Data Documentation for Mapping and Screening Criteria for Renewable Energy Generation Potential on EPA and State Tracked Sites
RE-Powering America's Land Initiative
Updated August 2015

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OVERVIEW

The U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) Center for Program Analysis (CPA) initiated the RE-Powering America's Land Initiative to demonstrate the enormous potential that contaminated lands, landfills, and mine sites provide for developing renewable energy in the United States. EPA developed national level site screening criteria in partnership with the U.S. Department of Energy (DOE) National Renewable Energy Laboratory (NREL) for wind, solar, biomass, and geothermal facilities. While the screening criteria demonstrate the potential to reuse contaminated land for renewable energy facilities, the criteria and data are neither designed to identify the best sites for developing renewable energy nor all-inclusive. Therefore, more detailed, site-specific analysis is necessary to identify or prioritize the best sites for developing renewable energy facilities based on the technical and economic potential.

Please note that these sites were only pre-screened for renewable energy potential. The sites were not evaluated for land use constraints or current on the ground conditions. Additional research and site-specific analysis are needed to verify viability for renewable energy potential at a given site.

The federal- and state-tracked sites included in this screening represent a subset of nationwide contaminated lands, landfills, and mine sites. RE-Powering screened sites currently tracked through EPA remediation and grant programs, as well as sites tracked by 11 state agencies. Additional sites are tracked at the state and local level.

RENEWABLE ENERGY TECHNOLOGIES EVALUATED

The following renewable energy technologies were evaluated for this analysis. They represent the most wide-spread types of renewable energy facilities being used today. This is not an inclusive list of all renewable energy technologies; new technologies continue to be developed while established technologies are refined. For information on how each renewable energy type was evaluated, refer to the Screening Criteria section in the Methodology section below.

Solar

Solar technologies generate electricity from the sun's energy. The two types of solar technologies evaluated—photovoltaic and concentrating solar power—are described below.

Solar resource is typically characterized by the amount of solar energy striking a panel tilted at latitude over a given area and reported as a daily average. Solar radiation is measured in kilowatt-hours per square meter per day ($kWh/m^2/day$).

For more information on solar technologies, visit: www.nrel.gov/learning/re_solar.html.

Photovoltaic (PV): Converts the sun's light energy directly into electricity. PV technology is scalable; the amount of electricity generated is directly related to the number and efficiency of installed panels. It can technically be sited anywhere, though the economics may make a project unfeasible in lower resource areas.

Three scales of solar PV energy were evaluated by EPA:

- Utility scale PV: Uses PV technology at the multi-megawatt scale at sites with the greatest resource and acreage availability. Electricity generated is typically exported to the grid.
- Large scale PV: Uses PV technology at the 300-kW scale or greater at sites with the strong resource and suitable acreage availability. Electricity generated may be exported to the grid or used to offset onsite electricity consumption, depending on site requirements and market conditions.
- Off-grid PV: This category represents PV technology being used at a smaller scale, typically to power the energy needs of a single property when interconnection to the grid may not be feasible. Additional sites with lower solar resource may be technically and economically feasible depending on the potential for battery back-up and cost barriers associated with grid interconnection (e.g., due to remote locations).

Economic viability of solar PV projects is tied closely to the policy and regulatory context of the jurisdiction where the installation would be sited. An additional parameter reflecting policies was included to identify sites with similar characteristics to the "Utility scale PV" requirements, as follows.

- PV policy driven: Represents sites that may have development potential due to state policies, including sites in areas with lower resource availability. It includes states with a renewable portfolio standard (RPS) or RPS goal that have one or more of the following provisions: a solar set-aside that requires a certain percentage of the state's electricity be generated from solar resources; a solar multiplier that gives additional credit for solar projects that contribute toward meeting the RPS requirements; or a requirement for distributed generation (i.e., electricity generation close to the point of use). These incentives may help to make PV projects financially viable in areas with lower solar resource availability.

Utility scale concentrating solar power (CSP): Uses the sun's thermal energy to heat a liquid that drives a generator to produce electricity. CSP technology is constructed at the megawatt or multi-megawatt scale and electricity generated is typically exported to the grid.

The following three types of utility scale CSP technologies were evaluated by EPA.

- Trough system: Collects the sun's thermal energy using long rectangular, curved (U-shaped) mirrors. The mirrors are tilted toward the sun, focusing sunlight on tubes that run the length of the mirrors. The reflected sunlight heats a fluid flowing through the tubes. The hot fluid then is used to boil water in a conventional steam-turbine generator to produce electricity.
- Power tower system: Uses a large field of flat, sun-tracking mirrors known as heliostats to focus and concentrate sunlight onto a receiver on the top of a tower. A heat-transfer fluid heated in the receiver is used to generate steam for a conventional steam-turbine generator to produce electricity. Some power towers use water/steam as the heat-transfer fluid, others use alternative materials such as molten salt.
- Stirling engine system: Uses a mirrored dish to direct and concentrate sunlight onto a thermal receiver. A fluid heated inside the receiver moves pistons and creates mechanical power, which runs the Stirling engine to produce electricity.

Wind

Wind energy is captured by wind turbines with propeller-like blades mounted on a tower. The force of the wind causes the rotor to spin and the turning shaft spins a turbine to generate electricity. Wind technology is scalable; based on site conditions, different turbines designs can be used to meet different electricity needs.

Wind resource is typically characterized by wind speed (meters per second) at a given height. The resource data are selected based on the turbine size. For example, utility-scale turbines with hub heights ranging from 80-90 meters (m) generally reference the wind resource data at 80 m for initial screening.

For more information on wind technologies, visit: www.nrel.gov/learning/re_wind.html.

The following four scales of wind energy were evaluated by EPA.

