
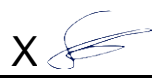
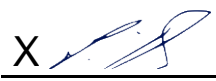


<b>Test Report No.:</b> <i>Prüfbericht-Nr.:</i>	<b>DE2372IA 001</b>	<b>Order No.:</b> <i>Auftrags-Nr.:</i>	300100844	Page 1 of 13 Seite 1 von 13
<b>Client Reference No.:</b> <i>Kunden-Referenz-Nr.:</i>	1863314	<b>Order date:</b> <i>Auftragsdatum:</i>	2022-10-13	
<b>Client:</b> <i>Auftraggeber:</i>	LONGi Green Energy Technology Co., Ltd. No. 388, Middle Hangtian Road, Chang'an District; Xi'an, Shaanxi; P.R.China (managed by TÜV Rheinland (Shanghai) Co., Ltd.)			
<b>Test item:</b> <i>Prüfgegenstand:</i>	Photovoltaic (PV) modules			
<b>Identification/ Type No.:</b> <i>Bezeichnung / Typ-Nr.</i>	see page 7			
<b>Order content:</b> <i>Auftrags-Inhalt:</i>	Measurement of Optical Reflectance of Photovoltaic (PV) Modules Messung des optischen Reflexionsgrads von Photovoltaik (PV)-Modulen			
<b>Test specification:</b> <i>Prüfgrundlage:</i>	see page 6			
<b>Date of sample receipt:</b> <i>Wareneingangsdatum:</i>	2022-12-30			
<b>Test sample No.:</b> <i>Prüfmuster-Nr.:</i>	see page 7			
<b>Testing period:</b> <i>Prüfzeitraum:</i>	2023-06-28 - 2023-06-28			
<b>Place of testing:</b> <i>Ort der Prüfung:</i>	Am Grauen Stein, 51105 Cologne/Germany			
<b>Testing laboratory:</b> <i>Prüflaboratorium:</i>	TÜV Rheinland Solar GmbH			
<b>Test result*:</b> <i>Prüfergebnis*:</i>	No pass/fail criteria applicable			
<b>tested by:</b> <i>geprüft von:</i>	<b>authorized by: /</b> <i>genehmigt von:</i>			
<b>Date:</b> 2023-06-30 <i>Datum:</i>	 Signiert von: Johannes Stang	<b>Issue Date:</b> 2022-12-12 <i>Ausstellungsdatum:</i>	 Signiert von: Lukas Jakisch	
<b>Position / Stellung:</b>	Expert	<b>Position / Stellung:</b>	Segment manager	
<b>Others /</b> ./. <i>Sonstiges:</i>				
<b>Condition of the test item at delivery:</b> <i>Zustand des Prüfgegenstandes bei Anlieferung:</i>	Test item complete and undamaged			
* Legend: P(ass) = passed a.m. test specification(s) F(ail) = failed a.m. test specification(s) N/A = not applicable N/T = not tested * Legende: P(ass) = entspricht o.g. Prüfgrundlage(n) F(ail) = entspricht nicht o.g. Prüfgrundlage(n) N/A = nicht anwendbar N/T = nicht getestet				
<p><b>This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.</b>                  Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.</p>				

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Prüfbericht-Nr.: DE2372IA 001  
Test report no.:

Seite 2 von 13  
Page 2 of 13

**Remarks**  
Anmerkungen

<b>A</b>	<p>Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden.</p> <p><i>The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system. Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.</i></p>
<b>B</b>	<p>Wie vertraglich vereinbart, wurde dieses Dokument nur digital unterzeichnet. Der TÜV Rheinland hat nicht überprüft, welche rechtlichen oder sonstigen diesbezüglichen Anforderungen für dieses Dokument gelten. Diese Überprüfung liegt in der Verantwortung des Benutzers dieses Dokuments. Auf Verlangen des Kunden kann der TÜV Rheinland die Gültigkeit der digitalen Signatur durch ein gesondertes Dokument bestätigen. Diese Anfrage ist an unseren Vertrieb zu richten. Eine Umweltgebühr für einen solchen zusätzlichen Service wird erhoben.</p> <p><i>As contractually agreed, this document has been signed digitally only. TUV Rheinland has not verified and unable to verify which legal or other pertaining requirements are applicable for this document. Such verification is within the responsibility of the user of this document. Upon request by its client, TUV Rheinland can confirm the validity of the digital signature by a separate document. Such request shall be addressed to our Sales department. An environmental fee for such additional service will be charged.</i></p>
<b>C</b>	<p>Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt.</p> <p><i>Test clauses with remark of * are subcontracted to qualified subcontractors and described under the respective test clause in the report.</i> <i>Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.</i></p>
<b>D</b>	<p>Die Entscheidungsregel für Konformitätserklärungen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC GC8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird.</p> <p><i>The decision rule for statements of conformity in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance to ILAC GC8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report.</i></p>

