The Future of Landfills Is Bright

How State and Local Governments Can Leverage Landfill Solar to Bring Clean Energy and Jobs to Communities across America

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On the cover: A 16.8 MW landfill solar development in Annapolis, Maryland; photo courtesy of BQ Energy Development, LLC.

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About Us

About RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

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Executive Summary

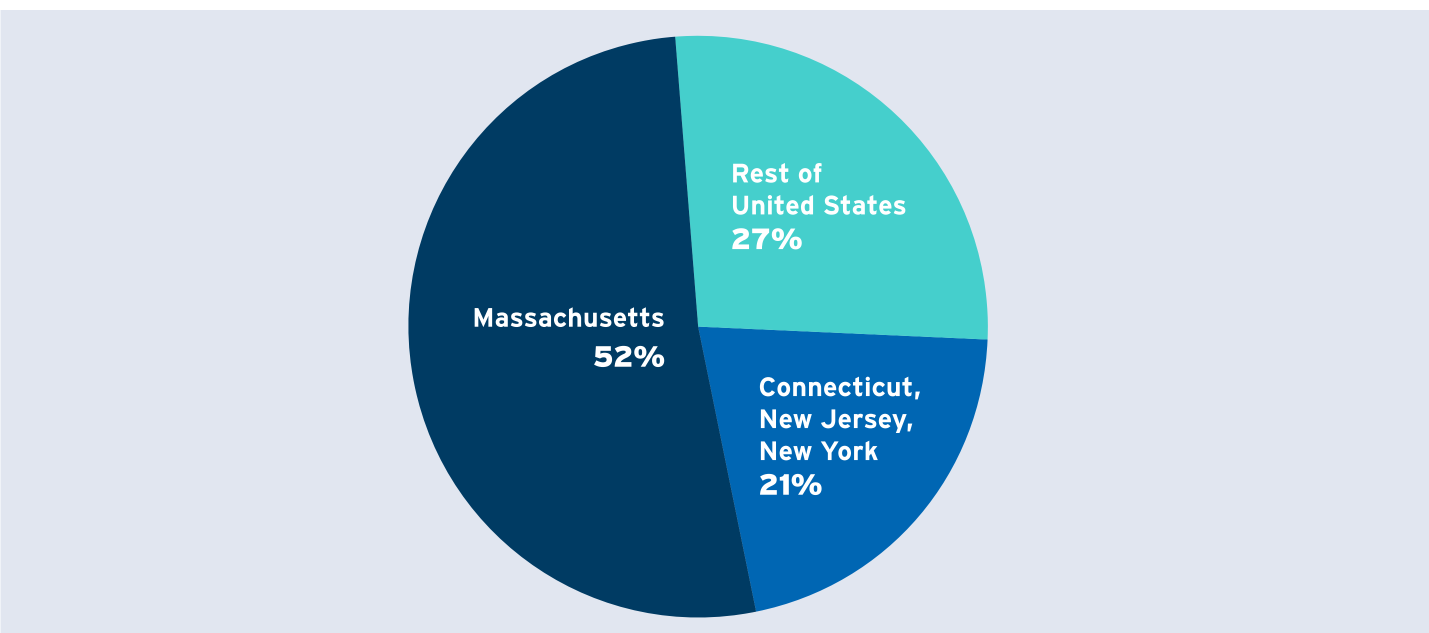
States and local governments across the United States are announcing ambitious renewable energy goals. Meanwhile, there are more than 10,000 closed and inactive landfills around the country.[1] These sites offer an incredible opportunity. By installing solar on closed landfills, states and municipalities advance local solar energy while repurposing relatively large, vacant sites within communities that have limited reuse potential.

According to the US Environmental Protection Agency **RE-Powering Tracking Matrix**, almost half of all renewable energy projects on brownfields—also known as brightfields—over the past 10 years were installed on closed landfills.[2] Solar and landfills are a natural combination for many communities looking to accelerate local renewable energy development. Landfills typically have good sun exposure—due to a lack of vegetation—and limited other redevelopment opportunities, making solar one of the few ways to put the land to productive use. Moreover, reinvesting in closed landfill sites can help revitalize the local, often lower-income, host communities. Landfill solar is also highly scalable, as there are **thousands of active landfills in the United States**—and many thousands more closed and inactive landfills.[3]

Yet, despite these benefits and opportunities, landfill solar is neither common practice nor common across the renewable energy industry. This report highlights our analysis of the status of landfill solar presently and the technical potential of what is possible if scaled across the United States. Our key findings include:

- **Landfill solar development has been geographically concentrated: Eighty-six percent** of all utility-scale (1 megawatt [MW] or greater) landfill solar projects developed through 2019 in the United States are in two regions: New England and the Mid-Atlantic.[4] In fact, four states—Connecticut, Massachusetts, New Jersey, and New York—outshine all others and host 73% of all utility-scale landfill solar projects developed through 2019.

Exhibit ES1 Geographic Concentration of Installed Landfill Solar Projects



Source: US Environmental Protection Agency RE-Powering Tracking Matrix 2020

- **The technical potential of landfill solar is significant:** Closed landfills could host an estimated 63 gigawatts (GW) of solar capacity in the near future. To date, just 500 MW have been installed on landfills in the United States. This 63 GW would be equivalent to 70% of all the solar capacity installed in the United States through 2020 (89 GW), and could produce 83 terawatt hours (TWh) annually—enough to power 7.8 million American homes or the **entire state of South Carolina.**[5]

- **The quality and availability of data matters for understanding deeper technical potential:** Limitations of state data, specifically regarding site acreage, closure status, and closure year, hinder a more complete understanding of technical potential across the country. The data that states maintain is key to informing future policies, incentives, and programs to encourage landfill solar.

- **States and municipalities are largely in control of their own fate to drive landfill solar deployment:** Trends in both the number of projects deployed and project scale indicate that the landfill solar industry is nowhere close to reaching full maturity. These trends also suggest that the deployment of landfill solar and the size of each project (plus the resulting clean electricity and jobs) are predominantly within the control of individual states and local governments.

The report concludes by highlighting how states and local governments can leapfrog to the latest policies, incentives, and best practices to encourage solar on brownfields and landfills. It includes lessons learned from governments that have piloted and refined their policies, incentive structures, and best practices over the past decade. Our findings, analysis, and research should offer clarity to elected officials, policymakers, planners, developers, and communities on how landfill solar can be part of a broader clean energy and land-use strategy to achieve ambitious community-wide sustainability and environmental justice goals.

Introduction

From Waste to Renewables

States and local governments are increasingly demonstrating their commitment to and support for decarbonization and renewables. Since the United States announced in June 2017 it would withdraw from the Paris Agreement, over 400 local governments and tribes have joined "**America Is All In.**"[6] More than **160 cities** have set 100% renewable energy targets, and at least **29 states** have established a renewable portfolio standard.[7] Since 2015, **US cities have announced 13.9 GW** of renewable energy transactions, the majority of which have been either smaller on-site solar projects or contracts with remote utility-scale wind and solar power plants.[8]

These standard approaches provide important benefits, yet also face significant drawbacks that can limit their value to a community. For example, large-scale projects provide economies of scale, yet they are often located far outside communities, limiting the potential of such projects to offer local jobs, educational opportunities, local tax revenue, and other community benefits. In contrast, while rooftop solar projects in a community create jobs and provide local benefits, they are often limited in scale and unable to capture economies of scale.

In recent years, a few states and municipalities have demonstrated the advantages of an alternative model: installing solar on brownfields (known as brightfields) and, more specifically, on closed landfills.[i] These landfill solar projects have the potential to bridge the gap between large off-site projects and small rooftop installations by taking advantage of relatively large vacant sites within communities that have limited reuse potential.

Landfill solar is also highly scalable. There are **thousands of active landfills in the United States**—and many thousands more closed and inactive landfills.[9] While neither closed nor inactive landfills actively receive waste, closed landfills have been properly capped, maintained, and monitored, whereas inactive landfills are typically uncapped and unmaintained. As states and local governments increase the ambitions of their renewable energy and sustainability goals, deploying renewable energy on closed landfills provides a prime opportunity to not only accelerate the development of locally produced renewable electricity but also transform an underutilized site known for its waste into a community asset.

