

The European Commission's science and knowledge service

Joint Research Centre

Directorate for Energy, Transport
and Climate

Energy efficiency and Renewables Unit

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PVGIS

Photovoltaic Geographical Information System

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Overview of presentation

1. Introduction
2. PVGIS: features, calculations, data, output
3. PVGIS tools
4. Other EC tools and applications

1. Introduction

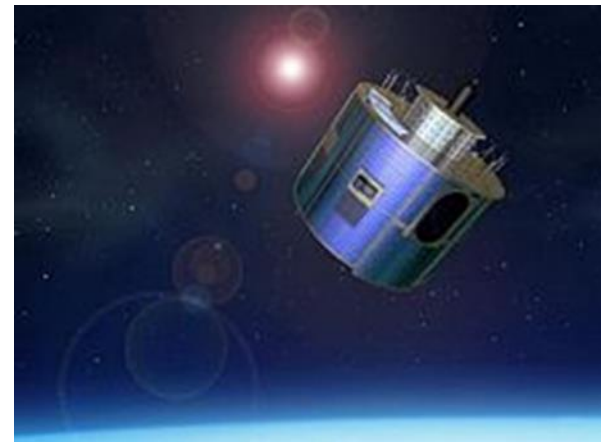
Ground measurements of solar radiation

- Best way to estimate the solar resource available at a given location.
- Requires **specific equipment** (pyranometers, pyrhemliometers and solar trackers) which need proper **maintenance**.
- Long term datasets are rare (spatially and temporally), especially in the developing world.

1. Introduction

Satellite-based solar radiation estimates

- The level of **quality** reached in many areas come close to that of ground-based measurements.
- Solar radiation estimates are mainly from **geostationary** meteorological satellites.
- Spatial resolution is typically a **few km at continental scale**.
- Temporal resolution **15-30 minutes** depending on the satellite.



2. PVGIS online tool for PV yield estimation

The JRC has for more than 10 years developed and maintained the PVGIS online tool for making quick estimates of PV energy yield and solar irradiation. The tool is freely available to everybody.

The last version, **PVGIS-5**, was launched in 2017 with enhanced capabilities.

<http://re.jrc.ec.europa.eu/pvgis.html>

Online tools:

http://re.jrc.ec.europa.eu/pvg_tools/en/tools.html

PVGIS features

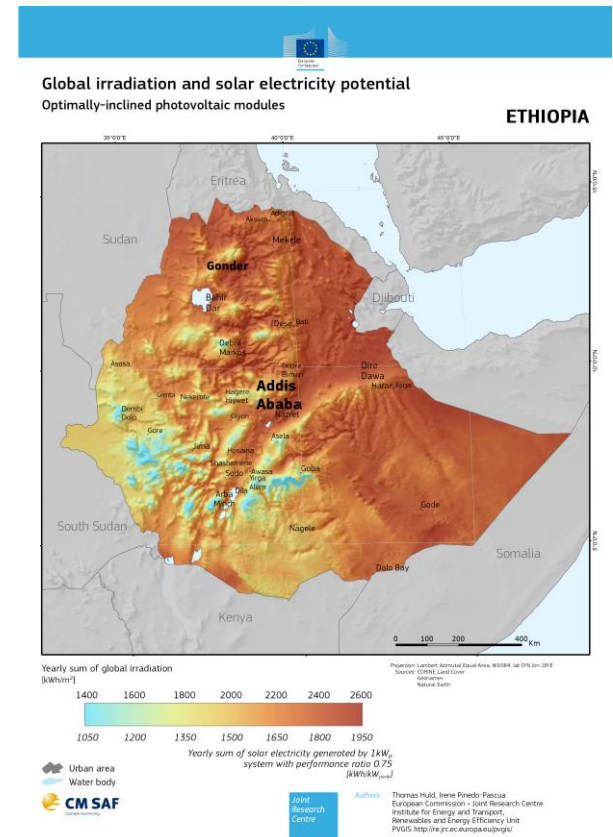
- Calculation of **power output** of grid-connected PV systems for **different PV technologies**.
- **Fixed mounting, building integrated or tracking systems** can be studied.
- It is possible to calculate the **optimum inclination and orientation** for any location.
- **Off-grid PV system** calculator.
- Calculates **monthly** averages of solar radiation, as well as the average **daily profile** for fixed and sun-tracking systems.
- Possibility to download **hourly time series** and **Typical Meteorological Years**.

