Maryland Landfill Solar Assessment

An evaluation and assessment of Maryland's inventory of landfills, rubble fills, and brownfields for solar development potential

Maryland ENVIRONMENTAL SERVICE

in partnership with

Maryland Energy Administration

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Summary

Maryland Environmental Service (MES), in partnership with the Maryland Energy Administration (MEA), investigated the potential for repurposing existing Maryland **landfill**, **rubble fill**, **brownfield**, and **superfund** sites (defined in the Glossary in Appendix A) to identify locations capable of producing economically viable amounts of solar **photovoltaic** energy. A study was conducted evaluating 2,148 potential sites in Maryland for solar development suitability. The study's goal is to pinpoint expansive commercial-scale sites on repurposed grounds for the creation of renewable energy generation centers. This concerted effort by MES and MEA not only identifies potential acreage but also aligns with statewide policy mandates, providing invaluable contributions to Maryland's sustainable energy pursuits. This study reviewed the availability of each site for solar generation. As a result, 45 landfills, four (4) brownfields, five (5) rubble fills, and two (2) superfund sites were identified as **suitable** for solar development after evaluation. Ultimately, there are six (6) landfills and one (1) brownfield out of the 56 evaluated suitable sites that are **recommended sites** for solar energy development to be pursued for planning and potential installation.

Background

Photovoltaic energy generation is an environmentally friendly form of power generation available to communities. Solar energy production does not create pollution such as a coal burning plant or other fossil fuel technology[1]. The cost of solar energy production is approximately 4.6 cents per kWh[2], whereas the cost of coal energy production is approximately 3.2 cents per kWh[3,4]. However, the cost of solar is projected to be cut in half by 2030[5] and the health-related cost of coal energy production is not considered in this evaluation. Furthermore, the operating costs of renewables are generally lower than the costs of thermal generation[6]. Solar systems offer a more sustainable and cleaner option to power Maryland’s future. Identifying available and suitable open space in Maryland is the first step toward implementing these systems to benefit communities with green energy. Constructing solar fields on these sites sustainably maximizes their land use value and will deliver the benefits of clean and affordable energy to Marylanders.

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[1] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[2] https://www.energy.gov/articles/doe-announces-goal-cut-solar-costs-more-half-2030

[3] https://www.amacad.org/publication/true-costs-our-energy-choices

[4] https://www.brookings.edu/articles/the-real-costs-of-u-s-energy/#:~:text=Consider%3A%20coal%20power%20plants%20provide,your%20microwave%20for%20an%20hour.

[5] https://www.energy.gov/articles/doe-announces-goal-cut-solar-costs-more-half-2030

[6] https://www.eia.gov/outlooks/steo/report/elec_coal_renew.php

Land Reuse

The EPA's Re-Powering America's Land Initiative[7] encourages renewable energy development on former landfills and other contaminated sites. By redeveloping sites for solar arrays, the public benefits from environmentally friendly technology that reduces environmental impacts and repurposes existing open space that would remain unused. Reusing these lands would reduce competition with agricultural land that solar systems have historically utilized[8].

Energy Policy

Maryland's General Assembly has passed numerous policies that help support the goal of growing renewable energy capacity throughout the state. The passage of the Climate Solutions Now Act of 2022[9] set Maryland on a path to reduce greenhouse gas emissions by 60% by 2031 and become net zero by 2045[10]. In April 2023, Governor Wes Moore announced a plan to achieve 100% clean energy in Maryland by 2035. These policy actions build upon the Renewable Portfolio Standard[11] (RPS) that was enacted in 2004 to increase the amount of renewable energy electricity suppliers must provide to their customers. This encourages the growth of renewable energy production, including solar. As of June 2024, the RPS requires that 14.5% of electricity sold in the state of Maryland must be from solar resources[12].

Community Solar

On July 1, 2023, House Bill 908[13] went into effect and adapted the Maryland Public Service Commission Community Solar Pilot Program[14] into a permanent program. This means that community solar has been made permanently available to Maryland. Community solar allows a customer to subscribe to part of a large solar system that is shared by many different subscribers. This is ideal for customers that do not own their homes, or those whose homes and properties cannot support a solar installation. Community solar provides electricity at affordable rates, with guaranteed reductions from standard offer service from the utility. It is quickly becoming an important part of Maryland's clean energy transition. Landfills and other brownfield sites are ideal for community solar systems.

