Landfill Solar: The future we see

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Introduction

Solar energy development is rapidly evolving to meet the complex demands of ambitious climate goals, environmentally conscious consumers, and hesitant host communities. At the same time, land is becoming more valuable than ever with a global population expected to reach nearly 10 billion people by 2050. While solar photovoltaics (PV) is the fastest-growing renewable alternative, major barriers prevent widespread social acceptance and ecological sustainability [1]. Namely, land-use conflict with agriculture and aesthetically disruptive siting practices are creating tension between rural communities and solar development. At present, the Department of Energy (DOE) Solar Energy Technology Office (SETO) is funding promising solutions such as agrivoltaics and the social science of solar adoption. Compared to other forms of solar siting, research indicates that the public strongly prefers to repurpose contaminated land to solar PV, known as brownfields to brightfields, or B2B [2]. While brownfields encompass a wide range of contaminated sites, landfills are some of the most common and will expand proportionally with a rapidly growing population. With limited industry participation in landfill-solar conversion, there is an immediate need for research to show such potential, particularly in regions where large-scale solar development has the potential to transform the rural landscape. Inspired by promising results from a case study in New York State (NYS), this project aims to inspire a new age of solar PV by demonstrating a concept for landfill-solar redevelopment to combat unbridled material consumption, pollution, and environmental degradation.

Case study

This case study uses Geographic Information System (GIS)-based tools to show the potential for landfill-solar redevelopment in NYS, incorporating siting considerations and evaluating four future infrastructure expansion scenarios. Feasibility criteria include slope, distance to the nearest substation, distance to the nearest road, and aspect, scored from least suitable (0) to most suitable (3) based on values in existing literature (Table 1) [3-5].

TABLE 1
SUITABILITY CRITERIA SCORING

Suitability	Slope (%)	Substation distance (m)	Road distance (m)	Aspect (degrees)
Good (3)	0-3	0-2575	0-15	135-225
Medium (2)	3-7	2575-4025	15-240	90-135, 225-270
Poor (1)	7-13.5	4025-6440	240-770	30-90, 270-330
Unsuitable (0)	>13.5	>6440	>770	0-30, 330-360

Using QGIS, the criteria were applied to NYS, then masked to a total of 38,803 landfills documented in the Inactive Landfill Initiative Database from the NYS Department of Environmental Conservation, Division of Materials Management [6]. Each pixel was assigned a sum of the four criteria, then reclassified based on techniques proposed in existing literature [3-5]. Then, each pixel was reclassified again based on four future infrastructure expansion scenarios: (1) expansion of roadway and electrical infrastructure, (2) no expansion of roadway infrastructure, (3) no expansion of electrical infrastructure, and (4) no expansion of roadway or electrical infrastructure. Figure 1 shows solar PV potential from unsuitable (0) to good (3) for these four scenarios.