PVGIS calculations

- Calculations are now made using the full **hourly** time series of solar radiation data for improved accuracy.
- Calculation takes into account shadows from **local terrain** using a DEM with resolution 3'' (~90m).
- The effect of the **spectral content, angle of incidence, temperature of the module** and **cooling by the wind** are accounted for in the estimation of the PV power output.

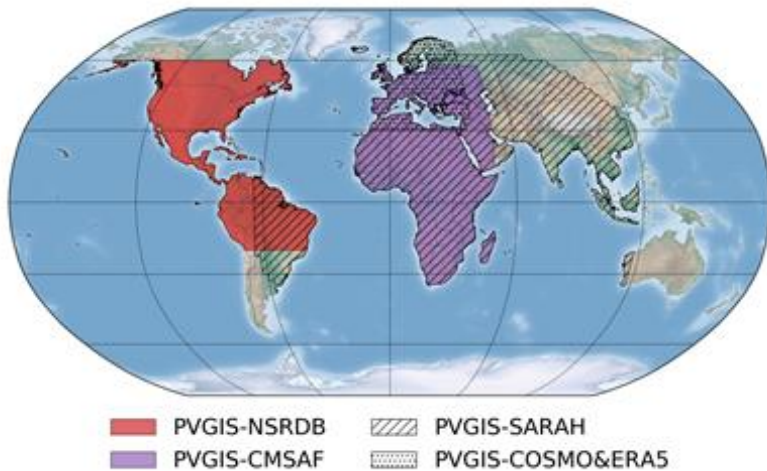
PVGIS output

- **Download** results and data via the tool: Screen output or download as CSV or PDF.
- **Web service interface** for download data.
- **Data and maps** for download:
 - Solar radiation and PV energy production data in raster format for GIS software
 - Maps in graphical format for printing or including in documents and presentations
 - Maps for all countries in Europe and Africa



PVGIS solar radiation data

- **Data coverage** was substantially extended in PVGIS-5.

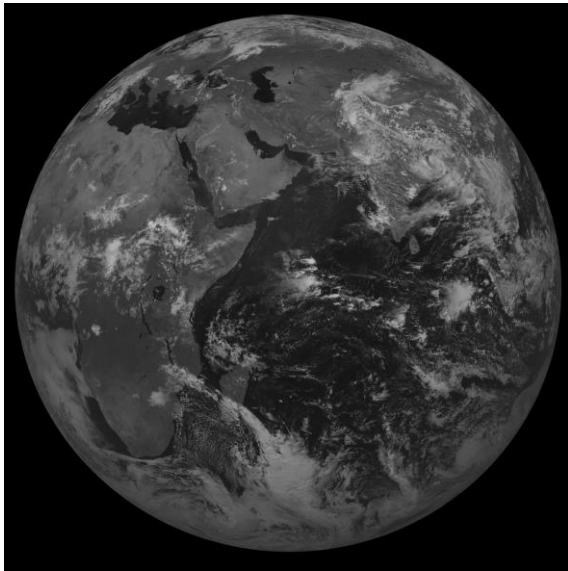


- PVGIS data are mostly from the European **METEOSAT** satellites, covering Europe, Africa and most of Asia.
(PVGIS-CMSAF, PVGIS-SARAH)
- Data for the Americas come from the **NSRDB** (National Renewable Energy Laboratory, NREL).
(PVGIS-NSRDB)
- High latitude data come from **reanalysis** products.
(PVGIS-COSMO, PVGIS-ERA5)