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[7] https://www.epa.gov/re-powering/what-re-powering

[8] https://farmland.org/encourage-solar-energy-that-doesnt-sacrifice-agricultural-land/

[9] https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/sb0528?ys=2022RS

[10] https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/sb0528?ys=2022RS

[11] https://www.psc.state.md.us/electricity/renewable-energy/

[12] https://www.psc.state.md.us/electricity/wp-content/uploads/sites/2/Solar-in-Maryland-Fact-Sheet-1.pdf

[13] https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb0908

[14] https://www.psc.state.md.us/electricity/community-solar-pilot-program

Limitations

A couple of examples of limitations for solar energy is continuous cloud cover or tree cover which impacts the ability of **photons** from the sun reaching the panels to activate their energy generation. Complete physical obstruction by tree cover prevents photons from reaching the panels, whereas cloud cover still permits some photons to pass through to the panels. However, the ideal condition is an unobstructed clear sky so that the maximum number of photons can reach the panels. Tree cover does not impact the suitable sites identified in this study, but cloud cover can occur multiple days in a row, limiting power generation. Another limitation is the cost of implementing the solar systems such as materials for manufacturing the solar panels[15] and implementing transmission lines in areas where infrastructure is not yet established. However, as technology advances and infrastructure practices continue to develop, solar systems will become increasingly cost-effective to install. Current solar technology limits mass produced panels to at least 19% efficiency[16] which does not utilize 81% of the potential energy the sun provides. Future technology will allow for most of this energy to be harnessed by typical solar systems, with current lab efficiencies reaching 48%[17].

The largest logistical limitation in solar energy is the space available for construction. Most brownfields in Maryland are parcels under one (1) acre in size. Solar energy production on a site is linearly proportional to the number of panels in an area; if the size of the site is less than an acre, the site is too small to be considered by MES for solar developments. It is important to note that not all utility companies participate in Maryland's Community Solar Program or accept community solar proposals. Also, there is currently a two (2) year moratorium at PJM Interconnection[18] for proposed large scale solar projects which will factor into development timelines. These limitations will reduce the number of suitable sites for solar development greatly, which will be explained in the methodology.

Data Sources

MES considered sites compiled from the Environmental Protection Agency[19] (EPA) "RE-Powering America's Land Initiative," the Homeland Infrastructure Foundation-Level

[15] https://www.energy.gov/eere/solar/solar-photovoltaic-manufacturing-basics

[16] https://css.umich.edu/publications/factsheets/energy/photovoltaic-energy-factsheet

[17] https://www.nrel.gov/pv/cell-efficiency.html

[18] https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/MWG/Solar%20Siting%20Project%20Problems%20in%20MD.pdf

[19] https://cimc.epa.gov/ords/cimc/f?p=cimc:MAP:::71:P71_WELSEARCH:MD|State|MD|||true|true|true|true|true|true||-1|sites|N|basic

Data[20] (HIFLD), and the Maryland Department of the Environment[21] (MDE). MES consulted with additional state agencies conducting similar research, including the Maryland Department of Planning[22], and reviewed similar case studies including Utility Scale Solar Energy Coalition[23] (USSEC) and the City of Annapolis Landfill Case Study[24]. Review of previous studies allowed MES to determine the feasibility of a study of this size and focus. It was determined that a project of this magnitude and focus would be beneficial but would need local and state government partnership as well as participation from solar installers and utility companies.

