

RE-POWERING AMERICA'S LAND INITIATIVE:

RE-POWERING MAPPER USER GUIDE AND DATA DOCUMENTATION

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*Office of Communications, Partnerships and Analysis
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1. INTRODUCTION TO THE RE-POWERING MAPPER

The RE-Powering Mapper (Mapper) provides federal and state data for over 190,000 brownfields, landfills, mine sites and other contaminated lands (collectively referred to as "RE-Powering sites" in this document) to help users identify sites for renewable energy development. Sites have been pre-screened for renewable energy potential using criteria from the National Renewable Energy Lab (NREL). **Please note: the sites were not evaluated for land use constraints or current conditions. Additional research and site-specific analyses are needed to verify viability for renewable energy project development at a given site.**¹

This user guide and data documentation accompanies the EPA RE-Powering America's Land Mapper 3.0 tool. The RE-Powering Mapper is a Web-based application that provides location data for RE-Powering sites that were collected from state and federal sources and pre-screened for renewable energy potential. A data layer (points) is provided with this renewable energy screened data. In addition to the point layer, the Mapper has additional supporting layers including Superfund site polygons, tribal boundaries, demographic information, roads, transmission lines, substations, solar radiance, wind speed, biomass feedstock and others.

Users can filter on multiple attributes to focus on the desired geographic scale, project size and/or distance to substations, among other details. A list of all attributes associated with the data layers can be found in Appendix A of this publication. The Mapper application includes several functional tools/widgets that are explained in Section 4.

The data points for RE-Powering sites are accessible through the Mapper and available for download from the [Mapper landing page](#).

For more information about data sources and the screening process, please see Section 5.

¹ The RE-Powering Mapper and associated documents are provided solely as general information on screening potentially or formerly contaminated lands, landfills and mine sites for renewable energy potential. It does not address all information, factors or considerations that may be relevant in a particular situation. Results do not reflect an endorsement or recommendation for development potential by EPA. References to third-party publications, websites, commercial products, process or services by trade name, trademark, manufacturer, or otherwise, are for informational purposes only. No endorsement or recommendation should be inferred and is not implied. EPA, NREL and the United States Government do not endorse any non-federal product service or enterprise.

2. QUICK START

Use this section if you want a quick overview of the main tools included in the RE-Powering Mapper 3.0 to assist you in quickly getting started using the RE-Powering Mapper.

Toolbar Widget Menu

The Toolbar Widget Menu includes tools to do the following: view the legend and turn layers on and off, filter, open attribute table, measure, change the basemap, create a bookmark of a view, print and use predefined queries.

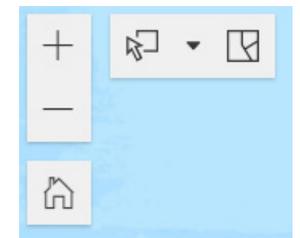


How to Filter and Search for RE-Powering Sites

- Select the Filter tool in the bottom middle of the screen and open the layers to select one or multiple options to filter the sites.
- Select a point in the map to view a pop-up with more information about that site.
- Turn on additional map layers by using the Layers and Legend tool to learn more about the site and surrounding area. Detailed site information, including site boundary, access and use limitations and other features, are available in some cases.
- To view or export a list of site results, use the Attribute tool to open the RE-Powering Site Attribute list and then right click on the table and select Export.
- Use the Predefined Queries tool to quickly identify lists of some of the most frequently searched site types.
- Use the search tool to search based on RE-Powering Site Name or location.

Actions Menu

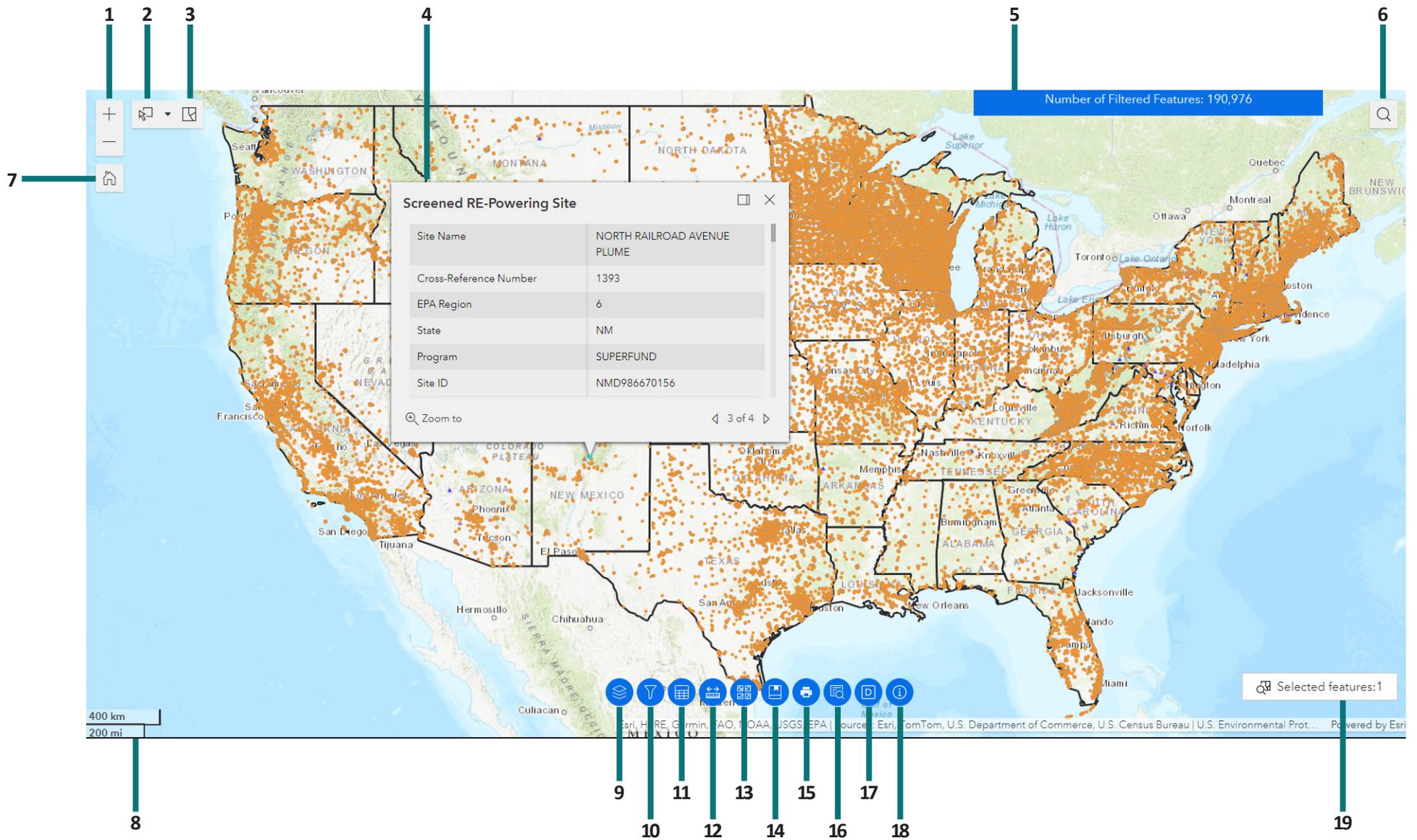
In the top left corner, zoom in and out, return to home view, select features and clear selections.



3. MAPPER ELEMENTS

To help learn about the Mapper Elements, this user manual assigns a number to each element—as shown and described below. These numbers are referenced throughout the user manual and are inside brackets; for example, references to the Layer and Legend icon have a [9] after it.

1. Mapper **Zoom In/Out** buttons.
2. **Select Features** allows users to use mouse to select features on the map.
3. **Unselect Features** unselects selected features.
4. Site-associated **Pop-Up** box shows attributes associated with a particular site. Information is pulled from the attribute table.
5. **Number of Filtered Features** provides a count of the Screened RE-Powering Sites that meet any filter settings.
6. **Search** allows user to easily find location or sites of interest.
7. **Home** returns map to original full extent (i.e., national view).
8. **Scale Bar** shows the scale of the map extent.
9. **Layers and Legend** tool allows users to control the layers and shows the symbology for each layer.
10. **Filter** tool allows users to filter the Screened RE-Powering sites to aid in identifying sites that meet specific criteria.
11. **Attribute Table** contains all the information that is connected to each site. The table may be sorted and filtered.
12. **Measure** tool measures area or distance.
13. **Basemap** tool changes the background image of the map.
14. **Bookmark** tool allows user to save a place of interest.
15. **Print** tool is used to print an image of the current map extent.
16. **Predefined Queries** tool includes a few pre-set frequently asked questions of the data.
17. **Add Data** tool enables the user to add data from individual, organizational or ArcGIS Online data libraries.
18. **Information/About** page describes the purpose of the Mapper tool and where to find more information about the data.
19. **Selected Features** provides a count of features that were selected using the Select Features tool.



4. USING THE MAPPER FUNCTIONS

4.1 Opening the Mapper

When you first open the Mapper tool from the RE-Powering landing page, you will see a box with an explanation of the Mapper and contact information for the RE-Powering America's Land Initiative. Click "OK" to access the application.

The Mapper will be populated with orange dots  representing the RE-Powering sites pre-screened for solar, wind, biopower and geothermal energy potential and purple triangles , representing completed renewable energy projects on contaminated lands. The active layers and their symbols will be visible in the Layer and Legend panel, which can be opened by selecting the

Layer and Legend icon  [9] at the bottom of the screen.

Note: The time it takes to load data into the web map roughly corresponds to internet speed, plus the number of layers you want to visualize and the scale at which you are looking at the map. Thus, it may take a few more seconds to load all data for the whole United States than to load one layer for a particular community.

4.2 Getting Around the Mapper

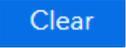
This section explains how to turn layers on and off, change the basemap, access the about information, zoom in an out of the map and go to the home page.

4.2.1 HOW TO ACCESS INFORMATION ABOUT THE MAPPER

If you are in the Mapper, click on the *About* icon  [18]. This tool will open a welcome screen that provides information about the RE-Powering Mapping application and links to resources like RE-Powering Team [contact information](#) and this User Guide.

4.2.2 TURNING DATA LAYERS ON AND OFF

You can turn layers on or off at any time.

1. If not already displayed, click the *Layers and Legend* icon  [9] (see Figure 1)
2. Expand layer groups by clicking the triangle  next to the group name to turn on and off each layer you wish to view.
3. To turn on layers, click the box next to the layer group name, which allows the layers in the group to be individually turned on and off. A check in the box indicates a layer is on; **note: the parent layer must be on before the child layer is viewable on the map (see Figure 1 below).**
4. Click the checked box to turn the layer off and remove it from map view.
5. Adjust opacity of each layer in the *Layers and Legend* tool by selecting  and using the up and down arrows to obtain the desired opacity. This can be useful when viewing multiple layers that overlap. **Note: Changing the opacity, or transparency, of a layer in a map allows you to see more, or less, of the underlying layers. In other words, it controls how much the layers below can show through.**
6. Click  to reset the layer visibility to the original view.

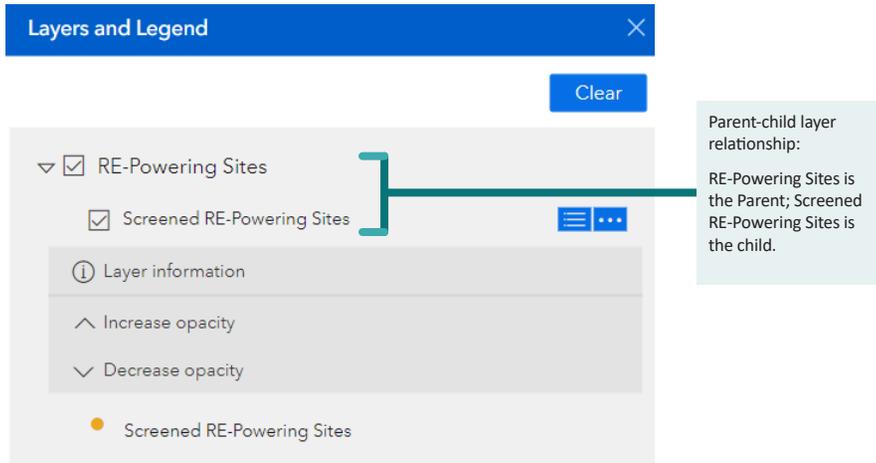


Figure 1: Layers and Legend Dialogue Box

4.2.3 ACCESSING THE ATTRIBUTE TABLE

Users can open an attribute table for the Screened RE-Powering sites by clicking

on the *Attribute Table* icon  [11]. This will open the attribute table, where users can scroll through site information for RE-Powering sites (see Figure 2). Users can also order RE-Powering sites by attribute by clicking the column

header, show selected features , clear selected features ,

reset the attribute table , hide columns  or export attribute table

content  (**note: you are limited to exporting 5,000 records at a time**).

Attribute Table

RE-Powering Sites

State	Program	Site ID	Site Information	Site Name
ME	AML	MED055715775	https://cumulis.epa.gov/s...	KERRAMERICA
VT	AML	VTN000105222	https://cumulis.epa.gov/s...	VERMONT ASE
NJ	AML	NJD067387472	https://cumulis.epa.gov/s...	WR GRACE HA
NY	AML	NYN000202035	https://cumulis.epa.gov/s...	WURTSBORO

Figure 2: Attribute Table

4.2.4 CHANGING THE BACKGROUND

The default background for the Mapper is a topographic map, which may be useful to get a better sense of terrain or to see names of places. If you would prefer a simpler background, a street-based background or even aerial photography, there are several options available that you can select depending

on your needs. To change the background, click on the *Basemap* icon  [13]. Choose from among the available options by clicking on the background type you wish to display (see Figure 3).

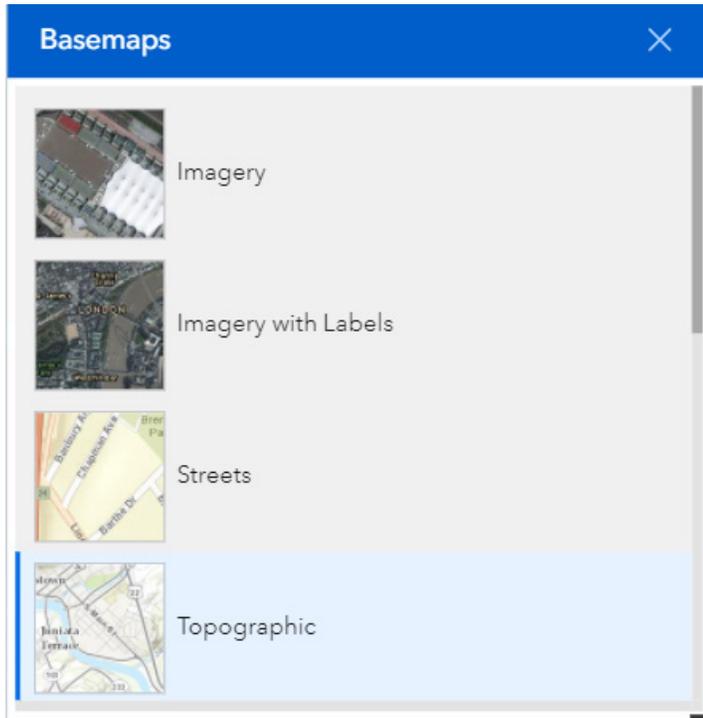


Figure 3: Changing the Basemap

4.2.5 ZOOM



To zoom in or out of the map use the *Zoom* tool [1] located in the upper left corner of the RE-Powering Mapping application. The “+” sign zooms the map in closer and the “-” zooms the map out.

4.2.6 HOME



The *Home* icon [7] located in the upper left corner of the Mapper application resets the mapping application view back to original extent.

4.3 Selecting Sites

There are several ways to search for sites using the **Filter**, **Predefined Queries**, **Search or Select Features** tools. Each of these tools is described in the sections below.

