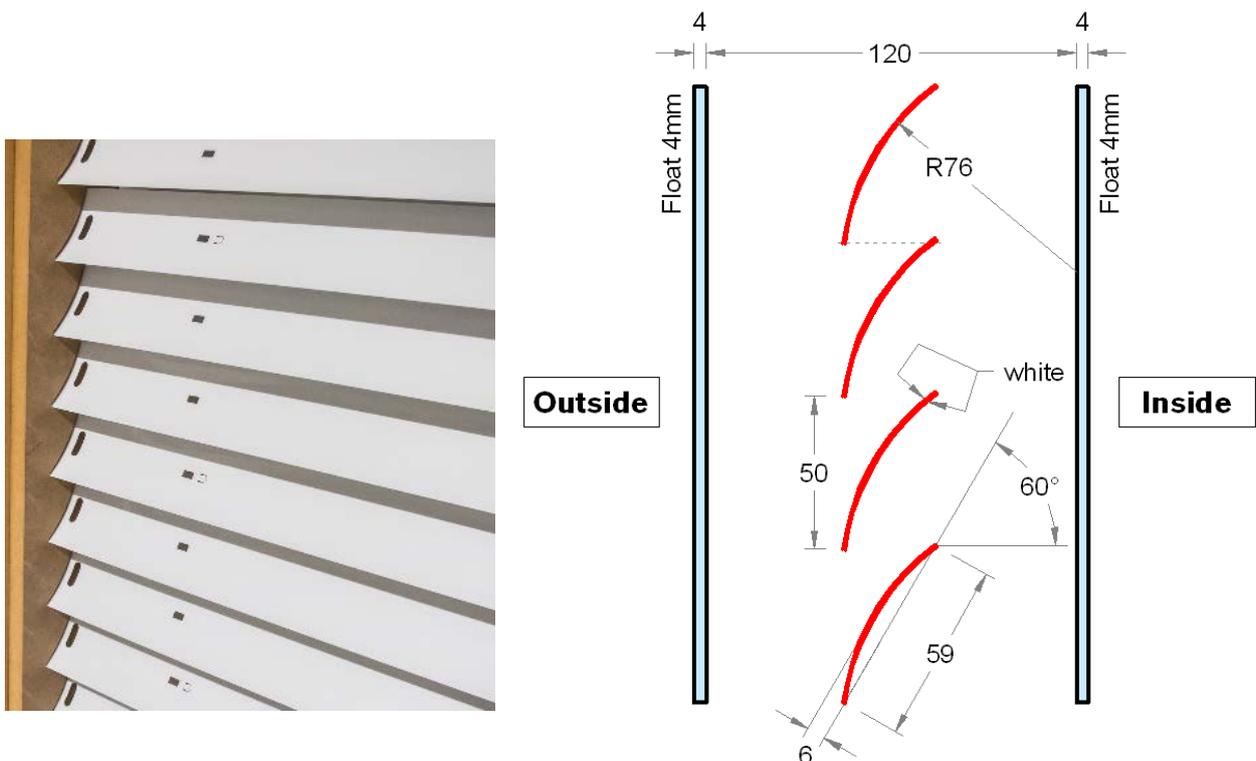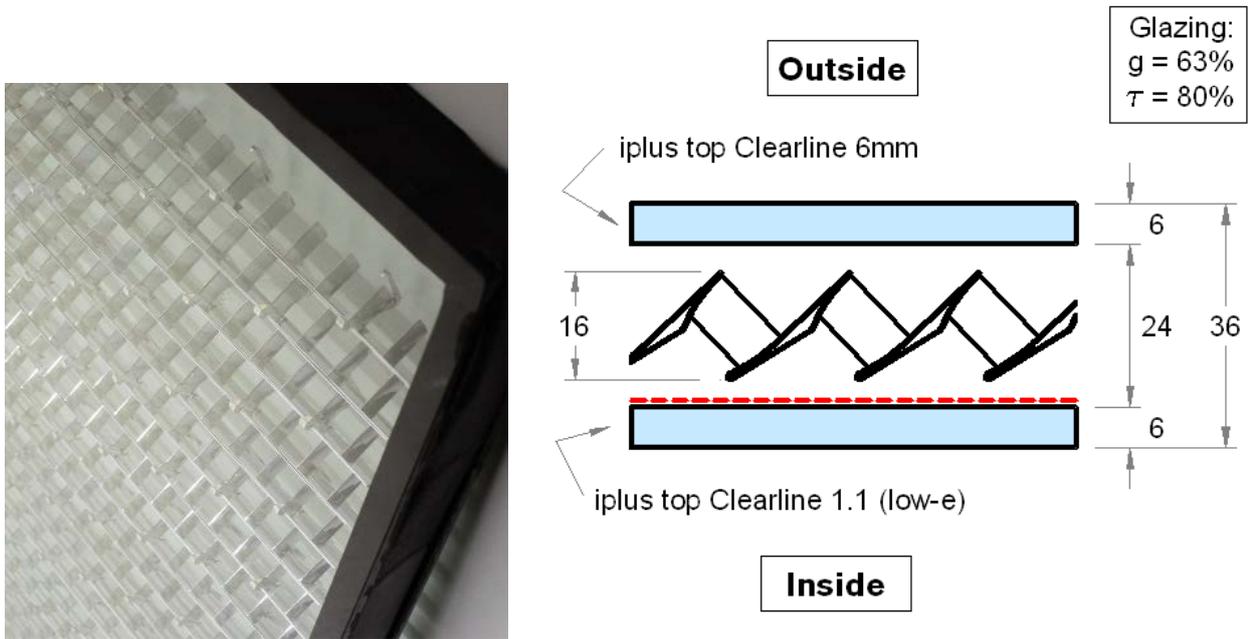**Figure 4: Probe #4 "Okasolar 3D", Dimensions: 1000mm x 1000mm x 120mm**