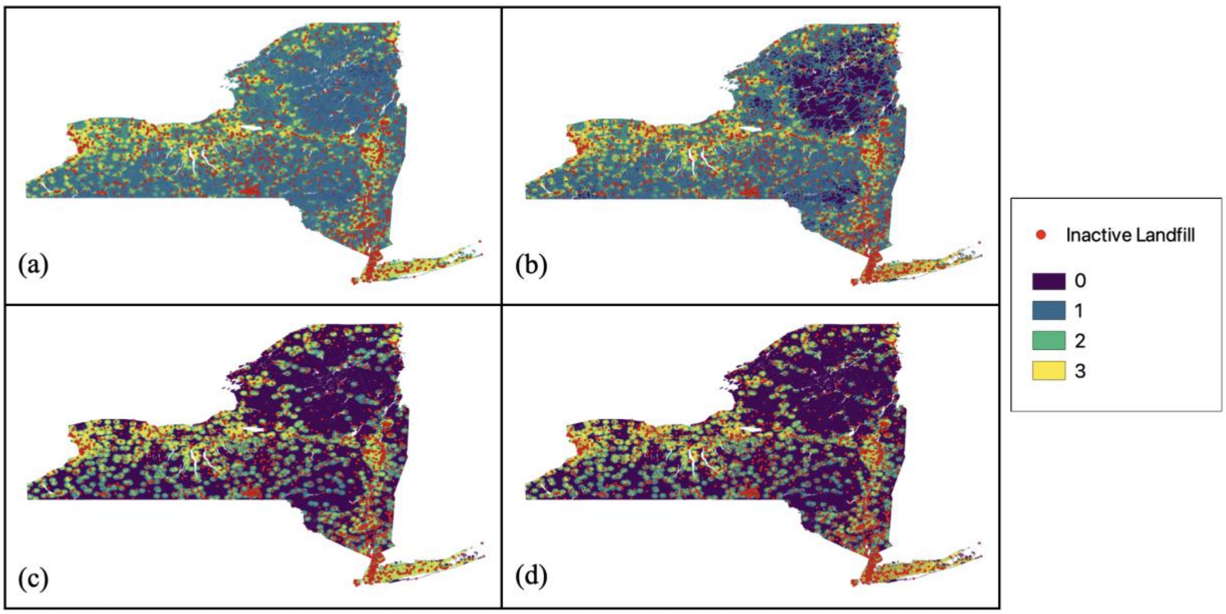

Fig. 1. Solar PV suitability from unsuitable (0) to good (3) for NYS considering inactive landfills in four scenarios: (a) base case, (b) no expansion of roadway infrastructure, (c) no expansion of roadway infrastructure, (d) combination of (b) and (c)

Considering good (3) and medium (2) suitability, 55 – 67 % of inactive landfill area in NYS shows potential for solar redevelopment, from Scenario 4 to Scenario 1. Full results are displayed in Table 2.

TABLE 2
NYS INACTIVE LANDFILL SUITABILITY

Scenario	Good (3) (%)	Medium (2) (%)	Poor (1) (%)	Unsuitable (0) (%)
1	35.3	31.8	32.9	0.01
2	35.3	27.4	28.2	9.1
3	35.3	26.4	15.3	23.1
4	35.3	22.0	12.4	30.4

In the context of the NYS Climate Leadership and Community Protection Act (CLCPA), whose goals correspond to an estimated 60 – 65 GW solar capacity by 2050 [7], these results indicate that landfill-solar redevelopment have the potential to contribute significantly. Based on 5 – 7 acres per MW solar capacity [8], an estimated 4.9 – 8.7 % of the estimated 2050 solar capacity can be achieved through landfill redevelopment (Table 3).

TABLE 3
POTENTIAL CAPACITY AND CONTRIBUTION TO CLCPA GOAL

Scenario	Medium (2) and good (3) suitability area (acres)	Contribution to CLCPA 60 – 65 GW 2050 capacity estimate (%)
1	26,018	5.7 – 8.7
2	24,315	5.3 – 8.1
3	23,918	5.2 – 7.9
4	22,216	4.9 – 7.4

This case study demonstrates strong potential for landfill-solar redevelopment and has inspired the corresponding artwork which aims to engage a wide audience in a future vision for alternative solar PV. The full research has been submitted to the 50th IEEE Photovoltaics Specialist Conference (PVSC) in Puerto Rico, June 11-16, 2023 [9].

Landfill solar redevelopment video

Untouched land…
Now urbanized…
Landfills grew…
A problem realized…
A new solution came to be…
Landfill solar,
The future we see.

The video begins with land untouched by human activity, then transitions to a state of urbanization before revealing the dark side of highly populated areas: pollution and waste management. After a brief tour of the landfill site, which was previously a picturesque field grazed by animals, a new future is presented: solar redevelopment. This new future, complete with dual-use animal grazing, is the manifestation of a decades-long struggle between humans and nature. The video depicts a utopia in which a city's waste can be transformed to a site for clean energy, and nature can begin its return to health. Our aim is to bridge the gap between scientific research and a broad audience, demonstrating our vision for sustainable solar siting practices which will improve social acceptance, enhance nearby ecosystems, and accelerate the nationwide transition to renewable energy.

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