Thermography Inspection of PV Module-Gut 104 and 105" – Location- Dhamangaon, Dist.: Amravati

OBJECTIVE

- Solar panel inspection using AI-powered surveillance drones provides you quick and cost-efficient early detection of potential power degradation and safety hazards to minimize operational risk and protect the value of your assets. Our experts prepare independent third-party documentation to support you with any claims you may have.

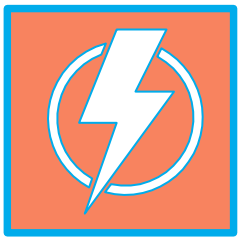
- We also provide an online platform on which to store digital data files for easy and instant access. Our inspection services help you reduce operational and maintenance costs by allowing targeted and more efficient ground inspections e.g. for Technical Due Diligence focusing on the findings.

- We provide you digital data and automated anomaly reporting with statistical clustering to allow for easy comparison and sensible optimization. We help you focus on the major issues to save you time and money. Regular inspections allow for progress monitoring and effectiveness of corrective actions assessments.

OBJECTIVE OF IR INSPECTION

- The primary objective of this IR/Thermal inspection is to find critical hotspots (high temperature zones) which indicate specific types of defects of various components of a Solar PV Module, the cause of such types of defects and to provide suitable corrective action to avoid further damage & ensure normal functioning of modules

SCOPE OF INSPECTION & METHODOLOGY



SCOPE

The scope of this project entails a non-contact infrared thermal inspection performed with the thermal sensor mounted on a UAV inspect thermal & visible anomalies on solar PV panels.

METHODOLOGY

This power plant was divided into Multiple geographical blocks and each block is converted as a part of report.

DATA COLLECTION

The Block was covered in multiple flights using FLIR Vue Pro thermal sensor mounted on a UAV – the flight path was optimized to enable the creation of thermal Ortho mosaic layer. The data collection process is explained in the following steps:

- The flight mission was designed for the specific layouts using compatible map files that contain the plants GPS boundaries.
- Image resolution & overlapped were specific at the time of mission planning. 4.2cm Pixels is the GSD resolution. The degree of overlap between consecutive images is specified using frontal overlap & side overlap parameters. The values of these parameters are 90% & 90% respectively for thermal.
- Upon reaching the site, the visual & thermal drone were assembled and the connected to the smartphone via the link app.
- Upon the receiving the confirmation that the environmental conditions were within satisfactory levels the scan was carried out. Some key parameters that were considered were irradiance, wind speed, cloud cover and tome of the day. The parameters thresholds were considered as the prescribed by the IEC TS62446.
- The UAV then embarked on a near autonomous flight with minimal inputs from the pilots.

FAULT CATEGORY

Fault category will help you decide your next actions steps based on severity and impact of findings.

REMEDIATION RECOMMENDED FAULTS

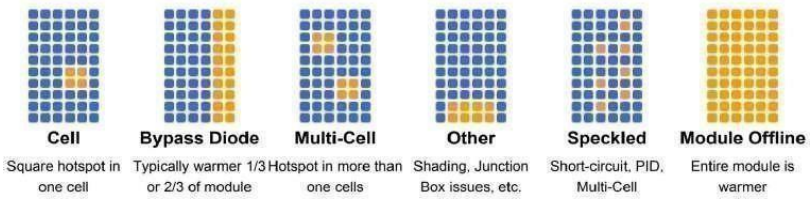
Modules with a high probability of causing system energy loss. The choice to remediate modules depends on anomaly density, replacement costs and replacement availability.

MONITOR & REMEDIATE FAULTS

Modules that pose a significant known energy loss or potential safety hazard on the site which require prioritized attention to recover energy loss and improve site safety

LONG-TERM MONITORING FAULTS

These modules have a low probability of causing extensive energy loss. Theses anomalies are unlikely to require remediation immediately but tracking the progression of anomalies over time is recommended.