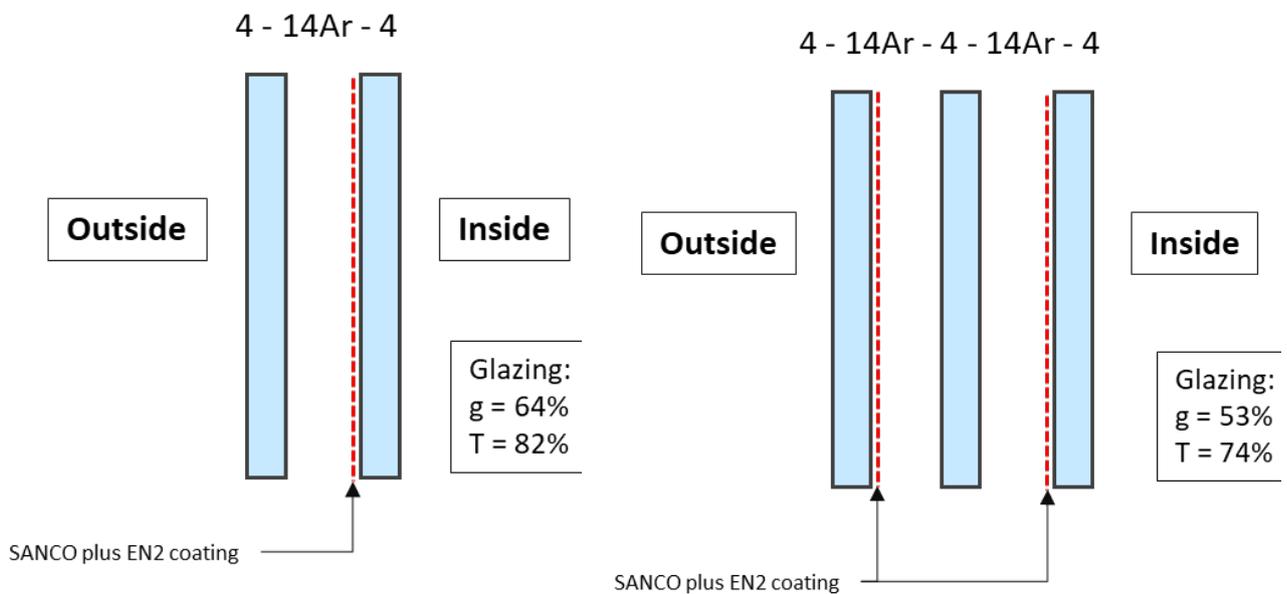### 2.2.4 Insulation glazing units (#6 and #7)

