Data Guidelines for "Clean and Renewable Energy Generation Potential on State Tracked Abandoned Coal Mine Areas and Non-Coal Orphaned Mineral Mines" Maps

Produced by EPA OSWER Center for Program Analysis and EPA Region 3 Brownfields Program

Overview

The U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) Center for Program Analysis (OCPA) and the EPA Region 3 Brownfields Program is encouraging the reuse of contaminated lands for siting clean and renewable energy facilities. According to the U.S. Energy Information Administration's *Annual Energy Outlook 2008*, by 2030 U.S. electricity production will need to increase by nearly 30 percent to meet growing demand.[1] Currently, wind, solar and biomass supply 2.3% of our nation's electricity.[2] While these renewable sources currently make up only a small fraction of energy production, renewable energy production is expected to increase by more than 70% between 2006 and 2030.[3] Identifying and using land located in areas with high quality renewable energy resource will be an essential component of developing more electricity from renewable energy sources.

Contaminated lands are a good fit for siting clean and renewable energy facilities because they generally have: existing transmission capacity and infrastructure in place; adequate zoning; and take the stress off undeveloped lands for construction of new energy facilities, preserving the land carbon sink. Clean and renewable energy is an economically viable reuse for sites with significant cleanup costs or low real estate development demand and it can provide job opportunities in urban and rural communities, particularly where factories, mining, and other manufacturing activities have ceased operations

In order to demonstrate that contaminated lands have clean and renewable energy potential, OCPA developed geographic information system (GIS)-based maps, a Google Earth interactive map, and an associated Excel data spreadsheet that demonstrate the viability of siting clean and renewable energy on contaminated lands and mining sties (i.e., sites that meet basic clean and renewable energy siting criteria) and generally show what geographical regions that have opportunities to reuse contaminated lands for clean and renewable energy development.

While these maps and data are beneficial as a screening tool to highlight areas with clean and renewable energy potential, they should not be used to identify or prioritize the best sites for developing clean and renewable energy, as site data is dynamic and more detailed site-specific analysis is necessary. Future projects to identify the best sites for clean and renewable energy development may be conducted by individual cleanup programs, EPA Regions, or other partnerships (e.g., public-private partnerships).

Methodology

EPA developed an inventory of abandoned coal mine lands and orphaned mineral mines (minerals other than coal) in EPA Region 3 and screened the sites against eight different clean and renewable energy screening criteria groupings. The inventory includes abandoned coal mine areas in Virginia, Pennsylvania and West Virginia and non-coal orphaned mineral mines in Virginia.

The screening criteria used to develop the OCPA clean and renewable energy potential maps were approved by OCPA and the National Renewable Energy Laboratory (NREL). Although slope is also a critical factor for siting clean and renewable energy facilities, it was not considered in the mapping analysis because site-specific slope information can not be accurately obtained from available electronic data sources. In addition, as many sites cover thousands of acres, the slope may vary widely over the entire site.

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[1] U.S. Department of Energy, Energy Information Administration. *Annual Energy Outlook 2008.* Table A8: Electricity Supply, Disposition, Prices, and Emissions. www.eia.doe.gov/oiaf/aeo/pdf/appa.pdf

[2] U.S. Department of Energy, Energy Information Administration. Renewable and Alternative Fuel, Table 4: 2007 U.S. Electric Net Summer Capacity. www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table4.html

[3] U.S. Department of Energy, Energy Information Administration. *Annual Energy Outlook 2008.* Table A8: Electricity Supply, Disposition, Prices, and Emissions. www.eia.doe.gov/oiaf/aeo/pdf/appa.pdf

Clean and Renewable Energy Mapping Screening Criteria

Please refer to the Data Considerations section for a description of the limitations of this methodology.