- Utility scale: Uses large turbines at the multi-megawatt scale on sites with the greatest resource and acreage availability. Electricity generated is typically exported to the grid.
- Large scale: Represents sites with less acreage than the utility scale wind sites, potentially using smaller or fewer turbines. Electricity generated may be distributed to the local area through the distribution system, often serving only adjacent properties.
- 1-2 Turbine sites: Represents sites with limited acreage, potentially using a range of turbine sizes. Electricity generated may be distributed to the local area through the distribution system, often serving only adjacent properties.
- Off-grid: Uses smaller and fewer turbines on a much smaller scale, typically to power the energy needs of a single property when interconnection to the grid may not be feasible.

Biomass

Biomass energy or "bioenergy" is generated from organic feedstocks. Wood is the largest biomass energy resource; other sources of biomass include food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. These feedstocks can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electric power, heat, chemicals, or fuels.

For more information on biomass technologies, visit: www.nrel.gov/learning/re_biomass.html.

Energy can also be generated by capturing methane and other emissions from landfills. For more information on EPA's Landfill Methane Outreach Program (LMOP) and landfill gas energy technologies, visit www.epa.gov/lmop/.

The following three types of biomass production were evaluated by EPA.

- Biopower facility: Burns biomass resources to produce heat, which is used to boil water for a conventional steam-turbine generator to produce electricity. Biopower facilities utilize cumulative biomass resources that can include residues from: forests, primary and secondary mills, and urban wood waste.
- Biorefinery facility: Integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. The technology utilizes cumulative crop residues that can include residues from crops or forests, primary and secondary mills, and urban wood waste, cumulatively.
- Landfill gas energy project: Uses gas that is created as organic solid waste decomposes in a landfill. This gas consists mostly of methane (the primary component of natural gas) and carbon dioxide. Instead of allowing landfill gas to escape into the air, it is extracted from landfills using a series of wells and a blower/flare (or vacuum) system. The landfill gas is directed to a central point where it can be processed and treated to produce various forms of energy, including electricity, boiler fuel, steam, alternate vehicle fuel, and pipeline quality gas.

Geothermal

Geothermal facilities use heat stored in the earth to generate electricity. This heat comes from the original formation of the planet, radioactive decay of minerals, tectonic activity, and solar energy absorbed at the surface. Geothermal facilities use heat from: hot water or steam reservoirs deep in the earth that are accessed by drilling; geothermal reservoirs located beneath the earth's surface —typically at depths less than three miles and mostly located in western states, Alaska, and Hawai'i— and the shallow ground near the Earth's surface that maintains a relatively constant temperature of 50°-60°F. Geothermal energy is unique, when compared to other renewable energy resources, in that it is more closely related to mineral or conventional fossil fuel resources, due to subsurface characterization.

Geothermal resource is typically characterized by temperature at a given depth, availability of water resources, and permeability of geologic layers.

For more information on geothermal technologies, visit the DOE Energy Efficiency and Renewable Energy (EERE) Geothermal Technologies Program at: www1.eere.energy.gov/geothermal/ or www.nrel.gov/learning/re_geothermal.html.

The following three types of geothermal technologies were evaluated by EPA.

- Hydrothermal: Uses steam produced from existing reservoirs of hot water beneath the earth's surface to power electrical generators. The steam rotates a turbine that activates a generator, which produces the electricity. Given the limited nature of the available resource data, hydrothermal potential is screened for in a general sense and not linked to a particular technology or power plant design, as onsite characterization of the available resource would be required. For the purposes of this screening, the resource potential is screened based on favorability ratings for geothermal resources, which take temperature, water resource, and permeability into account, and/or distance to known hydrothermal sites. Two typical types of geothermal power plants are described below for reference.
    - Flash Steam: Uses geothermal reservoirs of water with very high temperatures that flow up through wells in the ground under its own pressure. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine that generates electricity. Any leftover water and condensed steam are injected back into the reservoir, making this a sustainable resource.
    - Binary Cycle: Uses the heat from lower temperature geothermal resources to boil a working fluid, usually an organic compound with a low boiling point. The working fluid is vaporized in a heat exchanger and used to turn a turbine to generate electricity. The water is then injected via a closed-loop system back into the ground to be reheated in the geothermal reservoir. The water and the working fluid are kept separated during the whole process, so there are no air emissions.
- Enhanced Geothermal: Provides geothermal power by tapping into the Earth's geothermal resources that are otherwise not economical due to lack of water, location, or rock type. Enhanced geothermal systems (EGS) require engineering hydrothermal reservoirs in hot rocks for commercial use. The reservoirs are created by drilling wells into hot rock and fracturing the rock to enable a fluid to flow between the wells. The fluid flows along these fractures and other pathways, picking up heat from the rocks, and exits the reservoir via production wells. At the surface, the fluid passes through a power plant where electricity is generated. Upon leaving the power plant, the fluid is returned to the reservoir through injection wells to complete the circulation loop. EGS offers the chance to extend use of geothermal resources across more areas of the United States. Resource potential is screened based on temperature at depth.
- Geothermal Heat Pump: The upper 10 feet of the Earth maintains a nearly constant temperature between 50° and 60°F (10°-16°C). Geothermal heat pumps take advantage of this resource to heat and cool buildings and heat water. Geothermal heat pump systems consist of three parts: the ground loop heat exchanger, the heat pump unit, and the air delivery system (ductwork). The ground loop heat exchanger is a system of pipes buried in the shallow ground near the building or in a vertical well if land for a horizontal loop is limited. Water source heat pumps work on the same principle as ground source systems, but use an adjacent body of water as the heat sink. A fluid (usually water or a mixture of water and antifreeze) circulates through the loop to absorb or relinquish heat within the ground. Geothermal heat pumps use much less energy than conventional heating systems, since they draw heat from the ground. Geothermal heat pumps typically serve a single property, though they may also be viable for use in multi-tenant applications such as integrated district heating systems.