Methodology

MES conducted multi-level analysis of data layers to determine the best sites for solar production across Maryland. Initial review began with consultation of similar studies performed by the USSEC and Maryland Department of Planning[25] solar case studies, followed by an assessment of all landfills, brownfields, rubble fills, and superfund sites for suitability for hosting photovoltaic panels. This analysis utilized land slope, forest buffer, flood plain, and parcel data. Data sets for 2,148 sites across Maryland (Appendix C) were merged. After removal of duplicates, a subset of 1,969 landfill, rubble fill, brownfield, and superfund sites remained. This data was compiled in GIS mapping software based on parcel boundaries. These parcels were screened for suitability by providing buffers for the following industry standards needed for the installation of solar panels:

- Removed land acreage from parcel polygons within critical areas including wetlands identified by the National Wetlands Inventory (NWI)
- Removed land acreage from parcel polygons within the Federal Emergency Management Agency (FEMA) regulatory 1% annual chance flood plains
- Removed land acreage from parcel polygons within 50 feet of parcel boundaries, roadways, and structures (building footprints)
- Removed land acreage from parcel polygons within 50 feet of forested areas
- Removed land acreage from parcel polygons that had a slope greater than 10%

Polygons were clipped to remove the land mentioned above to result in final polygons indicating suitable acreage for solar on each site. An example of a clipped polygon

[20] https://hifld-geoplatform.opendata.arcgis.com/

[21] https://mde.maryland.gov/programs/land/solidwaste/pages/permittedfacilities.aspx

[22] https://planning.maryland.gov/Pages/OurWork/envr-planning/solar-siting/solar-siting-home.aspx

[23] http://www.mdcounties.org/DocumentCenter/View/2924/USSEC-Analysis-of-Solar-Potential-on-MD-Contaminated-Lands---FINAL-10918

[24] https://planning.maryland.gov/Pages/OurWork/envr-planning/solar-siting/solar-siting-case-annapolis-anne.aspx

[25] https://planning.maryland.gov/Pages/OurWork/envr-planning/solar-siting/solar-siting-case-studies.aspx

showing suitable land for solar development is displayed via the hatched area in Figure 1. Then, the clipped site acreage was used to calculate the predicted power output for each plot. Additional site-by-site cases were considered to remove unsuitable lands beyond the initial screening process.