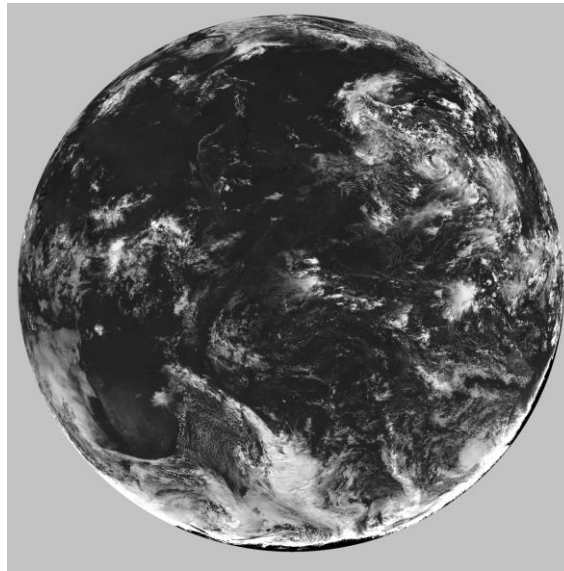
PVGIS solar radiation data

- The algorithms applied to Eurasia and Africa have been developed by the **CM SAF collaboration** (www.cmsaf.eu), especially Deutscher Wetterdienst (DWD).
- In a first step, a version of the **Heliosat method** is used to calculate the effective cloud albedo (CAL) which measures the reflectivity of clouds.
- The second step calculates the clear-sky irradiance using the **SPECMAGIC algorithm** (Müller et al. 2012) to calculate the transmissivity of the atmosphere, using as input:
 - Aerosols (long-term monthly climatology)
 - Water vapour (monthly averages)
 - Ozone (long-term monthly climatology)
- Finally the **global and direct irradiance** is calculated from the clear-sky radiation and cloud index.