METHODOLOGY

EPA developed an inventory of contaminated lands, landfills, and mine sites from various sources, including state agencies. From this inventory, EPA validated coordinates provided for sites and excluded sites where the coordinates did not match the state information provided. This subset of EPA and state tracked sites was then mapped against different renewable energy types, as described in the screening criteria in the following tables. For more information regarding the data sources and types of sites included in this inventory, see the Datasets section in this document.

Estimated Project Capacity and Screening Criteria

The following screening criteria used to evaluate renewable energy potential were approved by EPA and NREL. Although there are other critical factors for siting renewable energy facilities (e.g., slope), they were not considered in this analysis. Refer to the Data Considerations section for a description of screening criteria limitations.

	Estimated RE Project Capacity Range	**Renewable Energy Resource Availability**	**Acreage** (acres)	**Distance to Transmission** (miles)	**Distance to Graded Roads** (miles)
Solar PV		**Direct Normal** (kWh/m2/day)			
Utility scale	> 6.5 MW	≥ 5.0	≥ 40	≤ 10	≤ 10
Policy driven	> 6.5 MW	≥ 3.5	≥ 40	≤ 10	≤ 10
Large scale	> 300 kW	≥ 3.5	≥ 2	≤ 1	≤ 1
Off-grid	N/A	≥ 2.5	--	--	--
CSP		**Direct Normal** (kWh/m2/day)			
Stirling Engine	> 5 MW	≥ 6.0	≥ 40	≤ 10	≤ 10
Trough & Power tower	> 30 MW	≥ 6.0	≥ 250	≤ 10	≤ 10
Wind		**Wind speed (m/s)**			
Utility scale	> 10 MW	5.5 m/s at 80 m	≥ 100	≤ 10	≤ 10
Large scale	> 5 MW	5.5 m/s at 80 m	≥ 40	≤ 10	≤ 10
1-2 Turbine sites	> 1 MW turbine	5.5 m/s at 80 m	≥ 2	≤ 1	≤ 1
Off-grid	N/A	5.5 m/s at 50 m	≥ 0.25	--	-
Biomass		**Biomass potential within 50 miles** (metric tons/yr)			
Biopower	> 10 MW	≥ 280,000	≥ 50	≤ 10	≤ 3 road; ≤ 8 rail
Biorefinery	> 10,000 gal/yr	≥ 700,000	≥ 50	N/A	≤ 3road; ≤ 8 rail
Geothermal					
		Distance to "Identified Hydrothermal Sites" (miles) *OR* **Favorability Rating**			
Hydrothermal	N/A	Distance: ≤ 10 Favorability: ≥ 4	≥ 10	≤ 10	≤ 10
		Temperature at 4.5 km Well Depth			
Enhanced Geothermal Systems	N/A	≥ 150° C (300° F)	≥ 10	≤ 10	≤ 10

Geothermal			
	Estimated RE Project Capacity Rang	**Near Surface Temperature**	**Other Considerations**
Heat Pump	N/A	10° C (50° F) to 24° C (75° F)	All sites which have buildings or other heating or cooling needs (i.e., office buildings, warehouses, green houses) are generally considered favorable for geothermal heat pumps. This variable is not included in the prescreening.

	Landfill Gas Energy (LFGE) Project Screening Criteria
Landfill Gas Energy	**As defined by EPA's Landfill Methane Outreach Program (LMOP): www.epa.gov/lmop/**
Candidate LFGE	A landfill that is accepting waste or has been closed for five (5) years or less, has at least one (1) million tons of waste, does not have an operational or under construction LFGE project, or is designated based on actual interest or planning.
Potential for LFGE	A landfill that does not meet the candidate definition, whether because of complete or incomplete data. However, the landfill could have LFGE potential based on site-specific needs or if data were complete.

Pilot Screening: California Mega Utility Scale and Landfill Sites

With its unique market conditions and renewable energy development plans, the State of California faces significant pressures associated with conversion of open space for mega utility scale renewable energy projects, specifically desert lands developed for solar energy projects.

EPA completed a more refined screening of sites in California to identify prime locations for mega utility scale renewable energy development, based on the various renewable energy technologies and associated screening criteria. This level of state- or region-specific screening is a pilot to determine if similar refined screening would further support and promote the reuse of potentially contaminated lands, landfills, and mine sites by tailoring the screening criteria specific to market or regional considerations and/or renewable energy development trends.

Mega Utility Scale Projects

	Estimated RE Project Capacity Range	**Renewable Energy Resource Availability**	**Acreage** (acres)	**Distance to Transmission** (miles)	**Distance to Graded Roads** (miles)
Solar PV		**Direct Normal** (kWh/m2/day)			
Utility scale	> 33.3 MW	> 5.0	≥ 200	≤ 1	≤ 1
CSP		**Direct Normal** (kWh/m2/day)			
Trough & Power tower	> 50 MW	≥ 7.5	≥ 400	≤ 1	≤ 1
Wind		**Wind speed at 80 m** (m/s)			
Utility scale	> 20 MW	≥ 5.5	≥ 500	≤ 1	≤ 1

Large Scale Projects at Landfills

	Estimated RE Project Capacity Range	**Renewable Energy Resource Availability**	**Acreage** (acres)	**Distance to Transmission** (miles)	**Distance to Graded Roads** (miles)
Solar PV		**Direct Normal** (kWh/m2/day)			
Utility scale	≥ 6.5 MW	> 5.0	≥ 40	≤ 1	≤ 1
Wind		**Wind speed at 80 m** (m/s)			
Utility scale	≥ 5 MW	≥ 5.5	≥ 40	≤ 1	≤ 1

DATA CONSIDERATIONS

The following information should be considered when reviewing these data.

- EPA and state databases are updated continuously with information such as new sites and updated acreage. The information in the RE-Powering Mapper dataset provides a snapshot in time, as described in the Datasets section of this document. The use of site-specific information provided herein should only be used with the understanding that the information may change over time.
- EPA does not maintain or manage the state datasets. Currently, snapshots of the following states datasets are included: California, Hawai'i, Illinois, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Texas, Virginia, and West Virginia.

