Coal Ash Disposal Sites and Opportunities for Solar Photovoltaic Development

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The Office of Land and Emergency Management's *RE-Powering America's Land Initiative* is working with the National Renewable Energy Laboratory (NREL) to evaluate options for solar development on closed coal combustion residuals (CCR) landfills and surface impoundments where site conditions allow for safe development opportunities.

The purpose of this document is to identify closed CCR units and provide Key Factors to be considered to identify potential sites for solar photovoltaic (PV) development. Using the Key Factors, suitability of these sites may be further evaluated by analyzing site-specific characteristics, such as site ownership, access to transmission, and current redevelopment plans.

EPA recognizes the advantages of solar installations on top of closed CCR landfills because of the potential to make use of otherwise vacant land area and to connect directly with existing grid infrastructure. Solar installations on closed CCR units may have the potential to help manage the costs of post-closure care and generate local revenue through generation of clean electricity. In addition, productive use of CCR units for the generation of clean energy aligns with President Biden's January 2021 Executive Order[1] and its goals of revitalizing coal-based communities and pursuing environmental justice for populations negatively impacted by coal mining.[2]

The U.S. EPA regulates coal ash disposal units under the Resource Conservation and Recovery Act (RCRA). This document focuses on closed coal ash disposal units because they are the best situated for solar energy development in the near future. All the disposal units considered in this analysis are currently regulated under RCRA and the majority are on-site at electric utilities.

Solar on CCR Disposal Sites

Rock River Solar Plant
This 2.25-MW solar installation in Beloit, Wisconsin, was commissioned by Alliant Energy in 2016 on a 17-acre capped coal ash landfill site. Alliant buys the electricity from the facility under a Power Purchase Agreement (PPA). The facility uses a pre-cast concrete ballasting system to anchor the solar system, minimizing the impacts on the cap.

Orlando Utility Commission (OUC) Community Solar Plant
This 13-MW community solar facility was installed in 2017 on a 24-acre site that includes a coal ash landfill. The solar installed on the landfill uses a ballasted system, while the remainder uses a traditional racking structure. OUC buys electricity from the facility under a PPA with a private developer.

OUC's Community Solar Plant.
Photo courtesy of Orlando Utility Commission

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[1] Executive Order (E.O.) 14008: Tackling the Climate Crisis at Home and Abroad. January 27, 2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/ .
[2] E.O. 14008 Sections 218 and 220.

Coal Combustion Residuals (CCR)

CCR, otherwise known as coal ash,[3] is a byproduct of burning coal to generate electricity. According to the EPA, coal ash is one of the largest industrial waste streams in the United States, generating on average more than a 100 million tons per year that require disposal. Coal ash contains many toxic chemicals harmful to human health and the environment. EPA's 2015 rule establishes minimum requirements for the management of coal ash which are intended to address the risks that could result from improper disposal.

Once generated, coal ash may be managed in ponds (where the ash is mixed with water) or landfills (where the ash remains dry). EPA found that management in unlined ponds poses significant risk of contamination for groundwater and surface water. As a result, the 2015 rule required all new ponds and landfills to be lined. Since 2015, a growing number of facilities have converted to dry handling of coal ash, further reducing the need for ponds.

As an alternative to disposal, CCR may be repurposed under specific RCRA rules to substitute for virgin raw materials that would otherwise be used. Repurposing can take the form of encapsulated uses, in which coal ash might be used in production of concrete and drywall, or un-encapsulated uses, in which the coal ash might be used in construction of roadways or structural fill.[4,5] Preliminary efforts to extract rare and critical earth elements from the ash are also underway.

When a coal plant (or unit) closes, or is converted to natural gas, the utility ceases to generate coal ash as a waste stream. However, all the coal ash that remains onsite will need to be dewatered (ponds only), capped, and monitored to ensure the ash remains contained. The continued presence of waste onsite will limit the future uses of the property to prevent the ash from being disturbed.

Capped coal ash ponds and landfills may present opportunities for solar PV development, particularly when other productive uses for the land are limited. These sites are typically located near existing utility transmission facilities which can reduce costs.

However, capped coal ash ponds and landfills create unique challenges for development given that the integrity of the caps must be maintained to keep the ash safely in place. As a result, solar installations represent a viable opportunity to develop at these sites given various racking configurations (including ballasted) that can be used for this technology.[6]

In 2022, the EPA's RE-Powering Initiative identified 297 existing solar projects on capped landfills with an installed capacity of 882 MW.[7]

While these sites aren't expressly identified as capped coal ash landfills, the data highlights the opportunity that exists and that many of the challenges associated with installing solar on such sites have been overcome.

