Standards for PV Monitoring

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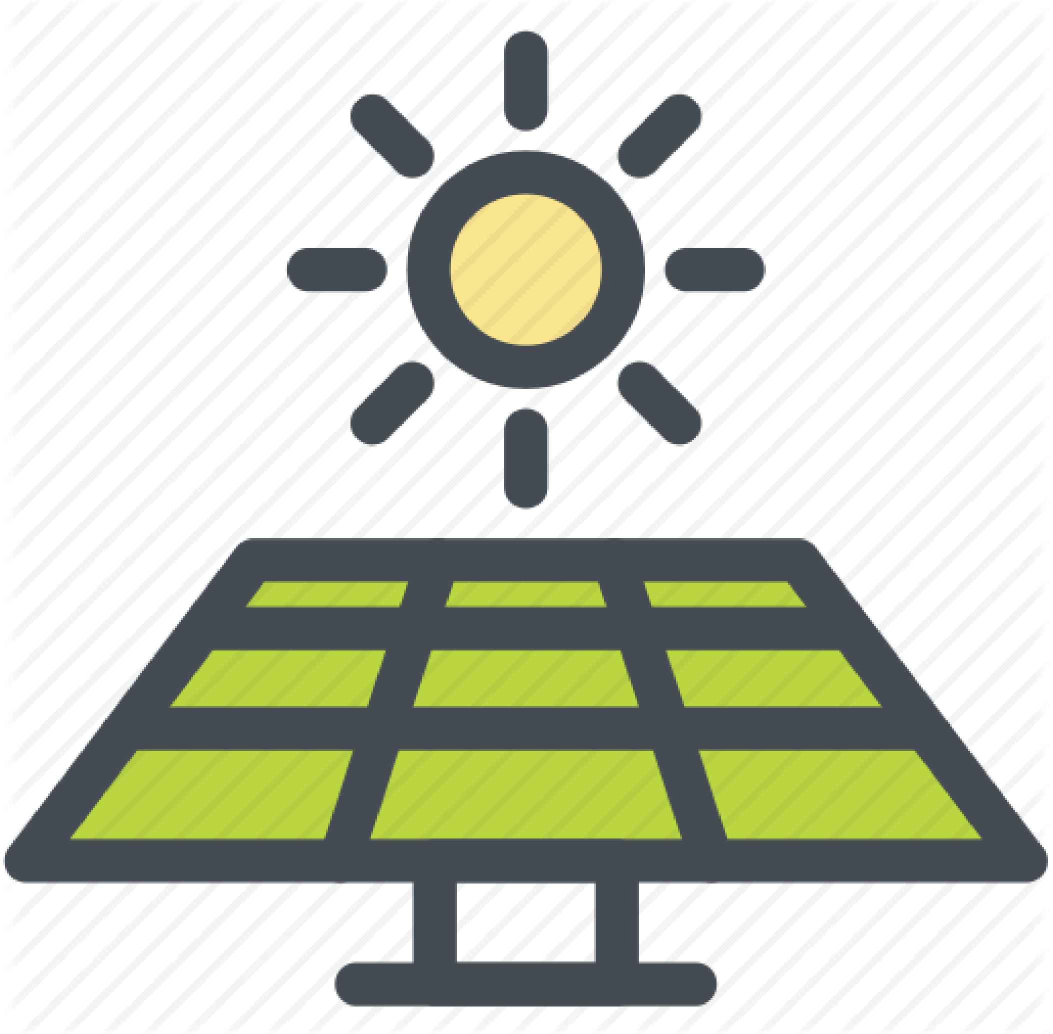
Purpose of this talk

1. What are standards and what do they do?
2. Who issues standards?
3. What advantages do standards offer Suntrace and technical developers?
4. How and where to find standards

Overview

5. IEC 61724-1 and ISO 9060:2018
6. What to note as a technical developer when using standards for solar on-site measurement stations
7. Example of using the standard

