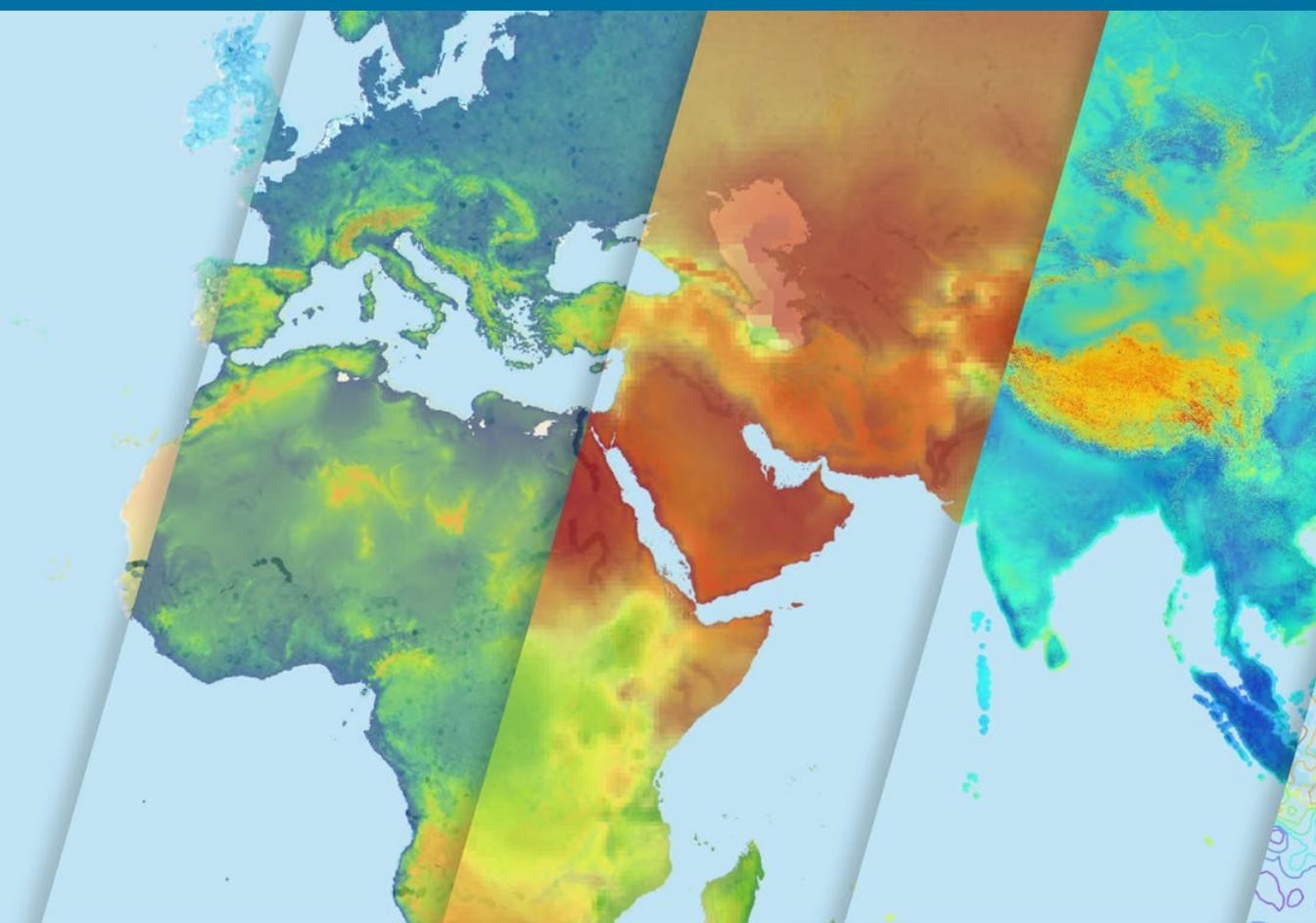


# THE GLOBAL ATLAS FOR RENEWABLE ENERGY

A DECADE IN THE MAKING



APRIL 2024



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## ABOUT IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. A global intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security, and low-carbon economic growth and prosperity.

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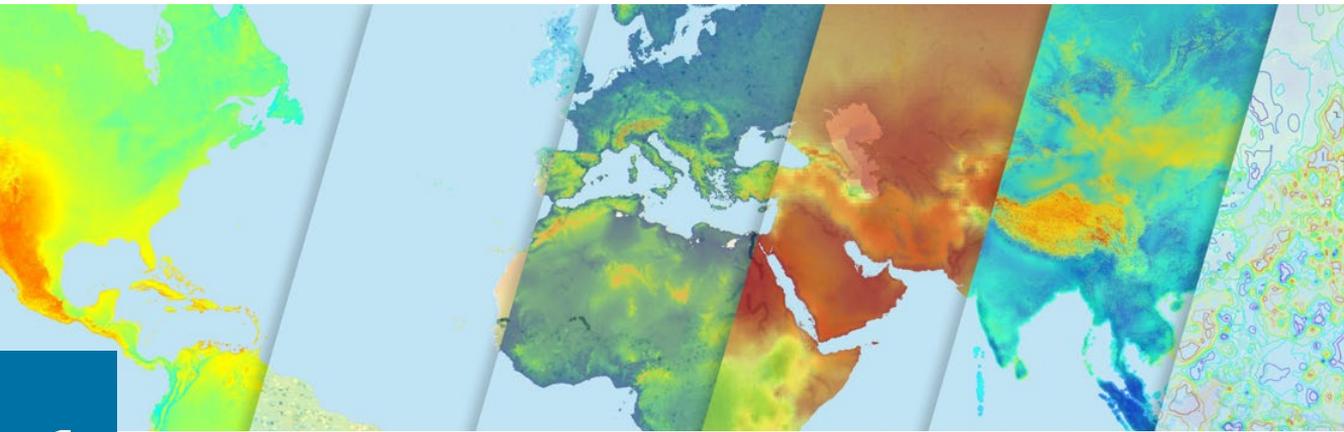
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# ABBREVIATIONS

<b>ANU</b>	Australian National University	<b>GWA</b>	Global Wind Atlas
<b>C3S</b>	Copernicus Climate Change Service	<b>IIASA</b>	International Institute for Applied Systems Analysis
<b>CAMS</b>	Copernicus Atmosphere Monitoring Service	<b>IRENA</b>	International Renewable Energy Agency
<b>CCI-LC</b>	Climate Change Initiative – Land Cover	<b>IUCN</b>	International Union for Conservation of Nature
<b>CIAT</b>	International Center for Tropical Agriculture	<b>MERRA-2</b>	Modern-Era Retrospective analysis for Research and Applications version 2
<b>DTU</b>	Technical University of Denmark	<b>MTSAT</b>	Multifunction Transport Satellite
<b>ECMWF</b>	European Centre for Medium-Range Weather Forecasts	<b>NASA</b>	National Aeronautics and Space Administration
<b>ECOWAS</b>	Economic Community of West African States	<b>NREL</b>	National Renewable Energy Laboratory
<b>ECREEE</b>	ECOWAS Centre for Renewable Energy and Energy Efficiency	<b>ORNL</b>	Oak Ridge National Laboratory
<b>EGS</b>	Global Enhanced Geothermal System	<b>PV</b>	Photovoltaic
<b>ESMAP</b>	Fifth-generation ECMWF Reanalysis	<b>RSME</b>	root mean square error
<b>FAO</b>	Energy Sector Management Assistance Program	<b>SMU</b>	Southern Methodist University
<b>GAEZ</b>	Food and Agriculture Organization	<b>SoDA</b>	Solar Radiation Data
<b>GEOS</b>	Global Agro-Ecological Zones	<b>SRTM</b>	Shuttle Radar Topography Mission
<b>GFS</b>	Geostationary Operational Environmental Satellites	<b>TU Delft</b>	Delft University of Technology
<b>GIS</b>	geographic information system	<b>UAE</b>	United Arab Emirates
<b>GMAO</b>	Global Modeling and Assimilation Office	<b>UNEP</b>	UN Environment Programme
<b>GOCE</b>	Gravity Field and Steady-State Ocean Circulation Explorer	<b>WCMC</b>	World Conservation Monitoring Centre
<b>GOES</b>	Geostationary Operational Environmental Satellites	<b>WDPA</b>	World Database on Protected Areas
		<b>WRF</b>	Weather Research and Forecast
		<b>VFDS</b>	Viet Nam Forestry Development Strategy



# 1 INTRODUCTION

In 2012 IRENA, in partnership with the Clean Energy Ministerial Multilateral working group, co-ordinated and developed the Global Atlas for Renewable Energy ("Global Atlas") platform to increase the share of renewable energy worldwide.

The Global Atlas is a free online hub where users – policy makers, energy planners, project developers, researchers, modellers and educators – can access data and tools to assess the renewable potential of a country or region, especially where such information is not publicly available.

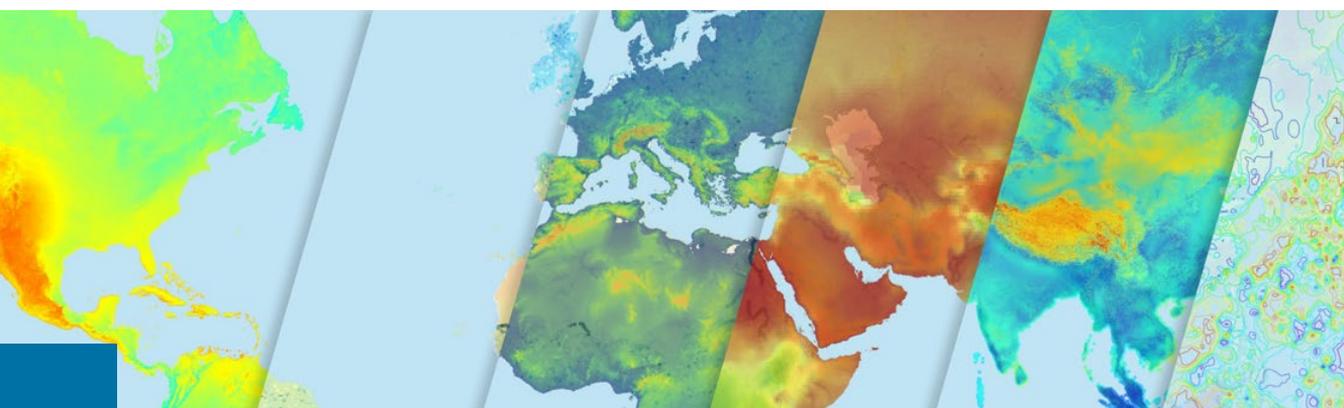
Currently, the Global Atlas platform allows users to access more than 1000 renewable resource datasets and ancillary information at different scales – global, regional and country-specific – from 50 leading international technical institutes and private companies as partners or data contributors. Such datasets aim to raise awareness of renewable development options to help meet global climate goals, decarbonise the world's energy system and ensure access to sustainable energy for all.

This brochure presents the Global Atlas platform with an extract of its published datasets and free online tools.

**Access the Global Atlas for Renewable Energy:** [globalatlas.irena.org](http://globalatlas.irena.org)

## ACKNOWLEDGEMENTS

IRENA thanks the data providers and contributors to the Global Atlas for making this publication possible.



# 2

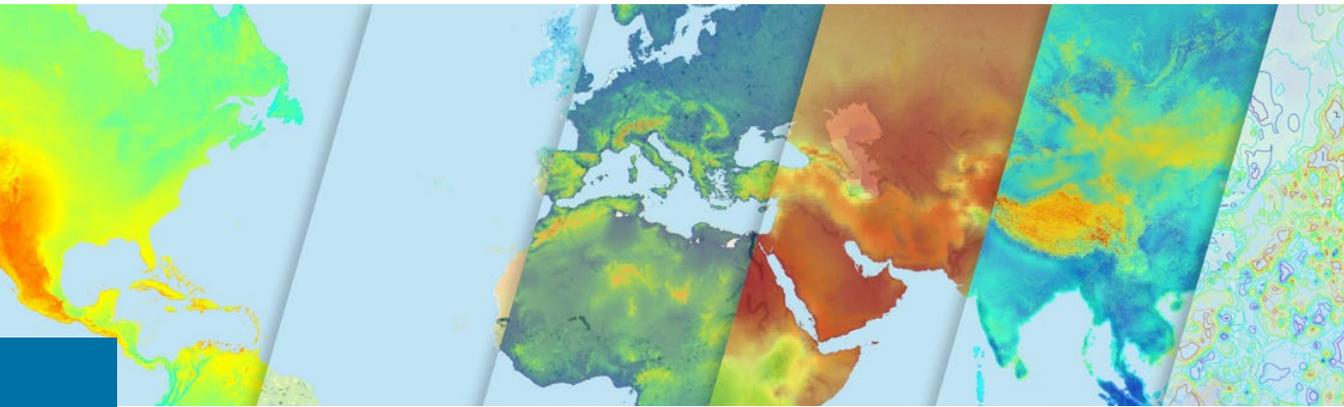
## THE GLOBAL ATLAS INTERFACE IN A NUTSHELL

As a unique single online repository that assembles renewable resource datasets and advanced tools, the Global Atlas is a free web-based geographic information system (GIS) platform with enhanced functionalities that enable its users – policy makers, practitioners and business developers – to:

- Display more than 1000 high-quality renewable resource datasets (solar, wind, bioenergy, geothermal, hydropower and marine) listed in a catalogue to identify areas of high potential.
- Overlay ancillary information (roads, power lines, protected areas, population density and topography) on renewable resource datasets to screen areas of opportunity where further assessment may be of relevance.
- Access recommended advanced tools (SolarCity simulator and Bioenergy simulator) to evaluate the technical and financial potential for renewable energy planning and development and estimate the possible renewable resources' contributions to transport, heating and electricity.

IRENA is continuously updating the renewable resource and ancillary datasets of the Global Atlas. Contact the team if you would like to contribute data, tools or expertise, or to promote the Global Atlas initiative.