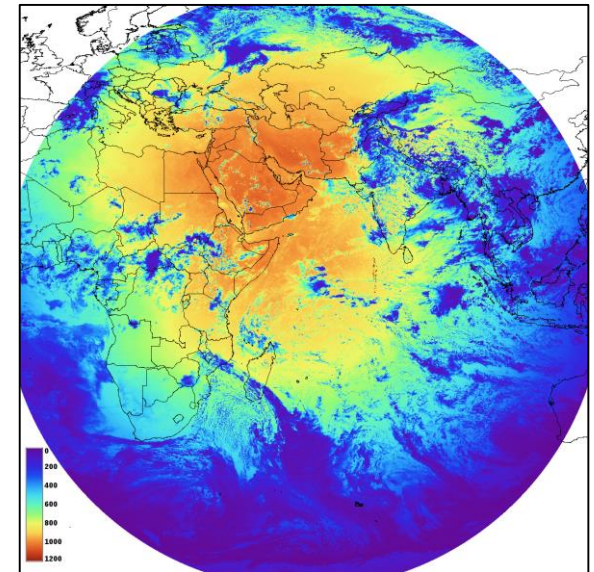
PVGIS solar radiation data



METEOSAT raw image



Cloud index, CAL

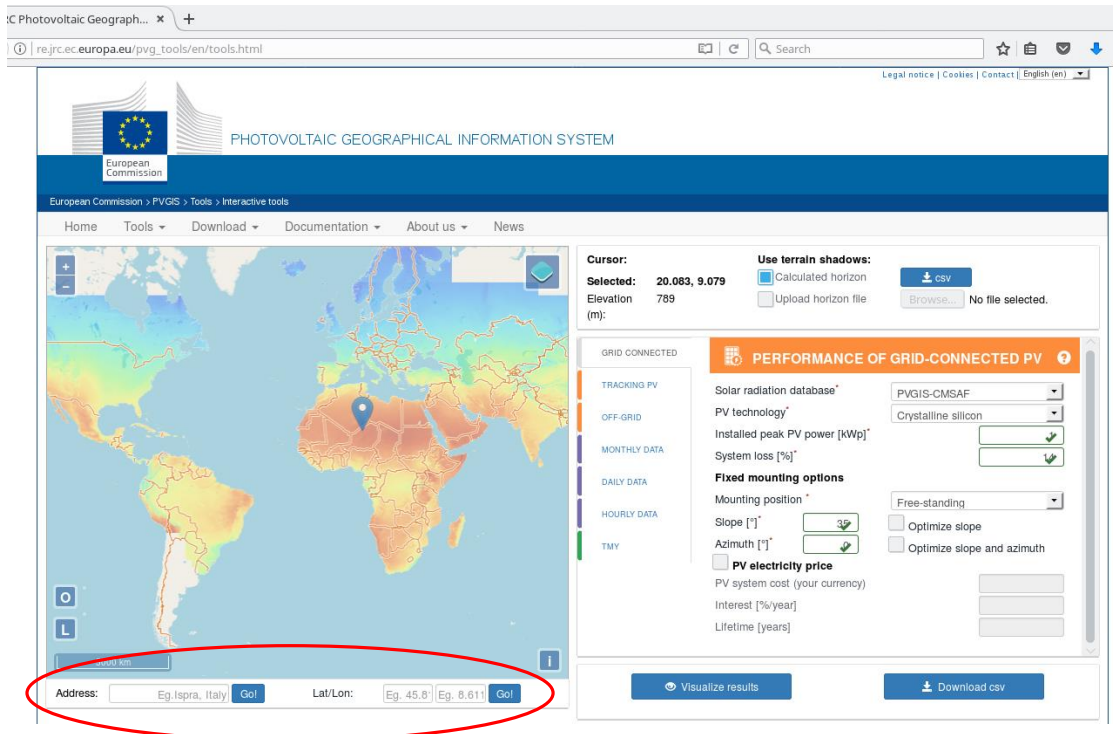


Global horizontal irradiance

PVGIS data sources

- **Satellite-based spectral and broadband irradiance** data calculated by the CM SAF collaboration (www.cmsaf.eu) and JRC Ispra.
 - Hourly time resolution
 - Spatial resolution around 3-5km (PVGIS-CMSAF, PVGIS-SARAH)
- **Temperature and wind speed** data from ECMWF (www.ecmwf.int) operational forecast data.
 - 3-hourly time resolution, linear interpolation to hourly values
 - Spatial resolution 0.75° latitude/longitude (~81km)
- **Module power measurements** mainly by the ESTI Laboratory (JRC), some data from literature

3. PVGIS tools



The screenshot shows the PVGIS web application interface. The browser address bar displays `re.jrc.ec.europa.eu/pvg_tools/en/tools.html`. The page header includes the European Commission logo and the title "PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM". A navigation menu contains "Home", "Tools", "Download", "Documentation", "About us", and "News". The main content area is divided into a map on the left and a configuration panel on the right. The map shows a world map with a location marker in Africa. The configuration panel, titled "PERFORMANCE OF GRID-CONNECTED PV", includes sections for "GRID CONNECTED", "TRACKING PV", "OFF-GRID", "MONTHLY DATA", "DAILY DATA", "HOURLY DATA", and "TMY". The "TRACKING PV" section contains fields for "Solar radiation database" (set to "PVGIS-CMSAF"), "PV technology" (set to "Crystalline silicon"), "Installed peak PV power [kWp]", and "System loss [%]". The "Fixed mounting options" section includes "Mounting position" (set to "Free-standing"), "Slope [°]", "Azimuth [°]", and checkboxes for "Optimize slope" and "Optimize slope and azimuth". The "PV electricity price" section includes fields for "PV system cost (your currency)", "Interest [%/year]", and "Lifetime [years]". At the bottom of the configuration panel, there are buttons for "Visualize results" and "Download csv". A red circle highlights the "Address" and "Lat/Lon" input fields at the bottom left of the map area, with the "Address" field containing "Eg. Ispra, Italy" and the "Lat/Lon" field containing "Eg. 45.8 | Eg. 8.611".

Choose a location/horizon

Enter a few parameters
(PV power, inclination etc.)