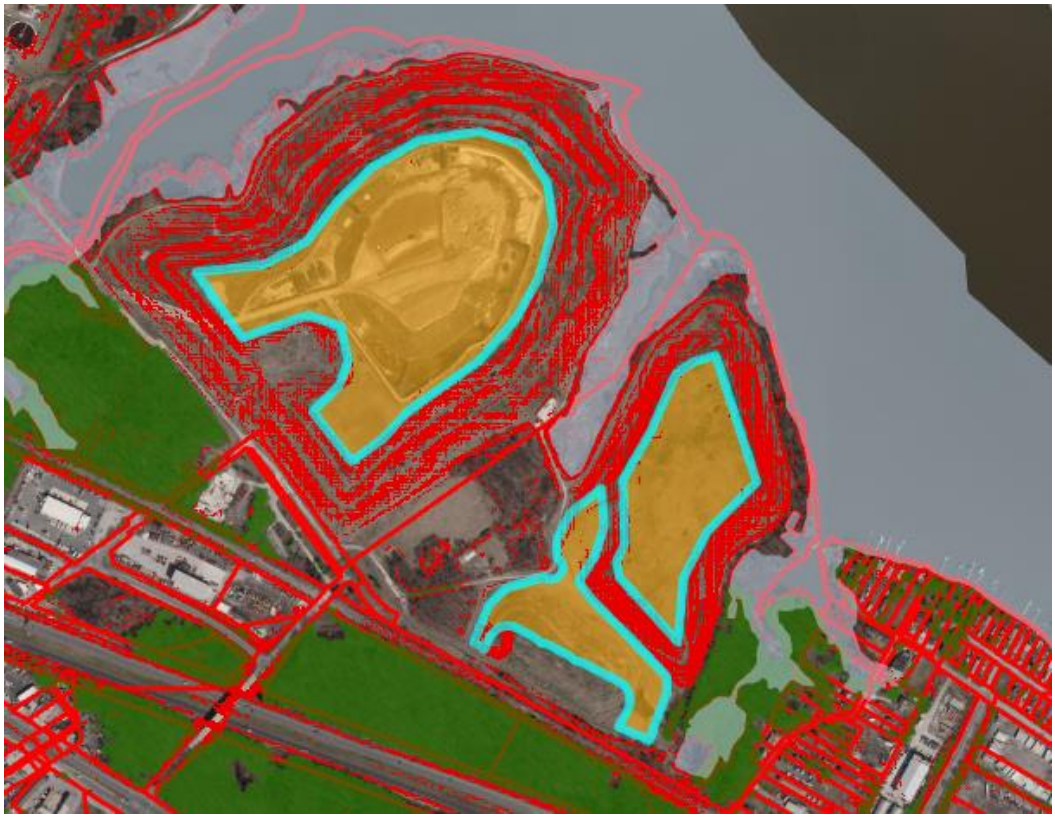


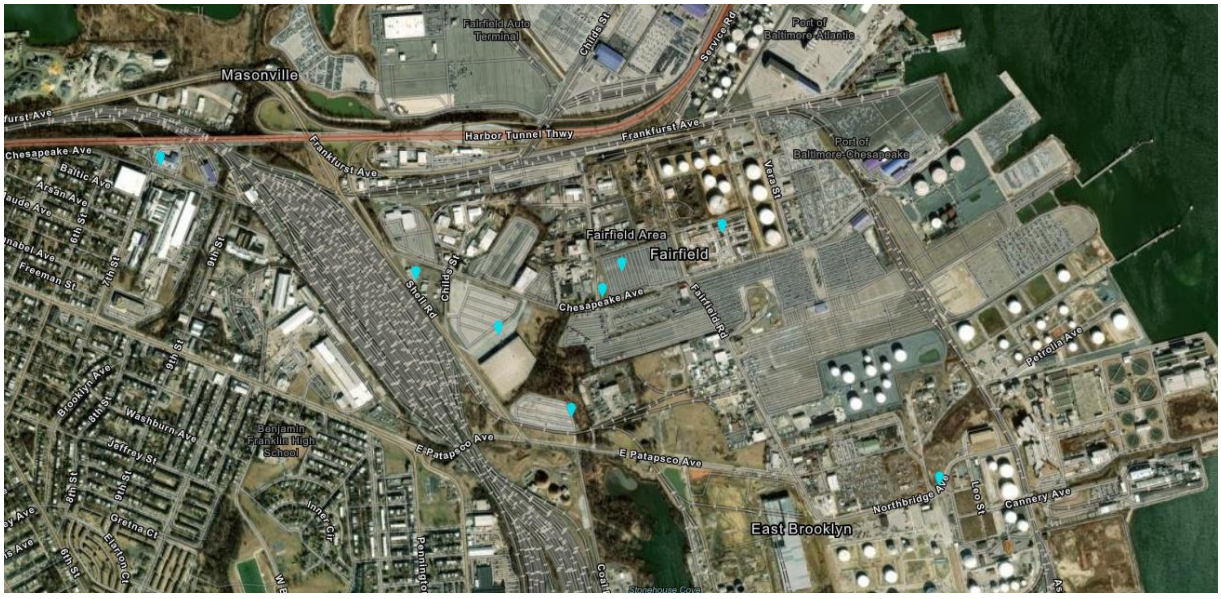
Figure 1 – Norris Farms Landfill Suitable Solar Development Area (Parcel Polygons), with land sloped greater than 10% shown in red.

Active solar ordinances (Appendix D) enacted by Maryland counties were considered when identifying suitable sites. These ordinances also removed land suitable for solar development from the site evaluation and are reflected in the resulting suitable parcel polygons. For example, Cecil County and Worcester County require that all utility scale solar developments must have a minimum 50-acre lot size, while Howard County requires a minimum 10-acre lot size. Somerset County and Queen Anne's County require that solar developments are placed 75 feet away from all parcel boundaries, unlike the typical 50 feet buffer. Other ordinances such as required solar panel height during construction must be followed when implementing these systems unless approval has been granted by the respective county. Solar moratoriums have also historically been enacted in Maryland, preventing development on agricultural land. This will not be an issue with the landfill solar development project as the landfill, brownfield, and superfund sites are not on agricultural land. However, it should be noted that

moratoriums could be developed in the future, preventing the development of landfill solar systems. MEA must consider these ordinances and moratoriums when proposing plans for solar development.

