Solar Energy

Suitable conditions for PV installation

Zakariae Ouachakradi, Research Engineer, Green Energy Park

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No. 101037141. This material reflect only the views of the Consortium, and the EC cannot be held responsible for any use that may be made of the information in it.

In this video you will learn:

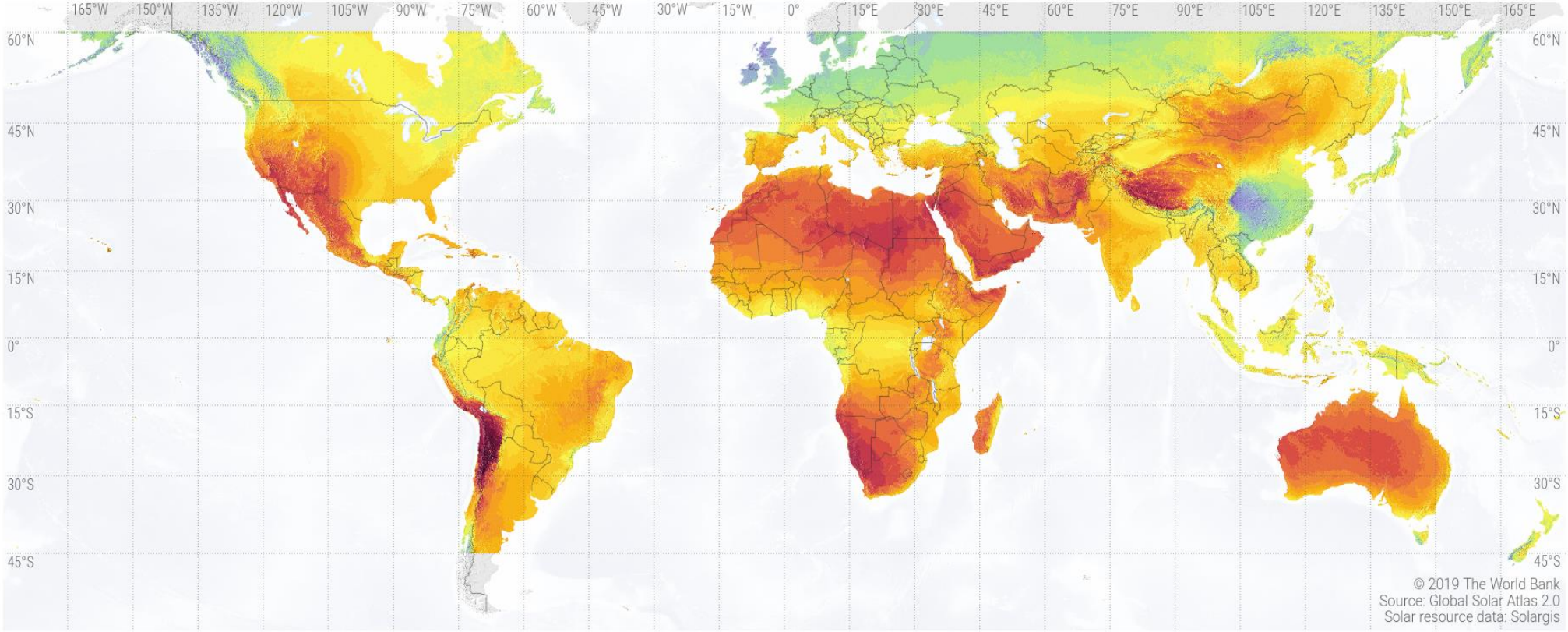
- Solar resource map
  - Meteo stations & Their roles in solar PV Pre-sizing
    - ROIs for different categories of PV modules (Poly, Mono, Thin film)
      - KPIs that determines the suitability of PV Systems (Performance, investment, O&M)
        - Tools developed by Green Energy Park

SESA

SOLAR RESOURCE MAP

PHOTOVOLTAIC POWER POTENTIAL

WORLD BANK GROUP ESMAP SOLARGIS



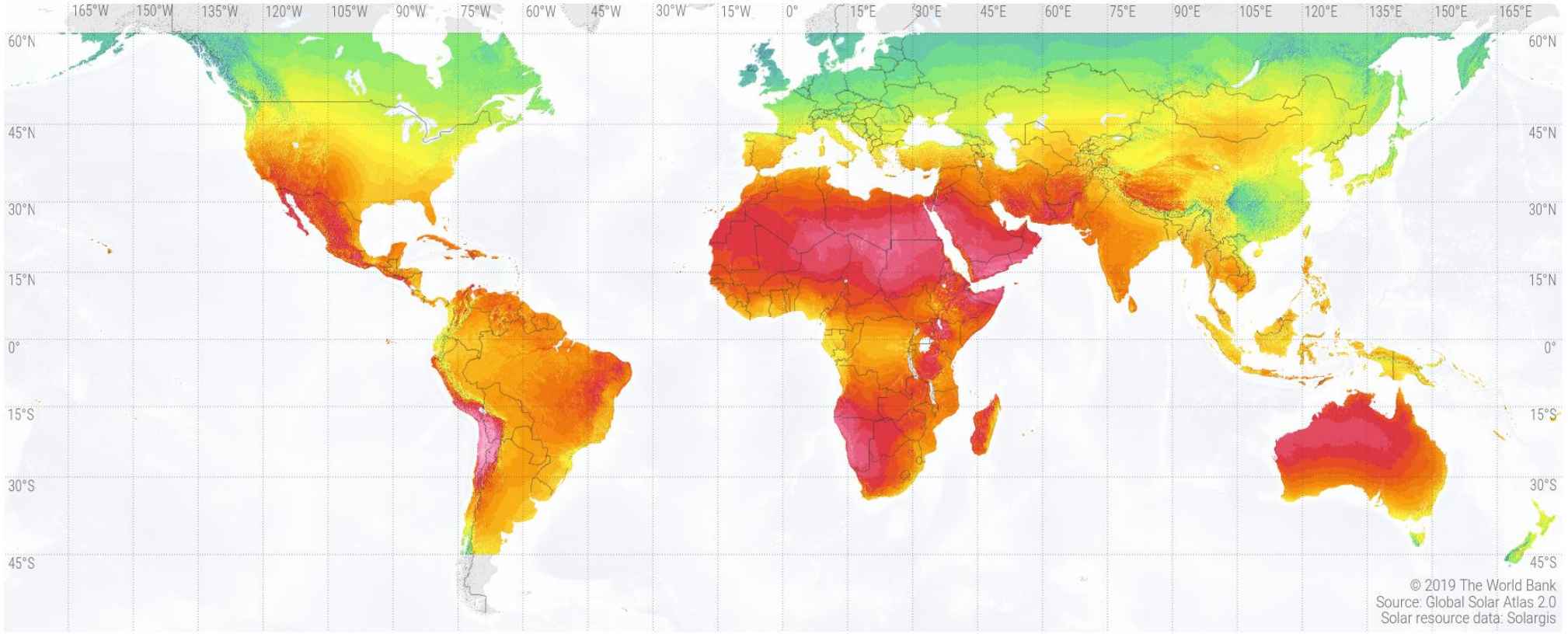
Long-term average of photovolaic power potential (PVOUT)

Daily totals:	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4
												kWh/kWp
Yearly totals:	730	876	1022	1168	1314	1461	1607	1753	1899	2045	2191	2337

SESA

SOLAR RESOURCE MAP

GLOBAL HORIZONTAL IRRADIATION



Long-term average of global horizontal irradiation (GHI)