Location and Acreage Data

- Boundary data are not collected consistently for EPA sites; therefore, each EPA tracked site was mapped using a single latitude and longitude point obtained from EPA's Program Office databases (see Datasets section for more information on program-specific databases). In order to approximate the site size/boundary and estimate the potential for renewable energy generation across an entire site, the site latitude and longitude point was mapped and a circular buffer was drawn around the site that was equal to the area reported for the site. The maximum renewable energy resource values that the buffer covered were recorded for solar and wind resources. This methodology has limitations in that sites are typically not circles and latitude and longitude are not always recorded at the geographic center of the site. However, given these limitations, this method will allow a more accurate snapshot of what energy potential may be available at the site better than the single data point.
- Acreage values for each site might not be representative of available land at each particular site, nor the total contaminated area. For example, many federal facilities on the National Priorities List (NPL) are listed "fence to fence," which encompasses the entire facility, rather than only the contaminated portions of the facility. As such, the potentially or formerly contaminated areas may represent only a portion of the total acreage of these Superfund sites. In addition, acreage values do not take into account the physical characteristics at the site (e.g., buildings, topography, tree cover, etc.) and, thus, may not represent the true usable acreage of the site.
- Data for state tracked sites in West Virginia, Pennsylvania, Virginia abandoned mine lands (AML), New York, New Jersey AML, New Jersey Landfills, New Jersey Quarries and Texas Landfills were provided as polygons in ESRI shapefile format. The polygon data provides site boundaries, and as such circular buffers were not modeled for these sites, the polygon site boundaries were used for the analysis.
- Data for state tracked sites in Virginia (Orphaned Mineral Mines), California, New Jersey Contaminated Land Sites, Texas (State Superfund and Voluntary Cleanup Program), Illinois, Massachusetts, and Oregon were mapped using a single latitude and longitude point; therefore, data were evaluated using the same methodology as was used for the EPA tracked sites (see first bullet in this section and the Datasets section for more information).
- Sites without coordinates were geocoded using the address provided. Geocoded site locations were verified by matching the location mapped by geocoded coordinates to the city provided in the database, approximately 600 EPA and State tracked sites were geocoded.
- EPA and state tracked sites that were identified as having potentially incorrect latitude and longitude data (i.e., mapped locations did not match city or county as recorded or coordinates could not be obtained by geocoding) are excluded from the analysis. Approximately 1,000 sites were eliminated from the screening due to issues with the location data.
- Acreage is not a screening criterion for off-grid solar because such systems are typically used to power a single property or local area, and are not constrained by limited acreage. For example, a property owner could install PV panels to supplement the electricity provided to the site from traditional sources. In most cases, these systems would need to be interconnected to the existing utility grid and may be subject

to utility regulations or policies. In some cases, an off-grid system may power a given load, (e.g., a small-scale pump and treat system).

Geographical Areas Not Analyzed

- With the exception of Puerto Rico and the Virgin Islands, the U.S. territories were not evaluated or included in this analysis as renewable energy resource and transmission data were not readily available for these territories.
- Biomass and geothermal resource data were not readily available for Puerto Rico and the Virgin Islands. Therefore, these renewable energy potential types were not evaluated for these sites.
- Geothermal data is limited for Hawai'i. Only known hydrothermal information was available at the time of this analysis.

Photovoltaic Policy Driven and State RPS Notes

- State renewable energy policy information used to develop the PV policy driven criteria is constantly changing and being updated. Refer to the DOE Database of State Incentives for Renewables & Efficiency at www.dsireusa.org.

Landfill Notes

- Landfills are subject to varying regulatory requirements. These requirements sometimes include a composite liner comprised of a flexible membrane lining the bottom and sides of the landfill and installation of a final landfill cover and providing long-term care of closed landfills. These regulatory requirements, the weight of wind turbines and CSP systems, and the drilling required for geothermal facilities may increase the difficulty of siting these technologies directly on closed landfills.
- The mapped acreage for landfills is the highest acreage value among landfill designed area, landfill current area and landfill total area.

Wind Notes

- Wind speed resource data was obtained through an agreement with NREL using model data developed by AWS Truepower LLC. Wind speeds were gathered for the site point locations at heights of 50, 80, and 110 meters. Sites located in the continental US (lower 48) also have wind speeds at 150 meters.
- Wind data information represents the modeled wind speed at the specific location of the site. As wind speeds can vary widely across large sites, screened results may not accurately reflect the true wind potential across the site. Moreover, although the modeled data reflect the current state-of-the-art in wind modeling, by nature they cannot be as accurate as meteorological measurements taken at a given location. Site-specific data collection over an extended period of time would be necessary to estimate true wind speeds at the site.

Geothermal Notes

- Geothermal resource data were obtained from two sources:
    - Hydrothermal: Two datasets were used for hydrothermal potential; both datasets came from the U.S. Geological Survey. A point shapefile "Identified Moderate and High Temperature Geothermal Systems of the Western United States including AK and HI" and a polygon shapefile and raster dataset "Geothermal Favorability Map Derived From Logistic Regression Models of the Western United States."
    - Enhanced Geothermal: Southern Methodist University in grid format and converted into raster images using Surfer 8.0 and ESRI ArcView 9.2. The raster data were then extracted to the site location points.
- For geothermal flash and binary plants, additional subsurface mineral rights covering adjacent acreage may be needed in order to capture enough of the resource to make development feasible. This is largely

specific to the size of the power generating facility; the larger the size of the facility the more resource is needed for extraction of the hot liquid and its injection into the geothermal reservoir.

