Southern and Eastern Africa Renewable Energy Zones (SEAREZ)

INTERACTIVE MAP | SOUTH AFRICA

Multi-criteria Analysis for Planning Renewable Energy

This interactive PDF map contains locations of high quality wind, solar photovoltaic (PV), and concentrated solar power (CSP) zones and estimated zone attributes important to the site-selection process (e.g., levelized cost of electricity; distance to nearest transmission lines, roads, and load centers; and proximity to load centers). Locations of existing or planned renewable energy power plants, transmission lines, substations, and load centers are also indicated on the map, conditional on data availability. In order to access different data layers and their attributes, this map must be opened using Adobe PDF Readers, which are free to download. This interactive map can be used in conjunction with the Renewable Energy Zone Ranking Tool. Please refer to the accompanying report for methods, assumptions, and references for data sources. Spatial data used in this interactive map can be downloaded from the mapRE (http://mapre.lbl.gov/) or the Global Atlas (http://globalatlas.irena.org/) websites.

This map and its supporting study are the results of a collaboration between the International Renewable Energy Agency (IRENA), the Lawrence Berkeley National Laboratory (LBNL), and University of California at Berkeley (UCB) as part of the Africa Clean Energy Corridor Initiative

International Renewable Energy Agency Disclaimer:

Lawrence Berkeley National Laboratory Disclaimer:

Acknowledgements:

We gratefully acknowledge the Africa Development Bank's Africa Infrastructure Country Diagnostic (AICD) Initiative for the inspiration to create these interactive PDF maps.

HOW TO USE THIS MAP

VIEWING LAYERS

a) On the left hand side menu, click on the layers icon.

b) Expand folders you wish to view. Individual layers are classified under three folders - INFRASTRUCTURE, RENEWABLE ENERGY ZONES, and DEVELOPMENT CONSTRAINTS.

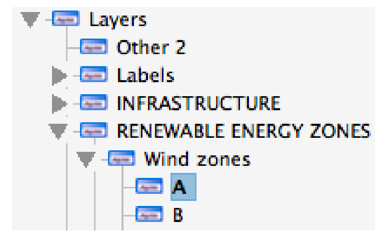
c) Each layer within a folder can be turned "on" or "off" by clicking on the "eye" icon. The legend on the right side of the map explains the symbology of each layer.

d) The renewable energy zones for each of the three technologies are colored by the estimated total levelized cost of energy (LCOE) for that technology. The legend on the right side of the map shows the corresponding LCOE costs (USD/MWh) for each color.

VIEWING ATTRIBUTES

The detailed attributes of each SEAREZ are embedded in this map. These attributes are described on page 5 of this interactive PDF. Below are two ways to access these attributes:

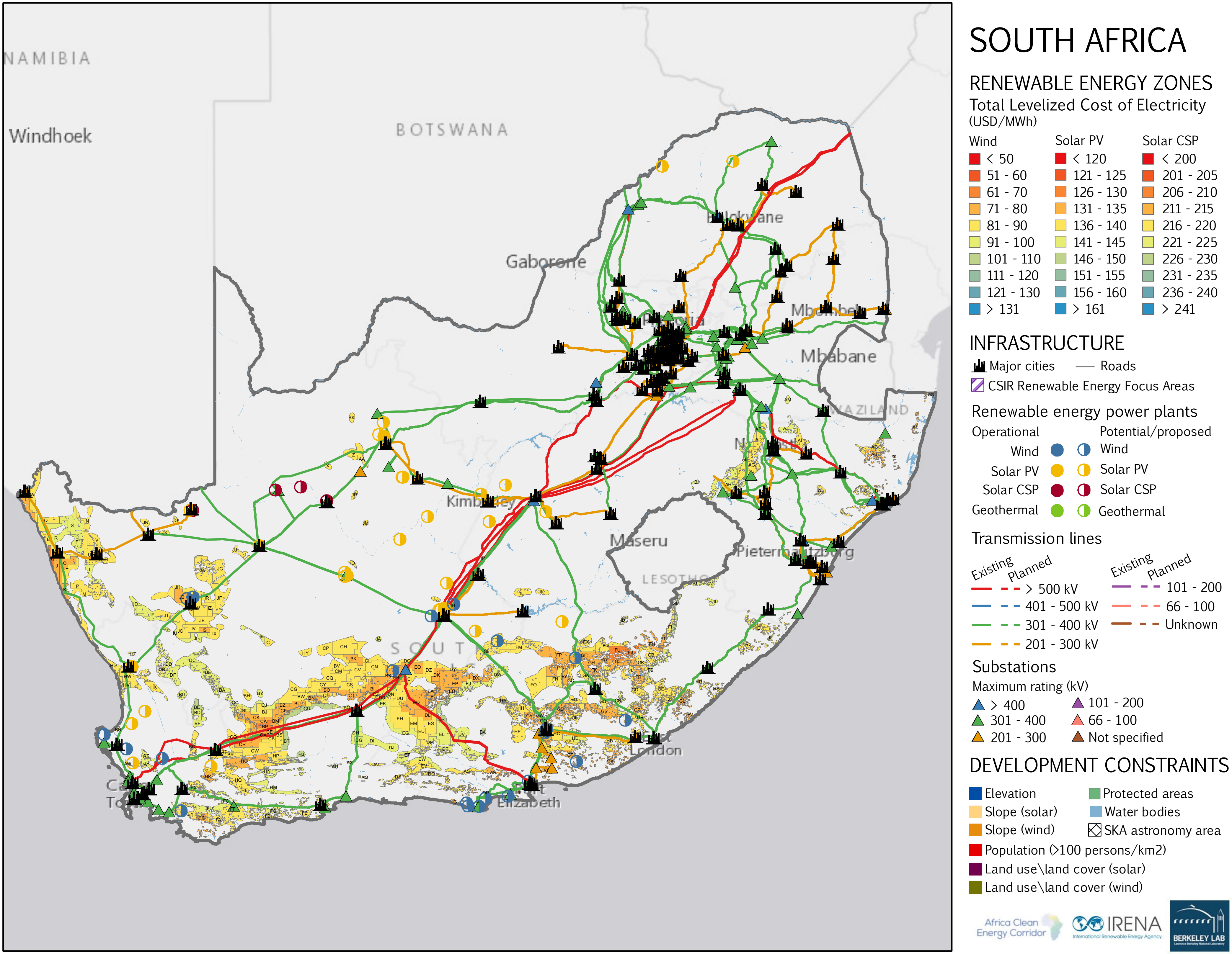
a) **Select Zone ID and retrieve attributes and location.**
The attribute table can be accessed for a zone by clicking on the Model Tree icon on the left menu. Within the Model Tree, expand the folders of the layers containing the zones and select a zone ID (e.g., "A"). An example Model Tree folder structure is shown here (right). The attributes (e.g. levelized cost of energy for generation, transmission and roads, distance to load centers) for each zone will be displayed on the bottom, left menu, beneath the Model Tree folder structure once you click on the zone ID. An example attribute table is shown here (lower right). You may also locate this zone on the map by right clicking on the zone ID-> Zoom to Selection. This feature is useful for locating zones identified through the Multi-Objective Zone Ranking Tool.