**Prüfbericht-Nr.: DE2372IA 001**  
Test report no.:

Seite 3 von 13  
Page 3 of 13

**Table of contents**  
*Inhaltsverzeichnis*

1	General information .....	4
1.1	Executive summary .....	4
1.2	Setting of tasks .....	5
1.3	Summary of test results .....	5
1.4	Test specifications .....	6
2	Product description .....	7
2.1	Test sample obtaining.....	7
2.2	List of test samples .....	7
3	Module examinations .....	8
3.1	Measurement of spectral optical reflectance .....	8
Appendix A:	Calculation of ISO 9050 external light reflectance $\rho_{v,o}$ (ISO 9050, Section 3.4.1) .....	12
Appendix B:	Abbreviations possible in the report .....	13

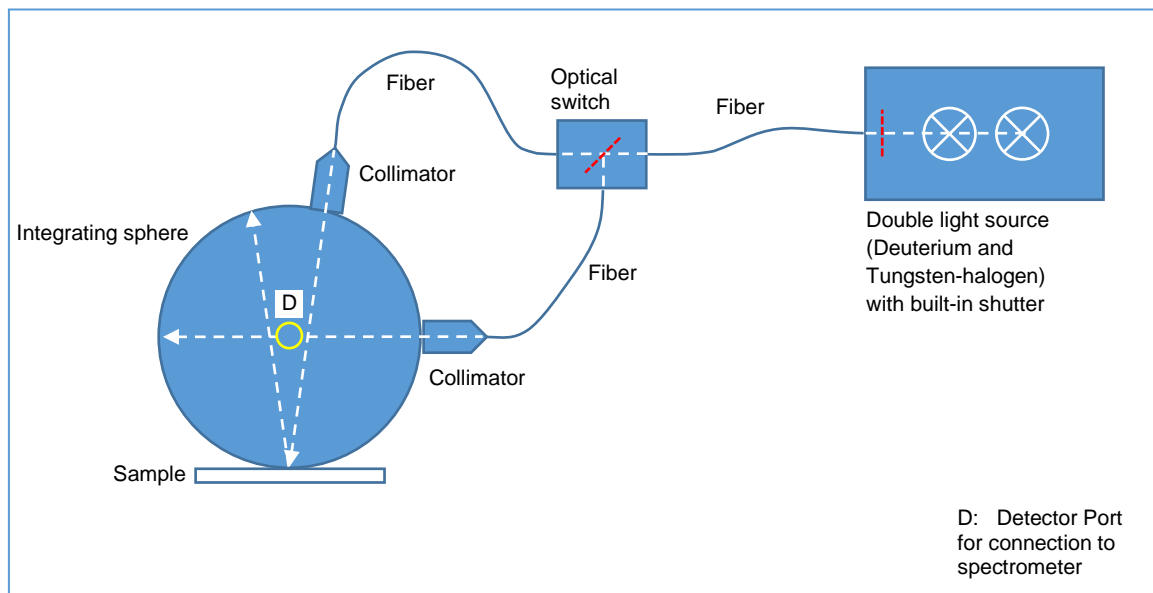
**General information**  
*Allgemeine Informationen*

**1 General information**

**1.1 Executive summary**

**Measurement of spectral optical reflectance**

The procedure used here is analogous to the determination of spectral transmittance described in Section 7 and 8 of ISO 13468-2. The test set-up is shown in the figure below. The sample is irradiated by a beam whose axis has an angle of  $8^\circ$  with respect to the vertical on the sample surface. Spectral reflectance is measured in the wavelength range 300 nm to 1600 nm. Measurement is performed using an integrating sphere with 150 mm inner diameter, suitable to collect the entire (hemispherically) reflected light. The measuring spot size is 10 mm in diameter.