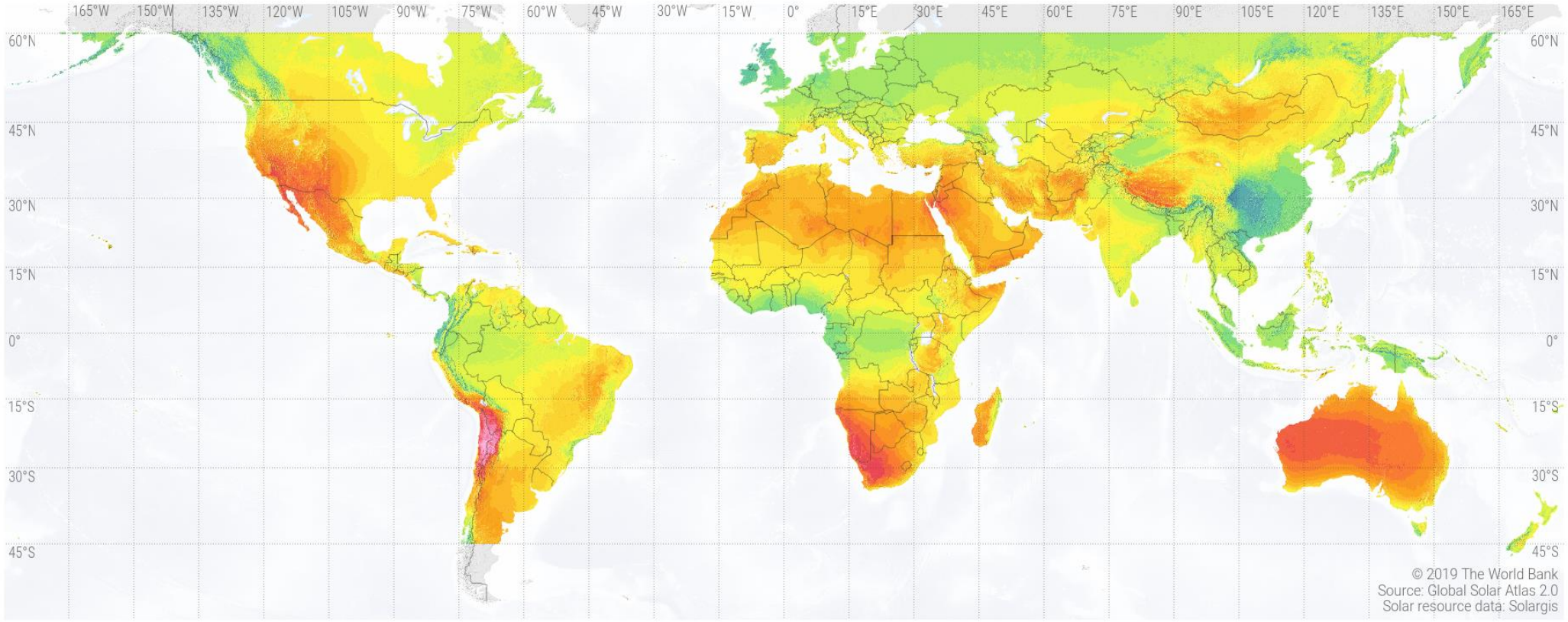
Daily totals:	2.2	2.6	3.0	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	7.0	7.4
Yearly totals:	803	949	1095	1241	1387	1534	1680	1826	1972	2118	2264	2410	2556	2702

kWh/m²

SESA

SOLAR RESOURCE MAP

DIRECT NORMAL IRRADIATION



Long-term average of direct normal irradiation (DNI)

Daily totals:	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
										kWh/m²
Yearly totals:	365	730	1095	1461	1826	2191	2556	2922	3287	3652

This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info.

Weather station and its role?

High precision weather station (installed by GEP)

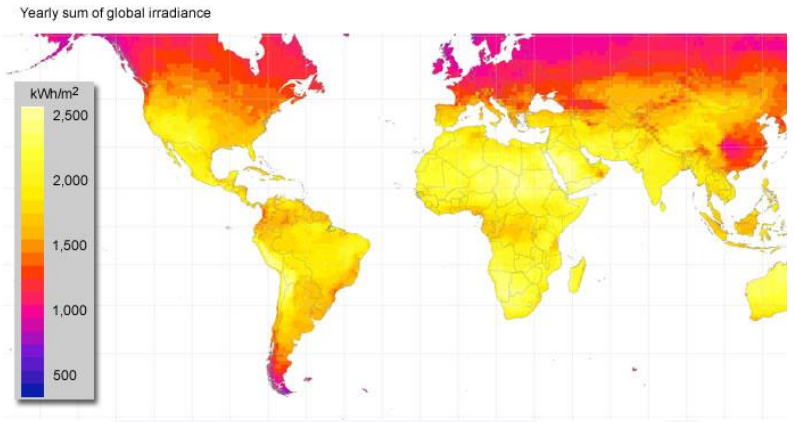
Weather station

A weather station is a structure that contains a set of instruments and equipment to measure environmental conditions, in order to provide information for the study of climate.

These stations are also used in the field of solar energy, as weather conditions have a considerable influence on the performance of solar systems. However, solar weather stations have additional and more specific collectors.

- Performance evaluation and fault detection at operational solar power plants.

- Pre-feasibility studies of large-scale solar projects.



- The validation of satellite meteorological databases and the development of solar maps.

Camarinha-Matos, Luis & Oliveira, Ana & Ferrada, Filipa & Thamburaj, Victor. (2017). Collaborative services provision for solar power plants. Industrial Management & Data Systems. 117. 10.1108/IMDS-06-2016-0246.

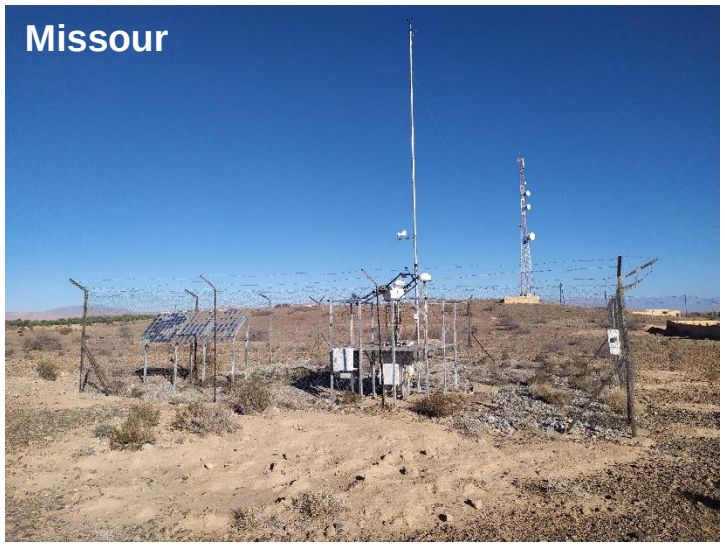
SESA

Our solar weather stations

7 installed, 3 outstanding

Benguerir
Missour
Erfoud
Zagora
Fkih ben wrong
Youssoufia-Mzinda
Khouribga-Sidi chennane
Guelmim-Zag (outstanding)
Guelmim-Lbourate (outstanding)
Safi (outstanding)

