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Avoiding Costly PV Module Measurements: A Spectral Transmittance-Based Power Estimation Method for Coloured PV Modules

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MOTIVATION

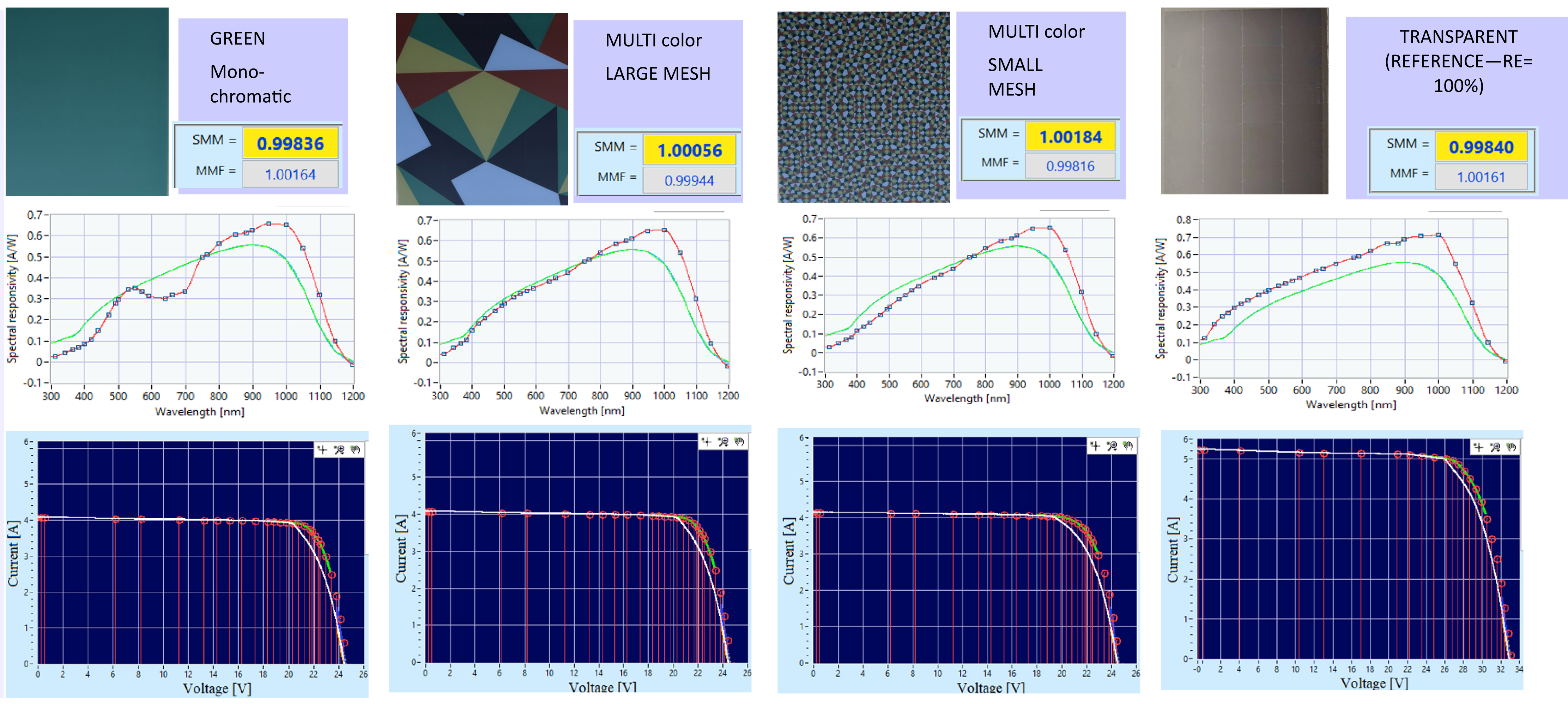
- The architectural integration of coloured photovoltaic (PV) modules as used in buildings for aesthetical reasons reduces the efficiency due to the lower light absorption. The conventional characterization of coloured PV modules requires the measurement of the spectral response of each individual module, which is time-consuming, expensive and impractical for customized color designs. The approach eliminates the need for PV module manufacturers to test each individual PV module design.

This study presents an approach for the estimation of the power output and efficiency of multicolored PV modules, based on the known **spectral response** of the transparent construction, using only the **spectral transmittance** measurement of the colored front glass. The experimental results are used to validate an innovative software design tool, developed by the Lucerne University of Applied Sciences and Arts (**HSLU**) within the project **'Solar Design Tools'** and its accuracy in terms of classification of the Relative Efficiency (RE%) of multicolored PV samples. It is aimed to support system designers and architects in adapting PV modules to the color scheme of the environment in combination with several design options and a prediction of the efficiency loss caused by the chosen color solution.

