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Energy Efficiency and Renewables
Unit



IEC 61853-4

Standard for calculating the energy rating of PV modules

Thomas Huld, Ana Gracia Amillo, Ewan Dunlop

European Commission, Joint Research Centre, Ispra

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Overview of presentation

1. How to calculate PV energy rating using data and models from IEC 61853 parts 1-3
2. Solar radiation data from satellite, methods and data
3. Data values needed for the energy rating calculation
4. Geographical variation of module performance ratio
5. Selecting locations for the data sets

Calculating yearly PV energy output

The models specified in IEC 61853-3 allows us to calculate the PV power for given conditions. The data sets in part 4 provide these conditions for every hour in one year. The total energy produced during a year can then be calculated as:

$$E_{tot} = \sum_{i=1}^{8760} P(G, T_{mod})$$

Module performance ratio

The Module Performance Ratio (MPR) is the ratio of actual module energy output to the output if the module always had the efficiency measured under Standard Test Conditions. It can be expressed as:

$$MPR = \frac{1000 E_{tot}}{P_{stc} H_{tot}}$$

Here H_{tot} is the total in-plane irradiation (kWh/m²) and E_{tot} is the total module energy output during the same period (kWh).

MPR is dimensionless

Data sources for the 61853-4 data sets

Spectral and broadband irradiance data calculated from satellite by the CM SAF collaboration (www.cmsaf.eu) and JRC Ispra.

- Hourly time resolution
- Spatial resolution around 3-5km
- Spectral resolution 29 bands 300-4600nm

Temperature and wind speed data from ECMWF (www.ecmwf.int) operational forecast data.

- 3-hourly time resolution, linear interpolation to hourly values
- Spatial resolution 0.125° latitude/longitude

Inclined plane irradiance calculated from the global and direct horizontal irradiance (20° equator-facing).

Contents of the data sets

The data consist of one year of hourly values of the following quantities:

- Date and time
- Air temperature ($^{\circ}\text{C}$)
- Wind speed, recalculated to 2m above ground (m/s)
- Solar elevation angle ($^{\circ}$)
- Incidence angle ($^{\circ}$)
- Global horizontal irradiance (W/m^2)
- Direct horizontal irradiance (W/m^2)
- Global in-plane irradiance (W/m^2)
- Direct in-plane irradiance (W/m^2)
- Global spectrally resolved irradiance, 29 components (W/m^2)
- Direct spectrally resolved irradiance, 29 components (W/m^2)

Locations of the climate data sets

Locations selected for the first Committee Draft:

Country	Gabon	Saudi Arabia	Spain	Slovakia	Scotland	India	China (Tibet)
Latitude	1S	24N	38N	48N	56N	18N	34N
Longitude	11E	46.9E	3.25W	18E	4W	80E	83E

Locations under consideration for CDV

Country	USA	USA	USA	Canada	Japan
Latitude	28.5N	33.5N	40N	57N	33.37N
Longitude	81W	112W	105.5W	112W	130.5E

Locations of the climate data sets



First set of sites in black, new sites under evaluation in red

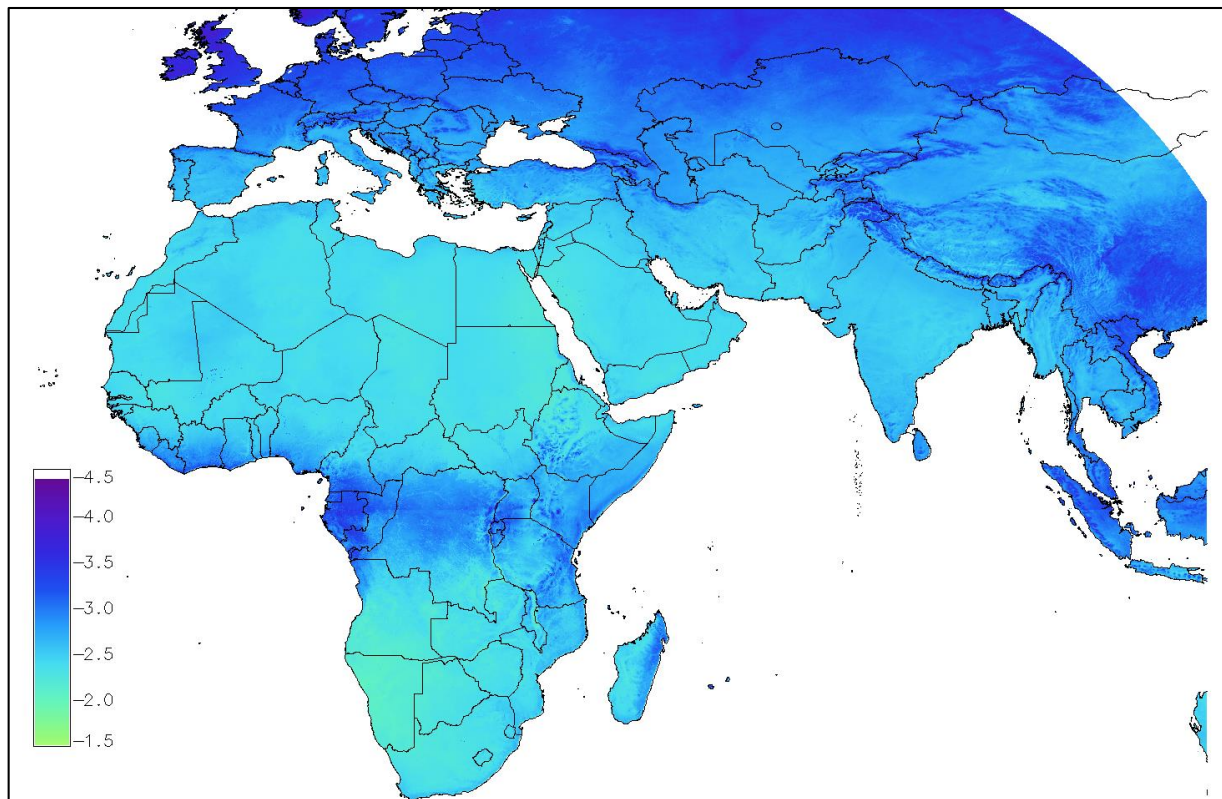
Interpolation vs. extrapolation in the power matrix