SESA

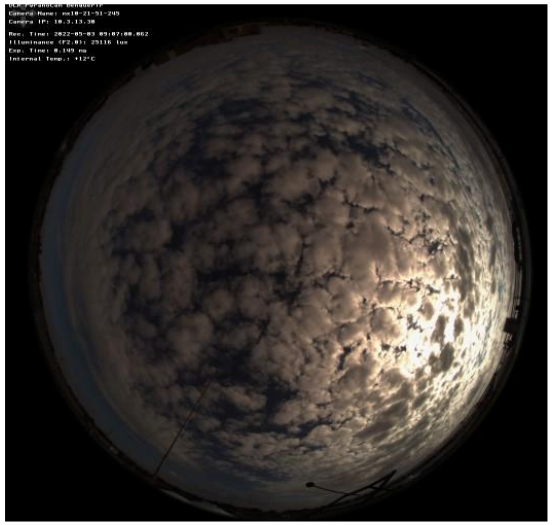


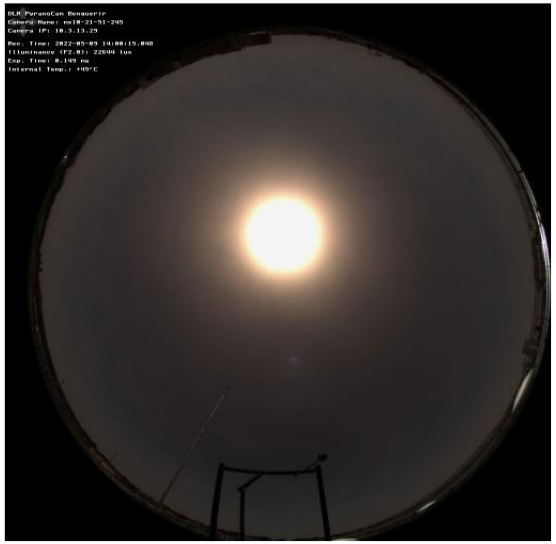
SESA

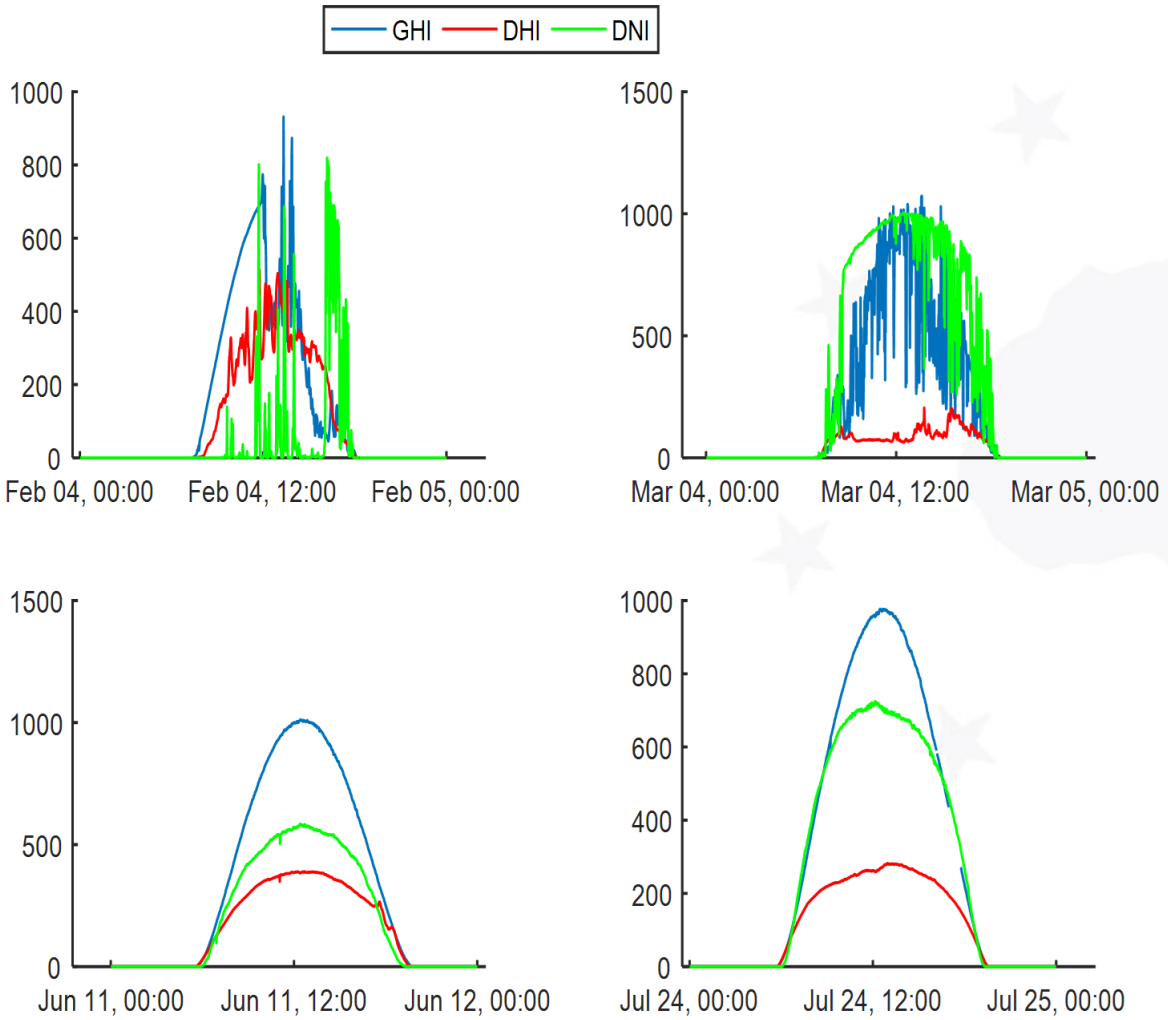
Soiling sensor

A PV soiling sensor **measures performance losses** caused by the accumulation of dust and other deposits on the glass surface of the PV module.

