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Critical raw materials in a new building integrated photovoltaic system

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Introduction & Background

REELCOOP, an EU-FP7 funded project which stands for *REnewable ELectricity COOPeration* (www.reelcoop.com), aimed to develop renewable electricity generation technologies and promoted cooperation between EU Partners. Three prototype systems, representative of both micro and large-scale approaches to electricity generation, were developed. One of them was a photovoltaic ventilated façade (6 kW_e), installed at Yazar University (Izmir, Turkey) (Figure 1). The c-Si modules used an innovative glass-glass configuration with high mechanical stability, without the need of an aluminium frame. The installation of the modules followed a novel procedure accomplished within 5 working days, considering façade and all electrical connections.

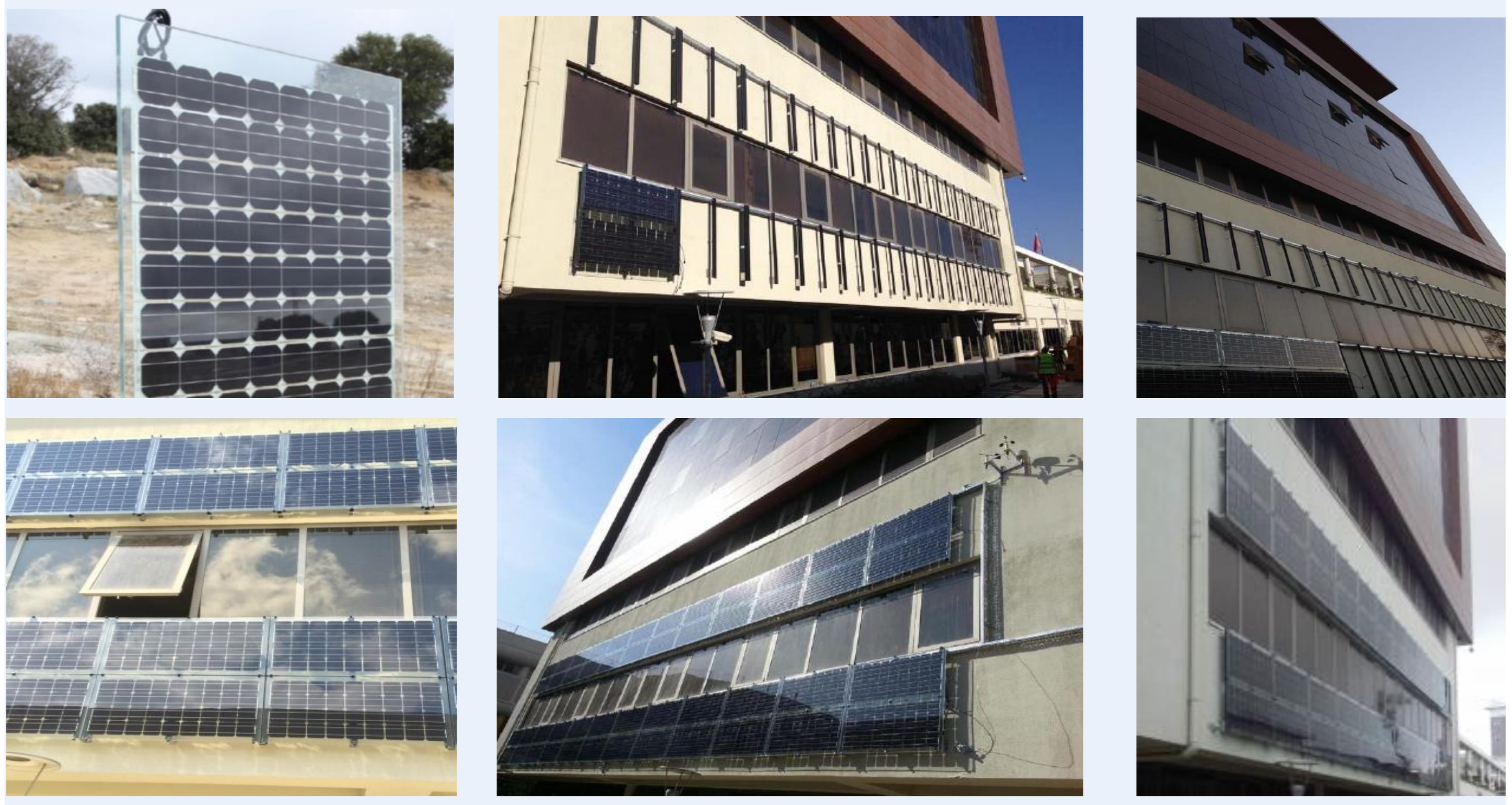

Figure 1. *PV modules installation process at Yazar University, Izmir.*

Critical raw materials (CRM) are those raw materials which are economically and strategically important for the world economy, have a high-risk associated with their supply, and there is a lack of viable substitutes and/or recycling processes. 26 CRM have been identified as critical in Europe from a list of 61 candidates (Figure 2). Energy systems, like PV solar panels, have particular raw materials in their components that are or could be considered as CRM.