**Access the Global Atlas for Renewable Energy:** [globalatlas.irena.org](http://globalatlas.irena.org)



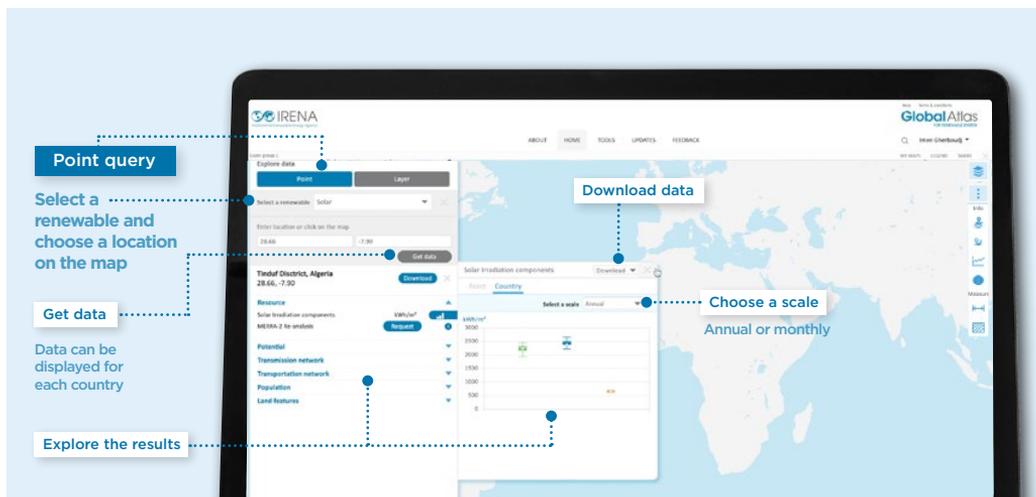
## 3

## THE GLOBAL ATLAS LATEST ENHANCED FEATURES

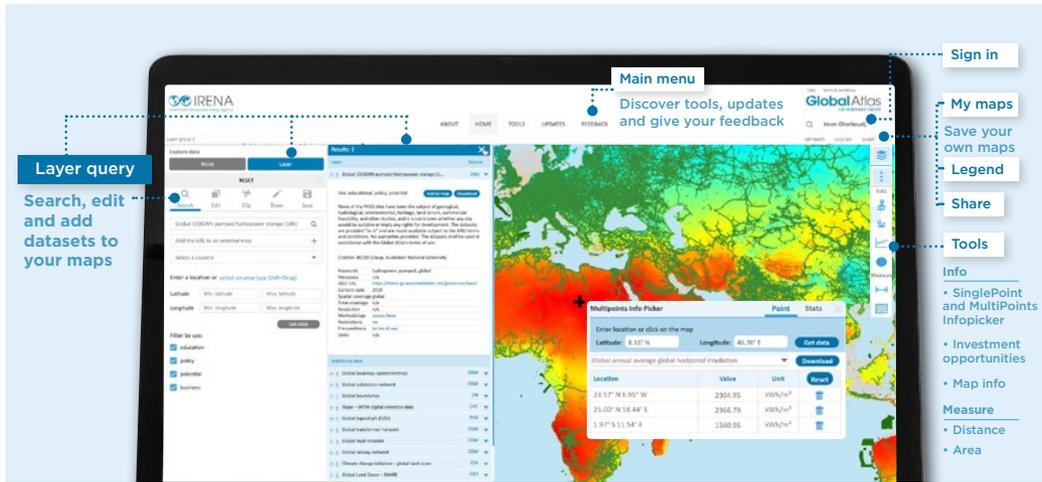
Since the launch of its ground-breaking Web-GIS renewable resource platform in 2012, IRENA has continuously updated and upgraded its Global Atlas to enable users to interact with a user-friendly front-end interface, complemented with a robust back end (geoservers and databases), both built using advanced and up-to-date technologies.

In 2021 and 2023 IRENA released its most significant advanced updates yet as Global Atlas 4.0 and 4.1, respectively, which allow users to access datasets in different modes:

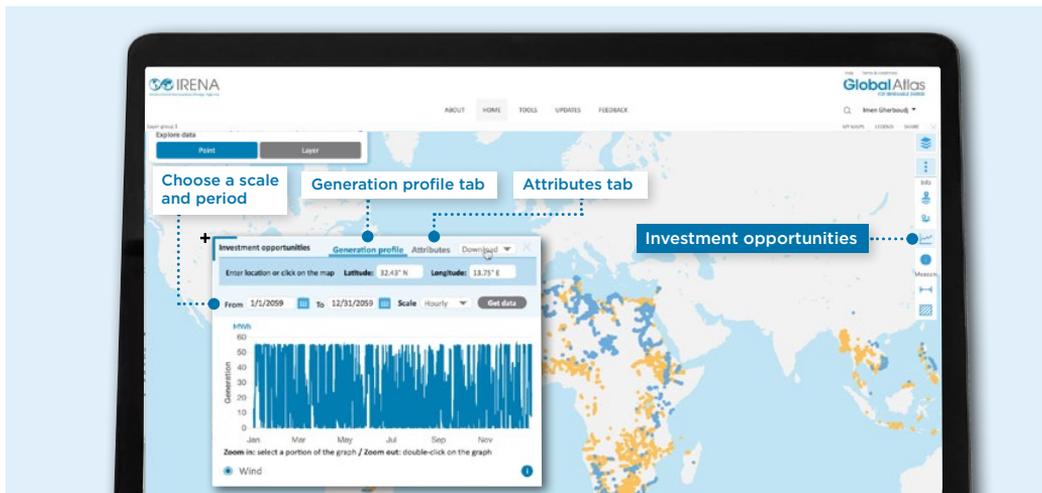
- Point query, which enables users to select a location on the base map to:
  - » Retrieve long-term annual and monthly average renewable resource datasets with the corresponding statistical data at country scale.
  - » Download long-term hourly reanalysis datasets from European Centre for Medium-Range Weather Forecasts (ECMWF ERA5) and the National Aeronautics and Space Administration (NASA MERRA-2).
  - » Get ancillary information related to the country's infrastructure, such as distance to power transmission lines and roads, and land cover.



- Layer query, which enables users to overlay several geospatial renewable resources and ancillary datasets on the base map to:
  - » Retrieve data with basic statistics at a selected location (single-point info picker) or several selected locations (multi-point info picker) on the base map.
  - » Render a visual of the key features for each layer in a map, clip data over selected country or region, make drawings on the map, and adopt changes in the layer sequence or layer configuration.
  - » Create and save a new map or customise an existing map using the available layer.
  - » Share a map on social media – LinkedIn, Facebook and Twitter – or share the HTML code for integrating a minimised version of the Global Atlas.
  - » Pinpoint and display the total distance (or area) between any points on a map.
  - » Download relevant datasets and maps for further offline analysis.



- Investment opportunities information, which enables users to display the best zones for deploying solar photovoltaic (PV) and onshore wind projects with their corresponding generation profiles and associated attributes.



These functionalities reflect the continuous refinement of IRENA’s initiative to support its country members to achieve sustainable energy goals.

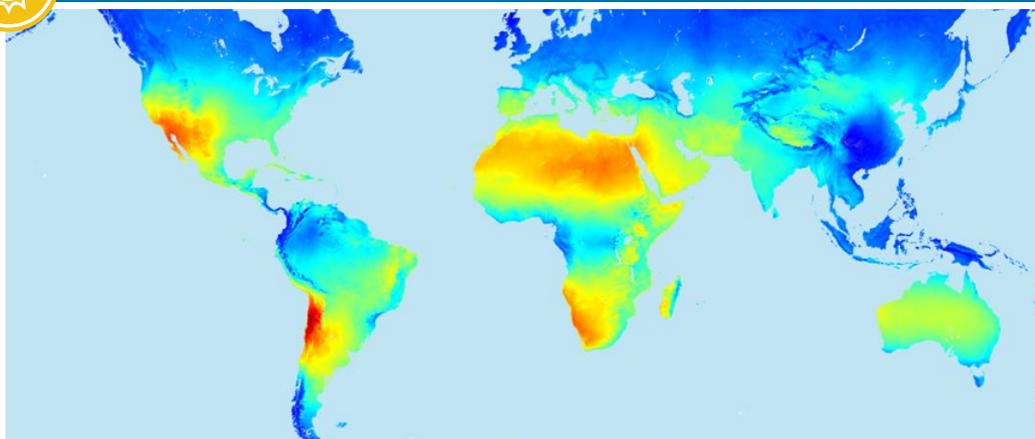
## 4

# THE GLOBAL ATLAS DATASETS

## 4.1 Solar



### Global Solar Data

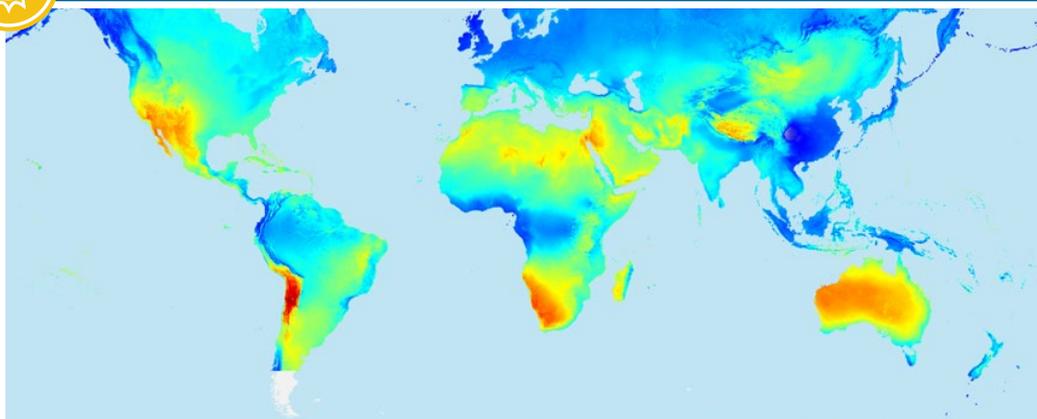


Global solar data have been developed by Vortex for the IRENA Global Atlas for Renewable Energy. They represent long-term yearly and monthly averages of solar irradiation estimates over a 20-year period. The estimates are generated using satellite data from various sources, such as Geostationary Operational Environmental Satellites (GOES), Multifunction Transport Satellite (MTSAT) and Himawari, complemented with solar data estimates based on the newest Goddard parametrisation, developed by the NASA Goddard Space Flight Center, under the Weather Research and Forecast (WRF) model. The parametrisation includes absorption, cloud particles and aerosols. The dataset includes global horizontal irradiation, global tilted irradiation at an optimum angle, direct normal irradiation, and diffuse horizontal irradiation.

<b>Renewables</b>	Solar
<b>Source name – full and acronym</b>	Vortex
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	3 km
<b>Content date</b>	2021
<b>Website</b>	<a href="https://vortexfdc.com">https://vortexfdc.com</a>
<b>Citations</b>	IRENA (2023), <i>Global Atlas for Renewable Energy</i> , International Renewable Energy Agency, <a href="http://globalatlas.irena.org">globalatlas.irena.org</a> .
<b>Keywords</b>	diffuse irradiation, tilted irradiation, global irradiation, direct irradiation, solar, global
<b>Best use</b>	education, potential, policy
<b>Methodology</b>	<a href="http://www.vortexfdc.com/assets/docs/vortex_solar_specifications_validation.pdf">www.vortexfdc.com/assets/docs/vortex_solar_specifications_validation.pdf</a>



## Global Solar Atlas

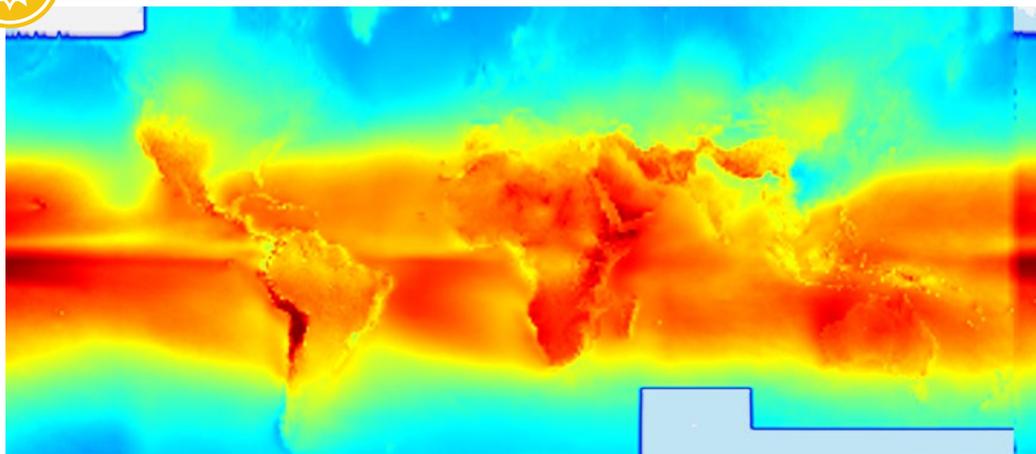


The Global Solar Atlas has been developed and operated by Solargis s.r.o. on behalf of the World Bank Group, utilising Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). The dataset represents global long-term yearly averages of solar irradiation, covering the period 1994, 1999 and 2007-2018. The atlas includes the global horizontal irradiation, diffuse horizontal irradiation, global terrain elevation, global optimum tilt for equator-tilted PV modules, global potential PV electricity production, global irradiation at optimum tilt, and global air temperature at 2 m height.

