

Life Cycle Environmental Impacts of Solar PV in New York State



LIFE CYCLE ASSESSMENT OF SOLAR PV SYSTEMS

KEY POINTS

1. The environmental impact of 120 operating PV solar system in NY State was assessed using Live Cycle Analysis (LCA).
2. Life cycle global warming potential (GWP) of 120 solar PV systems in NY was 45.6 gCO_{2eq}/kWh¹. Current grid emissions in NY range from 106 gCO_{2eq}/kWh in upstate NY to 546 gCO_{2eq}/kWh on Long Island.
3. For GWP, panel manufacturing contributed 79%; installation and operation contributed 10%.
4. End of life recycling of solar panels reduced GWP by 11%. Without end of life recycling the mean GWP was 52 gCO_{2eq}/kWh
5. NYS would need about 60,000 acres of land to meet the Climate Plan goal of 10,000 MW solar PV by 2030² and would get about 10,700 GWh electricity annually from these distributed solar PV systems.



State University of New York College of Environmental Science and Forestry

- Life cycle assessment (LCA) is a cradle-to-grave analysis of environmental impacts of a system. ESF researchers analyzed the life cycle stages of solar PV systems including: (1) raw materials' extraction and use to manufacture PV modules, (2) transportation of those PV modules, (3) manufacturing of PV components (e.g., systems' cement footings, stainless-steel supports), (4) the installation and operation of the PV system, and (5) end-of-life (EoL) (i.e., decommissioning, disposal, and recycling of PV components).
- This research note summarizes our: (1) assessment of the environmental impacts of distributed solar PV systems specifically for New York State (NYS); (2) analysis of the contribution of major life cycle stages to the overall impacts, namely PV manufacturing, transportation, balance of system installation and operation, and the EoL; and (3) identification of key parameters that estimated environmental impacts.
- Our research used actual electricity production data over a 12-month period from 120 distributed solar PV installations in NYS (Figure 1). We also incorporated a commonly agreed upon panel efficiency degradation factor of 0.5% per year to account for efficiency losses over a 20 years period.
- 10 other environmental impacts in addition to GWP were analyzed.

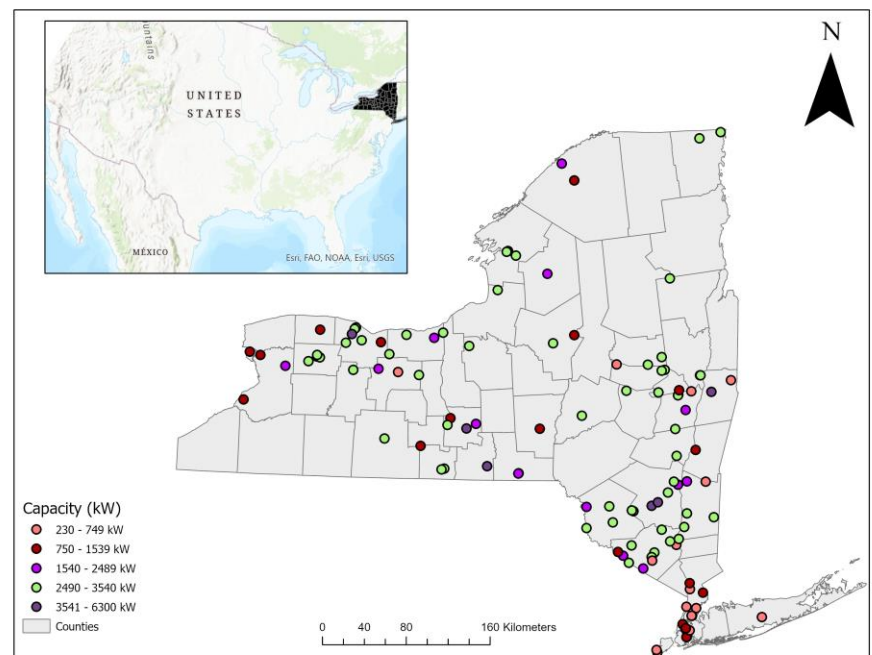


Figure 1: Location of 120 solar photovoltaic sites in New York State analyzed by this study. Only sites with more than one year of available electricity output data were analyzed.