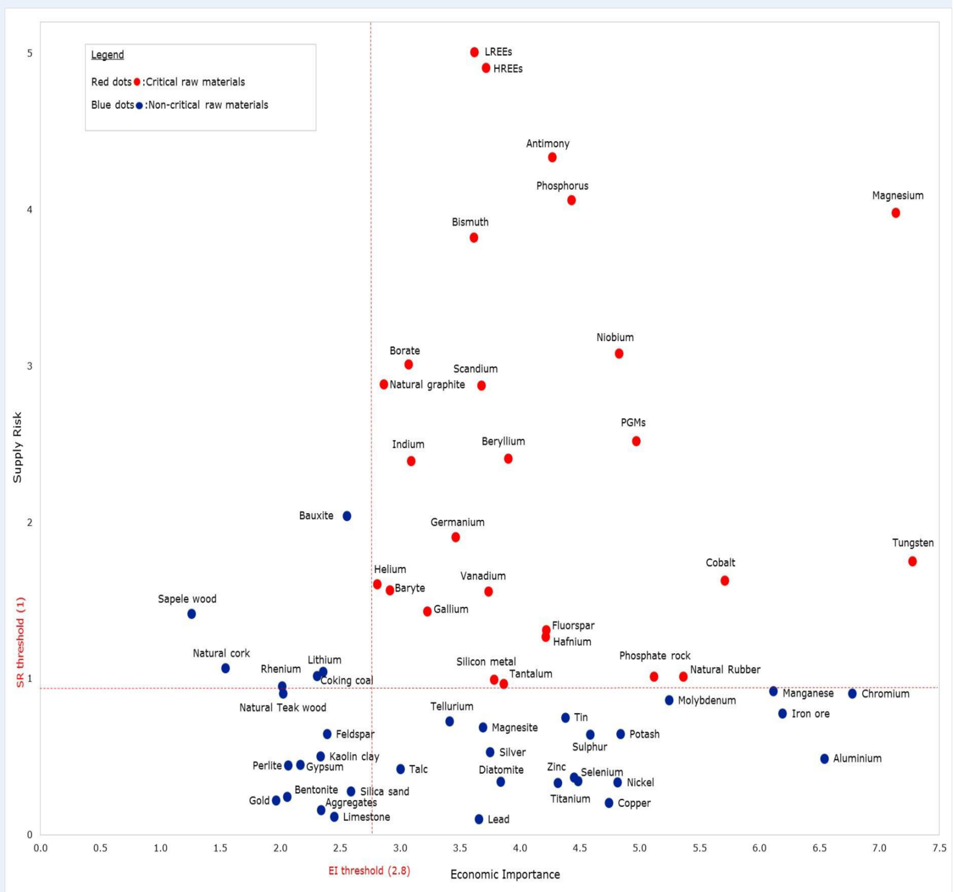

Figure 2. *List of CRM (in red) in Europe (2017) [1].*

Materials & Methods

An environmental assessment has been done by means of the calculation of the **Environmental Footprint (EF)**. After a deep analysis of the potential CRM included in the PV panel, several ways to improve the sustainability from a life-cycle approach were considered for two different materials:

Silicon 14 **Si**

- **Silicon:** The majority material of the cell is silicon. Considering that substitution of silicon is not feasible, the recycling processes are slightly improving [2]. Nevertheless, and due to the tiny value of its characterization factor in the Mineral, Fossil and Renewable Resources (MFR) category, this technique was not considered.

Silver 47 **Ag**

- **Silver:** Connections are made of silver alloys, because of its high conductivity. Silver can be substituted in a large degree by cooper [3], or recycled by different techniques. It is not considered as a CRM, but it is important due to its economic value and as a potential bottleneck for the development of this technology .

Results & Discussion

Figure 3 shows the contribution values of EF for each category by the different parts of the PV system. This prototype has the main environmental impact in the manufacturing of the modules, so a change to Best Available Technologies in PV sector could result in better values of global EF.