The Benefits of Landfill Solar

Landfills are attractive locations for local solar projects for two primary reasons.[ii] First, most cities and counties own or operate landfills that are either actively managed or have been closed. Having site control puts the planning and procurement decisions directly in the hands of communities. Second, landfills lack extensive reuse opportunities. While some closed landfills have been repurposed as open space or golf courses, most do not have any future planned use. Thus, installing solar on landfills avoids land-use conflicts with other economic, agricultural, housing, or recreational activities.

These reuse limitations are, in part, due to the potentially hazardous materials existing on these sites and the presence of landfill gas wells, both of which limit ground penetration for—and therefore development of—schools, shopping, and housing. Reuse is also hindered by settling that occurs over time, which can morph the ground's topography. However, solar arrays can be designed to accommodate the needs of landfill operations and monitoring post-closure.

[i] "Brightfields" are defined as brownfield sites hosting renewable energy (typically solar). The US Environmental Protection Agency (EPA) defines a brownfield as a property which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant for any expansion, redevelopment, or reuse. It is estimated that there are more than 450,000 brownfields in the United States. Typical brownfield sites include former industrial facilities, abandoned mines, and closed landfills.
[ii] For the purposes of this report, any future references to landfill solar presume the landfill is closed.

In addition to being feasible and among the few available reuse options, installing solar on landfills offers numerous environmental and economic benefits. These include:

- **Sun-Exposed Land:** Landfill sites are often broad tracts of land with little to no shading, providing locations with relatively strong solar irradiation, sometimes within more developed, dense communities.

- **Existing Infrastructure:** Due to their prior usage, landfill sites often have existing connections to electric distribution infrastructure and access roads necessary for the construction, operations, and maintenance of solar projects. This reduces the need to build out additional transmission, distribution, and interconnection infrastructure.

- **Economic Revitalization:** Landfill site reuse brings temporary construction jobs and permanent operations and maintenance jobs to underutilized sites. This not only stimulates the local economy but also provides a benefit to local businesses that support these employees.

- **Available Incentives:** Federal and state programs provide grants and other incentives for site assessment, cleanup, and reuse of landfills (and brownfields more generally) that can help alleviate additional upfront costs.

- **Environmental Justice:** Landfills are often close to lower-income communities. Reuse of these sites not only provides a sustainable, non-hazardous reuse, but also an opportunity for community solar, education, and non-hazardous reinvestment.

For many of these reasons, the US Environmental Protection Agency (EPA) determined in 2016 that, among brightfield sites, closed and capped municipal solid waste landfills often offer an **ideal location** for solar installations.[10]

Note: A 16.8 MW landfill solar development in Annapolis, MD. Photo courtesy of BQ Energy Development, LLC.

Landfill Solar Can Complement Local Environmental Justice Initiatives

Landfill solar can be **part of a just energy transition** and overcome hurdles to racial justice.[11] However, for this to be done successfully, planners must understand the historical racial context of the site and surrounding community. The project design process must also include frontline, disadvantaged, and minority communities. Reinventing one closed landfill with solar in a community will by no means alleviate decades of policy and planning failures, but it can be a productive step for communities that have often been taken advantage of for prior landfill siting decisions and operations.

Landfill siting decisions have been directly linked to detrimental outcomes for Black communities. The **first environmental justice case** regarding the decision to locate landfills in predominantly Black neighborhoods was brought in 1979 in Texas.[12] The Texas District Court was unable to establish intentional discrimination in ***Bean v. Southwestern Waste Management Corporation*** for a solid waste site in Harris County.[13] However, the court did find that the landfill would "affect the entire nature of the community, its land values, its tax base, its aesthetics, the health and safety of its inhabitants, and the operation of Smiley High School, located only 1,700 feet from the site."

Only a few years later in 1982, protests erupted in Warren County—a predominately Black community in North Carolina—over a proposed hazardous waste landfill. The **US Department of Energy notes** that studies conducted following the Warren County protests found links between race, poverty, and waste siting decisions, with one study concluding "race was the most significant factor in siting hazardous waste facilities, and that three out of every five African Americans and Hispanics live in a community housing toxic waste sites."[14]

While not every landfill presents concerning environmental justice impacts, explicitly planning for their sustainable reuse provides local governments with an opportunity to alleviate some of these past harms. Specifically, local governments may be able to use landfill solar projects to educate communities on solar energy, create local green jobs, and even reduce energy burdens for nearby residents through community solar.[iii] Though any solar project could deliver similar benefits, installing solar on landfills specifically revitalizes sites that have plagued communities for decades.

The **Sunnyside Energy project** in Southeast Houston is an illustrative example of how environmental injustice can persist in communities, and the role solar can play in alleviating the situation.[15] The 240-acre closed landfill in the Sunnyside neighborhood of Houston is located in a census tract that is far less White and far less wealthy than the city and state (see Exhibit 1). The seven surrounding census tracts juxtapose a non-White population of 97.9% compared with 75.4% in the city. The surrounding census tracts also show an average median household income just 59% of the city's average and 51% of Texas's average. Mayor Sylvester Turner recently reflected that "**for the last 50 years, this contaminated landfill has been there really pulling down the neighborhood**."[16]

[iii] The Renewable Denver Initiative specifically focuses on increasing equitable access to clean energy in Denver. Twenty percent of the energy generated by the community solar gardens is to be allocated to income-qualified housing and low-income residents to help alleviate their energy burden. In addition, the initiative includes a paid workforce training program available to Denver residents, run in partnership with GRID Alternatives, that will field about 10% of the City and County's solar workforce. For more information, visit: **https://cityrenewables.org/story/denver-co/**

Exhibit 1 Houston's Sunnyside Energy Project Area Socioeconomic Disparities

Geography	Population	Percent Non-White	Median Household Income	Per Capita Income
Project Site (Census Tract 3312)	3,285	97.7%	$26,612	$17,297
Average of Project-Adjacent Census Tracts	29,338	97.9%	$30,213	$15,581
City of Houston	2,320,268	75.4%	$51,140	$31,576
Harris County	4,713,325	70.9%	$60,146	$31,901
Texas	28,995,881	58.5%	$59,570	$30,143
United States	328,239,523	40%	$60,293	$32,621

Source: United States Census Bureau 2018 American Community Survey 5-Year Estimates

The City of Houston and the Sunnyside community reimagined and are now redesigning what the closed landfill could become with solar and other community facilities. This includes up to 52 MW of both utility-scale and community solar, battery storage, and an Agricultural Hub and Training Center, all coupled with plans to hire locally and create local partnerships with the community.

Houston's project continues to advance, and the city has since approved the site lease and selected a development team to design and build this landfill solar project.[17] Many co-benefits will be local and community-oriented, including site cleanup, educational opportunities, local partnerships, and increased economic activity due to project construction and on-site events. Not every urban area with a large landfill will observe such stark socioeconomic disparities as Houston's Sunnyside project. Nevertheless, decision makers, planners, and communities should evaluate whether other landfill solar could directly benefit historically disadvantaged communities and complement environmental justice efforts.

Factors That Complicate Landfill Solar Development

While landfill solar projects present various opportunities, these sites are inherently more complicated than an undeveloped land parcel. Project designs must account for landfill cap characteristics, site grading, land settlement as waste decays over time, existing on-site infrastructure, community concerns, and interdepartmental coordination.

- **Cap Considerations:** Capped landfills will likely require a lighter weight, ballasted system with non-invasive foundations. In older landfills where proper closure may not have occurred, effective capping may be necessary. One of the consequences of relying on ballasted systems is that they are not currently designed to accommodate fixed tilt solar racking systems. The lack of cost-effective tracking systems for ballasted systems may hinder solar generation potential and project cost-competitiveness.

- **Settlement:** It will be important to assess the landfill's prior and future settlement patterns to ensure that the solar panels do not become misaligned (decreasing electricity production) and do not create uneven stress on the cap. The rate of settlement at municipal solid waste (MSW) landfills capped more than 10 years ago is lower than those capped in recent years, though this can vary based on the composition of a landfill's contents.

