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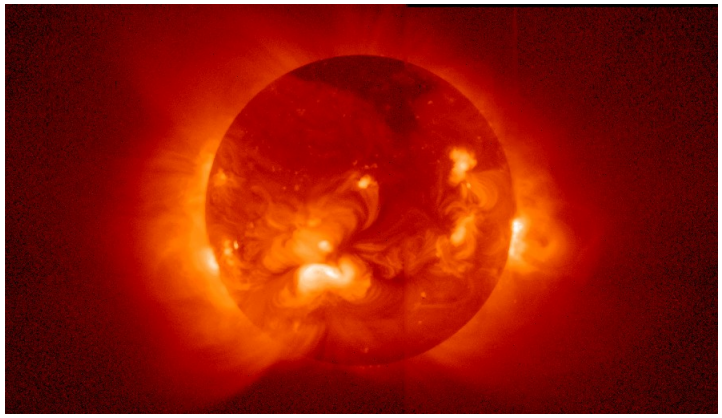

THE SOLAR RESOURCE

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The solar resource

- How much solar energy is there?
- How do we quantify it?
- Effect of angles and orientation?
- Where can we get reliable data?

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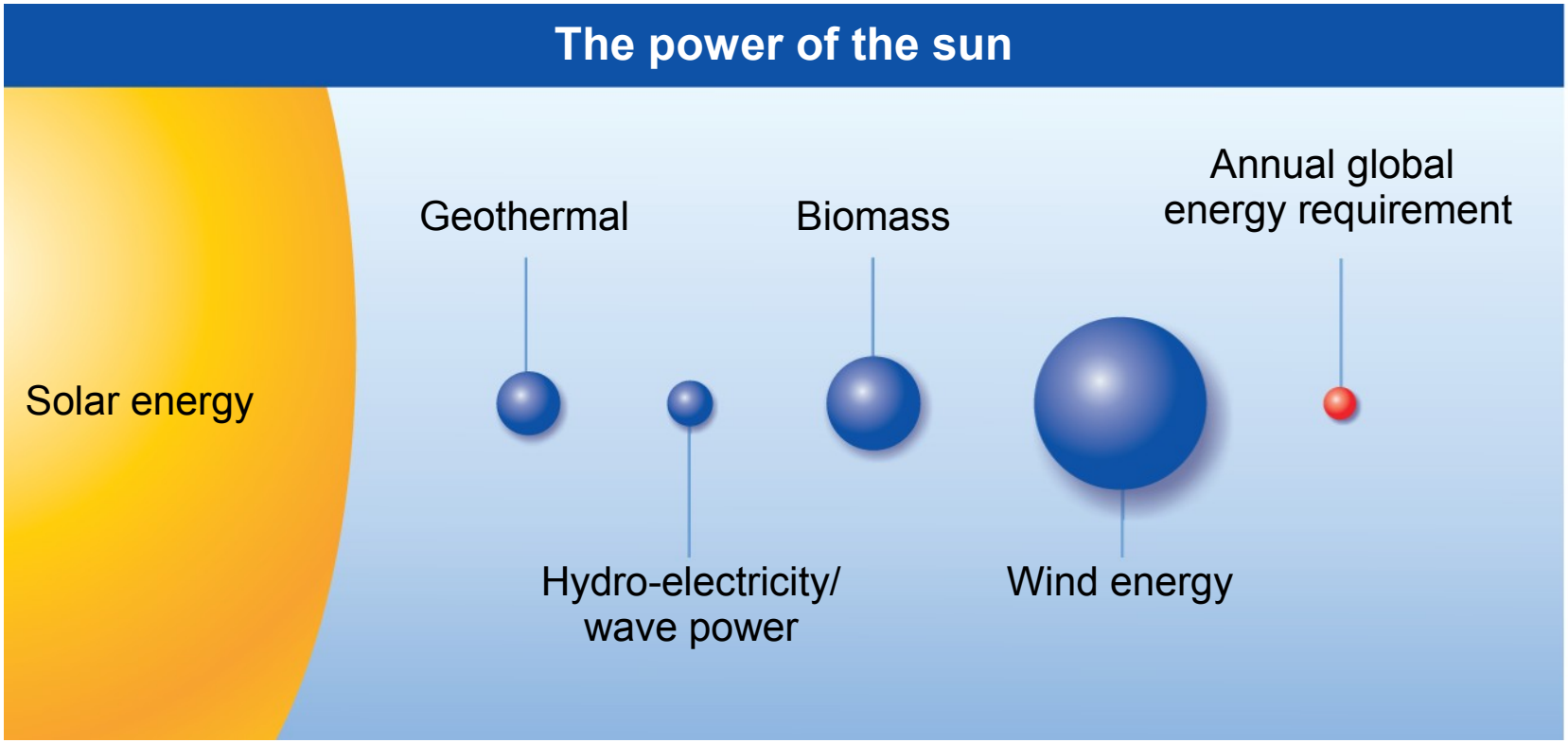
The potential of renewable energy



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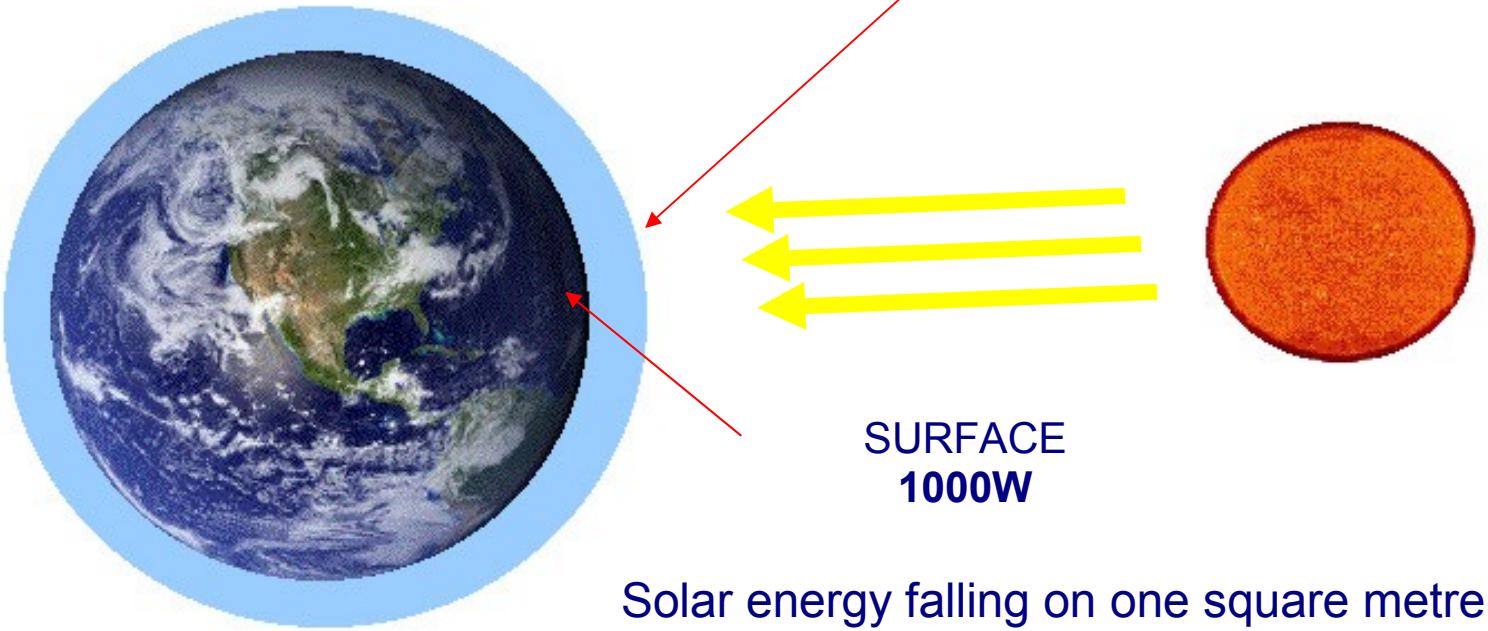
Solar energy availability



Solar energy falling on one square metre of the earth's surface in full sun
1000 W is one bar of an electric fire

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Solar resource – compared to oil

In places like northern California and southern Spain about 1,600 kilowatt-hours of solar energy falls on every square meter of land surface annually – that corresponds to the amount of energy that is found in a barrel of oil. The barrel of oil bought and sold on the world market contains 159 litres of oil

Source:

Photovoltaics for Professionals

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Peak sun hours

Solar insolation is measured in

PEAK SUN HOURS (PSH)

A peak sun hour is equivalent to 1000 watts of solar energy falling on an area of 1 square meter for 1 hour

Solar insolation data is usually expressed as the average number of peak sun hours available each day on any given month or ($kWh / m^2 / day$)