4.3.1 FILTER TOOL

The **Filter** tool is in the toolbar at the bottom of the screen and is accessed



by selecting the icon [10]. The filter dialogue box will open (see Figure 4). Expand the filter by selecting the triangle ▶, populate the filter as described by the text and toggle the filter on and off by using the sliding button . If the filter does not appear to be working, double check that you have turned it on with the sliding button. Multiple filters can be applied at the same time to create a specific set of sites that meet multiple requirements. The selected filters dynamically alter the map display to show only those filtered sites. The “Number of Filtered Features” **Number of Filtered Features: 17,756** at the top right also changes to indicate the number of filtered sites. The sites displayed in the attribute table also dynamically change to reflect what was selected by the filters.

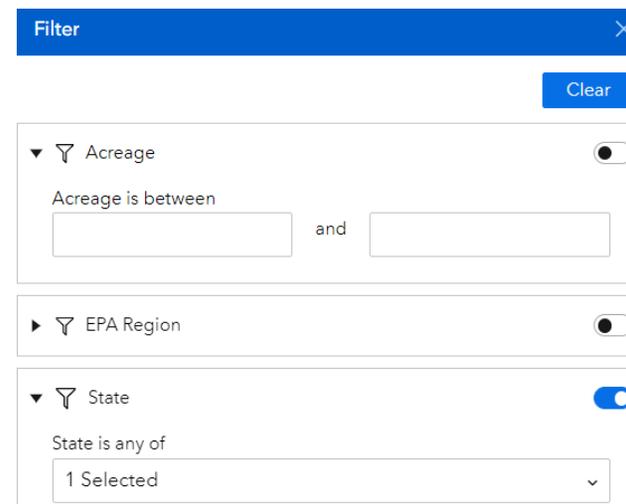


Figure 4: Filter Tool

4.3.1.1 Clearing the Filters

Use the clear button  at the top right of the filter box, to clear the filters from the map. This feature only turns off the filters, it does not reset your selections. If you wish to reapply your previously selected filters, just click the sliding button to turn the filter back on  again.

4.3.2 PREDEFINED QUERIES TOOL

The **Predefined Queries** tool  [16] is in the toolbar in the bottom center of the screen. Using this tool opens a list of predefined queries for some of the most common inquiries that RE-Powering has received. These lists can be a useful starting point for identifying and generating a list of potential sites. Click on the predefined query of interest (see Figure 5) to initialize the query.

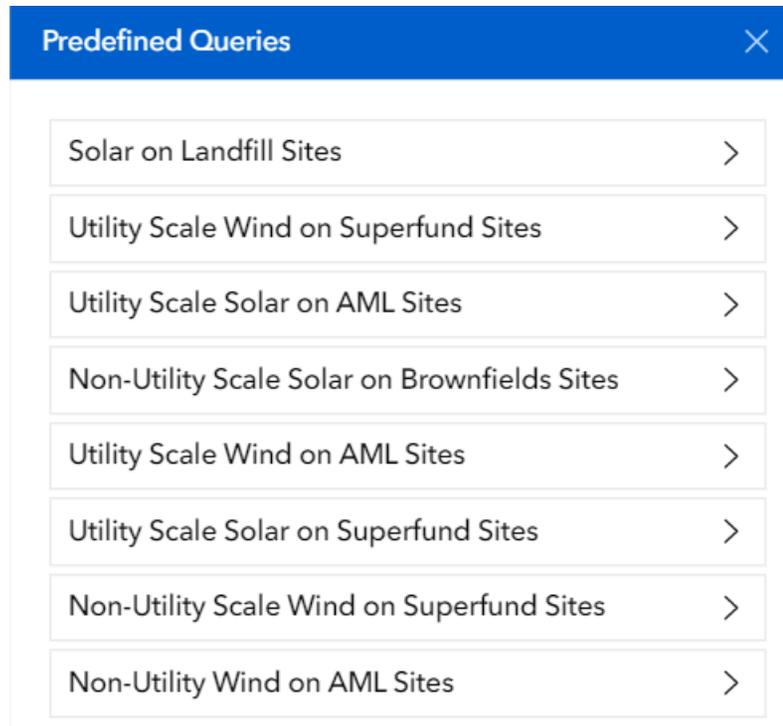


Figure 5: Predefined Queries

A description of the query will appear (see Figure 6). To run a query, click “Apply”.

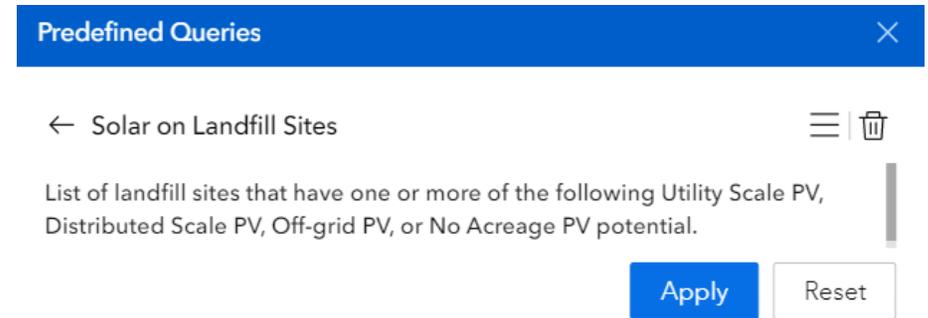


Figure 6: Predefined Query Description

The list of sites will be displayed after running the query (see [Exporting Data](#)). Click the four dots  in the right corner options to export the list (exporting is limited to 5,000 records), zoom, view in table, pan and show on map (sites will be highlighted in yellow) (See Figure 7).

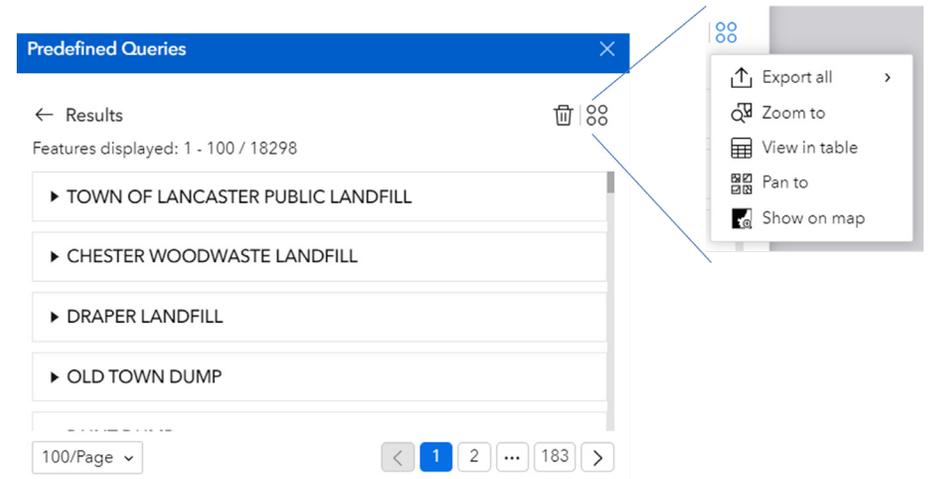


Figure 7: Predefined Query Results

4.3.3 SEARCH TOOL

The **Search** tool allows a user to search for a specific geographic location (for example a street address or county) or specific site name included in the

RE-Powering dataset. Select the magnifying glass  [6] in the upper right corner of the application. As you start typing, options that match your query will appear in a drop-down menu. In Figure 8 below you can see both a RE-Powering site name and a location are provided as choices. You can continue populating the field or select the correct item you wish to explore. The map will automatically zoom to the location. This tool is useful if you are interested in a particular site or area, while the Filter and Predefined Query tool are useful for generating lists of specific sites.

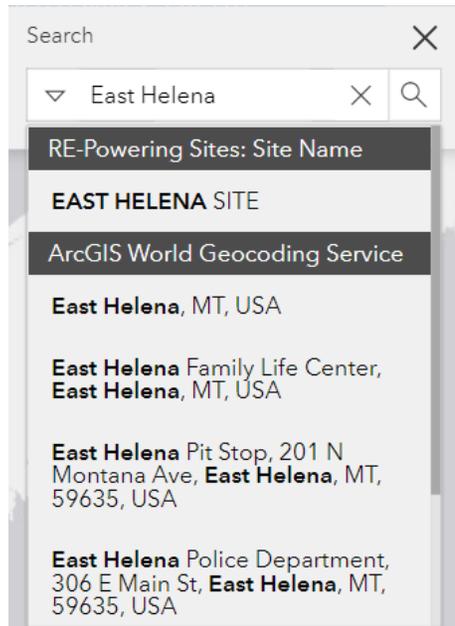


Figure 8: Search Tool

4.3.4 SELECTION TOOL

The **Select Features** tool  [2] allows a user to select features on the map. After clicking the tool, some options appear (see Figure 9), click the downward triangle to open options for the tool. You can select features in a rectangle, polygon, circle or along a line or a point. You can view and/or export selected sites in the attribute table (see Figure 9).

Use the **Clear Features** tool  [3] to clear selections. Features will be selected from all layers that are active. Click the Select Features tool again to deactivate the tool (tool is blue when active, gray when not active).

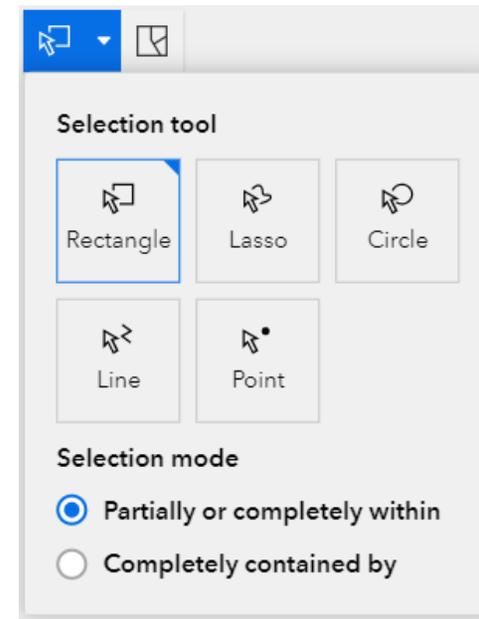


Figure 9: Select Features

4.3.5 EXAMPLES OF HOW TO FIND SITES

Example question 1:

Where are the landfills that have been pre-screened positively for solar in Massachusetts?

1. Click on the *Filter* icon [10].
2. Select the state filter and select "MA."
3. Turn the filter on with sliding button
4. Click on the *Predefined Queries* icon.
5. Apply the "Solar on Landfill Sites" query.

Sites that fit these criteria will now be displayed (if you followed the above steps there will be 547 features in the table). You may export, zoom to, view in table, pan to and show on map (sites will be highlighted in yellow).

Example question 2:

How many wind sites have a potential capacity of greater than 10 MW?

1. Click the Filter icon [10] to open the filter tool.
2. Turn on the Wind Potential filter by sliding the button.
3. Expand the Estimated Wind Energy Capacity (MW) filter.
4. Populate the Estimated Wind Energy Capacity is between boxes with 10 and 1600 (**note: 1,600 is the maximum wind capacity value used for the RE-Powering sites**).

Sites that fit these criteria will now be displayed on the map and in the attribute table (there will be 717 filtered features). You can export the table if you want.

4.4 Adding Data to the Mapper



In some instances, the user may wish to *Add Data* [17] layers to the Mapper. There are three ways to add data:

- **Search ArcGIS Online Content** – this allows you to search the ArcGIS online content for published data layers to add to your map.
- **Feature Service Layer URL** – if you know the URL for a feature service you wish to add you can type or paste the URL here.
- **A zipped shapefile or a GEOJSON file** – if you have your own geospatial data, you can add zipped shapefiles and GEOJSON files here.

Any data layers that are added to the RE-Powering Mapper will appear in the Layers and Legend and users can turn the layers on or off or adjust the opacity within this tool.

Figure 10 shows the add data screen for the ArcGIS online content, layers can be sorted several ways. Click "Add" to add the layer to the RE-Powering Mapper. To remove an added layer, select "Remove layers from the map."

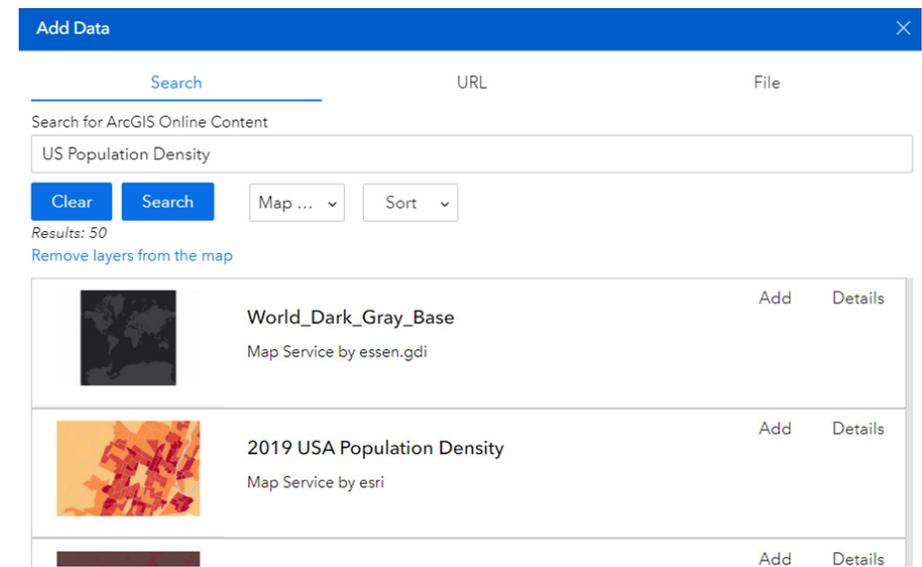


Figure 10: Adding ArcGIS Online Content

Figure 11 shows how to add data using an URL. Type or copy/paste the URL in the entry form and select **Add Layer** to add data. Press **Clear** to remove the layer from the Mapper.

The screenshot shows the 'Add Data' dialog box with a search bar containing 'URL'. Below the search bar, there is a text input field with the URL: `https://services1.arcgis.com/Hp6G80Pky0om7QvQ/arcgis/rest/services/General_Manufacturing_Facilities/Feat...`. There are 'Clear' and 'Add Layer' buttons at the bottom.

Figure 11: Adding Data Using An URL

Figure 12 shows how to add shapefiles or GEOJSON files. Shapefiles need to be zipped before they can be added. To add the files select **Choose File** and navigate to the file you wish to add, then select **Add Layer** to add data. Press **Clear** to remove the layer from the Mapper.

The screenshot shows the 'Add Data' dialog box with a search bar containing 'File'. Below the search bar, there is a checkbox labeled 'Generalize features for web display' which is checked. A dashed box indicates the file upload area with the text 'File to upload: NPL_Boundaries.zip'. Below this, there is a 'Choose File' button and the filename 'NPL_Boundaries.zip'. At the bottom, there are 'Clear' and 'Add Layer' buttons. A note at the bottom states 'Supported formats: zipped *.shp, *.geojson'.

Figure 12: Adding Shapefiles

4.5 Printing and Exporting Data

Sometimes it may be useful to print a map or export data to share with others, include in a report or save for later. This can be especially useful if you do not have a GIS department or to share information or provide an example for your GIS department or others.

4.5.1 PRINTING DATA

Images can be printed directly from the application. The print function will print

the current view of the mapping application. Click on the Print icon [15] in the toolbar at the bottom center of the screen. This will open the print dialogue box (Figure 13). Here you will have some options to choose from:

- Layout is the size and view of the printout.
- Format lets you choose from many common formats (PDF, PNG, JPG, GIF and more) to better suit your needs.
- Advanced Options let you add an author and/or copyright if you choose.
- Once the file has finished printing, click on the hyperlink under "Printed files" (Landfill.pdf in Figure 13 below) to open the map.