Figure 5. Probes #6 and #7, Dimensions of the IGU samples: 1000mm x 1000mm x 22mm (double pane) and 40mm (triple pane)

2.3 Testing sites description

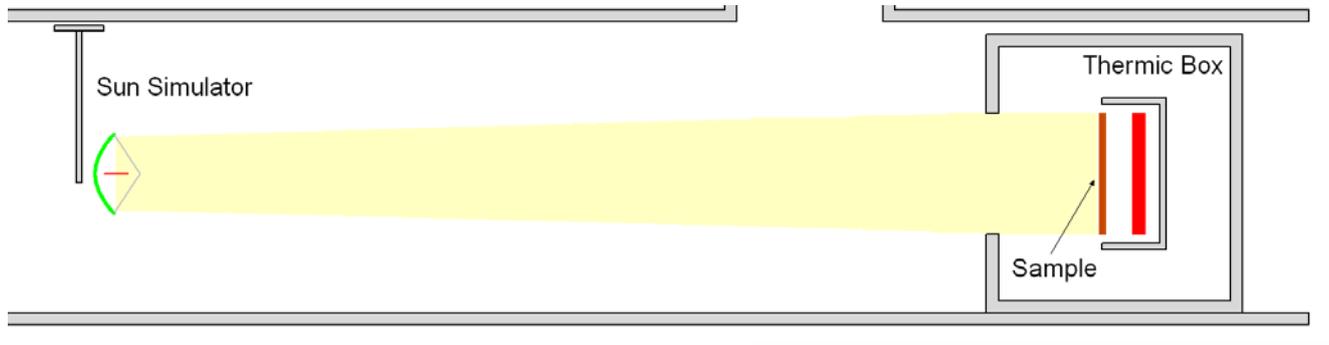### 2.3.1 Calorimetric test bench @Bartenbach

Figure 6: top: whole test stand, bottom-left: solar simulator, bottom-right: probe fixture in the climatic chamber

Measuring Method

At Bartenbach laboratory the caloric SHGC measurement is not limited to perpendicular irradiation (as mentioned in EN 410). The transmitted energy is calculated via the cooling load of a black absorber. The complete measurement system is located at a climatic controlled box, which allows simulating any boundary condition. In this case the air temperature is static (20°C ± 0.2°C) and the wind speed at the external face of sample is set to 4m/s ± 0.5m/s.

The irradiation is generated by the 'solar simulator' (HMI2.5kW lamp) which corresponds to AM1.5 spectrum.

2.3.2 In-situ g-value device @UIBK

The in-situ measuring instrument is installed directly on the inner glazing pane to be measured, and consists of two individual parts:

- Heat flux measurement: by means of a temperature-controlled plate apparatus with Peltier elements

- Transmittance measurement: by means of an individual PV cell on the inner facade and a steady-state one on the outer facade
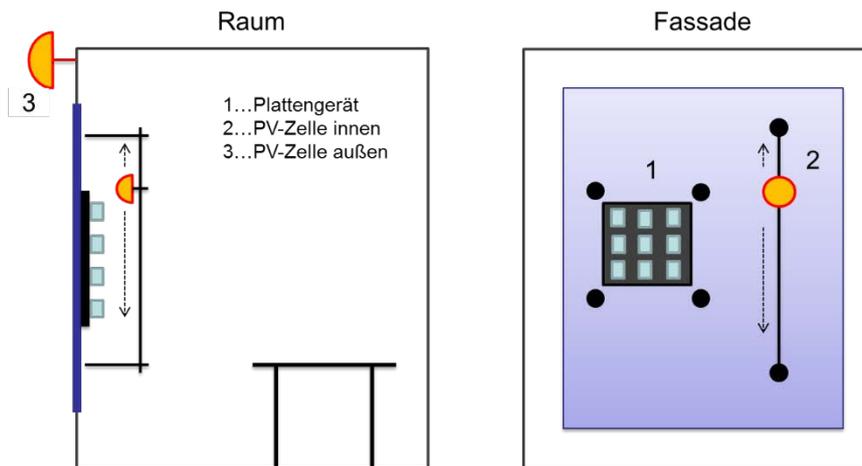
Figure 7: in-situ measurement concept in two independent parts