Based on the resulting spectral optical reflectance curves, the ISO 9050 external light reflectance is calculated, which involves weighting by:

- a) D65 solar spectral irradiance in accordance with ISO/CIE 10526
- b) Spectral luminous efficiency for photopic vision (standard observer for photometry) in accordance with ISO/CIE 10527

**For the detailed calculation specification, see Appendix A.**

**Prüfbericht-Nr.: DE2372IA 001**  
Test report no.:

Seite 5 von 13  
Page 5 of 13

**General information**  
*Allgemeine Informationen*

## 1.2 Setting of tasks

According to the inquiry of the customer following measurements on the below listed crystalline PV module(s) shall be performed:

- Spectral hemispherical optical reflectance of one PV module shall be measured analogous to ISO 13468-2:1999, but extended to the wavelength range 300 nm to 1600 nm.
- "External light reflectance" shall be calculated according to ISO 9050:2003.

## 1.3 Summary of test results

- When measuring on a solar cell, the external light reflectance of the PV module surface is on average 0.9%. External light reflectance varies between 0.8% and 1.2%, depending on the investigated solar cell.
- When measuring between the solar cells, external light reflectance of the PV module surface is approx. 46%, based on one measurement location.

**Prüfbericht-Nr.: DE2372IA 001**  
Test report no.:

Seite 6 von 13  
Page 6 of 13

**General information**  
*Allgemeine Informationen*

**1.4 Test specifications**

<b>QMA 2.581.102</b> (TÜV Rheinland Solar GmbH)	Optische Transmissions- und Reflexionsmessung Optical transmission and reflection measurement
<b>ISO 13468-2:1999</b>	Plastics – Determination of the total luminous transmittance of transparent materials – Part 2: Double-beam instrument
<b>ISO 9050:2003</b>	Glass in building – Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors

Prüfbericht-Nr.: DE2372IA 001  
Test report no.:

Seite 7 von 13  
Page 7 of 13

**Product Description**  
Produktbeschreibung

## 2 Product description

### 2.1 Test sample obtaining

- Sending by customer       Sampling by TÜV Rheinland Group  
 others:

### 2.2 List of test samples

Sample No.	Sample S/N	Manufacturer	Module type	Module technology
HV2022004294	LRR010111220701200220	LONGi Green Energy Technology Co., Ltd.	LR5-54HTM-435M	Mono c-Si half cut cells

Supplementary information: Measurement location(s): 4 locations as specified in Section 3.

**Prüfbericht-Nr.: DE2372IA 001**  
 Test report no.:

Seite 8 von 13  
 Page 8 of 13

**Module examination**  
*Modulprüfungen*

**3 Module examinations**

**3.1 Measurement of spectral optical reflectance**

External light reflectance was computed from spectral optical reflectance in accordance with ISO 9050, Section 3.4.1 (see Appendix A).

Test date [yyyy-mm-dd]	2023-06-28	
Sample No.	HV2022004294	
No. of measurement locations	4, as specified in the picture below	
<b>Measurement location</b>	<b>ISO 9050 external light reflectance</b>	<b>Average</b>
Cell R3C1	1.2%	0.9%
Cell R10C2	0.8%	
Cell R17C3	0.8%	
Backsheet	46%	

Summary of results:

- When measuring on a solar cell, the external light reflectance of the PV module surface is on average 0.9%. External light reflectance varies between 0.8% and 1.2%, depending on the investigated solar cell.
- When measuring between the solar cells, external light reflectance of the PV module surface is approx. 46%, based on one measurement location.

