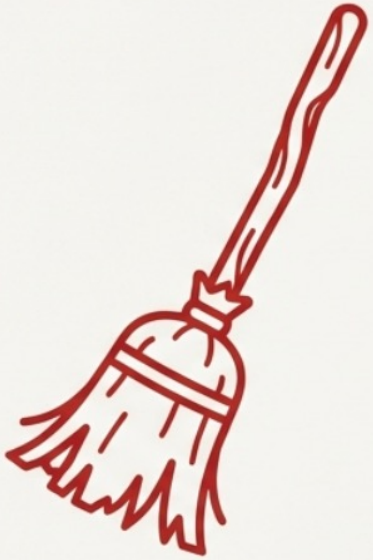

From Brooms to Brains: The Strategic Turnaround of a 4.5 MW Solar Asset.

A data-driven case study on escaping the ‘Availability Trap’ and unlocking the true value of renewable energy portfolios.

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The Solar Turnaround: How Data Revitalised a 4.5 MW Plant

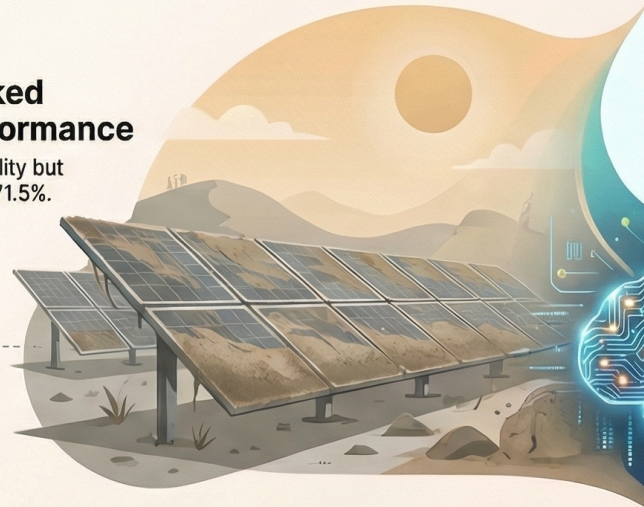
The Problem: The 'Availability Trap'

High Uptime Masked Severe Underperformance

Plant reported 98.5% availability but Performance Ratio was only 71.5%.

Caused by the Outdated 'Broom Model'

A reactive maintenance approach reliant on manual labour and fixed schedules, not real-world conditions.



Critical Failures Were Ignored

Issues included cemented dust blocking panels and overheating inverters throttling power during peak hours.

The Solution & Results: The 'Neural Core' Turnaround

A New Approach: The 'Neural Core'

Treating the plant like a living organism with a digital brain for predictive, intelligent maintenance.

0.3 Million Litres of Water Saved Annually

Achieved by shifting to smart, condition-based hybrid cleaning methods.

+800 Metric Tons of CO_2 Offset Annually

The 16% increase in clean energy generation created a measurable "Carbon ROI".

Performance Ratio	Annual Generation
81.2% ↑	+1.10
+9.7%	Million Units
71.5%	+1.10 Million Units