<b>Renewables</b>	Solar
<b>Source name - full and acronym</b>	Energy Sector Management Assistance Program (ESMAP)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	1km
<b>Content date</b>	2018
<b>Website</b>	<a href="http://www.esmap.org">www.esmap.org</a>
<b>Citations</b>	World Bank Group (2023), <i>Global Solar Atlas</i> , World Bank Group, Solargis and ESMAP, <a href="http://globalsolaratlas.info">globalsolaratlas.info</a> .
<b>Keywords</b>	global irradiation, solar, global, direct irradiation, diffuse irradiation, elevation, photovoltaic
<b>Best use</b>	education, potential, policy
<b>Methodology</b>	<a href="https://globalsolaratlas.info/support/methodology">https://globalsolaratlas.info/support/methodology</a>



## Global Solar Radiation



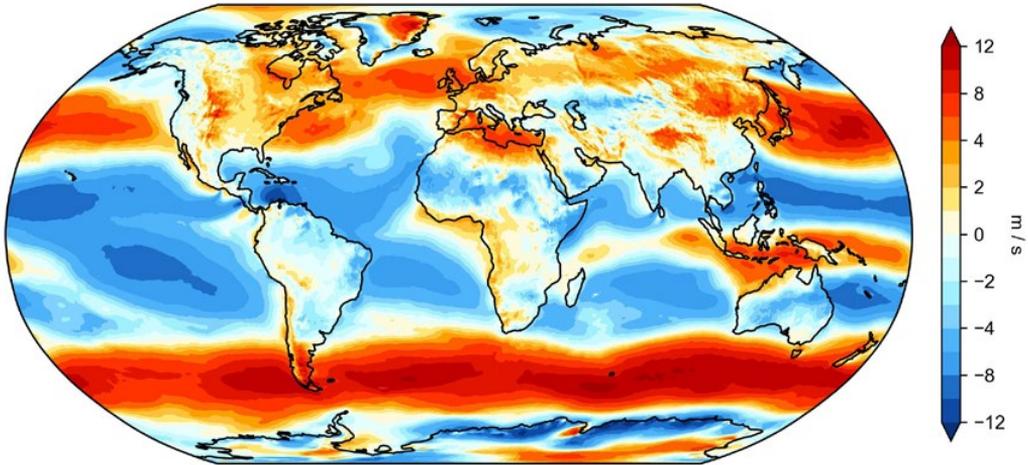
The global radiation estimates over land and ocean have been developed by Meteotest. The global horizontal irradiation data are obtained based on radiation from five geostationary satellites and ground measurements, while the direct and diffuse irradiation data are modelled with help of a chain of algorithms from the Meteonorm and Perez model for separation. The data have a precision of 20% (relative root mean square error [RMSE]) for hourly values, 10% for daily values and 5% for monthly values.

<b>Renewables</b>	Solar
<b>Source name – full and acronym</b>	Meteotest
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	8 km
<b>Content date</b>	2022
<b>Website</b>	<a href="https://meteotest.ch/en">https://meteotest.ch/en</a>
<b>Citations</b>	Meteotest (2023), <i>Meteonorm</i> , Version 8, <a href="https://meteonorm.com/en/meteonorm-documents">https://meteonorm.com/en/meteonorm-documents</a> .
<b>Keywords</b>	global irradiation, direct irradiation, diffuse irradiation, solar, global
<b>Best use</b>	education, potential, policy
<b>Methodology</b>	<a href="https://meteonorm.com/en/meteonorm-documents">https://meteonorm.com/en/meteonorm-documents</a>



## ECMWF ERA5 reanalysis data

ERA5 Monthly Mean U Wind Component at 100m Above Surface - January 2019

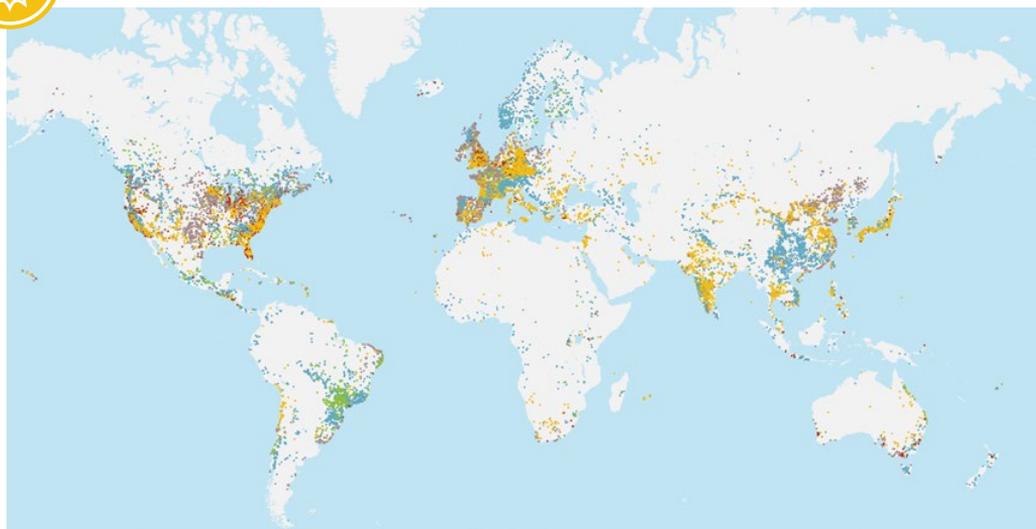


The ERA5 (the Fifth-generation ECMWF Reanalysis) is a series of climate reanalysis datasets produced by Copernicus Climate Change Service (C3S) at the ECMWF. Climate reanalysis combines model data with observations to generate consistent hourly time series of multiple atmospheric, land and oceanic climate variables for the past eight decades using the laws of physics. The data cover the Earth on a 30 km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80 km. ERA5 includes information about uncertainties for all variables at reduced spatial and temporal resolutions.

<b>Renewables</b>	Solar
<b>Source name - full and acronym</b>	European Centre for Medium-Range Weather Forecasts (ECMWF)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	0.25°
<b>Content date</b>	2023
<b>Website</b>	<a href="https://cds.climate.copernicus.eu/cdsapp#!/home">https://cds.climate.copernicus.eu/cdsapp#!/home</a>
<b>Citations</b>	Hersbach, H. <i>et al.</i> (2018), "ERA5 hourly data on single levels from 1979 to present", Copernicus Climate Change Service Climate Data Store, <a href="https://doi.org/10.24381/cds.adbb2d47">doi: 10.24381/cds.adbb2d47</a> .
<b>Keywords</b>	renewable, meteorology
<b>Best use</b>	education, potential
<b>Methodology</b>	<a href="https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview">https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview</a>



## Global Renewable Power Plants

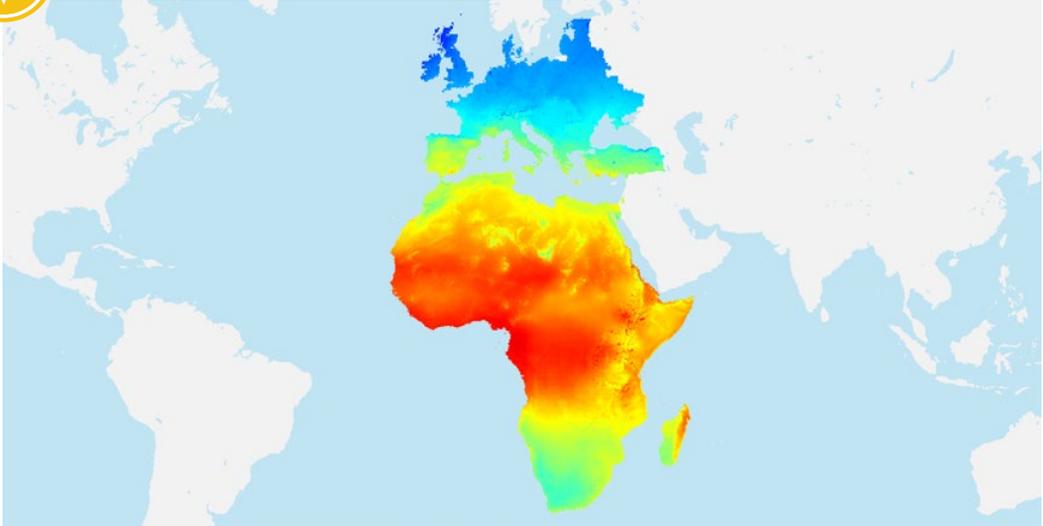


The Global Renewable Power Plant Database has been created by WRI experts and their partners from official government data and independent sources around the world. The database is open-source and comprehensive. It centralises the locations and technical specifications (technology, capacity, generation and ownership) of approximately 30 000 power plants from 164 countries to make it easier to navigate, compare and draw insights for one's own analysis.

<b>Renewables</b>	Solar
<b>Source name – full and acronym</b>	World Resource Institute (WRI)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2021
<b>Website</b>	<a href="http://www.wri.org">www.wri.org</a>
<b>Citations</b>	Global Energy Observatory <i>et al.</i> (2018), <i>Global Power Plant Database</i> , <a href="http://resourcewatch.org/">http://resourcewatch.org/</a> <a href="https://earthengine.google.com">https://earthengine.google.com</a> .
<b>Keywords</b>	renewable, meteorology
<b>Best use</b>	education, potential
<b>Methodology</b>	<a href="https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview">https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview</a>



## CAMS Radiation data



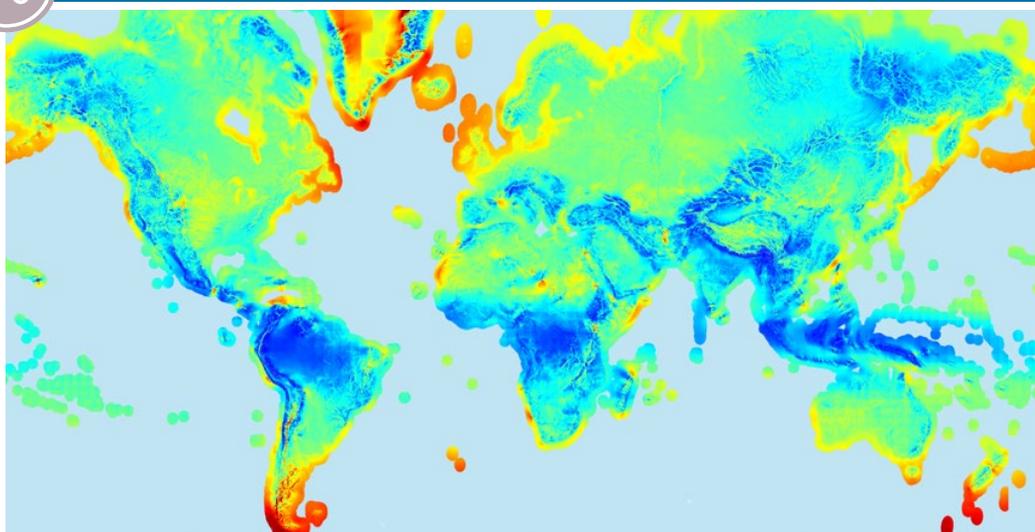
The Copernicus Atmosphere Monitoring Service (CAMS) Radiation service datasets for Europe (AGATE) and Africa (JADE) were derived from the SoDa Service, which originated from a European project funded by the European Commission, led by Mines ParisTech, and managed by the research centre O.I.E. of Mines ParisTech and ARMINES. The CAMS datasets are computed with McClear version 3 and CAMS radiation bias correction. They combine state-of-the-art atmospheric modelling with Earth observation data to provide information services on radiation values at ground level to fulfil the needs at regional and national levels for planning, monitoring, efficiency improvements and the integration of solar energy systems into energy supply grids.

<b>Renewables</b>	Solar
<b>Source name - full and acronym</b>	MINES ParisTech, Transvalor, ARMINES
<b>Geographic coverage</b>	Africa and Europe
<b>Spatial resolution</b>	20 km
<b>Content date</b>	2020
<b>Website</b>	<a href="http://www.soda-pro.com">www.soda-pro.com</a>
<b>Citations</b>	ARMINES <i>et al.</i> (2020), "Monthly and yearly average solar irradiation maps from CAMS Radiation Service over Europe (AGATE) and Africa (JADE), CAMS.
<b>Keywords</b>	global irradiation, direct irradiation, diffuse irradiation, solar, Africa, Europe
<b>Best use</b>	education, potential
<b>Methodology</b>	<a href="http://www.soda-pro.com/es/help/cams-services/introduction">www.soda-pro.com/es/help/cams-services/introduction</a>

## 4.2 Wind



### Global wind data

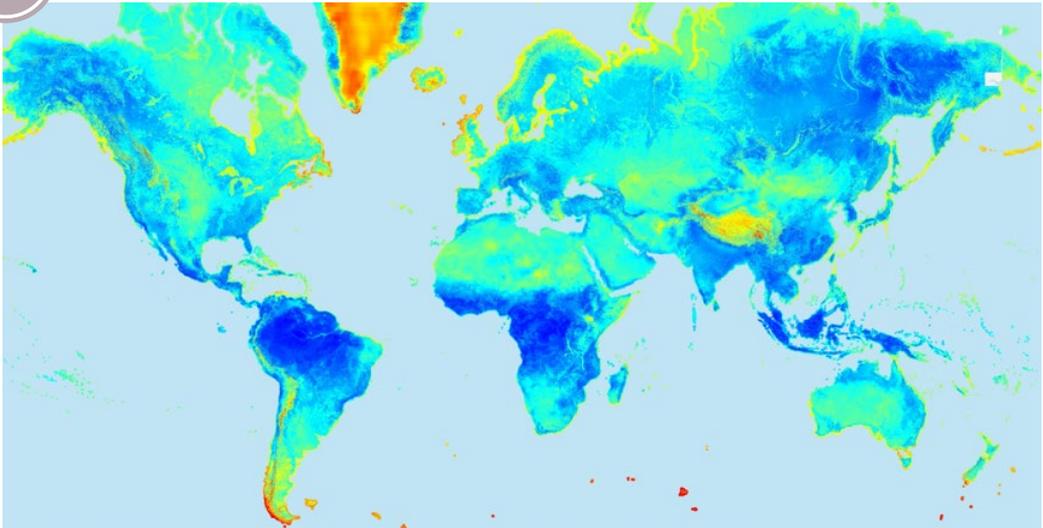


Global wind resource data has been developed by Vortex for the IRENA Global Atlas for Renewable Energy. They represent long-term yearly and monthly averages of the wind resource at different heights over a 20-year period. These data are estimates based on the WRF model, which uses a variety of global geophysical databases (topography from the Shuttle Radar Topography Mission [SRTM] and land use from European Space Agency GlobCover) and meteorological databases (the Global Forecast System [GFS] from National Centers for Environmental Prediction; MERRA-2 from NASA; and ERA5 from the ECMWF). The estimates have an acceptable accuracy.