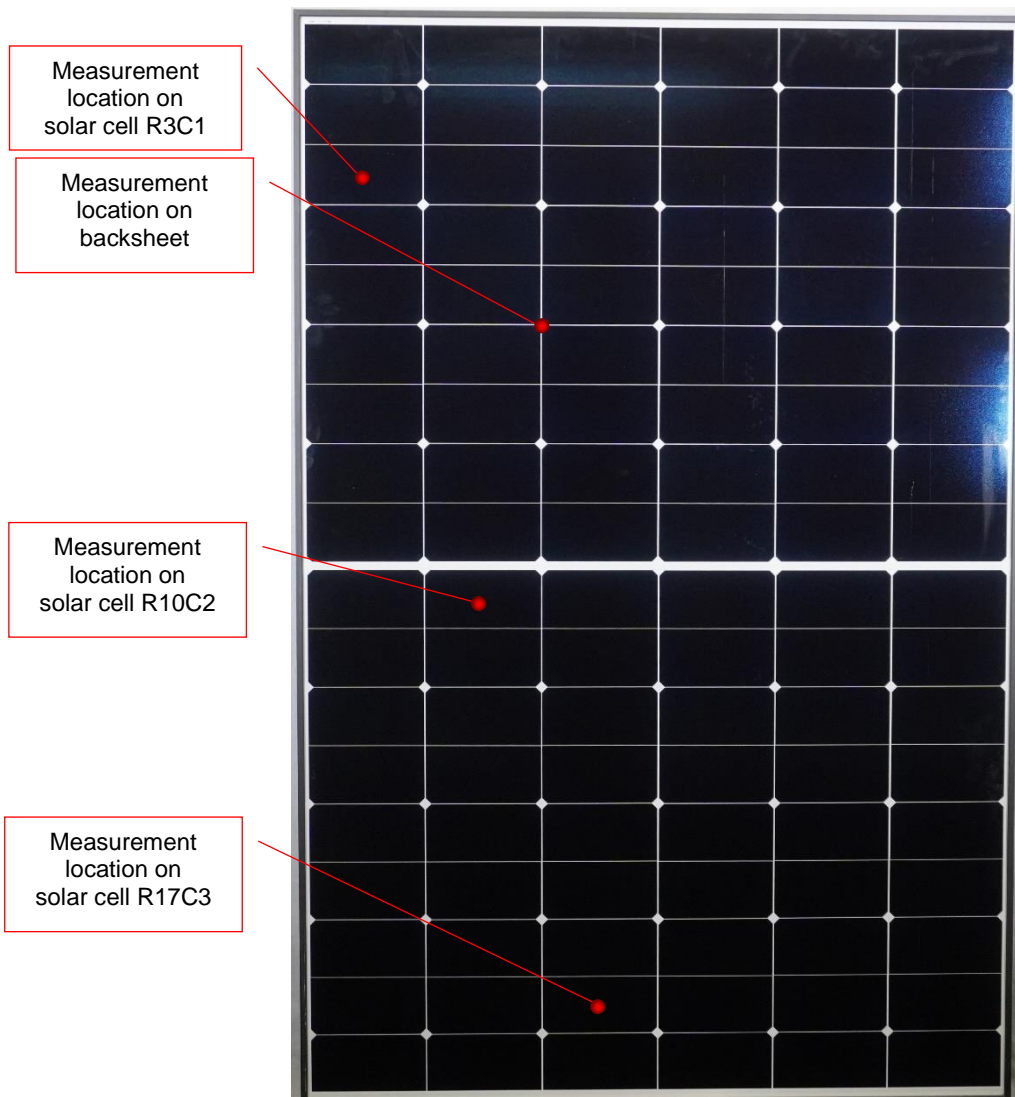
Supplementary information: Originally, the „Backsheet“ measurement location was planned to be in the center of the PV module. As the cell interconnection is visible there, the „Backsheet“ measurement location had to be moved to the lower border of the PV module.



Prüfbericht-Nr.: DE2372IA 001  
Test report no.:

Seite 9 von 13  
Page 9 of 13

**Module examination**  
*Modulprüfungen*



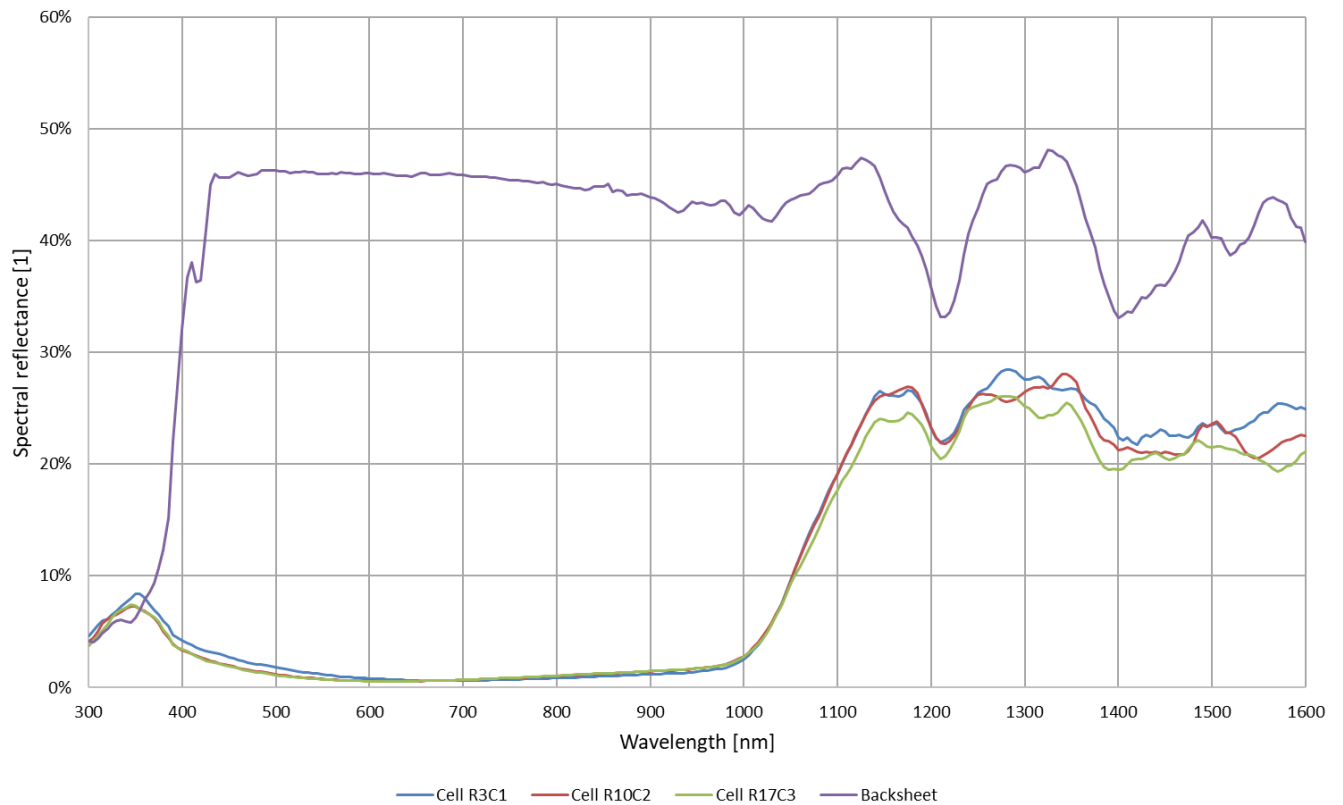
Measurement locations on test sample HV2022004294  
Row (R) and column (C) of the tested solar cells are indicated

Prüfbericht-Nr.: DE2372IA 001  
Test report no.:

Seite 10 von 13  
Page 10 of 13

**Module examination**  
*Modulprüfungen*

HV2022004294



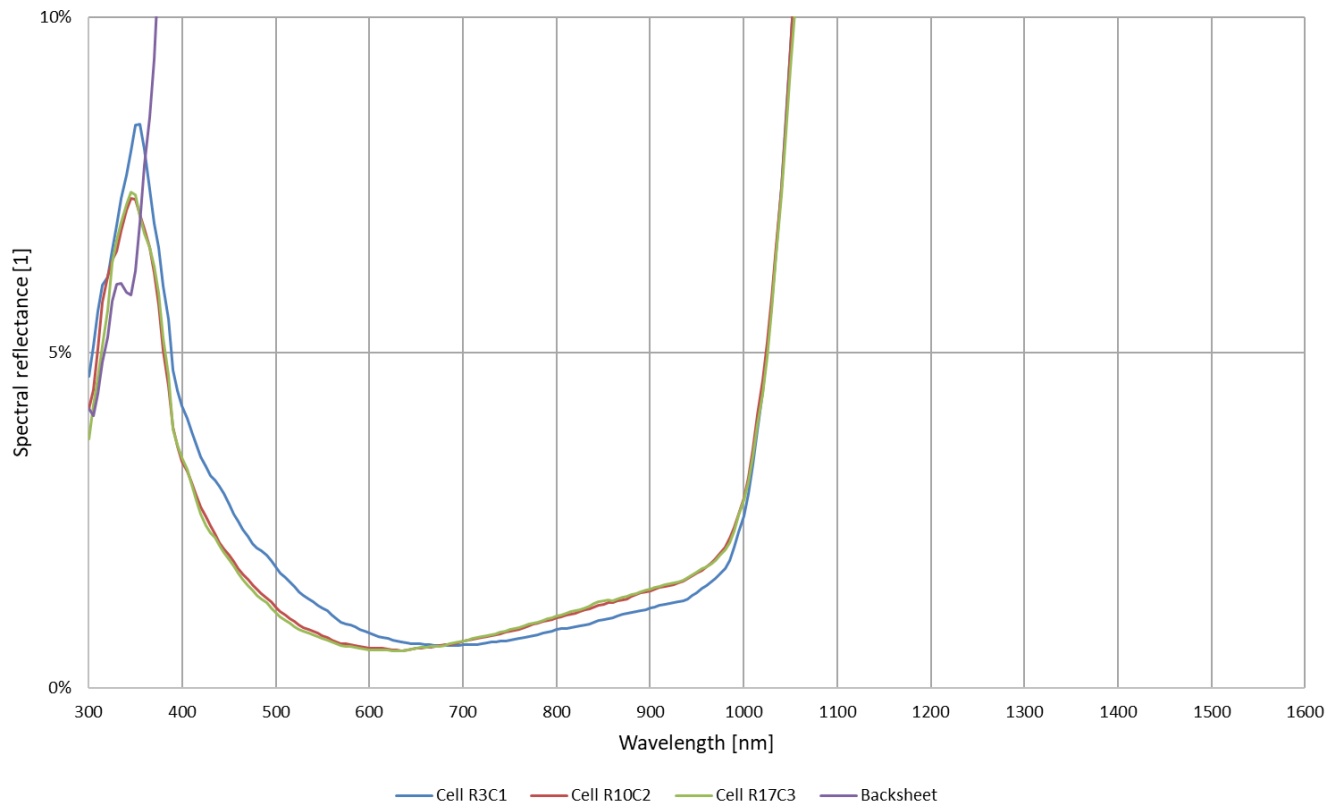
Measured spectral hemispherical reflectance curves

Prüfbericht-Nr.: DE2372IA 001  
Test report no.:

Seite 11 von 13  
Page 11 of 13

**Module examination**  
*Modulprüfungen*

HV2022004294



Measured spectral hemispherical reflectance curves (detail)

Prüfbericht-Nr.:  
 Test report no.:

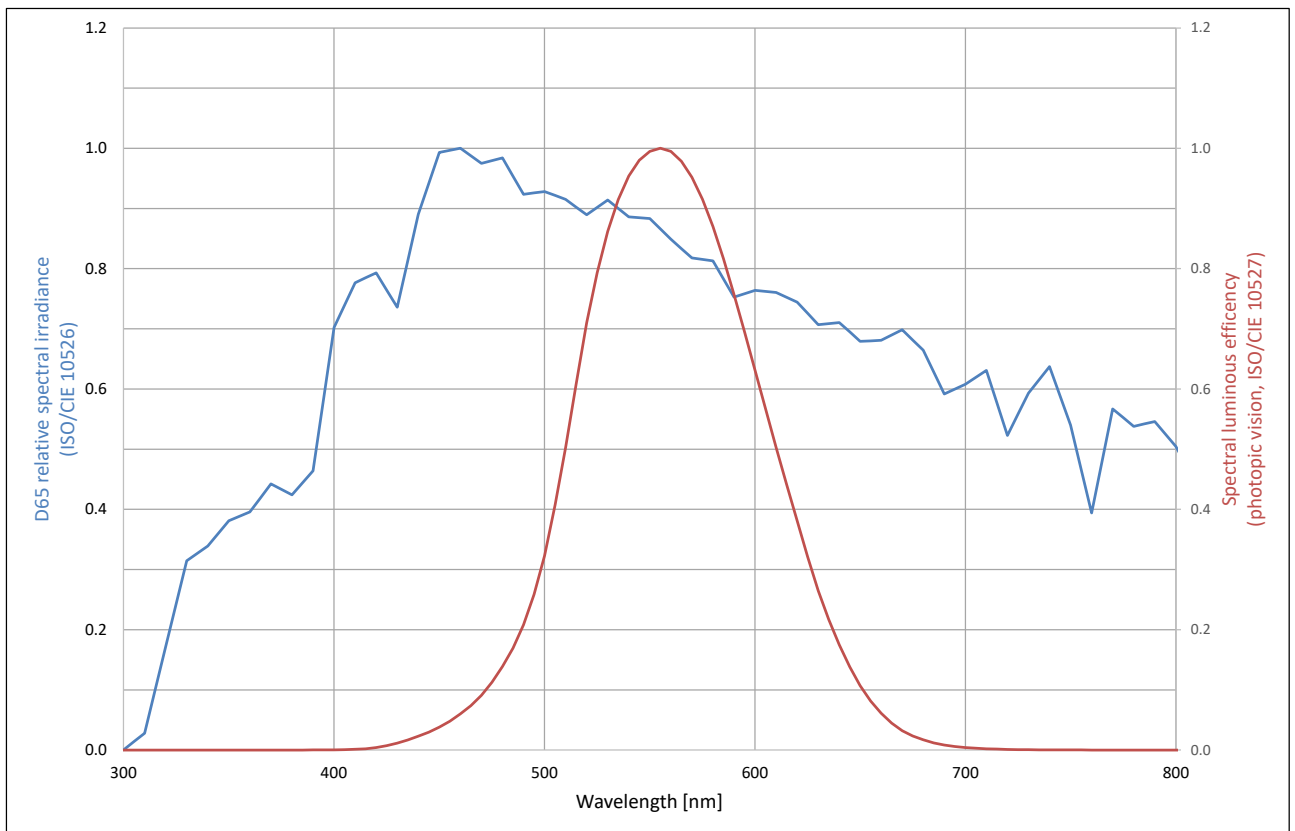
Seite 12 von 13  
 Page 12 of 13

Additional documentation  
 Zusatzdokumentation

Appendix A: Calculation of ISO 9050 external light reflectance  $\rho_{v,o}$   
 (ISO 9050, Section 3.4.1)

$$\rho_{v,o} = \frac{\sum_{\lambda = 380 \text{ nm}}^{780 \text{ nm}} \rho_o(\lambda) D_\lambda V(\lambda) \Delta\lambda}{\sum_{\lambda = 380 \text{ nm}}^{780 \text{ nm}} D_\lambda V(\lambda) \Delta\lambda}$$

- $\rho_o(\lambda)$  is the spectral external reflectance of the glazing
- $D_\lambda$  is the relative spectral distribution of illuminant D65 (see ISO/CIE 10526)
- $V(\lambda)$  is the spectral luminous efficiency for photopic vision defining the standard observer for photometry (see ISO/CIE 10527)
- $\Delta\lambda$  is the wavelength interval



D65 relative spectral irradiance and Spectral luminous efficiency

**Prüfbericht-Nr.:**  
 Test report no.:

Seite 13 von 13  
 Page 13 of 13

**Additional documentation**  
*Zusatzdokumentation*

**Appendix B: Abbreviations possible in the report**

$P_{max}$ – Maximum power	$R_{iso}$ – Insulation resistance
$I_{mpp}$ – Maximum power point current	A – Module surface
$V_{mpp}$ – Maximum power point voltage	SC – Stabilization cycle
$I_{sc}$ – Short circuit current	n-Stab – Non-Stability
$V_{oc}$ – Open circuit voltage	STC – Standard Test Conditions
FF – Fill factor	MQT – Module Quality Test
a – Irradiance correction factor	MST – Module Safety Test
$R_s$ – Series resistance	PID – Potential Induced Degradation
$\alpha$ – Temperature coefficient of $I_{sc}$	DHT – Damp heat test
$\beta$ – Temperature coefficient of $V_{oc}$	HFT – Humidity freeze test
$\gamma$ – Temperature coefficient of $P_{max}$	TCT – Thermal cycling test
$\kappa$ – Temperature coefficient of $R_s$	Hrs – Hours
	Deg. – Degradation

--- End of Test Report ---