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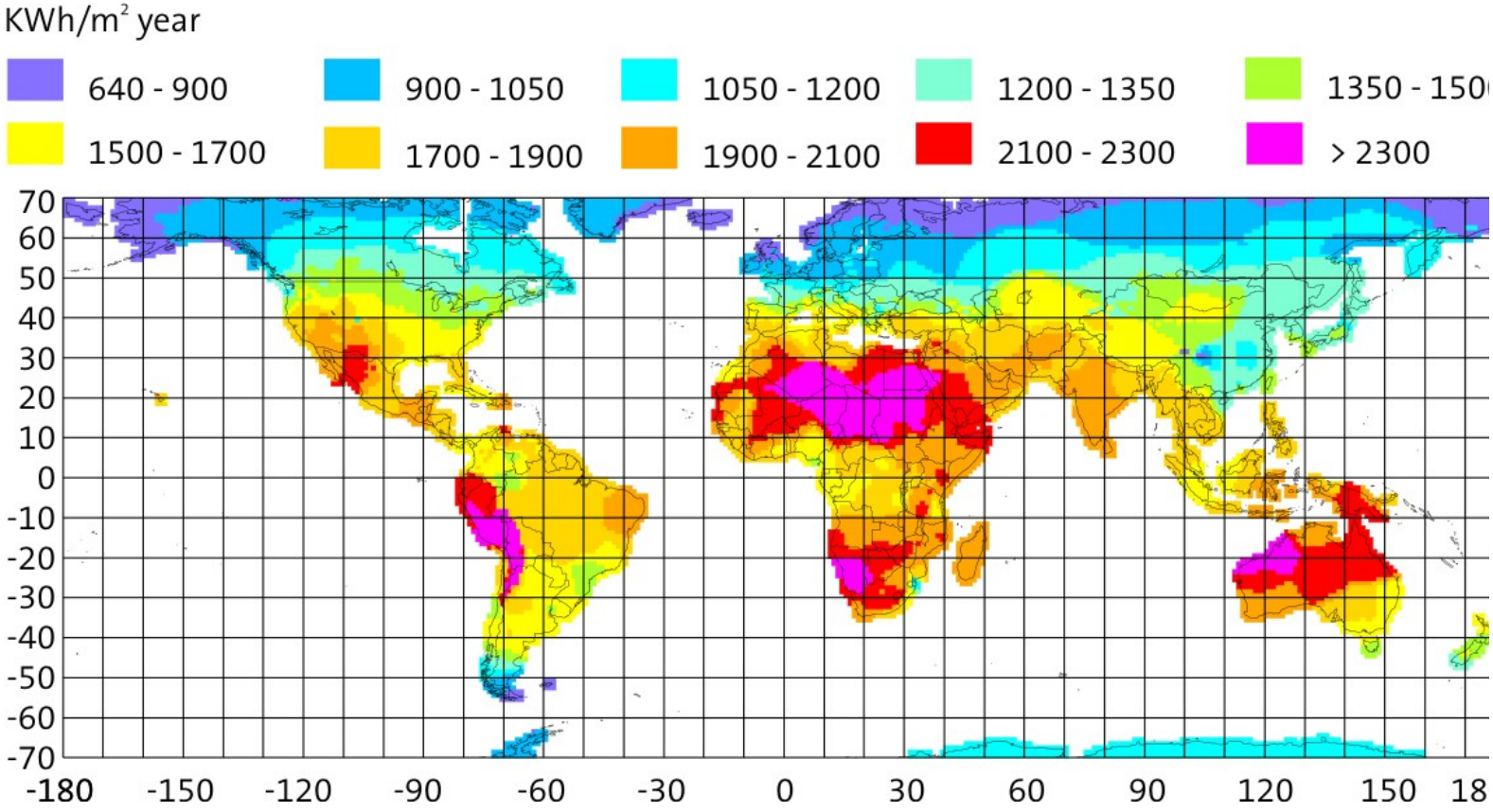
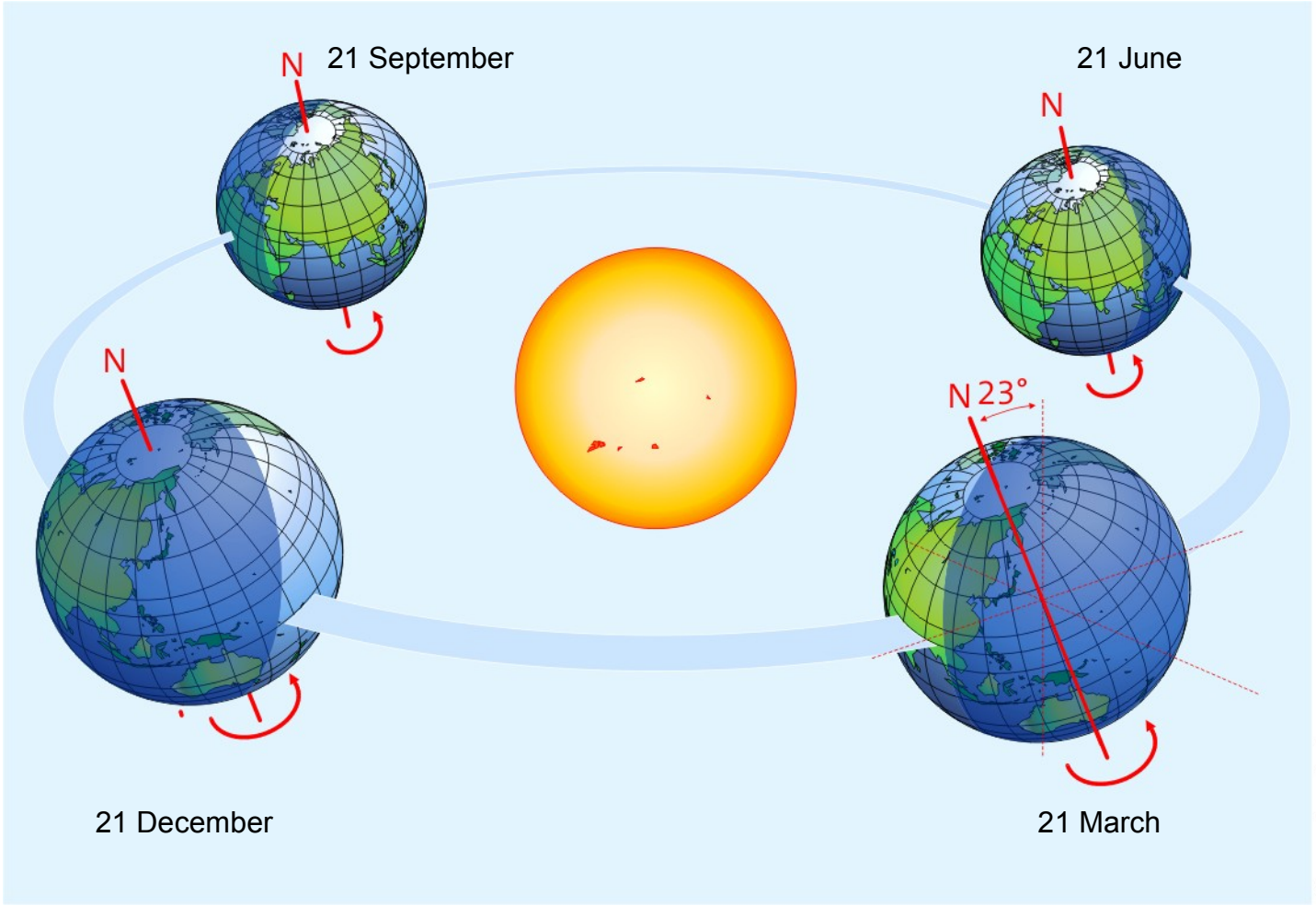
Annual radiation