Two examples of CCR sites successfully developed with solar are the Rock River Solar plant in Beloit, Wisconsin,[8] and the OUC Community Solar Plant in Orlando, Florida.[9]

Example of a ballasted racking system for solar. Photo courtesy of NREL.

[3] Included in the definition of coal ash are the compounds in the exhaust flue gases captured by scrubbers.
[4] These are some of the highest volume uses reported for the different types of coal ash, though other repurpose options exist as well.
[5] Coal ash can also be sent to municipal solid waste (MSW) landfills and other off-site landfills that meet minimum requirements for disposal of CCR; however, these off-site landfills are not the focus of this current effort.
[6] https://www.libra.com/en/news-and-insights/greenwood-dedication-of-stanton-ouc-solar-farm/
[7] https://www.epa.gov/re-powering/re-powering-tracking-matrix
[8] https://www.hdrinc.com/portfolio/rock-river-solar-project
[9] https://www.publicpower.org/periodical/article/ouc-dedicates-solar-farm-former-landfill-site-more-solar-planned

Site List

EPA identified 772 current and former coal combustion residuals (CCR) landfills and surface impoundments subject to Office of Resource Conservation and Recovery regulations, of which 64 are confirmed to have already completed closure with waste in place. These 64 units represent CCR from 49 coal-fired power plants across the United States and are well situated for further renewable energy project development.[10] This list of closed CCR sites is organized by EPA Region. Ownership and redevelopment activity is based on publicly available information only. A map showing the locations of total and closed CCR sites is provided at the end of this document.

EPA's RE-Powering America's Land Initiative (RE-Powering) has an established methodology to screen contaminated sites for renewable energy suitability in the RE-Powering Mapper tool. However, given the general lack of shading or other obstructions around these sites and the close proximity to utility transmission lines, closed CCR sites would all screen positively for solar under this screening methodology. Therefore, the RE-Powering Response Team compiled further information about each specific site to further inform stakeholder engagement on project development activities, such as:

- Site characteristics, such as unit and site acreage, site proximity to nearest body of water, water body type, distance to urban areas, road, utility transmission and substation interconnection;
- Existence of state policies that support or can be conducive to renewable energy projects;
- Information on annual site solar intensity (kWh/m^2/day); and
- Environmental Justice (EJScreen) percentile rankings.

How these types of information may factor into selection of individual sites for a future feasibility study is outlined in the table provided at the end of this document.

CCR sites may also be eligible for additional renewable energy incentives under the Energy Community Tax Credit Bonus under the 2022 Inflation Reduction Act (IRA). The IRA defines energy communities as:

- A "brownfield site" (as defined in certain subparagraphs of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA));
- A "metropolitan statistical area" or "non-metropolitan statistical area" that has (or had at any time after 2009)
  - A 0.17% or greater direct employment or 25% or greater local tax revenues related to the extraction, processing, transport, or storage of coal, oil, or natural gas; and
  - An unemployment rate at or above the national average unemployment rate for the previous year; and
- A census tract (or directly adjoining census tract)
  - In which a coal mine has closed after 1999; or
  - In which a coal-fired electric generating unit has been retired after 2009

An updated Summary of Key Factors project development screening tool tailored to CCR disposal sites is attached to standardize the collection of relevant site data and site factors for further study of one or more sites.

Next Steps

The RE-Powering Response Team is currently developing a stakeholder engagement outreach plan that will be designed to engage with utilities, and other stakeholders that may be interested in optimizing land associated with closed CCR units. The purpose of this outreach effort is to support further project development and feasibility work based on the site characteristics outlined above at closed CCR sites in line with the RE-Powering Initiative's mission.