In some cases the in-plane irradiance or module temperature will lie outside the range of values in the power matrix. Power estimates will then tend to have higher uncertainty. The percentage of solar energy that arrives under these conditions varies strongly with location.

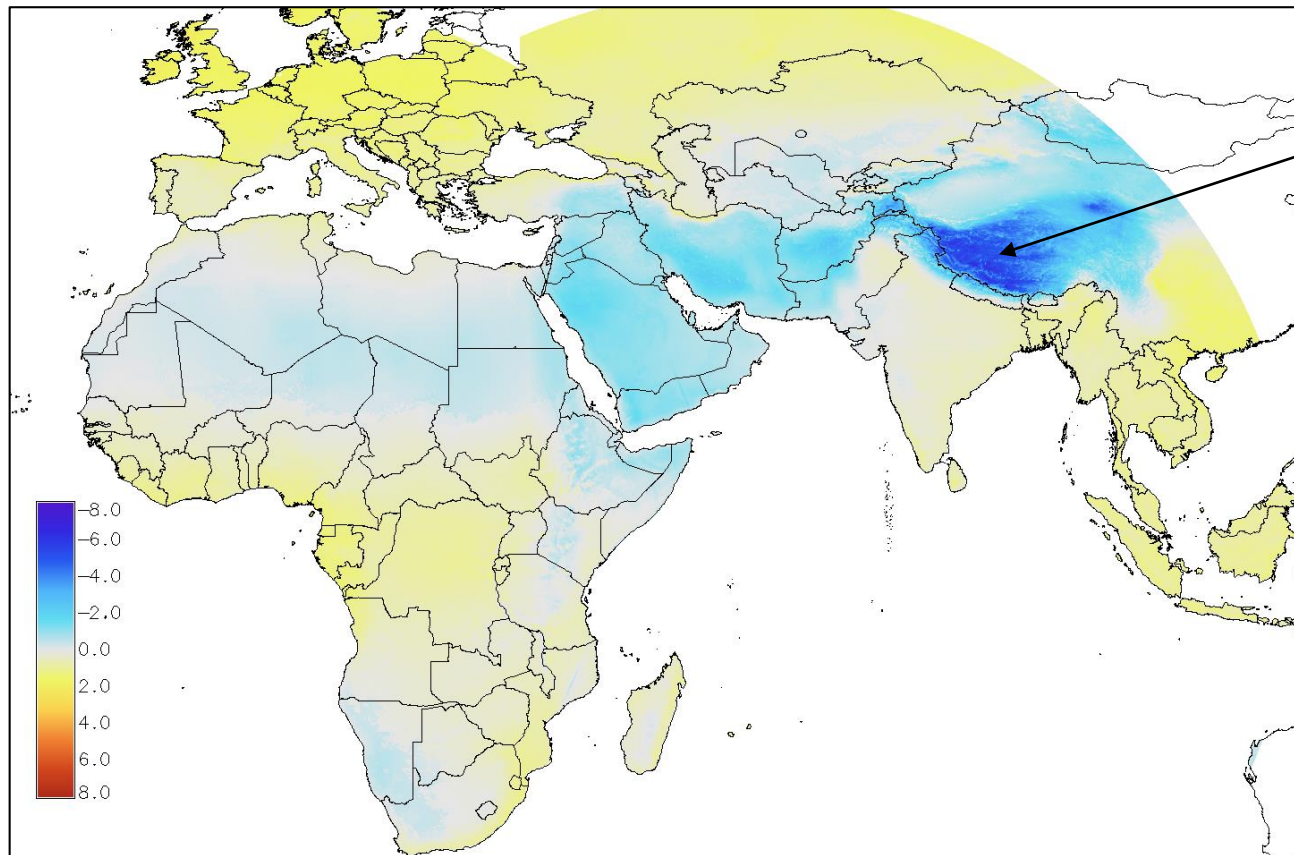
Latitude	Longitude	$G < 100 \text{ W/m}^2$	$G > 1100 \text{ W/m}^2$	$T < 15^\circ\text{C}$
1S	11E	2.2%	0	0
24.91N	46.41E	1.0%	0.09%	0.3%
38N	3.25W	1.6%	0.05%	2%
48N	18E	4.0%	0	9.2%
56N	4W	7.6%	0	17.4%

