Sustainable photovoltaics - Increasing recyclability and reparability of PV modules

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Sustainability is a key factor for all future technologies, especially when using natural resources, but also regarding End-of-Life management. Even though photovoltaics (PV) represents a renewable way of energy generation, sustainability in respect to composition and production of PV-modules does not play a major role in today´s PV technologies. However, within the last years, activities for improved sustainability started to arise, paired with an increased awareness of all stakeholders towards environmental safety [1,2].

The main objective of this study is to develop and test concepts for cost-effective, sustainable PV modules. Sustainability will be achieved via

(i) recycling-friendly design based on e.g. detachable joints and thermoplastic materials
(ii) reduced environmental impact through reduction or removal of toxic or hazardous materials
(iii) use of innovative materials (high reliability, reparability, recyclability).

Innovative thermoplastic polyolefin encapsulant films allow for reduced processing times and therefore reduced energy consumption during module lamination. Moreover, an increased recyclability by easier thermal module delamination seems feasible. Co-extruded polypropylene (PP) backsheets are produced in a single step unlike laminated backsheets. Also, unlike fluoropolymers, polyolefin films are non-hazardous and can easily be recycled. RoHS certified mono crystalline solar cells (5BB) with lead free metallization. For the front glazing a hardened glass with low antimony (Sb) content is selected, as high Sb content is troublesome for flat glass recycling. Regarding interconnection various lead-free system (SnBi, Ag coated) seem feasible to increase sustainability. Finally, reversible adhesive joints have been developed that allow for an easy removal of frame and junction box during repair and recycling processes.

A life cycle assessment has been started, with the production of one standard size module (1.659 x 0.985 m) as functional unit. In the first step the influence of the encapsulating materials and backsheets has been investigated. Here, three different module compositions have been compared:

(1) Standard Module: crosslinking EVA encapsulant, PVF/PET/PET laminate as backsheet; 3.2 mm front glass

(2) PV Re² Eco Module 1: thermoplastic polyolefin encapsulant; co-extruded PP backsheet; 3.2 mm front glass

(3) PV Re² Eco Module 2: thermoplastic polyolefin based front encapsulant; co-extruded back encapsulant (polyolefin) / backsheet (PP); 2 mm front glass

As expected, the eco-designed modules perform better in all considered impact categories. For example, around 10 kg CO_2 equivalent per Module is saved (= 30 kg/kWp) by choosing the PV Re² Eco Module 2 design compared to the standard module. The relative improvement however is rather small (around

2-3 %, Figure 1), as the main impacts (> 89 %, Figure 2) of the module production process are caused by cell and frame (incl. the relevant upstream processes). In a next step also positive effects on use phase (prolonged lifetime) and end of life phase (better recyclability / reparability) will be included in the sustainability assessment. These results will be shown at the conference.

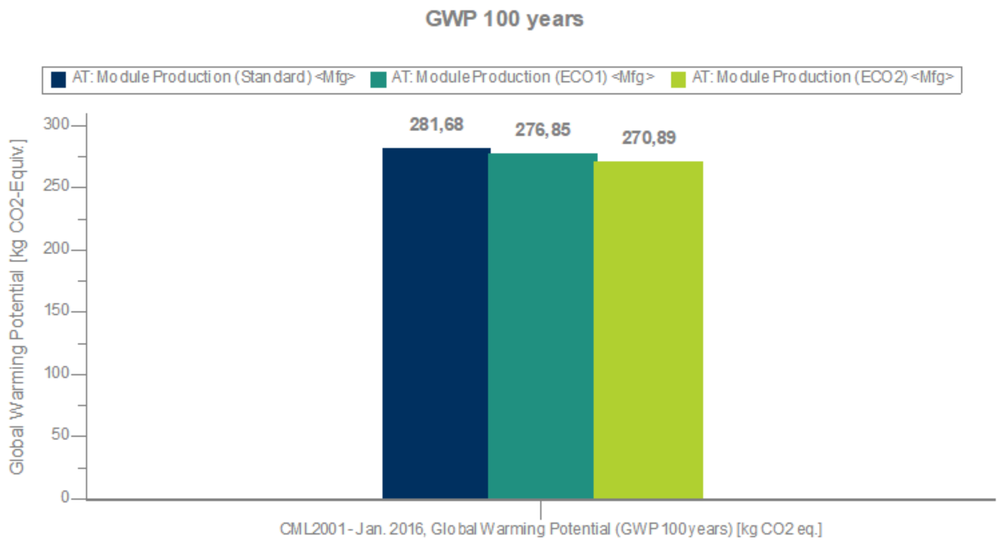

Figure 1: Global Warming Potential of different module designs

[1] IRENA: S. Weckend, IEA-PVPS: A. Wade, G. Heath; End-of-Life Management: Solar Photovoltaic Panels; International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems, 2016

[2] EC Ecodesign, Energy Label, EU Ecolabel, EU Green Public Procurement; http://susproc.jrc.ec.europa.eu/solar_photovoltaics/index.html

Bio:

Gernot Oreski holds a PhD in Polymer Engineering & Science Degree at Montanuniversität Leoben. Dr. Oreski is Division Manager at the Polymer Competence Center Leoben (Austria) and heads the »Smart Material Testing« division. He has over 17 years of expertise in polymers for photovoltaics. His main fields of research are reliability and sustainability of polymeric materials and components for demanding applications such as PV modules. Additionally, Dr. Oreski is teaching as external lecturer at the Department of Polymer Science and Engineering of the University of Leoben.