



IECRE OPERATIONAL DOCUMENT

**IEC System for Certification to Standards relating to Equipment for use in
Renewable Energy applications (IECRE System)**

PV Plant operational status Assessment



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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IECRE

PV PLANT OPERATIONAL STATUS ASSESSMENT**INTRODUCTION**

In preparation for transfer of an asset, estimation of needed repairs, or to assess the condition of a PV plant for a variety of reasons, it can be useful to inspect the plant and related records to ascertain past performance, current condition, anticipated need for repairs, and anticipated future performance with or without future repairs. A green rating is received when the plant has performed as expected, is in good condition, and expectations are that it will continue to perform to specifications. A yellow rating is received when the plant has underperformed, is in need of minor repairs, and/or concerns are identified that may prevent the plant from performing as expected in the future. A red rating is received when the plant underperformance is excessive, is in need of major repairs, and/or has or is anticipated to have safety issues. Ratings are assigned by category with the overall rating taken as the lowest of the individual ratings. Categories included in the evaluations include:

- Past performance (both energy and capacity tests) alignment with plant specifications
- Maintenance alignment with plant specifications
- Condition of physical plant (based on visual, infrared and electroluminescent imaging)

In addition, the assessment includes historical plant documentation.

1 Scope

This Operational Document defines the requirements for a PV Plant Operational Status Assessment Report that reflects the past performance, current condition and anticipated future performance of a PV plant based on an assessment that includes:

- Prior completion of OD-402 Annual PV Plant Performance Certificate and OD-410 Quality System Requirements for PV Plant Installation and Maintenance,
- Review of maintenance records relative to IEC 62446-2,
- Plant inspection using IEC 62446-1, IEC TS 62446-3, and IEC TS 60904-13 or similar,

In addition, the assessment includes historical plant documentation (such as as-built documentation, historical weather and plant-performance data, and operations and maintenance plan for the future).

The assessment may be applied to any PV plant using Class A, B, or C accuracy, as defined in IEC 61724-1 for the performance assessments. Similarly, the review of maintenance and other records will have expectations aligned with the type of assessment: U1, U2, U3, or U4.¹

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For

¹ U1 indicates "Utility scale", typically > 1 MW peak, U2 indicates "Residential", typically < 25 kW peak, U3 indicates "Commercial", typically < 1 MW, and U4 indicates "Aggregate Residential Systems" as discussed in the Rules of Procedure.

undated references, the latest edition of the referenced document (including any amendments) applies.²

IEC 61724-1 *Photovoltaic system performance – Part 1: Monitoring*

IEC/TS 61724-2 *Photovoltaic system performance – Part 2: Capacity evaluation method*

IEC 62446-1 *Grid connected photovoltaic (PV) systems – Part 1: Minimum requirements for system documentation, commissioning tests and inspection*

IEC/TS 62446-2 *Grid connected photovoltaic (PV) systems – Part 2: Maintenance of PV systems*

IEC/TS 63049 *Guideline for increased confidence in PV system installation*

IECRE 01 *System Basic Rules*

IECRE 02 *System Rules of Procedure*

IECRE 04 *PV-OMC Rules of Procedure*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the International Electrotechnical Commission Glossary (<http://std.iec.ch/glossary>) and the following apply.

3.1 Certification body (RECB)

organization that conducts conformity assessments and issues Certificate of Conformity (CoC) to PV plants. See 2.5 of ISO 17000.

3.2 Inspection Body (REIB)

Organization that performs inspection of PV power plants.

4 General Provisions

The normative ISO/IEC references define the general program requirements for RECB and REIB operating under the PV program.

Additional requirements for RECBs and REIBs operating the PV program are described in IECRE 01, IECRE 02, and IECRE 04 *PV OMC Rules of Procedure*.

5 Documentation of Past Performance

Performance of the PV plant is documented using OD-402 with a high-level summary documented as described in Annex A, Table A2. Taken together, Tables A2 and A3 provide the big picture of whether the plant has performed as predicted and how similar predictions extend into the future. Predictions usually include some degradation each year, which should be easily derived from Table A3. The predictions in Tables A2 and A3 may not exactly align if the start and end dates of each year of operation differ.

Measured performance less than the predicted performance may be caused either by a problem with the plant or by the weather being less sunny than the historical data. The assessment should include an attempt to differentiate these causes. If the historical weather data are found to differ from what is being measured, it may be appropriate to modify all of the predictions accordingly, reflecting the new values in both Table A2 and Table A3, with a note explaining why the predictions have been changed relative to the original predictions. The goal of the tables is to provide a quick assessment of how much electricity is anticipated in future years based on the predictions combined with past experience.