Source: METEONORM Software


N
21 September
21 June
N
N
N
23°
21 December
21 March
© www.solarpraxis.de

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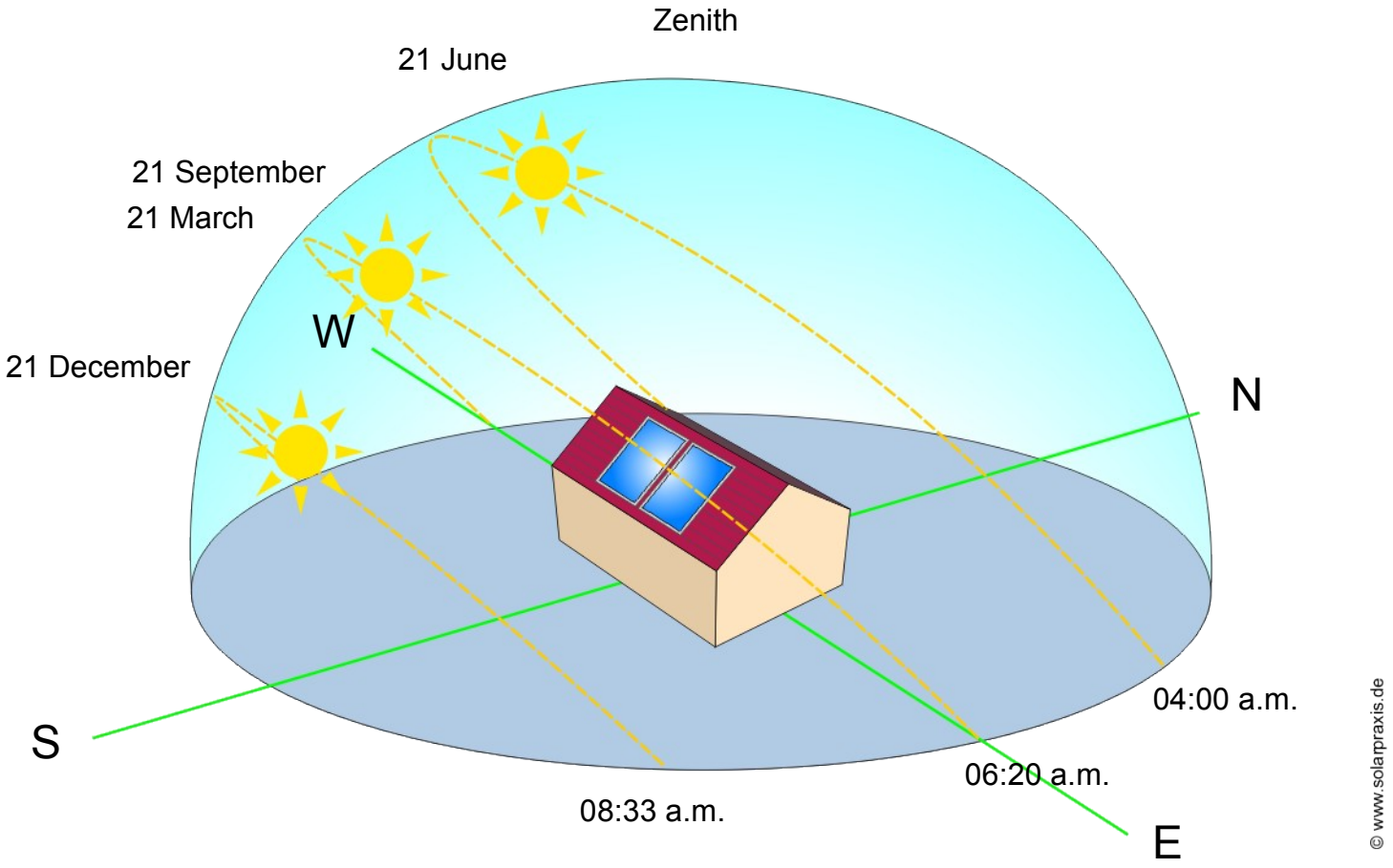
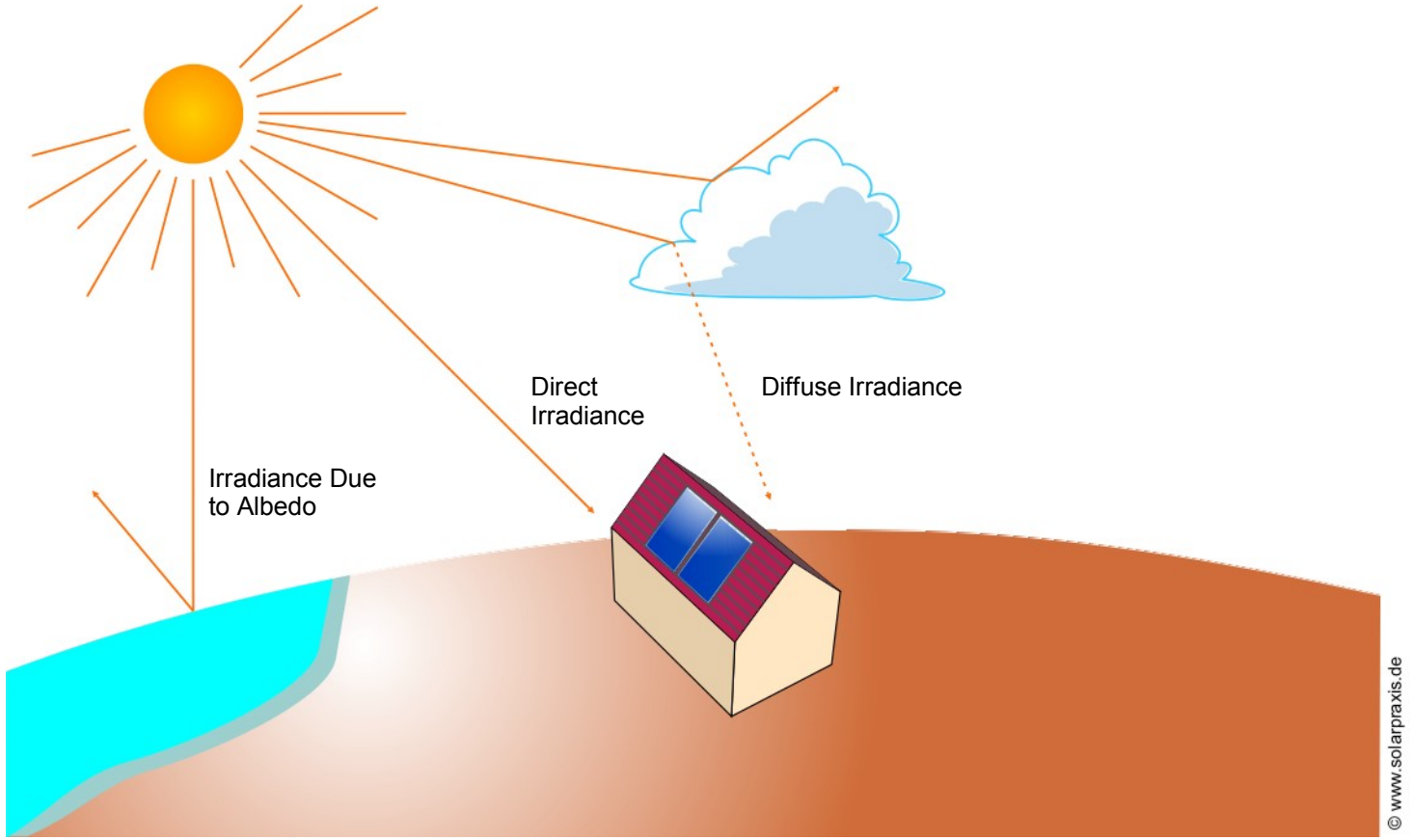
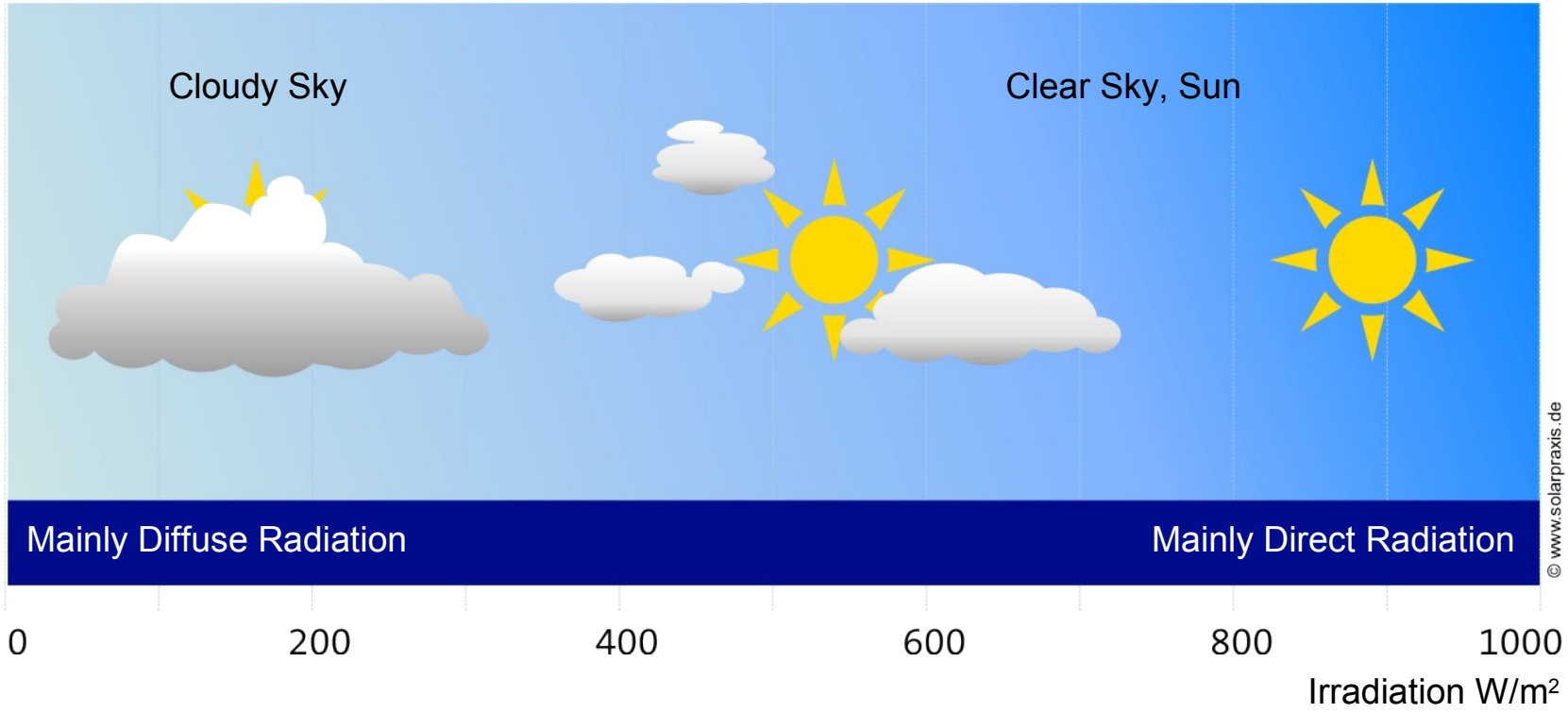
Solar trajectory




Direct
Irradiance
Diffuse Irradiance
Irradiance Due
to Albedo
© www.solarpraxis.de


Cloudy Sky
Clear Sky, Sun
Mainly Diffuse Radiation
Mainly Direct Radiation
© www.solarpraxis.de
0
200
400
600
800
1000
Irradiation W/m²

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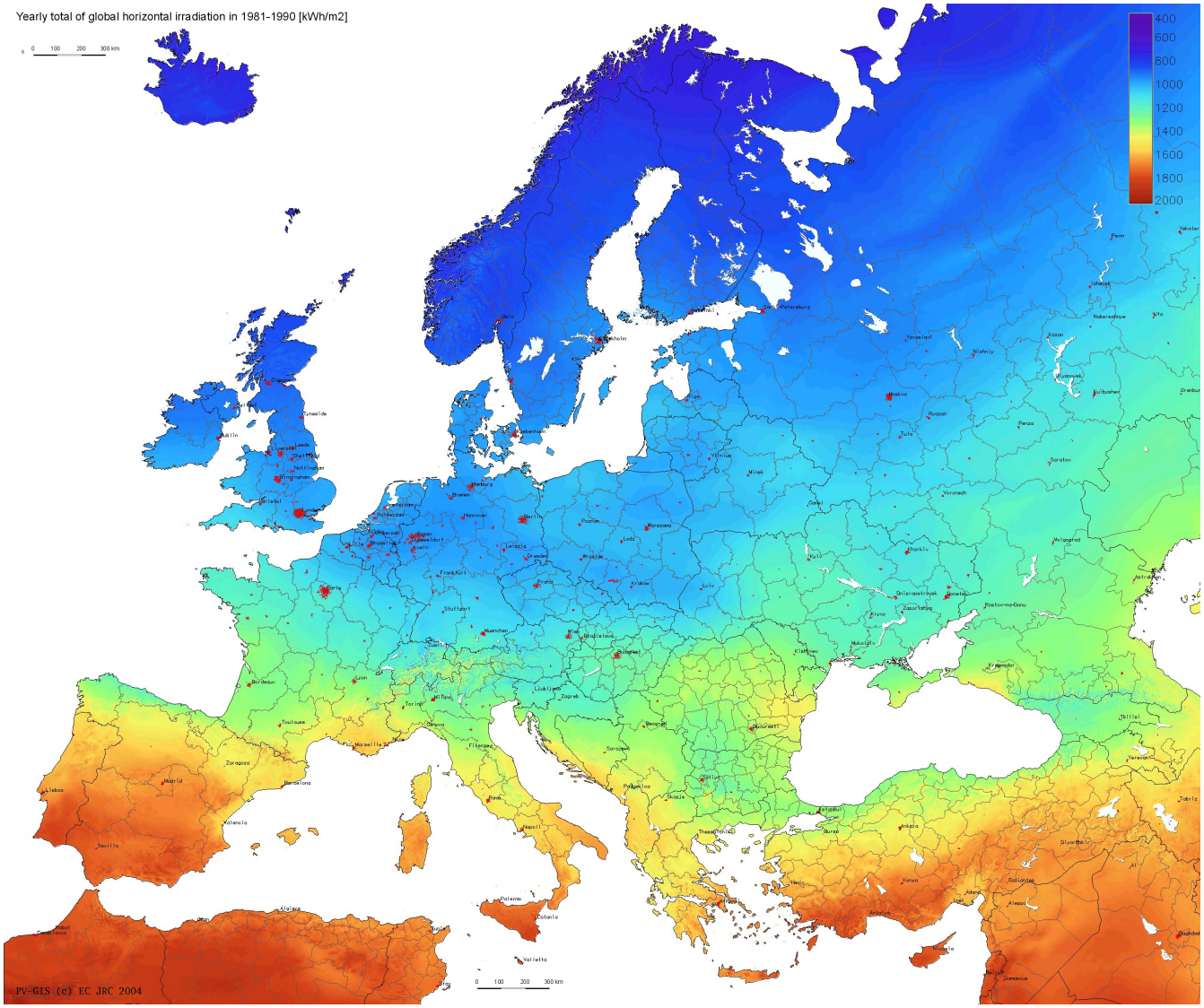

