# PERFORMANCE OF UV-ENHANCED PMMA FRESNEL LENSES AND IMPACT ON LCOE

**A. Cvetkovic[1], P. Battenhausen[2], R. Mohedano[1], U. Loeffler[2], P.Benítez[1, 2], Maikel Hernández[1], J.Chaves[1]**

[1] LPI, Altadena CA, US and Madrid, Spain

[2] Evonik Industries AG, Kirschenallee 64293 Darmstadt, Germany

[3] CEDINT, Universidad Politecnica de Madrid, Campus de Montegancedo, Edificio Cedint, 28223 Pozuelo de Alarcón, Spain

## 1. Introduction

Tiny increases in the transmittance of optical materials within a *CPV* module can have an important impact on the economy of a plant. This is certainly true in systems comprising multi-junction solar cells, whose high performance, based on a balanced photocurrent generation among the series-connected junctions, is very sensitive to spectrum variations. Every efficiency point gained causes not only an increase in the kilowatts hour produced, but a higher benefit on it, since the difference between electricity tariff and Levelized Cost of Electricity (*LCOE*) rises. This work studies the impact on the *LCOE* of a plant based on modules comprising *PMMA* lenses of two different types, standard UV blocking grade which is normally used for outdoor applications at high DNI climate and a specialty stabilized *UV*-enhanced transmittance acrylic (see Figure 1). Energy production will be compared for these two systems throughout the year at different sites to analyze when (season, time of the day) and where the usage of the enhanced *PMMA* is justified.

## 2. Approach

The goal of this work is quantifying the benefits that might arise when switching from a standard *PMMA* to another one with enhanced transmittance in the UV range. Such material would enable an efficiency rise at times of the day when there is a lack of blue light in the spectrum, and the top junction is limiting the photocurrent delivered by this 3series-connected junctions device. The calculations are based on a Fresnel lens based concentrator (the *FK* [1]) but would apply to any other solution using Fresnel lenses, since the work is focused on the compared performance when the Fresnel lens is made out of one of these two materials. Apart from the two spectral transmittance functions of the concentrator when utilizing these two materials, the other main input parameters for the calculations are the solar cell (Spectrolab *C3MJ*), defined by its *External Quantum Efficiencies* and the site selected, described by sun spectrums available at such locations throughout the year, generated by *SMARTS*. With these data, the energy generated per unit area of the two systems can be calculated and compared.

## 3. Results

The first models and calculations show 0.4-0.8% relative energy boosts can be attained with the enhanced PMMA, depending on location. The boost rises up to 0.9% (relative) peaks in some specific times (months/hours) of the year. We can assume the best material would imply a slight over cost (+2USD/$m^2$, for instance) in capital expenditures (*CAPEX*). Assuming 3% increase of total Lifetime cost owing this higher *CAPEX* (multiplied by the coefficient dealing with the weighted average cost of capital), the models for the economy of a 3MW plants show (see calculation of *LCOE* in the explanatory page):

- The 0.7% relative increase in the energy yield implies 0.5% relative drop in the *LCOE* and 1% relative boost in yearly incomes
- Less than two years pay-back time for the over-cost, depending on location

## References

[1] P.Benítez et al (2010) “High performance Fresnel-based photovoltaic concentrator”, *Energy Express*, OSA. Vol. 18, Issue S1, pp. A25-A40

**EXPLANATORY PAGE**

## Levelized cost of electricity calculation

*LCOE* can be calculated with the following formula

$$LCOE = \frac{TotalLifetimeCost}{TotalLifetimeEnergy} = \frac{CAPEX \cdot (1 + crf) + OPEX}{TotalLifetimeEnergy} \quad (1)$$

Where *CAPEX* is the investment and capital expenditures and the annuity factor *crf* is linked to *WACC*, the weighted average cost of capital along the lifetime of the installation.