² At the time of publication of this OD these standards have not yet been published by the IEC. Please refer to the IECRE website for relevant OMC guidance document.

Because of the importance of understanding the measured performance relative to the expected performance of the PV plant in order to ascertain its condition, the full report(s) from single or multiple applications of OD-402 shall be included in the Test Report, if available. At a minimum, a report shall be included that reflects application of OD-402 for a period of time ending within 12 months of the issuance of the Test Report.

NOTE: When performance has been low, the process of identifying all of the causes can be quite complex. Understanding, for example, whether soiling or curtailment is a key cause of reduced output might be very useful. This type of diagnostic work is beyond the scope of this assessment at this time.

6 Review of executed maintenance

Data for evaluation of executed maintenance shall be collected by the REIB.

The purpose of the review of executed maintenance is to determine whether the plant has experienced an unexpectedly high level of failures and whether needed preventative maintenance has been neglected that could lead to problems.

All site maintenance in the vicinity of the array – that could affect the array - (e.g. mowing of areas adjacent to the plant, or roof maintenance next to a rooftop system) should be included even if it does not directly pertain to the plant itself.

6.1 Review of maintenance schedule

Using IEC 62446-2 as a guide³ the PV plant's maintenance plan is reviewed. IEC 62446-2 Annex B provides an example of the expected maintenance schedule. Changes to the maintenance schedule are anticipated as part of an on-going quality assurance program as described in IEC 63049.

Deficiencies in the plant's written plan are tabulated as shown in Table A4. If no written maintenance plan is available for the plant, Table C1 of IEC 62446-2 should be used to create a plan that is appropriate for the plant being studied and all items noted in Table A4 as deficiencies in the original plan.

6.2 Comparison of maintenance log and maintenance schedule

The maintenance schedule and maintenance log are compared to identify discrepancies and opportunities for improvement. Each item is recorded in Table A5 and rated according to whether it presents an opportunity, is a minor problem, or reflects a potentially severe problem. A "minor" rating indicates something that is unlikely to cause or be related to a later problem with the plant. A "severe" rating suggests the possibility that a safety risk could occur or that maintenance costs are likely to exceed the planned maintenance.

An example of an opportunity for improvement is if the maintenance schedule calls for more frequent cleaning than appears to be necessary.

An example of a minor problem is finding that someone was storing something under the array, but the item has now been removed or that a planned maintenance item was not completed on schedule, but that the omission of completing the task led to no problems.

An example of a severe problem is frequent unplanned inverter repairs, significant gaps in the site irradiance data, significant error from other relevant sensors, or absence of calibration for a sensor.

In particular, Table A5 should include:

- Items that were replaced after commissioning was completed, when the replacements were unplanned,
- Serial defects leading to an upgrade, replacement or repair,
- Planned maintenance that apparently was not completed

³ Under preparation. Stage at time of publication: IEC/CD 62446-2:2017

6.3 Comparison of planned and actual maintenance costs

The planned costs for the maintenance by year (for the expected life of the plant) shall be tabulated in Table A6. If no written documentation is available for the plant, a plan may be created based on commonly observed values for similar PV plants with indication that this is a new plan. The actual costs shall also be tabulated in the same table for the life of the plant and a rating ascribed for each year of performance. If cost data have not been recorded for all years, the rating should be indicated as red for those years.

6.4 Quality Control system of PV Plant maintenance

The quality of maintenance work shall be assessed as described in IEC TS63049 or equivalent. Quality assessment report as defined in pv-omc OD408-3 or equivalent shall be checked and confirmed.

7 Plant inspection

This inspection shall be performed by the REIB.

The purpose of the plant inspection is to identify deficiencies in the physical condition of the plant including early indications of later problems. To ensure that the results reflect the current status of the system, the physical inspection shall be completed within three months of the issuance of the OD-404 assessment completion date. Preferably, the inspection should be as recent as possible, especially if any event (such as a hail storm) could have caused physical damage.

The plant inspection may depend on the type of plant. Table 1 provides guidance. It is suggested that inspections are carried out post maintenance activities such as vegetation control and panel washing. This offers the best possibility of observing potential subtle deficiencies that might otherwise be masked by soiling or shading.