Examples of measured solar radiation*



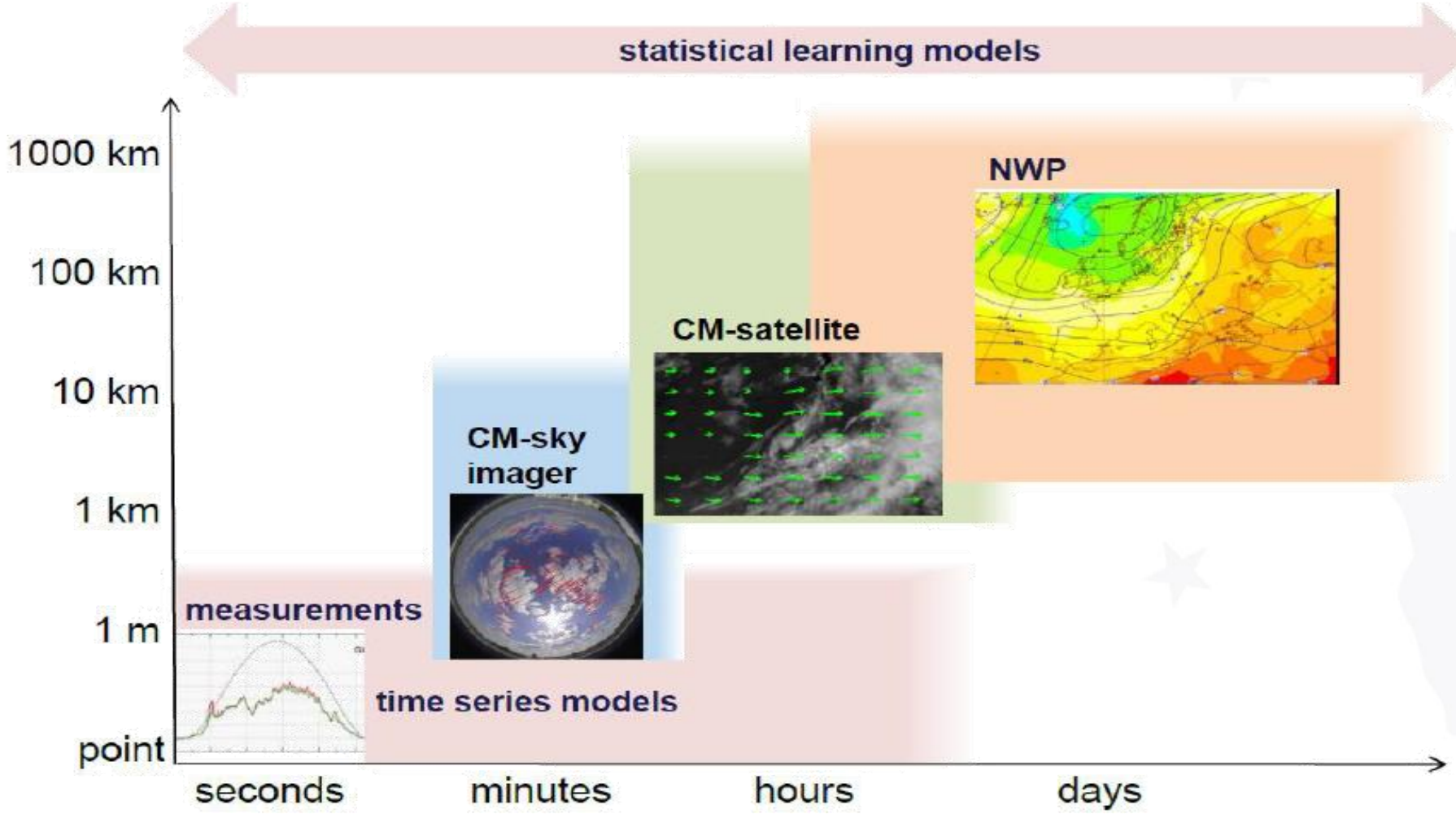




* Examples taken from the GEP station

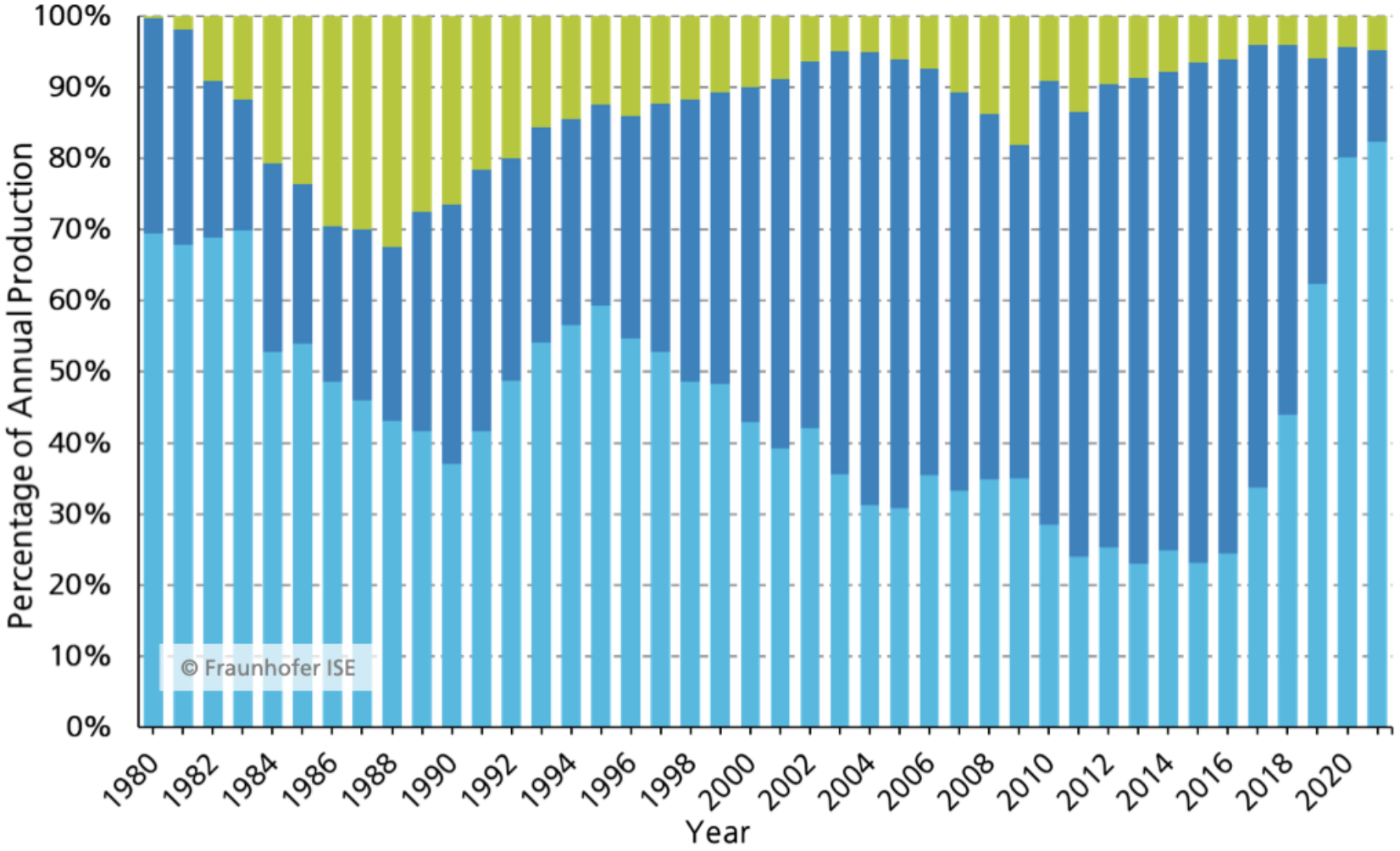
SESA

Characterization of the solar source



Parameter	Value	Status	Reference	Date of data
	Germany / EU27 / Worldwide			
PV installation market	4.9 / 18.2 / 126 GW 5.3 / 25.9 / 174 GW	End of 2020 End of 2021	BNA / SPE / IEA BNA / SPE / IEA	11/2021; 12/2020; 09/2022 02/2022; 12/2021; 09/2022
Cumulative installation	59.8 / 164.9 / 945 GW	End of 2021	ISE / SPE / IEA	07/2022; 12/2021; 09/2022
PV power generation	48.6_{net} / 160.4_{gross} / 1032.5_{gross} TWh	2021	ISE / BP / BP	06/2022; 06/2022; 06/2022
PV electricity share	$9.9\%_{net}$ / $5.5\%_{gross}$ / $3.6\%_{gross}$	2021	ISE / BP / BP	08/2022; 06/2022; 06/2022
	Worldwide			
c-Si share of production	95%	2021	ISE	08/2022
Record solar cell efficiency: III-V MJ (conc.) / mono-Si / CIGS / multi-Si / CdTe	47.1 / 26.7 / 23.4 / 24.4 / 21.0%	06/2021	Green et al.	06/2021
	Germany			
Price PV rooftop system	1,050 to 1,650 €/kWp	2022	BSW	05/2022
LCOE PV power plant	3.1 to 5.7 ct€ / kWh	2021	ISE	
Lowest/Latest PV-Tender Price	4.33/5.00 ct€ / kWh	02/2018; 11/2021	BNA	11/2021

PV Production by Technology Percentage of Global Annual Production



Production 2021* (GWp)

