RESEARCH INSIGHTS

ESF State University of New York College of Environmental Science and Forestry

CAFRI Climate & Applied Forest Research Institute

# Life Cycle Assessment of Distributed Solar Power in New York State

**Key points**

- Evaluates cradle-to-grave environmental impacts of 120 NYS distributed solar PV systems.
- Compares polycrystalline (67.5%) and monocrystalline (32.5%) panels across roof and ground mounts.
- Main impacts come from panel manufacturing and balance-of-system; end-of-life plays a minor role.
- Higher energy output (capacity factor) significantly reduces climate impact per MWh.

**Importance**

This research offers New York specific, real data-driven insight into solar PV's environmental footprint. It shows that even with lower insolation, solar PV in NYS significantly reduces lifecycle greenhouse gas emissions–more than an order of magnitude compared to fossil fuels. The findings stress that effective recycling processes are essential to maximizing climate benefits. As NYS aims for a zero-emissions grid by 2040, these results provide timely, actionable guidance for policymakers, planners, and communities.

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**Summary of research**

This research examines the full environmental impact of electricity generated by distributed solar photovoltaic (PV) systems in New York State (NYS), using a comprehensive method called life cycle assessment (LCA). Unlike many past studies that rely on modeled or ideal performance conditions, this study uniquely uses real-world electricity production data from 120 operational PV systems. These systems, installed between 2014 and 2021, include both rooftop and ground-mounted arrays and feature both mono crystalline and polycrystalline solar panel technologies.

The LCA approach follows international ISO standards and elevates the complete "cradle-to-grave" lifecycle of the systems. This includes the extraction of raw materials, manufacturing of panels, overseas shipping, domestic transport, installation, operation, and eventual decommissioning, recycling, or disposal at the end of the system's useful life. The researchers assessed ten impact categories, placing special focus on greenhouse gas emissions using the TRACI 2.1 tool.

Results show that on average, these PV systems generate 45.6 grams of carbon dioxide equivalents per kilowatt-hour (g CO2-equivalent/kWh). This figure varies from 25.2 to 88.5 depending on system type, efficiency, and location. Although this is slightly above the national average for solar–mainly due to NYS's relatively lower solar insolation and seasonal snow coverage–it is still drastically lower than the 763 g CO2-equivalent/kWh associated with the state's fossil fuel dominated electricity mix.

A key takeaway is that including end-of-life recycling in the analysis reduces overall emissions by roughly 13%, underscoring the importance of panel recycling programs. However, NYS currently lacks in-state recycling infrastructure, which could lead to added emissions from long-distance panel transport.

The study also notes potential land-use impacts from ground-mounted systems, which weren't modeled in detail. It encourages future research into placing PV systems on already disturbed land and integrating vegetation to enhance carbon benefits and ecological value.

**Publication citation**

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