Property	Value
OBJECTID	90
zone_identification	CL
electricity_generation_discounted_MWh	1971990.258745
area_km2	384.499998
LCOE_total_transmission_USDperMWh	65.125767

b) **Select location and retrieve attributes.**
Turn on the "Object Analysis Tool." In Adobe Acrobat Reader X, this tool is under Edit -> Analysis -> Object Data Tool. In Acrobat Pro X, this tool is under Tools -> Analyze -> Object Data Tool. For other versions of Adobe Reader, please refer to Adobe's documentation to find the Object Analysis Tool. The Model Tree icon will appear on the left menu if it not already available. Once the Object Analysis Tool has been activated, the cursor changes to a "cross". Move the cursor over a zone (or any other feature in the map), and click multiple times (giving at least a couple of seconds between each click). Each click opens a layer's folder in order to retrieve the final zone ID and its attributes. The map may highlight all selectable areas in red in between mouse clicks. Only the selected zone should be outlined in red once its attribute table has been retrieved. Please keep in mind that this way of assessing attributes may be slow.

c) If a map has been georeferenced, the latitude and longitude coordinates in decimal degrees can be displayed for any location on the map by accessing the "Geospatial Location Tool," found in the same menu as the "Object Analysis Tool."



NAMIBIA
Windhoek
BOTSWANA
Gaborone
Mbabane
Maseru
LESOTHO
SOUTH AFRICA
RENEWABLE ENERGY ZONES
Total Levelized Cost of Electricity (USD/MWh)
Wind
< 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
101 - 110
111 - 120
121 - 130
> 131
Solar PV
< 120
121 - 125
126 - 130
131 - 135
136 - 140
141 - 145
146 - 150
151 - 155
156 - 160
> 161
Solar CSP
< 200
201 - 205
206 - 210
211 - 215
216 - 220
221 - 225
226 - 230
231 - 235
236 - 240
> 241
INFRASTRUCTURE
Major cities
Roads
CSIR Renewable Energy Focus Areas
Renewable energy power plants
Operational
Potential/proposed
Wind
Solar PV
Solar CSP
Geothermal
Transmission lines
Existing
Planned
> 500 kV
401 - 500 kV
301 - 400 kV
201 - 300 kV
101 - 200
66 - 100
Unknown
Substations
Maximum rating (kV)
> 400
301 - 400
201 - 300
101 - 200
66 - 100
Not specified
DEVELOPMENT CONSTRAINTS
Elevation
Slope (solar)
Slope (wind)
Population (>100 persons/km2)
Land use\land cover (solar)
Land use\land cover (wind)
Protected areas
Water bodies
SKA astronomy area
Africa Clean Energy Corridor
IRENA
International Renewable Energy Agency
BERKELEY LAB

ATTRIBUTE TABLE DESCRIPTIONS

The attribute table, once retrieved, will be displayed on the bottom, left-hand side of the Model Tree menu. Blue highlighted cells indicate attributes that are specific to wind zones, orange highlighted cells indicate attributes specific to solar CSP zones, and yellow highlighted cells indicate attributes specific to solar PV. All other attributes are common between technologies.