Another critical consideration for solar field installations relates to the proximity of utility substations and transmission lines. Distances to transmission lines were factored into the dataset to ensure economic feasibility, as the lines cost over $2 million per mile to install[26]. In the absence of immediate proximity to existing infrastructure, constructing dedicated transmission lines will elevate project costs. MES does not recommend the development of sites that are more than one (1) mile away from an existing transmission line. This aspect emphasizes the necessity of establishing an early dialogue and collaborative relationship with potential clients and ensuring participation in power purchase agreements or Maryland's Community Solar Program to minimize up-front costs. This proactive engagement prevents developments from becoming stranded, regardless of the distance to the **point of interconnection (POI)**.

The distinct category of brownfield sites, characterized by prior development and often harboring hazardous substances, presented a unique set of considerations. Due to size limitations, challenging urban locations illustrated in Figure 2, and substantial cleanup costs averaging $602,000[27] per site, four (4) of the five (5) suitable brownfield sites are not recommended for solar developments; only one (1) site is recommended for development in the results. The potential for future redevelopment of brownfields is still possible, contingent on priorities shifting in favor of cleaning and developing these sites.



[26] https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEO2020.pdf
[27] https://www.nber.org/system/files/working_papers/w20296/w20296.pdf

Figure 2 – Brownfields (marked by blue points) displayed in Fairfield, Baltimore

Rubble fills were also considered when searching for suitable solar developments. The main limitation of these sites is that large construction waste causes large slopes on the land. Most of the rubble fills' open land is sloped greater than 10%, rendering this land unusable for solar development. The cost to level the sloped lands is not currently feasible, nor is it recommended when many landfill sites are available for development without such necessary site adjustments. An example of a large parcel limited by sloped land is shown in Figure 3. Four (4) rubble fills are listed with suitable acreage, but none of these sites will be recommended for solar development at this time.

Figure 3 – Oak Avenue Rubble Landfill with 10% or greater slopes shown in red, and suitable solar acreage shown within the blue outline.

GIS layers were downloaded from the Maryland Department of Planning and overlaid with the map to determine the suitable sites. Additional mapped data includes completed renewable energy projects to act as an example of sites that have been converted with land re-use. Please see the GIS Web Application[28] for more information and this layer.

[28] https://gis.menv.com/portal/apps/webappviewer/index.html?id=e2a09031cbe04bc5ad9c76207ef90cba

For detailed suitable site data, please refer to Appendix B. The complete dataset of original sites is available in Appendix C.

Results

To determine maximum solar generation, MES calculated the solar power potential of each site. Assuming the efficiency of the photovoltaic modules in the panels is 19%[29], one (1) kW is produced by 5.26 meters squared (m^2)[30] of solar panels. There are 4,046.86 m^2 in an acre, therefore the potential solar power for one (1) acre can be found with the equation:

$$\frac{4{,}046.86\ m^2}{acre} * \frac{1\ kW}{5.26\ m^2} = \frac{769.37\ kW}{acre}$$

One (1) acre is not fully outfitted with solar arrays because of spacing for ground mounts and access roads; thus, there is a Ground Coverage Ratio (GCR) multiplier of 0.40[31] so total solar power generated per acre would be:

$$\frac{769.37\ kW}{acre} * 0.40 = \frac{307.75\ kW}{acre}$$

This does not consider the Annual Global Horizontal Irradiation (GHI), in kWh/m^2/year, which varies slightly by location in Maryland[32]. This data can be found for each site in Appendix B. Theoretical local solar energy generated by one (1) acre in one (1) year is dependent on the local annual GHI and the GCR:

$$\frac{4046.86\ m^2}{acre} * 0.40 * Local\ Annual\ GHI\left(\frac{kWh}{m^2 - year}\right) * \frac{1\ MWh}{1{,}000\ kWh} = \frac{\{Local\ Solar\ Generation\}MWh}{acre - year}$$