Net Operational Income

₹3.2 Crores

+₹39.6 Lakhs Gain

₹2.81 Crores

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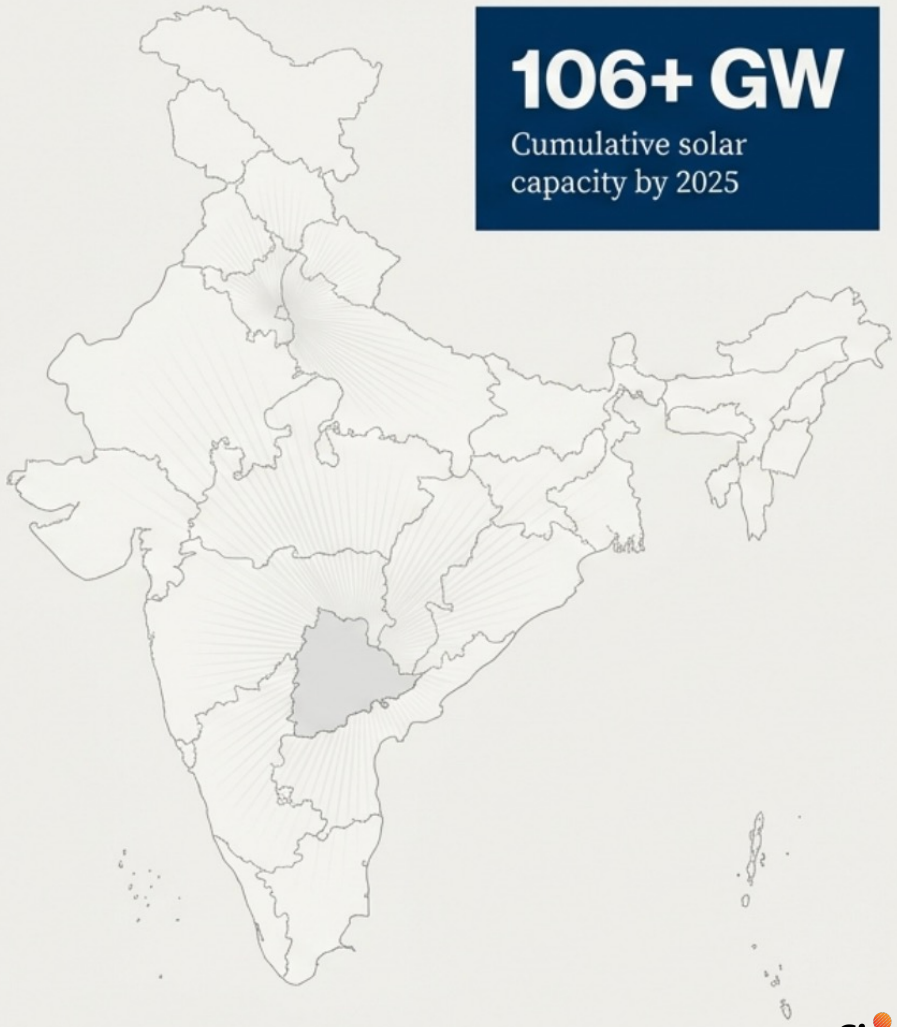
India's Solar Fleet is at an Inflection Point.

As India targets 500 GW of non-fossil fuel capacity, the industry's focus must shift from building new capacity to optimising existing assets.

- A significant vintage of plants (commissioned 2014-2018) is now entering a critical mid-life phase where component degradation accelerates.
- The legacy 'fit-and-forget' approach to Operations & Maintenance (O&M) is proving detrimental to long-term asset value and the Levelized Cost of Energy (LCOE).
- This case study provides a blueprint for professionalising asset management to safeguard returns.



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The Proving Ground: A 4.5 MW Asset in Telangana's High-Stress Environment.

Capacity:	4.5 MW (DC)
Location:	Telangana, India
Module Tech:	Polycrystalline Silicon (Higher temp. coefficient)
Commissioning:	~5 Years Prior to Takeover (Entering degradation phase)
Previous O&M:	Local Contractor ("Broom Model")

The Telangana Challenge

Thermal Stress: Ambient temperatures exceeding 40°C cause significant equipment derating.

Soiling Load: Red soil dust and industrial pollutants form a tenacious, cement-like layer.

Grid Dynamics: Congestion and curtailment risks require precise management.

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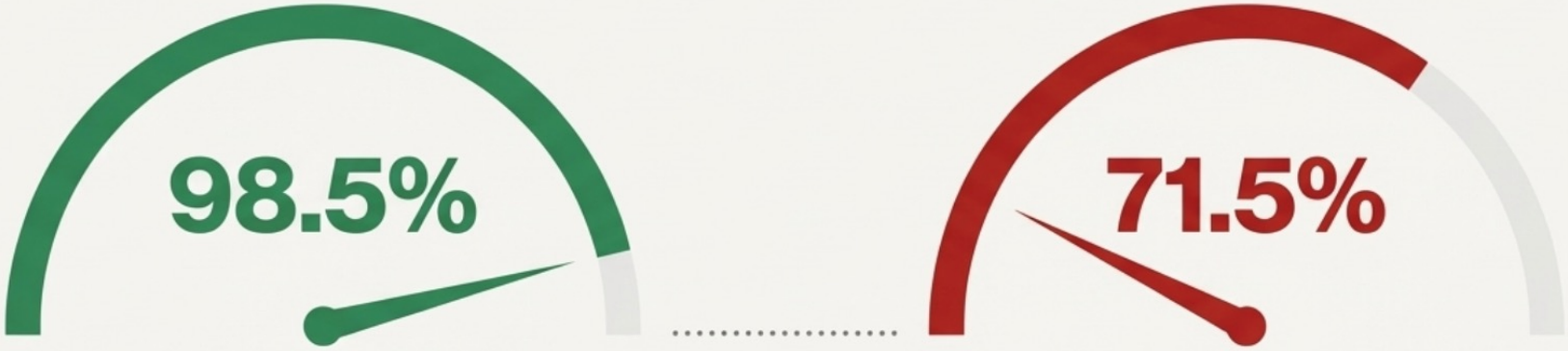
The Illusion of Uptime: How 98.5% Availability Masked Massive Revenue Leakage