- **Site Grade:** The slope of closed landfills may also limit the solar siting potential. Landfill sections with particularly steep profiles (greater than 15 degrees) may not be able to accommodate solar.

- **Existing Infrastructure and Operations:** Solar projects will need to accommodate existing on-site infrastructure, including leachate and gas collection systems, as well as ongoing landfill monitoring and site maintenance operations. In particular, the system design must account for the location and weight-bearing capacity of these pipe networks as well as necessary access points for maintenance staff.

- **Lack of On-Site Electricity Consumption:** Due to a lack of on-site operations on closed landfills, landfill solar has fewer opportunities for immediate electricity offtake or electric meter reduction. Flexible net metering or community solar programs can help make this more feasible, as discussed later in the section *How States Can Encourage Landfill Solar*.

- **Community Concerns:** When located in or adjacent to communities, projects need to consider potential longstanding environmental justice and site reuse concerns by explicitly educating residents and community groups about the plans and addressing any concerns or perceived risks.

- **Interdepartmental Coordination:** Reuse and revitalization of landfills for solar do not fit neatly in a single department's purview. Rather, such a project typically involves collaboration across at least two departments, including sustainability or energy management, solid waste, or planning. States also rarely provide guidance for local governments seeking multi-agency project approvals.

As a result of these considerations, permitting and project approval are usually subjected to a more rigorous review for brownfield sites than greenfield sites. Policies, incentives, and practices to streamline these review and approval processes are discussed later in the sections *How States Can Encourage Landfill Solar* and *How Local Governments Can Encourage Landfill Solar*. Moreover, the US EPA's **RE-Powering America's Land program** offers technical guidance that can help developers and communities mitigate the above-mentioned hurdles as well.

Analysis

The Current Status of Landfill Solar

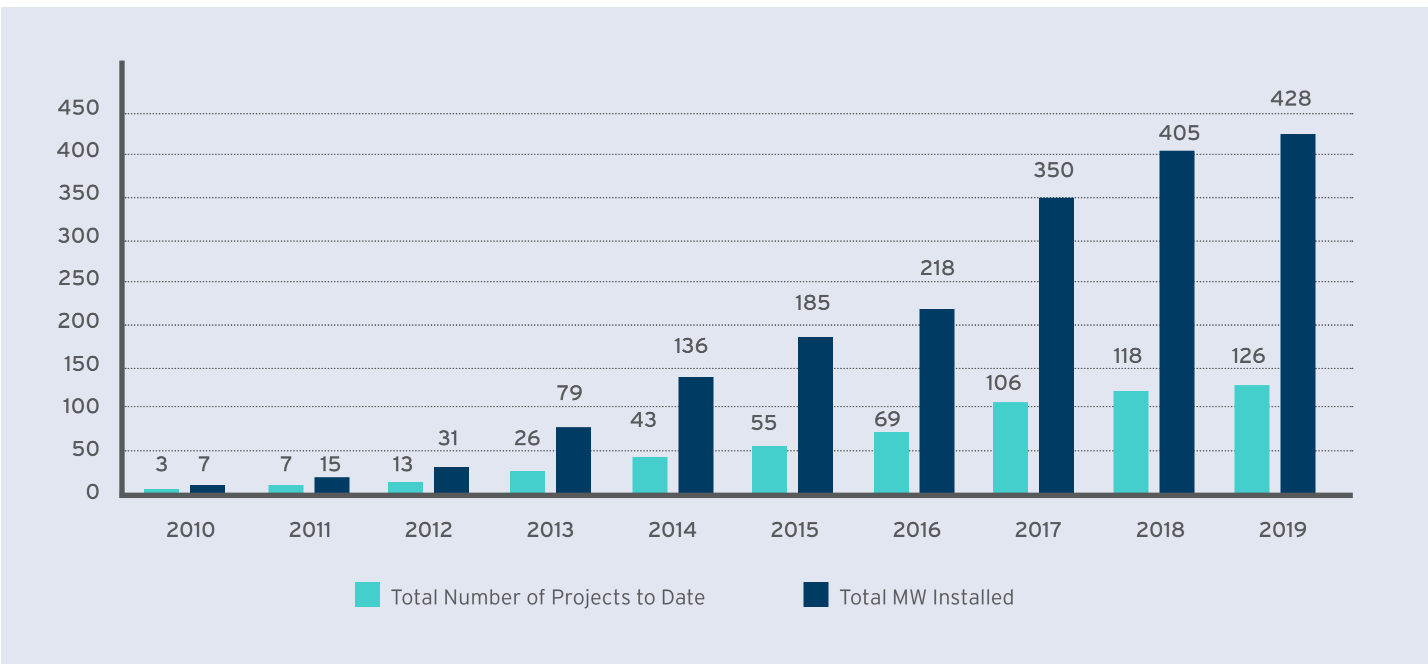
Evaluating the market size and geographic distribution of projects is key to telling the complete story.

Market Size

Since 2012, landfill solar deployment has steadily increased (see Exhibit 2). Moreover, an evaluation of US EPA data revealed additional market insights:

- Utility-scale landfill solar projects (defined here as projects 1 MW or greater in capacity) emerged as a viable market in 2012, with 90% of utility-scale projects having been built since 2012. These 113 projects collectively amount to 428 MW of installed solar capacity.
- Through 2019, the US EPA had identified 205 completed solar projects on or adjacent to landfills that, collectively, are capable of generating approximately 500 megawatts (MW) of electricity.[18]
- Local governments have been the primary hosts of landfill solar redevelopment, having installed 161, or 79%, of all 205 projects through 2019.

Exhibit 2 Total Utility-Scale Solar Projects and Installed Capacity on Landfills Since 2010[iv]



Source: US Environmental Protection Agency RE-Powering Tracking Matrix 2020

[iv] Note that Exhibit 2 includes three projects in 2010 that represent all projects up to and including 2010 for ease of visualization.

While cumulative growth in landfill solar capacity has been steady, this market has not seen the exponential expansion observed in the **overall US solar market since 2016**.[19] Though prices for solar panels have declined, the complicating factors noted previously have hindered the growth rate of discrete landfill solar projects and project scale.

Even so, the average solar capacity per project on landfills has been increasing, ranging from an average of 1.9 MW per project in 2013 to an average of 4.9 MW per project in 2018. This change is driven by both an increase in the median project size as well as a few large-scale projects. For example, the City of Annapolis made headlines with its **$30 million, 16.8 MW project** completed in 2018.[20] And others are looking to follow suit, with two other record-setting utility-scale landfill solar projects announced in recent years: Houston's planned 52 MW **Sunnyside Energy project** announced in 2019 and the **Solid Waste Authority of Central Ohio's planned 50 MW project in Franklin County** announced in 2020.[21] As states and local governments become more comfortable with landfill reuse, renewable energy interconnection, and electricity offtake, projects should continue to scale considerably.

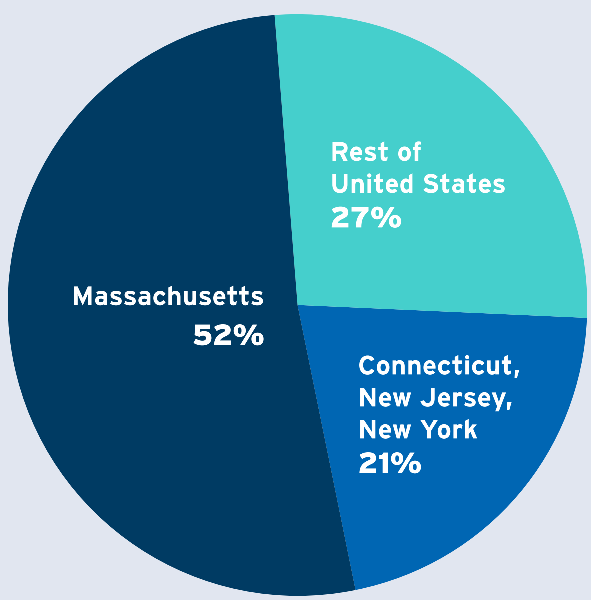
Geographic Distribution

In addition to market size, development of utility-scale landfill solar projects is quite geographically concentrated to date.