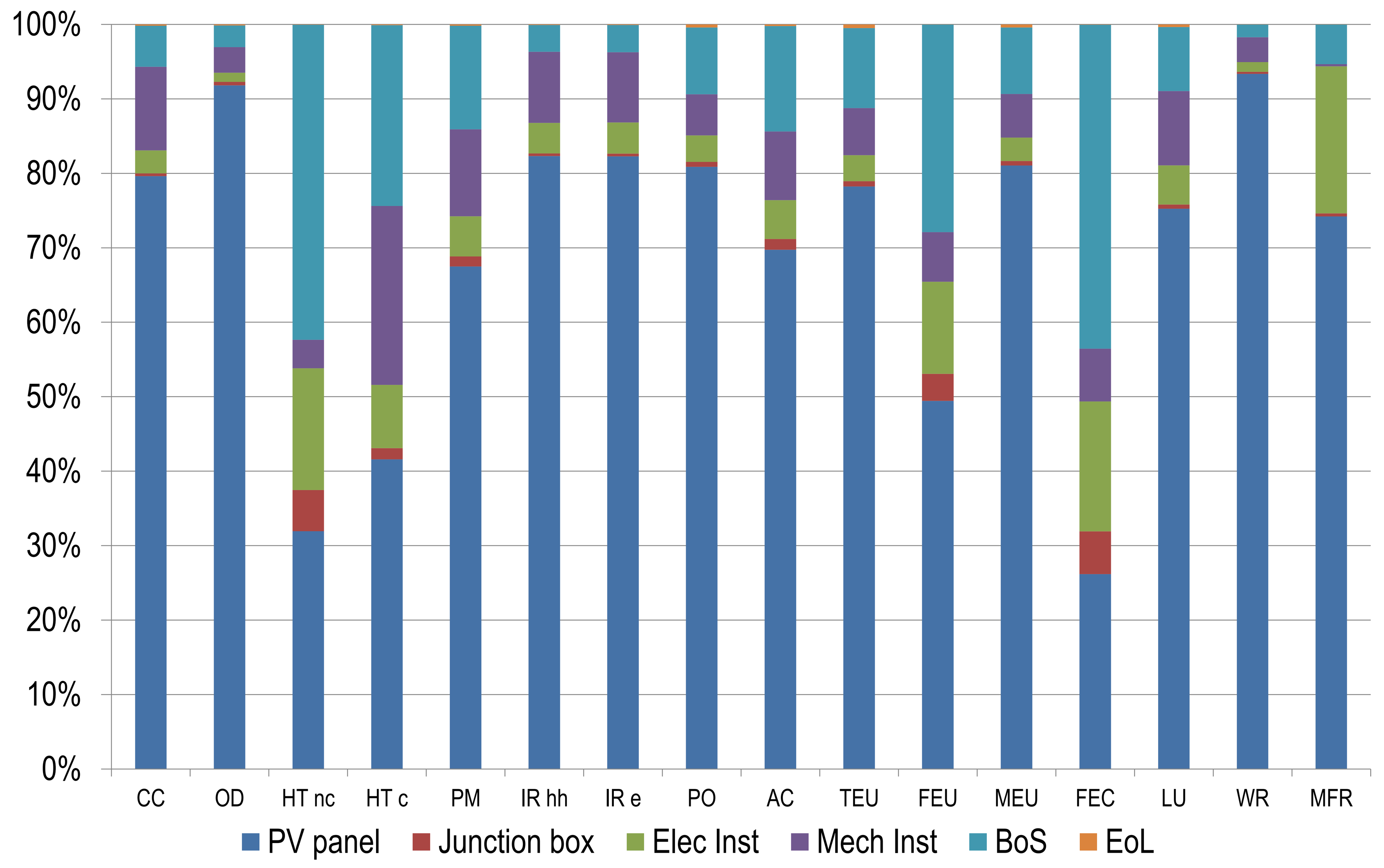

Figure 3. *EF of the prototype by part. BoS: Balance of the System; EoL: End-of-Life.*

Figure 4 presents the % of impact reduction considering two scenarios affecting the amount of silver used in panels: i) Consideration of the total recycling of silver, and ii) Substitution of silver by copper. The impact categories which have been modified were Human Toxicity, non-cancer effects (HT nc) and Mineral, Fossil and Renewable Resources (MFR). Other impact categories could be affected because of the pollution transfer effect.