ENVIRONMENTAL IMPACTS OF SOLAR PV SYSTEMS IN NYS

- The Global Warming Potential (GWP) of the 120 NYS PV systems we analyzed ranged from 25.2 to 88.5 gCO_{2eq}/kWh, with a mean of 45.6 gCO_{2eq}/kWh.
- Differences in type of panel (monocrystalline and polycrystalline), area power ratio, and capacity factor explained 81% of the variation in GWP.
- Panel manufacturing had the largest contribution to environmental impact, 79%, while installation and operation contributed 10%.
- The end-of-life recycling of panels reduced the total environmental impact across all categories of impacts (Figure 2).

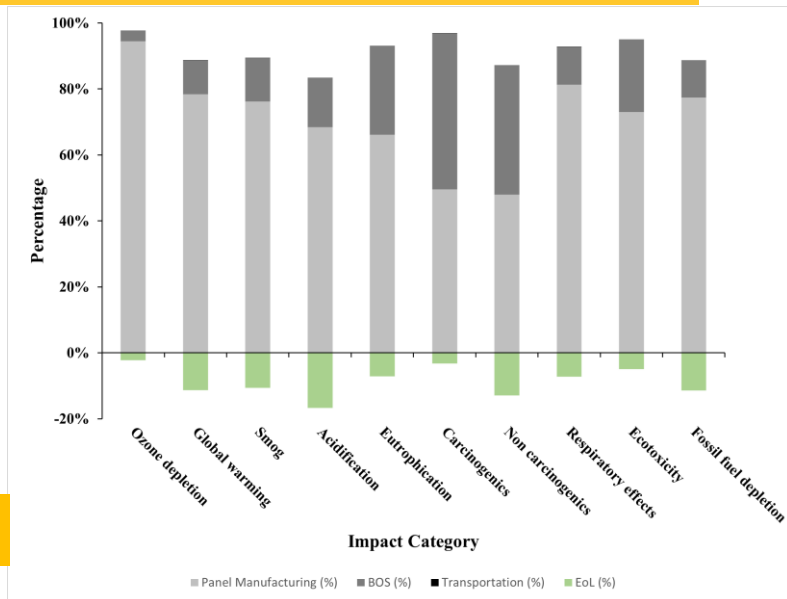


Figure 2: Contribution (%) of panel manufacturing, balance of system components manufacturing, installation, operation, transportation, and end-of-life to total impact of solar photovoltaic systems in NYS

IMPLICATIONS FOR CLCPA

- End of life recycling, which currently does not occur in NYS, can lower the environmental impacts of PV systems.
- NYS has a target of 10,000 MW of solar energy installed by 2030, which will require about 60,000 acres of land.
- This study did not include the impact of land use change that would result from the installation of solar systems on existing lands (e.g., agriculture land converted to a PV solar system), but it should be included in future studies.
- The average capacity factor of these 120 NYS solar systems was 12.2% (i.e., the systems only generated 12.2% of potential electricity). Given this, if NYS installs 10 GW of solar PV systems, these systems will generate about 10,700 GWh annually.
- NYS's average life cycle GHG emissions in 2020 for electricity generated from fossil fuels (99% of which is natural gas)⁴ is estimated to be 763 gCO_{2eq}/kWh.
- The installation of 10,000 MW of solar PV will reduce the state's life cycle GHG emissions by more than 7.67 million metric tonnes of CO_{2eq} per year, assuming the new solar PV installations displace existing fossil fuel-produced electricity.

COMPARISON WITH U.S. AVERAGE

The National Renewable Energy Laboratory (NREL) reported average life cycle GHG emissions of solar PV systems in the U.S. to be 40 gCO_{2eq}/kWh.³ Note that the NREL study does not include EoL disposal or recycling. The mean GHG emissions our study without EoL is 52 gCO_{2eq}/kWh or 26% higher than NREL value.

Contact CAFRI experts on **energy systems and life cycle assessment** at:

Dr. Timothy Volk
Professor SUNY-ESF
tavolk@esf.edu
315-470-6774

Dr. Obste Therasme
Assistant Professor SUNY-ESF
otherasm@esf.edu
315-470-4934

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