<b>Renewables</b>	Wind
<b>Source name - full and acronym</b>	Vortex
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	3 km
<b>Content date</b>	2012
<b>Website</b>	<a href="https://vortexfdc.com">https://vortexfdc.com</a>
<b>Citations</b>	IRENA (2021), <i>Global Atlas for Renewable Energy</i> , International Renewable Energy Agency, <a href="http://globalatlas.irena.org">globalatlas.irena.org</a> .
<b>Keywords</b>	wind speed, wind power, global, heights (10 m, 20 m, 30 m, 60 m, 80 m, 100 m and 120 m)
<b>Best use</b>	education, potential, policy
<b>Methodology</b>	<a href="http://www.vortexfdc.com/assets/docs/validation_ERA5.pdf">www.vortexfdc.com/assets/docs/validation_ERA5.pdf</a>



## Global Wind Atlas

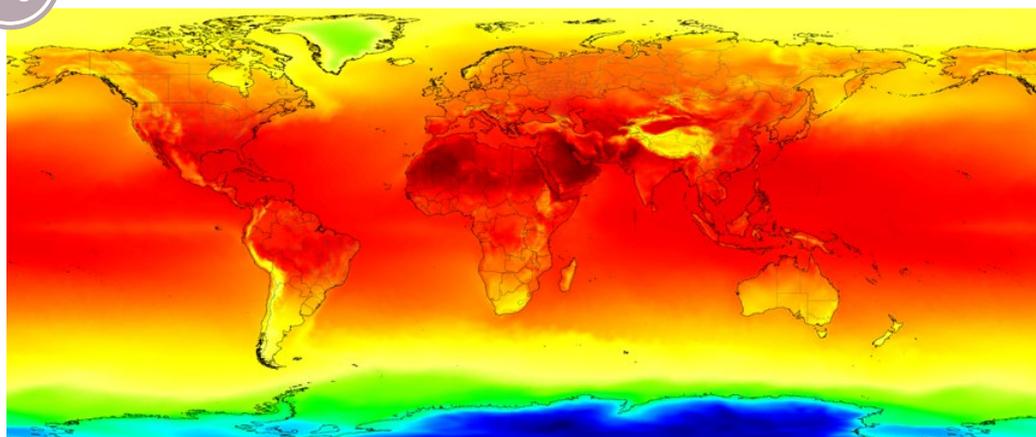


The Global Wind Atlas (GWA) has been developed, owned and operated by the Technical University of Denmark Wind Energy in partnership with the World Bank Group. It delivers high-resolution global wind climatology using microscale modelling that captures small-scale spatial variability of wind speeds due to high resolution orography and surface roughness change effects. The GWA continues to help policy makers, planners and investors identify global, regional, national and local high-wind areas in support of the development of wind power generation.

<b>Renewables</b>	Wind
<b>Source name – full and acronym</b>	Technical University of Denmark (DTU)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	1 km
<b>Content date</b>	2015
<b>Website</b>	<a href="http://www.dtu.dk/english">www.dtu.dk/english</a>
<b>Citations</b>	DTU (Technical University of Denmark) (2023), <i>Global Wind Atlas</i> , <a href="https://globalwindatlas.info">https://globalwindatlas.info</a> .
<b>Keywords</b>	Global, wind speed, height (50 m, 100 m and 200 m)
<b>Best use</b>	business, policy, potential
<b>Methodology</b>	<a href="https://globalwindatlas.info/about/method">https://globalwindatlas.info/about/method</a>



## NASA MERRA-2 Reanalysis data



The MERRA-2 (Modern-Era Retrospective analysis for Research and Applications version 2) is a global atmospheric reanalysis dataset produced by the NASA Global Modeling and Assimilation Office (GMAO) using the Goddard Earth Observing System Model (GEOS) version 5.12.4. Reanalysis combines model data with observations to produce an hourly time-averaged two-dimensional meteorological dataset (M2T1NXSLV or tavg1\_2d\_slv\_Nx) of multiple climate variables, beginning in 1980. The data consist of meteorology diagnostics at popularly used vertical levels, such as air temperature at 2 m, wind components at 50 m, sea level pressure, surface pressure and total precipitable water vapour, dedicated for use in a broad range of weather and climate timescale analyses.

<b>Renewables</b>	Wind
<b>Source name - full and acronym</b>	National Aeronautics and Space Administration (NASA)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	0.5° x 0.625°
<b>Content date</b>	1980 to present
<b>Website</b>	<a href="https://disc.gsfc.nasa.gov">https://disc.gsfc.nasa.gov</a>
<b>Citations</b>	GMAO (Global Modeling and Assimilation Office) (2015), MERRA-2 tavg1_2d_slv_Nx (2d, 1-hourly, time-averaged, single-level, assimilation, single-level diagnostics v5.12.4), NASA GES DISC, Greenbelt, MD, doi: 10.5067/VJAFPLIICSIV.
<b>Keywords</b>	global, air temperature, sea level pressure, surface pressure, wind
<b>Best use</b>	business, policy
<b>Methodology</b>	<a href="https://daac.gsfc.nasa.gov/information/documents?title=MERRA-2%20Data%20Access%20%E2%80%93%20Quick%20Guide">https://daac.gsfc.nasa.gov/information/documents?title=MERRA-2%20Data%20Access%20%E2%80%93%20Quick%20Guide</a>



## The Wind Power database



The Wind Power's database is a proficient and unique database collected for the development of the wind turbine sector worldwide. It describes the location and capacity of more than 31 000 wind farms around the world, and provides quantitative and qualitative data, which are systematically verified and updated twice a year at a minimum from various sources that are reviewed every six months. The data inventory is refined using a range of in-depth and customisable analyses of wind farms at the global, continental or national level, and include onshore and offshore wind farms that are planned, approved, under construction, operational or dismantled.

<b>Renewables</b>	Wind
<b>Source name – full and acronym</b>	The Wind Power (TWP)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2023
<b>Website</b>	<a href="http://www.thewindpower.net">www.thewindpower.net</a>
<b>Citations</b>	The Wind Power (2023), “Wind farms databases”, <a href="http://thewindpower.net">thewindpower.net</a> .
<b>Keywords</b>	wind power plants, wind, global
<b>Best use</b>	education, business, policy
<b>Methodology</b>	<a href="http://www.thewindpower.net/reports_en.php?area=1000">www.thewindpower.net/reports_en.php?area=1000</a>



## The United Arab Emirates (UAE) Wind Atlas



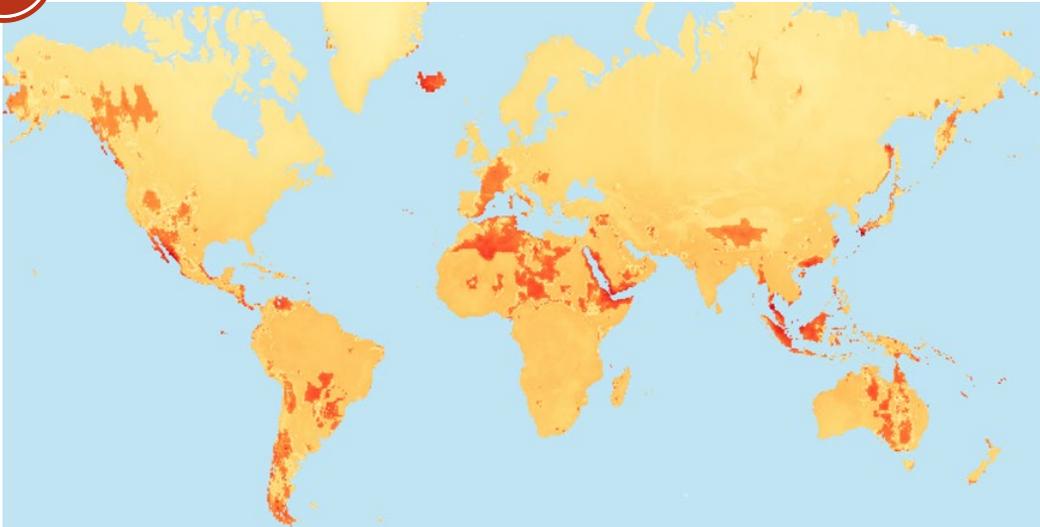
The United Arab Emirates (UAE) Wind Atlas is a collaboration between the Masdar Institute, Khalifa University, Abu Dhabi, and 3TIER. It was developed using the microscale modelling and long-term ground-based measurements collected over different locations in the UAE at different heights. At a spatial resolution of 500 m, the wind atlas aims to accurately characterise the UAE’s wind resources and to ultimately support investment in wind energy projects.

<b>Renewables</b>	Wind
<b>Source name - full and acronym</b>	Khalifa University (KU)
<b>Geographic coverage</b>	United Arab Emirates
<b>Spatial resolution</b>	500 m
<b>Content date</b>	2013
<b>Website</b>	<a href="http://www.ku.ac.ae/masdar-publishes-uae-wind-atlas">www.ku.ac.ae/masdar-publishes-uae-wind-atlas</a>
<b>Citations</b>	UAE wind atlas (2021), Khalifa University.
<b>Keywords</b>	wind speed, UAE, Middle East, height (50 m, 80 m, 100 m and 120 m)
<b>Best use</b>	education, business, potential
<b>Methodology</b>	n/a

## 4.3 Geothermal



### Global Enhanced Geothermal System (EGS) Potential

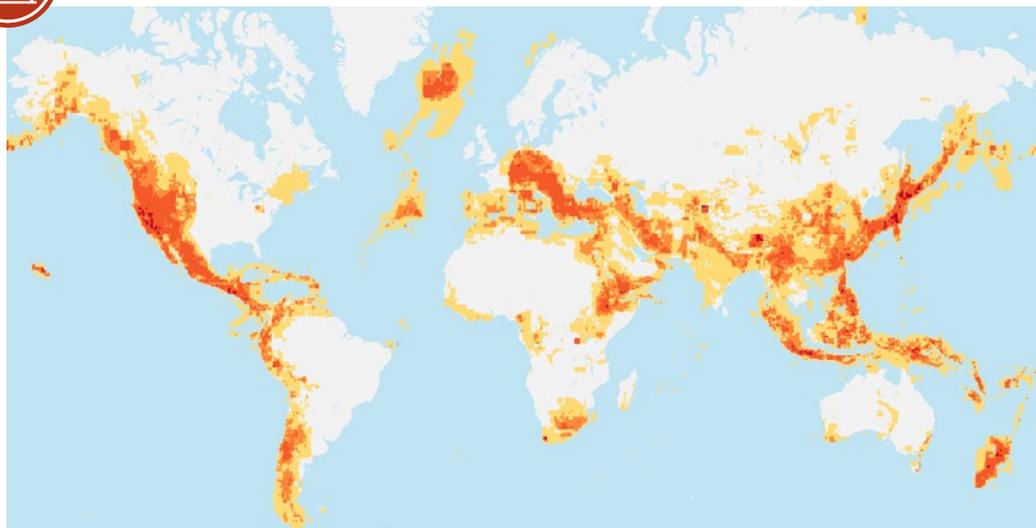


The Global Geothermal Protocol has been used by Hot Dry Rocks consultancy in collaboration with Southern Methodist University (SMU) to map: (i) the earth's theoretical and technical EGS potential at different depths using modified methodologies designed by SMU and the Massachusetts Institute of Technology (MIT), (ii) the temperature at different depths (between 0.5 km and 10 km), and (iii) the sediment basement interface.

<b>Renewables</b>	Geothermal
<b>Source name – full and acronym</b>	Hot Dry Rocks (HDR)
<b>Geographic coverage</b>	Global, Ethiopia, Indonesia, Eastern Caribbean, Australia
<b>Spatial resolution</b>	18 km, 8 km, 5 km and 1 km
<b>Content date</b>	2012, 2015, 2018
<b>Website</b>	<a href="http://www.hotdryrocks.com">www.hotdryrocks.com</a>
<b>Citations</b>	Beardsmore et al. (2011), "A Protocol for Estimating and Mapping Global EGS Potential", doi: 10.13140/RG.2.2.33475.71204.
<b>Keywords</b>	temperature, EGS, sediment basement, geothermal, technical potential, heat, global, Ethiopia, Indonesia, Eastern Caribbean, Australia
<b>Best use</b>	education, potential, policy
<b>Methodology</b>	<a href="http://www.researchgate.net/publication/325168934_A_Protocol_for_Estimating_and_Mapping_Global_EGS_Potential?channel=doi&amp;linkId=5afbbb1b458515c00b6e5b83&amp;showFulltext=true">www.researchgate.net/publication/325168934_A_Protocol_for_Estimating_and_Mapping_Global_EGS_Potential?channel=doi&amp;linkId=5afbbb1b458515c00b6e5b83&amp;showFulltext=true</a>



## Global and national geothermal data

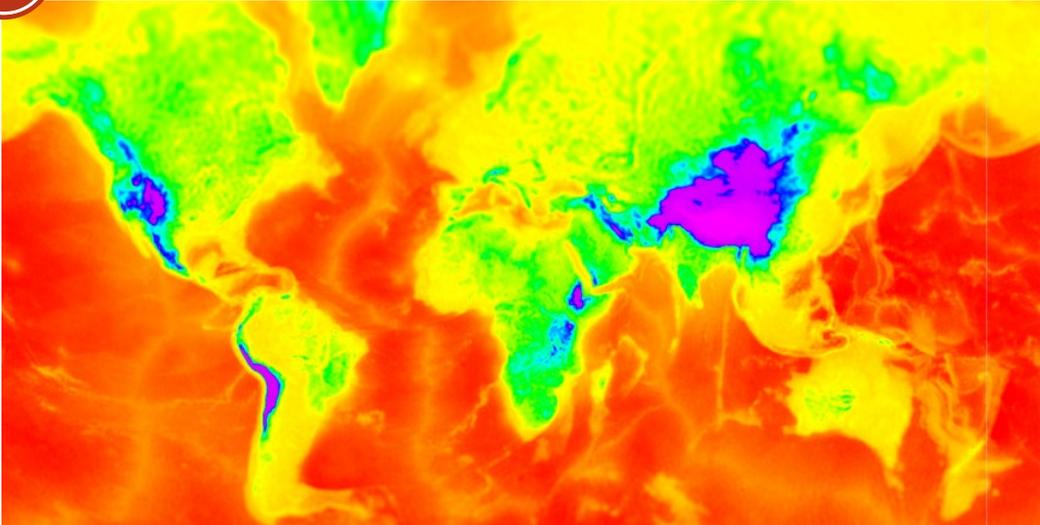


The Institute of Geosciences and Earth Resources (IGG), an institute of National Research Council of Italy (CNR), derived the following data as part of the Italian National Geothermal Database: (i) the global suitability map for planning and installing a highly efficient geothermal power plant by correlating geospatial data with geothermal site suitability data using the Maximum Entropy model; and (ii) the national surface heat flow, temperature at different depths, and deep boreholes dataset.