ATTRIBUTE NAME	DESCRIPTION
zone_identification	This is the unique alphabetical identifier for the zones. Zones are labeled on the map using this identifier.
Electricity generation attributes:	Estimated annual average electricity generation in MWh for the following:
A) Electricity_generation_discounted_MWhPerYr	**Solar PV**, assuming a 90% land use discount factor.
B) Electricity_generation_discounted_chosenTurbine_MWhPerYr	**Wind** using the optimally selected IEC turbine class, assuming a 75% land use discount factor.
C) Electricity_generation_discounted_classIIturbine_MWhPerYr	**Wind** using IEC Class II turbines, assuming a 75% land use discount factor.
D) Electricity_generation_discounted_noStorage_MWhPerYr	**Solar CSP** without storage, assuming a 90% land use discount factor.
E) Electricity_generation_discounted_6hrsStorage_MWhPerYr	**Solar CSP** with 6 hours of storage, assuming a 90% land use discount factor.
Potential installed capacity attributes:	Potential capacity (MW) that could be installed within a zone for the following:
installedCapacity_MW	**Solar PV or wind**, assuming a 90% and 75% land use discount factor, respectively.
installedCapacity_noStorage_MW	**Solar CSP** without storage, assuming a 90% land use discount factor.
installedCapacity_6hrsStorage_MW	**Solar CSP** with 6 hours of storage, assuming a 90% land use discount factor.
area_km2	Total area of the zone in units of square kilometers
Levelized cost of electricity (LCOE) of non-generation components attributes:	Average levelized cost of electricity (in USD/MWh) for the non-generation components of the following (values are only reported if transmission or substation data could be procured):
A) LCOE_transmission_USDperMWh	**Solar PV**, estimated using distance to the nearest transmission line, if available.
B) LCOE_substation_USDperMWh	**Solar PV**, estimated using distance to the nearest substation, if available.
C) LCOE_road_USDperMWh	**Solar PV**, estimated using distance to the nearest road.
D) LCOE_transmission_chosenTurbine_USDperMWh	**Wind** using the optimally selected IEC turbine, estimated using nearest transmission line.
E) LCOE_substation_chosenTurbine_USDperMWh	**Wind** using the optimally selected IEC turbine, estimated using nearest substation.
F) LCOE_road_chosenTurbine_USDperMWh	**Wind** using the optimally selected IEC turbine, estimated using nearest road.
G) LCOE_transmission_6hrsStorage_USDperMWh	**Solar CSP** with 6 hours of storage, estimated using nearest transmission line.
H) LCOE_substation_6hrsStorage_USDperMWh	**Solar CSP** with 6 hours of storage, estimated using nearest substation.
I) LCOE_road_6hrsStorage_USDperMWh	**Solar CSP** with 6 hours of storage, estimated using nearest road.
Levelized cost of electricity (LCOE) of generation component attributes:	Average levelized cost of electricity (in USD/MWh) for generation component of the following technologies (values were estimated using the location's capacity factor and efficiencies specific to the technology):
A) LCOE_generation_USDperMWh	**Solar PV**
B) LCOE_generation_chosenTurbine_USDperMWh	**Wind** using the optimally selected IEC turbine class.
C) LCOE_generation_classIIturbine_USDperMWh	**Wind** using IEC Class II turbine.
D) LCOE_generation_noStorage_USDperMWh	**Solar CSP** without storage.
E) LCOE_generation_6hrsStorage_USDperMWh	**Solar CSP** with 6 hours of storage.

Total levelized cost of electricity (LCOE) attributes:	Average total levelized cost of electricity estimated by summing the individual component LCOEs for generation, transmission line or substation (values are only available if data could be procured), and road for the following:
A) LCOE_total_transmission_USDperMWh	**Solar PV**, estimated using the transmission component.
B) LCOE_total_substation_USDperMWh	**Solar PV**, estimated using the substation component.
C) LCOE_total_transmission_chosenTurbine_USDperMWh	**Wind** using the optimally selected IEC turbine class, estimated using transmission
D) LCOE_total_transmission_classIIturbine_USDperMWh	**Wind** using IEC Class II turbine, estimated using transmission
E) LCOE_total_substation_chosenTurbine_USDperMWh	**Wind** using the optimally selected IEC turbine class, estimated using substation
F) LCOE_total_substation_classIIturbine_USDperMWh	**Wind** using IEC Class II turbine, estimated using substation
G) LCOE_total_transmission_noStorage_USDperMWh	**Solar CSP** without storage, estimated using transmission
H) LCOE_total_transmission_6hrsStorage_USDperMWh	**Solar CSP** with 6 hours of storage, estimated using transmission
I) LCOE_total_substation_noStorage_USDperMWh	**Solar CSP** without storage, estimated using substation
J) LCOE_total_substation_6hrsStorage_USDperMWh	**Solar CSP** with 6 hours of storage, estimated using substation
mean_slope_percent	Mean slope of the zone in units of percent rise.
mean_populationDensity_personsPerKm2	Mean population density of the zone in units of persons per square kilometer.
mean_HumanFootprint_0to100	Mean human footprint metric (0 – least human impact; 100 – most human impact)
mean_LULC_score	Mean score for land use/land cover categories in the zone. Scores range from 1 to 5, with 1 being most compatible for energy development and 5 being least compatible.
Mean_colocation_score	Mean score for the suitability of the zone for other renewable energy technologies. For example, the attribute table of a solar PV zone would display the colocation score calculated using the zone's overlap with wind and CSP potential. The score ranges from 0 to 1, with 0 being no overlap and 1 being overlap with both renewable technologies.
Num_projectsWithWaterAccess	Number of project opportunity areas within the zone that is within 10 km of surface water.
mean_resourceQuality_Wperm2	Mean resource quality in terms of wind power density or solar irradiance of the zone in units of watts per m^2.
mean_resourceQuality_kWhPerm2Day	Mean solar resource quality of the zone in units of annual average kWh per m^2 per day.
Capacity factor attributes:	Mean capacity factor of the zone for the following (values range from 0 to 1):
A) mean_capacityFactor	**Solar PV**
B) mean_capacityFactor_chosenTurbine	**Wind** using the optimally selected IEC turbine class.
C) mean_capacityFactor_classIIturbine	**Wind** using IEC Class II turbine.
D) mean_capacityFactor_noStorage	**Solar CSP** without storage.
E) mean_capacityFactor_6hrsStorage	**Solar CSP** with 6 hours of storage.
area_chosenTurbine_classIII_km2	Area (in km^2) within the zone for which IEC class III turbines would be most suitable
area_chosenTurbine_classII_km2	Area (in km^2) within the zone for which IEC class II turbines would be most suitable
area_chosenTurbine_classI_km2	Area (in km^2) within the zone for which IEC class I turbines would be most suitable
Distance attributes:	Distance to the nearest following locations (in units of kilometers):
A) distance_nearest_transmission_km	Transmission line
B) distance_nearest_substation_km	Substation
C) distance_nearest_road_km	Road