Plant Availability

The metric that hides the truth

Performance Ratio (PR)

The reality of performance

Upon takeover, a comprehensive "Zero-Date Audit" revealed a classic case of the "Availability Trap." The plant was technically *online*, but it was not converting sunlight into revenue efficiently. The ~8-9% gap between actual and design PR represented a significant, invisible financial loss.

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A Diagnosis of Underperformance: The Root Causes

Severe Soiling & Cementation

Frequency-based cleaning was ineffective. Morning dew mixed with red soil, forming a cement-like layer that caused permanent shading on module cell rows.

Thermal Derating & Clipping

Clogged filters and failed fans in inverters caused overheating, forcing them to throttle power output during peak generation hours ("clipping losses").

DC Health & Insulation Failures

Rodent damage and moisture ingress compromised DC cables, leading to low insulation resistance and "late wake-up" issues, losing 30-60 minutes of generation daily.

The 'Zero Inventory' Risk

No on-site critical spares meant minor component failures resulted in downtime of days or weeks, waiting for parts procurement.

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Rejecting the ‘Broom Model’: Introducing the Neural Core Paradigm.

The ‘Broom Model’

- Relies on unskilled manual labour.
- Uses fixed, reactive schedules.
- Views the plant as static hardware.
- Focus: Minimising OPEX.

The ‘Neural Core’

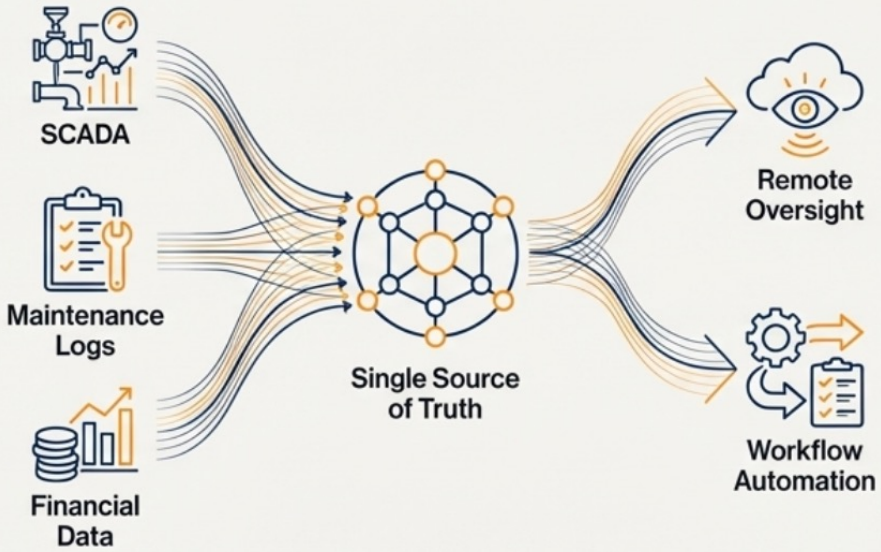
- Treats the plant as a living organism.
- Uses data as its sensory input (IoT, Drones).
- Analytics engine is the processing ‘brain’.
- Automated systems provide ‘reflexes’.
- Focus: Maximising ROI and Asset Value.

‘This conceptual framework treats the solar plant as a living organism with a central nervous system.’

The Digital Foundation: Sirius Operating System & Advanced Analytics.

Sirius Operating System – The Command Centre

- Functions as a 'single source of truth,' integrating SCADA, maintenance logs, and financial data.
- Enables 24/7 remote oversight and workflow automation via a digital ticketing system.
- Tracks Mean Time To Repair (MTTR) from alarm to resolution.