<b>Renewables</b>	Geothermal
<b>Source name – full and acronym</b>	Geosciences and Earth Resources, an institute of National Research Council of Italy (IGG-CNR)
<b>Geographic coverage</b>	Global, Italy
<b>Spatial resolution</b>	0.5°
<b>Content date</b>	1991, 2017, 2020
<b>Website</b>	<a href="http://www.igg.cnr.it/en">www.igg.cnr.it/en</a>
<b>Citations</b>	Calore <i>et al.</i> (1991), “Temperature map of Italy at 3000 m (below ground level)”, International Institute for Geothermal Research-CNR, Pisa.
<b>Keywords</b>	global and national geothermal data
<b>Best use</b>	business, policy, potential
<b>Methodology</b>	Coro, and Trumpy (2020). Predicting geographical suitability of geothermal power plants. <i>Journal of Cleaner Production</i> 267 (2020): 121874. Doi: <a href="https://doi.org/10.1016/j.jclepro.2020.121874">https://doi.org/10.1016/j.jclepro.2020.121874</a> <a href="https://doi.org/10.1016/j.jclepro.2020.121874">https://doi.org/10.1016/j.jclepro.2020.121874</a>



## Free air gravity and Bouguer anomalies



The free air gravity and Bouguer anomalies have been derived by the European Space Agency (ESA) in collaboration with IRENA. The free air gravity anomaly is derived by averaging observations from the Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) satellite's gravity observations to characterise geological structures, allowing assessment of the technical and economic potential of geothermal energy, especially in areas where no local gravity and seismic data are available. The Bouguer anomaly is derived by removing the effect of elevated regions and oceanic water from the gravity disturbance to distinguish thick from thin crust.

<b>Renewables</b>	Geothermal
<b>Source name – full and acronym</b>	European Space Agency (ESA)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	25 km
<b>Content date</b>	2015
<b>Website</b>	<a href="http://www.esa.int">www.esa.int</a>
<b>Citations</b>	© ESA/IRENA
<b>Keywords</b>	GOCE, free air anomaly, Bouguer anomaly, geothermal, global
<b>Best use</b>	education, potential
<b>Methodology</b>	<a href="http://www.lithoflex.org/IRENA">www.lithoflex.org/IRENA</a>



## Global geothermal power plant database

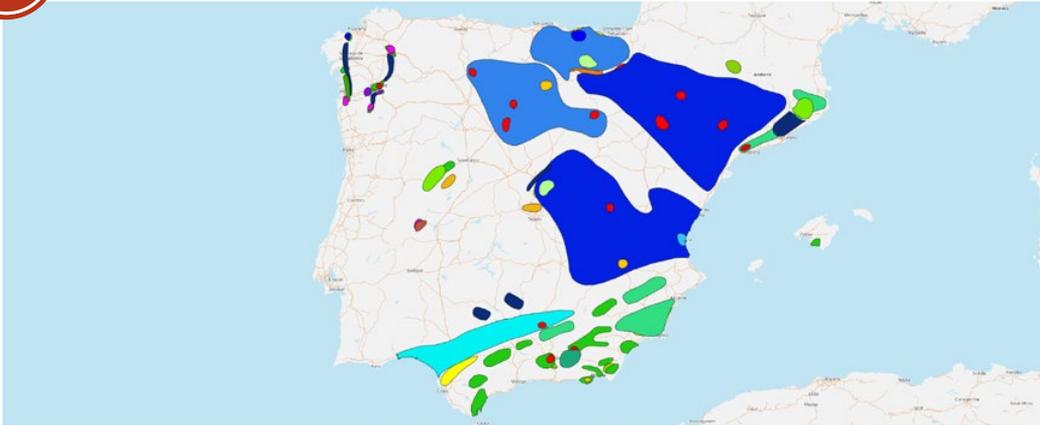


The global geothermal power plant database was developed by Think GeoEnergy in partnership with Invest Geothermal (IGC) and Enerchange. The database is an inventory of global geothermal power plants, comprising the name of the plant, the country, the installed power generation capacity in megawatt, and the technology used.

<b>Renewables</b>	Geothermal
<b>Source name – full and acronym</b>	Think GeoEnergy
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	Data points
<b>Content date</b>	2014
<b>Website</b>	<a href="http://www.thinkgeoenergy.com">www.thinkgeoenergy.com</a>
<b>Citations</b>	ThinkGeoEnergy (2021), “Global Geothermal Power Plant Database”, Think GeoEnergy, Invest Geothermal and Enerchange.
<b>Keywords</b>	geothermal power plants, geothermal, global
<b>Best use</b>	education
<b>Methodology</b>	<a href="http://www.thinkgeoenergy.com/mapping-geothermal-power-generation-our-approach-to-research-and-our-power-plant-map/">www.thinkgeoenergy.com/mapping-geothermal-power-generation-our-approach-to-research-and-our-power-plant-map/</a>



## Geothermal potential



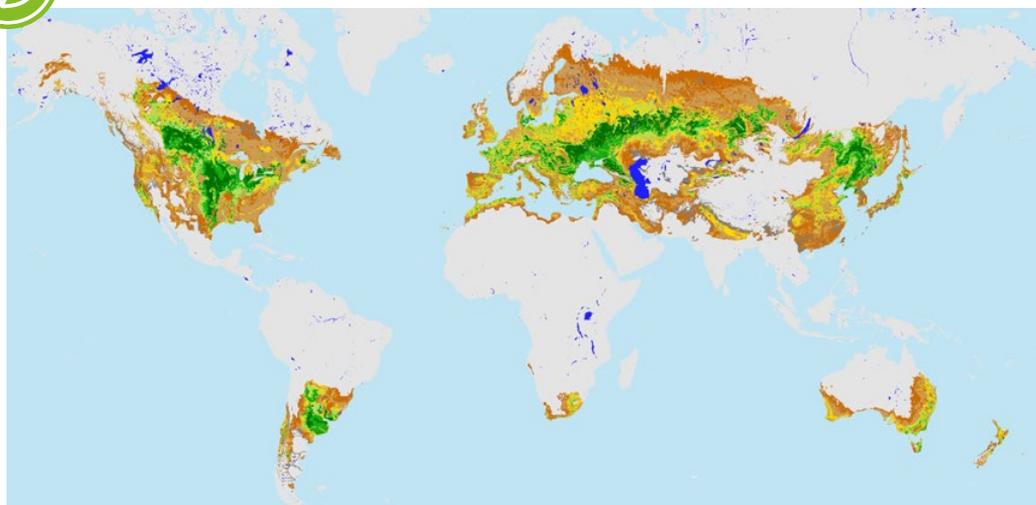
Instituto para la Diversificación y Ahorro de la Energía (IDAE) mapped different types of geothermal technologies to identify potential areas for the generation of electricity for heating purposes. The maps display areas suitable for enhanced geothermal systems (EGS), geothermal systems operating at different temperature levels (less than 100°C, between 100°C and 150°C, and greater than 100°C), and geothermal systems for shallow ground with temperatures less than 100°C. IDAE also estimated the geothermal energy (total, available and accessible) of each area in GWh.

<b>Renewables</b>	Geothermal
<b>Source name – full and acronym</b>	Instituto para la Diversificación y Ahorro de la Energía (IDAE)
<b>Geographic coverage</b>	Spain
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2016
<b>Website</b>	<a href="http://www.idae.es/en">www.idae.es/en</a>
<b>Citations</b>	Guzmán et al. (2011), “Evaluación del potencial de energía geotérmica”, Estudio Técnico PER 2011-2020, Tecnología y Recursos de la Tierra, IDAE.
<b>Keywords</b>	total potential, geothermal, Spain, high temperature, medium temperature, low temperature, aquifers, subsoil
<b>Best use</b>	education, potential
<b>Methodology</b>	<a href="http://www.idae.es/uploads/documentos/documentos_11227_e9_geotermia_A_db72b0ac.pdf">www.idae.es/uploads/documentos/documentos_11227_e9_geotermia_A_db72b0ac.pdf</a>

## 4.4 Bioenergy



### Global Agro-Ecological Zones (GAEZ) version 4



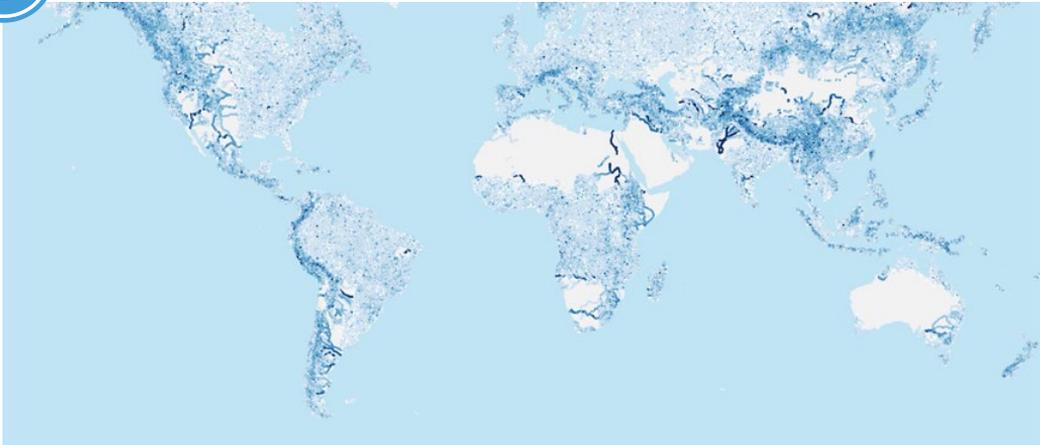
The GAEZ version 4 database, by the Food and Agriculture Organization (FAO) and the International Institute for Applied Systems Analysis (IIASA), is the most ambitious global assessment of crop potential to date. It relies on well-established land evaluation principles to assess soil suitability and production potentials for individual crop types under specific input and management conditions based on plant eco-physiological characteristics and on climatic and edaphic requirements of crops. The GAEZ framework contributes to several of the United Nations’ Sustainable Development Goals (SDGs) by providing information about current and future agricultural production risks and opportunities, irrigation water demand, and crop development and adaptation options.

<b>Renewables</b>	Bioenergy
<b>Source name – full and acronym</b>	Food and Agriculture Organization (FAO)
<b>Geographic coverage</b>	Global, Mozambique, Tanzania
<b>Spatial resolution</b>	1 km, 5.5 km, 10 km
<b>Content date</b>	2006, 2013, 2010, 2021
<b>Website</b>	<a href="https://gaez.fao.org">https://gaez.fao.org</a>
<b>Citations</b>	FAO and IIASA, <i>Global Agro-Ecological Zones version 4 (GAEZ v4)</i> , Food and Agriculture Organization and International Institute for Applied Systems Analysis, <a href="http://www.fao.org/gaez/">www.fao.org/gaez/</a> .
<b>Keywords</b>	crop suitability index, bioenergy, global, crops, land use, land availability, suitability index, farming, net primary production of biomass
<b>Best use</b>	education
<b>Methodology</b>	<a href="http://www.fao.org/3/a-i3044e.pdf">www.fao.org/3/a-i3044e.pdf</a>

## 4.5 Hydropower



### Global hydropower potential

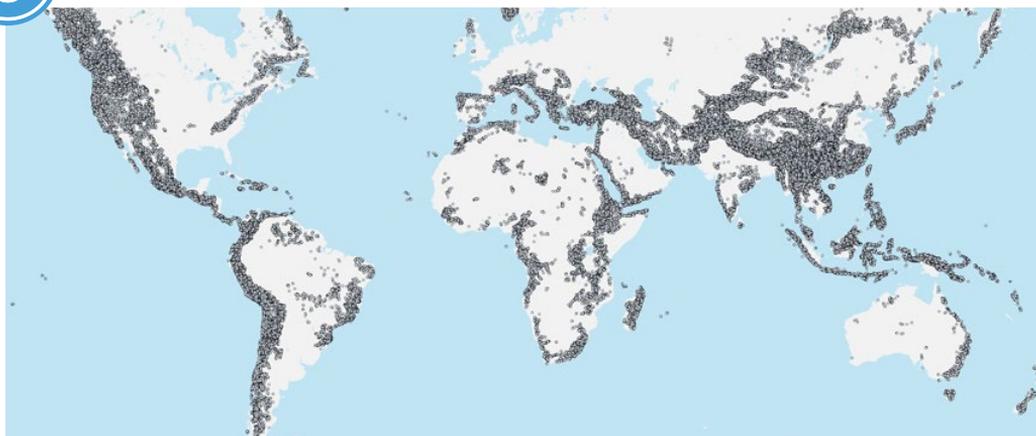


TU Delft has rendered global high-resolution generation estimates of potential hydropower plant locations for micro to large plants. The data are generated from the Global Multi-resolution Terrain Elevation Data (GMTED2010) and composite run-off data from the University of New Hampshire and the Global Runoff Data Centre (UNH/GRDC). The gross theoretical hydropower potential has been estimated to be 52 PWh/year from 11.8 million identified locations.