While the heat flux apparatus measures the overall energy flow, represented by the g-value (including transmittance and secondary heat flux), the PV cells measure only the transmitted radiation part as a ratio of the inside and outside measured values. By subtracting this result from the overall flux measured by the heat flow apparatus, the remaining part accounting only for the secondary heat flux can be determined. This separate evaluation of the transmitted and secondary heat flux part is an advantage where a detailed model validation is concerned as it also enables separated modeling.

The measuring instrument is equipped with a control unit regulating actual temperature levels and operating boundary conditions. An integrated thermocouple sensor (radiation shielded) measures the actual air temperature in the room and several thermocouples integrated in the heat flux apparatus relay the actual temperature of the heat flux apparatus to the control unit.

The instrument responds to the actual situation instantaneously, its low thermal capacity enabling it to react fast to changing conditions. All sensors, including the heat flux and both PV cells, are sampled at intervals of 20 seconds and can be recorded via logging software on a PC. The control software works online and affords an active PC connectivity throughout the measuring time.

For determining the solar transmission, two PV cells are installed, positioned inside and outside the test facade. The PV cell on the outside measures the global radiation on the facade and is oriented parallel to the glazing. In the case of integrated blinds, a determination of the varying transmission value due to a partly shading by the blinds is necessary. In the case of a glazing without shading, it is sufficient to mount the inner PV cell in a fixed position.

The transmission then results from the ratio of the internal measured (mean) value to the external transmission measurement.

For a direct comparison of the in-situ g-value measurements with the calorimetric measurements, the device was installed directly in the calorimetric chamber of the g-value test stand at Bartenbach (ref. Figure). By ensuring comparative measurement conditions (temperature boundaries, incident radiation), all measurements on the different probes were repeated using the g-value device. For this purpose, the finish of the heat flux plate on the in-situ device was equipped with a black absorbing foil, in order to create same conditions as the absorber plate of the calorimetric test stand.
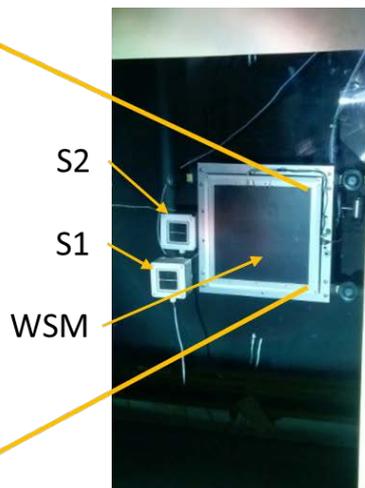
Figure 8: Prototype with absorbing foil (L) installation in calorimetric test stand at BB (R)

Due to a slightly varying pattern of the incident radiation by the solar simulator, the incident radiation field directly in front of the heat flux apparatus was scanned and evaluated within 9 subareas (ref. Figure). By this, the average incident radiation was calculated to evaluate the resulting g-value in a most accurate way.

$$\tau_{corr} = \frac{S2}{S1 * f_{corr,\tau}}$$

$$SHGC_{corr} = \frac{WSM_{mean}}{S1 * f_{corr,SHGC}}$$

Distribution – Incident radiation [W/m²]
Mean: 640 W/m²

Figure 9: Distribution of incident radiation and correction terms

2.3.3 G-value measurement system @EURAC

Figure 10. Left: g-value measuring system at Eurac with activated solar simulator, sample and climatic chamber, right: metering box inside the climatic chamber.

At Eurac laboratory the transmitted energy is calculated according two methodologies: direct heat flux measurement via heat flux plate sensors and calorimetric via the cooling load of a black absorber. The complete measurement system is located at a climatic controlled box, which allows simulating any boundary condition. In this case the air temperature is static (20°C ± 0.1°C) and the wind speed at the external face of sample is set to 4m/s ± 0.5m/s.