- Potential for geothermal direct use applications was not analyzed because required temperature data at shallow depths were not available. In addition, there are numerous direct use applications (e.g., district space heating, crop drying, greenhouse heating and aquaculture), and each has its own specific temperature requirements. More information is available at: www1.eere.energy.gov/geothermal/pdfs/directuse.pdf.
- All sites that have buildings are generally considered favorable for geothermal heat pump installation. The optimal temperature range of 10° C (50° F) to 24° C (75° F) was used for screening purposes for this analysis.

Miscellaneous Notes

- For the biomass analysis, the screening criteria include resources within a 50-mile radius of the site. Therefore, a 50-mile buffer was drawn around the site and the sum of the biomass resource within 50 miles of the site was recorded.
- In instances where distances to transmission lines, highways, or rails are zero, the transmission line, highway, or rail intersects the site buffer, meaning that the infrastructure is present within the generated site boundary.
- Although slope is a critical factor for siting some types of renewable energy, it was not considered in the analysis due to limitations in the availability of high resolution slope data for sites dispersed across the United States. In addition, slope can vary dramatically across a site, especially at large sites (many sites measure upwards of 1,000 acres), making it difficult to accurately estimate each site's slope and the area of each site that would be suitable for each type of renewable energy. Site-specific slope analysis should be performed for any site being considered for renewable energy development.
- EPA obtained infrastructure data from the Department of Homeland Security's (DHS) Homeland Security Infrastructure Program (HSIP). This dataset contains information related to substations, transmission lines, and railways.

DATASETS

The following data sources were used to develop the inventory of EPA and state tracked sites evaluated as part of this analysis. Site information and screening data were needed to conduct this analysis. Screening data were provided by a number of sources including NREL, the Federal Emergency Management Agency (FEMA), and HSIP.

Site Information - EPA Datasets

Note: EPA datasets are updated continuously so these data provide a snapshot in time.

Program Name	Description of Dataset used in Analyses	Data Current	Date of Screening
AML Program (Abandoned Mine Lands)	Includes all abandoned hardrock mines and mineral processing sites listed in the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS). Including abandoned mine sites on the National Priorities List (NPL), often referred to as "Superfund" Sites and abandoned mine sites where EPA also has made emergency response actions.	11/2013	6/2015
Brownfields	Brownfields are real property where expansion, redevelopment, or reuse may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Brownfields are often found in and around economically depressed neighborhoods. Includes data in the Assessment Cleanup and Redevelopment Exchange System (ACRES) database. Data include information on properties associated with Brownfields grants awarded in fiscal year 2003 and beyond, where an assessment or cleanup activity has been completed and EPA Brownfields funding was expended.	3/2015	6/2015
Resource Conservation and Recovery Act (RCRA)	RCRA sites are commercial, industrial, and federal facilities that treat, store, or dispose of hazardous wastes that require cleanup of the contamination under the RCRA Corrective Action (CA) Program. Includes all sites from the RCRA 2020 Universe Inventory.	10/2014	6/2015
Superfund	These sites are contaminated and include industrial facilities, waste management sites, mining and sediment sites, and federal facilities Site data for these sites were extracted from CERCLIS.[1] This universe includes sites listed on, proposed to, and deleted from the National Priorities List (NPL), as well as some sites that are not included on the NPL (e.g., removal sites and others), in addition to Superfund Alternative Approach sites.	11/2013	6/2015
Landfill Methane Outreach Program (LMOP)	Includes data from LMOP, which is a voluntary assistance and partnership program that promotes the use of landfill gas as a renewable, green energy resource. LMOP screens landfills to determine if they are candidates for landfill gas energy projects or have potential for landfill gas energy projects. In addition, it tracks landfills that have operational, under construction, or shutdown landfill gas energy projects. This universe of sites includes all landfills that have partnered with LMOP. Visit EPA's LMOP website at www.epa.gov/lmop/ for more information and definitions of landfill gas energy projects.	3/2015	6/2015

[1] The data for these sites were gathered during the time of transition from CERCLIS to SEMS; thus, sites that were not in CERCLIS were pulled from Federal Register information from 11/2013 to 6/2015 when possible.

Site Information - State Datasets

Note: State datasets are updated continuously so this provides a snapshot in time. Please check with states for the most up-to-date information.

State	Contact Information
California	California Department of Toxic Substances Control (CA DTSC) EnviroStor 1001 I Street P.O. Box 806 Sacramento, CA 95812-0806 1-877-786-9427 Email: envirostor@dtsc.ca.gov www.envirostor.dtsc.ca.gov/public/
Hawai'i	Hawai'i State Department of Health (HI DOH) Hazard Evaluation and Emergency Response Office 919 Ala Moana Boulevard, Room 206 Honolulu, HI 96814 Telephone: (808) 586-4249 Fax: (808) 586-7537 http://eha-web.doh.hawaii.gov/eha-cma/Org/HEER/
Illinois	Remediation Projects Management Section 1021 North Grand Avenue East P.O. Box 19276 Springfield, Illinois 62794-9276 217-524-3300 Site Remediation program: www.epa.illinois.gov/topics/cleanup-programs/srp/index Brownfield program: www.epa.illinois.gov/topics/cleanup-programs/brownfields/index
New Jersey	Sustainability and Green Energy (SAGE) New Jersey Department of Environmental Protection 7th Floor, East Wing P.O. Box 402, Mail Code: 401-07E 401 East State Street Trenton, NJ 08625 609-292-8601 Email: sage_inquiries@dep.state.nj.us www.nj.gov/dep/sage/
New York	New York Department of Environmental Conservation (NYS DEC) Environmental Remediation 625 Broadway Albany, NY 12233-7012 518-402-9764 Email: derweb@gw.dec.state.ny.us www.dec.ny.gov/chemical/brownfields.html
Massachusetts	Clean Energy Results Program MassDEP 1 Winter St. Boston, MA 02108 617-292-5500 Email: BWSC.Information@state.ma.us www.mass.gov/eea/agencies/massdep/climate-energy/energy/