The screenshot shows the 'Print' dialog box. It has a 'Print Title' field with 'Landfill'. The 'Layout' dropdown is set to 'A3 Landscape' and the 'Format' dropdown is set to 'PDF'. There is an 'Advanced Options' button with a right-pointing arrow. A 'Print' button with a printer icon is at the bottom right. Below the print settings, there is a 'Printed files' section with a 'Clear' button and a list containing 'Landfill.pdf' with a document icon.

Figure 13: Printing a Map

Note: printing may take a few seconds depending on how many features are included and the extent of the zoom. While printing is in progress the name of the file under "Printed files" is grayed out with a circle:



when the printed file is complete the name of the file is darker with a square:



Landfill



April 20, 2022

State Boundaries

Superfund Site Boundaries

1:25,890

0 0.17 0.35 0.7 mi

0 0.3 0.6 1.2 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 14: Example of a Printed Map

The printout includes a collar with a map title, legend, date and scale bar (See figure 14). Unless you chose to print "Map Only" and then no mapping collar or information is included.

4.5.2 EXPORTING DATA

To export your lists from the above filters or any other specific search click in the



Attribute Table icon [11]. This will open the attribute table; click the four

dots in the right corner to expand the options for exporting (see Figure 15).

You are limited to exporting 5,000 records at a time. If you wish to obtain all the sites, you can download a Microsoft Excel file or a geodatabase containing all the RE-Powering sites [here](#).

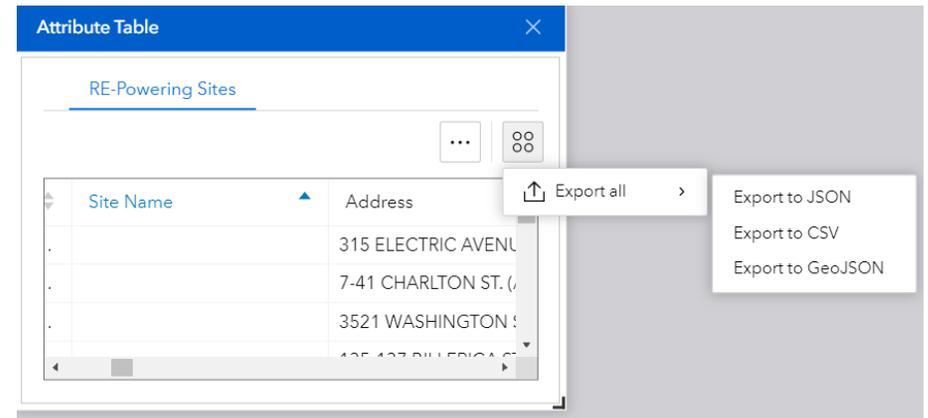


Figure 15: Exporting Data

4.6 Measuring Features

A user may know an area well and want to use knowledge of a site boundary to take a measurement of an area. Or a user may want to calculate the distance of a site to another feature on the landscape. The Measure tool [12] allows a user to do both.

Click Measure icon  [12], in the toolbar at the bottom center of the screen. This will open the Measure tool (Figure 16).

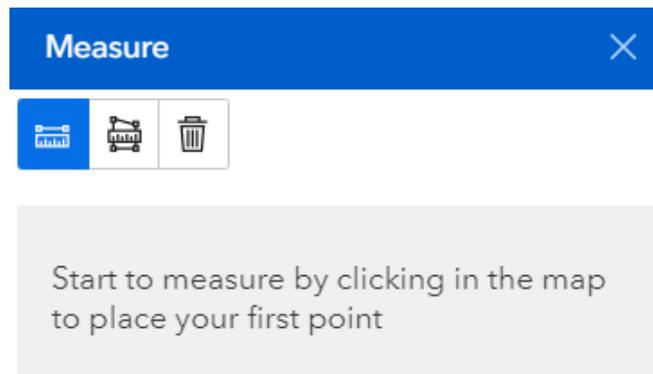


Figure 16: Measure Tool

Click on  to measure distance in a line. Click along the line to measure a distance. Double click on the last point to finish the measurement.

Click  to measure a polygon area. Click at the vertices of your polygon to measure the area. Double click on the last point to finish the measurement. Use the drop down menu to change units (see Figure 17).

4.6.1 EXAMPLE OF TAKING A MEASUREMENT

Example question:

What is the area of a landfill of interest?

- Open the Measure tool  [12].
- Select the polygon measuring tool .
- Click on the vertices of the polygon.
- Double click to close the polygon.
- Use the drop-down menu to change the units to Acres.

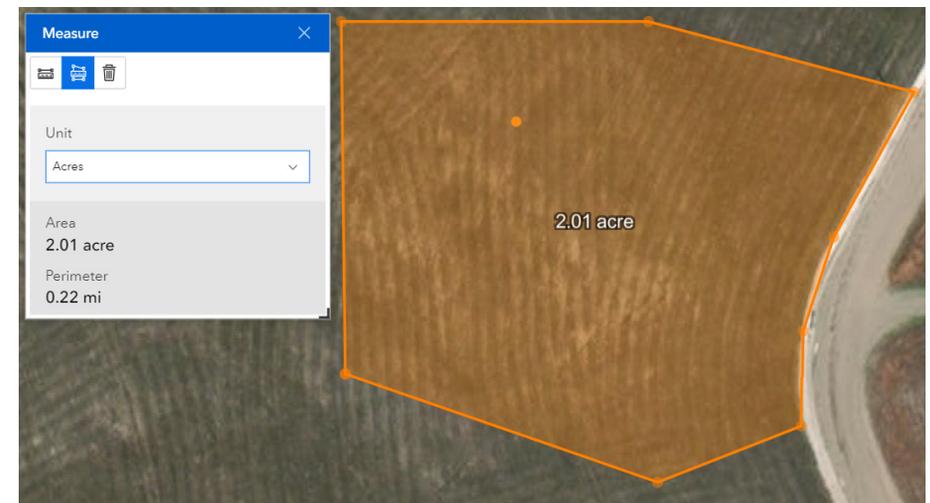


Figure 17: Example of Using the Measure Tool

4.7 Bookmarking

It may be necessary for a user to keep track of places that are meaningful or worth saving for future review. In this case, you can use the Bookmark tool



[14] to create a custom bookmark to the desired location, layers and scale. These will be available any time you open the application. To add a Bookmark, zoom to the desired spot, type in the name and click the plus button (Figure 18).

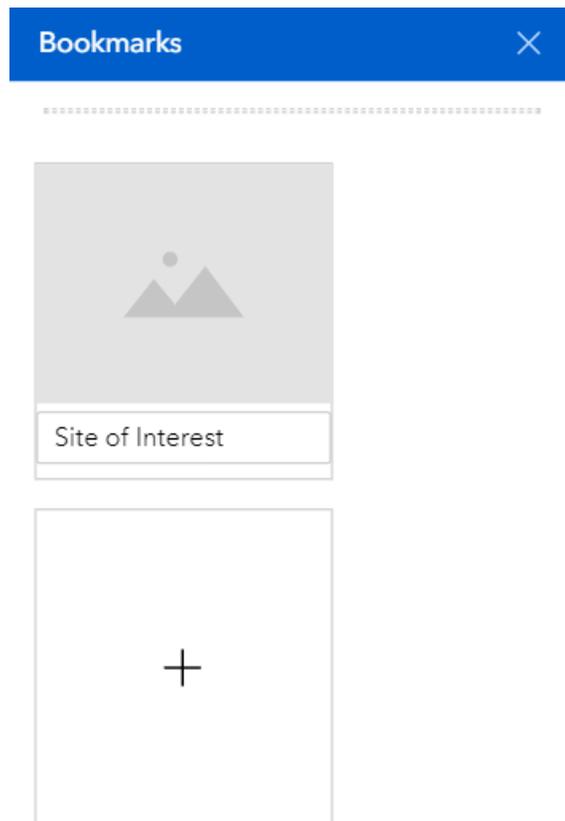


Figure 18: Bookmark

4.8 Read Pop-up Box for Site Information Summary

You may wish to see a quick snapshot of a site of interest. Pop-up boxes have information about a site, drawn directly from the attribute table. The box appears when the user clicks on the site symbol in the map. In addition to pop-ups for the RE-Powering sites, they are also available for the other layers.

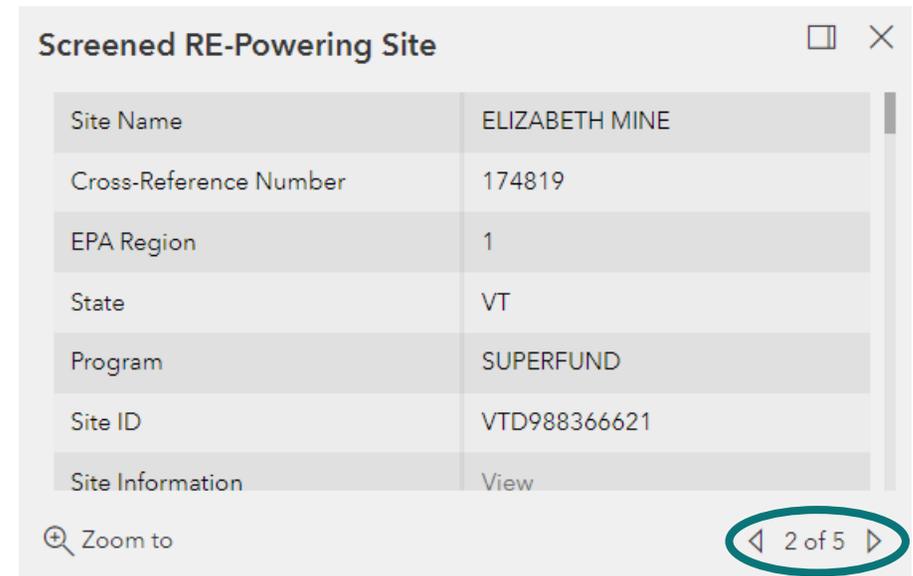


Figure 19: Screened RE-Powering Site Pop-up

Sometimes there might be multiple entries made when you click on a site. This could be due to selecting multiple sites or multiple layers are turned on. You can click on a site and scroll through the pop-up boxes using the arrows at the bottom of the pop-up. The example in Figure 19 has five popups. The popups can also be docked in the mapping application for easier viewing.

Inside the Pop-Up box, you will see two links that provide more specific information about the site and might be useful in determining an appropriate reuse option for the site (Figure 20).

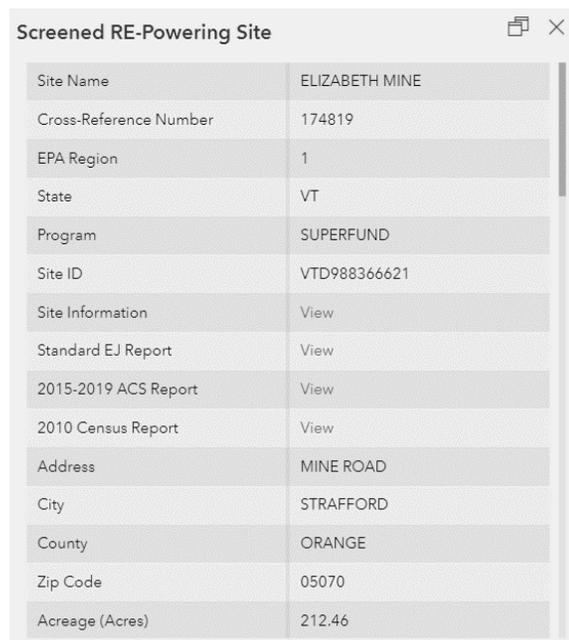
- **Site Information** links to EPA or state program responsible for managing the site and includes more information about the site clean-up progress and status.
- **RE-Powering Profile** links to a summary page describing the renewable energy screening results for that site.

4.9 Accessing Environmental Justice and Demographic Data

Users may wish to see potential EJ issues or demographic information near a particular site. The site pop-up boxes have links that will provide this information. Click on the site of interest and scroll down to these three links (see Figure 20):

- **Standard EJ Report** links to the standard EPA EJ Screen report based on the latitude and longitude of the site with a 1-mile radius.
- **2015-2019 ACS Report** links to the EPA EJ Screen 2015-2019 ACS report and is based on the latitude and longitude of the site with a 1-mile radius.
- **2010 Census Report** links to the EPA EJ Screen 2010 Census report and is based on the latitude and longitude of the site with a 1-mile radius.

This data is provided by EPA's EJScreen: Environmental Justice Screening and Mapping Tool. For more information, visit <https://www.epa.gov/ejscreen>.



Screened RE-Powering Site	
Site Name	ELIZABETH MINE
Cross-Reference Number	174819
EPA Region	1
State	VT
Program	SUPERFUND
Site ID	VTD988366621
Site Information	View
Standard EJ Report	View
2015-2019 ACS Report	View
2010 Census Report	View
Address	MINE ROAD
City	STRAFFORD
County	ORANGE
Zip Code	05070
Acreage (Acres)	212.46

Figure 20: Accessing EJ Screen Report for Screened RE-Powering Sites

In addition to the reports available in the pop-up for each site, Demographic Information layers are included in the Layers and Legend tool. These data layers are provided by EJScreen and include the following:

- **Demographic Index:** The Demographic Index in EJSCREEN is created using the two demographic indicators that were explicitly named in EO12898, low-income and people of color. For each Census block group, these two indicators are simply averaged together: $\text{Demographic Index} = (\% \text{ people of color} + \% \text{ low-income}) / 2$.
- **People of Color:** The percent 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. That is, all people other than non-Hispanic white-alone individuals. The word "alone" in this case indicates that the person is of a single race, not multiracial.
- **Low Income:** The percent of a block group's population in households where the household income is less than or equal to twice the federal "poverty level."
- **Unemployment Rate:** The percent of a block group's population that did not have a job at all during the reporting period, made at least one specific active effort to find a job during the prior 4 weeks, and were available for work (unless temporarily ill).
- **Linguistically Isolated:** Percent of people in a block group living in linguistically isolated households. A household in which all members aged 4 years and over speak a non-English language and speak English less than "very well" (have difficulty with English) is linguistically isolated.
- **Less Than High School Education:** Percent of people aged 25 or older in a block group whose education is short of a high school diploma.
- **Individuals under age 5:** Percent of people in a block group under the age of 5.
- **Individuals over age 64:** Percent of people in a block group over the age of 64.

4.10 Data Layers Included

The data layers presented below show RE-Powering specific information and supplemental information to help users better visualize site details and information that might be beneficial in determining renewable energy potential at these sites. Figure 21 shows the parent data layer categories. Below is a brief description of the layers provided, metadata can be accessed within the RE-Powering Mapper.