<b>Renewables</b>	Hydropower
<b>Source name - full and acronym</b>	Delft University of Technology (TU Delft)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	1m - 4 m
<b>Content date</b>	2014
<b>Website</b>	<a href="http://www.tudelft.nl">www.tudelft.nl</a>
<b>Citations</b>	Hoes OAC, Meijer LJJ, van der Ent RJ, van de Giesen NC (2017) "Systematic high-resolution assessment of global hydropower potential". PLoS ONE 12(2): e0171844. <a href="https://doi.org/10.1371/journal.pone.0171844">https://doi.org/10.1371/journal.pone.0171844</a>
<b>Keywords</b>	hydropower, river, global
<b>Best use</b>	education, potential, policy
<b>Methodology</b>	<a href="http://www.researchgate.net/publication/325168934_A_Protocol_for_Estimating_and_Mapping_Global_EGS_Potential?channel=doi&amp;linkId=5afbbb1b458515c00b6e5b83&amp;showFulltext=true">www.researchgate.net/publication/325168934_A_Protocol_for_Estimating_and_Mapping_Global_EGS_Potential?channel=doi&amp;linkId=5afbbb1b458515c00b6e5b83&amp;showFulltext=true</a>



## Global closed-loop pumped hydro energy storage

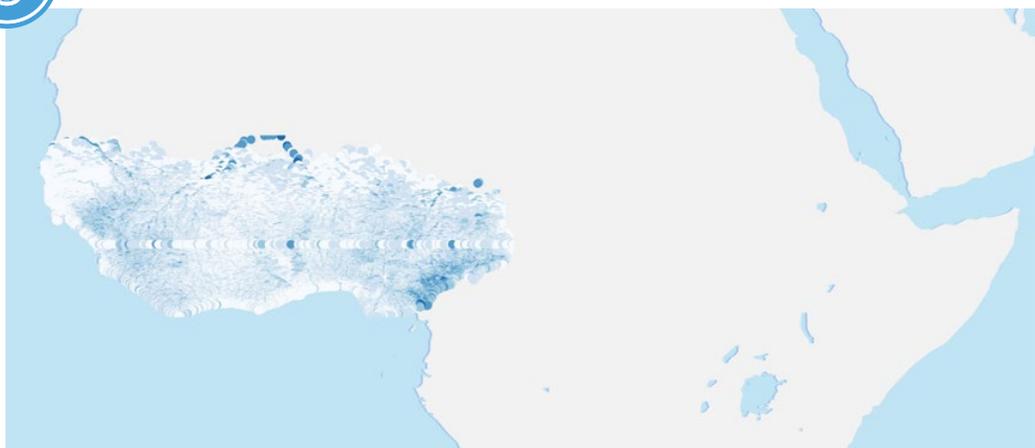


Global closed-loop off-river pumped hydro energy storage (PHES) sites have been mapped by the Australian National University (ANU). These economically feasible sites are identified outside protected and urban areas using a GIS analysis of high-resolution global digital elevation models with certain search criteria and an approximate cost model. The combined storage potential has been estimated at 23 000 TWh from 616 000 identified locations.

<b>Renewables</b>	Hydropower
<b>Source name – full and acronym</b>	Australian National University (ANU)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2019
<b>Website</b>	<a href="http://re100.eng.anu.edu.au">http://re100.eng.anu.edu.au</a>
<b>Citations</b>	RE100 Group, Australian National University, <a href="http://re100.eng.anu.edu.au">http://re100.eng.anu.edu.au</a>
<b>Keywords</b>	hydropower, pumped, global
<b>Best use</b>	educational, policy, potential
<b>Methodology</b>	<a href="http://www.cell.com/joule/fulltext/S2542-4351(20)30559-6?returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS2542435120305596%3Fshowall%3Dtrue">#"&gt;www.cell.com/joule/fulltext/S2542-4351(20)30559-6?returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS2542435120305596%3Fshowall%3Dtrue#</a>



## ECOWAS hydropower potential



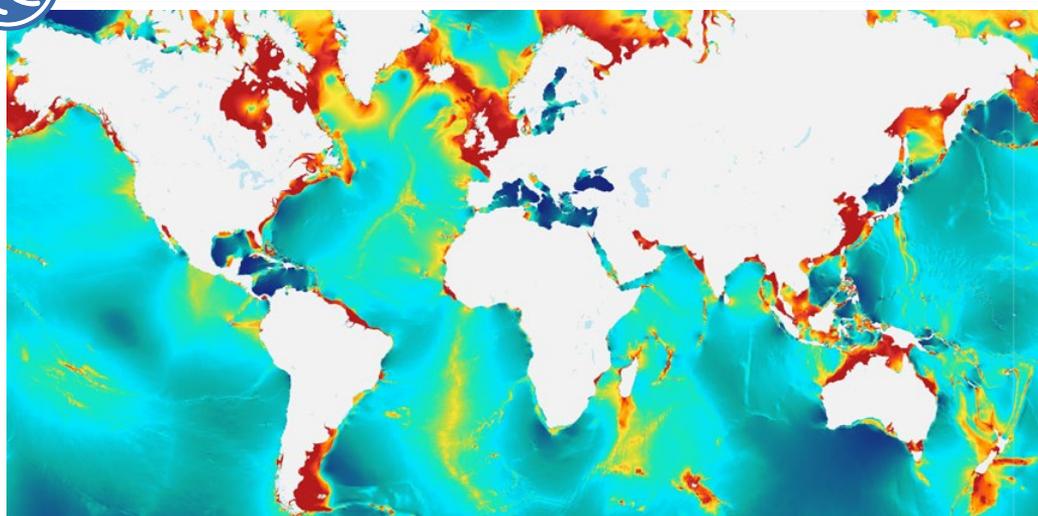
The ECREEE small-scale hydropower programme addresses the untapped potential of mini, micro and small hydropower in Economic Community of West African States (ECOWAS) countries, excluding Cabo Verde. This dataset, mapped by Pöyry Energy GmbH using the latest GIS technology, shows the river networks and sub-catchments for West Africa and the estimated hydropower potential. It aims to overcome existing barriers related to the missing awareness, technical skills and capacity, discharge data gaps, and a lack of policies and private sector involvement.

<b>Renewables</b>	Hydropower
<b>Source name - full and acronym</b>	ECOWAS Centre for Renewable Energy and Energy Efficiency (ECEEE)
<b>Geographic coverage</b>	West Africa
<b>Spatial resolution</b>	90 m-450 m
<b>Content date</b>	2016
<b>Website</b>	<a href="http://www.ecowrex.org">www.ecowrex.org</a>
<b>Citations</b>	Pöyry Energy Ltd. and ECREEE (ECOWAS Centre for Renewable Energy and Energy Efficiency), GIS Hydropower Resource Mapping Including Climate Change Scenarios for West Africa - Methodology and Lessons Learnt.
<b>Keywords</b>	hydropower, river, ECOWAS
<b>Best use</b>	educational, policy, potential
<b>Methodology</b>	<a href="http://www.ecowrex.org/sites/default/files/final_technical_report_on_methodology_and_lessons_learnt_for_ecowas_countries.pdf">www.ecowrex.org/sites/default/files/final_technical_report_on_methodology_and_lessons_learnt_for_ecowas_countries.pdf</a>

## 4.6 Marine



### Global marine data



The global tidal atlases – containing global ocean currents and elevation data – have been developed by NOVELTIS on behalf of the French National Centre for Space Studies (CNES) and European Space Agency (ESA). NOVELTIS has used the best satellite and in-situ observations for generating these atlases with other indicators dedicated for a first level of tidal energy assessment in the coastal areas (bathymetry lower than 100 m), including average power density, percentage of time where the current speed is higher than different thresholds, and maximum current speed. The tidal atlases were developed for users in the offshore operations and renewable marine energy industries.

<b>Renewables</b>	Marine
<b>Source name – full and acronym</b>	NOVELTIS
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	7 km
<b>Content date</b>	2022
<b>Website</b>	<a href="http://www.noveltis.fr">www.noveltis.fr</a>
<b>Citations</b>	NOVELTIS (2023), <a href="http://www.noveltis.fr">www.noveltis.fr</a>
<b>Keywords</b>	global, tidal, velocity, marine energy
<b>Best use</b>	policy, potential
<b>Methodology</b>	<a href="http://www.noveltis.fr/en/references/web-service-for-tidal-elevations-and-currents-predictions">www.noveltis.fr/en/references/web-service-for-tidal-elevations-and-currents-predictions</a>

## 4.7 Infrastructure



### World Database on Protected Areas (WDPA)

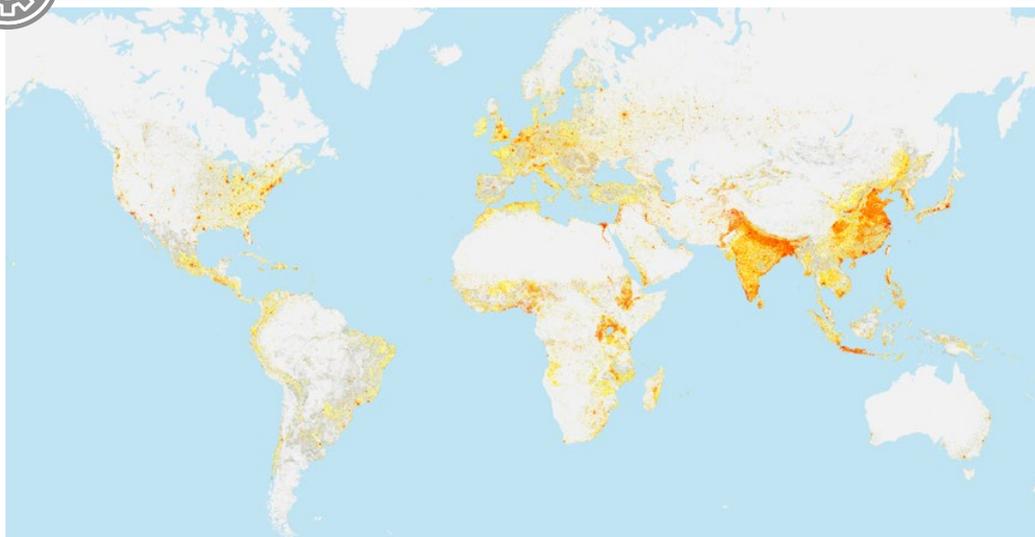


The WDPA is a joint project between the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas (WCPA). The WDPA is collected in collaboration with international convention secretariats, governments, non-governmental organisations and other data providers following IUCN standards. It is the largest and most comprehensive spatial dataset on the world's marine and terrestrial protected areas, containing hundreds of thousands of protected areas covering several countries and territories across the world.

<b>Ancillary data</b>	Protected areas
<b>Source name – full and acronym</b>	United Nations Environment Programme (UNEP)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2023
<b>Website</b>	<a href="http://www.unep-wcmc.org">www.unep-wcmc.org</a>
<b>Citations</b>	IUCN and UNEP-WCMC (2020), The World Database on Protected Areas (WDPA) [ <a href="http://www.protectedplanet.net/en/search-areas?filters%5Bdb_type%5D%5B%5D=wdpa&amp;geo_type=region">www.protectedplanet.net/en/search-areas?filters%5Bdb_type%5D%5B%5D=wdpa&amp;geo_type=region</a> ], [08/2020], Cambridge, UK: UNEP-WCMC. <a href="http://www.protectedplanet.net">www.protectedplanet.net</a> .
<b>Keywords</b>	protected areas, biodiversity
<b>Best use</b>	education, potential
<b>Methodology</b>	<a href="https://wdpa.s3-eu-west-1.amazonaws.com/WDPA_Manual/English/WDPA_WDOECM_Manual_1_6.pdf">https://wdpa.s3-eu-west-1.amazonaws.com/WDPA_Manual/English/WDPA_WDOECM_Manual_1_6.pdf</a>



## LandScan global population database

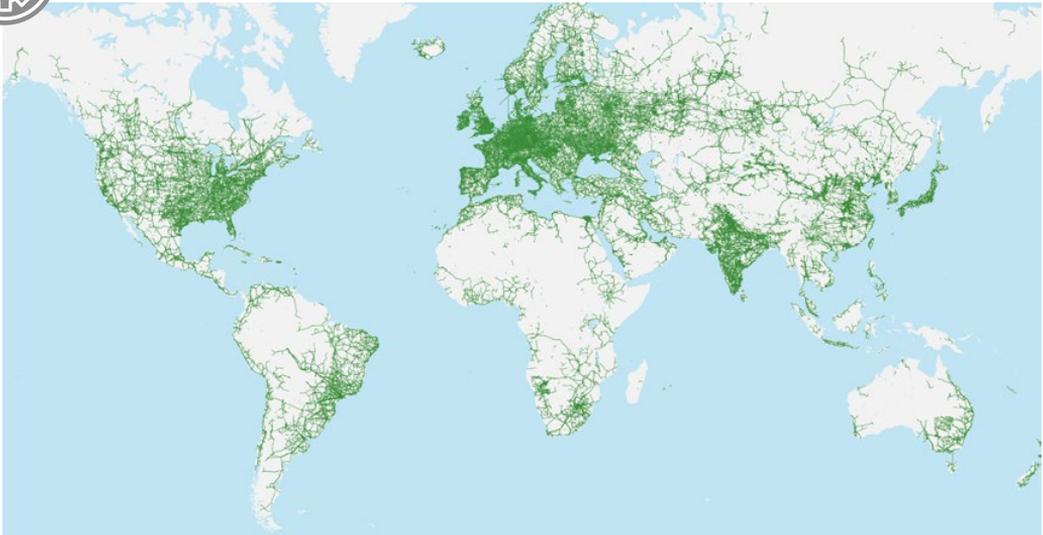


The LandScan Program was initiated by Oak Ridge National Laboratory (ORNL) to address the need for improved estimates of population for consequence assessment. It combines geospatial science, remote sensing technology and machine learning algorithms to generate the latest and finest resolution global population distribution data since 1997.

<b>Ancillary data</b>	Population density
<b>Source name - full and acronym</b>	Oak Ridge National Laboratory - ORNL
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	1km
<b>Content date</b>	2022
<b>Website</b>	<a href="https://landscan.ornl.gov">https://landscan.ornl.gov</a>
<b>Citations</b>	Sims, K., Reith, A., Bright, E., Kaufman, J., Pyle, J., Epting, J., Gonzales, J., Adams, D., Powell, E., Urban, M., & Rose, A. (2023). LandScan Global 2022 [Data set]. Oak Ridge National Laboratory. <a href="https://doi.org/10.48690/1529167">https://doi.org/10.48690/1529167</a>
<b>Keywords</b>	global population, land cover
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="https://landscan.ornl.gov/documentation">https://landscan.ornl.gov/documentation</a>



## Global power and transport networks



Global power and transport networks are part of the OpenStreetMap (OSM) geographical database established in a joint collaborative effort by thousands of volunteer contributors. The database is growing every day to document all power facilities (transmission lines, power generators, substations and transformers) and route options (road and railway) in the world and is validated using high-resolution aerial images.