State	Contact Information
Oregon	Oregon Department of Environmental Quality (OR DEQ) Environmental Cleanup 811 SW Sixth Ave. Portland, OR 97204-1390 503-229-5512 Email: WISTAR.Gil@deq.state.or.us or DEQInfo@deq.state.or.us
Pennsylvania	Bureau of Abandoned Mine Reclamation (PA BAMR) Rachel Carson State Office Building P.O. Box 8461 Harrisburg, PA 17105-8461 717-783-2267 Email: RA-epcontactus@pa.gov www.portal.state.pa.us/portal/server.pt/community/abandoned_mine_reclamation/13961
Texas	Superfund Section, Remediation Division, Texas Commission on Environmental Quality Texas Commission on Environmental Quality P.O. Box 13087 Austin, TX 78711-3087 Phone: 512-239-1000 Email: ac@tceq.texas.gov www.tceq.texas.gov/
Virginia	Coal AML Virginia Division of Mined Land Reclamation (VA DMLR) 3405 Mountain Empire Road P.O. Drawer 900 Big Stone Gap, VA 24219 276-523-8100 Email: dmlrinfo@dmme.virginia.gov https://www.dmme.virginia.gov/DMLR/DmlrLandingPage.shtml Orphaned Mineral Mines Virginia Division of Mineral Mining (VA DMM) Suite 400 Charlottesville, VA 22903-0667 434951-6310 Email: dmmInfo@dmme.virginia.gov https://www.dmme.virginia.gov/DMM/divisionmineralmining.shtml
West Virginia	Office of Abandoned Mine Lands and Reclamation (WV AMLR) 601 57th Street, SE Charleston, WV 25304 304-926-0499 Contact form: www.dep.wv.gov/Pages/contact.aspx www.dep.wv.gov/aml/Pages/default.aspx

State Tracked Abandoned Mine Lands

Two types of AMLs were included in this study. Some of the AMLs included in this analysis are coal mining sites that were operated prior to August 3, 1977. The enactment of Surface Mining Control and Reclamation Act (SMCRA) of 1977 created a fund to eliminate (reclaim) health and safety hazards associated with coal mining operations that were abandoned before the enactment of the statute. As a result of SMCRA, Pennsylvania, Virginia, and West Virginia developed these datasets as inventories of AML sites eligible for reclamation. The other type of AML includes hard rock and other mineral mine sites.

State	Description of Dataset used in Analyses	Data Current	Date of Screening
West Virginia AML	This dataset is a polygon shapefile and was downloaded from the West Virginia Geographic Information System (GIS) Technical Center website (http://wvgis.wvu.edu/data/dataset.php?action=search&ID=150). Coal AML features were digitized from Abandoned Mine Land Reclamation source materials by the West Virginia University (WVU) Department of Geology & Geography and the WVU Natural Resource Analysis Center. This polygon dataset was published in 1996. A description of the dataset indicates that typical AML features include highwalls, portals, refuse piles, and mining structures such as tipples. Acreage values should be considered as approximate estimations for the features and may not represent actual site conditions. The dataset does not include ownership or parcel information.	7/10/2008	6/2015
Pennsylvania AML	This dataset is a polygon shapefile and was downloaded from the Pennsylvania Spatial Data Access Clearinghouse website (www.pasda.psu.edu/uci/MetadataDisplay.aspx?entry=PASDA&file=AMLInventorySites2008_07.xml&dataset=460). This dataset portrays the approximate location of Abandoned Mine Land Problem Areas containing public health, safety, and public welfare problems created by past coal mining. The data represent the AML Inventory Sites, which are the boundary of an entire problem area and may contain multiple actual mining features. The dataset does not include ownership or parcel information. Most sites are owned privately. When needed, ownership information must be researched through other means, typically county real estate records.	7/05/2012	6/2015
Virginia AML	This dataset is a polygon shapefile and was obtained from the Virginia Department of Mines, Minerals and Energy's Division of Mined Land Reclamation. The dataset represents polygons of mines extracted from U.S. Geological Survey (USGS) topographic maps, last photo revised in the late 1970s and early 1980s. Some of these areas may represent sites that have been re-mined.	1/21/2008	6/2015
Virginia Orphaned Mineral Mines	The dataset was obtained from the Virginia Department of Mines, Minerals and Energy's Division of Mineral Mining. This dataset represents orphaned mineral mining sites in Virginia operated prior to 1968, the enactment of the Virginia Reclamation Law. Once identified, an orphaned mine site is evaluated for its potential hazards to the environment and the public's health and safety. This includes soil and water investigations, studies on the feasibility of reclaiming the site, cost analysis and seeking the landowner's consent to allow reclamation to proceed.	7/16/2012	6/2015
New Jersey AML	This dataset is a polygon shapefile and contains abandoned mine lands in New Jersey.	11/6/2011	6/2015
New Jersey Sand and Gravel Operations	This dataset is a polygon shapefile and contains registered and non-registered sand and gravel operations in New Jersey. Only non-registered sand and gravel operations were evaluated in this study.	11/16/2011	6/2015

State Tracked Contaminated Sites

Most states track and remediate contaminated sites. Information tracked, reported, and provided varies from state to state. The data gathered as part of this study was "standardized" in a manner to capture the most important information consistently reported across a wide range of states. Locations were verified to map in the associated states.