Sirius.Analytics – The Intelligence Layer

- Deploys machine learning to perform 'Virtual String Monitoring,' detecting underperformance without expensive hardware retrofits.
- Calculates a real-time Soiling Ratio to trigger cleaning precisely when it is most profitable.

Key Principle: Data Sovereignty

"The Asset Owner retains complete ownership of the digital history, ensuring full transparency and independent verification of ROI."

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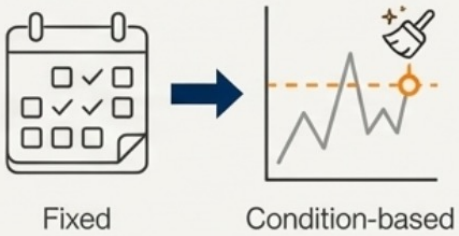
From Data to Action: Re-engineering Physical O&M.

1. Smart Cleaning Strategy

From: Fixed schedules.

To: Condition-based triggers driven by the Soiling Ratio. A fundamental shift from 'cleaning for cleanliness' to '**cleaning for profit**'.

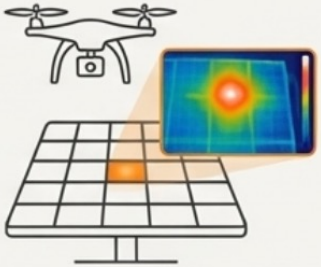


Method: Introduced Hybrid cleaning (dry microfiber brushes) to combat cementation, reduce water usage, and eliminate human error.

2. Comprehensive Preventive Maintenance

Method: Standardised quarterly drone-based thermography to detect hotspots (1.2% of modules found with severe issues).

Method: Implemented a rigorous "Inverter Hygiene" protocol, proactively replacing high-mortality components based on running hours, not failure.



3. Strategic Spare Parts Inventory

Action: Created an on-site stock of critical spares (fuses, PCBs, fans).

Impact: Reduced MTTR for minor faults from **48 hours to under 2 hours.**

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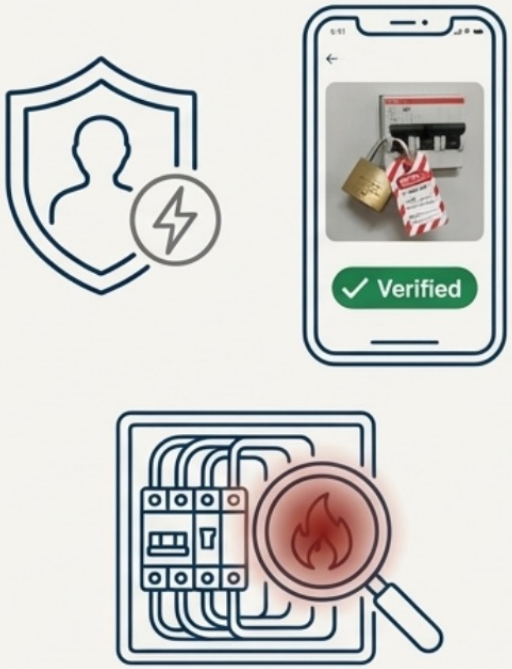
Mitigating Risk: Engineering a Systemic Safety & Compliance Framework.

Safety is not a checklist; it is a ‘cognitive function’ of the operational brain.

Key Safety Protocols Implemented

- **The Safety Liability Framework:** Sirius assumes the role of safety custodian. A **Qualified Electrical Person in Charge (QEPIC)** was appointed to authorise all high-voltage operations.
- **Digital LOTO (Lockout/Tagout):** Integrated into the mobile app, requiring photographic evidence of LOTO application before work commences.
- **Fire Risk Mitigation:** Thermographic scanning of all terminations in Combiner Boxes identified and rectified 14 critical heating points, a primary cause of DC arc faults.
- **Regulatory Alignment:** Full compliance with the **Factories Act, 1948** and state regulations. Earth pit resistance maintained at < 2 Ohms to ensure personnel safety.



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The Economics of Excellence: A 4:1 Return on O&M Investment.