Utility Wind	
Wind class, measured at 50 meters above ground	≥4
Distance to transmission lines	≤10 miles
Acreage	≥2,000
Distance to graded roads	≤25 miles

Utility Solar (CSP)	
Direct normal solar resource availability	≥6 kWh/m^2/day
Distance to transmission lines	≤10 miles
Acreage (stirling engine system)[2]	≥40
Acreage (trough and power tower	≥250
Distance to graded roads	≤25 miles

Biopower Facility Siting	
Cumulative biomass resources[4]	≥140,000 metric tons/year within 50 miles
Distance to transmission lines	≤10 miles
Acreage	≥50
Distance to graded roads	≤3 miles
Distance to rail	≤8 miles

Community Wind	
Wind class, measured at 50 meters above ground	≥3
Distance to transmission lines[1]	N/A
Acreage	100 - 1,999
Distance to graded roads	≤25 miles

Utility Solar (Photovoltaic (PV))	
Direct normal solar resource availability	≥5 kWh/m^2/day
Distance to transmission lines	≤10 miles
Acreage	≥40
Distance to graded roads	≤25 miles

Biorefinery Facility Siting	
Cumulative crop residues[5]	≥330,000 metric tons/year within 50 miles
Acreage	≥50
Distance to graded roads	≤3 miles
Distance to rail	≤8 miles

Non-Grid-Connected Wind	
Wind class, measured at 50 meters above ground[1]	≥3

Non-Grid-Connected Solar (PV)
There are no formal screening criteria as PV technology can be sited at all properties[3]

[1] Energy is generally distributed only to the local area, often serving only adjacent properties so distance to transmission lines is not a screening criterion.
[2] For more information on various Concentrating Solar Power (CPS) technologies, please visit: http://www.nrel.gov/learning/re_csp.html
[3] Systems are typically used to power a single property and are not constrained by solar resource availability, acreage and distance to transmission lines and roads.
[4] Cumulative biomass resources include residues from: crops, forests, primary and secondary mills; urban wood waste; and methane emissions from manure management, landfills, and domestic wastewater treatment.
[5] Cumulative crop residues include residues from: crops; forests; primary and secondary mills and urban wood waste.

A biopower facility is defined as the use of biomass to generate electricity (NREL). A biorefinery facility is defined as a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass.

Data Considerations

The following information should be considered when reviewing OCPA's maps:

- EPA does not maintain or manage the West Virginia, Pennsylvania or Virginia site datasets.
- The screening criteria used to determine renewable energy potential for these sites was developed based on national criteria. These abandoned mine land (AML) sites might have a higher potential if the regional market is researched more closely and updated screening criteria was applied to these sites. For example these AML sites did not meet the national screening criteria for utility scale solar generation

but there are several solar energy sites currently being developed in Region 3. A more focused study on regional dynamics and market could yield more viable sites for siting renewable energy.

- Since acreage is a key screening criterion, sites that do not have acreage information are not included in the maps, except for the non-grid connected wind and non-grid connected PV solar maps as acreage is not a screening criterion for these clean and renewable energy types. Acreage is not a screening criterion for non-grid connected wind and non-grid connected solar PV maps because such systems are typically used to power a single property and are not constrained by limited acreage. For example, a property owner could install PV panels or "micro" or small-scale wind turbines to supplement the electricity provided to the site from traditional sources, but would not generate power for use off-site.
- For biomass analysis, resources within a 50 mile radius of the site were considered. Therefore, a 50 mile buffer was drawn around the site and the sum of the biomass resource within 50 miles of the site was recorded.
- In instances where distances to transmission lines, highways or rails are zero, the transmission line, highway or rail is intersecting the site buffer, meaning that the infrastructure is present within the generated site boundary.

Datasets

The following data sources were used to develop maps and data describing AML sites with renewable energy generation potential. These maps provide a snapshot in time and may not represent actual current site conditions or market dynamics.

Abandoned Mine Lands (AML) and Orphaned Mineral Mines

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

The orphaned mineral mines included in this analysis are sites other than coal mines that were operated in Virginia prior to 1968, the enactment of the Virginia Reclamation Law. Once identified, an orphaned mine site is evaluated for its potential hazards to the environment and the public's health and safety. This includes soil and water investigations, studies on the feasibility of reclaiming the site, cost analysis, and seeking the landowner's consent to allow reclamation to proceed.