MES identified 45 landfills, four (4) brownfields, five (5) rubble fills, and two (2) superfund sites out of 1,969 sites that are suitable for solar generation, as shown in Figure 4. 18 of the identified landfills still have active permits and are in operation. Active sites do not need to be excluded from qualifying for solar development, as long as there are areas that can host panels that have been capped. 24 sites were determined to have a transmission line within one (1) mile of the site. Seven (7) sites already have established solar systems on site. Of those seven (7) projects, Hoods Mill

[29] https://www.nrel.gov/pv/cell-efficiency.html
[30] https://pvwatts.nrel.gov/pvwatts.php
[31] https://pvwatts.nrel.gov/downloads/pvwattsv5.pdf
[32] https://www.nrel.gov/gis/solar-resource-maps.html

Landfill and Annapolis Solar Landfill (SLF) are at maximum capacity for solar but are displayed in Figure 4. The remaining five (5) sites have the potential to build upon their existing solar projects.

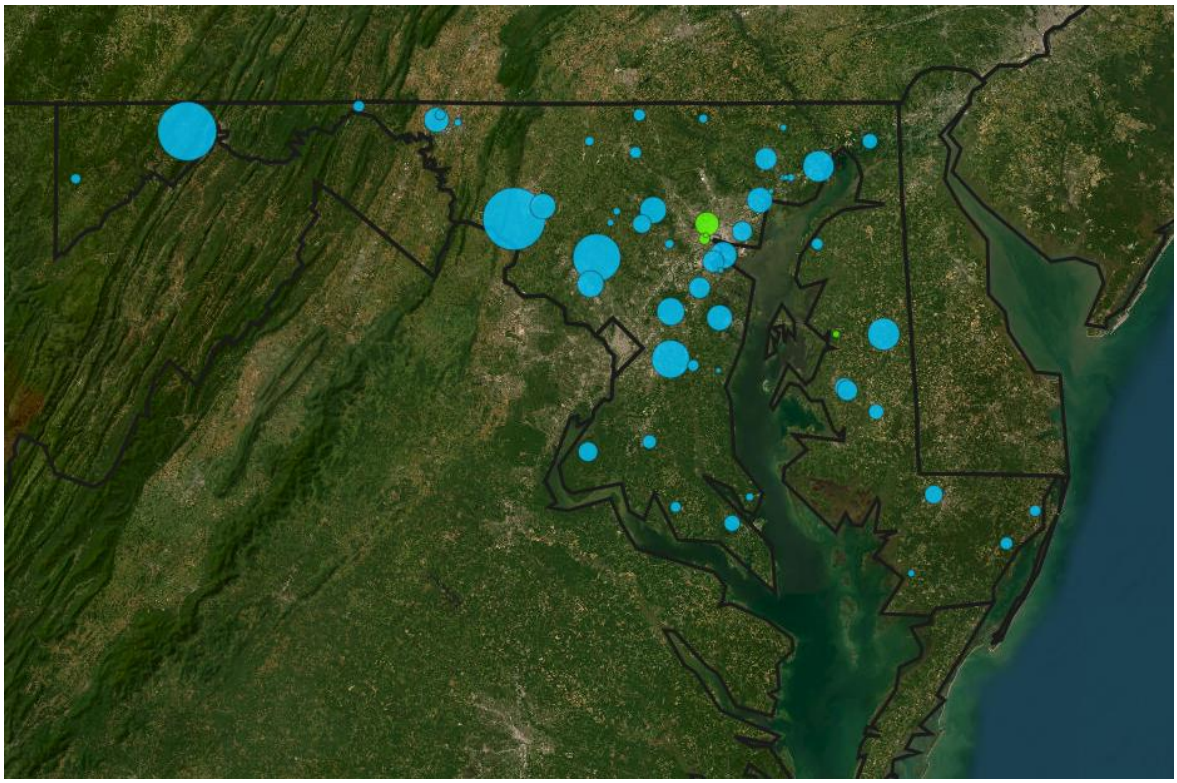


Figure 4 – Map of landfills (blue) and brownfields (green) suitable for solar development.