The irradiation is generated by a solar simulator (ARRIMAX 18/12 18kW SE Lamp) in accordance with the requirements of ISO 19467:2017.

The SHGC measurement is not limited to perpendicular irradiation (as mentioned in EN 410).

3 Results

3.1 Overview

The measurement results show a very good correspondence between the calorimetric measurements done by BB, the calorimetric and flux-metric measurement done by Eurac and the in-situ measurements done by UIBK. Also, the correspondence with the theoretically calculated values in WINDOW7 is satisfying.

Compared to the calorimetric measurement procedure, the in-situ measurement shows a faster reaction and less time-constants until getting stable measurement conditions. Therefore, the in-situ device could be advantageous in measuring different states of the probe (e.g. different incident angles or blind positions) in a faster time.

Table 1: g-value measurement results

Sample	Sample name	Theoretical (WINDOW7)	BB	EURAC	UIBK
n.1	3-pane float glazing	0.703	0.71	-	0.73
n.2	3-pane IGU with low-e coating on #2 and #5	0.496	0.54	-	0.52
n.3	3-pane IGU with sun protecting coating on #5	0.29 (Manuf.)	0.29	-	0.29-0.3
n.4	Okasolar – sun shade raster	0.15 (Manuf.)	0.15	0.15 (calorimeter) 0.14 (flux-meter)	0.14-0.15
n.5	2-pane float glazing with in-between shading blind	0.25	0.24	-	0.24
n.6	2-pane IGU with low-e coating on #3	0.64 (Manuf.)	0.61 (calorimeter)	0.60 (calorimeter) 0.61 (flux-meter)	0.63
n.7	3-pane IGU with low-e coating on #2 and #5	0.53 (Manuf.)	0.53 (calorimetric)	0.51 (calorimeter) 0.52 (flux-meter)	0.57

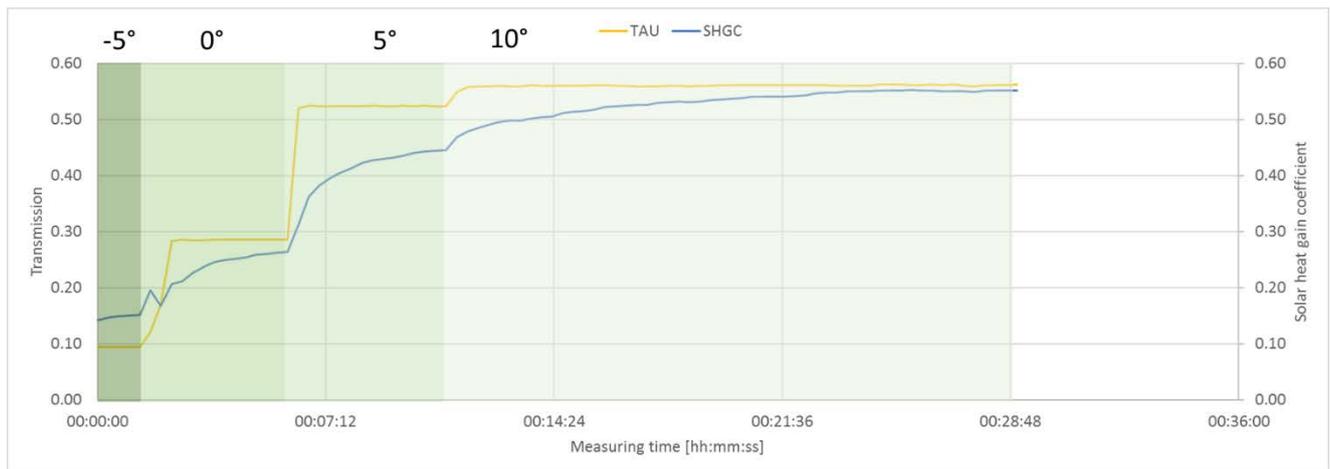## 3.2 Detailed results (probe n.4: Okasolar) by the in-situ device