- ***West Virginia AML -*** The data set containing the West Virginia AML polygons was taken from the West Virginia GIS Technical Center website http://wvgis.wvu.edu/data/dataset.php?action=search&ID=150 and was downloaded on July 10, 2008. Coal AML features were digitized from AMLR source materials by the WVU Department of Geology & Geography and the WVU Natural Resource Analysis Center. This polygon dataset was published in 1996. A description of the data set indicates that typical AML features include highwalls, portals, refuse piles, and mining structures such as tipples. Acreage values should be considered as approximate estimations for the features and may not represent actual site conditions. The data set does not include ownership or parcel information. For additional information on West Virginia's AML Program or the data set contact the West Virginia Office of Abandoned Mine Lands & Reclamation http://www.wvdep.org/item.cfm?ssid=12.

- ***Pennsylvania AML -*** The data set containing the Pennsylvania AML polygons was taken from the Pennsylvania Spatial Data Access Clearinghouse website and was downloaded July 10, 2008 (http://www.pasda.psu.edu/uci/MetadataDisplay.aspx?entry=PASDA&file=AMLInventorySites2008_07.xml&dataset=460). This data set portrays the approximate location of Abandoned Mine Land Problem Areas containing public health, safety, and public welfare problems created by past coal mining. The data represents the AML Inventory Sites, which are the boundary of an entire problem area and may contain multiple actual mining features. The data set does not include ownership or parcel information.

Most sites are privately owned. When needed, ownership information must be researched through other means, typically county real estate records. For additional information on Pennsylvania's AML Program or contacting the Bureau of Abandoned Mine Reclamation, please visit www.depweb.state.pa.us, keyword: Abandoned Mines.

- ***Virginia AML -*** The data set containing the Virginia AML polygons was obtained from the Virginia Department of Mines, Minerals and Energy's Division of Mined Land Reclamation on January 21, 2008. The data set represents polygons of mines extracted from USGS topographic maps, last photo revised in the late 1970s and early 1980s. Some of these areas may represent sites that have been re-mined. For more information contact the Virginia Department of Mines, Minerals and Energy's Title IV AML program at dmlrinfo@dmme.virginia.gov or visit http://www.mme.state.va.us/.

- ***Virginia Orphaned Mineral Mines -*** The data set containing the Virginia Orphaned Mineral Mine point data was obtained from the Virginia Department of Mines, Minerals and Energy's Division of Mineral Mining and was downloaded August 29, 2008. This data set represents orphaned mineral mining sites in Virginia operated prior to 1968. Because site boundary data is not readily available for the orphaned mineral mine sites, these maps may not reflect the total potential for clean energy generation across an entire site. For example, a portion of a site could have a high wind power class due to being situated on a ridge line, but if the latitude and longitude recorded were not along this ridgeline, the site may not meet screening criteria and may not be represented on a map. To help account for this, the site latitude and longitude point was mapped and a circular buffer was drawn around the site that was equal to the area reported for the site. The maximum and minimum resource values that the buffer covered were recorded for solar and wind resources. This methodology has limitations in that sites are typically not circles and latitude and longitude are not always recorded at the center of the site. However, it is hoped that this method will allow a more accurate snapshot of what energy potential may be available than a single data point. For additional information on Virginia's Orphaned Mineral Mines program or contacting the Virginia Department of Mines, Minerals and Energy, please visit http://www.mme.state.va.us/DMM/orphaned%20land.shtml.

In addition, the following GIS data was compiled and used to produce the OCPA clean and renewable energy potential maps.

National Renewable Energy Laboratory (NREL) Data

NREL data was downloaded on October 12, 2007 (http://www.nrel.gov/gis/). Specific information on how the data was collected by NREL is available at: http://www.nrel.gov/gis/data_analysis.html

- Low resolution wind data for KY (which are included in the VA AML data set) and high resolution wind data for PA, VA and WV: Used to determine potential for utility scale wind, community wind, and non-grid-connected wind.
- High resolution direct normal solar resource data for the lower 48 states: Used to determine potential for utility scale concentrating solar power (CSP) stirling engine system, utility scale CSP trough and power tower systems, and utility scale photovoltaic (PV) solar power.
- High resolution latitude tilt collected solar resource data for the lower 48 states: Used to determine potential for non-grid-connected PV solar power.
- Biomass data: Biomass resources available by county, used to determine potential for biorefinery and biopower facility siting.
- FEMA Transmission Lines (FEMA Electric): Used to determine the distance to transmission lines. Note: there is more accurate transmission line data available from other sources, but due to security concerns it is not publicly available and therefore not used in this analysis.