Click "Visualize"

3. PVGIS tools



Address: Lat/Lon:

Lifetime [years]

PERFORMANCE OF GRID-CONNECTED PV: RESULTS

Summary

Provided inputs:

Location [Lat/Lon]: 46.275, 8.376
Horizon: Calculated
Database used: PVGIS-CMSAF
PV technology: Crystalline silicon
PV installed [kWp]: 1
System loss [%]: 14

Simulation outputs:

Slope angle [°]: 35
Azimuth angle [°]: 0
Yearly PV energy production [kWh]: 907
Yearly in-plane irradiation [kWh/m²]: 1140
Year to year variability [kWh]: 32.30

Changes in output due to:

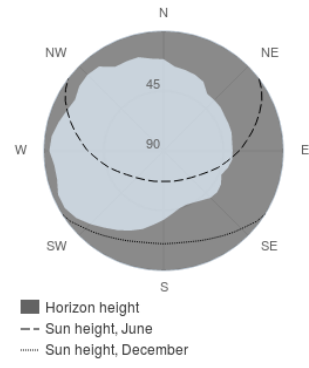
Angle of incidence [%]: -2.9
Spectral effects [%]: 1.2
Temperature and low irradiance [%]: -6.1
Total loss [%]: -20.7

Monthly energy output from fix-angle PV system



| Month | Output [kWh] |
|-------|--------------|
| Jan | 15 |
| Feb | 40 |
| Mar | 75 |
| Apr | 100 |
| May | 120 |
| Jun | 125 |
| Jul | 135 |
| Aug | 120 |
| Sep | 85 |
| Oct | 50 |
| Nov | 20 |
| Dec | 15 |

Outline of horizon



■ Horizon height
-- Sun height, June
..... Sun height, December

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3. PVGIS tools – PV performance

Grid connected

Tracking PV

Off-grid



Cursor:

Selected: 45.815, 8.610

Elevation (m): 225

Use terrain shadows:

Calculated horizon

Upload horizon file

[↓ CSV](#)

No file selected.

GRID CONNECTED

TRACKING PV

OFF-GRID

MONTHLY DATA

DAILY DATA

HOURLY DATA

TMY

PERFORMANCE OF GRID-CONNECTED PV ?

Solar radiation database* PVGIS-CMSAF

PV technology* Crystalline silicon

Installed peak PV power [kWp]*

System loss [%]*

Fixed mounting options

Mounting position* Free-standing

Slope [°]*

Azimuth [°]*

PV electricity price

PV system cost (your currency)

Interest [%/year]

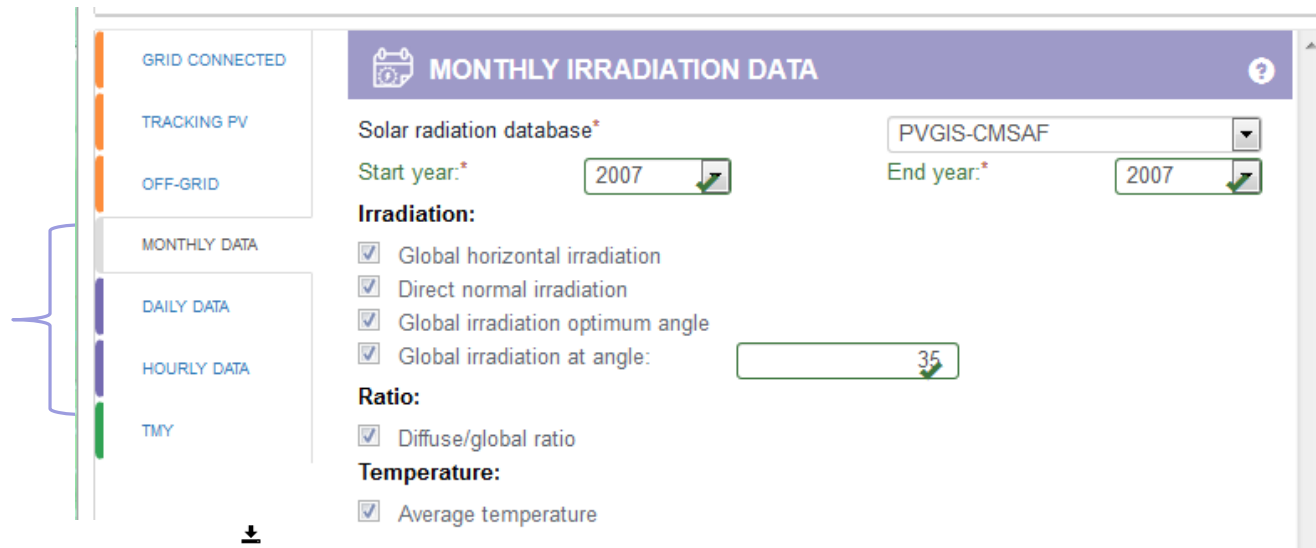
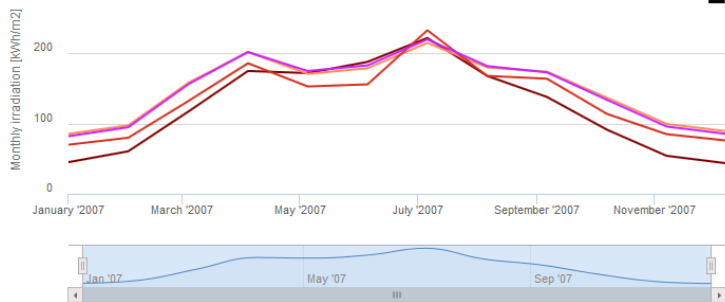
Lifetime [years]