From PVGIS website

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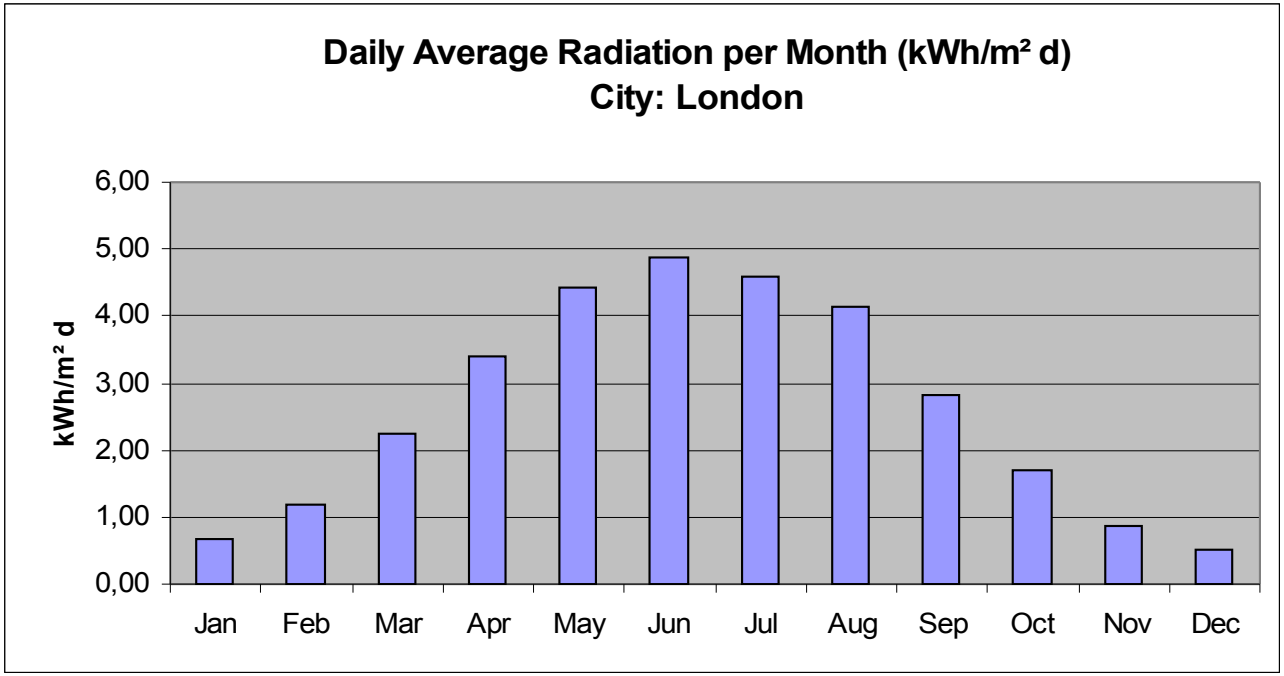
Solar radiation over the year



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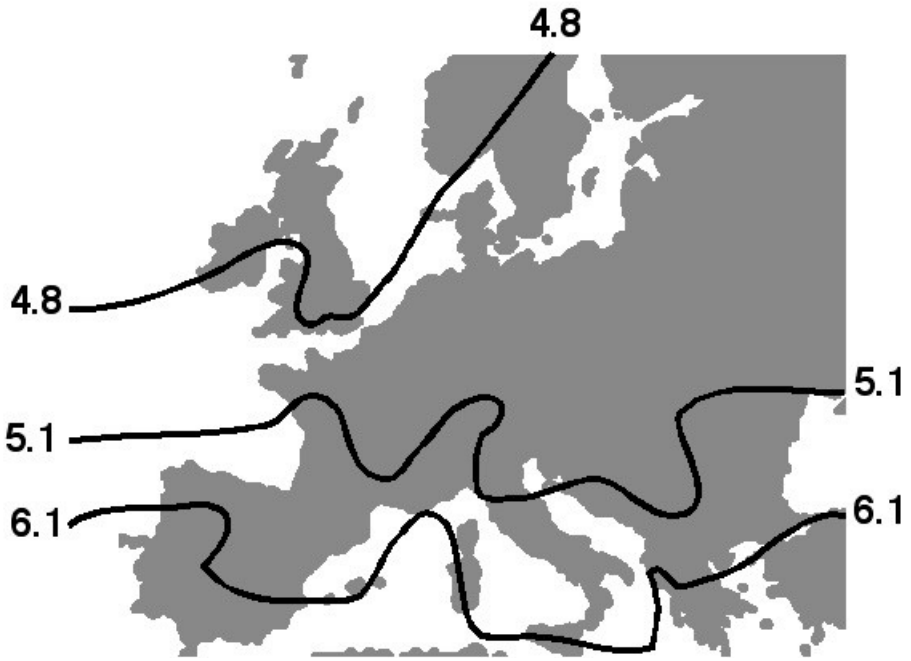
Solar insolation Europe - June



Average daily solar insolation in peak sun hours for June on a surface inclined at the angle of latitude
1 peak sun hour = 1kWh / m^2

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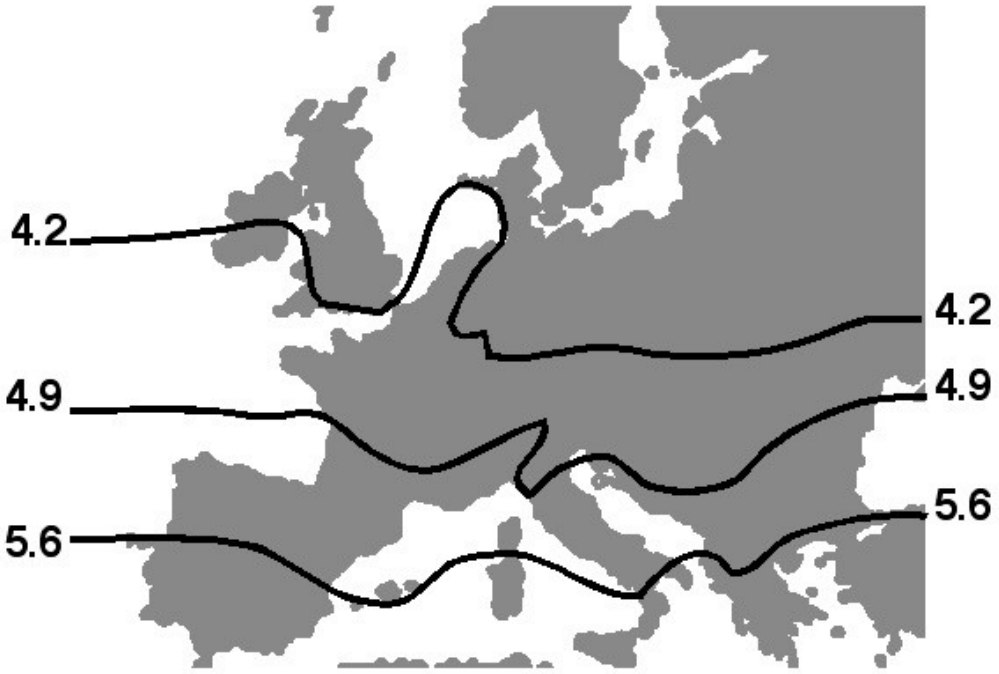
Solar insolation Europe - September



Average daily solar insolation in peak sun hours for September on a surface inclined at the angle of latitude
1 peak sun hour = 1kWh/m^2

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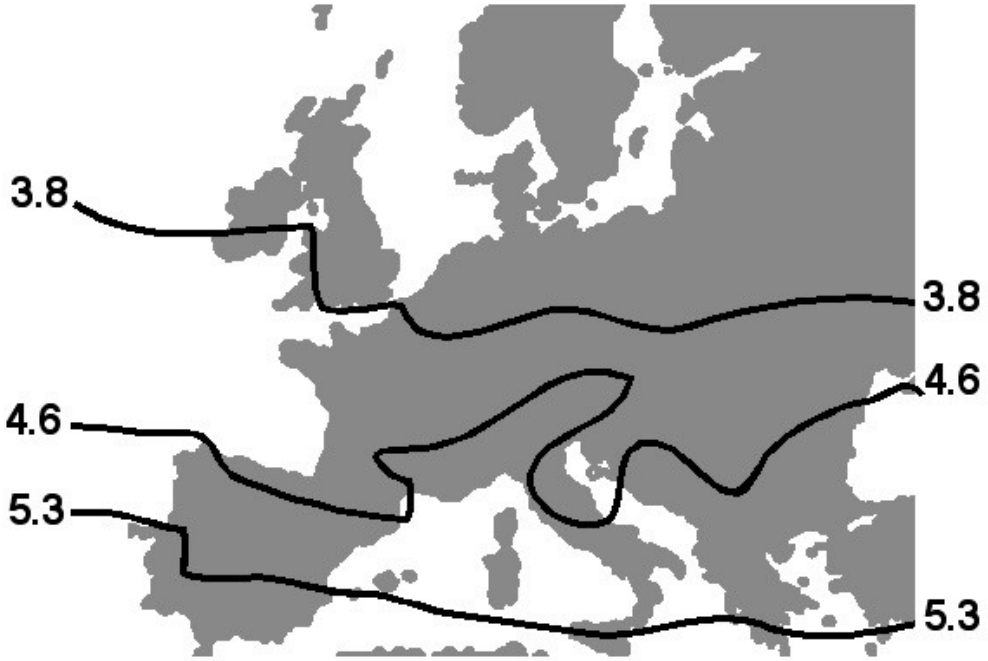
Solar insolation Europe - March



Average daily solar insolation in peak sun hours for March on a surface inclined at the angle of latitude
1 peak sun hour = 1kWh / m^2