NREL resource potential information is described below:

Wind Resource (For Utility Scale, Community and Non-Grid Wind Maps)

Power Class	Resource Potential	50 m Wind Power Density (Watts/m^2; W/m^2)
1	Poor	0 - 200
2	Marginal	200 - 300
3	Fair	300 - 400
4	Good	400 - 500
5	Excellent	500 - 600
6	Outstanding	600 - 800
7	Superb	> 800

Solar Resource (For Utility Scale CSP and PV and Non-Grid Solar Maps)

$kWh/m^2/day$	Resource Potential
< 4	Moderate
> 4 - 5	Good
> 5 - 6	Very Good
> 6	Excellent

Biomass Resource (For Biopower and Biofinery Facility Maps)

Metric Tons/ Year	Resource Potential
< 50,000	Low
50,000 - 100,000	Marginal
100,000 - 150,000	Good
150,000 - 250,000	Very Good
250,000 - 500,000	Excellent
> 500,000	Outstanding

ESRI Data

ESRI software, copyright 2001-2006

- U.S. Highways: Used to calculate the approximate distance to the nearest graded road.
- U.S. States: Used to provide state outlines for mapping purposes.
- U.S. National Transportation Atlas Railroads: Used to calculate the approximate distance to the nearest railway.

Contact Information

For more information, please visit http://www.epa.gov/renewableenergyland or contact EPA's OSWER Center for Program Analysis (OCPA) at cleanenergy@epa.gov or EPA's Region 3 Brownfields Coordinator at Gaffney.Kristeen@epamail.epa.gov.

Common Attributes

The following is a description of attributes used in the data tables that accompanies the OCPA clean and renewable energy potential maps, which is available at: http://www.epa.gov/renewableenergyland.

Attribute Name	Attribute Description
Site #	Site number
Site ID	Site ID
Program	Program that oversees site
County	County
City	City derived from US Census data using plotted location of the site
State	State (Some of the sites in the Virginia Coal AML data set map in neighboring states, but were included for the purposes of this study due to their close proximity to Virginia. These sites are listed with the state they mapped in but are marked with an asterisk.)
Mineral	Mineral mined at site
Mapped Acreage	Acreage used for mapping
Renewable Energy Potential Types	Indicates which renewable energy types have potential at the site
*Utility Wind Map	Indicates sites with utility wind energy generation potential
*Comm Wind Map	Indicates sites with community wind energy generation potential
*CSP Utility Solar Map	Indicates sites with utility stirling engine and/or trough and power tower system Concentrated Solar Power (CSP) energy generation potential
*PV Utility Solar Map	Indicates sites with utility Photovoltaic (PV) solar energy generation potential
*Biopower Facility Map	Indicates sites with biopower facility siting potential
*Biorefinery Facility Map	Indicates sites with biorefinery facility siting potential
*Non-Grid Wind Map	Indicates sites with non-grid connected wind energy generation potential
*Non-Grid PV Solar Map	Indicates sites with non-grid Photovoltaic (PV) generation potential
Latitude	Latitude of polygon centroid in decimal degrees, NAD 27 projection
Longitude	Longitude of polygon centroid in decimal degrees, NAD 27 projection
Dist Power (miles)	Distance to the nearest transmission line
KV	Kilovolt capacity of the nearest transmission line
Dist Hwys (miles)	Distance to the nearest graded road
Dist Rail (miles)	Distance to the nearest railway
Max Wind	Measurement of the wind power class, measured at 50 meters above ground
Wind Range (W/m2 at 50m)	Measurement of the wind speed, measured in Watts per meter squared (W/m2) at 50 meters
Wind Potential	Description of the wind energy potential
Max DNI Solar (kWh/m2/day)	Measurement of the direct normal irradiance (DNI) solar resource availability in kilowatt hour per meter squared per day (kWh/m2/day) for utility scale projects
DNI Solar Potential	Description of the solar energy potential for utility scale project
Max LATilt Solar (kWh/m2/day)	Measurement of the solar resource availability in kilowatt hour per meter squared per day (kWh/m2/day) for non-grid connected projects
Non-Grid PV Solar Potential	Description of the solar energy potential for non-grid projects
Cum Biomass Resources (metric tons/yr w/i 50 miles)	Cumulative biomass resources in metric tons/year, used to determine biopower facility siting potential (includes: crops, forests, primary and secondary mills; urban wood waste; and methane emissions from manure management, landfills, and domestic wastewater treatment)
Biopower Potential	Description of the biomass energy potential for siting biopower facilities