These suitable sites were rigorously analyzed to determine the best candidates for pursuing developments. The Tier 1 candidates, six (6) landfills and one (1) brownfield, are categorized below into Community Solar or Utility Solar projects. These are highlighted in green in Appendix B. Seven (7) additional Tier 2 candidates that are also attractive sites for development are highlighted in purple in Appendix B.

Community Solar

Solar projects are categorized in terms of capacity. Projects with ten (10) or fewer MW of capacity are considered Community Solar projects, while solar projects with more than ten (10) MW are considered Utility Solar projects. MES identified a brownfield in Druid Heights, Baltimore between Lennox St and W North Ave that has 8.2 acres of suitable land in an urban area shown in Figure 5. This site has a transmission line within 0.5 miles of the property. This brownfield that used to host a small neighborhood, now deconstructed with rubble, is unutilized. This property provides a unique opportunity that would deliver solar energy to the residents of Baltimore and revitalize the current

deteriorated site within Druid Heights. This site would need to be cleaned and flattened, but the area appears mostly flat with rubble hills that are feasible to level, compared to most other analyzed sites. This area could provide up to 1.76 MW of renewable power to the local communities and would be classified as a Community Solar project. This brownfield is recommended with reservations due to the established setbacks of a brownfield for construction, but it is the best brownfield for solar development identified in Maryland.

Figure 5 – 738-800 West North Avenue Brownfield

Utility Solar

Utility scale projects are larger and typically connect directly to a substation or a transmission line. MES determined that there are ten (10) applicable landfills at this scale, however at least three (3) already have solar projects completed or in process. This includes the case study of Annapolis SLF.

The six (6) top ranked Utility scale sites that would be the most beneficial for solar production in the state are shown in Table 1. These sites have an existing transmission line within 0.5 miles of the site, over 50 acres of land on the parcel, and have level land available for construction. Quarantine Road Landfill in Baltimore is an example of a site that is still active but has capped sections that can be converted to reusable space for solar, benefitting residents of the City of Baltimore. Sites can deliver energy to any entity within their utility company's respective areas.

Site Name	County	Utility Company Area	Suitable Acreage	Solar Power Potential before Transmission Filters (MW)
Eastalco Industrial Waste Landfill	Frederick	The Potomac Edison Company	**205.87**	63.32
Vale Summit Landfill I	Allegany	The Potomac Edison Company	**193.15**	59.40
Sandy Hill SLF	Prince George's	Baltimore Gas and Electric Co	**82.21**	25.29
Quarantine Road SLF*	Baltimore City	Baltimore Gas and Electric Co	**79.09**	24.33
Norris Farms Landfill	Baltimore	Baltimore Gas and Electric Co	**55.29**	17.01
Pisgah SLF	Charles	Southern Maryland Electric Coop	**53.12**	16.34

Table 1 – Recommended Utility Solar Development Sites

Funding

The Maryland Strategic Energy Investment Fund (SEIF)[33] was made available to help construct new Tier 1 renewable energy sources that directly benefit residents as outlined in 2023 Maryland House Bill 550[34]. This bill broadened the pool of eligible applicants, opening funding opportunities to Marylanders who could benefit from solar renewables and other Tier 1 renewable sources. MEA administers funding from the SEIF to support Maryland's energy policies that address global climate change concerns, improve resiliency, enhance energy efficiency and reduce consumption, and help mitigate energy access. The purpose of the SEIF is to decrease energy demand, increase clean energy efficiency, and reduce the costs of green energy to power Maryland's future.

The Maryland Clean Energy Center (MCEC) applied for and received $62,450,000 from the federal Environmental Protection Agency (EPA) Solar for All[35] $7 billion grant opportunity which will enable millions of low-income Maryland households' access to affordable, resilient, and clean solar energy. The Maryland Coalition of Green Banks (Montgomery County Green Bank, MCEC, and Climate Access Fund) as part of a larger coalition applied for the $14 billion National Clean Investment Fund[36], which was

[33] https://energy.maryland.gov/Pages/Strategic-Energy-Investment-Fund-(SEIF)-.aspx
[34] https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/HB0550
[35] https://www.epa.gov/greenhouse-gas-reduction-fund/solar-all
[36] https://www.epa.gov/greenhouse-gas-reduction-fund/national-clean-investment-fund

awarded. Landfill solar systems developed in these areas identified by MEA and MES could qualify for this funding and will be pursued alongside project development.