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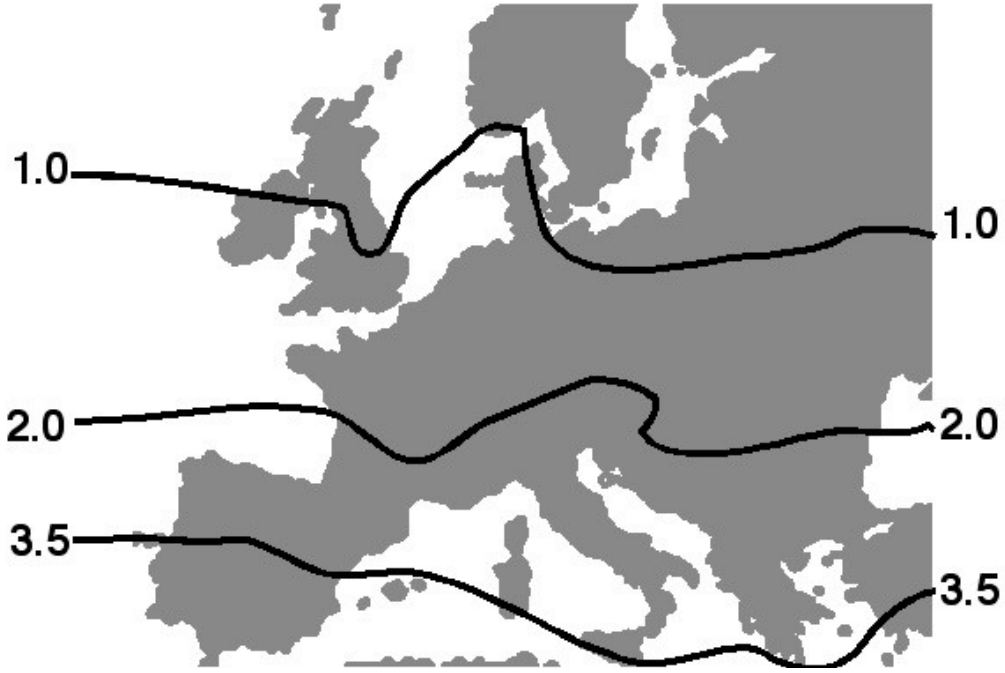
Solar insolation Europe - December



Average daily solar insolation in peak sun hours for December on a surface inclined at the angle of latitude

1 peak sun hour = 1kWh / m^2

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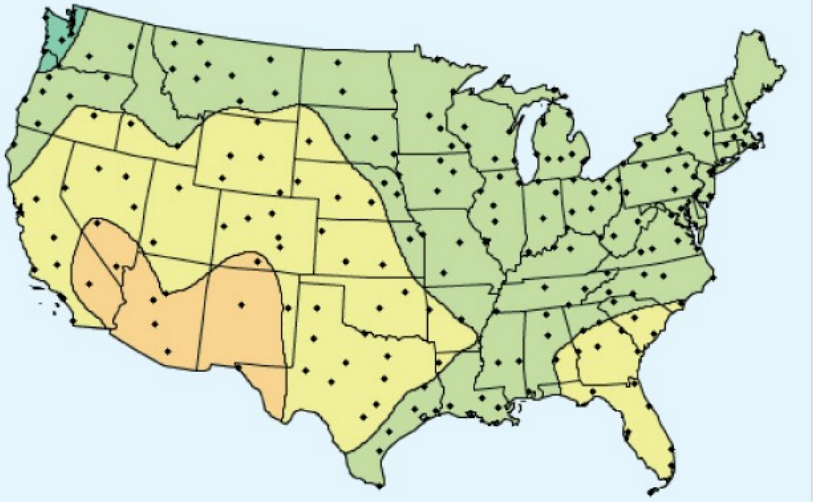
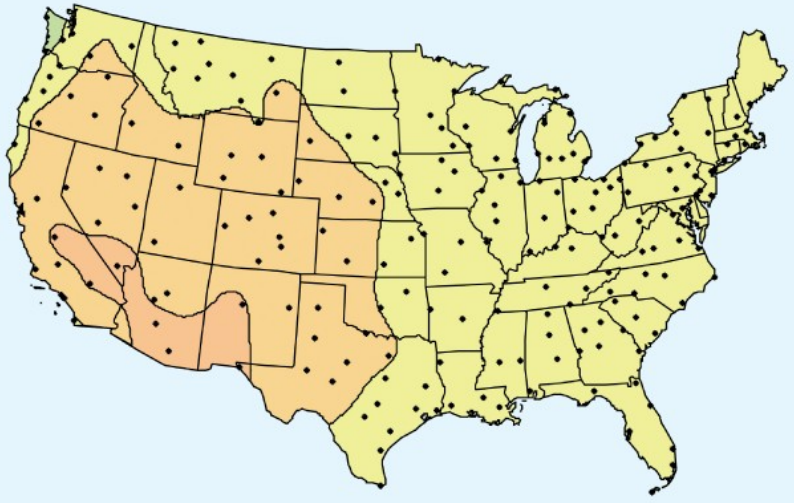
Annual



June



kWh/m²/day
10 to 14
8 to 10
7 to 8
6 to 7
5 to 6
4 to 5
3 to 4
2 to 3
0 to 2
none

At angle of latitude

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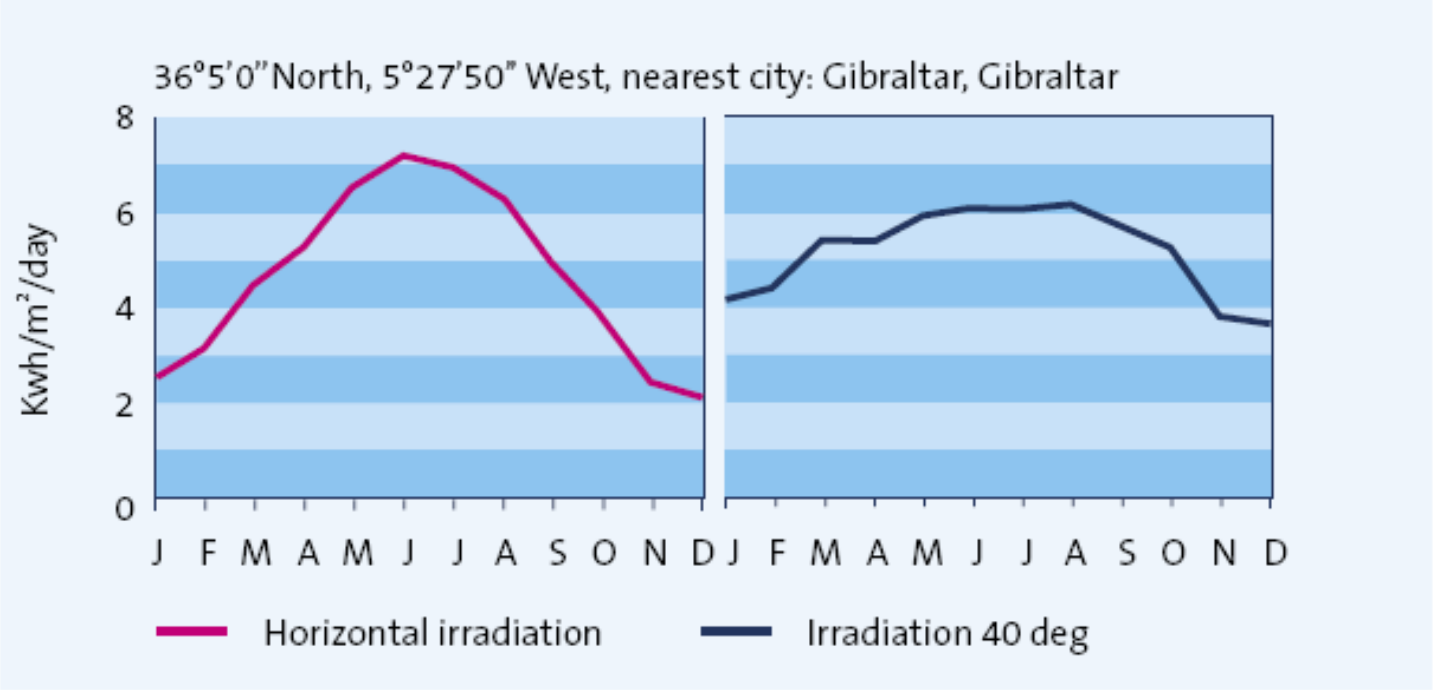
Angles – horizontal & inclined



Source: Photovoltaics for Professionals, *based of PVGIS data*

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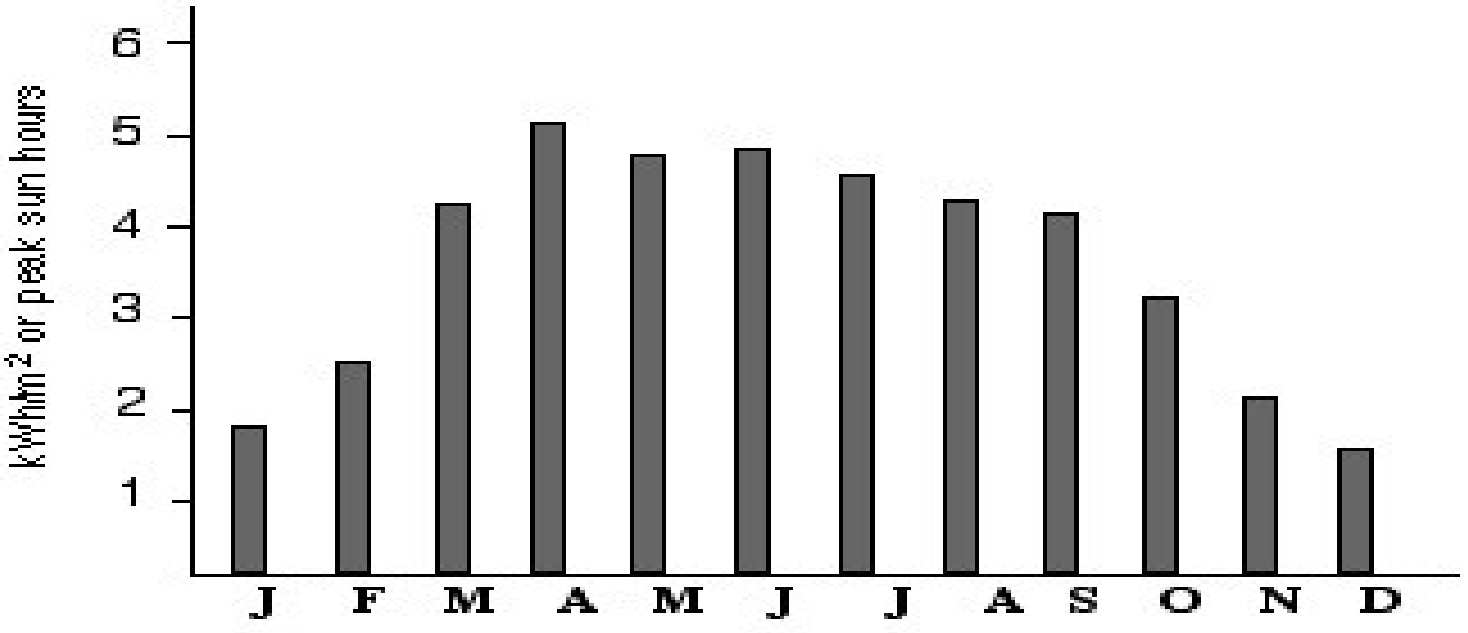
Monthly solar insolation in Cornwall