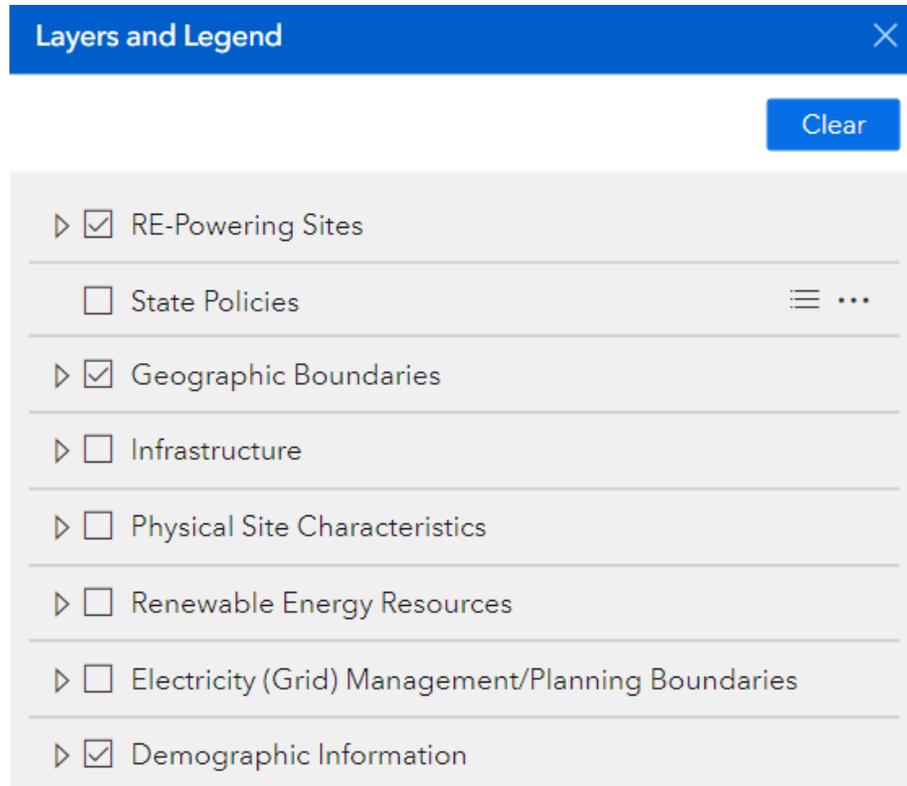


Figure 21: List of Layer Categories

RE-POWERING LAYERS

- **RE-Powering Sites**
 - *Screened RE-Powering Sites* - national set of contaminated lands, landfills and mine sites that have pre-screened favorably for solar (PV), wind, biomass and geothermal heat pump resource potential.
 - *Completed Renewable Energy Projects* – this dataset reflects completed (currently operating) renewable energy installations on contaminated lands, landfills and mine sites. See RE-Powering America's Land Tracking Matrix (<https://www.epa.gov/re-powering/re-powering-tracking-matrix>) for more information on these sites.
 - *State Policies* - the economic viability of renewable energy projects is closely tied to the policy context of the jurisdiction in which the projects are sited. States have adopted numerous policies to support greater investment in renewable technologies. The RE-Powering Mapper includes a layer with common types of policies that support or can be conducive to renewable energy at the state level.

SUPPLEMENTAL LAYERS

- **Geographic Boundaries**
 - *State Boundaries* – shows the borders of a state.
 - *Counties* – displays county boundaries.
 - *American Indian Reservations* - represents locations of American Indian Reservation lands in the lower 48 states as well as Alaska. The areas include all Reservations associated with Federally recognized tribal entities.
 - *Superfund Site Boundaries* - contains polygons depicting EPA Superfund Site boundaries.
 - *Superfund Operable Unit Boundaries* - contains polygons depicting EPA Superfund Operable Unit boundaries.
 - *Superfund Institutional Control Boundaries* - contains polygons depicting EPA Superfund Institutional Control boundaries.

- **Infrastructure**

- *Electric Substations* - represents electric power substations primarily associated with electric power transmission.
- *Electric Transmission Lines* - represents electric power transmission lines.
- *Power Plants* - represents electric power plants.
- *Transportation* - consists of roads, railroads, trails, airports and other features associated with the transport of people or commerce.

- **Physical Site Characteristics**

- *Land Cover* - provides nationwide data on land cover classes at a 30m resolution.
- *Slope/Hillshade* - provides a hill-shaded surface generated dynamically using the elevation layer with a solar azimuth of 315 degrees and solar altitude of 45 degrees.

- **Renewable Energy Resources**

- *Solar* - provides annual average daily total solar resource averaged over surface cells of 0.038 degrees in both latitude and longitude, or nominally 4 km in size.
- *Wind* - multi-year (2007-2013) annual average wind speed, meters per second, at 80 meters above surface level.
- *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.

- **Electricity (Grid) Management/Planning Boundaries**

- *Electric Retail Service* - represents electric power retail service territories. These are areas serviced by electric power utilities responsible for the retail sale of electric power to local customers, whether residential, industrial or commercial.
- *NERC Regions* - Represents North American Electric Reliability Corporation (NERC) regions. NERC is an international regulatory authority that works to improve the reliability of the bulk power system in North America.
- *Control Areas (Balancing Authorities)* - represents electric power control areas. Control Areas, also known as Balancing Authority Areas, are controlled by Balancing Authorities, who are responsible for monitoring and balancing the generation, load, and transmission of electric power within their region, often comprised of the retail service territories of numerous electric power utilities.
- *Independent System Operators* - represents electric power Independent System Operators. Independent System Operators were set up by the Federal Energy Regulatory Commission (FERC) to provide non-discriminatory access to power and to more adequately administer the transmission grid on a regional basis throughout North America.

- **Demographic Information** - see [Section 4.9 Accessing Environmental Justice and Demographic Data](#) for more information about the Demographic data.

5.0 DATA DOCUMENTATION FOR MAPPING AND SCREENING CRITERIA FOR RENEWABLE ENERGY GENERATION POTENTIAL ON EPA- AND STATE-TRACKED SITES

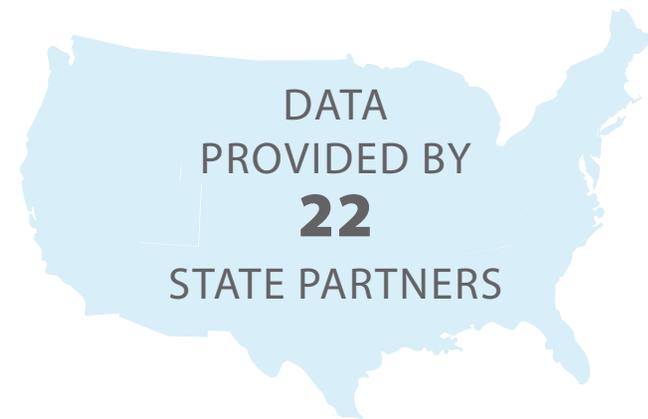
5.1 Overview

The U.S. Environmental Protection Agency (EPA) Office of Land and Emergency Management (OLEM), Office of Partnerships, Communication and Analysis (OCPA) created 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. To that end, the Initiative developed the RE-Powering Mapper tool. The tool is a publicly available spatial database of more than 190,000 sites that have been evaluated for renewable energy potential. This section details the screening process and data underlying the Mapper.

EPA developed national-level site screening criteria in partnership with the U.S. Department of Energy (DOE) National Renewable Energy Laboratory (NREL). The most recent screening occurred in August 2021. Described in this document, the screening criteria demonstrate the potential to reuse contaminated land for solar, wind, biomass and geothermal energy production based on resource availability, acreage and distance to transmission lines and roads. Although these sites have been preliminarily screened for renewable energy potential based on several technical considerations, many other factors should be considered to determine a project's ultimate feasibility. Renewable energy developers and/or relevant stakeholders usually conduct rigorous site-specific analyses to verify both technical and economic feasibility.

For the purposes of this screening, the Mapper does not consider site status in terms of clean-up or potential contamination status. Sites may or may not have been assessed and/or remediated. The Mapper database includes a link for each site to a source with more information about the site's environmental conditions.

The federal- and state-tracked sites included in this screening represent a subset of nationwide contaminated lands, landfills and mine sites. The inventory includes sites that are tracked at the national level through EPA remediation and grant programs, as well as datasets provided from 22 state partners. Many additional sites are tracked at the state and local level but EPA did not screen them in the Mapper. Information regarding state brownfields and response programs can be found [here](#).



5.2 Data, Criteria and Methodology

EPA developed an inventory of contaminated lands, landfills and mine sites from various sources, as listed here. Next, EPA screened this subset of EPA- and state-tracked sites for renewable energy resource potential, as described in the Screening Criteria.

5.2.1 SITE INFORMATION DATASETS

While EPA and state databases are refreshed regularly with new sites and updated acreage, the data in the Mapper represent a snapshot in time. The tables in this section provide sources and timing of data extraction and screening. Users should understand that the site-specific information provided herein may change over time.

EPA does not maintain or manage state datasets. Snapshots of the following states' data are included in this update of the Mapper: California, Colorado, Connecticut, Florida, Hawai'i, Illinois, Iowa, Maine, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Texas, Virginia, West Virginia, and Wisconsin.

5.2.2 EPA DATASETS

PROGRAM NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATA ACCESSED	DATE OF SCREENING
Abandoned Mine Lands (AML) Program	AML sites include abandoned hardrock mines and mineral processing sites listed in the Superfund Enterprise Management System (SEMS) at this time. Includes AML sites on the National Priorities List (NPL), often referred to as "Superfund" Sites, and abandoned mine sites where EPA has conducted response actions under Superfund Removal Authorities. Visit EPA's AML website at for more information on AMLs.	5/2021	8/2021
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 EPA Brownfields grants awarded in fiscal year 2010 and beyond, where an assessment or cleanup activity has been completed and EPA Brownfields funding was expended. Visit EPA's Brownfields website for more information about Brownfields.	3/2021	8/2021
Landfill Methane Outreach Program (LMOP)	LMOP 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 their landfill gas potential. In addition, LMOP tracks landfills that have operational, under construction or shutdown landfill gas energy projects. Visit EPA's LMOP website for more information and definitions of landfill gas energy projects.	6/2021	8/2021
Resource Conservation and Recovery Act (RCRA) – Corrective Action	RCRA sites are commercial, industrial and federal facilities that treat, store or dispose of hazardous wastes and that require cleanup under the RCRA Hazardous Waste Corrective Action Program. Includes all facilities from the RCRA Corrective Action Progress Track. Visit EPA's RCRA website for more information about RCRA.	5/2021	8/2021
Superfund	Superfund sites are inactive or abandoned contaminated facilities or locations where there is a release or threatened release, into the environment, of hazardous substances, contaminants or pollutants being dumped, discharged, emitted or otherwise improperly maintained or managed. These sites may include manufacturing and industrial facilities, processing plants, landfills and mining sites, among others. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) authorizes cleanup response actions at these sites. The data for these sites were extracted from the SEMS. This dataset includes sites listed on, proposed to and deleted from the NPL, as well as some Superfund Alternative Approach sites. Visit EPA's Superfund website for more information about Superfund.	4/2021	8/2021
Underground Storage Tanks (UST)	As of August 2021, there are over 63,000 open Leaking Underground Storage Tank (LUST) sites that have not reached cleanup completed and almost 500,000 LUST sites that have a status of cleanup complete. It is important to note that the 50 LUST sites being piloted in the RE-Powering Mapper are a very small subset of the entire LUST universe. These 50 LUST sites are considered active releases located at inactive facilities. Many more LUST sites have the potential for redevelopment. On average these sites are typically around 0.5 acres and are located along highways and major roadways in cities and towns. Given their size and location, inactive facilities, along with open gas stations with active releases, may be good candidates for electric vehicle charging stations. The national universe of UST and LUST sites can be found in EPA's UST Finder.	8/2021	8/2021

5.2.3 STATE AGENCIES

The following tables contain contact information for state agencies that provided information and data for the state-tracked sites included in the RE-Powering Mapper.

STATE	CONTACT INFORMATION
California	California Department of Toxic Substances Control EnviroStor 1001 I Street P.O. Box 806 Sacramento, CA 95812-0806 877-786-9427 Email: envirostor@dtsc.ca.gov http://www.envirostor.dtsc.ca.gov/public/
Colorado	Colorado Department of Public Health and Environment 4300 Cherry Creek Drive South Denver, CO 80246 303-692-2000 Email: cdphe.information@state.co.us https://cdphe.colorado.gov/environmental-cleanup
Connecticut	Connecticut Department of Energy and Environmental Protection 79 Elm Street Hartford, CT 06106-5127 860-424-3768 Email: mark.lewis@ct.gov Brownfields - https://portal.ct.gov/DEEP/Remediation--Site-Clean-Up/Brownfields/ Brownfields-in-Connecticut Landfills - https://portal.ct.gov/DEEP/About/Main/Waste-Management

STATE	CONTACT INFORMATION
Florida	Florida Department of Environmental Protection Brownfield Program 2600 Blair Stone Road Tallahassee, Florida 32399-2400 Name: Kelly Crain 850-245-8953 Email: Kelly.crain@dep.state.fl.us https://floridadep.gov/waste/waste-cleanup/content/brownfields-program Public Services 2600 Blair Stone Road Tallahassee, Florida 32399-2400 850-245-8765 Email: public.services@dep.state.fl.us https://floridadep.gov/ Name: Christopher Williams 850-245-8758 Email: Christopher.A.Williams@dep.state.fl.us Florida Solid Waste Management 2600 Blair Stone Road Tallahassee, Florida 32399-2400 Name: El Kromhout 850-245-8744 Email: Elizabeth.Kromhout@floridadep.gov https://floridadep.gov/waste/permitting-compliance-assistance/content/solid-waste-section Waste Cleanup Program 2600 Blair Stone Road Tallahassee, Florida 32399-2400 Name: Jennifer A. Farrell 850-245-8937 Email: Jennifer.A.Farrell@floridadep.gov https://floridadep.gov/waste/waste-cleanup

STATE	CONTACT INFORMATION
Hawaii	Hawai'i State Department of Health Hazard Evaluation and Emergency Response Office 2385 Waimano Home Road #100 Pearl City, HI 96782 Telephone: 808-586-4249 Fax: 808-586-7537 https://health.hawaii.gov/heer/
Illinois	Illinois Environmental Protection Agency Office of Site Evaluations Bureau of Land 1021 North Grand Avenue East P.O. Box 19276 Springfield, IL 62794-9276 Redevelopment Assessment Database: http://epadata.epa.state.il.us/land/ose/ose-site-evaluations-all.asp Illinois Environmental Protection Agency Site Remediation Program Bureau of Land 1021 North Grand Avenue East P.O. Box 19276 Springfield, IL 62794-9276 Site Remediation Program Database: https://www2.illinois.gov/epa/topics/cleanup-programs/bol-database/Pages/srp.aspx
Iowa	Natural Resources Department Wallace State Office Building 502 E 9th St 4th Floor Des Moines, IA 50319-0034 515-725-8200 https://www.iowadnr.gov/

STATE	CONTACT INFORMATION
Maine	Maine Department of Environmental Protection 17 State House Station 28 Tyson Drive Augusta, Maine 04333-0017 207-287-7688 https://www.maine.gov/dep/index.html
Maryland	Maryland Land Restoration Program 1800 Washington Boulevard Baltimore, MD 21230 410-537-3493 Email: mde.webmaster@maryland.gov https://mde.maryland.gov/programs/Land/MarylandBrownfieldVCP/Pages/index.aspx
Massachusetts	Clean Energy Results Program 100 Cambridge Street, Suite 1020 Boston, MA 02114 617-626-1000 Email: BWSC.Information@state.ma.us https://www.mass.gov/clean-energy-results-program
Minnesota	Minnesota Pollution Control Agency 520 Lafayette Road N. St. Paul, MN 55155-4194 800-657-3864 Email: info.pca@state.mn.us https://www.pca.state.mn.us/waste/cleanup-contaminated-sites
Missouri	Missouri Land Reclamation Program P.O. Box 176 Jefferson City, MO 65102-0176 573-751-4041 Email: mining@dnr.mo.gov https://dnr.mo.gov/land-geology/mining-land-reclamation

STATE	CONTACT INFORMATION
New Jersey	Bureau of Climate Change & Clean Energy Division of Climate, Clean Energy and Radiation Protection Air Quality, Energy and Sustainability Program New Jersey Department of Environmental Protection 401 East State Street 2nd Floor East Wing Mail Code 401-02H PO Box 420 Trenton, NJ 08625-420 609-633-0538 Email: solar-siting-analysis@dep.nj.gov https://www.state.nj.us/dep/aqes/bes.html
New York	New York Department of Environmental Conservation 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