D) distance_nearest_existingPlanned_wind_km (or distance_nearest_existingPlanned_PV_km, distance_nearest_existingPlaned_CSP_km)	Operational or planned wind (or solar PV, solar CSP) power plant.
E) distance_nearest_geothermalLocation_km	Operational or planned geothermal power plant.
F) distance_nearest_anyRenewableEnergyLocation_km	Operational or planned renewable energy (wind, solar PV, solar CSP, geothermal) power plant.
G) distance_nearest_majorCity_km	Major city or load center.
H) distance_nearest_waterSource_km	Surface water (lake or river) source.
GroupVal	Identifier that is used to assign a project opportunity area to a zone.
Capacity value attributes:	
A) distance_nearest_3TierWindLocation_km	From the centroid of the zone, distance in km to the nearest location where simulated wind speed time series data were acquired from 3Tier. Hourly time series were used to estimate capacity value ratios.
B) capacityValueRatio_10percentPeakHours	The ratio of the capacity factor for the top 10% of hours with the largest electricity demand within a year (876 hrs) to the capacity factor of all hours within the same year (8760 hrs).
C) capacityValueRatio_chosen3peakHours	The ratio of the capacity factor for the daily top 3 hours with the largest electricity demand across an entire year (1095 hrs) to the capacity factor of all hours within the same year (8760 hrs).
D) capacityValueRatio_chosen3peakHours_multiyear	The ratio of the capacity factor for the daily top 3 hours with the largest electricity demand across an entire year, extrapolated to 10 years (10,950 hrs), to the capacity factor of all hours within the same 10 years (87,600 hrs). 3Tier provided 10 years of hourly time series data for each point location.
E) adjustedCF_top10percent	The capacity factor of the top 10% of hours with the largest electricity demand within a year (876 hrs). This value was estimated by multiplying the capacityValueRatio_10percentPeakHours with the mean_capacityFactor_chosenTurbine.
F) adjustedCF_top3hrs	The capacity factor of the daily top 3 hours with the largest electricity demand across an entire year (1095 hrs). This value was estimated by multiplying the capacityValueRatio_chosen3peakHours with the mean_capacityFactor_chosenTurbine.