Greenhouse gas footprints of polymer-based photovoltaic modules between the pilot and early industrial phases

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Prapti Maharjan*, Arjan Kirkels, Lukas Simurka**, Heleen de Coninck, Mara Hauck
Eindhoven University of Technology, Department of Industrial Engineering and Innovation Science, The Netherlands
**Solarge, Marconilaan 8, 6003 DD Weert, The Netherlands | Email: *p.maharjan@tue.nl

Introduction

Photovoltaic (PV) modules are crucial for decarbonising the power sector [1], but their production emissions are non-negligible and vary by module design and manufacturing location [2]. While conventional PV modules based on glass-backsheet have been extensively studied, studies on PV with new module designs are scarce in the literature [3]. Therefore, we assess the greenhouse gas footprint of a polymer-based PV module at an industrial scale and compare the pilot- and early-industrial-scale modules to understand how production emissions change as the technological readiness level changes.

Goal & scope

The goal of the LCA is to assess the GHG impacts of polymer PV module production in the early industrial and pilot phases and to compare them.

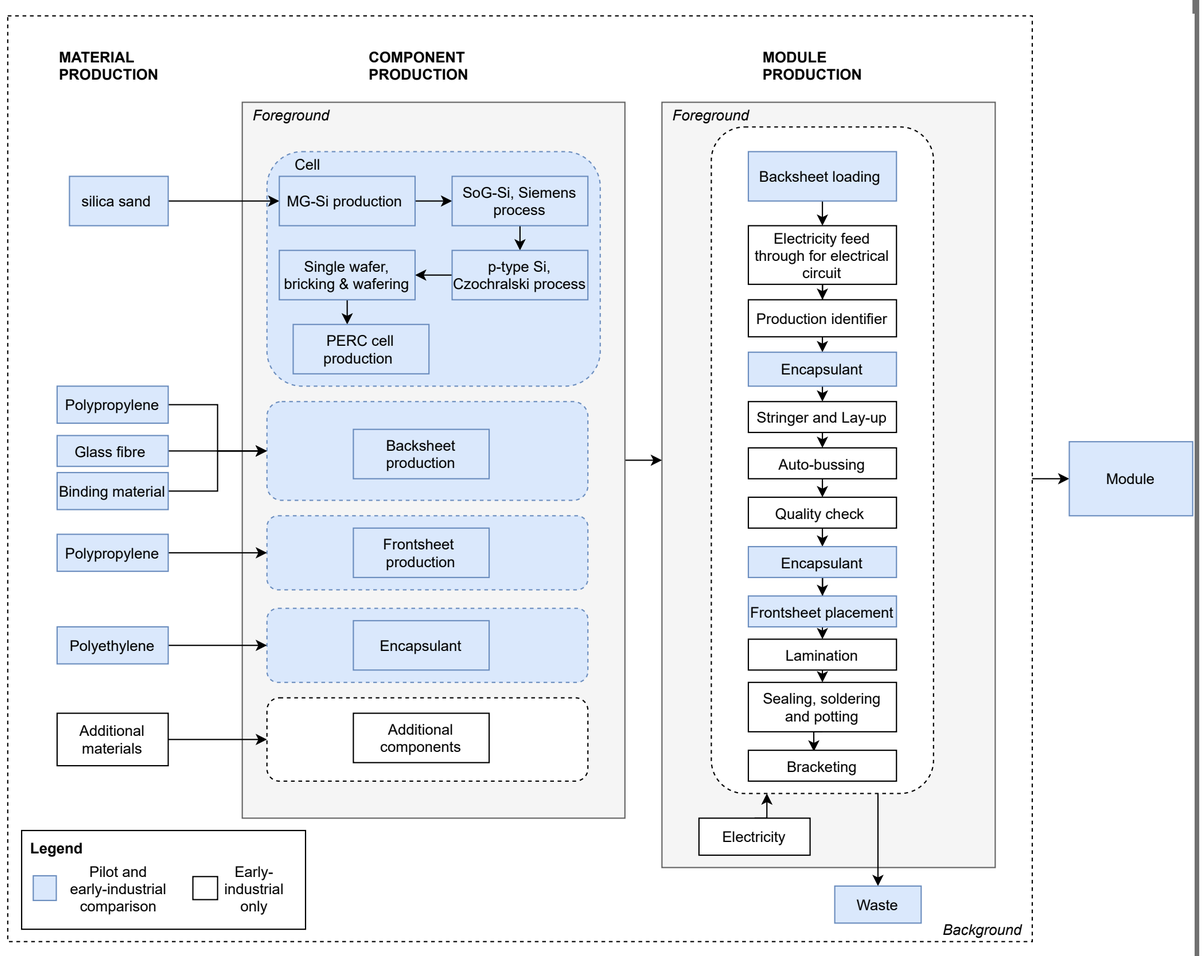
Important assumptions and simplifications:

- Scope: Cradle-to-gate, excluding use and end-of-life phases
- Functional unit: Production of 1 kW_p of a module
- Reference flow: Provision of all module components and energy required for the module production
- Dataset: Primary data for assembly in the Netherlands, updated cell inventory, ecoinvent 3.9.1 (cut-off) - updated using Premise
- Impact assessment method: IPCC 'global warming potential 100 years (GWP 100)' [4]
- Reduced system boundary for the comparison between pilot and early industrial phase to retain information symmetry

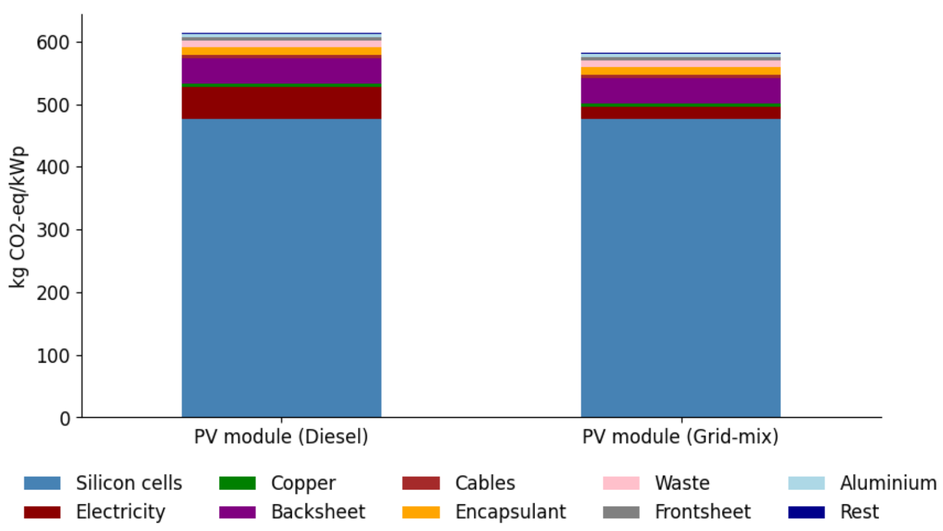
Technical specifications for pilot and early industrial module

Parameter	Unit	Early-industrial	Pilot
Rated power	W_p	500	365
Module size	m^2	2.66	2.21
Number of cells	pcs	72	72
Module efficiency	%	18.5	18
Aluminum brackets	pcs	4	-

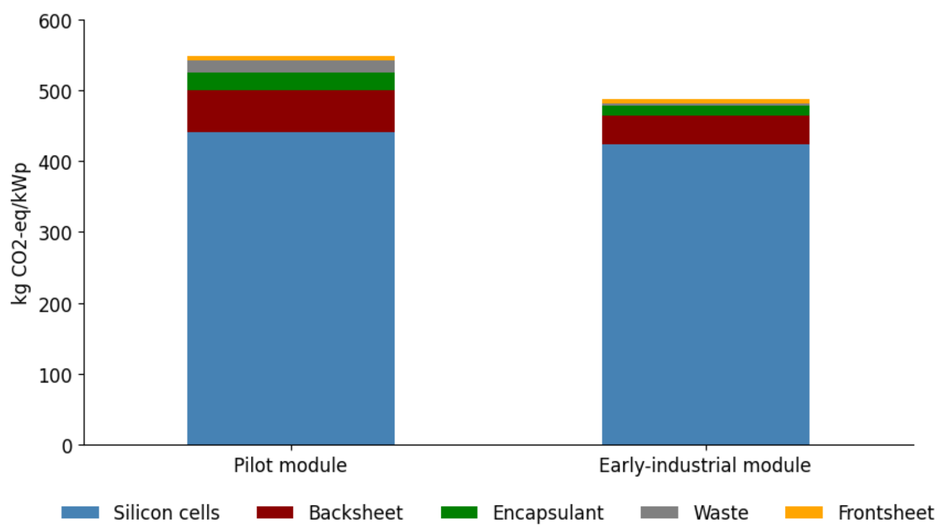
Process flow-chart



Detailed early-industrial LCA



Comparison pilot & early-industrial



Differences in pilot and early-industrial assembly

Attributes	Pilot scale	Early-industrial scale
Design	Smaller designs, several demonstrators	Larger design, plane with bifacial cells
Material choices	Testing right ratio of glass fibre and polymer for lamination	Standardised mix of glass fibre and polymer
Equipment and process change	Manual	Automation
Electricity	Electricity from grid	Diesel generator for electricity production
Capacity	5 modules per day	80-100 modules per day
Waste	Generation of higher waste per module, not documented	Waste per day documented

Conclusion

- Cradle-to-gate GHG footprint of polymer-based PV module is 613 kg CO_2-eq/kWp
- Switching from diesel to electricity from the grid reduces the module assembly impact by 5%
- Transition from pilot to early-industrial scale reduces GHG footprint by 11% for the Solarge modules
- Manufacturing-level changes influence GHG emission

Literature

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