Table 1. Inspection expectations according to project type

Project Type	U1 – Utility	U2 – Residential	U3 – Commercial	U4 – Distributed
IEC 62446-1 Category	1&2	1	1&2	1&2
Infrared inspection	Entire plant required	Recommended	Entire plant recommended	Entire fleet recommended
EL inspection	At least 25% or 400 modules, whichever is smaller	Recommended	At least 25% or 200 modules, whichever is smaller	At least 25% or 200 modules, whichever is smaller

7.1 Visual inspection and electrical testing

Inspection of the plant shall be completed as described in Clause 5 of IEC 62446-1, as per clause 9.3 description of periodic inspections. A full report is completed as described in IEC 62446-1.

A summary of deficiencies identified during the IEC 62446-1 inspection are summarized in Table A7.

7.2 Infrared inspection

Infrared imaging of the plant shall be completed as described in IEC TS 62446-3. Imaging is completed as indicated in Table 1. A full report is completed as described in IEC TS 62446-3 Clause 8.

A summary of deficiencies identified during the IEC TS 62446-3 inspection are tabulated in Table A7.

7.3 Electroluminescent (EL) inspection

Inspection of the plant shall include EL imaging as indicated in Table 1. IEC TS 60904-13 should be used as a guide for collecting and evaluating the EL images. Indoor imaging (as treated in IEC TS 60904-13) or outdoor imaging using the concepts in IEC TS 60904-13 may be applied. The sample set may be selected randomly throughout the plant or may target a part of the plant that may be expected to have issues based on the IEC 62446-1 or IEC TS 62446-3 inspection and/or other observations such as low performance for one part of the plant or localized hail.

If the collected EL images suggest issues with the modules, additional modules may be selected for imaging.

The EL imaging results shall be summarized in full as described in IEC TS 60904-13 clause 6. Deficiencies shall be summarised in Table A8 along with the other deficiencies.

7.4 Diagnostic inspections

When deficiencies are noted, understanding the origins of these can be useful, but can also require substantial effort. Thus, diagnostic inspections are optional. Recommendations are provided in Annex B.

8 Historical documentation

Historical documentation for the plant shall be included as a part of the assessment. Any missing documents shall be noted as deficiencies in Table A8. The required documents and other details are tabulated in Table 2.

The alert history should include all safety related alerts as well as warnings of significant outages being anticipated or observed.

Table 2. Historical documentation requirements by category

Project Type	U1 – Utility	U2 – Residential	U3 – Commercial	U4 – Distributed
IEC 61724-1 Accuracy Class for performance measurements	A	C	B	B
Documents				
1. As-built drawings (confirmed to be accurate during the IEC 62446-1 inspection)	X	X	X	X
2. Supporting documents (interconnection agreement, warranty documents, site control.)	X	X	X	X
3. Weather and production data as described in IEC 61724-2 and IEC 61724-3, including summary reports from OD-402	X	X	X	Optional

4. Full description of performance model including inputs and assumptions (maybe a simple performance ratio depending on the accuracy class); should include soiling assumptions.	X	X	X	Optional
5. Planned maintenance schedule (including both operations and maintenance planned events)	X	X	X	X
6. Maintenance log (including repairs)	X	Optional	X	Optional
7. Alert history	X	Optional	Optional	Optional
8. Other SCADA data	Optional	Optional	Optional	Optional
9. Available APIs	Optional	Optional	Optional	Optional
10. Existing O&M contracts	X	Optional	Optional	Optional
11. Spares list	X	Optional	X	X
12. Source list for all array components	X	Optional	Optional	Optional
13. Obsolescence plan in case replacement components are not available	X	Optional	Optional	Optional
14. Decommissioning plans	Optional	Optional	Optional	Optional

9 Test report

This evaluation shall be performed by the RECB based in the report of the REIB.

The final test report will include the following using the template and the standardized format in Annex A in this document or IECRE’s standard template?.