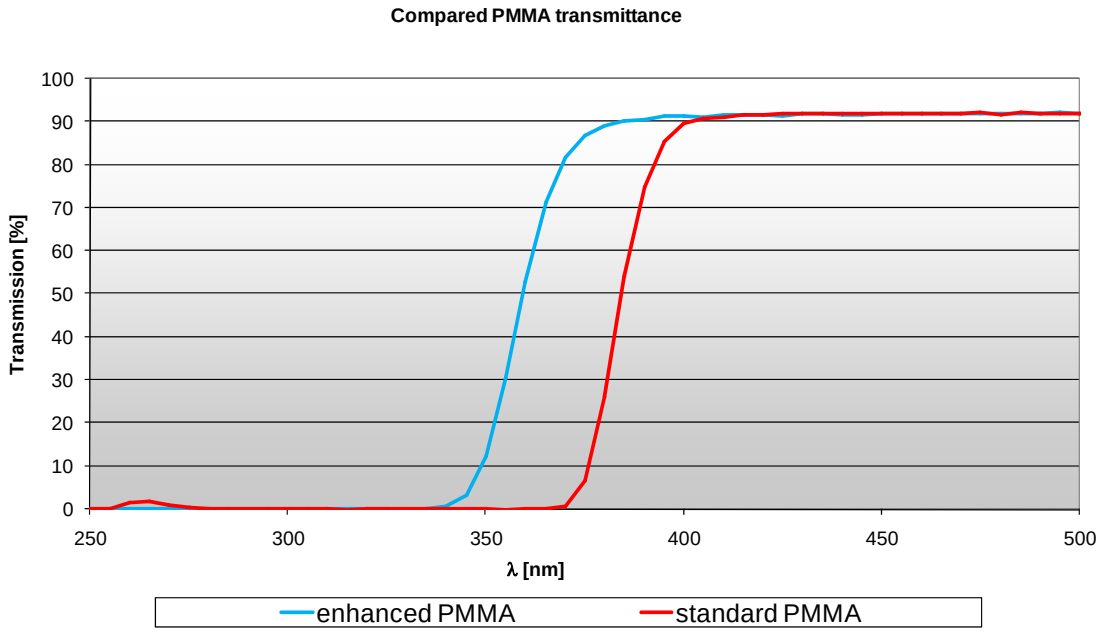


*Figure 1 Detail of Transmittance characteristics of the two Fresnel lens PMMA materials analized in this work*

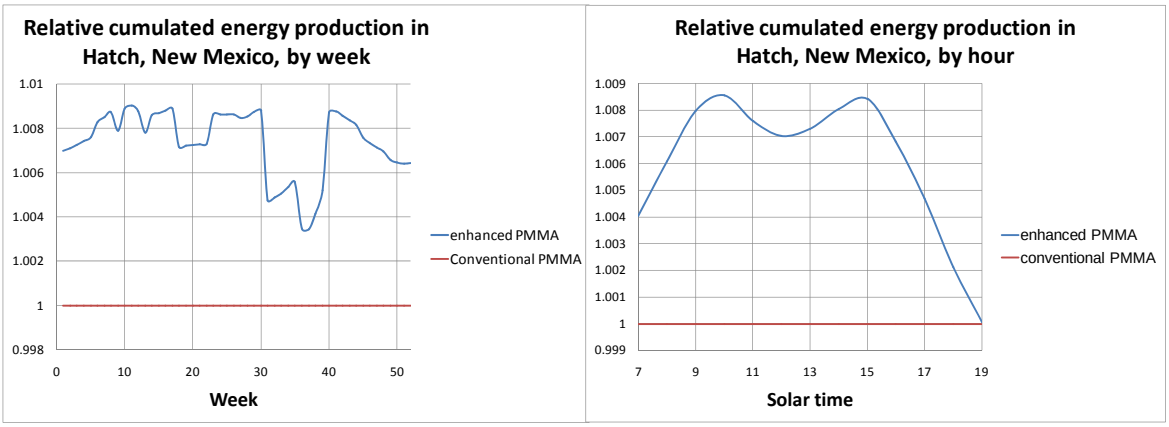


*Figure 2 Relative energy boost thanks to the usage of enhanced UV-material*