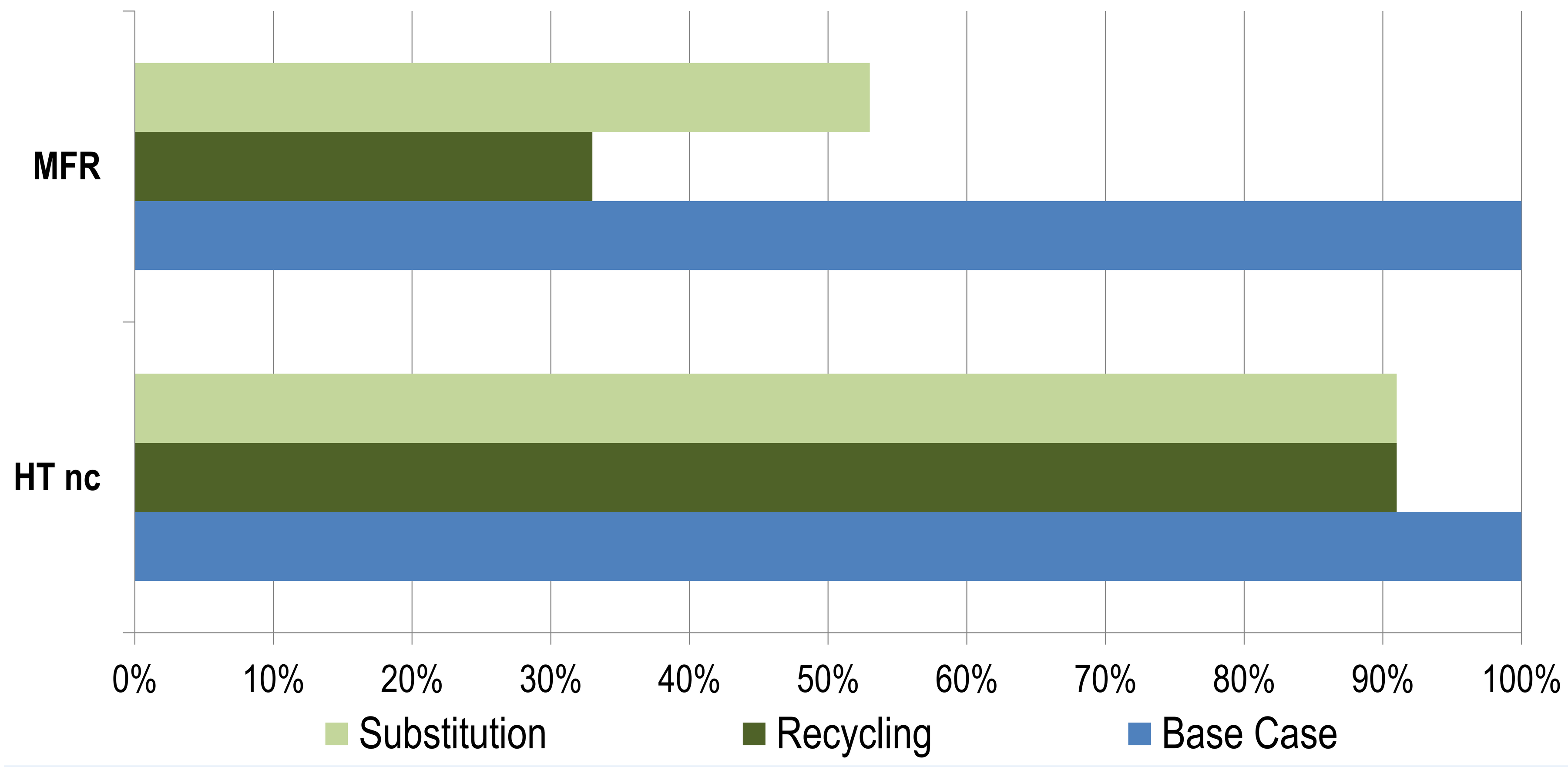

Figure 4. *Reduction values in HTnc and MFR when silver is recycled or substituted in PV panels.*

Conclusions

It is important to examine the resource scarcity from the perspectives of both supply and demand. Substitution could be a relevant mitigation option which can alleviate the pressure on the supply of CRM in the short term (*e.g.* 2020) by easing future demand.

Regarding the recycling, further developments in large scale processes of PV panels recycling must be done in order to maximize process efficiencies.

Finally, improvements on CRM characterization factors or even a new impact category for this materials should be considered linked to the methodology for selecting the official list of CRM proposed by the European Commission.

References

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[3] Grandel L, Lehtilä A, Kivinen M, Koljonen T, Kihlman S, Lauri LS. *Role of critical metals in future markets of clean energy technologies.* Renewable Energy 95 (2016) 23-62. https://doi.org/10.1016/j.renene.2016.03.102

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