EXPERIMENTAL DATA

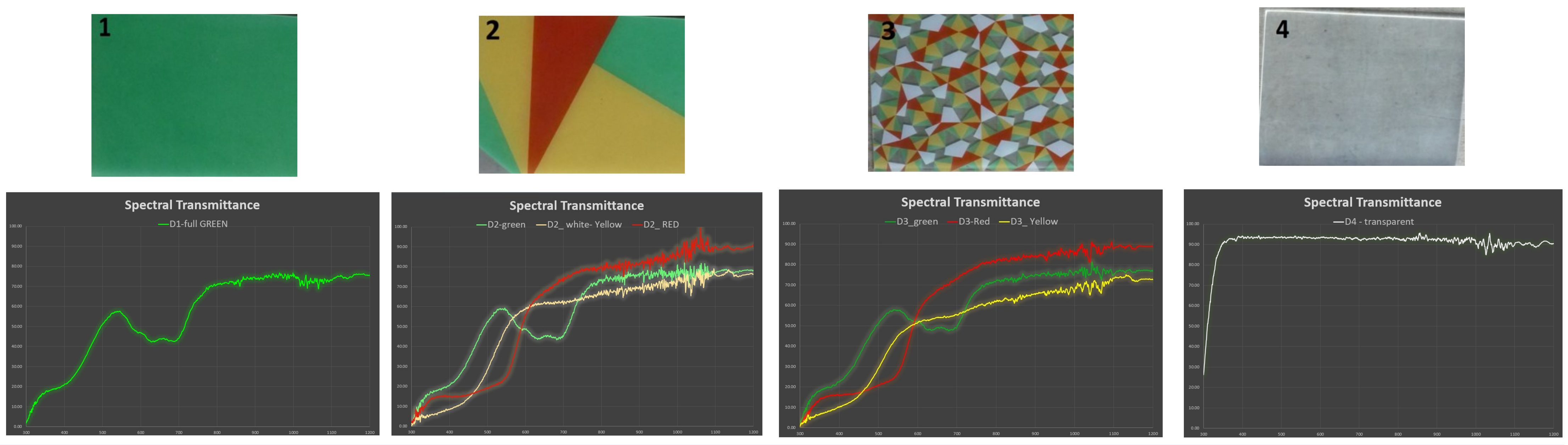
SPECTRAL RESPONSIVITY AND SPECTRAL MISMATCH CORRECTION OF I_V CURVE ON COLOURED ACTIVE SAMPLES

- Measurement of the spectral responsivity of 3 differently coloured active PV samples +1 reference transparent reference sample, according to IEC 60904-8 [1]
- Measurement of the I_V curve according to IEC 60904-1 [2] and Spectral Mismatch (SMM) correction according to IEC 60904-7 [3]