STATE	CONTACT INFORMATION
North Carolina	North Carolina Department of Environmental Quality 217 West Jones Street Raleigh, NC 27603 Brownfields Program: https://deq.nc.gov/about/divisions/waste-management/brownfields-program Hazardous Waste Section: https://deq.nc.gov/about/divisions/waste-management/hw Solid Waste Section: https://deq.nc.gov/about/divisions/waste-management/solid-waste-section Pre-Regulatory Landfills Program: https://deq.nc.gov/about/divisions/waste-management/superfund-section/inactive-hazardous-sites-program/pre-regulatory-landfill-program
Oregon	Oregon Department of Environmental Quality Quality Environmental Cleanup Program 700 NE Multnomah St., Suite 600 Portland, OR Email: DEQInfo@deq.state.or.us https://www.oregon.gov/deq/Hazards-and-Cleanup/env-cleanup/Pages/ecsi.aspx
Pennsylvania	Bureau of Abandoned Mine Reclamation Rachel Carson State Office Building P.O. Box 69205 Harrisburg, PA 17106-9205 717-783-2267 Email: RA-epcontactus@pa.gov dep.pa.gov/AML

STATE	CONTACT INFORMATION
Rhode Island	Rhode Island Department of Environmental Management Office of Land Revitalization and Sustainable Materials Management Site Remediation Program 235 Promenade Street Providence, RI 02908-5767 401-222-2797 http://www.dem.ri.gov/programs/wastemanagement/site-remediation/
Texas	Municipal Solid Waste Permits Section, Waste Permits Division, Texas Commission on Environmental Quality Texas Commission on Environmental Quality, MC-124 P.O. Box 13087 MC124 Austin, Texas 78711-3087 512-239-2335 Email: Armando.Barrera@tceq.texas.gov https://www.tceq.texas.gov/permitting/waste_permits/msw_permits/msw-data Superfund Section, Remediation Division, Texas Commission on Environmental Quality Texas Commission on Environmental Quality, MC-136 P.O. Box 13087 MC136 Austin, Texas 78711-3087 Phone: 512-239-2505 Fax: 512-239-2450 Texas Commission on Environmental Quality Voluntary Cleanup Program Section MC-221 P.O. Box 13087 Austin, Texas 78711-3087 512-239-2200 Email: vcp@tceq.texas.gov

STATE	CONTACT INFORMATION
Virginia	Abandoned Coal Mine Areas Virginia Division of Mined Land Reclamation 3405 Mountain Empire Road P.O. Drawer 900 Big Stone Gap, VA 24219 276-523-8100 Email: dmlrinfo@dmme.virginia.gov https://energy.virginia.gov/coal/mined-land-repurposing/mined-land-repurposing.shtml Orphaned Land Program Division of Mineral Mining Virginia Department of Mines, Minerals and Energy 900 Natural Resources Drive, Suite 400 Charlottesville, VA 22903-0667 434-951-6310 Email: dmmlinfo@dmme.virginia.gov https://energy.virginia.gov/mineral-mining/mineralmining.shtml
West Virginia	Office of Abandoned Mine Lands and Reclamation 601 57th Street, SE Charleston, WV 25304 304-926-0499 Contact form: https://dep.wv.gov/dlr/aml/Pages/default.aspx
Wisconsin	Wisconsin Department of Natural Resources Remediation and Redevelopment Program 101 S. Webster Madison, WI 53707 https://dnr.wisconsin.gov/topic/Brownfields/WRRD.html

5.2.4 STATE-TRACKED ABANDONED MINE LANDS DATASETS

EPA included two types of AMLs in this analysis. The first are coal mining sites that were operated prior to August 3, 1977. The federal 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 statute was enacted. As a result of SMCRA, Pennsylvania, Virginia and West Virginia developed these datasets as inventories of AML sites eligible for reclamation. The second type of AMLs in the Mapper includes hard rock and other mineral mine sites.

STATE AML DATASET	DESCRIPTION OF DATASET USED IN ANALYSES	DATA ACCESSED	DATE OF SCREENING
Missouri AML	Depicts boundaries of AML projects in Missouri. This data set contains polygons that represent the construction boundary for past AML reclamation projects. This is not an exhaustive list.	3/2021	8/2021
Missouri Industrial Minerals	Contains industrial (limestone, barite, sand, gravel, clay and others) mineral sites that have or have had permits.	3/2021	8/2021
Missouri Metallic Minerals	Contains metallic (lead, zinc, iron, gold and others) mineral sites that have or have had permits.	3/2021	8/2021
New Jersey Geological and Water Survey – AML	A polygon shapefile that contains AMLs in New Jersey: https://gisdata-njdep.opendata.arcgis.com/datasets/abandoned-mines-in-new-jersey?geometry=-77.275%2C40.469%2C-72.048%2C41.196	4/2021	8/2021
New Jersey Geological and Water Survey - Sand and Gravel Operations	A polygon shapefile that contains registered and non-registered sand and gravel operations in New Jersey. Only non-registered sand and gravel operations were evaluated in this study: https://gisdata-njdep.opendata.arcgis.com/datasets/quarries-sand-and-gravel-in-new-jersey?geometry=-85.193%2C38.645%2C-64.286%2C41.585	4/2021	8/2021
Pennsylvania Abandoned Coal Mine Lands	Portrays the approximate location of AMLs Problem Areas containing public health, safety and environmental problems created by past coal mining that occurred prior to SMCRA enactment. 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.	4/2021	8/2021
Virginia Abandoned Coal Mine Areas	A polygon shapefile obtained from the Virginia Department of Mines, Minerals and Energy's Division of Mined Land Reclamation. The dataset represents polygons of lands impacted by coal mining. This dataset is derived from several sources, including USGS topographic quadrangles, coal mine permit applications and mine map collections. These datasets were created with various methods and at different scales and resolutions and will vary in accuracy. Some of these areas may represent sites that have been re-mined.	4/2021	8/2021
Virginia Orphan Land Program	Represents orphaned mineral mining sites in Virginia operated prior to 1968, when the Virginia Reclamation Law was enacted. Once identified, an orphaned mine site is evaluated for its potential hazards to the environment and the public's health and safety. This may include soil and water investigations, studies on the feasibility of reclaiming the site, cost analysis, and seeking landowner consent to allow reclamation to proceed. This data comes from the Virginia Department of Mines, Minerals and Energy's Division of Mineral Mining.	5/2018	8/2021
West Virginia Abandoned Coal Mine Areas	Represents AML problem areas comprising various types (portals, highwalls, piles or embankments, etc.). These are identified by PAD Name and Number (WV-****). Each PAD can contain one feature, or multiple features of one or more problem type. Data comes from the West Virginia Office of Abandoned Mine Lands and Reclamation.	3/2021	8/2021

5.2.5 STATE-TRACKED CONTAMINATED SITE DATASETS

Most states track and remediate contaminated sites; the level of detail and types of information tracked and reported varies from state to state. EPA aims to standardize the reported data gathered in this study to capture the most important information consistently across a wide range of states. In addition, EPA eliminated duplicates between state and federal datasets (to the extent possible) and verified locations. These data represent a snapshot in time.

NAME DATASET	DESCRIPTION OF DATASET USED IN ANALYSES	DATA DOWNLOADED	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.	7/2021	8/2021
Colorado Brownfield	Includes sites in the Colorado Brownfields Program, which provides public and private property owners with resources to facilitate cleanups at abandoned industrial facilities, long-forgotten gas stations and other potentially contaminated properties that would otherwise languish and hinder economic development.	7/2021	8/2021
Colorado Institutional Control	Includes sites classified under State of Colorado SB 145 and SB 037 (collectively referred to hereafter as "SB 145") create three different mechanisms for implementing Institutional Controls (ICs) imposed as part of remediation decisions. But the statute does more than simply create these legal mechanisms. It also requires ICs be implemented in specific situations, and establishes procedures for ensuring that the people who need to know about the restrictions do, in fact, know of them. The statute specifies certain terms that must be included in all covenants and restrictive notices. It also creates procedures for modifying and terminating covenants and restrictive notices.	7/2021	8/2021
Colorado Municipal Landfills	Includes municipal landfills open for public access within the State of Colorado.	7/2021	8/2021
Colorado Uranium Mill Tailings Radiation Control Act	Contains sites classified under the Uranium Mill Tailings Radiation Control Act of 1978. The Act gave the Department of Energy (DOE) the responsibility of stabilizing, disposing and controlling uranium mill tailings and other contaminated material at 24 uranium mill processing sites located across 10 states and at approximately 5,200 associated properties. In the 1950s and 1960s, private firms processed most uranium ore mined in the United States. After uranium mining came under federal control, companies abandoned their mill operations, leaving behind materials with potential long-term health hazards. These mills contained low-level radioactive wastes and other hazardous substances that eventually migrated to surrounding soil, groundwater and surface water, and also emitted radon gas.	7/2021	8/2021
Colorado Voluntary Cleanup and Redevelopment Program	Contains sites listed under Colorado's Voluntary Cleanup and Redevelopment Program, which was created in 1994 to facilitate the redevelopment and transfer of contaminated properties.	7/2021	8/2021
Connecticut Department of Energy & Environmental Protection	Includes sites in Connecticut that have received a brownfields grant or loan from EPA or the state, or that have enrolled in one of the state's liability relief programs.	5/2018	8/2021
Connecticut Closed Landfills	Includes closed landfills in Connecticut.	5/2018	8/2021

NAME DATASET	DESCRIPTION OF DATASET USED IN ANALYSES	DATA DOWNLOADED	DATE OF SCREENING
Florida Solid Waste Management	Contains facility-specific information on solid waste management facilities statewide.	3/2021	8/2021
Florida Brownfield	Brownfields are defined by the Florida Department of Environmental Protection (FDEP) as abandoned, idled or underused industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.	3/2021	8/2021
Florida Waste Cleanup Program	Contains information associated with waste cleanup sites at all stages of cleanup until final site rehabilitation completion is approved. Program areas include the Waste Site Cleanup Section, Site Investigation Section, Federal Programs Section, CERCLA Site Screening and Brownfields Redevelopment.	3/2021	8/2021
Florida Institutional Control Registry	Contains institutional control sites or sites that have certain restrictions on the property. For example, a site may be cleaned up to satisfy commercial contamination target levels. An institutional control may be placed on that property indicating that it may only be used for commercial levels. If the owner of the property ever wants to use that property for residential purposes, the owner will have to ensure that the contamination meets residential target levels.	3/2021	8/2021
Hawai'i Hazard Evaluation and Emergency Response Office	Inventory of brownfield sites from the Hawai'i State Department of Health - Hazard Evaluation and Emergency Response (HEER) Office see real-time (use keyword "Brownfields" in the Viewer "Sites" Panel, left hand side).	5/2021	8/2021
Illinois Office of Site Evaluations Assessment	The Office of Site Evaluations Redevelopment Assessment database identifies the status of all properties within the state in which the Illinois EPA's Office of Site Evaluation has conducted a municipal Brownfield Redevelopment Assessment.	4/2021	8/2021
Illinois Site Remediation Program	These sites are part of the Illinois Site Remediation Program, which identifies voluntary remediation projects administered through the Pre-Notice Site Cleanup Program (1989 to 1995) and now the Site Remediation Program (SRP) (1996 to the present). The SRP provides Remediation Applicants (i.e., any persons seeking to perform investigative or remedial activities) the opportunity to receive Illinois EPA review, technical assistance and no further remediation determinations from the Illinois EPA. This program is designed to be flexible and responsive to the needs of the Remediation Applicants. The goals and scope of actions at these sites are normally defined by the Remediation Applicants. See the Site Remediation Program Database for more information.	4/2021	8/2021
Iowa Land Recycling Program	The database has site information primarily from two state programs, Chapter 133 and Chapter 137 (also known as the Land Recycling Program).Chapter 133 and the Land Recycling Program (LRP) are administered to address sites that are contaminated by hazardous materials or wastes. These programs focus on assessing the severity of such problems and on identifying and carrying out the appropriate remedial measures to assure the protection of public health and environment. In addition, the Land Recycling Program provides for limited liability protection from further regulatory action relative to the problem(s) addressed. Sites come to the attention of Iowa in various ways; however, the largest group consists of properties that have been the subject of environmental assessments, generally associated with real estate transfers.	7/2021	8/2021

NAME DATASET	DESCRIPTION OF DATASET USED IN ANALYSES	DATA DOWNLOADED	DATE OF SCREENING
Maine Remediation Sites	This data contains the locations of past and current sites located in Maine that are in the Voluntary Response Action Program, the Brownfields Program, the Landfill Closure Program, the Federal Facilities Program, the Superfund Program and/or the Uncontrolled Sites Program. The data includes location coordinates and status, and if the property has institutional controls.	5/2021	8/2021
Maryland Land Restoration Program	Consists of digital data describing sites under the oversight of Maryland's Land Restoration Program (LRP). Within the Land Restoration Program, three programs exist to investigate eligible properties with known or perceived controlled hazardous substance contamination, protect public health and the environment, accelerate cleanup of properties and provide liability releases and finality to site cleanup: the Voluntary Cleanup Program (VCP), the Brownfields Initiative and State Remediation Sites.	4/2021	8/2021
Massachusetts Land Disposal of Solid Waste	The Solid Waste Land Disposal data layer, which 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 that is not established or maintained pursuant to a valid site assignment or permit (Dumping Ground).	4/2021	8/2021
Massachusetts Contaminated Land Profiles	Contains sites in the Massachusetts Contaminated Land Profile List, which was compiled by MassDEP to identify sites that have had a release of oil or hazardous materials and are regulated under MGL c. 21E and 310 CMR 40.0000. This list includes a small subset of sites having characteristics favorable for renewable energy redevelopment, including historical and/or current industrial/commercial use; proximity to existing infrastructure (transmission lines, substations, roads, water and rail); potential local zoning/permitting designations compatible with reuse; and revitalization of distressed property versus degradation of open space. NOTE: Although many sites on this list may be considered brownfields under the Solar Massachusetts Renewable Target regulations at 225 CMR 20.00 (DOER Regulations) issued by the Massachusetts Department of Energy Resources (DOER), a site's inclusion on this list DOES NOT AUTOMATICALLY QUALIFY IT as a brownfield under such regulations. Similarly, other sites not included on this list may qualify as a brownfield under the DOER Regulations. See the DOER Regulations and applicable DOER guidance for more information on which sites will be eligible for consideration as a brownfield.	6/2021	8/2021
Minnesota Pollution Control Agency Contaminated	A list of properties within the state that are contaminated.	3/2021	8/2021
New Jersey Site Remediation - Known Contaminated Sites	Known Contaminated Sites Known Contaminated Sites List (KCSNJ) for New Jersey (Non-Homeowner), which contains those non-homeowner sites and properties within the state where contamination of soil or groundwater 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. See this webpage for more details.	4/2021	8/2021
New Jersey Solid & Hazardous Waste	A polygon shapefile of landfill parcel or parcels greater than 35 acres located in New Jersey.	4/2021	8/2021