Report prepared by Jason Coughlin, William Tokash, and Gail Mosey, June 2023

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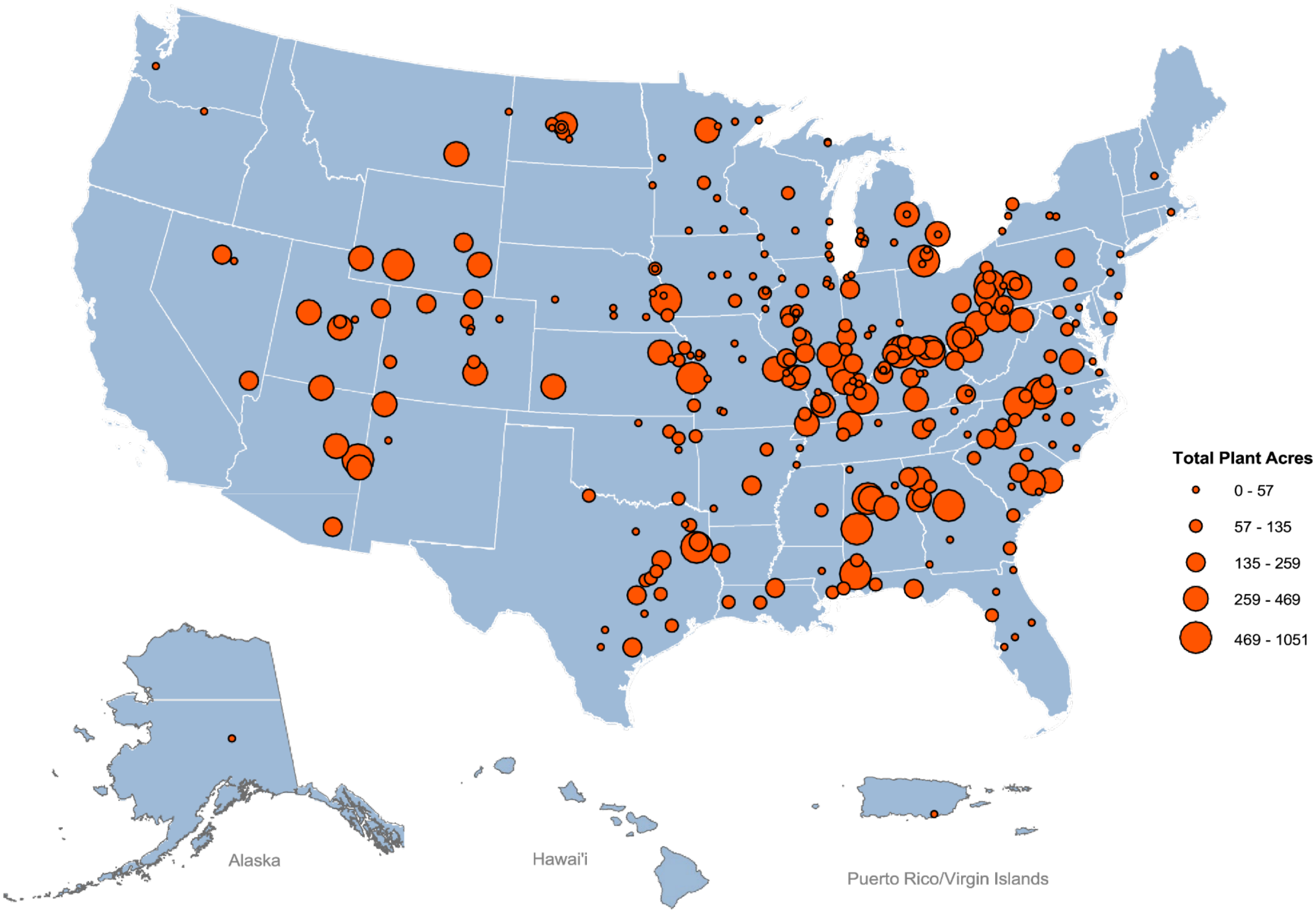
[10] EPA identified an additional 87 units that are confirmed to have completed closure through waste removal ("clean closure"). Because these units no longer have any waste in place, there may be additional opportunities for site redevelopment beyond solar installation. Therefore, these units were not the focus of this initial evaluation.

Power Plants with Operational and Closed Coal Ash Disposal Units



The U.S. EPA regulates coal ash disposal units under the Resource Conservation and Recovery Act - RCRA in the United States. This map shows coal ash disposal units that are operational and closed. All of the facilities are currently regulated under RCRA and are onsite at electric utilities.

Key Factors for Renewable Energy Techno-Economic Feasibility Studies on Closed Coal Ash Disposal Site

These are Key Factors to consider when determining whether a coal ash disposal site should receive a techno-economic feasibility study for renewable energy technology development. These sites could include both capped coal ash ponds and coal ash landfills.