Specifics

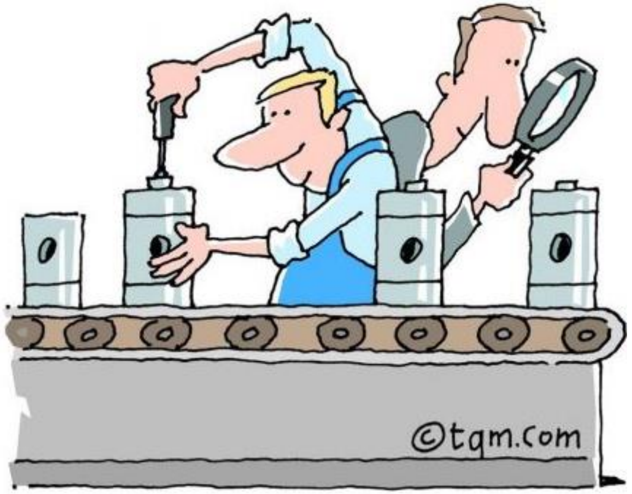


Standards and their Purpose

Standard: a technical document designed to be used as a rule, guideline or definition

1. Conformity in requirements
2. Reduce costs and delays
3. Safety

Standard



Regulation

Guarantee

Agencies Involved in Implementing Solar Standards

- The International Electrotechnical Commission (IEC) develops and publishes consensus-based international standards for electrotechnology
  - 95 Technical Committees (TCs) and 80 Subcommittees (SCs)
    - TC 82 “Solar photovoltaic energy systems” is responsible for writing all IEC standards in photovoltaics (early 1980’s)
    - Includes more than 60 countries
- The International Organization for Standardization (ISO) constitutes varies standards bodies
  - More than 160 countries
  - Successor to the International Federation of the National Standardizing Associations (ISA)
  - More than 22,000 standards

IEC International Electrotechnical Commission

Why are these Standards Important to Suntrace?

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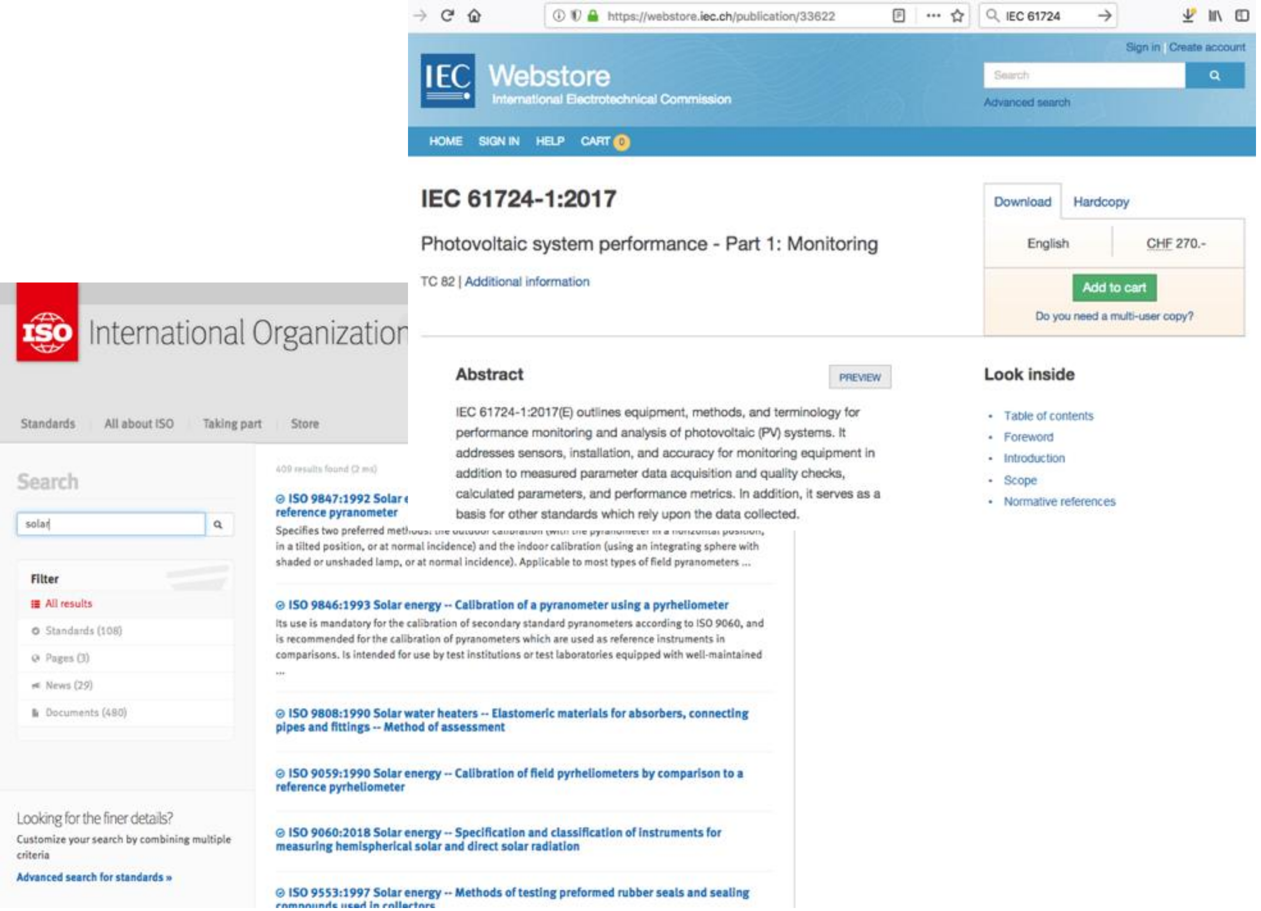
1. Provide assurance of quality for customers
2. Improve reputation
3. Direct comparison with competitors
4. Analyze new technologies that come to market
5. Access markets across the globe
6. Increase efficiency of work by providing guidelines
7. Increase safety and ease of transfer of knowledge