Name	Description of Dataset used in Analyses	Data Current	Date of Screening
California Department of Toxic Substances Control (DTSC)	DTSC populates the EnviroStor database system with information about sites that are known to be contaminated with hazardous substances as well as information on uncharacterized properties where further studies may reveal problems. The dataset was downloaded from www.envirostor.dtsc.ca.gov/public/data_download.asp	9/8/2011	6/2015
Hawai'i State Department of Health	The Hawai'i State Department of Health - Hazard Evaluation and Emergency Response (HEER) Office provided an inventory of brownfield sites, http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/public-records. Note that summary information is available in two forms: a HEER Sites of Interest Lookup Spreadsheet, and a Public Record Report in single page per site PDF format.	3/2013	6/2015
Illinois Site Remediation Program	Identifies the status of all voluntary remediation projects administered through the Pre-Notice Site Cleanup Program (1989 to 1995) and the Site Remediation Program (1996 to the present).	4/2015	6/2015
Illinois State Response Action Program	This dataset identifies all sites that have been identified as having potential contamination not covered by another program, some have been addressed under the Illinois EPA's State Sites Unit.	4/2015	6/2015
New Jersey - Known Contaminated Sites	The Known Contaminated Sites List (KCSNJ) for New Jersey (Non-Homeowner) are those non-homeowner sites and properties within the state where contamination of soil or ground water has been confirmed at levels equal to or greater than applicable standards. This list of Known Contaminated Sites may include sites where remediation is either currently under way, required but not yet initiated, or has been completed. The dataset was provided by New Jersey.	11/16/2011	6/2015
New Jersey – Landfills	This dataset is a polygon shapefile of a parcel or parcels greater than 35 acres located in New Jersey. New Jersey provided this dataset.	11/21/2011	6/2015
New York – Environmental Remediation Sites	This dataset is a polygon shapefile and contains records of the sites which have been remediated or are being managed under one of Division of Environmental Remediation's (DER) remedial programs (i.e., State Superfund, Brownfield Cleanup, etc.). All sites listed on the "Registry of Inactive Hazardous Waste Disposal Sites in New York State" are included in this database. The Database also includes sites with entries on the "Registry of Institutional and Engineering Controls in New York State." This dataset was provided by New York.	7/8/2011	6/2015

Name	Description of Dataset used in Analyses	Data Current	Date of Screening
Massachusetts Land Disposal of Solid Waste	The Solid Waste Land Disposal Datalayer was compiled by the Department of Environmental Protection (MassDEP) to track the locations of land disposal of solid waste. Land Disposal refers to an operation established in accordance with a valid site assignment for the disposal of solid waste into or on land (Landfill), or a location for disposal of solid waste from one or more sources which is not established or maintained pursuant to a valid site assignment or permit (Dumping Ground).	4/2014	6/2015
Massachusetts Contaminated Land Profiles	This spreadsheet describes sites that have had a release of oil or hazardous materials and are regulated under Massachusetts regulations. The Contaminated Land Profiles list was compiled by the Department of Environmental Protection (MassDEP) to track the locations of land where a disposal site exists due to a release of oil and/or hazardous materials. Disposal sites are either regulated under Massachusetts Contingency Plan or adequately regulated by another government agency (e.g. USEPA). A file number know as a Release Tracking Number (RTN) is assigned to each disposal site.	4/2014	6/2015
Oregon – Environmental Cleanup Sites	The Oregon Department of Environmental Quality (DEQ) maintains its Environmental Cleanup Site Information (ECSI) database to track sites in the state with known or potential contamination from hazardous substances, and to document sites where DEQ has determined that no further action is required. Data in ECSI is "working information" used by DEQ's Environmental Cleanup Section. This dataset was provided by Oregon.	9/12/2011	6/2015
Texas Municipal Solid Waste Facilities	A spreadsheet listing issued permits and other authorizations as well as pending applications for MSW landfills and processing facilities that are active, inactive, or not yet constructed. As well as issued and revoked permits and other authorizations for MSW landfills and processing facilities that have closed, and applications that were withdrawn or denied.	4/2015	6/2015
Texas Superfund Sites	Sites in the State of Texas that have been designated as Superfund cleanup sites; it includes both Federal and State sites. Note Federal sites were excluded for the purpose of this analysis as to not double count those already included in the EPA Superfund dataset.	7/2014	6/2015
Texas Voluntary Cleanup Sites (VCP)	The Texas VCP provides administrative, technical, and legal incentives to encourage the cleanup of contaminated sites in Texas. All non-responsible parties, including future lenders and landowners, receive protection from liability to the state of Texas for cleanup of sites under the VCP, most of the constraints for completing real estate transactions at those sites are eliminated. As a result, many unused or under used properties may be restored to economically productive or community beneficial use.	1/2015	6/2015

Screening Data

In addition, the following GIS data were compiled and used to perform this analysis.

National Renewable Energy Laboratory (NREL) Data

Specific information on how the data were collected by NREL is available at: www.nrel.gov/gis/.

Resource Name	Description of Dataset used in Analyses	Date of Access
Lower 48 Direct Normal Resource (us9809_dni)	Direct normal solar resource data for the lower 48 states and Hawai'i. Used to determine potential for utility scale CSP Stirling engine system, utility scale CSP trough, and power tower systems, and all scales of solar PV.	6/2015
Alaska Direct Normal Resource (akdirect)	Direct normal solar resource data for Alaska. Used to determine potential for utility scale CSP Stirling engine system, utility scale CSP trough, and power tower systems, and all scales of solar PV.	6/2015
Caribbean Direct Normal Resource (csr_carib_dir)	Direct normal solar resource data for the Caribbean (Puerto Rico and Virgin Islands). Used to determine potential for utility scale CSP Stirling engine system, utility scale CSP trough, and power tower systems, and all scales of solar PV.	6/2015
Solid Biomass	Contains information about the biomass resources generated by county in the United States. It includes the following feedstock categories: crop residues, forest residues, primary mill residues, secondary mill residues, and urban wood waste. Used to determine potential for biorefinery and biopower facility siting. Data available for all jurisdictions except for Puerto Rico and Virgin Islands.	6/2015
Wind	Wind speed resource data at heights of 50, 80, 110, and140 meters (m); developed by AWS Truepower LLC. Wind speeds at 80-m height used to determine potential for wind energy at utility- and large-scale, as well as 1-2 turbine sites. Wind speeds at 50-m height used to determine potential for wind energy at off-grid scale to allow for use of smaller turbines.	7/2015

Homeland Security Infrastructure Program (HSIP) Data

Distances to transmission lines, substations, and rail were calculated using data obtained from the HSIP database. Source: HSIP Gold 2015.