- Of the 126 utility-scale projects developed through 2019, 65, or 52%, are sited in Massachusetts.
- Three other states—Connecticut, New Jersey, and New York—host 27 of the remaining 61 projects.
- Combined, those four northeastern states contained 73% of all utility-scale landfill solar projects as of 2019.

Since the Northeast only contains an **estimated 7% of the nation's landfills** and certainly does not have the best sun exposure relative to the southern and western United States, it seems fair to conclude that deliberate state policies, explicit incentives, and targeted practices have enabled landfill solar to thrive in these states.[22] This is explored further in the final section of this report: *Recommendations*.

Exhibit 3 Geographic Concentration of Installed Landfill Solar Projects



Source: US Environmental Protection Agency RE-Powering Tracking Matrix 2020

The Technical Potential of Landfill Solar

Based on our analysis, there is significant potential nationwide for landfill solar. We evaluated 4,314 landfill sites in the United States for solar capacity using industry-standard assumptions and PVWatts, a National Renewable Energy Laboratory tool, to estimate site-specific generation estimates.[v] Our calculations yielded 63.2 gigawatts (GW) of solar capacity across landfills that are closed and scheduled to close by 2030, with total annual electricity generation amounting to 83.3 terawatt hours (TWh). Over 86% of that estimated generation is from closed landfills—in other words, sites that are no longer active or accepting new waste. While closed landfill sites can help decision makers understand the solar potential that is available now, local and state officials should understand the portfolio of landfills scheduled to close by 2030 in the context of their longer-term climate action and community planning between now and 2050.

Moreover, this is, if anything, a significant underestimate of the true potential. The lack of readily available and comprehensive state data for open and closed landfills limited our ability to fully estimate the nationwide potential of landfill solar. Only six states—Texas, Minnesota, Massachusetts, Connecticut, New Jersey, and New Hampshire—had accessible, comprehensive data profiles necessary for a complete analysis. Moreover, 44 states and 2 US territories had incomplete or unavailable data for at least one of the following categories: site acreage, closure status, and locational data—all of which were critical for assessing the technical capacity and generation potential. Given this incomplete data, the estimates and rankings discussed in this report should therefore be interpreted, by and large, as a lower bound of the landfill solar technical potential—provided the right policies and practices are implemented to facilitate development.

Landfill Solar Potential in Context:

- 83.3 TWh is roughly equal to the average annual electricity consumption of the state of South Carolina.
- This is roughly equivalent to the average annual electricity consumption of 7.8 million American homes.
- The 63.2 GW of capacity is just shy of the 89 GW of solar that had been installed across all types of sites in the United States as of mid-2020.

This analysis includes multiple assumptions—all of which are detailed in *Appendix A: Sources, Methodology, and Assumptions*. A few overarching assumptions are outlined below:

- National technical potential includes estimates across the 50 states, Puerto Rico, and the US Virgin Islands for closed landfills and landfills scheduled to close by 2030.
- Sites were only evaluated if they were at least one acre in size.
- Sites were assumed to be capable of hosting solar across 70% of the full site to accommodate landfill infrastructure and service roads. Individual site grading, floodplains, and other natural or human-made obstacles were not considered directly (i.e., trees or other structures).

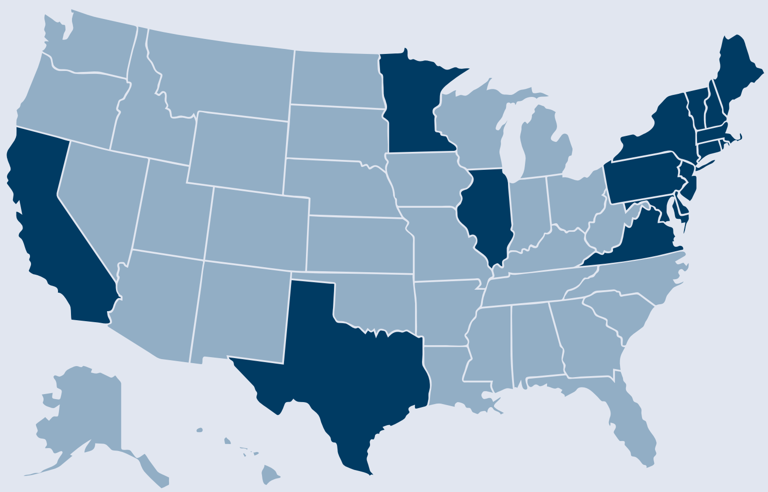
[v] For this analysis, industry standards include an assumed 9.5 watts per square foot and 70% site viability. This is approximately a ratio of 1 MWac per 3.5 acres. Actual numbers would vary by site.

States Ready to Leverage Landfill Solar Potential

Our analysis of current project data identified only a few states across New England and the Mid-Atlantic with maturing industries and straightforward development guidelines. As a result, the development and deployment of landfill solar is still in its infancy across much of the country.

Based on the technical potential assessment, existing renewable energy and climate change mitigation policies, and quality of publicly available data, the following states and regions stand out as those with the potential to lead (or continue leading) on landfill solar.

Exhibit 4 States Ready to Leverage Landfill Solar Potential

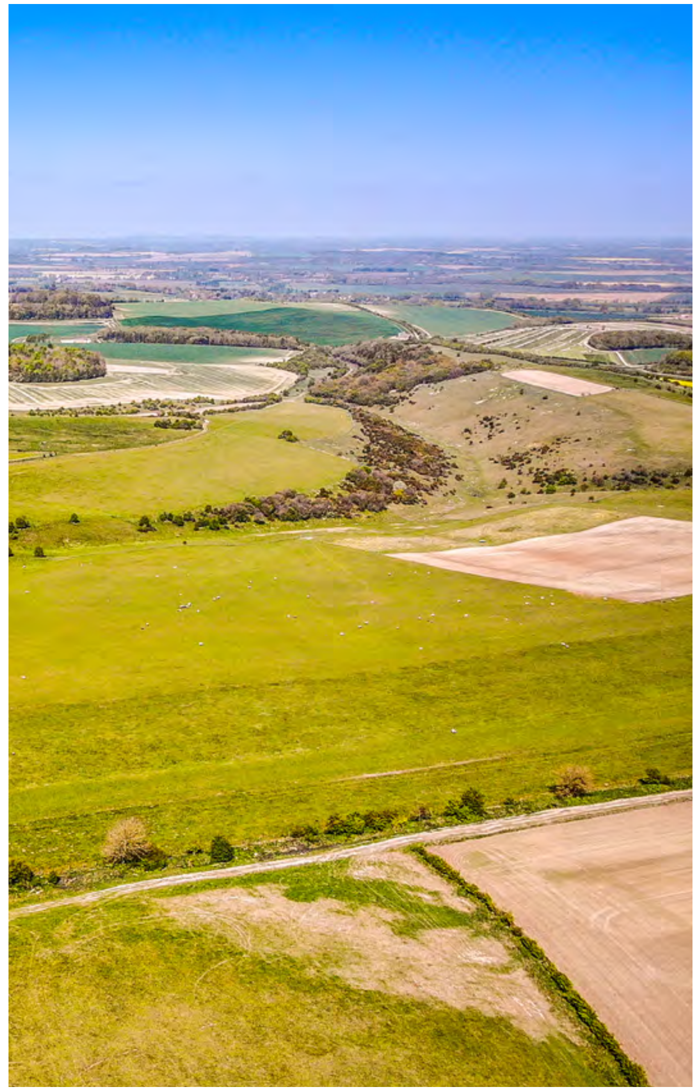


State/Region	Opportunity
California	California ranks second only to Texas in terms of estimated potential capacity (4.8 GW) and potential generation (6.3 TWh annually), but these estimates only include the 186 sites that we could evaluate (out of more than 3,700 closed, closing, or inactive landfills). Given California's aggressive emissions and renewable energy goals, specific program carve-outs and practices should enable landfill solar to scale.
Illinois	Illinois updated its renewable energy targets in 2021 to designate 3% of renewables for brightfields development, which would include landfill solar. This specific program carve-out positions Illinois to lead the Midwest and create additional energy jobs in-state while tapping into our highly conservative landfill solar potential of 1.5 GW across 52 sites.
Minnesota	With a robust community solar program and a growing renewable generation portfolio, landfill solar is ripe for deployment in Minnesota. The state already identified ~1 GW of solar capacity through its own technical assessment of its closed landfills in December 2020, after accounting for site grading, floodplains, and other factors.
Mid-Atlantic States	New York and New Jersey are already leaders in landfill solar deployment and have over 4,200 inactive sites. We estimated over 9 GW across this region, even with limited data for Pennsylvania, Delaware, Maryland, and Virginia, which could easily build on their already ambitious greenhouse gas emissions targets. Plus, Maryland already boasts one of the largest landfill solar projects nationwide.
New England States	Connecticut, Massachusetts, and New Hampshire combined offer almost 7.6 GW across 811 potential sites. This opportunity combined with the existing policies and incentives could help scale landfill solar to reduce energy burdens for communities.
Texas	Texas offers the greatest potential of any state evaluated with 2,134 sites, most of which are closed, potentially hosting 27.3 GW of capacity and generating 41.4 TWh annually. With state data coupled with its excellent solar irradiance, Texas could develop a nation-leading landfill solar program in its deregulated market.