Happy customers = Good Reputation = More Sales

Standards Relating to On-Site Measurements

- Easy to search for standards related to solar: https://webstore.iec.ch/searchform&q= and https://www.iso.org/search.html
- Over 100 standards in each related to solar energy
- Some examples:
  - IEC 61683:1999
  - IEC 62446-1 (Edition 2018-08 revised from 2016)
  - ISO 9901:1990 (to be replaced)
  - IEC 61724-1 (2017)
  - ISO 9060:2018 (revised from 1990)



Standard of Focus: Changes in IEC 61724

- Three part revision to IEC 61724:1998 in 2017
  - Part 1: PV System Monitoring
  - Part 2 and Part 3: Performance analysis based on the monitoring data (not covered in this presentation)
- Three precision classes of irradiance monitoring
  - Device requirements and maintenance
- Soiling
- Satellite-based irradiance (not covered in this presentation)
- Power efficiency, clipping and curtailment (not covered in this presentation)

Sensor Requirements

- Table 5 – Sensor choices and requirements for in-plane and global irradiance

Sensor type	Class A High Accuracy	Class B Medium Accuracy	Class C Basic Accuracy
Thermopile pyranometer	Secondary standard per ISO 9060 or High quality per WMO Guide No. 8 (Uncertainty ≤ 3% for hourly totals)	First class per ISO 9060 or Good quality per WMO Guide No. 8 (Uncertainty ≤ 8% for hourly totals)	Any
PV reference device	Uncertainty ≤ 3% From 100 W m^-2 to 1500 W m^-2	Uncertainty ≤ 8% From 100 W m^-2 to 1500 W m^-2	Any
Photodiode sensors	Not applicable	Not applicable	Any

Source: (IEC 61724-1, 2017)