** Key Factor categories of Environmental Justice, Techno-Economic, and Site Information Provider (item 1 under Other Site Considerations) will receive priority consideration*.

Prepared by: NREL
Prepared: 21-Nov-2021
Updated: April 2023

Name of Unit(s):

Address or Location of Unit(s):

Contact Person Completing Form (Name and Email):

Key Factor Categories

a. Environmental Justice (EJ)*

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys:

- The same degree of protection from environmental and health hazards, and
- Equal access to the decision-making process to have a healthy environment in which to live, learn, and work. (Source: EPA)

Key Factors	Notes	Response/Input
1. Demographics	Demographics considered are income, presence of minority, education level, linguistic isolation, and individuals in household younger than age 5 and older than age 65. More detail on EJSCREEN demographic indicators is included at the end of this table.	
2. Environmental indicators	These include measures related to Air, Waste, Water, Dust/Lead Paint. A complete list of indicators and sources is included at the end of this table.	

Note: EJ will be evaluated using EPA's EJSCREEN tool. EJSCREEN is an environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic indicators. In situations where the data from EJSCREEN is outdated or does not apply (e.g., for tribes) we will look at the same indicators with new or appropriate data. EPA should identify the community that would likely be impacted by the project within a certain distance of the site, for example, a two-mile buffer around the site point. Indicators that fall within a 70th percentile category would be flagged as potential for EJ concerns based on historical information. EPA will need to consider values across the state, region, and nation to compare indicators. For example, if a site in Missoula, Montana, was in the 86th percentile of the state for linguistically isolated, but that indicator dropped significantly when compared to the Region (57th percentile) or Nation (46th percentile) based on the fact that Montana as a state has very few linguistically isolated people, but Missoula (relatively speaking) has more than most Montana areas, then it would be considered an area with EJ concerns.

b. Energy Equity (EE)

Energy equity is the fair distribution of benefits and burdens from energy production and consumption. (Source: The Partnership for Southern Equity)
We will look to encourage a feasibility study at sites that are under-represented for renewable energy.

Key Factors	Notes	Response/Input
1. Percent renewables in the state/region/ area	These are examples of factors that can be reviewed and considered as part of the assessment for Energy Equity. Additional or different factors may be available and site specific.	
2. State Renewable Portfolio Standard (RPS)		
3. Access to clean energy options from the utility		
4. Access to power at a reduced price		

c. Techno-Economic Criteria*

Techno-economic criteria considers site characteristics that may determine the success of a renewable energy installation.

Key Factors	Notes	Response/Input
1. Renewable resource availability	Threshold for each of these varies by renewable energy technology. These five factors are assessed using the RE-Powering Mapper. Or when a site is not listed in the mapper, by evaluating the site using comparable information.	
2. Useable acreage		
3. Slope		
4. Proximity to transmission		
5. Proximity to roads		

Key Factors	Notes	Response/Input
6. Shading and other obstructions	No substantial shading or other obstructions like buildings and vegetative conditions as assessed by reviewing Google Earth images.	
7. Electricity Price	Moderate electric rates as determined through U.S. Utility Rate Database. Note that very low rates may make the economics challenging for an economically viable renewable energy project.	
8. Proximity to population centers	Generating electricity close to larger population centers can be attractive as it creates a potential market for the power. Being close to the end users of the electricity also limits line losses due to transmission.	
9. Proximity to waterways/bodies of water?	Alternative development options may exist if the site is located near or along a body of water. Water quality considerations also play a factor in determining the best use of the site.	
10. IRA Energy Community Tax Credit Bonus eligible?	Might the site meet Energy Community Tax Credit Bonus applies a bonus of up to 10% (for production tax credits) or 10 percentage points (for investment tax credits) for projects, facilities, and technologies located in energy communities.	

d. Coal Combustion Residuals (CCR) Disposal Sites - Specific Considerations

Given the unique nature of coal ash disposal sites, the following factors seek to identify considerations, risks, and opportunities specific to these locations.

Key Factors	Notes	Response/Input
1. Site information and data provider*	Is there someone sufficiently familiar with the site who can and is willing to provide the necessary data and information to conduct a feasibility study?	
2. Utility Considerations	Who is the local utility, and do they own the CCR site? Have they been approached about a project on the site? If so, are they receptive?	