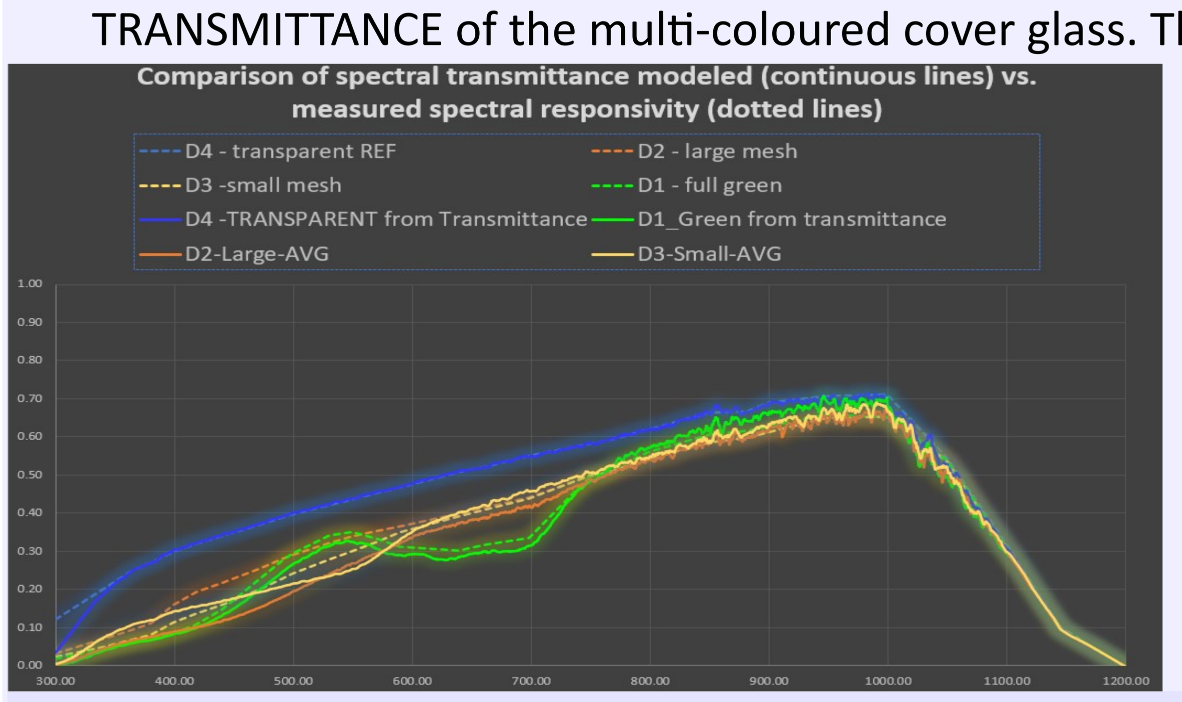
SPECTRAL TRANSMITTANCE MEASUREMENTS ON COLOURED GLASSES

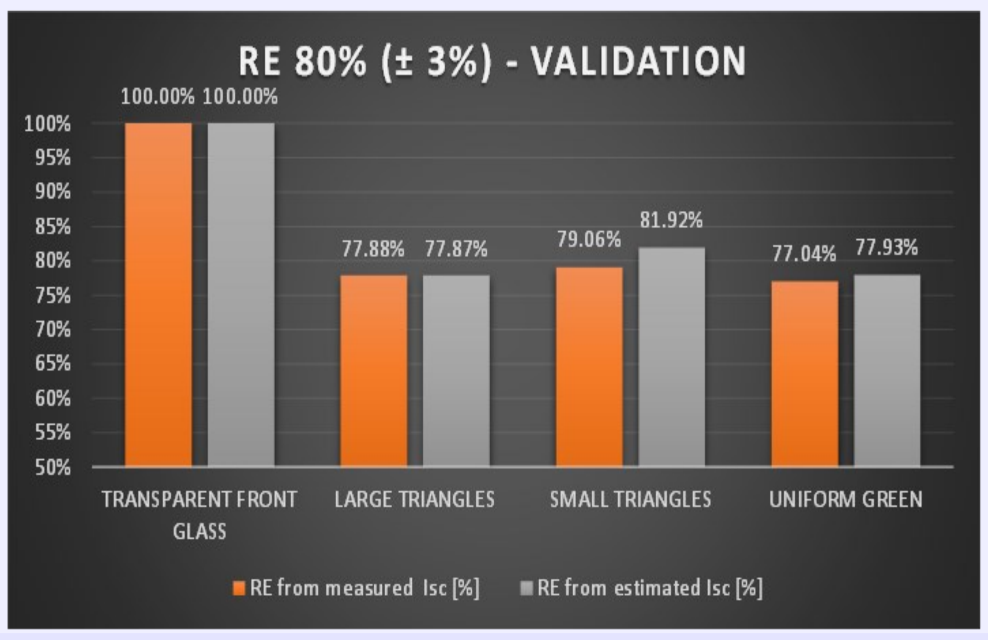
- Measurement of the spectral transmittance in %, by means of a Class AAA steady state solar simulator and a calibrated spectroradiometer in the wavelength rage 300÷1200nm



RESULTS & DISCUSSION

- The Relative Efficiency (RE%) of a multi-coloured PV module is defined as the ratio of its efficiency (Maximum Power at Standard Test Condition / Gross area of the module) and the efficiency of the correspondent transparent PV module (RE% = 100%). The RE% of the multi-coloured module is modelled based on the known spectral responsivity of the reference transparent glass and by the measured spectral transmittance of the coloured cover glass. The evaluation is performed by integration of the SPECTRAL RESPONSIVITY of the transparent PV modules, normalized to the measured short circuit current at STC and multiplied by the measured SPECTRAL TRANSMITTANCE of the multi-coloured cover glass. The short circuit current is then assumed as the reference parameter for the evaluation of the relative efficiency.





HSLU - results summary (36 SBC M6 HC Cells)

COLOR PATTERN	Measured Isc [A]	Isc - Estimated from Spectral TransmittanceColored * Spectral ResponseTransparent [A]	RE from measured Isc [%]	RE from estimated Isc [%]	Δ
TRANSPARENT FRONT GLASS	5.25	5.18	100.00%	100.00%	*0.00%*
LARGE TRIANGLES	4.09	4.03	77.88%	77.87%	*-0.01%*
SMALL TRIANGLES	4.15	4.24	79.06%	81.92%	*2.86%*
UNIFORM GREEN	4.04	4.04	77.04%	77.93%	*0.89%*

The deviations between the measured and modelled values of the short circuit current resulted within ±3%.

CONCLUSION: The proposed method demonstrates a good accuracy in modelling the power output reduction of multi-coloured PV modules, based on the measurement of the spectral transmittance of the coloured glass only and the known spectral responsivity of the underlaying PV circuit, while significantly reducing testing time and costs

References:
[1]IEC 60904-8:2014—Photovoltaic devices - Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device
[2] IEC 60904-1:2020—Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics
[3]IEC 60904-7:2019—Photovoltaic devices - Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices

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