Life Cycle Analysis of a Adaptive Solar Facade[☆]

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Abstract

Text

Keywords: Adaptive Solar Facade, Life Cycle Analysis

1. Introduction

- In the last decades, building integrated photovoltaics (BIPV) have been adopted as part of the energy strategy towards 2050... (advantages of BIPV, potential of BIPV)

- The current developments of light weight efficient thin film technologies have brought new design possibilities for architects in BIPV design... (Adaptive Building Envelopes, Envelope is the barrier between the internal and external environment, Advantages, seamless coupling with solar tracking mechanics)

- The aim of this paper is to analyse the life cycle emissions of an adaptive solar facade and provide comparisons with standard shading systems and static BIPV solutions.

[☆] This document is a collaborative effort.

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2. Life cycle analysis methodology

- The analysis is performed according to ISO 14040, ISO 14044 and ISO 15804.

- The impact category, which will be evaluated, is the global warming potential (GWP). This is described as the emissions of CO_2eq in kilograms divided by the functional unit.

- The functional unit used is twofold and based on the function of the adaptive building envelope. For the comparison with other shading systems facade area in m^2 is used, while comparison with other photovoltaic systems is done using electricity produced in kWh. According to the guidelines of the International Energy Agency (IEA), the calculation of kWh produced needs to be based for consistency on conversion efficiency η, performance ratio PR, irradiation I, lifetime LT and area A of the module. Equation 1 gives the exact formulation:

$$G = \frac{\mathrm{GWP}}{\mathrm{I} \cdot \eta \cdot \mathrm{PR} \cdot \mathrm{LT} \cdot \mathrm{A}} \tag{1}$$

- The scope of the LCA comprises of the embodied, operational and disposal global warming potential. Figure 1 shows the system boundaries of the process flows. The supporting structures are also included in the system boundaries. The reason for this is that technologies within the building envelope also change the design of the supporting structures. The supporting structure of solar panels is referred to as balance of systems (BOS).

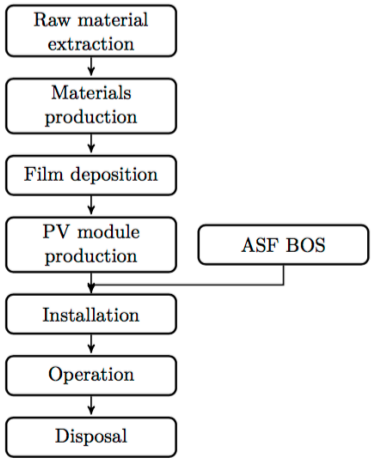

Figure 1: Thin-film incl. BOS system boundaries

- The cut-off approach is used for recycling and landfill. This means that recycling does not generate any credit for the product and resulting benefits are not taken into account. Furthermore the use of recycled products do not bear the burden of processes higher up the chain.
- The recipe midpoint-H allocation method allows for an accurate evaluation of the GWP based on human impact factors.
- The adaptive solar facade uses CIGS thin film panels with an aluminum backing. This allows for a light weight panel, needed for the flexible control of the system using silicone soft-robotic actuators.

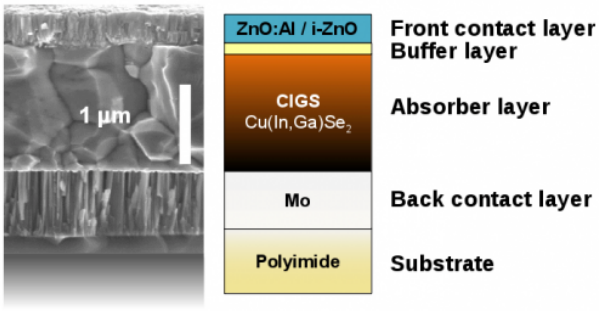

Figure 2: CIGS thin film structure

3. Environmental Performance of the Adaptive Solar Facade

- The results of the analysis can be summarized in Figure 3...