NAME DATASET	DESCRIPTION OF DATASET USED IN ANALYSES	DATA DOWNLOADED	DATE OF SCREENING
New York Environmental Remediation Sites	A polygon shapefile containing records of the sites that 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 (Registry)" are included in this database. The link for "More Info" will take the user to the NYSDEC online database, which provides all Registry information and access to site-related documents, including institutional controls and site management plans.	3/2021	8/2021
North Carolina Brownfield Projects	This dataset shows boundaries of Brownfields Projects that have entered into the program to receive a Brownfields Agreement. The boundaries and areas shown reflect the current status of the project in its progression towards having a recorded Notice of Brownfields Property with a finalized Brownfields Agreement.	5/2021	8/2021
North Carolina Hazardous Waste Sites	This dataset represents the location of sites within North Carolina that are regulated by the hazardous waste portions of the Resource Conservation and Recovery Act (RCRA). This includes Large Quantity Generators, Small Quantity Generators, Transporters of Hazardous Waste, permitted treatment, storage or disposal (TSD) facilities and TSD facilities that are under an Order or a Consent Agreement. (Note: facilities that are Conditionally Exempt Small Quantity Generators may also be included if they are also a Transporter or TSD facility.) The data is extracted from the EPA RCRAInfo database. The State of North Carolina, Division of Waste Management, Hazardous Waste Section is the implementer of record for this data. The Hazardous Waste Section is authorized by EPA to administer the hazardous waste program. This dataset is intended for general planning and mapping purposes (rather than highly accurate analytical or public health purposes).	5/2021	8/2021
North Carolina Permitted Solid Waste Landfills	This dataset reflects all active and closed, but permitted Municipal Solid Waste (MSW), Construction and Demolition (CDLF), Land-Clearing and Inert Debris (LCID) and Demolition (Older facilities) landfill facilities. For all other Solid Waste facilities, please see the "Other Permitted Solid Waste Facilities" layer. The purpose of this map is to provide the public and other government entities a visual overview of facilities that undergo inspections and groundwater monitoring as part of facility management.	5/2021	8/2021
North Carolina Pre-regulatory Landfills	Includes pre-regulatory landfills. The Inactive Hazardous Sites Branch has a separate program for addressing pre-regulatory non-industrial landfills that ceased accepting waste before 1983. The Branch conducts the assessment and remediation of these sites directly. Local governments may conduct the assessment work and seek reimbursement of expenses if the work was pre-approved by the Branch. The Inactive Hazardous Sites Branch is located in the Superfund Section of the Division of Waste Management.	5/2021	8/2021
Oregon Environmental Cleanup Sites	Oregon Department of Environmental Quality (DEQ) Environmental Cleanup Site Information (ECSI) database. DEQ maintains the database to track cleanup sites in the state with known or potential contamination from hazardous substances, and to document sites where the Oregon Department of Environmental Quality has determined that no further action is required. Data in ECSI is "working information" used by DEQ's Environmental Cleanup Section.	7/2021	8/2021
Rhode Island DEM's Office of Land Revitalization & Sustainable Materials Management Sites	This program also supports the redevelopment and reuse of contaminated Brownfield sites through the Brownfields program. Sites are identified, evaluated, cleaned up and brought back to beneficial reuse in Rhode Island communities.	7/2021	8/2021

NAME DATASET	DESCRIPTION OF DATASET USED IN ANALYSES	DATA DOWNLOADED	DATE OF SCREENING
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. Also lists issued and revoked permits and other authorizations for MSW landfills and processing facilities that have closed, and applications that were withdrawn or denied.	4/2021	8/2021
Texas Superfund Sites	Sites in the state of Texas that have been designated as Superfund cleanup sites; includes both federal- and state-designated sites. Federal sites were excluded for the purpose of this analysis so as not to double count those already included in the EPA Superfund dataset.	3/2021	8/2021
Texas Voluntary Cleanup Program Sites (VCP)	Contains sites under the Texas Commission on Environmental Quality VCP, which 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, eliminating most of the constraints for completing real estate transactions at those sites. As a result, many unused or underused properties may be restored to economically productive or community beneficial use.	4/2021	8/2021
Wisconsin Department of Natural Resources Waste Materials Management Program	Polygon representation of approximate extent of solid waste landfills and known historic waste sites. This dataset includes active and inactive solid waste landfills and known historic waste site points.	7/2021	8/2021
Wisconsin Department of Natural Resources Remediation Sites	Includes open and closed environmental remediation sites. Includes Environmental Repair Program (ERP) and Leaking Underground Storage Tank (LUST) sites where contamination affected soil, groundwater or other media. Closed sites are when the department has determined, based on information available at the time, that no further remedial action is required and open sites require additional action. A "site" is a contamination incident, not a property.	7/2021	8/2021

5.3 Screening Criteria

EPA and NREL developed the following screening criteria to evaluate renewable energy potential. Planners should consider other critical factors for siting renewable energy facilities (e.g., slope) on a site-by-site basis.

RENEWABLE ENERGY TYPE AND SCALE	ESTIMATED RENEWABLE ENERGY PROJECT CAPACITY RANGE*	RENEWABLE ENERGY RESOURCE AVAILABILITY	ACREAGE (ACRES)	DISTANCE TO TRANSMISSION** (MILES)	DISTANCE TO GRADED ROADS (MILES)
Solar Photovoltaic (PV)		Global Horizontal Irradiance (kWh/m ² /day)			
Utility scale PV	≥ 5 MW	N/A	≥ 35	≤ 10	≤ 10
Distributed scale PV	< 5 MW	N/A	< 35	N/A	N/A
Off-grid PV***	N/A	N/A	N/A	N/A	N/A
Unknown acreage PV****	N/A	N/A	N/A	N/A	N/A
Wind		Wind speed (m/s)*****			
Utility scale wind	≥ 15 MW	5.5 m/s at 80 m	≥ 1,200	≤ 5	≤ 10
Community scale wind	1.5 MW - 15 MW	5.5 m/s at 80 m	40 - 1,200	N/A	≤ 1
Facility scale wind	<1.5 MW	5.0 m/s at 40 m	0.5 - 40	N/A	N/A
Unknown acreage wind****	N/A	5.5 m/s at 80 m	N/A	N/A	N/A
Biomass		Biomass potential within 50 miles (metric tons/year)			
Biopower	> 10 MW	≥ 150,000 (woody)	≥ 6	≤ 10	≤ 3 road; ≤ 8 rail
Biorefinery	> 20 MMgal/year	≥ 286,000 (herbaceous)	≥ 132	N/A	≤ 3 road; ≤ 8 rail
Geothermal		Permafrost Presence			
Heat pump	N/A	Absence of glacier or continuous permafrost	Acreage and distance variables are not included in the prescreening.		

* MW is megawatts, MMgal/year is million gallons per year.

** Transmission lines are typically defined as power lines with voltages greater than or equal to 69 kilovolts (kV).

*** Off-grid would not be connected to the grid for the purposes of this screening criteria. Off-grid does not include no-acreage sites.

**** Acreage information is not readily available for these sites; this is the only category in which sites without acreage information are included.

***** Wind speed is represented in meters per second (m/s) at heights of 40 and 80 m, as specified for each resource type.

N/A is not applicable.

The screening categories for wind and solar (other than off-grid) are based on a review of past and current projects. These guidelines can be used generally to screen sites, but more in-depth analysis should be used prior to making investment decisions. The main consideration for distinguishing between project potential is the relationship between size (based on acreage value) and relative distance to transmission lines. Transmission lines are typically defined as power lines with voltages greater than or equal to 69kV. Large capacity (≥ 15 MW) projects require these high-voltage transmission lines to move large amounts of power. The larger a project, the greater the ability to absorb the cost of a long-distance connection to existing transmission and higher cost substations. Distributed generation projects (0–15 MW for wind and 0–2 MW for solar) are typically connected to power lines with distribution voltages less than 69 kilovolts (kV); as such, for the purposes of this screening the criteria do not factor a distance to transmission for these projects. For example, smaller projects may be quite far from transmission lines, assuming there is distribution voltage infrastructure available. However, the distance to the nearest substation can be critical depending on project size. Existing generation on the feeder, which connects the consumer/load end with the substation, is also an important consideration. Coordination with the local utility is highly recommended when assessing the potential of a distributed generation project.^{1,2,3}

EPA collaborated with the U.S. Department of Energy (DOE) National Renewable Energy Laboratory (NREL). EPA and NREL collaborated to create national-scale renewable energy screening criteria to assist in identifying sites.

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 typically small enough that limited acreage is not a constraint. For example, a property owner could install PV panels to supplement the electricity provided to the site from traditional sources. In some cases, an off-grid system may power a given load (e.g., a small-scale pump and treat system).

Approximately 108,000 sites in EPA's inventory do not include acreage values. These Acreage Unknown sites cannot be screened, but EPA does include sites that may potentially meet the resource criteria for wind and solar. Further investigation of these sites is required.

The total acreage required for a given wind project varies widely depending on total project capacity (MW), turbine type, resource strength, geographic region, power market and the cost of leasing land. Land requirements for single turbine projects are frequently driven by the requirement that the distance from the turbine to the property boundary be greater than the turbine tip height, which can go up to 500 feet for a utility scale turbine. Based on this criterion, minimum parcel sizes range from roughly an acre for a 100-kilowatt (kW) turbine (tip height 52 m) to roughly 7-8 acres for a utility scale turbine (tip height 150 m). These data illustrate the wide range of capacity densities that are found among wind installations in the United States.⁴

The main biomass feedstocks for power are paper mill residue, lumber mill scrap and municipal waste. For biomass fuels, the most common feedstocks are corn grain (for ethanol) and soybeans (for biodiesel).⁵ See additional sources on biopower screening criteria.^{6,7}

Acreage is not a screening criterion for geothermal heat pumps because they have a small, primarily subterranean footprint. Typically, any site with existing or planned buildings or that has other heating or cooling needs (e.g., office buildings, warehouses or greenhouses) could be considered for geothermal heat pumps. Near surface temperatures of 10° C (50° F) to 24° C (75° F) are most suitable for geothermal heat pumps but were not considered for prescreening criteria. Additionally, geothermal heat pumps should not be cited on permafrost locations, which only impacts sites in Alaska. For general information about geothermal heat pumps see additional sources.^{8,9}

1 Source: Bank, J. et al. *High Penetration Photovoltaic Case Study Report*. No. NREL/TP-5500-54742. NREL, Golden, CO (United States), 2013. <https://www.nrel.gov/docs/fy13osti/54742.pdf>

2 Source for PV Cost: 2017 Cost Benchmark - <https://www.nrel.gov/docs/fy17osti/68925.pdf>

3 Source: *Interconnection Plugging RE-Powering Sites Into the Electric Grid*, EPA, 2019 - https://www.epa.gov/sites/default/files/2019-10/documents/interconnection_plugging_re_powering_sites_into_the_electric_grid_oct2019_508.pdf

4 Source: Denholm, Paul, et al. *Land use requirements of modern wind power plants in the United States*. No. NREL/TP-6A2-45834. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2009. <https://www.nrel.gov/docs/fy09osti/45834.pdf>

5 Source: NREL <https://www.nrel.gov/research/re-biomass.html>

6 Humbird, D.; Davis, R.; Tao, L.; Kinchin, C.; Hsu, D.; Aden, A.; Schoen, P.; Lukas, J.; Olthof, B.; Worley, M.; Sexton, D.; Dudgeon, D. (2011). *Process Design and Economics for Biochemical Conversion of Lignocellulosic Biomass to Ethanol: Dilute-Acid Pretreatment and Enzymatic Hydrolysis of Corn Stover*. 147 pp.; NREL Report No. TP-5100-47764. <http://www.nrel.gov/docs/fy11osti/47764.pdf>

7 Biofuels criteria furnished by Gregg Tomberlin, Senior Engineer, NREL

8 DOE Geothermal Heat Pumps: <https://www.energy.gov/energysaver/heat-and-cool/heat-pump-systems/geothermal-heat-pumps>

9 DOE (2009). *Ground-Source Heat Pumps: Overview of Market Status, Barriers to Adoption, and Options for Overcoming Barriers*. Navigant Consulting, Inc. https://www1.eere.energy.gov/geothermal/pdfs/gshp_overview.pdf

5.4 State Policies

The economic viability of renewable energy projects is closely tied to the policy context of the jurisdiction in which the projects are sited. States have adopted numerous policies to support greater investment in renewable technologies. The RE-Powering Mapper includes a layer with common types of policies that support or can be conducive to renewable energy at the state level. These policies are described in more detail below, and the Mapper values for each policy are listed in the table at the end of this section.¹⁰

Renewable Portfolio Standard (RPS): An RPS establishes the minimum percentage of electricity supplied within the state each year that comes from eligible renewable sources, such as wind, solar, geothermal and certain types of biomass, biogas and hydropower. The list of eligible resources varies from state to state. An RPS can be mandatory or voluntary. Voluntary RPS are also called RPS goals, as opposed to requirements. In states with mandatory RPS, electricity suppliers must include at least the required level of renewable sources in their supply mix each year or be faced with making alternative compliance payments for their shortfalls.

Thirty states, the District of Columbia, Puerto Rico and the U.S. Virgin Islands have adopted a mandatory RPS, and additional states have voluntary RPS policies.¹¹ Several states have also included sub-requirements (or “carve-outs”) within their RPS for specific technologies such as solar PV. According to NREL, RPS policies have been one of the primary policy drivers for the growth of renewable energy over the last two decades in the United States, alongside federal tax credits like the investment tax credit and production tax credit.¹²

Clean Energy Standard (CES): A CES is like an RPS but “may include low-carbon or otherwise low-polluting, non-renewable electricity sources.”¹³ Five states have a mandatory CES, while additional states have CES goals.¹⁴

This section does not contain a comprehensive list of relevant state policies. There are other types of policies, such as grants, loans, rebates and tax incentives, available in certain states to encourage renewable energy development.

Deregulated Retail Electricity Market: A deregulated retail electricity market, also called a competitive generation and transmission (G&T) market, is one in which electricity end-users can choose a supplier of G&T for their home, business or government agency. End-users will still have the delivery or distribution part of their electricity service provided by the local electric utility. A total of 17 states and the District of Columbia offer at least some degree of a deregulated retail electricity market.¹⁵ Deregulated markets can be beneficial to renewable energy development because they may offer additional options for including renewable electricity in customers’ supply.

Markets that are not deregulated generally follow the traditional “vertically-integrated utility” structure, with the local utility providing bundled electricity service including generation, transmission and distribution. However, vertically integrated utilities increasingly offer more renewable options, through “green tariffs” or other mechanisms.¹⁶

Community Choice Aggregation (CCA) Market: CCA allows local governments to procure electricity on behalf of residents, businesses and governmental end-users, which still receive power delivery from the local electric utility. A CCA market is similar to a deregulated retail electricity market in some ways, but with a local government-established entity serving as the supplier in place of a competitive supplier. Ten states have CCA legislation.¹⁷ Depending on local government priorities, a CCA market may emphasize renewable energy procurement to a greater degree than the prior market structure or the state RPS or CES.

¹⁰ For information on a broader range of state policies for renewable energy, the NC Clean Energy Technology Center (NCCETC) maintains the Database of State Incentives for Renewables & Efficiency® (DSIRE®) at: <https://www.dsireusa.org/>. Readers interested in learning about state policies specific to contaminated lands, landfills and mine sites can contact EPA’s RE-Powering office at: <https://www.epa.gov/re-powering/forms/contact-us-about-re-powering-americas-land#rpn>.

¹¹ Lawrence Berkeley National Laboratory (LBNL), U.S. Renewables Portfolio Standards 2021 Status Update: Early Release, p. 9, https://eta-publications.lbl.gov/sites/default/files/rps_status_update-2021_early_release.pdf; and NCCETC, DSIRE®, Renewable & Clean Energy Standards, <https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2020/09/RPS-CES-Sept2020.pdf>.

¹² LBNL, U.S. Renewables Portfolio Standards 2021 Status Update: Early Release, p. 16, https://eta-publications.lbl.gov/sites/default/files/rps_status_update-2021_early_release.pdf.

¹³ U.S. Department of Agriculture (USDA), Renewable Energy Trends, Options, and Potentials for Agriculture, Forestry, and Rural America, p. 28, <https://www.usda.gov/sites/default/files/documents/renewable-energy-trends-2020.pdf>.

¹⁴ NCCETC, DSIRE®, Renewable & Clean Energy Standards, <https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2020/09/RPS-CES-Sept2020.pdf>.

¹⁵ U.S. Environmental Protection Agency (EPA), *Understanding Electricity Market Frameworks & Policies*, <https://www.epa.gov/repowertoolbox/understanding-electricity-market-frameworks-policies>.

¹⁶ See, for example, EPA, *Green Power Partnership: Utility Green Tariffs*, <https://www.epa.gov/greenpower>.