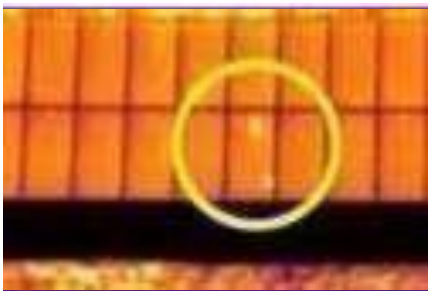


EXAMPLE OF ANOMALIES

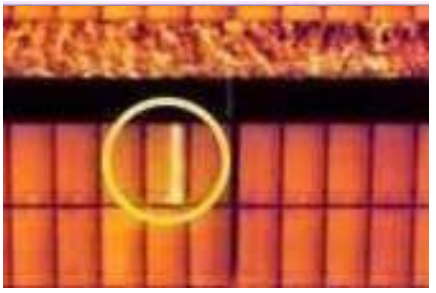
Below are visual examples of anomalies

Cell Hotspot

Multi Cell Hotspot

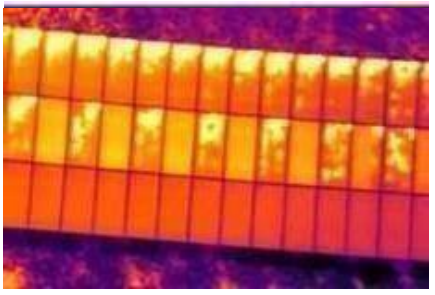


Bypass Diode

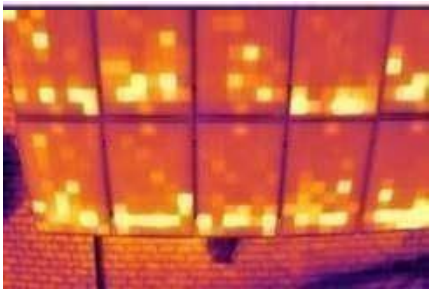


Power Mismatch

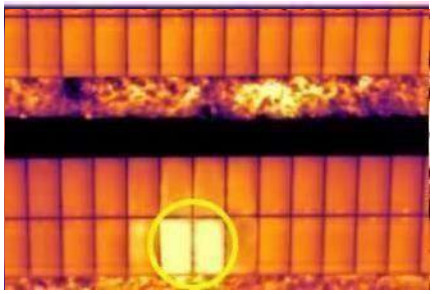
Speckled



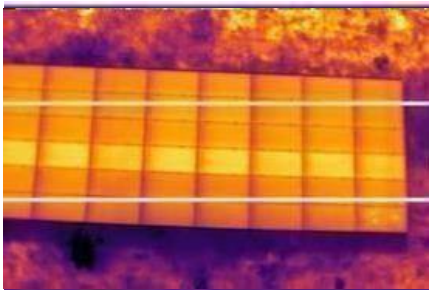
PID



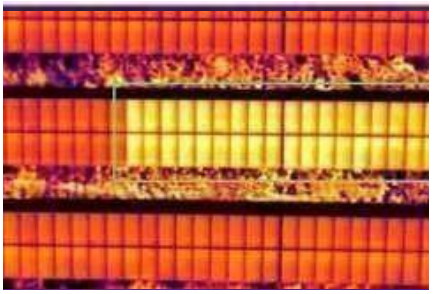
Module Offline



Partial String Offline



String Offline



CLARIFICATION OF SEVERITY RATING

• Efforts were made for the client to provide a comparative rating of the severity of the defects. The range of the scale indicates influence to performance and/or reliability, and given is from **1 (low severity) to 5 (high severity).**

• A range is provided when the severity of a defect can vary, for example with the size of the affected area. An additional annotation is given if the defect poses a potential safety risk to the installer or the end user.

SEVERITY CRITERIA

- **Severity 1**- The defect is an indicator of poor quality with no direct effect on performance or reliability.
- **Severity 2-** The defect has a minor impact on performance and/or reliability.
- **Severity 3-** The defect has a moderate impact on performance and/or reliability.
- **Severity 4**- The defect has a high impact on performance and/or reliability.
- **Severity 5**- The defect is indicative of a major quality issue, a critical failure, or a counterfeit panel.