Table 2: Measurement results for probe #4 "Okasolar 3D" by the in-situ device

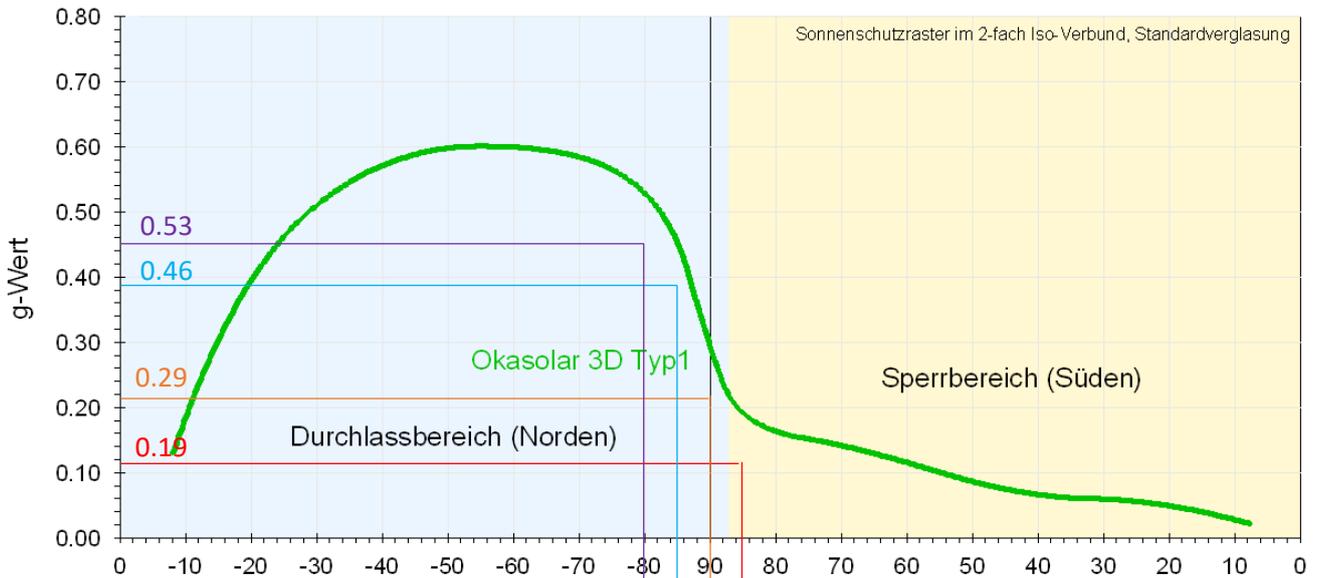|	Mean value		End value	
Tilt angle probe	TAU	SHGC	TAU	SHGC
-5°	0.09	0.15	0.09	0.15
0°	0.27	0.23	0.29	0.26
5°	0.52	0.41	0.52	0.45
10°	0.56	0.53	0.56	0.55

Figure 11: Angular-dependent g-value of probe #4 "Okasolar 3D"

4 Conclusions

The Round Robin campaign offered a solid test base for benchmarking the three measurement systems. The test allowed to compare three different setups on different façade systems (e.g. simple glazing and complex shading devices), and to share "good measurement practices" within the FACEcamp consortium. Result of the comparison shows an acceptable agreement among the measurement approaches, highlighting the robustness of the apparatus and methodology of the three research institutions. The availability of such infrastructures and methodologies is a relevant asset available for building owner, companies and practitioners over the trans-border territory (North and South Tirol).

FACEcamp partners

eurac research	EURAC Eurac Research, Institute for Renewable Energy	Coordinator
IDM SÜDTIROL ALTO ADIGE	IDM IDM Suedtirol - Alto Adige	Partner
universität innsbruck	UIBK Universität Innsbruck, Arbeitsbereich Energieeffizientes Bauen	Partner
HELLA Jalousien. Markisen. Rollläden.	HELLA HELLA Sonnen- und Wetterschutztechnik GmbH	Partner
Bartenbach	BB, Bartenbach GmbH	Partner
glassAdvisor	gA, Glassadvisor Srl	Partner
FRENER REIFER	F&R, FRENER & REIFER SrL	Partner

Contact points:

Project coordinator, Stefano Avesani stefano.avesani@eurac.edu

FACEcamp website www.facecamp.it