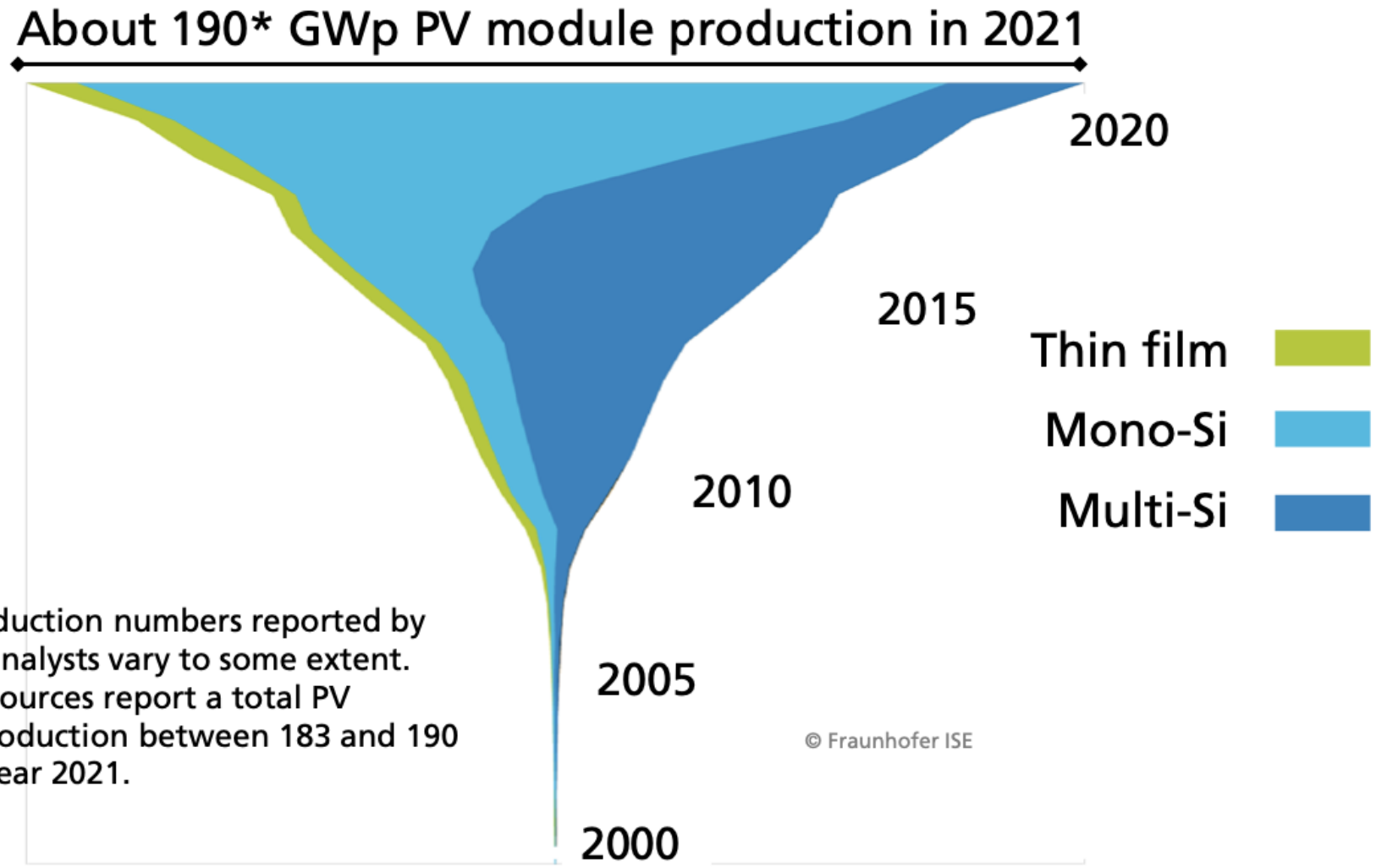
Thin film	10
Multi-Si	20
Mono-Si	160

*estimated numbers

Data: from 2000 to 2009: Navigant; from 2010 to 2021 IHS Markit; from 2022 IEA. Graph: PSE 2022 . Date of data: July 2022

SESA

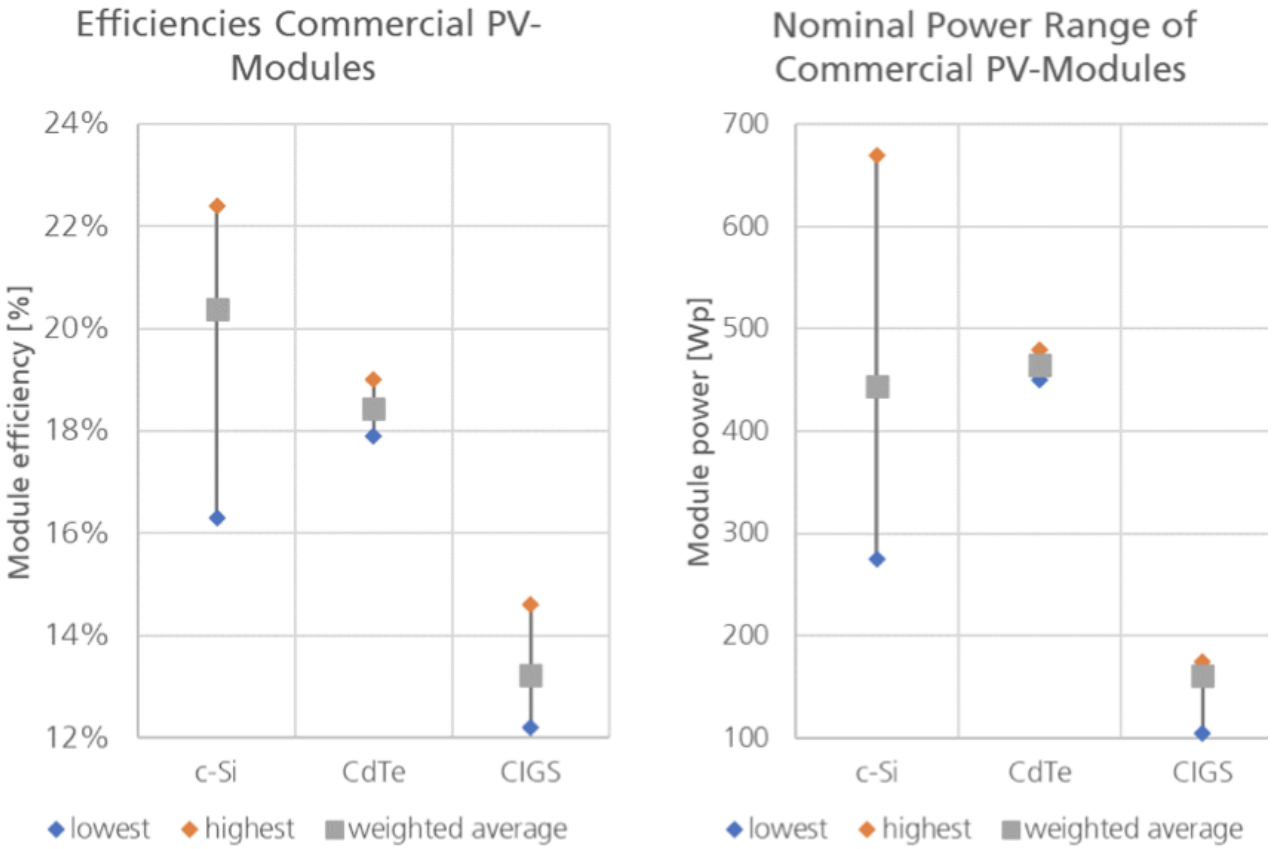
Annual PV Production by Technology Worldwide (in GWp)



Data: from 2000 to 2009: Navigant; from 2010: IHS Markit. Graph: PSE 2022. Date of data: Jan-2022

SESA

Current Efficiencies and power of commercial PV Modules – sorted by technology



- Total weighted average efficiency of crystalline Silicon(c-Si) wafer-based modules is **20.4%** in Q4- 2021 (weighting factor is total shipments in year 2020). Lowest module efficiency in this group is 16.3% and highest value is 22.4%.
- Top 10 manufacturers represent about 78% of total shipment volume and origin mainly in Asia.
- Predominant c-Si technology is mono-PERC with half-cut cells and Multi-Busbar

Data Source: Company product data sheets; Date of data: 04-Nov. 2021 Fraunhofer ISE

Note: Selection based on modules of Top10 manufacturers in year 2020 (exception CIGS) with global available module data sheets at end of Oct-2021.

SESA

Historic Trend in Energy Payback Time: Harmonized Study data for mono-crystalline Silicon Rooftop PV-Systems

Learning Rate:

Each time the cumulative production doubled, the EPBT went down by 12.8 % for the last 24 years.