<b>Ancillary data</b>	Power grids and transport networks
<b>Source name - full and acronym</b>	OpenStreetMap (OSM)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2021
<b>Website</b>	<a href="https://blog.openstreetmap.org">https://blog.openstreetmap.org</a>
<b>Citations</b>	OpenStreetMap contributors (2021), <a href="https://blog.openstreetmap.org">https://blog.openstreetmap.org</a>
<b>Keywords</b>	transmission lines, power generator, substation, transformer, road network, railway network
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="http://www.geofabrik.de/data/geofabrik-osm-gis-standard-0.7.pdf">www.geofabrik.de/data/geofabrik-osm-gis-standard-0.7.pdf</a>



## Climate Change Initiative - Land Cover (CCI-LC)

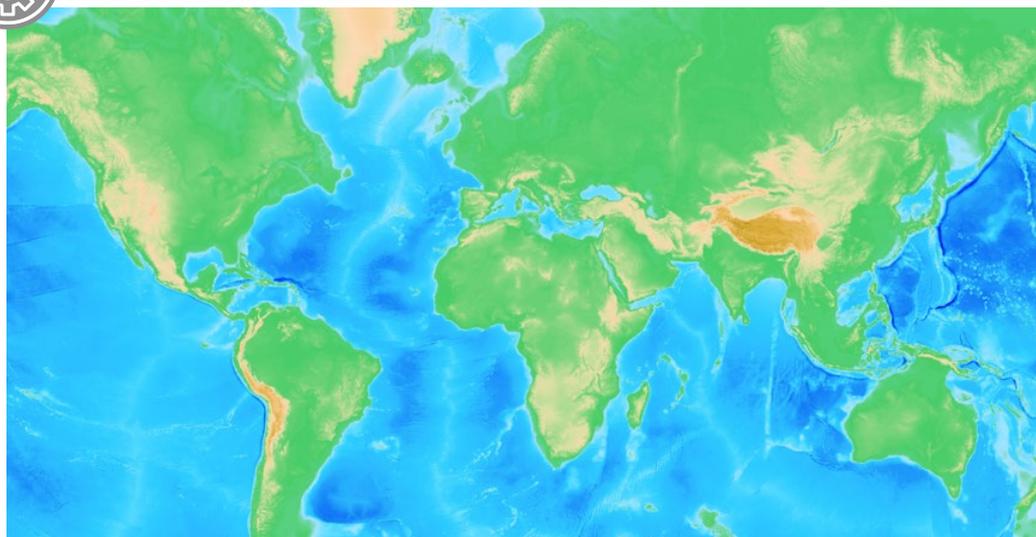


The CCI-LC database was created by the Climate Change Initiative global land cover consortium led by UCL-Geomatics (Belgium) and is made available to the public by ESA and the consortium. The database is a consistent series of 300 m global land cover products produced annually between 1992 and 2015 and developed on the basis of several satellite products (AVHRR, SPOT-VGT, Medium Resolution Imaging Spectrometer, and PROBA-V). The database has 37 original land cover types using the land cover classification system developed by the FAO.

<b>Ancillary data</b>	Land cover
<b>Source name - full and acronym</b>	European Space Agency (ESA)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	300 m
<b>Content date</b>	1997
<b>Website</b>	<a href="http://www.esa.int">www.esa.int</a>
<b>Citations</b>	ESA. Land Cover CCI Product User Guide Version 2. Tech. Rep. (2017), <a href="http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf">maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf</a>
<b>Keywords</b>	land cover, climate change, roughness, wind flow, land cover, elevation
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="http://due.esrin.esa.int/files/GLOBCOVER2009_Validation_Report_2.2.pdf">http://due.esrin.esa.int/files/GLOBCOVER2009_Validation_Report_2.2.pdf</a>



## Global gridded bathymetry

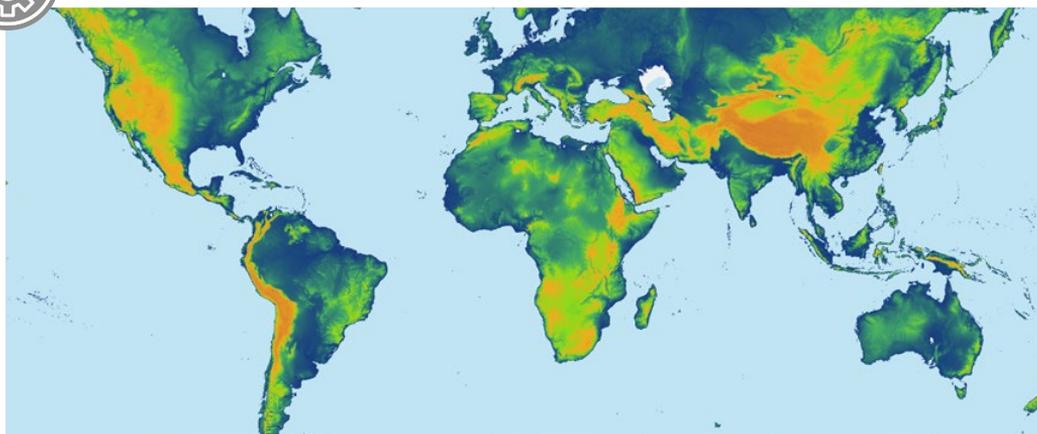


The General Bathymetric Chart of the Oceans (GEBCO) data were published as a collaborative project (the Nippon Foundation-GEBCO Seabed 2030 Project) between the Nippon Foundation of Japan and GEBCO, an international group of mapping experts operating under the joint auspices of the International Hydrographic Organisation and the Intergovernmental Oceanographic Commission of UNESCO. The project was conceived with the aim of producing a definitive map of the world's ocean floor. Over the years it has become a reference map of the bathymetry of the world's oceans for scientists.

<b>Ancillary data</b>	Bathymetry
<b>Source name – full and acronym</b>	The General Bathymetric Chart of the Oceans (GEBCO)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	15 arc seconds (")
<b>Content date</b>	2021
<b>Website</b>	<a href="http://www.gebco.net/data_and_products/gridded_bathymetry_data">www.gebco.net/data_and_products/gridded_bathymetry_data</a>
<b>Citations</b>	GEBCO Compilation Group (2021) GEBCO 2021 Grid, doi: 10.5285/a29c5465-b138-234de053-6c86abc040b9.
<b>Keywords</b>	bathymetry, elevation, global
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="http://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2021/">www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2021/</a>



## Shuttle Radar Topography Mission (SRTM) Digital Elevation Model

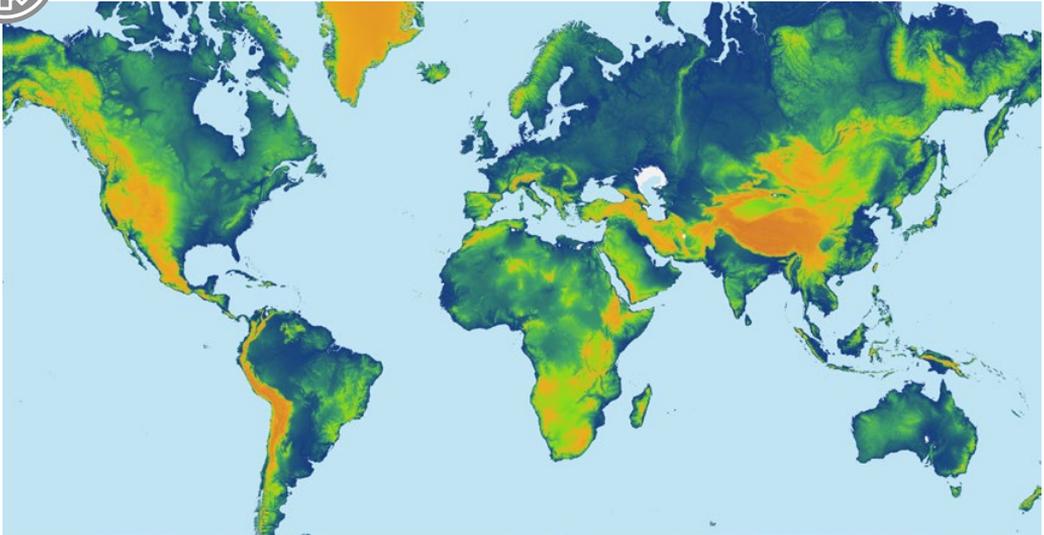


The SRTM is a joint initiative between NASA and the US National Geospatial-Intelligence Agency (NGA). It provided digital elevation data for over 80% of the globe based on the images acquired by two synthetic aperture radars aboard Space Shuttle Endeavour. The International Center for Tropical Agriculture (CIAT) has further processed this data to provide seamless continuous topography surfaces where areas with regions of no data in the original SRTM data have been filled using interpolation methods described by Reuter *et al.*

<b>Ancillary data</b>	Elevation
<b>Source name - full and acronym</b>	International Center for Tropical Agriculture (CIAT)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	250 m, 500 m, 1 km,
<b>Content date</b>	2005, 2006, 2007, 2021
<b>Website</b>	<a href="https://ciat.cgiar.org/">https://ciat.cgiar.org/</a>
<b>Citations</b>	Jarvis <i>et al.</i> (2008), "Hole-filled seamless SRTM data V4", International Centre for Tropical Agriculture (CIAT), <a href="http://srtm.csi.cgiar.org">http://srtm.csi.cgiar.org</a> .
<b>Keywords</b>	elevation
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="https://srtm.csi.cgiar.org/">https://srtm.csi.cgiar.org/</a>



## Copernicus Digital Elevation Model (DEM)

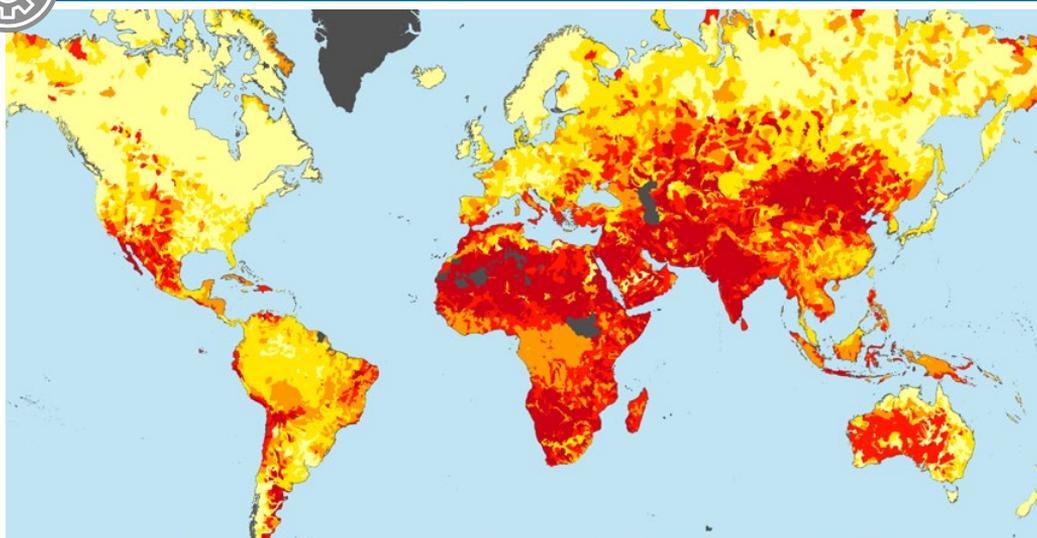


The Copernicus DEM is derived from the German Aerospace Centre (DLR) and Airbus Defence and Space GmbH. It is a digital surface model that represents the surface of the earth, including buildings, infrastructure and vegetation at 90 m resolution. The data were acquired through the TanDEM-X mission between 2011 and 2015 and will be maintained until 2026.

<b>Ancillary data</b>	Elevation
<b>Source name – full and acronym</b>	European Space Agency (ESA)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	90 m
<b>Content date</b>	2021
<b>Website</b>	<a href="http://www.esa.int">www.esa.int</a>
<b>Citations</b>	© DLR e.V. 2010-2014 and © Airbus Defence and Space GmbH 2014-2018 provided under Copernicus by the European Union and ESA; all rights reserved.
<b>Keywords</b>	elevation
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="https://spacedata.copernicus.eu/documents/20126/0/GEO1988-CopernicusDEM-SPE-002_ProductHandbook_11.00.pdf/082dd479-f908-bf42-51bf-4c0053129f7c?t=1586526993604">https://spacedata.copernicus.eu/documents/20126/0/GEO1988-CopernicusDEM-SPE-002_ProductHandbook_11.00.pdf/082dd479-f908-bf42-51bf-4c0053129f7c?t=1586526993604</a>



## Aqueduct Global Water Risk Atlas

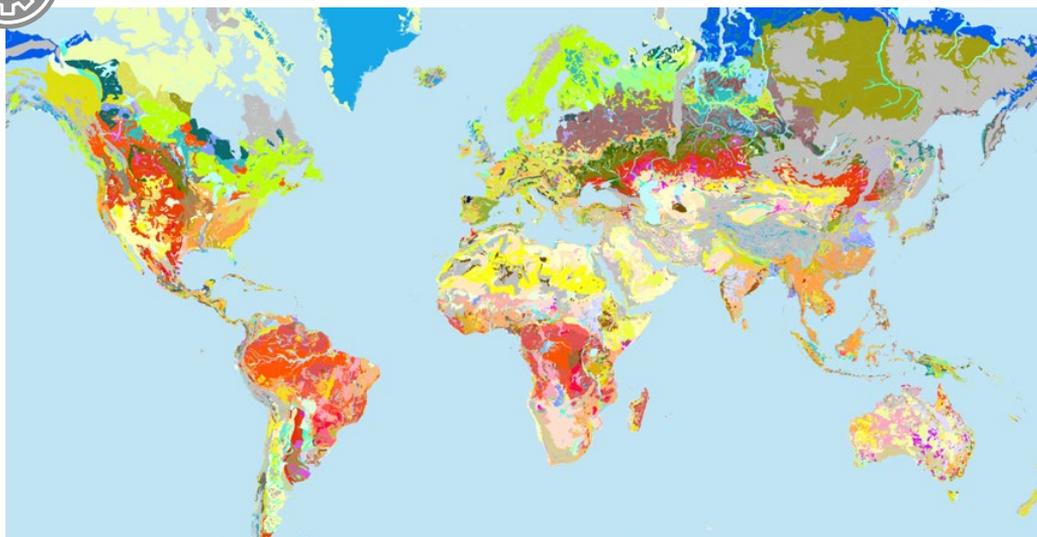


The Aqueduct Water Risk Atlas has been developed by the WRI with the support of the Aqueduct Alliance, a coalition of companies, governments and foundations at the cutting edge of water stewardship. The atlas uses the best available data to create high-resolution customisable global maps to display current and future issues related to water supply and water quality, potential regulatory pressure, governance, climate change impacts and socio-economic dynamics, while tracking the distribution of population, industry and irrigated agriculture.