Average daily solar energy at falling on a solar panel tilted at the angle of latitude at a site in Cornwall

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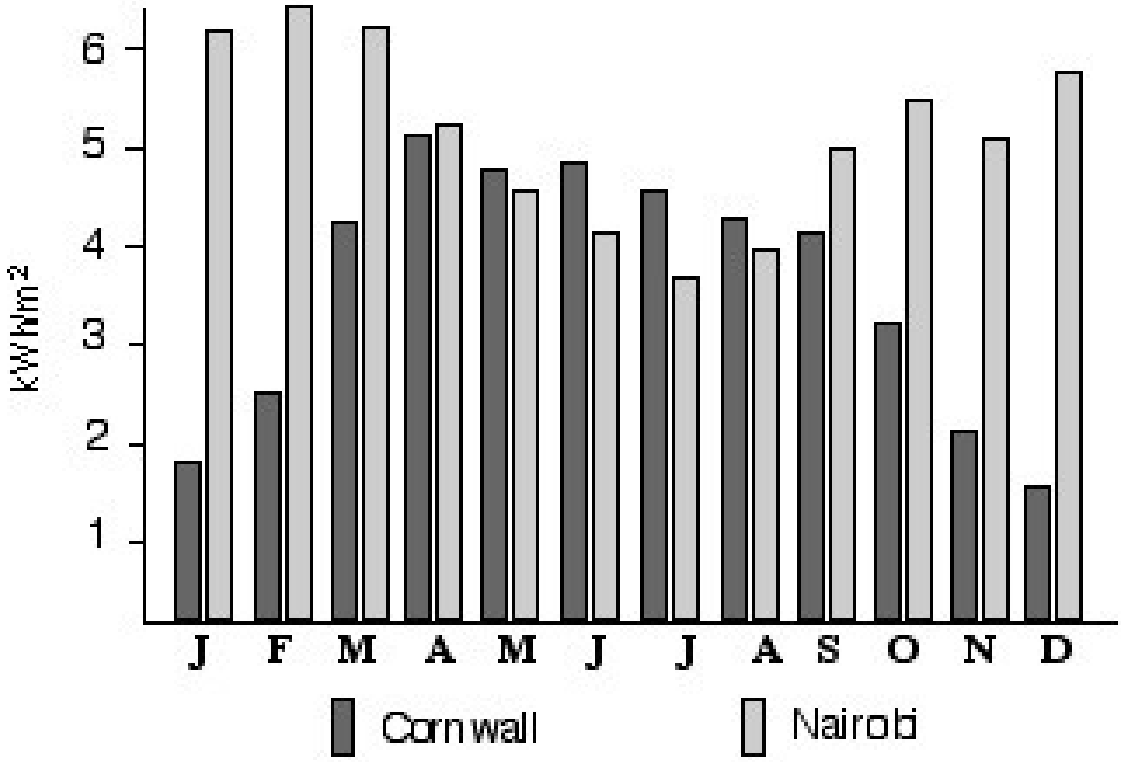
Comparison of solar insolation levels in Cornwall and Nairobi



Solar panels are tilted at the angle of latitude

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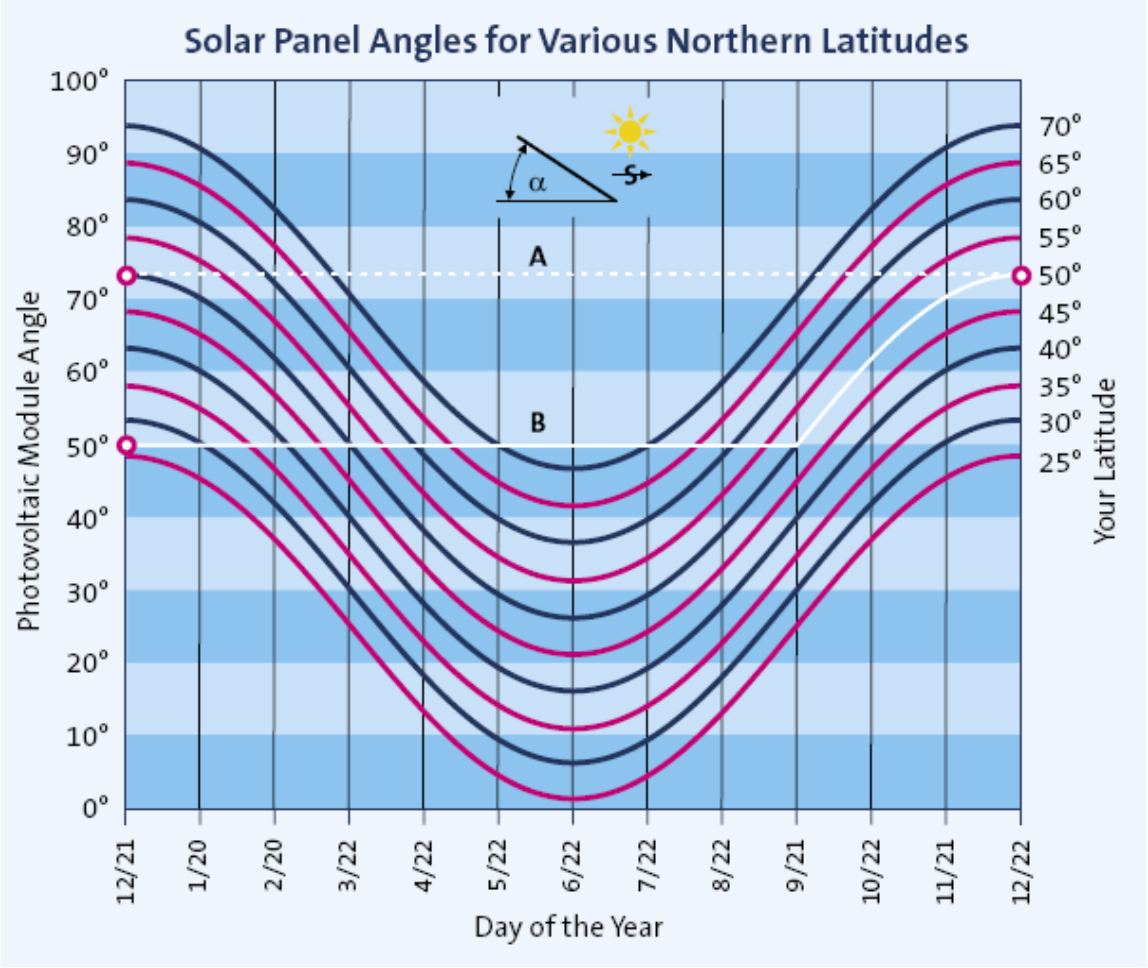
Optimum angles - stand-alone



Not valid in the tropics

www.homepower.com

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Optimum angles – grid-tied - for a specific location

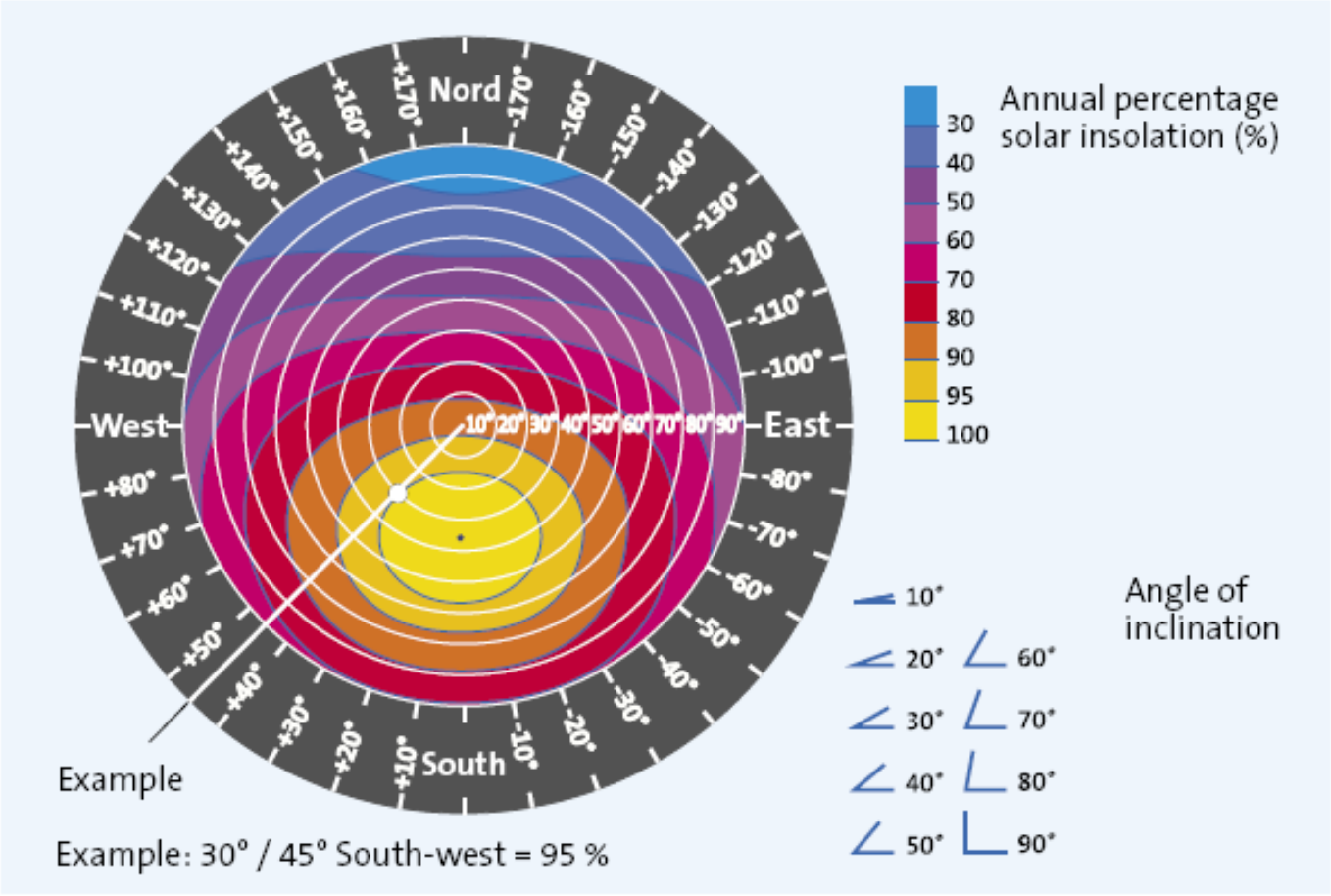

Figure 2.26: Solar yield diagrams are a very useful tool for estimating approximate outputs of grid-tied PV array on roofs. They are also available from some module manufacturers (Source: Ecofys)