- 1) Description of the party reviewing the design
- 2) Description of the selected site, including latitude, longitude, and altitude (see Annex A)
- 3) Description of the plant design including DC and AC power ratings, module model and manufacturer, inverter model and manufacturer, tilt and azimuth (See Annex A)
- 4) Additional information, as relevant, including racking type, utility, interconnection voltage, COD and assumed degradation rate (See Annex A).
- 5) Completed summary tables A1 through A8 (See Annex A).
- 6) Documents tabulated in Table 1.
- 7) A list of any irregularities observed

Annex A: Template for PV Plant Assessment Report

<p>PV Plant Assessment Report Report Type: _____ *</p>

***(U1, U2, U3, or U4, as in the Rules of Procedure)**

Client	
Installation Address	
Latitude	
Longitude	
Altitude	
Design review date	
Contractor names and addresses	

Plant Description (brief)	
Rated power – kW DC	
Rated power – kW AC	
Location	
Module type & model	
Inverter type & model	
Tilt	
Azimuth	
Racking Type	
Utility	
Interconnection voltage	
COD	
Assumed Annual Degradation Rate	

I / we being the person(s) responsible for the issuance of the PV Plant Assessment Report for the electrical installation (as indicated by the signature(s) below), particulars of which are described above, having exercised reasonable skill and care when carrying out the assessment, hereby certify that the said work for which I/we have been responsible is, to the best of my/our knowledge and belief, in accordance with

<p>Signature(s):</p> <p>Name(s):</p> <p>Date</p> <p>(The extent of liability of the signatory(s) is limited to the work described above)</p>	<p>COMMENTS:</p>
--	--

Table A1. Summary of Assessment

Category	Rating (Green, Yellow, Red)	Rationale for rating
Overall		
Past performance		
Maintenance		
Plant inspection		

Table A2. Past performance assessment and rating

Year (start-to-end dates)	Predicted* performance	Expected* performance	Measured performance	Ratio Measured/ Predicted (Baseline Performance Index)	Rating**	Comments***
	MWh/y	MWh/y	MWh/y	%		
[include line for each year after installation]	MWh/y	MWh/y	MWh/y	%		

*Predicted performance shall be calculated using same model and historical weather data used for Table A3. If the design of the plant changed from year to year, the model should be adjusted accordingly with documentation of that.

** Rating is assigned from the Ratio in the fourth column: Green > 100%; Yellow > 95%; Red < 95%.

*** The comment should note whether a low rating is because of poor plant performance, because the insolation was less than the historical data predicted, or because of both. If the cause was poor plant performance, the comments should indicate whether the poor performance could be addressed by plant maintenance. If the cause of the low performance was found to be low insolation, the comment should reflect whether the historical data may overestimate the weather systematically, or whether there is evidence that the given year was anomalous.

Table A3. Predicted plant performance

Year (start-to-end dates)	Predicted performance*	Comment
	MWh/y	
[include line for each year of expected life]		

*Predicted performance shall be calculated using same model and historical weather data used for Table A2. If the design of the plant changed from year to year, the model should be adjusted accordingly with documentation of that in the Comment column.

Table A4. Deficiencies in Preventative Maintenance Schedule

Component/Task*	Maintenance Interval	Description of deficiency**

* Tasks are listed in table only if a deficiency is identified

** The deficiency may be that a necessary maintenance item was omitted from the plan or that the indicated interval is inappropriate

Table A5. Deviations of Logged Maintenance from Planned Maintenance Including Observations of Opportunities for Improvement

Task	Description of deviation or opportunity	Rating (opportunity, minor or severe)*

* As described in 6.2

Table A6. Past and Planned Plant Maintenance Costs

Year (start-to-end dates)	Planned maintenance cost*	Actual maintenance cost**	Ratio Measured/ Predicted	Rating***	Comments
	cost/y	cost/y	%		
[include line for each year after installation and extend to life of plant]	cost/y	cost/y	%		

*The basis for the planned maintenance cost should be included in the plant documentation.

** The actual maintenance costs for each year should be calculated using the same basis as the values in the planned column.

*** The rating should be green if the ratio is < 100%, yellow if between 100% and 120% and red if > 120%.

Table A7. Deficiencies in Plant Condition

Item	Description of deficiency	Rating*

*Yellow for minor concerns; red for severe concerns, as described in 6.2.

Table A8. Deficiencies in Historical Documentation

Item	Description of deficiency	Rating*

*Yellow for minor concerns; red for severe concerns, as described in 6.2.

Annex B: Examples of diagnostics (informative)

B.1 Diagnostic actions can vary depending on the observations. Table B1 describes some common observations, diagnostic actions to take and severity associated with these various actions.

Table B1. Examples of diagnostics that may be applied

Observed deficiency	Recommended action	Severity	Comment
Low performance			
IR image indicates string not operating	Check fuse; check connections within string		

[Others may be added to this table]

**INTERNATIONAL
ELECTROTECHNICAL
COMMISSION**

3, rue de Varembe
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
info@iec.ch
www.iec.ch

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3, rue de Varembe
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
secretariat@iecre.org
www.iecre.org