Conclusion

MES has identified numerous landfills, brownfields, rubble fills, and two (2) superfund sites across Maryland that could host large-scale solar systems that would benefit Maryland residents. There is solar potential at most of the 56 suitable sites; however, the seven (7) sites recommended in the results are the locations with the most suitable existing conditions to provide the largest beneficial output.

Moving forward, establishing a partnership with utility companies early in the proposal process is imperative. This will help facilitate an interconnection agreement. These companies may need to establish new substations or upgrade existing substations. A key consideration during construction is to ensure that the integrity of the closed landfill caps remains uncompromised during the installation process and operation of the site. To ensure the environmentally responsible implementation of solar installations, it is imperative to establish a collaborative task force or working group in partnership with the Maryland Department of the Environment (MDE). This collaboration will be instrumental in preventing any adverse environmental impacts resulting from development, imitating the approach taken with the Annapolis SLF. Developing renewable solar systems on these recommended sites will repurpose unused and available land to deliver clean energy to the residents and businesses of Maryland.

About MES

MES employs over 700 teammates and operates more than 1,000 environmental projects across Maryland and the Mid-Atlantic Region. As a not-for-profit business unit of the state of Maryland, MES provides multidisciplinary environmental compliance services to enhance and protect the environment through innovative solutions to the region's most complex environmental challenges. For more information see: www.menv.com.

About MEA

The mission of the Maryland Energy Administration (MEA) is to promote clean, affordable, reliable energy and energy-related greenhouse gas emission reductions to benefit Marylanders in a just and equitable manner. MEA advises the Governor and General Assembly on all energy matters, and provides incentive programs, resources, and promotes policy to support and expand all sectors of the state's economy while leaving no Marylander behind and implementing legislation. For more information see: www.energy.maryland.gov.

Appendix A
Glossary

Brownfield - A brownfield is a property; the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

Landfill - Modern landfills are well-engineered facilities designed to receive specific kinds of waste, including municipal solid waste (MSW), construction and demolition debris (C&D), and hazardous waste. Landfill facilities must be designed to protect the environment from contaminants, which may be present in the solid waste disposed in the unit.

Photons - a particle representing a quantum of light or other electromagnetic radiation. A photon carries electromagnetic energy proportional to the radiation frequency but has zero resting mass.

Photovoltaic - of, relating to, or utilizing the generation of a voltage when radiant energy falls on the boundary between dissimilar substances (such as two different semiconductors)

Point of Interconnection (POI) - The point of connection between an electrical generating system, such as a solar PV system, and the utility grid. This is the transition point between things that are considered “behind-the-meter” and things that are considered “in-front-of-the-meter."

Recommended site – A site that is not only suitable but is an excellent candidate for solar development that is recommended by MES.

Rubble fill - A subtype of landfill that only accepts large construction, demolition, land clearing, or household appliance debris. Rubble fills also accept tires and asbestos waste. Rubble fills often have highly sloped land as a result of the larger debris deposited on site.

Substations - A set of equipment decreasing the high voltage of electrical power transmission to that suitable for supply to consumers or increasing the voltage of generation or distribution electricity to that suitable for transmission through the bulk power system (generation and transmission grid). Substations are also where electricity flows from the bulk power system to the utility distribution system for delivery to consumers, and vice versa.

Suitable site – A site that is available to be pursued for solar development, but not recommended at this time by MES.

Superfund site - EPA's Superfund program is responsible for cleaning up some of the nation's most contaminated land and responding to environmental emergencies, oil spills, and natural disasters. Associated sites have been deemed "Superfund sites" through this program.

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END OF APPENDIX A.

Appendix B
Solar Data for 56 Suitable Sites
PROVIDED IN SEPARATE FILE

Appendix C
All Landfill, Rubble Fill, and Brownfield Sites
PROVIDED IN SEPARATE FILE

Appendix D
Solar Ordinances in Maryland
PROVIDED IN SEPARATE FILE