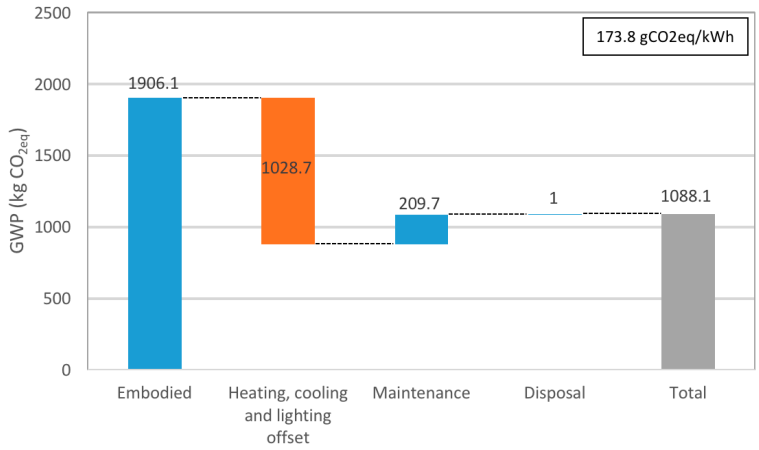

Figure 3: Breakdown of GWP of the ASF into embodied, operational and disposal emissions

- A breakdown of the embodied carbon emissions can be found in Figure 4... (brief discussion and design consideration)...

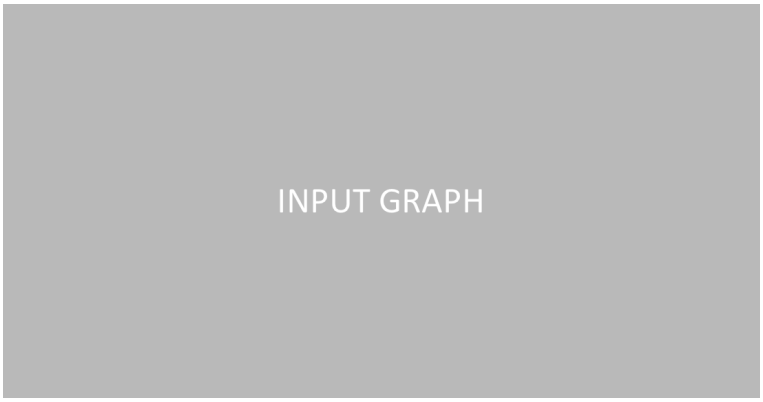

Figure 4: Breakdown of the embodied carbon emissions, it can be seen that xxxx has the greatest GWP contribution

- As input parameters of production processes are stochastic, a Monte Carlo simulation is used to include this stochastic behavior in the results, as shown in Figure 5...

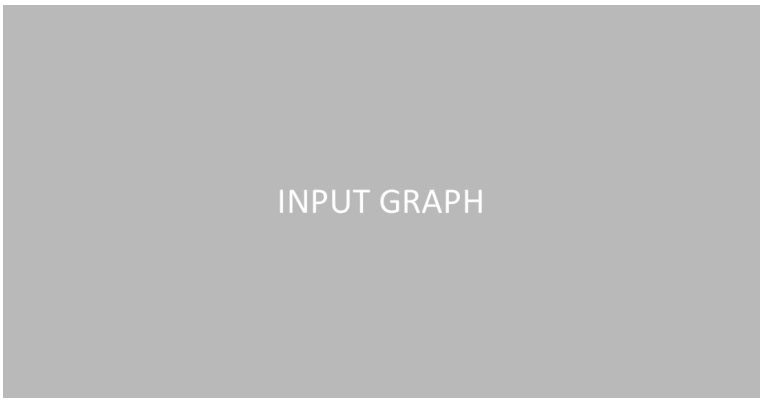

Figure 5: Monte carlo simulation based on input uncertainties

- Sourcing location greatly influences the embodied GWP. For photovoltaic panels, the majority of embodied emissions result from the use of electricity during production. The GWP per kwh of the Chinese electricity mix is 1145.8 gCO_2eq/kWh, while in Switzerland this is only 119.6 gCO_2eq/kWh.