Geographical variation of the effects influencing PV performance

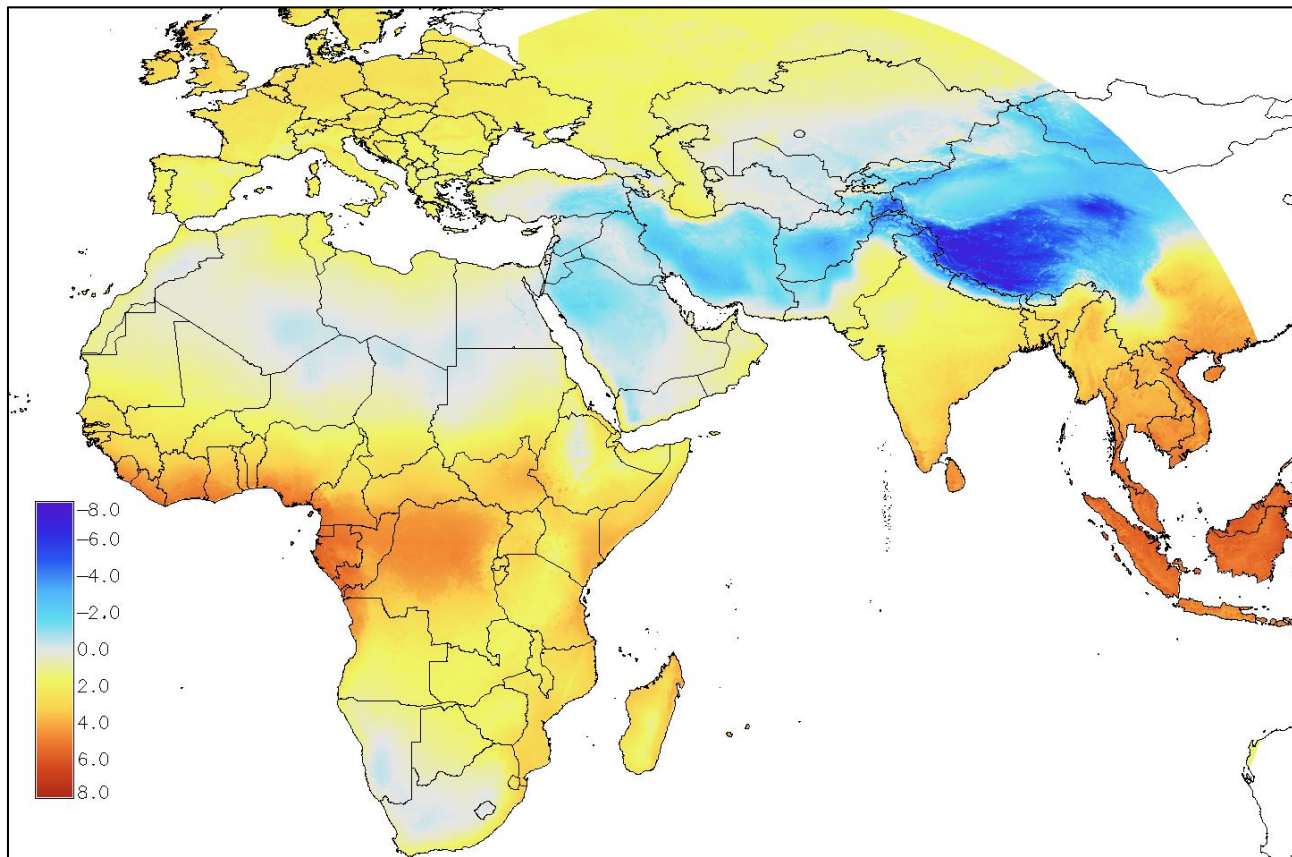
AOI, % reduction in transmitted irradiation