This initial list is by no means exclusive or suggestive of the fact that other states should not consider leveraging landfill solar. Rather, this highlights those states and regions with notably high potential or a more complete understanding of what their sites and potential offer, given publicly available data.

Other states may want to consider landfill solar development for many of the reasons described in this report or to circumvent energy and land-use conflicts. For instance, as solar and wind continue to be built across the country, farmers, crop managers, and rural communities are **raising concerns** about local land-use decision-making, a lack of land-use regulations, and threats to agricultural-based economies.[23] Many of these organizations recognize the value of solar, like the **American Farmland Trust**, but encourage solar not to be sited on prime agricultural lands.[24]

In 2020, for instance, **Oregon's community solar program spurred tension** between farmers, winemakers, and solar developers over the land use, leading the state to develop additional rules limiting solar development on farmland.[25] Encouraging landfill solar—and brightfields generally—relieves impacts and pressure on agricultural lands. The remaining sections outline policies and best practices for states and local governments to spur landfill solar development.



Recommendations

How States Can Encourage Landfill Solar

States can deploy a combination of policies and incentive structures to support the growth of landfill solar (and brightfields in general). While at this time no consensus has emerged on the best means of encouraging landfill solar, Massachusetts, Connecticut, New Jersey, and New York have all enacted a range of policies and practices that are proving to be effective. Building on research and conversations with state agencies, we identified a set of state policies and incentives that should encourage landfill solar to scale.

1. **Implement (or Update) a Renewable Portfolio Standard with Brightfields Carve-Outs:**
   - **Description:** A renewable portfolio standard (RPS) is a legislative mandate requiring electric utilities to source a percentage of their electricity from renewable sources such as wind or solar. Legislators could require that specific percentages, or carve-outs, come from landfill solar projects.
   - **Examples:** New Jersey has a 50% renewable energy by 2030 goal and a solar carve-out of 5.1%.[26] New Jersey's Solar Act of 2012 explicitly authorized solar projects located on a "brownfield, on an area of historic fill or on a properly closed sanitary landfill facility."[27] Illinois actually went further and updated its RPS in 2021 to designate at least 3% of renewables for brightfields development.[28]
2. **Create Explicit Incentives for Landfill Solar:**
   - **Description:** Incentives help communities overcome the higher costs of landfill solar and thereby advance projects. In addition to solar rebates and grants, states can implement targeted incentives for projects that meet certain criteria.[vi]
   - **Example:** Massachusetts' SMART program offers compensation rate "adders"—incentives based on project location, off-taker type, and other variables to incentivize landfill solar projects.[29] Landfill solar projects can receive $0.04/kWh. Moreover, adders can be "stacked," meaning a project can be eligible for and benefit from multiple distinct adders; for example, a landfill project serving a public entity would receive two adder incentives.
3. **Align Land Use with Sustainability and Economic Goals:**
   - **Description:** States and local governments may also consider a range of incentives or disincentives to align solar project development with non-energy priorities that could support landfill solar indirectly. For example, "subtractors," which discourage the use of protected areas and natural park space for solar development, may make landfill sites more attractive by comparison. Meanwhile, incentives for pairing landfill solar with solar prairies and other pollinator-friendly habitats—which can boost crop yields, reduce soil erosion, and strengthen local vegetation and habitats—could prompt greater uptake of these project design practices among developers.
   - **Example:** In 2020, Massachusetts updated its SMART program to increase existing greenfield "subtractors" that reduce the compensation for projects on undeveloped areas. The 2020 update also designated "ineligible land uses" if a project is sited in a priority habitat, core habitat, or critical natural landscape.[30]

[vi] Due to greater costs and complexity related to potential liability, site assessment, cleanup, or site preparation, landfill solar projects may require external funding. State and local governments can seek public funding from two main sources: US EPA's Brownfields Program and state brownfield and remediation funds. For instance, New Jersey's Hazardous Discharge Site Remediation Fund includes a municipal grant program and a low-interest loan program that can be used to conduct environmental assessments and remedial actions prior to project development.

4. **Enable Net Metering Flexibility:**
   - **Description: Aggregated and virtual net metering** greatly enhance the economics of landfill projects by enabling multiple electric meter accounts to capture the net metering benefits of a single project.[31] While most states with aggregated or virtual net metering have created a cap on eligible project capacity, brightfields are sometimes exempted from these restrictions.

   - **Example:** The state of Maryland allows for aggregate net metering for agricultural producers, nonprofit organizations, and local governments and their affiliates, capped at 2 MW per project. However, projects on brownfields, including landfills, are exempt from this cap.

5. **Enable and Encourage Community Solar on Landfills:**
   - **Description:** Community solar is a procurement model in which output of the solar array is divided among multiple subscribers who then receive bill credits for their share of the local solar project's generation.[vii] These programs are especially helpful for renters or for homeowners with roofs that are unsuitable for solar PV. States should allow for and incentivize installing community solar on landfills to convert community waste sites into shared energy facilities. As noted in the previous recommendation, there should be no constraint on project capacity for brightfields to maximize potential generation.

   - **Examples:** In states with multiple adders, like New York and Massachusetts, projects can stack landfill adders with community solar adders. For example, in **Massachusetts**, a project could layer a landfill adder of $0.04/kWh with a low-income community shared solar adder of $0.06/kWh.[32] Meanwhile, although **Minnesota** does not have an explicit carve-out for brightfields or landfills at this time, it does offer a community solar rate adder for residential subscribers of $0.015/kWh and has not set a program-wide capacity limit for community solar projects.[33] This helps encourage longer-term planning and reduces the rush for developers to get the easiest projects into the approval pipeline. Other states could consider carving out a percentage of their program, like **Maryland's Community Solar Pilot Program**, for landfill solar as well as other brightfield sites.[34]

Massachusetts Is Encouraging Innovation in Renewable Energy and Land-Use Policy

States regularly serve as laboratories for policies that other states or the federal government can embrace. In 2018, Massachusetts' SMART program set a goal of 1.6 GW of installed solar capacity with explicit adders for landfill solar, brownfields, parking facilities, agricultural areas, pollinator-friendly solar, floating solar, and others—and filled up almost immediately with planned projects. As John Weaver with ***PV Magazine*** put it: "The problem might be that the state has created a program that is too successful."[35] While landfill solar may be only one piece of that successful program, Massachusetts' success with easier landfill sites is now encouraging developers to install solar on more challenging landfills. This will only further spur innovation in the landfill solar industry.

[vii] For municipalities and states interested in learning more about community solar procurement, the American Cities Climate Challenge Renewables Accelerator, a jointly led effort by RMI and World Resources Institute, has developed step-by-step **community solar procurement guidance**.

Policies and incentives are two key pieces of the puzzle, but thoughtful practices—techniques and strategies to implement policy—are critical to successful project development. Based on our review of and discussions with pioneering states and practitioners, we recommend that states seeking to encourage landfill solar adopt the following practices that have been tried and tested over the past decade.