Harmonization methodology
based on Koppelaar (2016) harmonized results and harmonization parameters

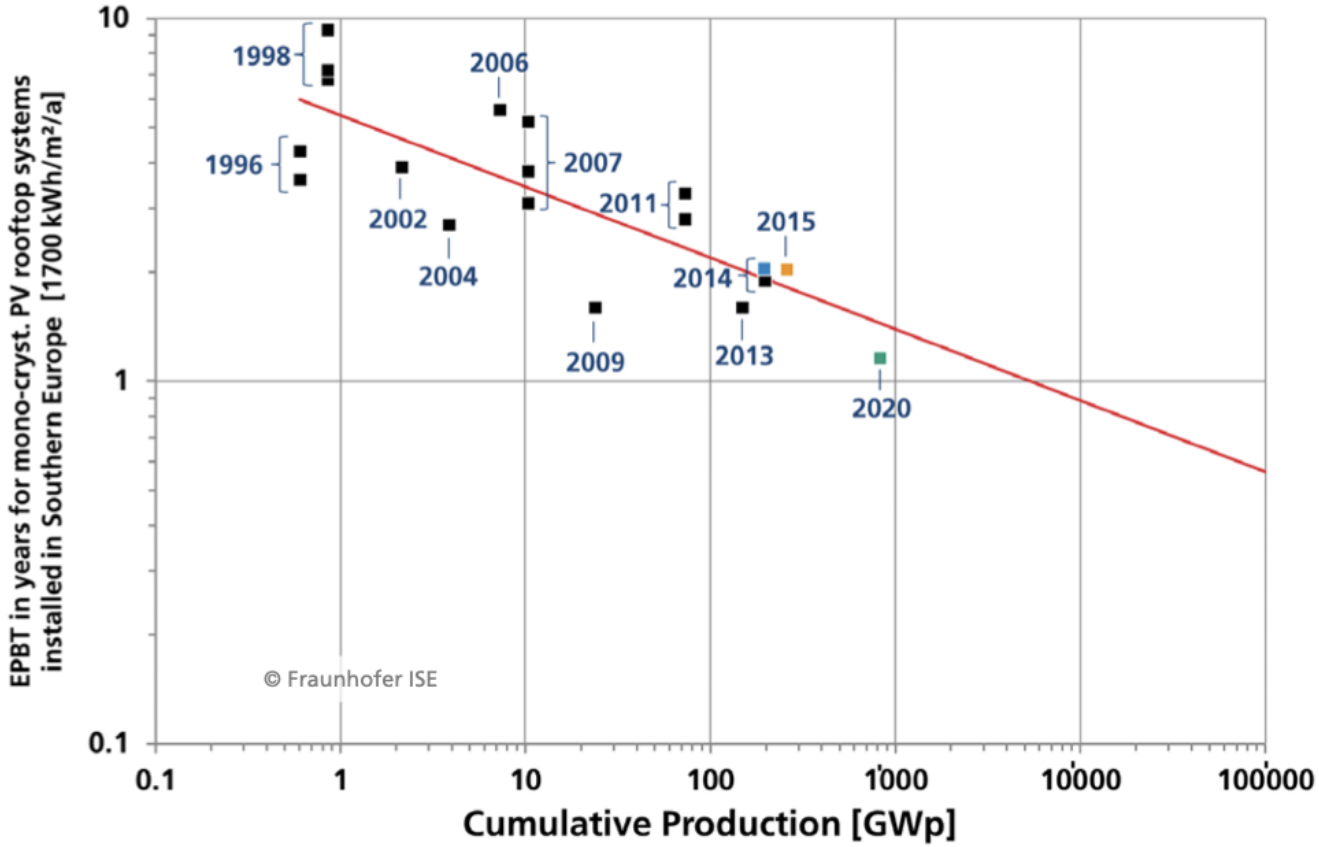
1) Performance Ratio
based on average annual PV yield during lifetime

PV system lifetime	25
Degradation	0.70%
PR (initial)	80%
PR (incl. average degradation during lifetime)	**73.6%**

2) Grid efficiency
for converting PV yield in primary energy equivalents

grid efficiency	**35%**

EPBT of Leccisi (2016), Louwen (2014) and Friedrich (2020) were harmonized with 1) PR (incl. average degradation) and 2) grid efficiency to results of Koppelaar (2016)*



Irradiation: 1700 kWh/m²/a at an optimized tilt angle; **Years:** Estimated average year of original data