¹⁷ Local Energy Aggregation Network (LEAN), CCA by State, <https://www.leanenergyus.org/cc-by-state>.

Traditional Net Metering: Net metering, or net energy metering, policies “are established at the state or local utility level and define both (1) what size and other characteristics of generation projects interconnected with household or business customer meters are eligible for compensation from the utility for excess production (above what is consumed on-site), and (2) what compensation they receive for such excess production.”¹⁸ To the extent that net metering policies provide ready means and/or high levels of compensation for excess production, they can be supportive of renewable energy development.¹⁹ Thirty-nine states, the District of Columbia, Puerto Rico and the U.S. Virgin Islands presently have some form of mandatory net metering rules. Eight states have or are in transition to compensation rules other than traditional net metering.²⁰

Distributed Generation (DG) Compensation Rules other than Net Metering:

Increasingly, states are starting to phase out traditional net metering programs and are adopting a range of successor policy designs. These changes are driven by concerns about the overall cost of traditional net metering to utility ratepayers, cost allocation between net metering participants (e.g., with on-site solar projects) and non-participants, a desire to better tailor compensation based on project location, and other factors.²¹ Five states have DG compensation rules other than traditional net metering, and another five states are transitioning to such policies.²²

Community Solar: “Community solar, also known as shared solar or solar gardens, allows customers to buy or lease part of a larger, off-site shared solar PV system and receive benefits of their participation.”²³ By doing so, community solar policies can greatly increase customer access to solar for electricity users beyond those that are candidates for on-site projects. Community solar projects tend to be 5 MW or less in capacity and, therefore, are similar to the typical

scale of RE-Powering projects.²⁴ “Twenty states (and the District of Columbia) have passed some form of legislation enabling community solar, either through statewide programs or the authorization of a limited number of pilot projects.”²⁵

RE-Powering State Policy: Certain states have adopted policies or regulations specifically targeted at reuse of contaminated lands, landfills and/or mine sites for renewable energy. These are labeled as “RE-Powering State Policies” and cover the following types of policies: financial incentives, procurement preferences or requirements and streamlined permitting or environmental reviews. States with such policies tend to have the highest levels of deployment of RE-Powering projects. The annual tracking matrix published by the RE-Powering Office contains additional information on these policies.²⁶

Completed Renewable Energy Projects on RE-Powering Sites:

The RE-Powering Office publishes an [annual tracking matrix](#) of known projects that have been completed on contaminated lands, landfills and mine sites. The number of renewable energy projects completed in each state reflects, in part, the state policies in effect to encourage development on these types of sites. As of October 2021, there were a total of 459 RE-Powering projects across the United States.²⁷



18 USDA, Renewable Energy Trends, Options, and Potentials for Agriculture, Forestry, and Rural America, p. 58, <https://www.usda.gov/sites/default/files/documents/renewable-energy-trends-2020.pdf>.

19 “There also are ‘virtual net metering’ (or ‘meter aggregation’) arrangements in some cases that allow customers with multiple electricity meters with a utility to transfer excess solar production between the meters for billing purposes.” USDA, Renewable Energy Trends, Options, and Potentials for Agriculture, Forestry, and Rural America, p. 90, <https://www.usda.gov/sites/default/files/documents/renewable-energy-trends-2020.pdf>. Virtual net metering policies also vary by state and utility and can be conducive to renewable energy development by separating the site of electricity production from the site of electricity consumption.

20 NCCETC, DSIRE®, Net Metering, https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2021/08/DSIRE_Net_Metering_August2021.pdf.

21 For more information on this topic, see National Regulatory Research Institute, Review of State Net Energy Metering and Successor Rate Designs, <https://pubs.naruc.org/pub/A107102C-92E5-776D-4114-9148841DE668/>.

22 NCCETC, DSIRE®, Net Metering, https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2021/08/DSIRE_Net_Metering_August2021.pdf.

23 NREL, Community Solar 101, p. 3, <https://www.nrel.gov/docs/fy20osti/75982.pdf>.

24 For more information on community solar policies as they relate to RE-Powering sites, see EPA, Community Solar: An Opportunity to Enhance Sustainable Development on Landfills and Other Contaminated Sites, <https://www.epa.gov/re-powering/community-solar-opportunity-enhance-sustainable-development-landfills-and-other>.

25 NREL, Community Solar 101, p. 28, <https://www.nrel.gov/docs/fy20osti/75982.pdf>.

26 EPA, RE-Powering Tracking Matrix, <https://www.epa.gov/re-powering/re-powering-tracking-matrix>.

27 EPA, RE-Powering Tracking Matrix, <https://www.epa.gov/re-powering/re-powering-tracking-matrix>.

The following information is included in the Mapper as a state policies layer:

STATE POLICY NAME	POLICY SHORT DEFINITION	MAPPER VALUE	SOURCE	DATE ACCESSED
Renewable Portfolio Standard (RPS)	States with a mandatory or voluntary RPS indicating the percentage of electricity supply from renewable sources	"Yes" if mandatory RPS is in state, "Goal" for voluntary RPS, and "No" for no RPS	NCCETC, DSIRE®, Renewable & Clean Energy Standards, https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2020/09/RPS-CES-Sept2020.pdf	6/2021
Clean Energy Standard (CES)	States with a mandatory or voluntary CES indicating the percentage of electricity supply from clean sources	"Yes" if mandatory CES is in state, "Goal" for voluntary CES, and "No" for no CES	NCCETC, DSIRE®, Renewable & Clean Energy Standards, https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2020/09/RPS-CES-Sept2020.pdf	6/2021
Deregulated Retail Electricity Market	State electricity markets that are deregulated (i.e., competitive markets for generation and transmission for retail customers)	Yes/No – "Yes" if state has a deregulated retail electricity market	EPA, Understanding Electricity Market Frameworks & Policies, https://www.epa.gov/repowertoolbox/understanding-electricity-market-frameworks-policies	6/2021
Community Choice Aggregation (CCA) Market	States with legislation that specifically allows CCA statewide or in specific markets	Yes/No – "Yes" if state allows CCA	LEAN, CCA by State, https://www.leanenergyus.org/cca-by-state	6/2021
Traditional Net Metering	States have traditional net metering compensation mechanisms, in at least some utilities, for renewable electricity projects at retail customer sites	Yes/No – "Yes" if state has traditional net metering rules	https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2021/08/DSIRE_Net_Metering_August2021.pdf	9/2021
Distributed Generation (DG) Compensation Rules other than Net Metering	States with DG compensation rules other than traditional net metering in place or that are in the process of transitioning to such rules	Yes/No – "Yes" if state has DG compensation rules other than traditional net metering in place or is transitioning to them	https://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2021/08/DSIRE_Net_Metering_August2021.pdf	9/2021
Community Solar	State has legislation enabling statewide community solar programs or pilot projects	Yes/No – "Yes" if state has community solar legislation	NREL, Community Solar 101, p. 28, https://www.nrel.gov/docs/fy20osti/75982.pdf	6/2021
State RE-Powering Policy	States that encourage, through specific policies or regulations, renewable energy on contaminated lands, landfills and/or mine sites	Yes/No – "Yes" if state has RE-Powering policy	EPA, RE-Powering Tracking Matrix, https://www.epa.gov/re-powering/re-powering-tracking-matrix	9/2021
Completed Renewable Energy Projects on RE-Powering Sites	The total number of completed renewable energy projects on contaminated lands, landfills and mine sites (collectively "RE-Powering sites") in the state known to and recorded by the RE-Powering Office as of its most recent Tracking Matrix	Number of known renewable energy projects on RE-Powering sites in the state	EPA, RE-Powering Tracking Matrix, https://www.epa.gov/re-powering/re-powering-tracking-matrix	10/2021

5.5 Screening Methodology and Constraints

EPA screened all sites by comparing the site location with renewable energy resources. Specific renewable energy technology type, site size and proximity to infrastructure criteria are applied to give the Mapper user a high-level indication of sites with likely renewable energy potential. These criteria are described in the Screening Criteria section of this document.

As noted in the [Overview](#) section of this document, this analysis represents an initial screening, and planners should investigate sites further for both technical and economic feasibility. For example, 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. Site-specific slope analysis should be performed for any site being considered for renewable energy development.

EPA validated sites by identifying and eliminating those with potentially incorrect spatial reference data. If mapped locations did not match state data as recorded, they were excluded from the analysis.

EPA removed sites that appeared to be residential sites from consideration in the dataset.

EPA also considered duplication in developing the full dataset. In instances where a state-tracked site was also in an EPA database, that site was removed from the state dataset. Additionally, if a property was listed in a state-tracked database multiple times (e.g., multiple responses at a single property), it was revised to only be included once per property. One exception is EPA Superfund and RCRA sites; if a site is designated as both, it is included twice in the data. It is likely that some unidentified duplicates still exist in the dataset.

For the LUST program, 50 sites are being piloted in the RE-Powering Mapper and are a very small subset of the entire LUST universe. These 50 LUST sites are considered active releases located at inactive facilities. The national universe of UST and LUST sites can be found in EPA's [UST Finder](#).

EPA performed all screening on site polygons, i.e., sites with area over which a renewable resource can be assessed. Polygon site boundary files are not consistently available, so EPA collected data in both point and polygon ESRI shapefile format. Some site boundary polygons for Superfund (National Priorities List) sites were available and used for screening. State-tracked sites were provided as polygons in these state programs: Colorado Institutional Control, Colorado Uranium Mill Tailings Radiation Control Act, Florida Brownfield, Florida Institutional Control Registry, Missouri Abandoned Mine

Additional research and site-specific analyses are needed to verify viability for renewable energy potential at a given site.

Land, Missouri Industrial Minerals Unit, Missouri Metallic Minerals Unit, New Jersey Solid & Hazardous Waste, New York Environmental Site Remediation Program, North Carolina Brownfield Projects, Oregon DEQ Environmental Cleanup Program, Pennsylvania Abandoned Coal Mine Lands, Virginia Abandoned Coal Mine Areas, Virginia Orphan Land Program and West Virginia Abandoned Coal Mine Areas.

Those polygons were used as is, and the remaining site boundaries were estimated. To approximate the site size/boundary and estimate the potential for renewable energy generation across an entire site, EPA mapped the site latitude and longitude point and drew a circular buffer corresponding to the area reported around that latitude/longitude point. The maximum renewable energy resource values were recorded for these areas. Sites are typically not circular, and latitude and longitude are not always recorded at the geographic center of the site. Despite these limitations, the method employed allows for a more accurate snapshot of the energy potential available at the site versus a single data point.

For sites that did not have acreage size reported, a minimal acreage buffer was generated using a radius of 0.01 meters (approximately 0.03 feet); the buffer was approximately 0.0000007 acres. This allowed for consistent geoprocessing across the datasets and gave each property a small footprint.

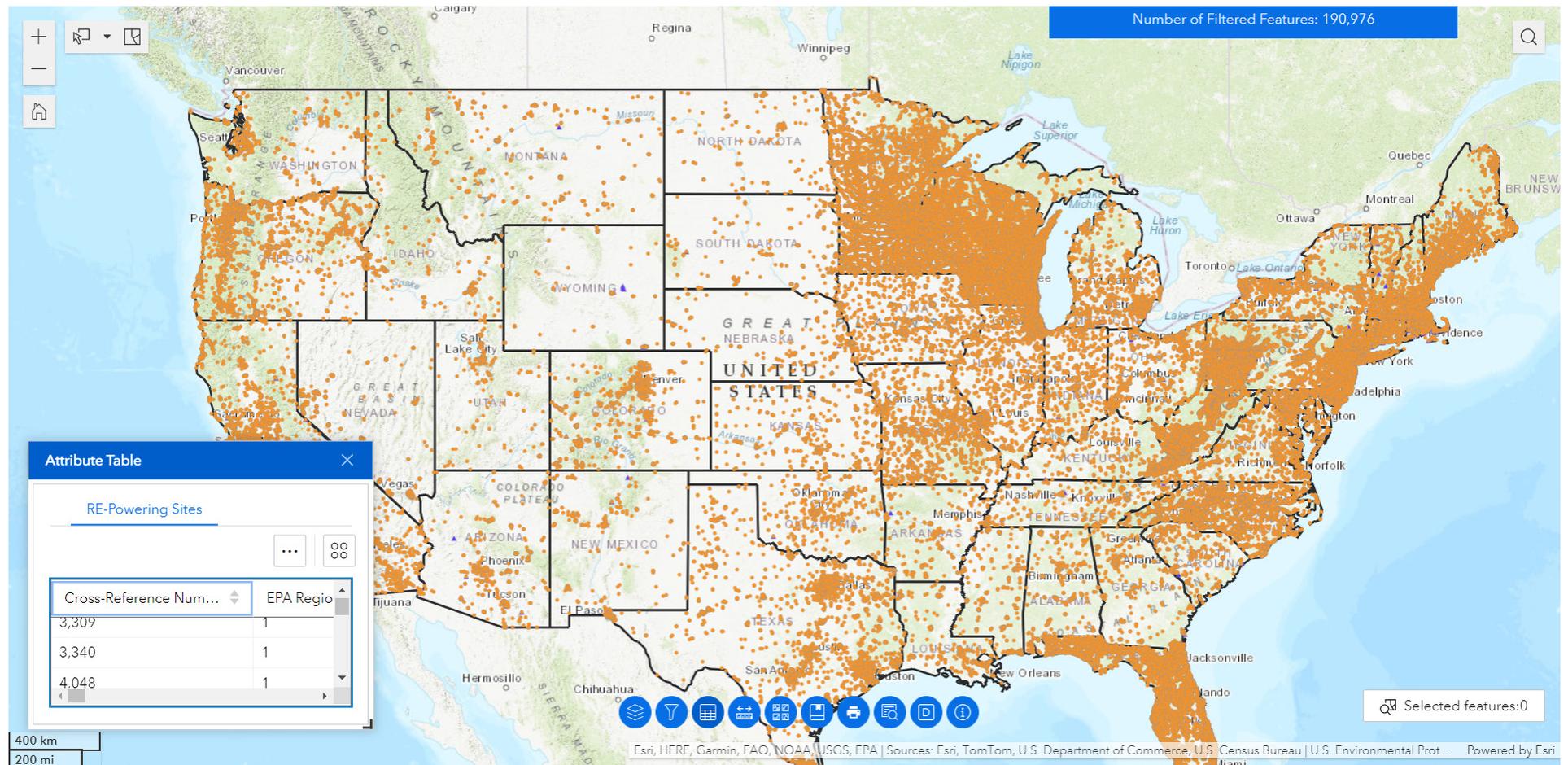
Except for Puerto Rico and the Virgin Islands, U.S. territories were not evaluated or included in this analysis because renewable energy resource and transmission data were not readily available for these territories. Other limitations to the datasets are as follows. Biomass, geothermal near surface temperature and rail data were not readily available for Puerto Rico and the Virgin Islands. Geothermal near surface temperature data are limited for Alaska and Hawai'i. A similar wind dataset was not readily available for Alaska, Puerto Rico or the Virgin Islands. Transmission line and substation data was not readily available for the Virgin Islands.

Acreage values for each site might not represent available land or the total contaminated area. For example, some sites 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 sites. In addition, acreage values do not consider the physical characteristics at the site (e.g., buildings, topography, tree cover) and, thus, may not represent the true usable acreage of the site.

For the biomass analysis, note that the resources are evaluated within a 50-mile radius of the site. Therefore, EPA drew a 50-mile buffer around the actual

or modeled site boundary and recorded the sum of the biomass resource within 50 miles of the site.

Distances were calculated using GIS software to determine the proximity of the site boundary to specific infrastructure. 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 site boundary. Because these distances were calculated using GIS software, they may not reflect real-world conditions or distances due to inaccurate or incomplete geospatial datasets and topography.