Basically non-existent

Detailed Table of Additional Maintenence Requirements

- Table 7 – Irradiance sensor maintenance requirements

Item	Class A High Accuracy	Class B Medium Accuracy	Class C Basic Accuracy
Recalibration	Once a year	Once every 2 years	As per manufacturer’s requirements
Cleaning	At least once per week	Optional	
Heating to prevent accumulation of condensation and/or frozen precipitation	Required in locations where condensation and/or frozen precipitation would affect measurements on more than 7 days per year	Required in locations where condensation and/or frozen precipitation would affect measurements on more than 14 days per year	
Ventilation (for thermopile pyranometers)	Required	Optional	
Desiccant inspection and replacement (for thermopile pyranometers	As per manufacturer’s requirements	As per manufacturer’s requirements	As per manufacturer’s requirements

Source: (IEC 61724-1, 2017)

Sensor Options Price and Class Comparison

Hukseflux SR30

Hukseflux SR20

Sensor Name	Price (€)	Class A High Accuracy	Class B Medium Accuracy
Hukseflux SR30	2799	X	
Hukseflux SR20	2599		X
Hukseflux SR20 + Ventilation*	3399	X	
EKO MS-80	2499		X
EKO MS-80 + Ventilation*	3399	X	
Kipp&Zonnen SMP10	2599		X
Kipp&Zonnen SMP10 + Ventilation*	3969	X	

EKO MS-80

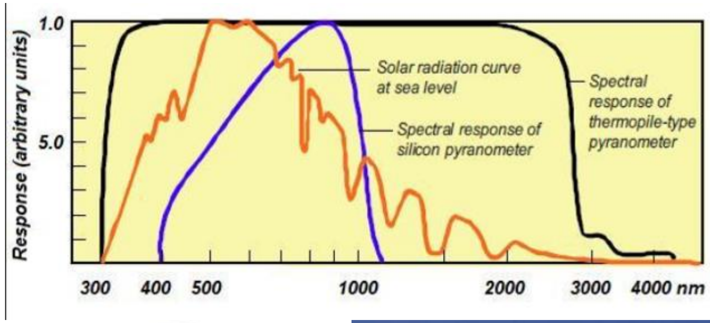
Kipp&Zonnen SMP10

ISO 9060:2018 Radiometer classification

- Change to more logical class names for newcomers

Old Name	New Name
Secondary Standard	Class A
First Class	Class B
Second Class	Class C

- Separation between fast response (photodiodes, RSI) and spectrally flat (thermopile pyranometers)
- Includes Si-pyranometers, fast thermopiles with diffusors, and any technology that reaches the limits from the classification
    - Classification of diffusometers (including RSIs and shadow patterns)
- Correction functions
- Distinctions between spectral error and spectral selectivity
- Include temperature and directional response test reports for Class A instruments



What does an On-Site Technical Developer Need to Know from these Standards (just a few things)?

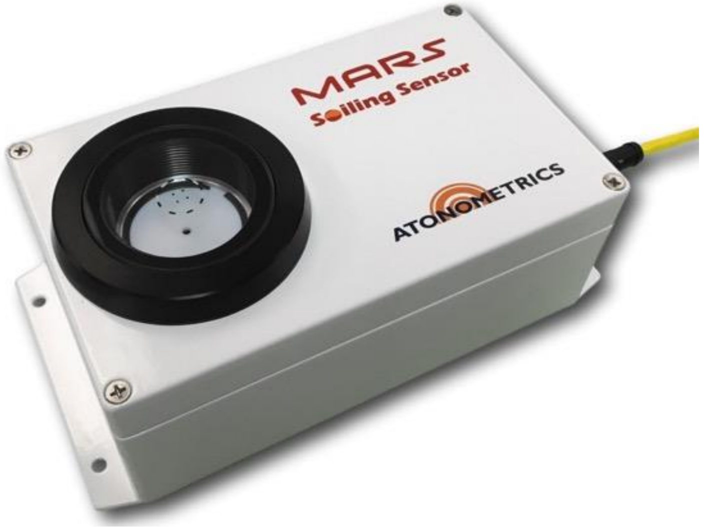
- Class A requires almost all measures of irradiance (except circumsolar ratio), environmental factors (except snow and humidity), tracker system (for CPV <20x concentration), and electrical output to be taken directly at site
- Class B is similar to Class A, but all irradiance and environmental factor measurements may be estimated (E) based on local or regional meteorological or satellite data
- Class C requires only measurements of POA (or E), ambient air temperature (E), output power, and output energy