Resource Name	Description of Dataset used in Analyses	Date of Access
Transmission Lines	Depict market significant existing and proposed electric power transmission lines in North America. Included lines generally have a capacity of greater than 69 kilovolts. Source: HSIP Gold 2015 – Ventyx	6/2015
Substations	Identifies existing and proposed substations in North American power transmission grids. Substations are facilities that switch, change, and/or regulate electric voltage. Source: HSIP Gold 2015 – Ventyx	6/2015
Rails	Represents the freight lines of the nation's railroad system. Source: HSIP Gold 2015 - Oak Ridge National Laboratory.	6/2015

Southern Methodist University (SMU) Data

Geothermal data for geothermal heat pumps and EGS were obtained from SMU.

Resource Name	Description of Dataset used in Analyses	Date of Download
Temperature at Depths	Information was obtained from SMU in May 2011 in grid format. Depths provided were 3, 3.5, 4.5, 5.5, and 6.5 kilometers (km). Temperature –at-Depth Maps for the Conterminous U.S. and Geothermal Resource Estimates. David Blackwell, Maria Richards, Zachary Frone, Joseph Batir, Andres Ruzo, Ryan Dingwall, and Mitchell Williams, Geothermal Laboratory, SMU, Dallas, Texas 75275 Geothermal Resources Transactions, October 2011.	5/2011
Surface Temperature	Grid depth information was obtained from SMU on June 27, 2009. (Dr. David Blackwell, Maria Richards and Petru Negraru, 2006, SMU Geothermal Laboratory Temperature Maps).	6/27/2009

Resource Name	Description of Dataset used in Analyses	Date of Download
Heat Flow Gradient	Data were obtained from the 2004 Geothermal Map of the United States. (Dr. David Blackwell and Maria Richards, Geothermal Map of North America, AAPG Map, scale 1:6,500,000, Product Code 423, 2004).	5/1/2009

U. S. Geological Survey (USGS)

Geothermal data for hydrothermal potential were obtained from USGS.

Resource Name	Description of Dataset used in Analyses	Date of Download
Identified Moderate and High Temperature Geothermal Systems of the Western United States including AK and HI	This dataset contains the locations of identified moderate (90 - 150° C) and high (> 150° C) temperature geothermal systems and associated reservoir volumes, temperatures, and estimated electric power generation potential. This is to be used to identify locations and characteristics of identified geothermal systems. http://certmapper.cr.usgs.gov/data/geothermal/western_us/spatial/shape/identifiedgeothermalsystems.zip	6/2015
Geothermal Favorability Map Derived From Logistic Regression Models of the Western United States	This dataset shows relative favorability for the presence of geothermal systems in the western United States. It is intended to highlight areas of elevated potential for the presence of undiscovered moderate (90 - 150° C) to high (> 150° C) temperature geothermal systems. It is not meant to be used to locate exact areas for exploration. http://certmapper.cr.usgs.gov/data/geothermal/western_us/spatial/shape/favorabilitysurface.zip	6/2015

Renewable Energy Zone (REZ) Data

REZs typically look at high renewable resource areas (i.e., areas that have a high potential for generating a specific number of megawatts via solar, wind, biomass, or geothermal). From these high resource areas, exclusion and avoidance areas, such as sensitive environmental areas and inaccessible areas, among others, are removed and the remaining areas are identified as prime areas for potential renewable energy development. Five REZs were identified at the time this document was completed; however other states and regions are in the process of creating and generating REZs.

Resource Name	Description of Dataset used in Analyses	Date of Download
Western Governors Association	Identifies areas with the potential for large scale development of renewable resources and low environmental impacts, subject to resource-specific permitting processes. The Western Governors Association and Department of Energy jointly produced the Western REZ. This dataset was provided by the Western Governors Association	6/2015
Bureau of Land Management (BLM) Solar Zones	BLM-administered lands potentially available for solar development and which are proposed as priority development areas for utility scale solar energy facilities These files were downloaded from www.solareis.anl.gov/maps/resource/index.cfm .	6/2015
Colorado State Wind and Solar Generation Development Areas	Areas where the resource can be developed with competition among developers for utility-scale wind and solar projects. These datasets were obtained from the Governor's Energy Office.	6/2015
California Competitive Renewable Energy Zones	Areas of developable resources (without significant, immitigable, barriers to development). This dataset was downloaded from www.energy.ca.gov/reti/documents/	6/2015
Utah Renewable Energy Zones	The Utah Renewable Energy Zones (UREZ) identifies areas in Utah where utility-scale renewable energy development could occur and assesses the electrical generation potential of wind, solar, and geothermal technologies. ftp://ftp.agrc.utah.gov/UtahSGID_Vector/UTM12_NAD83/ENERGY/PackagedData/_Statewide/RenewableEnergyResources/	6/2015

Database of State Incentives for Renewables & Efficiency (DSIRE) Data

DOE's DSIRE website is a comprehensive database of information on state, local, utility, and federal incentives and policies that promote renewable energy and energy efficiency. DSIRE was consulted for information for the PV policy criteria Analysis was completed August 2015. Refer to www.dsireusa.org for the most up-to-date information regarding state and federal policies.

ESRI Data

ESRI software, copyright 2001-2006

Resource Name	Description of Dataset used in Analyses	Date of Download
U.S. Highways (highways.sdc)	Used to calculate the approximate distance to the nearest graded road.	N/A

CONTACT INFORMATION

For more information, visit www.epa.gov/renewableenergyland or contact EPA's RE-Powering America's Land Initiative at cleanenergy@epa.gov.

Program and regional contacts are available at: www.epa.gov/renewableenergyland/rd_contacts.htm.