3. PVGIS tools – Solar radiation data

Monthly data

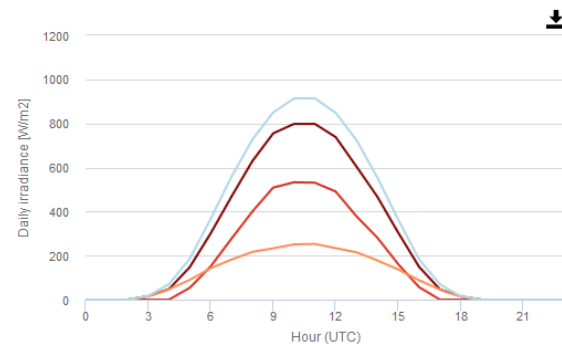
Daily data

Hourly data

Irradiation
(Click on series to hide)

- Horizontal irradiation
- Direct Normal Irradiation
- Optimal angle irradiation
- Selected angle irradiation



Irradiance(Click on series to hide)

- Global
- Diffuse
- Direct
- Clearsky

3. PVGIS tools – TMY

- GRID CONNECTED
- TRACKING PV
- OFF-GRID
- MONTHLY DATA
- DAILY DATA
- HOURLY DATA
- TMY

TYPICAL METEOROLOGICAL YEAR

Select period *

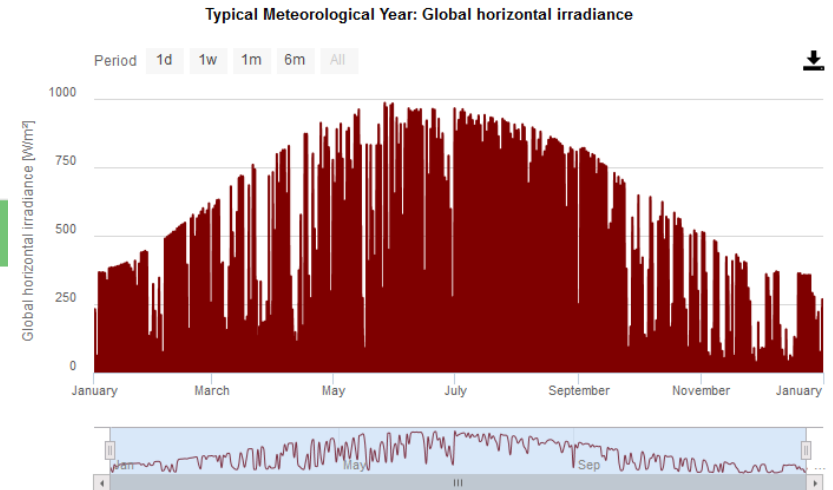
2007 - 2016
▼

Global horizontal irradiance

View!