In general, Class A will always be the most accurate but the most costly
Refer to tables in Wiki for reference

- Soiling methods
- Number of sensors based on system size

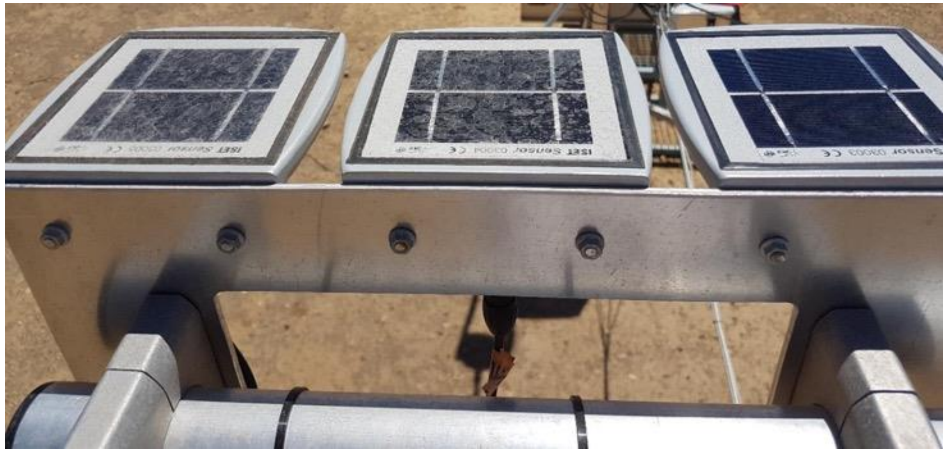
Soiling Measurement Methods

1. Measure the short-circuit current and temperature of the clean and soiled devices to calculate irradiance (we measure the effective irradiance directly instead of the short-circuit current and temperature)
2. Calculate the expected max power of the soiled device at the irradiance determined and the temperature measured using the calibration values
3. Calculate the soiling ratio SR by dividing the soiled device max power measured by its expected



Atonometrics - Mars Optical Soiling Sensor

Kipp&Zonnen - DustIQ



HelioScale - Soiling Assembly

Number of Sensors Depending on Size of System

- Table 4 – Relation between system size (AC) and number of sensors for specific sensors referenced in Table 3

System size (AC)	Number of sensors per parameter	
	Column 1	Column 2 (Module Temperature)
< 5 MW	1	6
≥ 5 MW to < 40 MW	2	12
≥ 40 MW to < 100 MW	3	18
≥ 100 MW to < 200 MW	4	24
≥ 200 MW to < 300 MW	5	30
≥ 300 MW to < 500 MW	6	36
≥ 500 MW to < 750 MW	7	42
≥ 750 MW	8	48

Source: (IEC 61724-1, 2017)

Example Comparison between 50 MW PV and 50 MW CPV Requirements (Class A)

PV	Shared	CPV (<20x concentration)

• GHI (Uncertainty ≤ 3% for hourly totals)
 	

	• Number of sensors: 3
	• Cleaning: Once per week
	• Recalibration: Once per year
	• Soiling: Use Helioscale soiling assembly
		• DNI (no specific uncertainty)
		  ○ Two axis tracking stage which automatically tracks the sun
		• DHI (no specific uncertainty)
		  ○ Horizontally-mounted irradiance sensor with rotating shadow band or tracked blocking ball
		• Very precise tracker system with limited error for primary, secondary, and tilt angle (single axis tracker)
		  ○ Ideal pointing errror of 0°
		  ○ Width of scan at most ±0.75°
		  ○ IEC 62817:2014
		
		

What would this look like for Class A?

What would this look like for Class A 50 MW PV Plant?

