Beyond Energy: LCA of Organic Photovoltaic Solar Cells

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Outline

• Photovoltaics
• Organic Photovoltaics
• LCA: Methods
• LCA: Results
• Sensitivity Analysis
• Comparison to Conventional Cells
• Conclusions
Photovoltaics

- General PV Technology: conversion of light energy to electrical energy

- Semiconductor absorbs light, “knocking” loose electrons which create electricity (in a circuit)

Photo Credits: www.solarcell.net
Organic Photovoltaics

- Third generation solar technology, organic materials act as semiconductor

Photo Credits: www.phys.org
Organic Photovoltaics

Solar Cell-Efficiencies (Research Scale)

Embodied Energy of Organic and Other PV Cells

Photo Credits: NREL
Motivation for the Study

• Objective: prospective assessment of the environmental profile of organic photovoltaics using roll-to-roll technology

• Part of a larger LCA to understand the environmental and human health impacts from organic photovoltaics from cradle-to-grave
LCA: Goal and Scope

• Cradle-to-Gate

• Functional Unit: 1 watt-peak (Wp); power output under standard testing conditions

• Sensitivity Analysis

• Comparison to Conventional Cells
LCA: System Boundaries

- Inventory data from scientific literature, stoichiometric calculations, and Ecoinvent

- Ecoinvent 2.2 | ReCiPe v1.0.5 Midpoint (H) | openLCA 1.4
Sensitivity Analysis

DCBpcbm: Fullerene production using DCB as solvent in place of toluene
FTOinkjet: Deposition of FTO substrate using inkjet printing in place of sputtering
Comparison to Conventional Cells
Minimum Required Lifetime

• Compared impacts of organic models to amorphous silicon to estimate the minimum lifetime needed such that its impacts are no worse than amorphous silicon over a lifetime of 25 years.
## Minimum Required Lifetime

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<th>DCB Minimum lifetime (yrs)</th>
<th>FTOinkjet Minimum lifetime (yrs)</th>
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Energy Payback Time

- Default: 0.0
- FTOink: 0.2
- DCBpcbm: 0.4
- Multi-C Si: 1.8
- Amorphous Si: 400 days

24-35 days

Days: 0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

Years: 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8
Carbon Payback Time

- Default
- FTOink
- DCBpcbm
- Multi-C Si
- Amorphous Si

7-11 days
Conclusions and Future Work

• The results suggest that organic photovoltaics have advantages over traditional (silicon) cells from a life cycle perspective.

• Room for continued improvement with materials selection and solar cell fabrication options.

• Average minimum required lifetime 3.1-4.2 years.

• Energy and carbon payback times are 1-2 orders of magnitude lower.
Conclusions and Future Work

• Potential exposure of nanomaterials during production (ongoing project).

• No large scale production embodying these production pathways exists. Important to take into account hot-spots in early stage development.

• Continue through the use and disposal phases to understand how environmental profile changes
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References