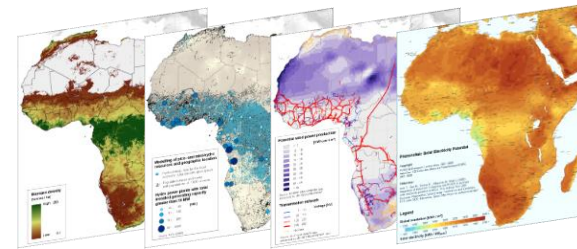
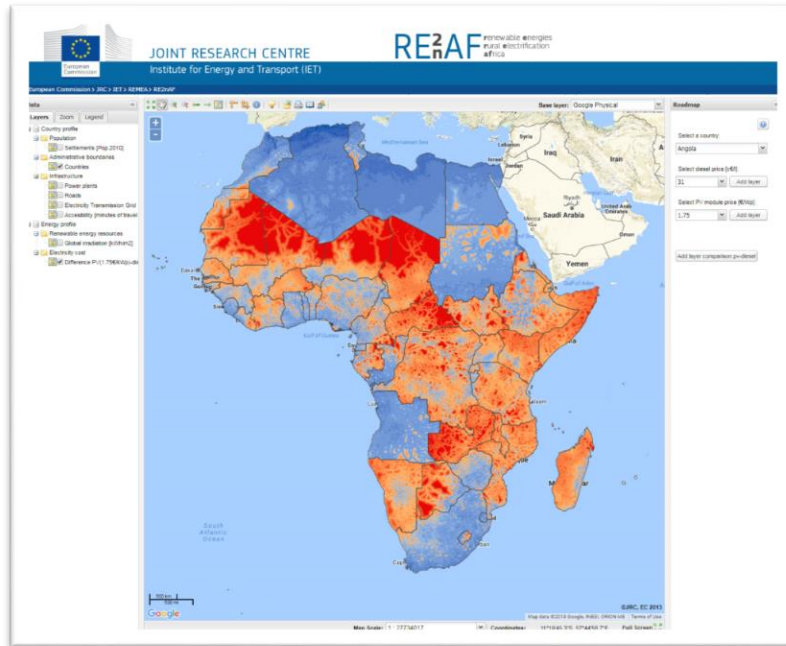
csv