<b>Ancillary data</b>	Water risk
<b>Source name – full and acronym</b>	World Resource Institute (WRI)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	n/a
<b>Content date</b>	2019
<b>Website</b>	<a href="http://www.wri.org">www.wri.org</a>
<b>Citations</b>	Hofste, R., S. <i>et. al.</i> (2019), “Aqueduct 3.0: Updated Decision Relevant Global Water Risk Indicators.” Technical Note, <i>World Resources Institute</i> , Washington, D.C. <a href="http://www.wri.org/publication/aqueduct-30">www.wri.org/publication/aqueduct-30</a>
<b>Keywords</b>	water, global
<b>Best use</b>	education
<b>Methodology</b>	<a href="http://www.wri.org/research/aqueduct-30-updated-decision-relevant-global-water-risk-indicators">www.wri.org/research/aqueduct-30-updated-decision-relevant-global-water-risk-indicators</a>



## Harmonized World Soil Database (HWSD)



The HWSD version 1.2 is the result of a collaboration between the FAO and IIASA, ISRIC-World Soil Information, the Institute of Soil Science, the Chinese Academy of Sciences (ISSCAS) and the Joint Research Centre of the European Commission (JRC). It is a unique global soil inventory providing information on the morphological, chemical and physical properties of soils at approximately 1 km resolution. Its main objective is to serve as a basis for prospective studies on agro-ecological zoning, food security and climate change. The database includes global topsoil clay fraction, sand fraction, silt fraction, organic carbon, pH (H<sub>2</sub>O), reference bulk density, textural class and global land cover (GLC-SHARE).

<b>Ancillary data</b>	Soil
<b>Source name – full and acronym</b>	Food and Agriculture Organisation (FAO)
<b>Geographic coverage</b>	Global
<b>Spatial resolution</b>	1km
<b>Content date</b>	2012
<b>Website</b>	<a href="http://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1028012/">www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1028012/</a>
<b>Citations</b>	FAO/IIASA/ISRIC/ISS-CAS/JRC, (2012), <i>Harmonized World Soil Database</i> (version 1.2), FAO, Rome and IIASA, Laxenburg
<b>Keywords</b>	clay, global, sand, silt, organic carbon, pH, density, texture class
<b>Best use</b>	business, education, potential
<b>Methodology</b>	<a href="http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HWSD_Documentation.pdf">http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HWSD_Documentation.pdf</a>

# THE GLOBAL ATLAS TOOLS

The Global Atlas integrates free online tools that simulate real-life situations for the assessment of renewable projects.

## 5.1 Bioenergy simulator

### Bioenergy Simulator (IRENA)



The Bioenergy Simulator is a user-friendly web-based application developed as part of the Global Atlas for Renewable Energy Initiative. The simulator relies on different spatial datasets (biomass resources, protected areas, water scarcity distribution, population density, and power lines), and technologies processes and parameters to identify opportunities for and limitations on using biomass resources for bioenergy production. The simulator helps users, such as policy makers, practitioners and business developers, to:

- (i) Retrieve site-specific information on the potential bioenergy when users select the required parameters, including the area, biomass characteristics, conversion technology and end use (electricity, heating and transport).
- (ii) Estimate bioenergy potential, including yield, production and gross electricity or heat production, according to the selected biomass and technological process.
- (iii) Suggest an application for the potential bioenergy production and provide further information on how to interpret the data.

<b>Citations</b>	IRENA (2023), <i>Bioenergy Simulator</i> , International Renewable Energy Agency, <a href="https://biosimulator.irena.org">biosimulator.irena.org</a> .
<b>Link (data platform)</b>	<a href="https://biosimulator.irena.org">biosimulator.irena.org</a>
<b>Link (more information)</b>	<a href="https://biosimulator.irena.org">Bioenergy Simulator (irena.org)</a>
<b>Sponsors</b>	IRENA, Khalifa University, and Valbiom. The Ministry of Foreign Affairs (MFA) of the Government of Norway
<b>Outputs</b>	Total biomass production and average biomass yield, bioenergy potentials, and possible applications of the bioenergy produced.
<b>Geographic coverage</b>	Global
<b>Contact info</b>	<a href="mailto:GARE@irena.org">GARE@irena.org</a>

## 5.2 SolarCity simulator



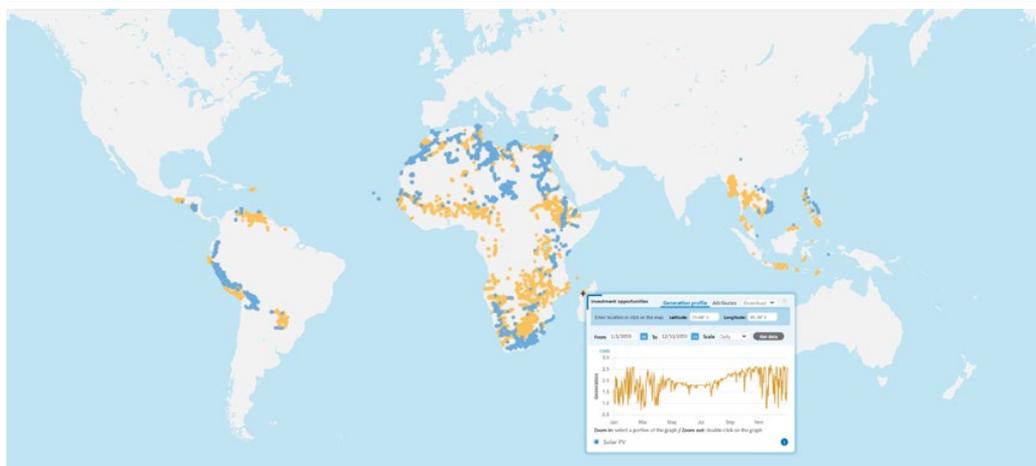
The SolarCity Simulator is a web-based application developed by IRENA as part of the Global Atlas for Renewable Energy Initiative. The simulator uses data on the local context of cities (ultra-high-resolution three-dimensional building footprints, solar irradiation and financial data) to estimate the potential for deploying rooftop solar systems using a robust power generation model and simplified financial model. The simulator allows users – households, businesses and municipal authorities – to test different scenarios for assessing:

- (i) The technical potential for each selected roof, which includes the mapping of the suitable areas to install PV systems at 1 m<sup>2</sup> spatial resolution, with its corresponding electricity production at different scales (hourly, daily and annual).
- (ii) The financial potential of different case studies (homeowner, investor and government), which includes a range of economic indicators, such as payback, equity internal rate of return (EIRR) and investment cash flow, considering different subsidies (generation or installation).
- (iii) The impact of the different policy instruments and incentive schemes – such as generation or capital subsidies – on each city’s rooftop solar PV market that could lead to potential economic savings.
- (iv) The socio-environmental benefits, which include the annual carbon emissions avoided, equivalent number of tropical trees planted, and equivalent number of cars taken off the street when sourcing the electricity from rooftop solar PV systems, and number of jobs created.

<b>Citations</b>	IRENA (2023), <i>SolarCity Simulator</i> , International Renewable Energy Agency, <a href="https://solarcity.irena.org">solarcity.irena.org</a> .
<b>Link (data platform)</b>	<a href="https://solarcity.irena.org">solarcity.irena.org</a>
<b>Link (more information)</b>	<a href="https://solarcity.irena.org">SolarCity Simulator (irena.org)</a>
<b>Sponsors</b>	The International Climate Initiative (IKI) and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) of Germany The Ministry of Foreign Affairs of Denmark The Ministry of Economy, Trade and Industry (METI) of the Government of Japan The Ministry of Foreign Affairs (MFA) of the Government of Norway
<b>Outputs</b>	Electricity production, economic indicators, socio-environmental benefits
<b>Geographic coverage</b>	City-specific
<b>Contact info</b>	<a href="mailto:GARE@irena.org">GARE@irena.org</a>

### 5.3 Investment opportunities for utility-scale renewable projects

#### Investment opportunities for utility-scale solar and wind areas



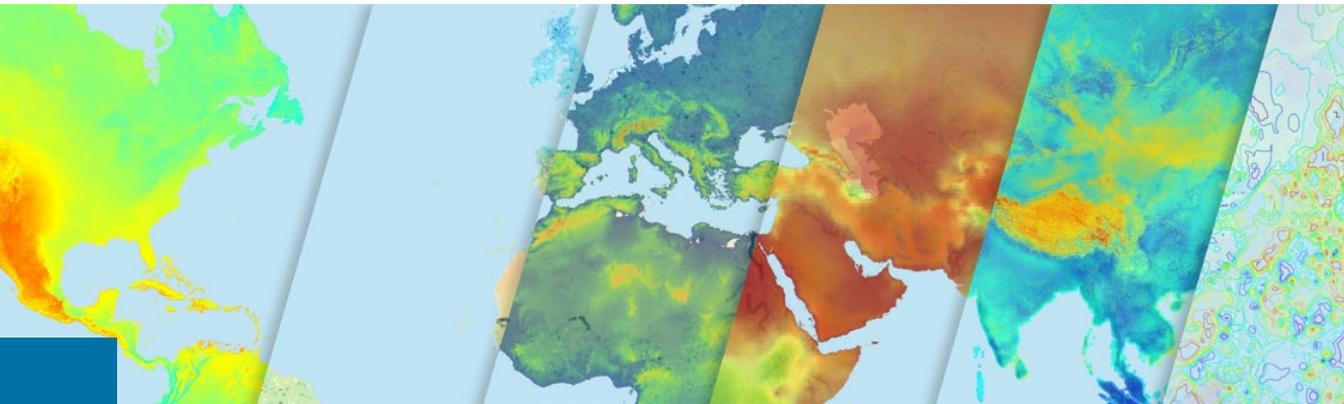
Investment opportunities for deploying utility-scale solar and wind areas are represented by the mapping of the most promising zones, including their corresponding techno-economic attributes (capacity factor, energy output and levelised cost of energy). This mapping is conducted based on the zoning assessment approach developed under the IRENA Global Atlas for Renewable Energy. The zoning assessment uses advanced modelling approaches and a simplified financial model to estimate techno-economic attributes based on the ECMWF’s ERA5 and NASA’s MERRA-2 reanalysis data (facilitated by Vortex) with other ancillary data, including on local population density (LandScan), protected areas (UNEP-WCMC and IUCN [2020]), land use (ESA Climate Change Initiative – Land Cover project 2017), power transmission lines and road networks (OpenStreetMap contributors [2022]), costs (capital and operational), and technological parameters (from IRENA’s datasets).

<b>Citations</b>	IRENA (2023), <i>Global Atlas for Renewable Energy</i> , International Renewable Energy Agency, <a href="https://globalatlas.irena.org">globalatlas.irena.org</a> .
<b>Link (data platform)</b>	<a href="https://globalatlas.irena.org">https://globalatlas.irena.org</a>
<b>Link (more information)</b>	<a href="https://globalatlas.irena.org/technical-assessment-services">Technical assessment services (irena.org)</a>
<b>Sponsors</b>	The International Climate Initiative (IKI) and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) of Germany The Ministry of Foreign Affairs of Denmark The Ministry of Economy, Trade and Industry (METI) of the Government of Japan The Ministry of Foreign Affairs (MFA) of the Government of Norway
<b>Outputs</b>	Best zones locations, capacity factor, energy output, levelised cost of energy
<b>Geographic coverage</b>	Global
<b>Contact info</b>	<a href="mailto:GARE@irena.org">GARE@irena.org</a>

## 5.4 PVWatts calculator

The PVWatts calculator is a web application developed by NREL in 2014. The calculator combines several sub-models with built-in parameters to predict overall system performance. It allows non-expert users – developers, homeowners, small building owners, installers and manufacturers – to easily estimate the annual and monthly electricity production of grid-connected, roof-mounted and ground-mounted PV systems throughout the world based on a few simple inputs that include hourly meteorological data, system location and basic design parameters (system size, module type, array type, array tilt and azimuth angles, and system losses).

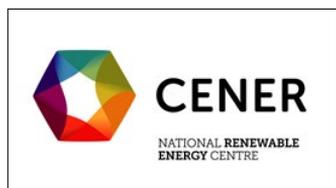
<b>Citations</b>	NREL (2023), <i>PVWatts Calculator</i> , National Renewable Energy Laboratory, <a href="https://pvwatts.nrel.gov">pvwatts.nrel.gov</a> .
<b>Link (data platform)</b>	<a href="https://pvwatts.nrel.gov">https://pvwatts.nrel.gov</a> .
<b>Link (more information)</b>	
<b>Sponsors</b>	NREL
<b>Outputs</b>	Electricity production
<b>Geographic coverage</b>	Global
<b>Contact info</b>	<a href="mailto:PVWatts@nrel.gov">PVWatts@nrel.gov</a>



# 6

## THE GLOBAL ATLAS PARTNERS AND DATA PROVIDERS

### 6.1 Partners



## 6.2 Data providers