SEVERITY 5- CRITICAL

SEVERITY 4- MAJOR

SEVERITY 3- MODERATE

SEVERITY 2- MINOR

DEFECT DESCRIPTION

RECOMMENDEDACTION FOR EACH DEFECT TYPE

TYPES OF ABNORMALITY	DESCRIPTION	ACTION REQUIRED
Dirt/Vegetation	Assessable by thermal pattern, visual image, and classified Typically, as an extended area abnormality.	Normal Dirt or vegetation e.g. dust or bird droppings on modules will be washed away by rain. However, Cleaning of PV modules is highly recommended in near future to avoid damage to PV module
Cell Failure Cell Chipping and De-Lamination	Difference in temperature increases with load, cell efficiency, and the number of cells in a substring	A personal review by a PV expert or thermograph level 2 or equivalent is recommended. Check that there is no shading or severe soiling.
ByPass Diode Failure	Temperature difference increases with load caused by increased contact resistance within the junction box. Alternatively, it could be caused by low resistive bypass diodes that carry a significant current although they should be biased in the reverse direction.	May have burned a spot at the module. Hence, a personal Review by a PV expert or thermography level 2 or equivalent is recommended. Be aware of high voltages.
Short Circuit	At one or more substrings, easily mistaken for cell breakage or cell defects, Potential induced degradation (PID) or mismatch. (or failure of a bypass diode)	Check module and bypass diodes for proper function under reverse biasing.

Multi Cell Hotspot	Similar pattern as Modules in short circuit, with PID, cell defects. Some time just single broken cells are heated.	Check module wiring and cabling. (Check isolation resistance) Beware of high voltage as isolation resistance is lost and found broken,

Open Circuit	Part of the module surface is homogeneously heated up and heat dissipation by the Bypass diode, which is operating, is visible. The temperature difference of the glass on top of the junction box containing the operating bypass diode differs with construction (Or failure of bypass diode). Loss of contact at a cell connection might lead to a serial arc visible on the module's backside surface.	Check the wiring and cabling in module junction box and/or cell connectors.

DEFECT DESCRPITION

CLASS OF ABNORMALITY (COA)	1 NO ABNORMALITY (OK)	2 (THERMAL ABNORMALITY)	3 (SAFETY RELEVANT THERMAL ABNORMALITY – DTA)
Recommendation for actions	No imminent action	Checking the cause and, if necessary, rectification in a reasonable period.	Prompt interruption of operation, checking the cause and rectification in a reasonable period.

EQUIPMENT & PAYLOAD REQUIREMENTS

IMAGE RESOLUTION	FRAME RATE	RADIOMETRY CAPABILITY	FLIGHTSPEED	FOCAL LENGTHOF LENS	ANGLE OF VIEW
Less than 640*512 Pixels	30Hz (Recommended	YES	2 m/s	13 or 19 mm	Nadir-90Deg (Min30 Deg)

EQUIPMENT TYPE

UAV/DRONE TYPE	CONTROLLER USED	CAMERA TYPE
Thermal Drone	Smart Controller	Uncooled VOx Microbolometer

ACQUISITION DETAILS

Acquisition Date	29/01/2025
Area Covered	18 Acres
Wind Speed	3 m/s-5 m/s
Weather	Sunny

RESULTS& INFERENCES

QUICK SUMMARY

Sr. No	**Type of Defect**	**Total**	**Percentage**
1	Multi Cell Hotspot	25	65.78947368
2	PID	1	2.631578947
3	Cell Hotspot	7	18.42105263
4	Bypass Doide	3	7.894736842
5	string Offline	2	5.263157895
		38	100

Sr. No	**Severity Level**	**Total**	**Percentage**
1	Severity 5- Critical	3	7.894736842
2	Severity 4- Major	4	10.52631579
3	Severity 3- Moderate	24	63.15789474
4	Severity 2- Minor	7	18.42105263
		38	100

STATISTICS OF ANOMALIES AND SEVERITY