Financial Transformation (Annualized)			
Metric	'Broom Model' (Pre-Sirius)	'Neural Core' (Sirius)	Net Impact
Performance Ratio	71.5%	81.2%	**+9.7%**
Annual Generation	~6.50 MUs	~7.60 MUs	**+1.10 MUs**
Gross Revenue (@₹4.5)	₹2.92 Crores	₹3.42 Crores	**+₹50 Lakhs**
O&M Cost	₹11.25 Lakhs	₹21.4 Lakhs	-₹10.15 Lakhs
Net Operational Income	**₹2.81 Crores**	**₹3.2 Crores**	**+₹39.6 Lakhs Gain**

The Bottom Line: The revenue gain outpaced the increased O&M cost by a factor of nearly 4:1, delivering a powerful ROI for the asset owner.

The Turnaround in Numbers: Restoring the Asset to Peak Performance

Performance Ratio Recovery

From **71.5%** to **>81.2%**

An absolute gain of **9.7%**.

Energy Generation Boost

+ ~1.1 Million Units (MUs) ↑

Increase in annual generation.

Specific Yield Improvement

From **~3.8** to **~4.4** kWh/kWp/day

A direct measure of efficiency gain.

This recovery was achieved within the first 2 months of intervention, demonstrating the rapid impact of the new framework.

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Value Beyond the Balance Sheet: A Measurable ESG Impact.

Water Conservation Leadership

Shift to Hybrid cleaning methods reduced water consumption by **~30%.** Saved approximately **0.3 million litres of water annually** in the water-stressed Telangana region.

Carbon Footprint Reduction

The 16% increase in energy yield translates to an additional **~800-900 metric tons of CO2 offset annually.** This creates a tangible 'Carbon ROI' for the asset owner.

Circular Economy & Waste Management

A strict 'Zero-Landfill' policy for e-waste. Damaged modules were routed to certified recyclers for material recovery, ensuring environmental compliance.

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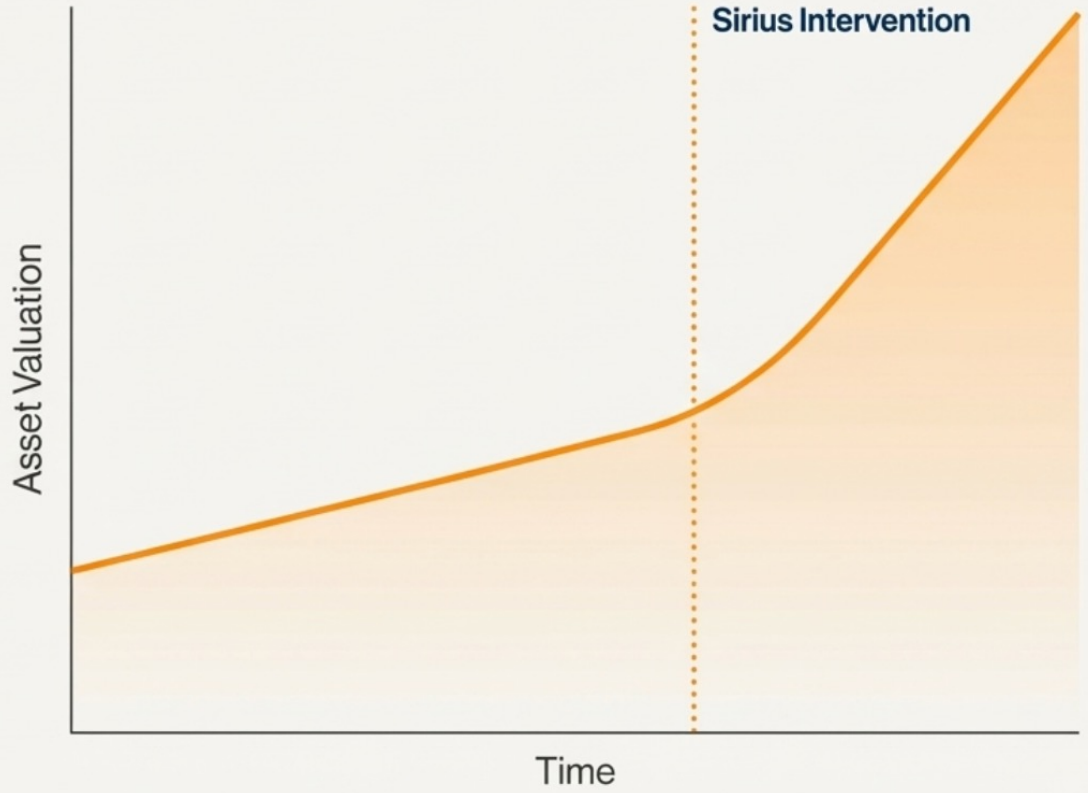
Enhancing Long-Term Asset Valuation and Bankability.