Key Factors	Notes	Response/Input
3. Ownership	Who owns the site? Will site ownership be a favorable or complicating factor to re-developing the site with renewable energy? A simple ownership structure paves the way toward a more straightforward arrangement. Does the site owner have previous experience with solar energy facilities on its property?	
4. Property Status	Are there on-going activities at the site (i.e., mining, generation, or other)?	
5. On-site Electricity Demand	Is there a need for on-site electricity?	
6. Status of Coal Ash Disposal Site(s)	What is the status of the disposal site? Active, Inactive, Scheduled for Closure, or Closed? What is the Closure type? What is the regulatory status?	
7. Champion for the Site (Driver)	Is there someone associated with the site who is driven to make a renewable energy installation a reality? A Champion is often a key determinant of success.	
8. Community Intention/Planning for the Site	Is the community in favor of a renewable energy project at the site or do they have another re-use in mind? What re-use was planned for the site? A supportive community can determine the success of a renewable energy project.	
9. Zoning and Permitting	Are there any specific code requirements or restrictions? Is the site in an area already zoned for a renewable energy installation? Zoning already in place that permits a renewable energy installation can make the permitting process less complex. What agencies have jurisdiction over the site?	
10. Complexity of the Site	Are there any other complexities, site liabilities, or other risks not already captured that may be associated with the site?	
11. Other Sensitivities with the Site	Are there any other sensitivities not already captured that may be impactful to the success of the project?	

EJSCREEN Demographic Indicators

Demographics	
Low Income:	Household income is less than or equal to twice the federal "poverty level."
Minority:	The number or percentage of individuals in a block group who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino.
Education:	The number or percentage of people age 25 or older in a block group whose education is short of a high school diploma.
Linguistic isolation:	The number or percentage of people age 25 or older in a block group whose education is short of a high school diploma.
Individuals under age 5:	The number or percentage of people in a block group under the age of 5.
Individuals over age 64:	The number or percentage of people in a block group over the age of 64.
Source:	American Community Survey (ACS) 5-year summary file, which the U.S. Census Bureau compiles yearly.

EJSCREEN Tool Environmental Factors

Key Medium	Indicator	Details	Source	Data Year
Air	National-Scale Air Toxics Assessment (NATA) air toxics cancer risk	Lifetime cancer risk from inhalation of air toxics	EPA NATA	2014
Air	NATA respiratory hazard index	Air toxics respiratory hazard index (ratio of exposure concentration to health- based reference concentration)	EPA NATA	2014
Air	NATA diesel PM	Diesel particulate matter level in air, µg/m3	EPA NATA	2014
Air	Particulate matter	PM2.5 levels in air, µg/m3 annual average	EPA, Office of Air and Radiation (OAR) fusion of model and monitor data	2017
Air	Ozone	Ozone summer seasonal average of daily maximum 8- hour concentration in air in parts per billion	EPA, OAR fusion of model and monitor data	2017
Air/other	Traffic proximity and volume	Count of vehicles (AADT, average annual daily traffic) at major roads within 500 m, divided by distance in meters(not kilometers)	Calculated from 2017 U.S. Department of Transportation (DOT) traffic data, retrieved 2019	2017
Dust/lead paint	Lead paint indicator	Percent of housing units built pre-1960, as indicator of potential lead paint exposure	Calculated based on Census/American Community Survey (ACS) data, retrieved 2020	2014-2018
Waste/air/water	Proximity to Risk Management Plan (RMP) sites	Count of RMP (potential chemical accident management plan) facilities within 5 km (or nearest one beyond 5 km), each divided by distance in kilometers	Calculated from EPA RMP database, retrieved 04/05/2020	2020
Waste/air/water	Proximity to Hazardous Waste Facilities	Count of hazardous waste facilities (TSDFs and LQGs) within 5 km (or nearest beyond 5 km), each divided by distance in kilometers	TSDF data calculated from EPA RCRAInfo database, retrieved 07/06/2020	2020
Waste/air/water	Proximity to National Priorities List (NPL) sites	Count of proposed or listed NPL—also known as superfund—sites within 5 km (or nearest one beyond 5 km), each divided by distance in kilometers	Calculated from EPA CERCLIS database, retrieved 04/22/2020	2020
Water	Wastewater Discharge Indicator (Stream Proximity and Toxic Concentration)	RSEI modeled Toxic Concentrations at stream segments within 500 m, divided by distance in kilometers	Calculated from RSEI modeled toxic concentrations to stream reach segments, created 07/06/2020	2020