Attribute Name	Attribute Description
Cum Crop Residues (metric tons/yr w/i 50 miles)	Cumulative crop residues in metric tons/year, used to determine biorefinery siting potential (includes: crops; forests; primary and secondary mills and urban wood waste)
Biorefinery Potential	Description of the biomass energy potential for siting biorefinery facilities
Crops (metric tons/yr w/i 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
Manure (metric tons/yr w/i 50 miles)	Methane emissions from manure management (metric tons/year), includes dairy cows, beef cows, hogs and pigs, sheep, chickens and layers, broilers, and turkey
Forest (metric tons/yr w/i 50 miles)	Forest residues (dry metric tons/year), includes logging residues and other removable material left after carrying out silviculture operations and site conversions
Primmill (metric tons/yr w/i 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
Secmil (metric tons/yr w/i 50 miles)	Secondary mill residues (dry metric tons/year), includes wood scraps and sawdust from woodworking shops
Urban (metric tons/yr w/i 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
Landfill (metric tons/yr w/i 50 miles)	Methane emissions from landfills (metric tons/year)
WWTreat (metric tons/yr w/i 50 miles)	Methane emissions from domestic wastewater treatment (metric tons/year)
Energy Crops (metric tons/yr w/i 50 miles)	Energy crops (dry metric tons/year), includes hybrid poplar, willow, and switchgrass on Conservation Reserve Program lands
**Cum Biomass Resources (TJ/yr w/i 50 miles)	Cumulative biomass resources (terajoule/year) (includes: crops, forests, primary and secondary mills; urban wood waste; and methane emissions from manure management, landfills, and domestic wastewater treatment)
**Cum Crop Residues (TJ/yr w/i 50 miles)	Cumulative crop residues (terajoule/year) (includes: crops; forests; primary and secondary mills and urban wood waste)
**Crops (TJ/yr w/i 50 miles)	Crop residues (terajoule/year) a conversion factor of 6,500 BTU/pound was used
**Manure (TJ /yr w/i 50 miles)	Methane emissions from manure management (terajoule/year), a conversion factor of 24,000 BTU/pound was used
**Forest (TJ/yr w/i 50 miles)	Forest residues (terajoule/year), a conversion factor of 8,500 BTU/pound was used
**Primmill (TJ/yr w/i 50 miles)	Primary mill residues (terajoule/year), a conversion factor of 4,700 BTU/pound was used
**Secmil (TJ/yr w/i 50 miles)	Secondary mill residues (terajoule/year), a conversion factor of 4,700 BTU/pound was used
**Urban (TJ/yr w/i 50 miles)	Urban wood residues (terajoule/year), a conversion factor of 4,700 BTU/pound was used
**Landfill (TJ/yr w/i 50 miles)	Methane emissions from landfills (terajoule/year), a conversion factor of 24,000 BTU/pound was used
**WWTreat (TJ/yr w/i 50 miles)	Methane emissions from domestic wastewater treatment (terajoule/year) , a conversion factor of 24,000 BTU/pound was used
**Energy Crops (TJ/yr w/i 50 miles)	Energy crops (terajoule/yr), includes hybrid poplar, willow, and switchgrass on Conservation Reserve Program lands a conversion factor of 6,500 BTU/pound was used

* These attributes have comments which indicate the screening criteria for each map.

** One terajoule is equivalent to 947,817,077.75 BTUs