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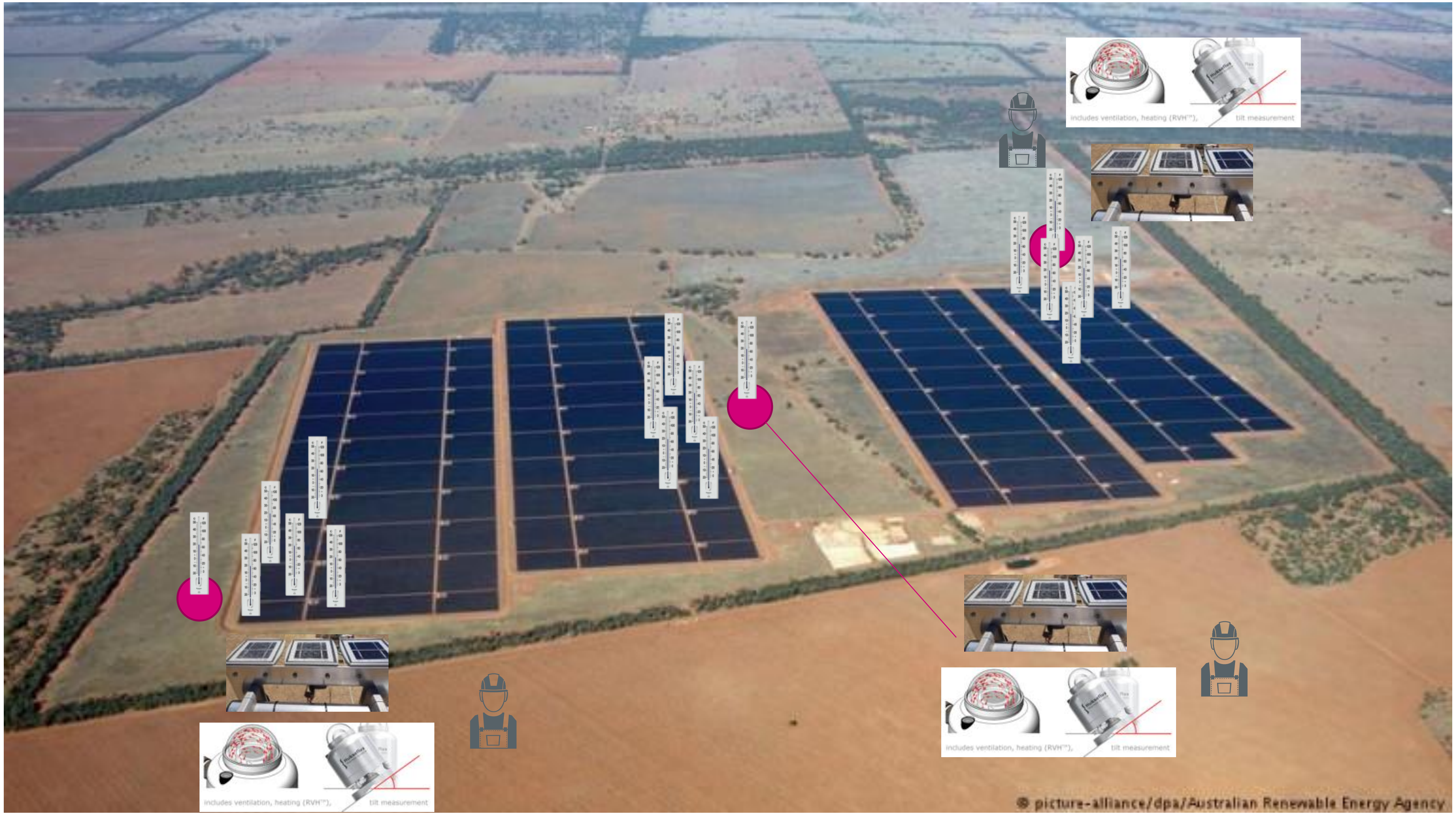
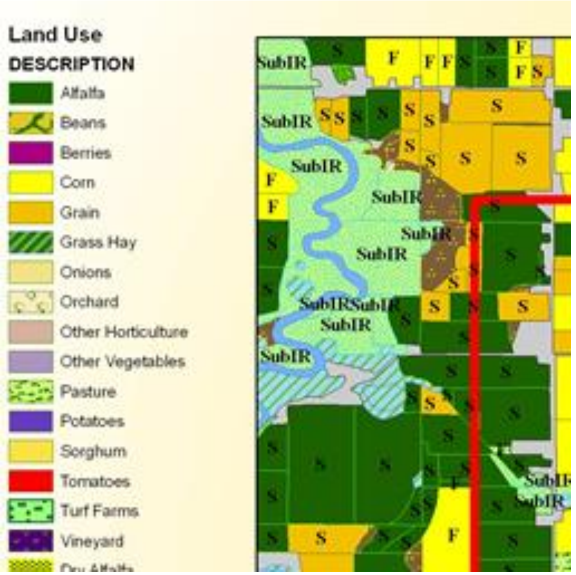
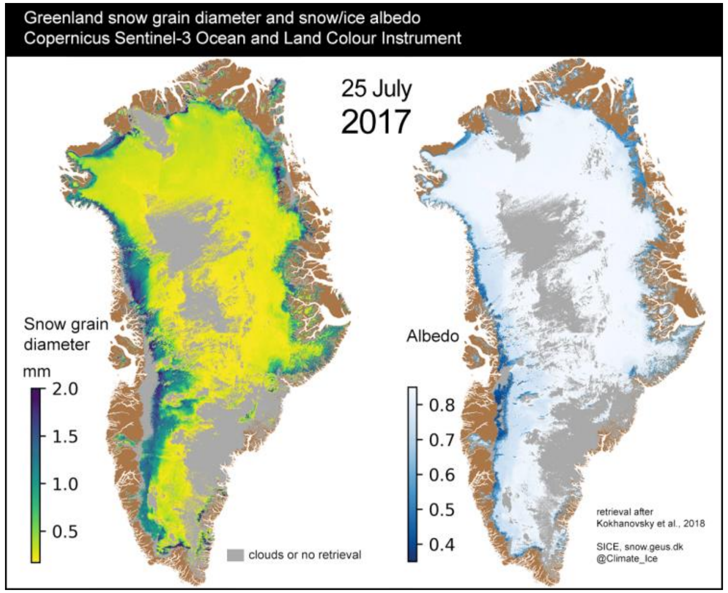