Data: Lorenz Friedrich, Fraunhofer ISE. Graph: PSE 2021

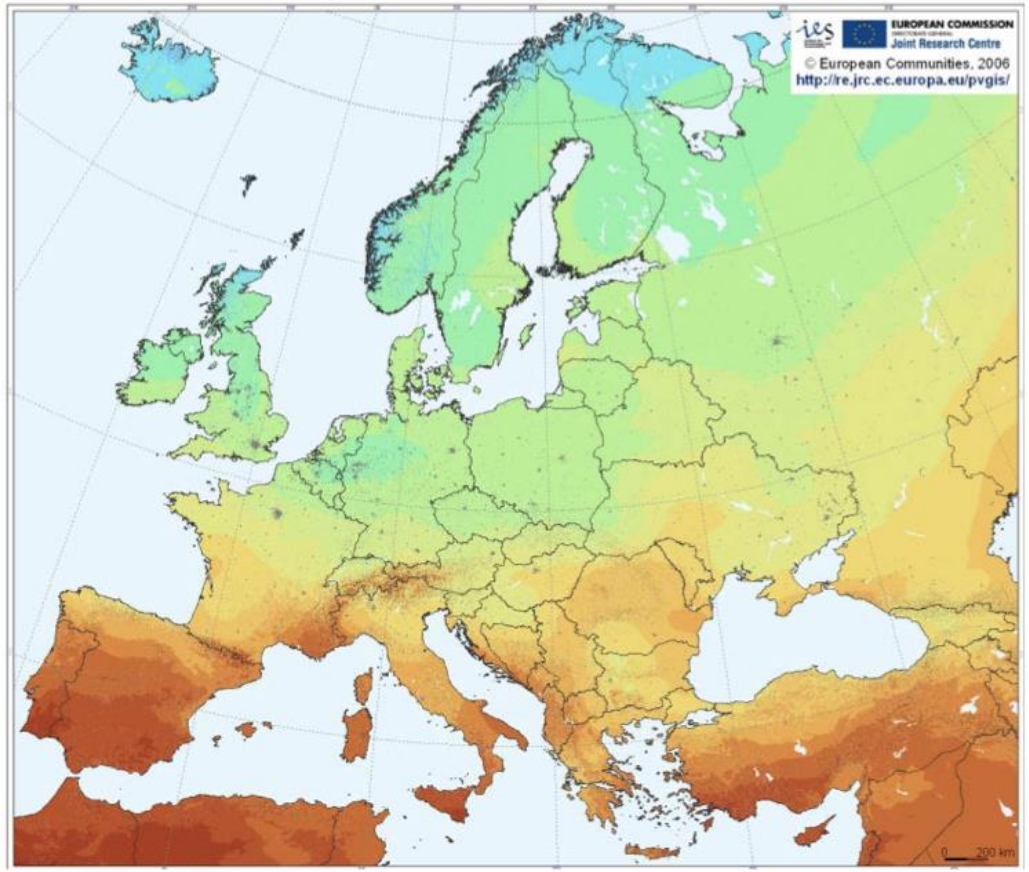
SESA

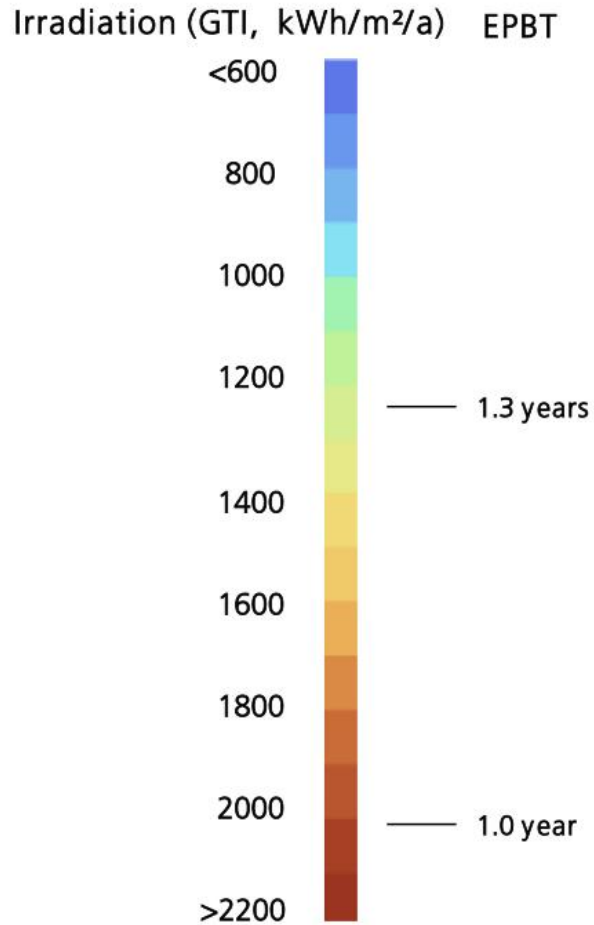
Energy Pay-Back Time of Silicon PV Rooftop Systems Geographical Comparison

Rooftop PV-system using Mono-crystalline Silicon cells* produced in China

EPBT is dependent on irradiation, but also on other factors like grid efficiency**.

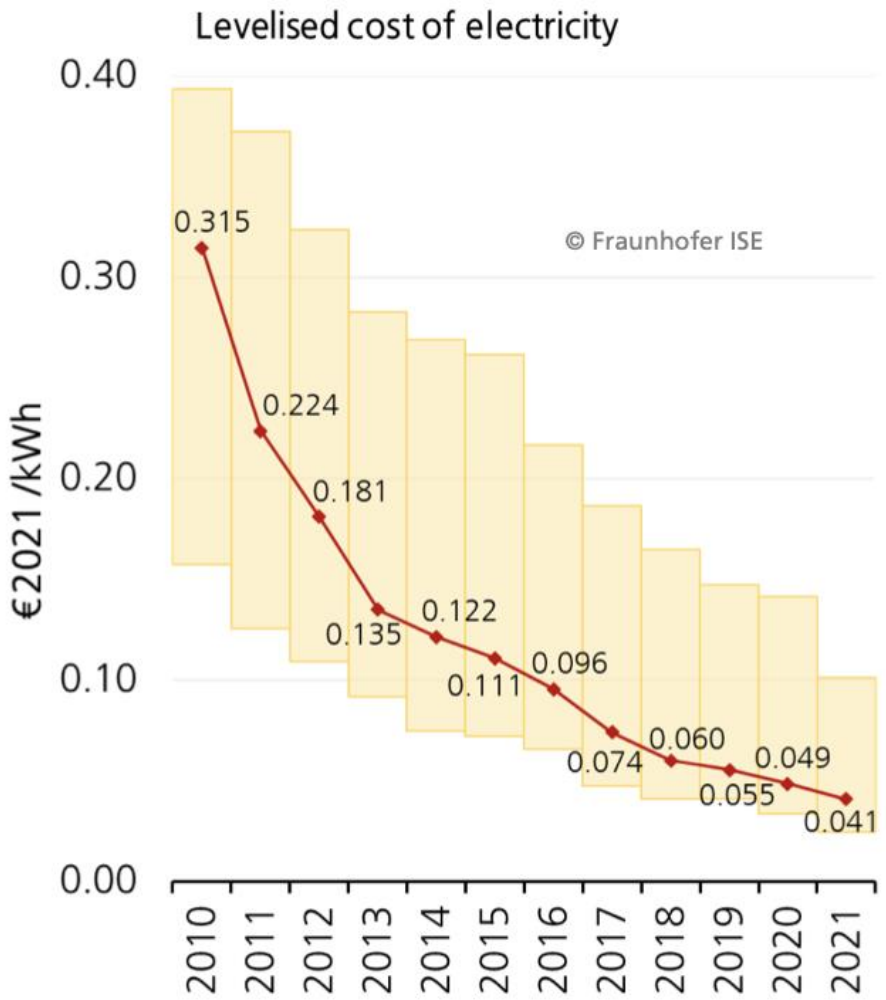
Better grid efficiency in Europe may decrease the EPBT by typically 9.5 % compared to PV modules produced in China.