Source:
Photovoltaics for Professionals

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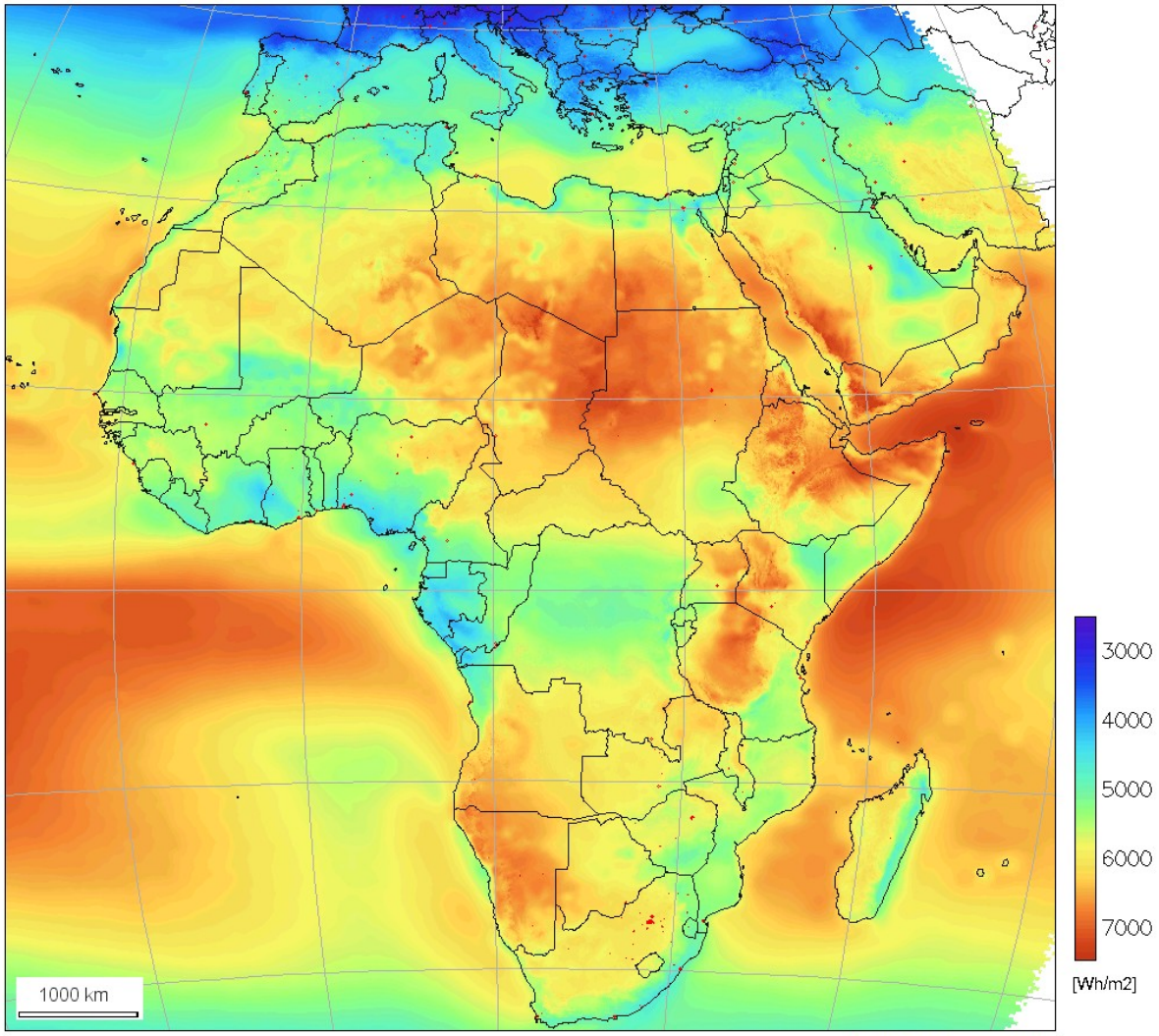
Global horizontal irradiation (1985-2004)
(annual average of daily sums, Gh)

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

MINES PARIS



PVGIS (c) European Communities 2002-2006
HelioClim-1 (c) Ecole des Mines de Paris/ARMINES 1985-2005

http://re.jrc.ec.europa.eu/pvgis/

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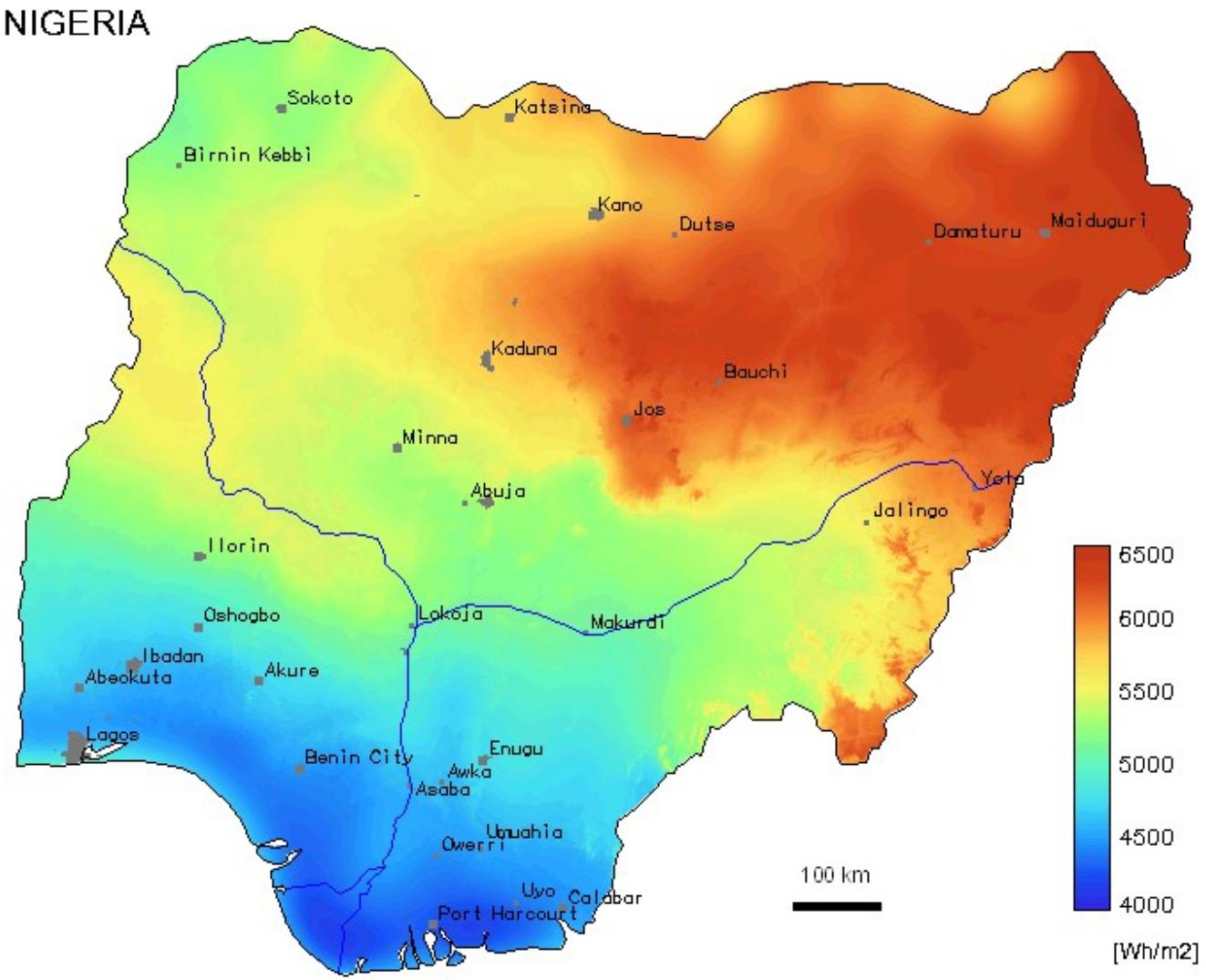
Yearly average of daily sums of global horizontal irradiation

(HelioClim-1/PVGIS data, period 1985-2004)