epw



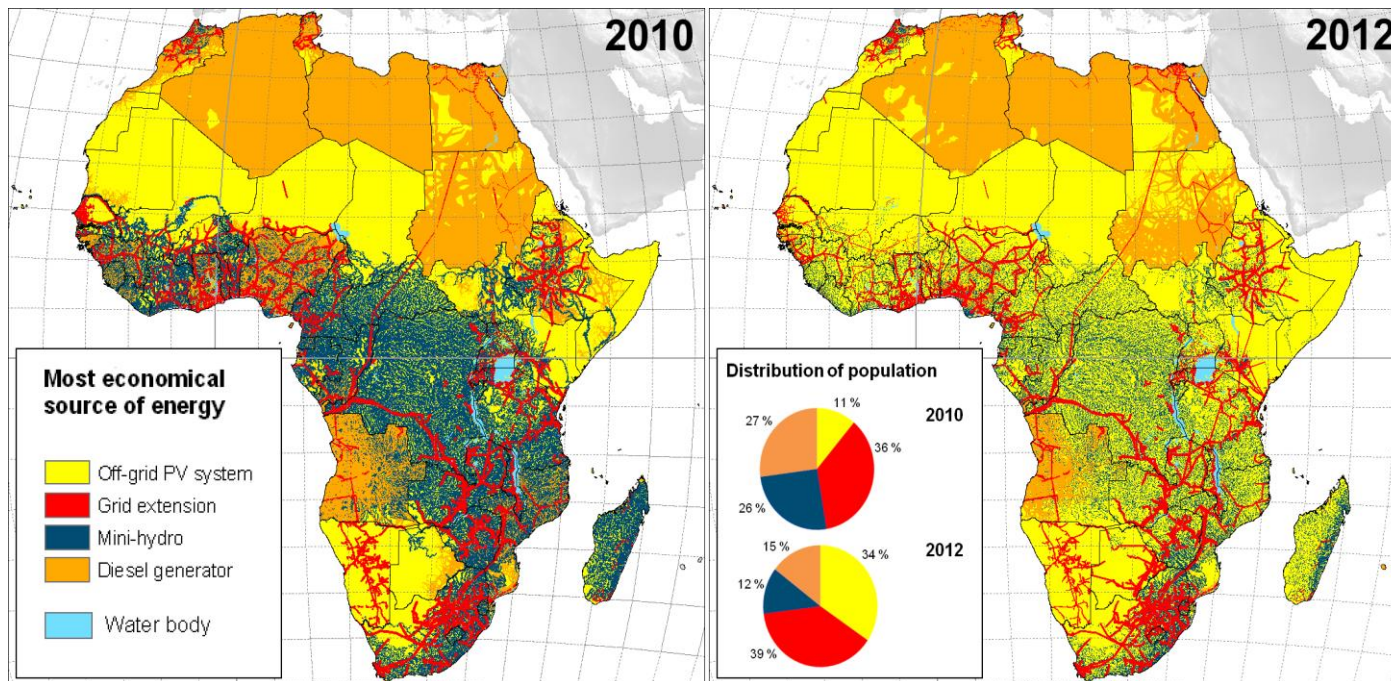
4. EC tools and applications

RE2nAF: Renewable Energy and Rural Electrification for Africa



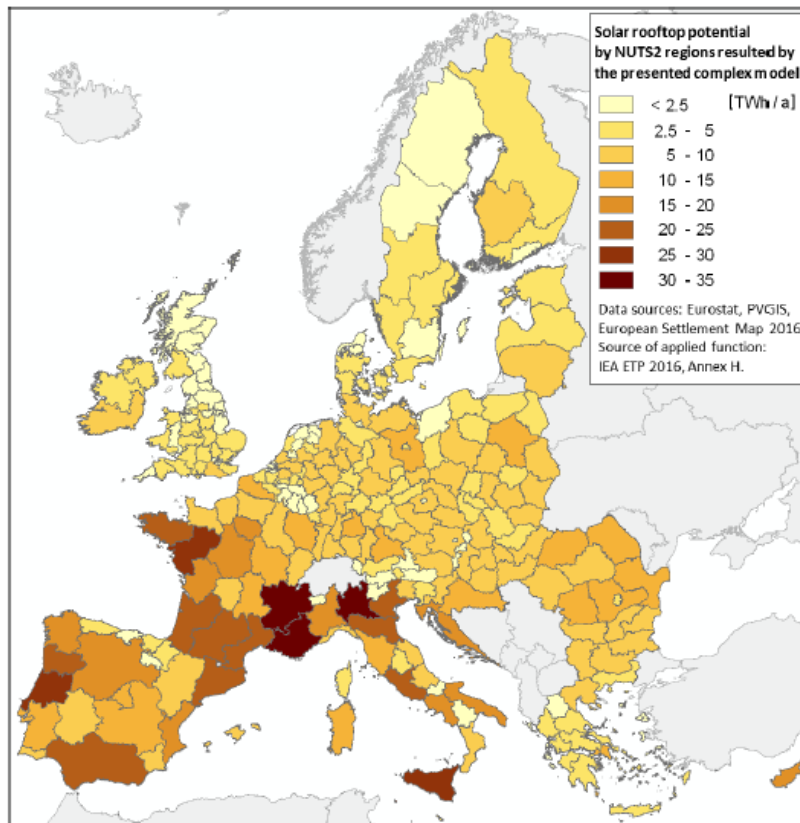
4. EC tools and applications

Electrification options for Africa



4. EC tools and applications

PV rooftop potential for EU member states



European distribution in NUTS 2 level of solar rooftop potential resulted by geospatial modelling in high spatial resolution

4. IEC 61853 Standard Series

The IEC 61853 Standard Series "*Photovoltaic (PV) module performance testing and energy rating*" describes how to perform the PV module measurements and calculations required to produce an energy rating analysis for a specific PV module under consideration. The standard has four parts:

1. "*Irradiance and temperature performance measurements and power rating*" (2011)
2. "*Spectral responsivity, incidence angle and module operating temperature measurements*" (2016)
3. "*Energy rating of PV modules*" (2018)
4. "**Standard Reference Climatic Profiles**" (2018) contains six reference climatic data sets. **Hourly values for one year** of several variables, including **horizontal and in-plane broadband and spectrally resolved irradiance**
BIPV & Bifacial PV modules

Thank you for your attention!

<http://re.jrc.ec.europa.eu/pvgis.html>

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