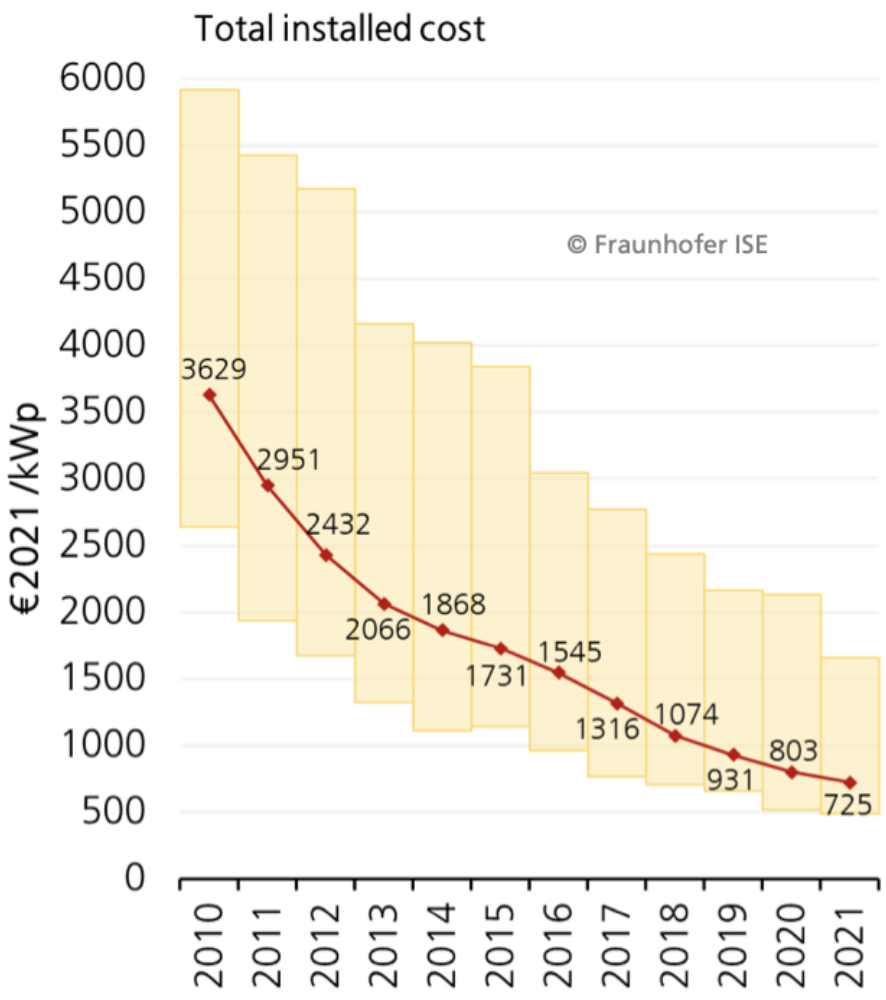


SESA

Global Weighted Average Total Installed Costs For Large PV System

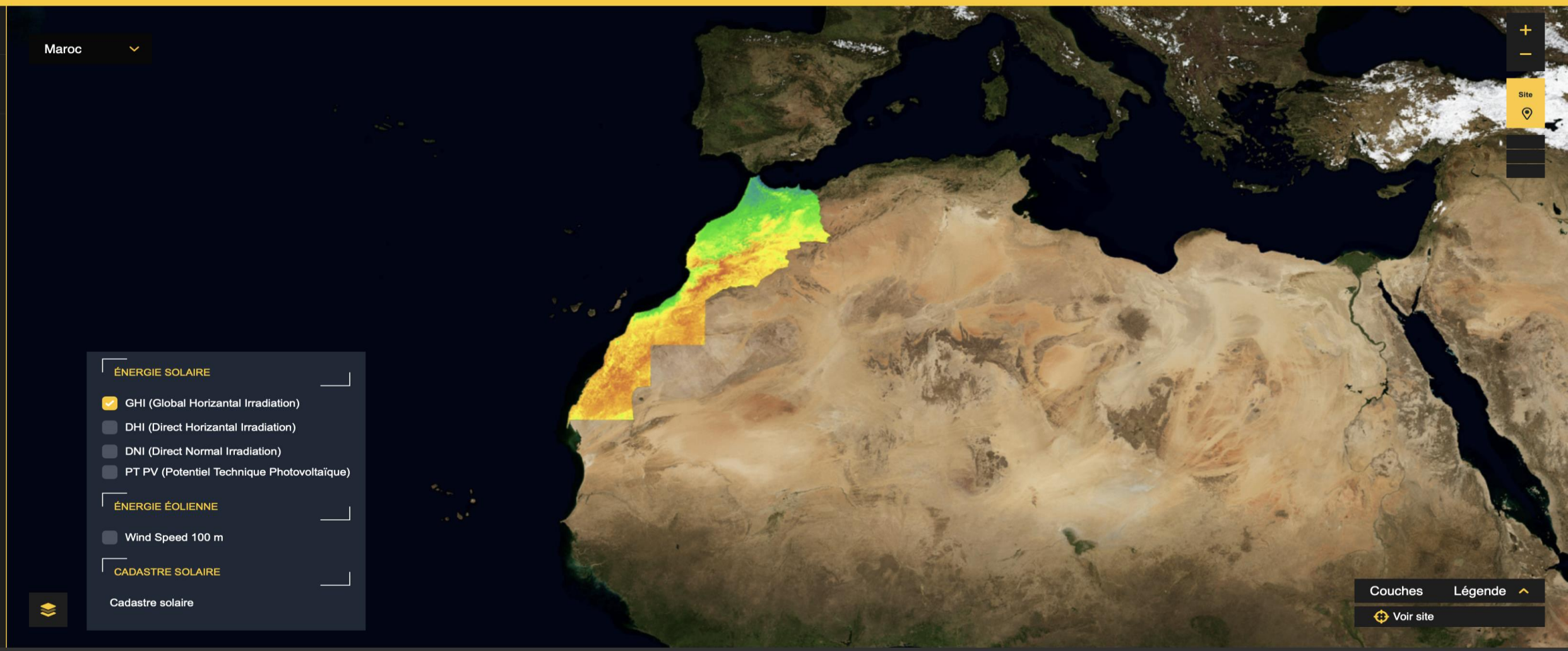


Global Weighted Average Levelised Costs of Electricity for Large PV Systems



SESA

Tools developed by Green Energy Park (Morocco)


Maroc
Site
ÉNERGIE SOLAIRE
GHI (Global Horizantal Irradiation)
DHI (Direct Horizantal Irradiation)
DNI (Direct Normal Irradiation)
PT PV (Potentiel Technique Photovoltaïque)
ÉNERGIE ÉOLIENNE
Wind Speed 100 m
CADASTRE SOLAIRE
Cadastre solaire
Couches
Légende
Voir site

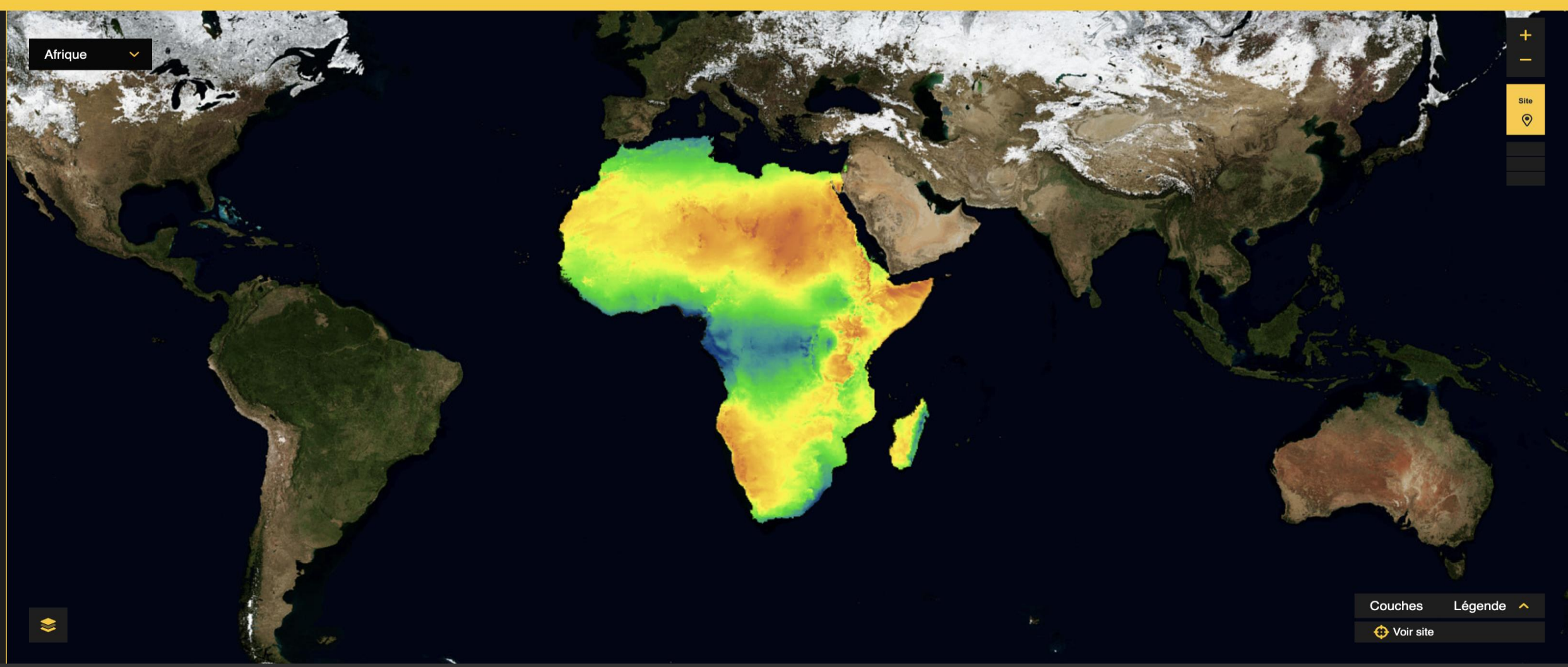
GEPMapping

E-mail
contact@greenenergypark.ma

Téléphone
+212 (0) 537 68 22 36

CONTACT

ACCUEIL CARTES À PROPOS FAQ



TERMES ET CONDITIONS

SESA

Additional References

- Solar Cadastre developped by Green Energy Park : http://gepmapping.ma
- Photovoltaics report : https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

THANK YOU

sesa-euafrica.eu/
toolbox.sesa-euafrica.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No. 101037141. This material reflect only the views of the Consortium, and the EC cannot be held responsible for any use that may be made of the information in it.