- **Provide Clear, Cross-Departmental Guidance:** Because landfills and brightfields tend to involve regulatory oversight from multiple agencies or departments within an agency, interdepartmental or interagency collaboration and education is essential for success. State environmental or energy agencies should start early in the process and establish state-specific guidelines for deploying landfill solar development. Such guidance is an often overlooked part of a successful program and should include a mutual understanding of incentives available, permits needed, and a point of contact who can help communities and developers alike. Examples of guidance are linked here for **Massachusetts**, **New York**, **New Jersey**, **Connecticut**, and **Maine**.

- **Offer Technical Assistance:** State policies and incentives may be well-intentioned, but with limited staff capacity, competing priorities, and evolving regulations, local governments often require direct assistance to implement landfill solar projects. For example, Massachusetts provides direct assistance to local governments through its **Green Communities** program.

- **Use an "Alternative Fill" Approach:** In states with limited waste capacity or where many landfills are not properly closed and capped, consider allowing landfill owners to use lightly contaminated fill (i.e., soils, dredge, and other materials) from other contaminated sites and construction sites around the state to aid in closing the site. This accelerates remediation and closure by reducing costs and supports appropriate grading and capping requirements to enable renewable energy deployment. For instance, New Jersey landfill owners can receive approval from the **state Department of Environmental Protection**.[36] The beneficial reuse of this fill also keeps this material out of the waste stream and out of the limited number of active landfills in New Jersey.

- **Track Project Data and Embrace Mapping Technologies:** States should work with site owners and developers to track key metrics to make the case for future projects and programs.[viii] State agencies can help visually convey the solar potential of landfills as well as orient developers to prospective opportunities. These can be easily layered with other demographic or socioeconomic data as well. For example, New Jersey's **Community Solar PV Siting Tool** is a state-of-the-art mapping tool that can visualize landfill locations, demographic information, priority regions, utility territories, municipal boundaries, and other factors.[37] Another approach could be to work with utilities to produce "heat maps" of load and additional capacity opportunities, like **this example** from National Grid in Massachusetts.

[viii] Helpful metrics include landfill-specific data points such as closure status, closure year, location and acreage of project, type of waste, and contact information, as well as overall statistics such as the number of remediated sites hosting solar, total installed solar capacity, and annual generation. Additional data on local revenue generated, jobs created, cost savings, and the number of subscribers for community solar projects can illustrate project co-benefits.

How Local Governments Can Encourage Landfill Solar

While states are key players in advancing landfill solar, local governments are by no means mere spectators. In fact, local governments are even pursuing landfill solar project in states in the absence of explicit policies and incentives. Local governments can accelerate landfill solar project development by taking the following actions:

- **Conduct and Promote an Inventory of Available Landfills:** Local governments should take inventory of their landfill portfolio and capture baseline information including address, site acreage, current status, closure data, and waste type.[ix] Local governments should directly share closed landfill inventories that may be ready to host solar with states to elevate such sites to the market. In 2016, **municipalities coordinated with Connecticut** to proactively release a list of closed municipal landfills seeking renewable energy developers and included the types of key baseline information indicated.[38]

- **Plan for Solar in Landfill Closure Plans:** Closure plans are designed to ensure that landfills meet regulations throughout their active life and can continue to be maintained safely and monitored once capped. By considering solar installations when designing or updating closure plans, solid waste departments can optimize a future solar project's size while minimizing installation costs and potential obstacles.

- **Encourage Cross-Departmental Collaboration:** Given the often-siloed nature of municipal agencies, authorities, and departments, local leaders should be intentional about aligning early on landfill solar planning across sustainability, energy, and solid waste departments. This is particularly relevant when drafting climate action plans, master plans, and site closure plans as well as when preparing for energy procurement.[x]

- **Be Strategic with Leases:** Landfill solar development leases allow for site reuse without transferring responsibility of site maintenance and monitoring. Surface leases enable developers to make use of the area above the cap without interfering with the landfill itself, allow for site access for both the developer and local government, and specify what, if any, taxes or lease fees will be collected. In states without policies and incentives encouraging landfill solar, low-cost or no-cost leases can be offered to reduce the cost of energy on a $/kWh basis for users.

- **Design Equitable Community Solar Projects:** Community solar can be **intentionally designed to promote racial and economic equity**.[39] For instance, a project should be communicated clearly in languages representative of the community; it can include priority subscriptions, carve-outs, or discounts; and it can avoid traditional credit score requirements to make programs more accessible for frontline, disadvantaged, and minority households. Municipalities can partner with local companies or other institutions to secure "anchor off-takers" for landfill solar projects to reduce uncertainty for the developer and, as a result, costs for other program participants.[xi] It is important to note that community solar is not a panacea for legacies of environmental injustices or neighborhood-scale gentrification. However, when designed effectively and in partnership with the impacted communities, community solar programs can reduce the energy burdens for homeowners and renters alike and offer greater economic stability to families and individuals on a month-to-month basis.

[ix] For a more detailed inventory approach for landfills and other municipal sites, consider using RMI's **Municipal Solar Siting Selection Tool (MSSST)** available on cityrenewables.org.

[x] To help local governments plan and procure landfill solar, the American Cities Climate Challenge Renewables Accelerator offers numerous resources and tools available at **cityrenewables.org**.

[xi] An anchor off-taker is a large institutional buyer (local government, university, school, hospital, etc.) that commits to subscribe to take on a large portion of the project in order to mitigate the risk that a project will be undersubscribed.

- **Utilize Landfill Solar to Create Local Jobs:** Economic revitalization is a key benefit of landfill solar development. Based on the technical potential estimated previously and the data available to us, we calculated that robust landfill solar development in the United States could result in at least 695,000 jobs.[xii] Even a smaller state like New Jersey could realize over 40,000 construction and operations jobs for the 3.8 GW of solar estimated.

Annapolis at the Nexus of State and Local Efforts

While both state and local governments can make progress individually, landfill solar projects and programs will be most successful if different branches of government work together in a coordinated fashion. For example, in 2018, the City of Annapolis, Maryland, completed a **$30 million, 16.8 MW solar energy park** on an 88-acre landfill.[40] This project is notable not only for its size, but also for the level of government collaboration. First, the city, Anne Arundel County, and the County Board of Education committed to being electricity off-takers for the project together. Second, the city and project team navigated a multi-jurisdictional effort involving Anne Arundel County (re-zoning), Baltimore Gas & Electric (project connection to substation), and Maryland Department of the Environment (permitting and approval). As a result, Annapolis was able to take advantage of Maryland's aggregate net metering capacity exception and successfully install one of the largest, if not the largest, municipal landfill solar projects to date.

The 16.8 MW landfill solar development in Annapolis, MD. Photo courtesy of BQ Energy Development, LLC.

[xii] Most of the jobs created would be short-term construction opportunities with a small subset going toward long-term operations and maintenance. We assumed a multiplier of 11 jobs per megawatt, informed by NREL's JEDI modeling, the Institute for Local Self-Reliance's *Equitable Community Solar* report in 2020, and familiarity with a range of utility-scale solar projects.

Conclusion

Landfills are generous hosts that also come with baggage to navigate. While not all landfills will be suitable for hosting an extensive solar array, those that are provide new opportunities for communities to leverage for clean energy.

Recently, cities have increasingly pursued more ambitious landfill solar projects. Annapolis, Maryland, and Orlando, Florida, have deployed 16.8 MW and 13 MW projects respectively, and Houston announced in late January 2021 that it has signed a site lease for what is expected to be a 52 MW project in the aptly named Sunnyside neighborhood. While projects at this scale remain few and far between, smart policies, timely incentives, and the clear guidance outlined in this report can help state and local governments accelerate the development of this scalable approach to enhance local renewable generation, job growth, economic revitalization, and other elements without sacrificing existing green space.

The technical energy potential assessed in this analysis, while not comprehensive, establishes a baseline understanding in terms of the data needed to better inform state policymaking and the substantial technical potential for solar capacity across the country. Thanks to the US EPA's tracking efforts, the robust data for existing projects also offers insights into where progress is occurring and how a range of policies, incentives, and practices already support the development of landfill solar projects.