Spectral effects, c-Si module

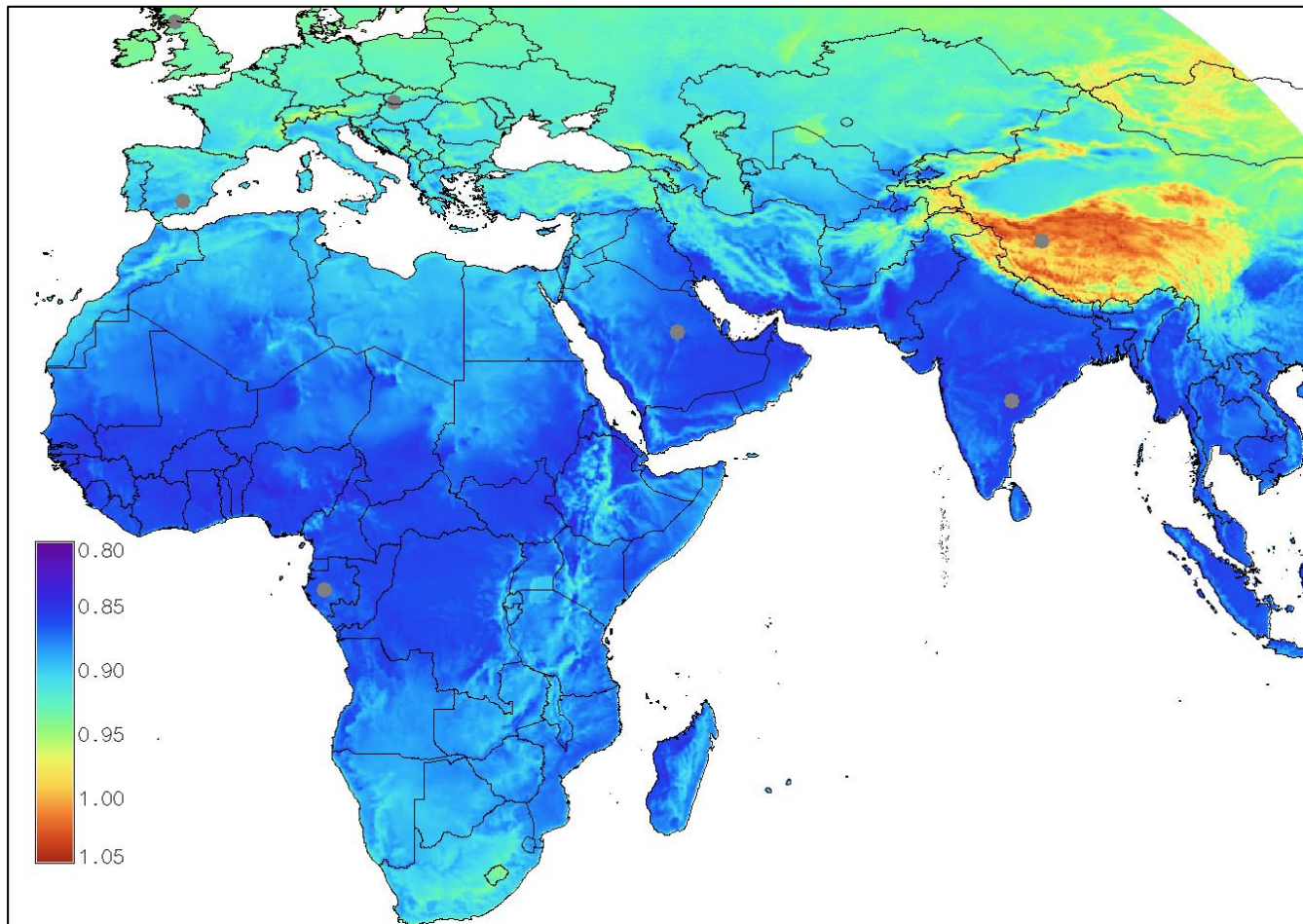


Spectral effects, CdTe module



Annual percentage
change in MPR
due to spectral
effects, CdTe
modules

Overall MPR, c-Si modules



Annual average
MPR, c-Si module,
including AOI,
spectral effects,
temperature and
wind speed

Discussion

Selecting energy rating data sets will involve a number of compromises:

- The number of data sets should be fairly low to avoid confusion, though this may mean that some climates are not properly represented.
- Different module technologies will have different sensitivity to the climate parameters. For instance, some will be less sensitive to temperature changes, others may be more sensitive to changes in the solar spectrum.
- The energy rating method will therefore be an imperfect indicator of actual module performance.
- That said, the uncertainty will be much reduced relative to using STC conditions only.

Status and next steps

- Both parts 3 and 4 have been through a Committee Draft stage. The comments and suggestions of the national committees have been analysed.
- The next step will be the submission of a Committee Draft for Vote, to be presented this spring, as soon as the analysis of the new proposed data sets is complete.

Thank you for your patience!

Acknowledgments

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