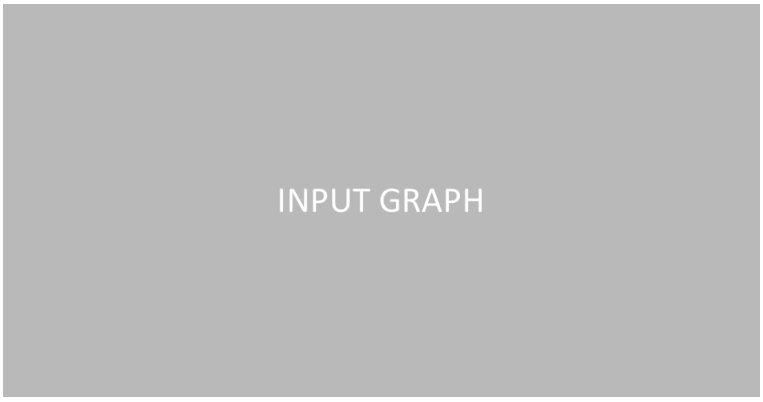

Figure 6: Sensitivity analysis based on sourcing location

4. Comparison to other technologies

- The adaptive solar facade was compared with standard facade shading systems and other static BIPV solutions...

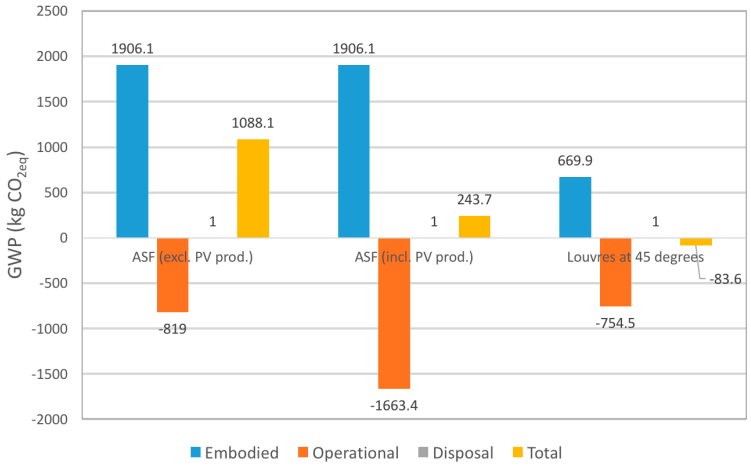

Figure 7: Shading system comparison

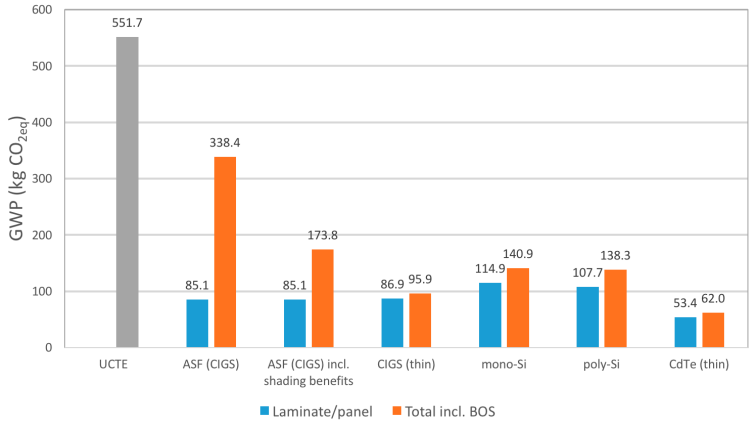

Figure 8: BIPV comparison of thin-film and BOS

5. Conclusion

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6. Acknowledgments

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