The findings of this analysis should offer clarity to elected officials, policymakers, planners, developers, and communities on how landfill solar can be part of a broader clean energy and land-use strategy to achieve ambitious community-wide climate, sustainability, and environmental justice goals. Ultimately, it is our hope that by understanding what is possible, communities can comprehend the value of assessing and repurposing their closed and soon-to-be-closed landfills with solar in their future master planning process, post-closure planning process, or both—and how landfill solar can be a part of broader community revitalization.

Appendix A: Sources, Methodology, and Assumptions

National Solar Technical Potential

Assumptions for Calculating Technical Potential:

- Estimates were calculated across the 50 states, Puerto Rico, and the US Virgin Islands.
- This analysis was limited to landfills that met a variety of key criteria:
  - Sites where closure status was not publicly available were excluded.
  - Sites for which acreage data was not available were excluded, as this information was required to calculate the technical solar potential of the landfill. Moreover, sites were only considered if they were at least one acre in size on the assumption that smaller sites would be financially inviable.
  - Sites for which locational data (e.g., site address or geographic coordinates) was not available were also excluded, as this information was necessary to adjust the electricity generation estimates to account for local solar irradiance.
- Sites were assumed to be capable of hosting solar projects (including landfill infrastructure and service roads) across 70% of their land area. Individual site grading, floodplains, and other natural or human-made obstacles (e.g., trees or existing structures) were not considered.
- The capacity per land-usage assumption was 9.5 watts per square foot.

PVWatts Input Assumptions:

- Module Type: Both standard and premium were assessed and then averaged.
- System Losses: 14%
- Array Type: Fixed tilt and open rack
- Tilt: 20°
- Azimuth: 180°
- Granularity of Output: Annual
- Inverter Efficiency: 96%
- DC to AC Ratio: 1.2

Employment Potential

- We assumed a multiplier of 11 jobs per megawatt, informed by NREL's JEDI modeling and ILSR's *Equitable Community Solar* report in 2020.
  - Timothy DenHerder-Thomas, Jonathan Welle, et al., *Equitable Community Solar: Policy and Program Guidance for Community Solar Programs that Promote Racial and Economic Equity*, Institute for Local Self-Reliance, February 2020, **https://ilsr.org/wp-content/uploads/2020/02/Equitable-Community-Solar-Report.pdf**.
  - Jobs and Economic Development Impact Models, National Renewable Energy Laboratory, **https://www.nrel.gov/analysis/jedi/**.

Sources:

- RE-Powering America's Land Initiative: Project Tracking Matrix, US Environmental Protection Agency, October 2020, **https://www.epa.gov/sites/production/files/2020-10/documents/repowering_tracking_matrix_october_2020_508.pdf**.

- "RE-Powering Mapper," US Environmental Protection Agency, March 12, 2020, **https://geopub.epa.gov/repoweringApp/**.

- S. Ong et al., "Land-Use Requirements for Solar Power Plants in The United States," National Renewable Energy Laboratory, 2013, **https://www.nrel.gov/docs/fy13osti/56290.pdf**.

- "PVWatts Calculator," Version 6.1.3, National Renewable Energy Laboratory, **https://pvwatts.nrel.gov/pvwatts.php**.

- "Landfill Methane Outreach Program," US Environmental Protection Agency, March 11, 2021, **https://www.epa.gov/lmop/lmop-landfill-and-project-database**.

- State-specific data from the following agencies:
  - Connecticut Department of Energy and Environmental Resources
  - Massachusetts Department of Energy Resources
  - Minnesota Pollution Control Agency
  - New Hampshire Department of Environmental Services
  - New Jersey Department of Environmental Protection
  - Texas Commission on Environmental Quality

Appendix B: Landfill Solar Technical Potential—State Rankings

Note: Only six states—Texas, Minnesota, Massachusetts, Connecticut, New Jersey, and New Hampshire—had readily available comprehensive data profiles necessary for a complete analysis. This caveat should be strongly factored into any interpretations of these state rankings.

State	Acreage	Site Count	Estimated PV Capacity (MW)	Electricity Generation (GWh)	Rank (by Capacity)	Jobs
TX	94,091	2,134	27,300	41,375	1	300,297
CA	16,427	186	4,758	6,329	2	52,342
CT	14,593	255	4,264	4,472	3	46,908
NJ	13,271	381	3,844	5,001	4	42,286
MN	9,063	150	2,625	3,375	5	28,879
MA	8,738	354	2,562	2,701	6	28,184
IL	5,421	52	1,570	1,706	7	17,273
PA	5,110	35	1,454	1,496	8	15,994
NY	4,755	43	1,377	1,429	9	15,151
FL	3,818	39	1,106	1,363	10	12,166
MI	2,660	21	771	804	11	8,476
NH	2,616	202	758	933	12	8,335
OH	2,508	30	727	748	13	7,992
GA	2,478	33	718	825	14	7,897
WI	2,362	27	684	732	15	7,527
NC	2,095	39	607	698	16	6,675
SC	1,754	19	499	582	17	5,491

State	Acreage	Site Count	Estimated PV Capacity (MW)	Electricity Generation (GWh)	Rank (by Capacity)	Jobs
TN	1,716	23	497	551	18	5,469
AZ	1,711	12	496	700	19	5,452
VA	1,687	25	471	518	20	5,185
MD	1,546	16	448	497	21	4,927
LA	1,478	12	428	508	22	4,710
MO	1,463	23	424	482	23	4,666
IN	1,396	16	404	433	24	4,448
KS	1,220	9	364	448	25	4,009
AL	1,240	14	359	407	26	3,951
CO	976	9	326	389	27	3,582
WA	1,162	19	322	305	28	3,544
NE	886	7	257	297	29	2,824
KY	885	10	256	279	30	2,818
AR	810	7	235	268	31	2,581
OK	759	10	220	268	32	2,419
PR	752	18	218	278	33	2,397
MS	726	9	210	242	34	2,315
OR	697	7	202	209	35	2,222
ID	634	6	184	206	36	2,020
UT	486	10	141	170	37	1,547
NM	450	5	130	186	38	1,434
ME	440	8	127	129	39	1,402
NV	437	2	127	175	40	1,392
WV	368	4	107	106	41	1,172
ND	364	4	105	109	42	1,160
IA	345	5	100	110	43	1,098
AK	283	2	82	65	44	903

State	Acreage	Site Count	Estimated PV Capacity (MW)	Electricity Generation (GWh)	Rank (by Capacity)	Jobs
DE	266	2	77	86	45	846
HI	246	4	71	88	46	785
MT	177	3	51	55	47	564
VT	146	5	42	41	48	466
WY	131	2	38	45	49	418
RI	112	3	33	35	50	358
VI	67	2	19	26	51	213
SD	14	1	4	5	52	45
Total (All 52)	217,838	4,314	63,201	83,284	-	695,214

Endnotes

1. "Landfills," Zero Waste America, accessed July 27, 2021, **http://www.zerowasteamerica.org/Landfills.htm**.

2. "RE-Powering Tracking Matrix," United States Environmental Protection Agency, accessed November 3, 2020, **https://www.epa.gov/re-powering/re-powering-tracking-matrix**.

3. "National Overview: Facts and Figures on Materials, Wastes and Recycling," United States Environmental Protection Agency, accessed January 28, 2021, **https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#Landfilling**.

4. "RE-Powering Tracking Matrix," United States Environmental Protection Agency, accessed November 3, 2020, **https://www.epa.gov/re-powering/re-powering-tracking-matrix**.

5. "Solar Industry Research Data," Solar Energy Industries Association, accessed March 18, 2021, **https://www.seia.org/solar-industry-research-data**; and "State Electricity Profiles," United States Energy Information Administration, accessed November 2, 2020, **https://www.eia.gov/electricity/state/**.

6. "America Is All In," America Is All In, accessed July 12, 2021, **https://www.americaisallin.com/**.

7. "Check Out Where We Are Ready for 100%," Sierra Club, accessed July 11, 2021, **https://www.sierraclub.org/ready-for-100/map**; and "U.S. State Electricity Portfolio Standards," Center for Climate and Energy Solutions, accessed April 20, 2021, **https://www.c2es.org/document/renewable-and-alternate-energy-portfolio-standards/**.

8. "Transaction Tracker," American Cities Climate Challenge Renewables Accelerator, accessed July 16, 2021, **https://cityrenewables.org/transaction-tracker/**.