ies

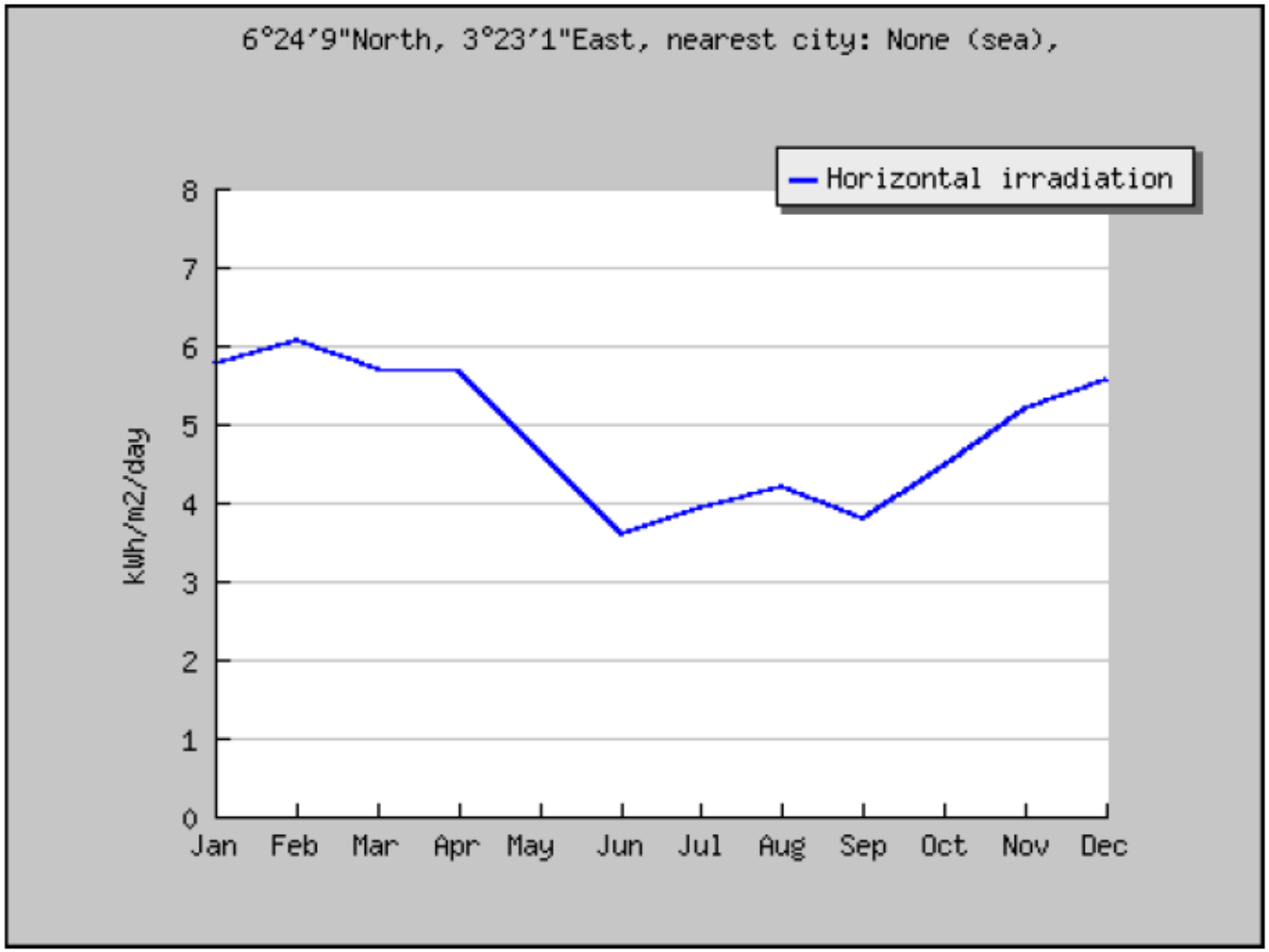
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre



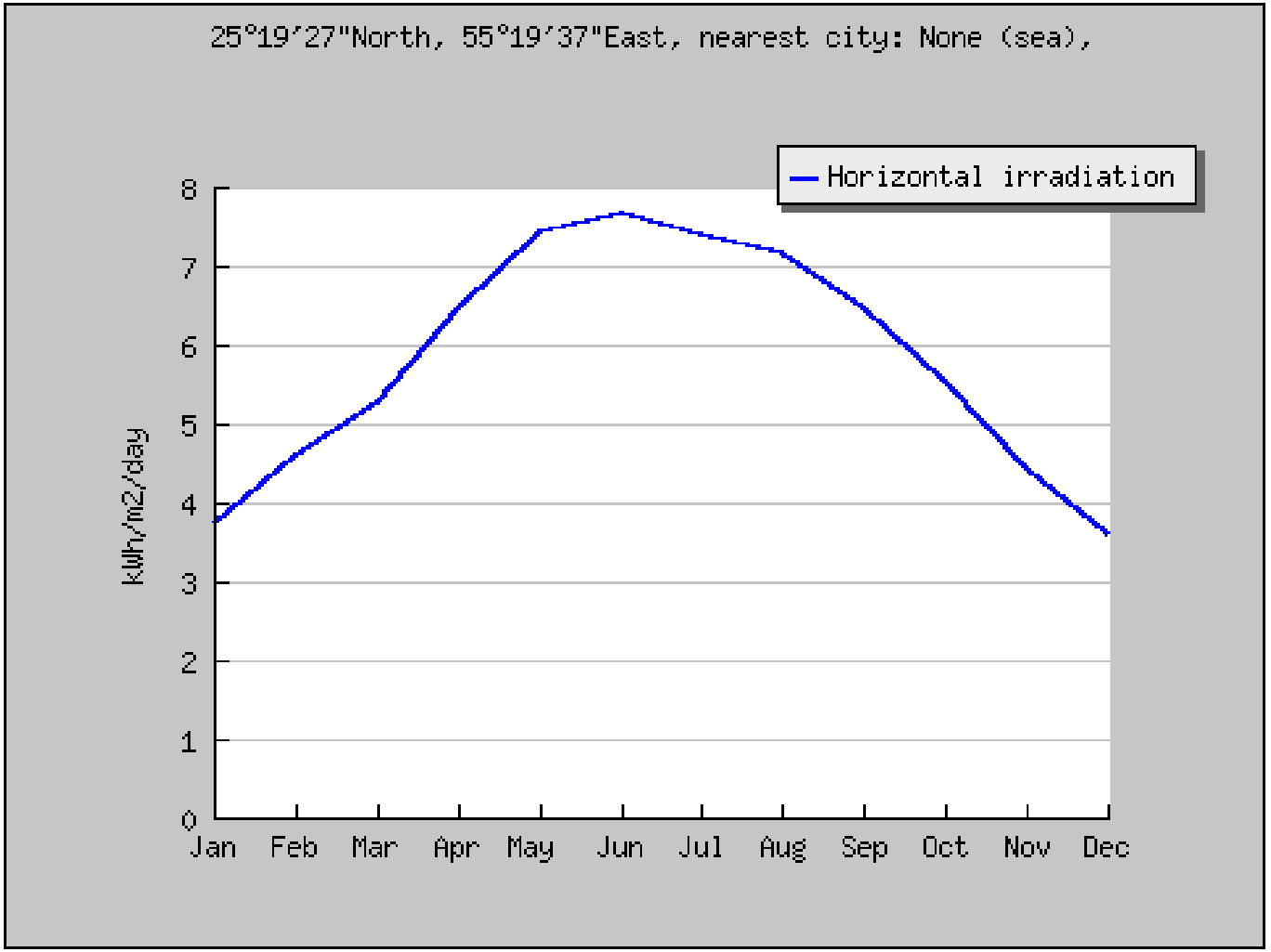
PVGIS (c) European Communities 2002-2006
HelioClim-1 (c) Ecole des Mines de Paris/Armines 2001-2006

http://re.jrc.ec.europa.eu/pvgis/

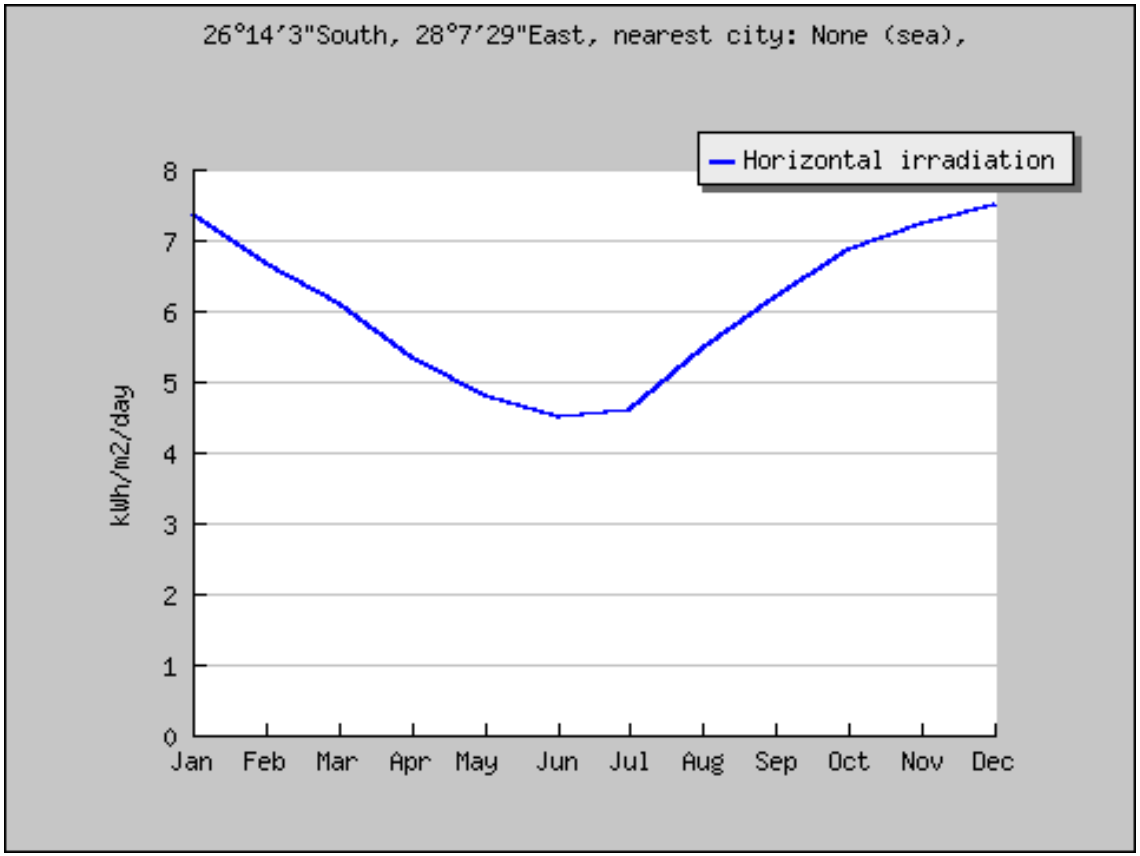
Lagos PVGIS



Dubai PVGIS



Johannesburg PVGIS



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NASA Solar Insolation Data

Insolation (kWh/m2/day)
Lat 52

Lon -4	Jan	Feb	Mar	Apr	May	Jun
10 Year Average	0.60	1.12	2.06	3.32	4.43	4.36
10 Year Average Min	0.53	0.98	1.82	3.01	3.88	3.65
10 Year Average Max	0.65	1.29	2.27	4.16	5.24	5.13
El Nino Year (1987)	0.53	1.06	2.10	3.23	4.26	3.65
La Nina Year (1988)	0.59	1.13	1.86	3.49	4.47	4.55

Insolation (kWh/m2/day)
Lat 52

Lon -4	Jul	Aug	Sep	Oct	Nov	Dec
10 Year Average	4.50	3.74	2.78	1.51	0.80	0.46
10 Year Average Min	3.82	3.08	2.49	1.36	0.67	0.39
10 Year Average Max	5.32	4.38	3.18	1.61	0.88	0.55
El Nino Year (1987)	4.01	3.59	2.80	1.57	0.76	0.40
La Nina Year (1988)	3.82	3.48	2.64	1.45	0.87	0.45

These are peak sun hours on a horizontal surface. They need to be adjust for tilted surfaces