Key Value Drivers

- **Improved Bankability:** A complete digitised history, documented compliance, and stable high-performance data make the asset more attractive for refinancing at lower interest rates.
- **Life Extension:** Proactive maintenance, especially reducing thermal stress on inverters and rectifying cable faults, effectively extends the Residual Useful Life (RUL) of the plant.
- **Partnership Model:** The Bonus & Liquidated Damages (LD) commercial model aligns financial interests, transforming the vendor-client relationship into a true partnership focused on maximising generation.



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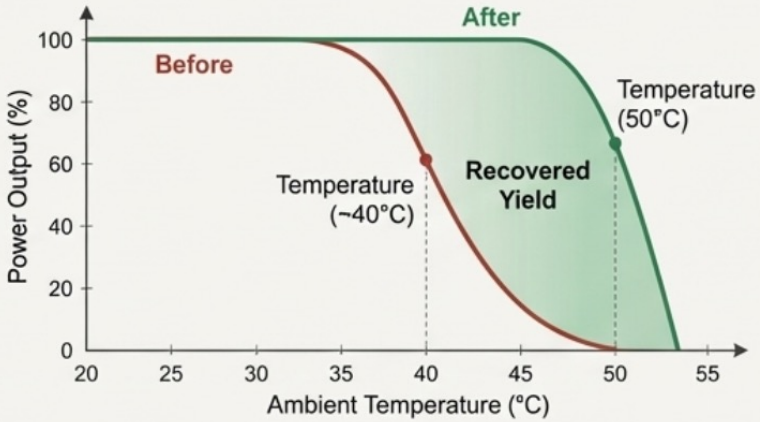
Technical Deep Dive: Solving Critical Engineering Failures

Case 1: Inverter Thermal Management

The Issue: Inverters were 'clipping' power at 40°C instead of the rated 50°C due to poor heat dissipation.

The Fix: Revamped cooling systems with high-static pressure fans and chemical cleaning of heat sinks.

The Result: Shifted the derating curve, recovering ~2% of total daily yield during summer months.

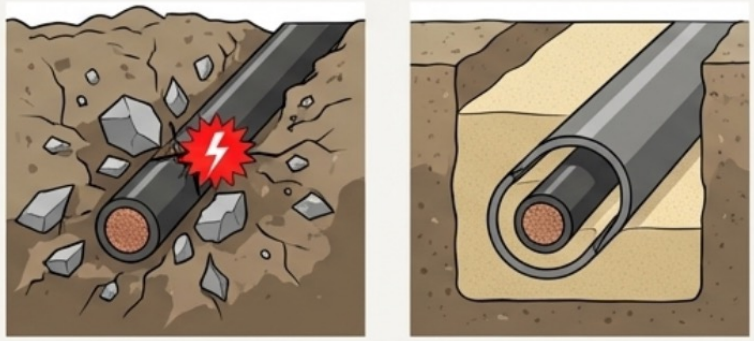


Case 2: Underground Cable Fault Remediation

The Issue: Improper backfilling during construction led to 12 major cable faults, causing low insulation resistance (<1 MΩ) and morning trips.

The Fix: Used Time Domain Reflectometry (TDR) to locate faults with precision, then excavated and re-laid cables in protective sand bedding.

The Result: Insulation values improved to >100 MΩ, eliminating faults and enhancing safety.



Before

After

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The Project V Turnaround is a Blueprint for India's Solar Future

The 'Availability Trap' is real, but escapable.
By replacing the 'Broom Model' with the 'Neural Core,' we did not just restore an asset's performance; we redefined its potential.

Data is the New Oil

Without granular, real-time data, asset owners are flying blind.

Quality is an Investment

The premium for professional O&M yields exponential returns in revenue, asset life, and risk mitigation.

Safety is Systemic

Operational discipline and uptime depend on integrating safety and compliance into the core of operations.

As India marches toward its 2030 goals, operational excellence is no longer optional. It is the foundation of a sustainable and profitable green energy future.

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