9. "National Overview: Facts and Figures on Materials, Wastes and Recycling," United States Environmental Protection Agency, accessed January 28, 2021, **https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#Landfilling**.

10. *Community Solar—An Opportunity to Enhance Sustainable Development on Landfills and Other Contaminated Sites*, United States Environmental Protection Agency, December 7, 2016, **https://www.epa.gov/sites/production/files/2016-12/documents/epa_repowering_community_solar_discussion_paper_final_120716_508.pdf**.

11. Ted Wong, Lacey Shaver, Eric Mackres, and Yeou-Rong Jih, "3 Hurdles to Racial Justice in Clean Energy – and 3 Ways U.S. Cities Can Overcome Them," World Resources Institute, September 2, 2020, **https://www.wri.org/blog/2020/09/3-hurdles-racial-justice-clean-energy-and-3-ways-us-cities-can-overcome-them**.

12. "Not in My Backyard: Executive Order 12,898 and Title VI as Tools for Achieving Environmental Justice," United States Commission on Civil Rights, accessed April 19, 2021, **https://www.usccr.gov/pubs/envjust/ch2.htm**.

13. "Bean v. Southwestern Waste Management Corp," United States District Court for the Southern District of Texas, Justia US Law, December 21, 1979, **https://law.justia.com/cases/federal/district-courts/FSupp/482/673/2095959/**.

14. "Environmental Justice History," United States Department of Energy Office of Legacy Management, accessed April 19, 2021, **https://www.energy.gov/lm/services/environmental-justice/environmental-justice-history#:~:text=The%20initial%20environmental%20justice%20spark,of%20toxic%20waste%20along%20roadways**.

15. "Sunnyside Landfill – Houston, United States," C40 Cities Reinventing Cities, accessed April 19, 2021, **https://www.c40reinventingcities.org/en/professionals/winning-projects/holmes-road-landfill-1271.html**.

16. Matt Dougherty, "Sunnyside will soon be home to the largest urban solar farm in the country," *KHOU11 – Local News*, January 14, 2021, **https://www.khou.com/article/news/local/sunnyside-will-soon-be-home-to-the-largest-urban-solar-farm-in-the-country/285-4fe5b0c6-c2de-4cc4-bbf0-170036fad089**.

17. Ibid.

18. "RE-Powering Tracking Matrix," United States Environmental Protection Agency, accessed November 3, 2020, **https://www.epa.gov/re-powering/re-powering-tracking-matrix**.

19. "Solar Industry Research Data," Solar Energy Industries Association, accessed March 18, 2021, **https://www.seia.org/solar-industry-research-data**.

20. Matthew Mosk, "Annapolis officials tout bright future for solar panel plant, even on a cloudy day," *Capital Gazette*, September 12, 2018, **https://www.capitalgazette.com/environment/ac-cn-annapolis-solar-park-0912-story.html**.

21. "The City of Houston Selects Firm Proposing Solar Energy Farm at Former Sunnyside Landfill," City of Houston, August 29, 2019, **https://cityofhouston.news/the-city-of-houston-selects-firm-proposing-solar-energy-farm-at-former-sunnyside-landfill/**; and "Solar Project: Firm Selected to Plan Large Solar Energy Facility on Closed Landfill Site," Solid Waste Authority of Central Ohio, accessed April 19, 2021, **https://www.swaco.org/413/Solar-Project**.

22. Laurie Stone, "Some See Garbage, Others See an Opportunity: Installing Solar on Landfills," RMI, September 16, 2014, **https://rmi.org/blog_2014_09_16_installing_solar_on_landfills**.

23. Scott Dance, "As massive solar farms blossom, officials face conflict between state energy policy and local preferences," *The Baltimore Sun*, October 15, 2016, **https://www.baltimoresun.com/maryland/bs-md-renewable-energy-conflict-20161015-story.html**.

24. "Encourage solar energy that doesn't sacrifice agricultural land," American Farmland Trust, accessed April 15, 2021, **https://farmland.org/encourage-solar-energy-that-doesnt-sacrifice-agricultural-land/**.

25. Christian Roselund, "Oregon Further Limits Use of Prime Farmland for Solar Development," *PV Magazine*, May 24, 2019, **https://pv-magazine-usa.com/2019/05/24/oregon-further-limits-use-of-prime-farmland-for-solar-development/**.

26. "SREC Registration Program," New Jersey's Clean Energy Program, accessed April 25, 2021, **https://www.njcleanenergy.com/srec**.

27. "Solar Act Proceedings, Implementation, and Milestones," New Jersey's Clean Energy Program, accessed April 22, 2021, **https://www.njcleanenergy.com/renewable-energy/program-updates/solar-act/solar-act-proceedings-archive**.

28. Public Act 102-0662 - Clean and Equitable Jobs Act," Illinois General Assembly, September 15, 2021, accessed September 29, 2021, **https://www.ilga.gov/legislation/publicacts/fulltext.asp?Name=102-0662**.

29. "Capacity Block, Base Compensation Rate, and Compensation Rate Adder Guideline," Massachusetts Department of Energy Resources, accessed October 29, 2020, **https://clearesult5.sharepoint.com/:x:/s/MassSMARTSolar/ERxwXZde-5pJvMdKuOULQzkBtWXbog29OGn17p7dM6ia8w?rtime=7xGO_cro2Eg**.

30. "Solar Massachusetts Renewable Target (SMART) Program," Massachusetts Department of Energy Resources, accessed November 8, 2021, **https://www.mass.gov/doc/225-cmr-2000-smart-redline-0/download**.

31. "Net Metering," Institute for Local Self-Reliance, accessed October 20, 2021, **https://ilsr.org/rule/net-metering/**.

32. John Farrell, "The New 1,600 MW Solar Program for Massachusetts Really Is SMART," Institute for Local Self-Reliance, April 11, 2017, **https://ilsr.org/the-new-1600-mw-solar-program-for-massachusetts-really-is-smart/**.

33. John Farrell, "Why Minnesota's Community Solar Program Is the Best," Institute for Local Self-Reliance, February 5, 2021, **https://ilsr.org/minnesotas-community-solar-program/**.

34. "Community Solar Pilot Program," Maryland Public Service Commission, accessed April 18, 2021, **https://www.psc.state.md.us/electricity/community-solar-pilot-program/**.

35. John Fitzgerald Weaver, "SMART Problems in Massachusetts," *PV Magazine*, August 16, 2018, **https://pv-magazine-usa.com/2018/08/16/smart-problems-in-massachusetts/**.

36. "Alternative Fill Protocol Guidance – Guidance for Beneficial Use of Soil and Non-Soil Material in the Remediation of Contaminated Sites and Closure of Solid Waste Landfills," New Jersey Department of Environmental Protection, June 2008, **https://www.nj.gov/dep/srp/guidance/alternative_fill/afp_guide.pdf**.

37. "Solar Siting Analysis," New Jersey Department of Environmental Protection, Office of Air Quality, Energy, & Sustainability, February 13, 2020, **https://www.state.nj.us/dep/aqes/solar-siting.html**.

38. "Parties Seeking Renewable Energy Developers for Landfill Sites," Connecticut Department of Energy and Environmental Protection, accessed October 20, 2021, **https://portal.ct.gov/-/media/DEEP/site_clean_up/brownfields/TownsRenewableEnergyDeveloperspdf.pdf**.

39. John Farrell and Maria McCoy, *Report: Designing Community Solar Programs that Promote Racial and Economic Equity*, Institute for Local Self-Reliance, February 27, 2020, **https://ilsr.org/report-designing-community-solar-programs-that-promote-racial-and-economic-equity/**.

40. Matthew Mosk, "Annapolis officials tout bright future for solar panel plant, even on a cloudy day," *Capital Gazette*, September 12, 2018, **https://www.capitalgazette.com/environment/ac-cn-annapolis-solar-park-0912-story.html**.

Matthew Popkin and Akshay Krishnan, ***The Future of Landfills Is Bright: How State and Local Governments Can Leverage Landfill Solar to Bring Clean Energy and Jobs to Communities across America***, RMI, 2021, https://rmi.org/insight/the-future-of-landfills-is-bright.

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