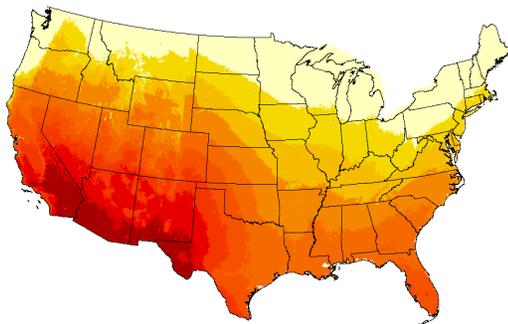
5.6 Screening Datasets

EPA compiled and used the following geospatial data to perform the screening.

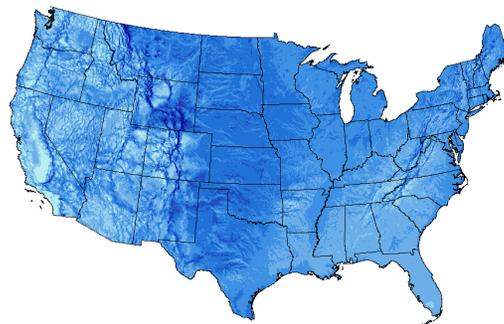
5.6.1 NATIONAL RENEWABLE ENERGY LABORATORY (NREL) DATA

Solar, wind and biomass resource data was obtained from NREL.

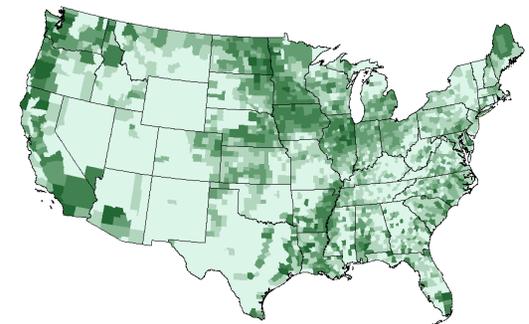
RESOURCE NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATE OF ACCESS
Global Horizontal Irradiance Re-source 1998 to 2019	Provides annual average of the daily total solar resource using 1998-2019 data covering 0.038-degree latitude by 0.038-degree longitude. Source: Sengupta, Manajit, Yu Xie, Anthony Lopez, Aron Habte, Galen Maclaurin, and James Shelby. "The National Solar Radiation Data Base (NSRDB)." <i>Renewable and Sustainable Energy Reviews</i> 89 (2018): 51–60. For more information visit: https://doi.org/10.1016/j.rser.2018.03.003 .	7/2021
Solid Biomass	Contains information about the biomass resources generated by county in the United States. 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. Source: NREL Biomass Data, https://www.nrel.gov/gis/biomass.html .	7/2021
NREL WIND Toolkit	The WIND Toolkit includes meteorological conditions and turbine power for sites in the continental United States for the years 2007–2013. Source: Draxl, Caroline, Andrew Clifton, Bri-Mathias Hodge, and Jim McCaa. "The Wind Integration National Dataset (WIND) Toolkit." <i>Applied Energy</i> 151 (2015): 355–66. For more information visit: https://doi.org/10.1016/j.apenergy.2015.03.121 .	7/2021
Hawai'i Wind	Wind speed resource data at heights of 40 and 80 meters, the data encompasses annual average wind speeds for 2000-2019 inclusive. Source: Optis, Michael, Rybchuk, Oleksa, Bodini, Nicola, Ros-sol, Michael, and Musial, Walter. "2020 Offshore Wind Resource Assessment for the California Pacific Outer Continental Shelf". United States. For more information visit: https://doi.org/10.2172/1677466 .	7/2021



Solar Map



Wind Map



Biomass Map

5.6.2 CENSUS DATA

Distances to rails and roads were obtained from U.S. Census Bureau.

RESOURCE NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATE OF ACCESS
Rails	Includes main lines such as spur lines, rail yards, mass transit rail lines (such as carlines), streetcar track, monorail or other mass transit rail and special purpose rail lines such as cog rail lines, incline rail lines and trams. Extracted from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB). Source: Census TIGER Files.	7/2021
Primary and Secondary Roads - Puerto Rico	Includes primary and secondary roads extracted from the U.S. Census Bureau's MAF/TIGER MTDB. Primary roads are generally divided, limited-access highways within the Interstate Highway System or under state management, and are distinguished by the presence of interchanges. Secondary roads are main arteries, usually in the U.S. Highway, State Highway and/or County Highway system. These roads have one or more lanes of traffic in each direction, may or may not be divided, and usually have at-grade intersections with many other roads and driveways. Source: Census TIGER Files.	7/2021
Primary and Secondary Roads - Virgin Islands	Includes primary and secondary roads extracted from the U.S. Census Bureau's MAF/TIGER MTDB. Primary roads are generally divided, limited-access highways within the Interstate Highway System or under state management, and are distinguished by the presence of interchanges. Secondary roads are main arteries, usually in the U.S. Highway, State Highway, and/or County Highway system. These roads have one or more lanes of traffic in each direction, may or may not be divided, and usually have at-grade intersections with many other roads and driveways. Source: Census TIGER Files.	7/2021

5.6.3 HOMELAND INFRASTRUCTURE FOUNDATION-LEVEL DATA (HIFLD) OPEN DATA

Distances to transmission lines and substations were obtained from HIFLD Open Data. HIFLD Open Data provides national foundation-level geospatial data within the open public domain.

RESOURCE NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATE OF ACCESS
Electric Power Transmission Lines	This feature class/shapefile represents electric power transmission lines. Transmission lines are the system of structures, wires, insulators and associated hardware that carry electric energy from one point to another in an electric power system. Lines are operated at relatively high voltages varying from 69 kV up to 765 kV and are capable of transmitting large quantities of electricity over long distances. Underground transmission lines are included where sources were available. The following updates have been made since the previous release: 6,457 features added. Source: HIFLD Open Data.	7/2021
Electric Substations	This feature class/shapefile is for HIFLD (https://gii.dhs.gov/HIFLD) as well as the Energy modeling and simulation community. This feature class/shapefile represents electric power substations primarily associated with electric power transmission. In this layer, substations are considered facilities and equipment that switch, transform or regulate electric power at voltages equal to, or greater than, 69 kilovolts. Substations with a maximum operating voltage less than 69 kilovolts may be included, depending on the availability of authoritative sources, but coverage of these features should not be considered complete. Source: HIFLD Open Data.	7/2021

5.6.4 SOUTHERN METHODIST UNIVERSITY (SMU) DATA

Surface temperature data for geothermal heat pumps were obtained from SMU.

RESOURCE NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATE OF ACCESS
Surface Temperature	Grid depth information was obtained from SMU on June 27, 2009. Source: Dr. David Blackwell, Maria Richards and Petru Negraru, 2006, SMU Geothermal Laboratory Temperature Maps.	7/2021

5.6.5 ESRI DATA

Distances to roads were obtained from Esri Data and Maps 2021.

RESOURCE NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATE OF ACCESS
U.S. Highways	U.S. Highways represents the major and minor highways of the United States. These include interstates, U.S. highways, state highways, major roads and minor roads. This dataset is from the Census 2000 TIGER/Line files. Source: Esri.	7/2021

5.6.6 UNIVERSITY OF ALASKA

EPA obtained permafrost data from the University of Alaska.

RESOURCE NAME	DESCRIPTION OF DATASET USED IN ANALYSES	DATE OF ACCESS
Permafrost Characteristics of Alaska	Identifies glacier and permafrost locations across Alaska. Source: Torre Jorgenson et al. 2008. "Permafrost Characteristics of Alaska" Institute of Northern Engineering, University of Alaska Fairbanks. 2008.	7/2021

APPENDIX A: RE-POWERING SCREENED SITES ATTRIBUTE TABLE DETAILS

ATTRIBUTE	DESCRIPTION	UNITS	DATA TYPE
Cross-Reference Number	Site identification number for cross-reference purposes.		Long Integer
EPA Region	EPA Region where site is located.		Short Integer
State	State where site is located.		Text
Program	EPA or state program from which site data were collected. See notes about program in data documentation for the mapping application.		Text
Site ID	EPA or state unique identification code.		Text
Site Information	Link to the federal or state program area responsible for collecting information about the site. Follow this link to find contamination and clean-up status. See notes in Data Documentation.		Text
Site Name	Name of site/property.		Text
Address	Address of site.		Text
City	City where site is located.		Text
County	County where latitude and longitude plots.		Text
Zip Code	Zip Code for the site.		Text
Acreage (Acres)	Acreage used for analysis	Acres	Double
Known Landfill	Known landfill. Some sites that are landfills may not be identified.		Text

ATTRIBUTE	DESCRIPTION	UNITS	DATA TYPE
Known Abandoned Mine Land	Known abandoned mine land. Some sites that are abandoned mine lands may not be identified.		Text
RE-Powering Profile	Link to the RE-Powering summary of site's renewable energy potential. May include solar, wind, biomass and geothermal.		Text
Estimated PV Capacity (MW)	Estimated PV solar capacity potential based on land requirement of 6.9 acres per MW (subject to a maximum value of 600 MW).	Megawatts	Float
Utility Scale PV	Indicates sites with utility scale solar PV potential.		Text
Distributed Scale PV	Indicates sites with distributed/commercial scale solar PV potential.		Text
Off-grid PV	Indicates sites with off-grid or stand-alone solar PV potential.		Text
No Acreage PV	Indicates sites with possible potential but size undetermined because acreage was not available.		Text
Maximum Annual GHI (kWh/m²/day)	Measurement of the global horizontal irradiance (GHI) solar resource availability in kilowatt hour per meter squared per day.	Kilowatt-hour per meter squared per day	Float

ATTRIBUTE	DESCRIPTION	UNITS	DATA TYPE
Estimated Wind Energy Capacity (MW)	Estimated potential based on land requirements calculated from wind farms installed from community- to utility-scale (approximately 80 MW per acre) (subject to a maximum of 1,600 MW).	Megawatts	Float
Utility Scale Wind	Indicates sites with utility-scale wind energy generation potential.		Text
Community Scale Wind	Indicates sites with large, distributed scale / 1-2 utility-sized turbines wind energy generation potential.		Text
Facility Scale Wind	Indicates sites with wind energy generation potential with sufficient acreage for individual consumers such as factories or farms.		Text
No Acreage Wind	Indicates sites with possible potential but size undetermined because acreage was not available.		Text
Wind speed at 40 m (m/s)	Measurement of the wind speed measured at 40m above ground.	Meters/second	Float
Wind speed at 80 m (m/s)	Measurement of the wind speed measured at 80m above ground.	Meters/second	Float
Wind speed at 100 m (m/s)	Measurement of the wind speed measured at 100m above ground.	Meters/second	Float
Biopower Facility Potential	Indicates sites with biopower facility siting potential based on woody biomass or crop feedstock.		Double

ATTRIBUTE	DESCRIPTION	UNITS	DATA TYPE
Biorefinery Facility Potential	Indicates sites with biorefinery facility siting potential based on woody biomass or crop feedstock.		Double
Cumulative Biopower Residues (metric tons / year within 50 miles)	Cumulative biomass resources in metric tons/year, used to determine biopower facility siting potential, including forests, primary and secondary mills and urban wood stock.	Metric tons/year	Double
Cumulative Biorefinery Residues (metric tons / year within 50 miles)	Cumulative biorefinery resources in metric tons/year, used to determine biopower facility siting potential, including crops.	Metric tons/year	Double
Crop Residues (metric tons / year within 50 miles)	Crop residues (dry metric tons/year), includes residues from corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, dry edible beans, dry edible peas, peanuts, potatoes, safflower, sunflower, sugarcane and flaxseed.	Metric tons/year	Double
Forest Residues (metric tons / year within 50 miles)	Forest residues (dry metric tons/year), includes logging residues and other removable material left after carrying out silviculture operations and site conversions.	Metric tons/year	Double
Primary Mill Residues (metric tons / year within 50 miles)	Primary mill residues (dry metric tons/year), includes wood materials (coarse and fine) and bark generated at manufacturing plants (primary wood-using mills) when round wood products are processed into primary wood products.	Metric tons/year	Double

ATTRIBUTE	DESCRIPTION	UNITS	DATA TYPE
Secondary Mill Residues (metric tons / year within 50 miles)	Secondary mill residues (dry metric tons/year), includes wood scraps and sawdust from woodworking shops.	Metric tons/year	Double
Urban Waste Wood Residues (metric tons / year within 50 miles)	Urban wood residues (dry metric tons/year), includes wood residues from wood chips, pallets, utility tree trimming and/or private tree companies, and construction and demolition sites.	Metric tons/year	Double
Geothermal Heat Pump Potential	Indicates sites with geothermal heat pump potential.		Text
Surface Temperature (°C)	Mean ground surface temperature.	Celsius	Short Integer
Permafrost Presence	Permafrost distribution and characteristics of surficial deposits in Alaska.		Text
Distance to Nearest Substation (miles)	Distance of site to nearest substation.	Miles	Double
Nearest Substation Voltage (Volts)	Voltage of nearest substation.	Volts	Short Integer
Distance to Nearest Transmission Line (miles)	Distance to nearest transmission line.	Miles	Double
Nearest Transmission Line Status	Status of nearest transmission line.		Text

ATTRIBUTE	DESCRIPTION	UNITS	DATA TYPE
Nearest Transmission Line kV (kilovolts)	kV capacity of nearest transmission line.	Kilovolts	Short Integer
Distance to Nearest Road (miles)	Distance to nearest road.	Miles	Double
Distance to Nearest Rail (miles)	Distance to nearest rail.	Miles	Double
Latitude	Latitude of the point.	Decimal degrees	Double
Longitude	Longitude of the point.	Decimal degrees	Double

APPENDIX B: RENEWABLE ENERGY TECHNOLOGY BASICS

EPA evaluated the following renewable energy technologies for this analysis. They represent the most common types of renewable energy facilities being used as of 2021. This is not an inclusive list of all renewable energy technologies; new technologies continue to be developed, while established technologies are refined.



Solar

Solar resource at a given location is typically characterized by the amount of solar energy striking a panel tilted up from the horizontal at an angle equal to the local latitude over a given area and reported as a daily average. Solar radiation is measured in kilowatt-hours per square meter per day (kWh/m²/day).

PV cells convert 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.

See [solar technologies](#) for more information.



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 turbine designs can be used to meet different electricity needs.

Wind resource is typically characterized by average 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.

See [wind technologies](#) for more information.



Biomass power plant with storage of wooden fuel.

Biomass

Biomass energy, or “bioenergy,” is generated from organic feedstocks. Wood is the most abundant and commonly used 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.

A 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 use cumulative biomass resources that can include residues from forests, primary and secondary mills and urban wood waste.

A biorefinery facility integrates biomass conversion processes and equipment to produce fuels, power and chemicals from biomass. The technology uses cumulative crop residues that can include residues from crops or forests, primary and secondary mills and urban wood waste.

See [biomass technologies](#) for more information.

Energy can also be generated by capturing methane and other emissions from landfills. See EPA's [Landfill Methane Outreach Program \(LMOP\)](#) for more information about landfill gas energy technologies.



Tech Town campus in Dayton, Ohio.

Photo courtesy of City Wide Development

Geothermal

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

A geothermal heat pump (GHP) system exchanges heat in the shallow subsurface. In most locations without permafrost, the upper 10 feet of the Earth maintains a nearly constant temperature between 50° and 60°F (10°–16°C). GHPs take advantage of this resource to heat and cool buildings and heat water. GHPs 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 they 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 reject heat from the ground. GHPs use much less energy than conventional heating systems since they draw heat from the ground, avoiding the high and low swings of ambient air temperatures. GHPs typically serve a single property, though they may also be viable for use in multi-tenant applications, such as integrated district heating systems.

Visit the [DOE Energy Efficiency and Renewable Energy \(EERE\) Geothermal Technologies Office](#) for more information. See the [NREL Geothermal Prospector](#) additional information about a site's geothermal favorability or hydrothermal potential.



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