Source: (IEC 61724-1, 2017)

Other Factors for a Site Developer to Consider

- Setting stations in representative locations (including terrain, land use, local climate, local albedo)
- Setting enough stations to cover the variety of weather/physical environment conditions at the site
- Avoid setting sensors in area where shading occurs between sunrise and sunset
- Note that standards are different not only for different kinds of systems but also materials (i.e. crystalline silicon uses IEC 61215 but thin film IEC 61646)





IEC 61724-1 Available on Wiki

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- https://wiki.suntrace.de/wiki/IEC_61724-1
- Provides technical tables and details for reference

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IEC 61724-1

Contents [hide]

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The contents included in this page were taken directly and indirectly from the IEC 61724-1 International Standard for Photovoltaic system performance. Credit is also given to Raul Granados for his contributions.

1. Purpose of these standards [edit | edit source]

We outline the necessary components to assess the overall performance of PV systems, namely for:

- mid to big stand-alone PV systems
- mid to big grid-connected PV systems
- hybrid PV systems, i.e. Diesel-PV systems

Monitoring System classification and suggested applications (Table 1 in IEC 61724) [edit | edit source]

Typical Application	Class A - High Accuracy	Class B - Medium Accuracy	Class C - Basic Accuracy
Basic system performance assessment	x	x	x
Documentation of a performance guarantee	x	x	
System losses analysis	x	x	
Electricity network interaction assessment	x		
Fault localization	x		
PV technology assessment	x		
Precise PV system degradation measurement	x		

Thank you! Any questions?