Update on Edition 2 of IEC 61724: PV System Performance Monitoring

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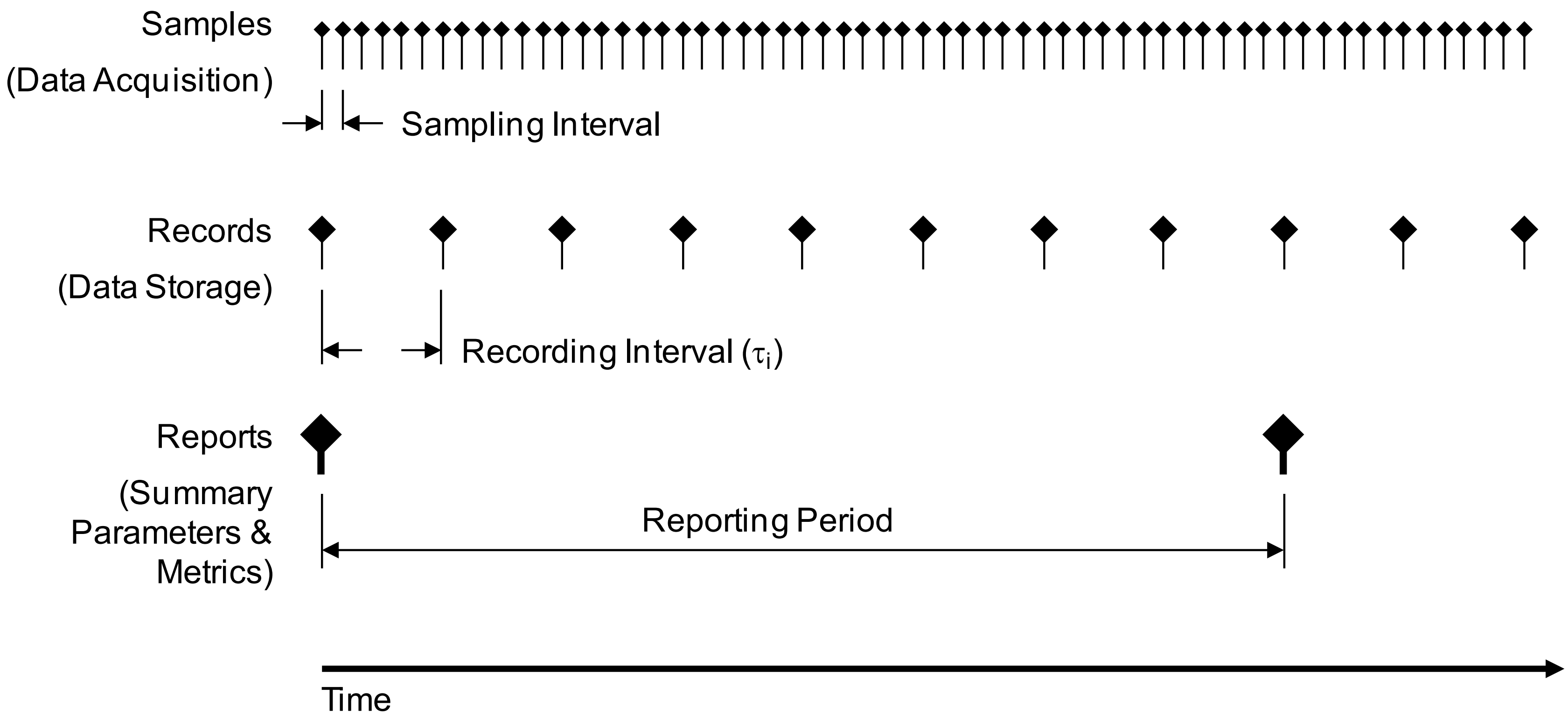
Overview

- Draft of second revision of IEC 61724 is in progress
- Text completely revised and updated from 1st Rev dated 1998
- Monitoring system classification introduced
  - User may select classification (A, B, or C) according to PV project size or monitoring objectives
  - Measurement parameters and sensor requirements to be specified according to monitoring system class
- New measured parameters include additional irradiance values, soiling, and power quality
- Addressing curtailment & clipping
- New metrics include temperature-corrected performance ratios
- Highlights presented here from current draft – not final

Samples, Records, & Reports



Monitoring System Classifications

	Class A	Class B	Class C
Description	Greatest precision	Medium-level precision	Basic precision
Typically targeted PV system size	Utility-scale	Commercial-scale	Residential and small commercial
Suitable applications			
System performance assessment	X	X	X
Documentation of a performance guarantee	X	X	
Forecasting performance	X	X	
Electricity network interaction assessment	X	X	
Monitoring integration of distributed generation, storage, & loads	X	X	
System losses analysis	X		
PV technology assessment	X		
PV system degradation measurement	X		

Measured Parameters

Category	Parameter	Symbol	Units	Required?		
				Class A	Class B	Class C
Irradiance	In-plane irradiance	G_i	W·m^{-2}	√	√	√
	In-plane direct beam irradiance	$G_{i,b}$	W·m^{-2}	for concentrator systems	for concentrator systems	for concentrator systems
	In-plane diffuse irradiance	$G_{i,d}$	W·m^{-2}	for concentrator systems	for concentrator systems	
	Global horizontal irradiance	G_G	W·m^{-2}	√		
	Diffuse horizontal irradiance	G_d	W·m^{-2}			
Environmental Factors	Ambient air temperature	T_{amb}	°C	√	√	√
	PV module temperature	T_{mod}	°C	√	√	
	Soiling ratio	SR		√		
	Wind speed	WS	m·s^{-1}	√	√	
	Wind direction	WD	degrees	√		

Sensor requirements for each classification will be provided in the Standard.

