EuroSun2026

FROM BASELINE TO SCENARIO-BASED ANALYSIS: LIFE CYCLE ASSESSMENT OF BIPV FAÇADES UNDER FUTURE DECARBONIZATION PATHWAYS

Summary

With the growing focus on low-carbon buildings, building-integrated photovoltaics (BIPV) are increasingly considered as part of building envelope design. This study develops a life cycle assessment (LCA) model for façade-integrated photovoltaic systems to support scenario-based evaluation under a prospective 2050 decarbonization context in Canada. A baseline BIPV façade system is modeled in OpenLCA, reflecting a global supply chain with material production in China, module assembly in Toronto, and deployment in Québec. The system boundary follows a cradle-to-grave approach, including manufacturing, transportation, installation, use-phase electricity generation, and end-of-life processes. Results show that manufacturing dominates life cycle greenhouse gas emissions (257 kg CO_2-eq/m²), while electricity generation during operation provides substantial emission reductions (–123 kg CO_2-eq/m², equivalent to about 77% of the total embodied emissions over 30 years). However, under Québec's low-carbon electricity grid (1.2 g CO_2-eq/kWh for operational emissions and 34.5 g CO_2-eq/kWh on a life cycle basis), the avoided emissions from BIPV electricity do not fully offset the embodied emissions of the system, indicating that the environmental performance of BIPV is strongly dependent on the local electricity context. Building on this baseline, the study defines an extensible scenario framework that considers variations in supply chain origins (e.g., China, Europe, and North America), assembly locations, regional electricity mixes across Canadian provinces, end-of-life treatment pathways, and a prospective decarbonization context. This framework enables the evaluation of the combined effects of these factors on BIPV life cycle performance.

Keywords: Building-integrated photovoltaics (BIPV), life cycle assessment (LCA), façade systems, scenario analysis, prospective LCA

Field of application for the findings: Sustainable and Solar Energy Transition

Addressed audience: Researchers in life cycle assessment and building energy systems