Measured Parameters, Cont'd

Category	Parameter	Symbol	Units	Required?		
				Class A	Class B	Class C
Tracker system	Tracker tilt angle	ϕ_T	Degrees	for tracked systems		
	Tracker azimuth angle	ϕ_A	Degrees	for tracked systems		
PV array output	PV array output voltage (DC)	V_A	V	√		
	PV array output current (DC)	I_A	A	√		
	PV array output power (DC)	P_A	kW	√	√	
Inverter output	Inverter output voltage (AC)	V_{inv}	V	√		
	Inverter output current (AC)	I_{inv}	A	√		
	Inverter output power (AC)	P_{inv}	kVA	√	√	√
	Inverter output power factor	λ_{inv}		√		
System output	Output voltage (AC)	V_{out}	V	√		
	Output current (AC)	I_{out}	A	√		
	Output power (AC)	P_{out}	kVAr	√	√	√
	System power factor			√		

Soiling Ratio

- Soiling ratio SR = ratio of PV array output power to the power that would be obtained if the PV array were clean and free of soiling.
- Setup: Side-by-side comparison of: 1) Routinely cleaned cell or module and 2) Soiled module.
- Methods
    - 1: Normalization of temperature-corrected Pmax of soiled module when compared to clean reference.
    - 2: Normalization of temperature-corrected Isc of soiled module when compared to clean reference.**
    - Equations given in Standard.
- **Method 2 shortcut is suitable for modules that are unaffected by non-uniform shading.
    - But do not hold c-Si modules continuously at Isc.

Calculated Parameters

Parameter	Symbol	Unit
Irradiation		
In-plane irradiation	H_i	kWh·m^{-2}
Electrical energy		
PV array output energy	E_A	kWh
Inverter output energy	E_{inv}	kWh
Energy output from pv system	E_{out}	kWh
Array power rating		
Array power rating (DC)	P_0	kWp
Yields and yield losses		
PV array energy yield	Y_A	kWh·kWp^{-1}
Final system yield	Y_f	kWh·kWp^{-1}
Reference yield	Y_r	kWh·kWp^{-1}
Array capture loss	L_C	kWh· kWp^{-1}
Balance of system (BOS) loss	L_{BOS}	kWh· kWp^{-1}
Efficiencies		
Array efficiency	η_A	None
System efficiency	η_f	None
BOS efficiency	η_{BOS}	None

Traditional Performance Ratio

- Indicates the overall effect of losses on the system output
- Quotient of the system's final yield Y_f to its reference yield Y_r

$$PR = Y_f / Y_r$$

$$= (E_{out} / P_0) / (H_i / G_{i,ref})$$

$$= \left(\sum_k \frac{P_{out,k} \times \tau_k}{P_0}\right) \Big/ \left(\sum_k \frac{G_{i,k} \times \tau_k}{G_{i,ref}}\right)$$

Units = h / h

- Moving P_0 to the denominator sum expresses both numerator and denominator in units of energy:

$$PR = \left(\sum_k P_{out,k} \times \tau_k\right) \Big/ \left(\sum_k \frac{P_0 \times G_{i,k} \times \tau_k}{G_{i,ref}}\right)$$

Units = kW-h / kW-h

- Traditional *PR* neglects array temperature, resulting in seasonal variation when calculated for time periods less than one year

Temperature-Corrected Performance Ratios

- Seasonal variation of the traditional *PR* is removed by calculating a temperature-corrected performance ratio:

$$PR' = \left(\sum_k P_{out,k} \times \tau_k\right) \Bigg/ \left(\sum_k \frac{(C_k \times P_0) \times G_{i,k} \times \tau_k}{G_{i,ref}}\right)$$

$$C_k = 1 + \gamma \times (T_{mod,k} - T_{ref})$$ Temp. correction to power

- Using 25 °C as T_{ref} gives $\boldsymbol{PR'_{STC}}$.
  - Corrects for difference between actual temperature and STC temperature used for power rating.
  - Values of PR'_{STC} are closer to 1 than for traditional *PR*.
- Using irradiance-weighted annual average module temperature for T_{ref} gives $\boldsymbol{PR'_{annual\text{-}eq}}$.
  - Approximates the value that would be obtained for traditional *PR* evaluated over one full year, by compensating for seasonal variation.

Clipping and Curtailment

- Clipping
  - Inverter clipping often considered a loss of the system due to design limitations.
  - But many systems now intentionally designed with high DC/AC ratio for more stable output to grid.
  - For these system types, considering additional performance metric based on system AC power rating instead of DC rating.
- Curtailment
  - Periods of reduced grid/load demand or availability should not count against PV system performance.
  - Standard notes that irradiation and yield sums should be calculated with such periods excluded for purposes of performance assessments and performance guarantees (while still documenting complete sums).

Open Issues / Work in Progress

- Treatment of systems with local loads, storage, or hybrid sources
- Precision requirements for each sensor type
- Dealing with missing data
- Systems with high DC/AC ratio
- Additional performance metrics