SolarArise Deploys Quadrical Ai's Digital Twin Based Solution for Performance Improvement

SolarArise invests and manages large scale, grid connected solar projects - both commissioned and greenfield - with a long-term hold philosophy. Backed by Kotak Infrastructure, Global Energy Efficiency, Renewable Fund (GEEREF)and Thomas Lloyd, SolarArise aims to develop, own, and operate a large Solar portfolio in India.

Challenge

The team at SolarArise knew there had to be a way to increase generation at their plants – perhaps even beyond budgeted expectations set forth by PV Syst models. Too dependent on pyranometer accuracy, those models were losing precision with Solar plants becoming ever larger. Though Quadrical Ai can operate with data from any CMMS, SolarArise already had a Quadrical Ai Monitoring platform. The next step was to use the data to utilize O&M teams more effectively in order to increase yield generation.

The Plant

The Yield Improvement plan for SolarArise was to use data to benchmark its 18-Month Pre-Engagement performance. It was followed up with a 3-Month Pre-Engagement Audit and a 1-Week Remediation Report. This was iterated multiple times as a monthly Audit - Remediation cycle. Culminating in RealTime information being updated daily in an Operation Dashboard made Performance Improvement become both continuous (daily) and seamless. Solar Industry specific algorithms used by Quadrical Ai are part of a robust, secure, engineering solution. With plug &play integration capability, and an intuitive interface, they continue to provide speed-to-value and enhanced security over time.

Our Digital Twin Benchmark

Our solution for SolarArise used Digital Twin AI, built on Peer Comparison, Environmental Context and Time. Being a weather and module corrected benchmark, our Digital Twin based Machine Learning continues to be reliable at tracking needle-in-a-haystack issues even down to the module level. Using SCADA, tracker, weather, calibration and manufacturer data, plus data from their own RealTime Monitoring Platform.

Plant Studied

Capacity	67 MW
Location	Maharashtra, India
Sensor Level	Combiner Box
Pre-Engagement Daily Loss	Avg Loss 7.3%

Results

3.1% Post-Engagement Daily Loss

4.2% Reduction – Average Daily Loss| Downward Trend Continuing

Plant Configuration

# of inverters	20
# of string-combiner boxes	400
Configurations	Single-Axis and Seasonal Tracker

SolarArise received predictive insights for O&M. Integrating all these types of data allowed us to build stacked Digital Twins for all hardware relationships in the plant. This allowed for Automatic RealTime Plant Monitoring with tickets issued to solve O&M issues prioritized by revenue impact. Though not required by SolarArise, Yield Forecasting is also available on the Quadrical Ai Platform. Contracted (Budgeted) energy is less useful as its overly dependent on:

- Simplistic PVSyst calculations of Irradiance
- Pyranometer accuracy

This makes it more unreliable as plants become larger.

Digital Twin – 3-Dimensional Benchmark:

- Context - Satellite Weather Data, Weather Station (Pyranometer), and Plant Yield
- Peer and Proximity Data for better gauge of granular conditions
- Meter specific using Time Series performance of individual meters

Pre-Engagement Performance Benchmark (18 Mos)

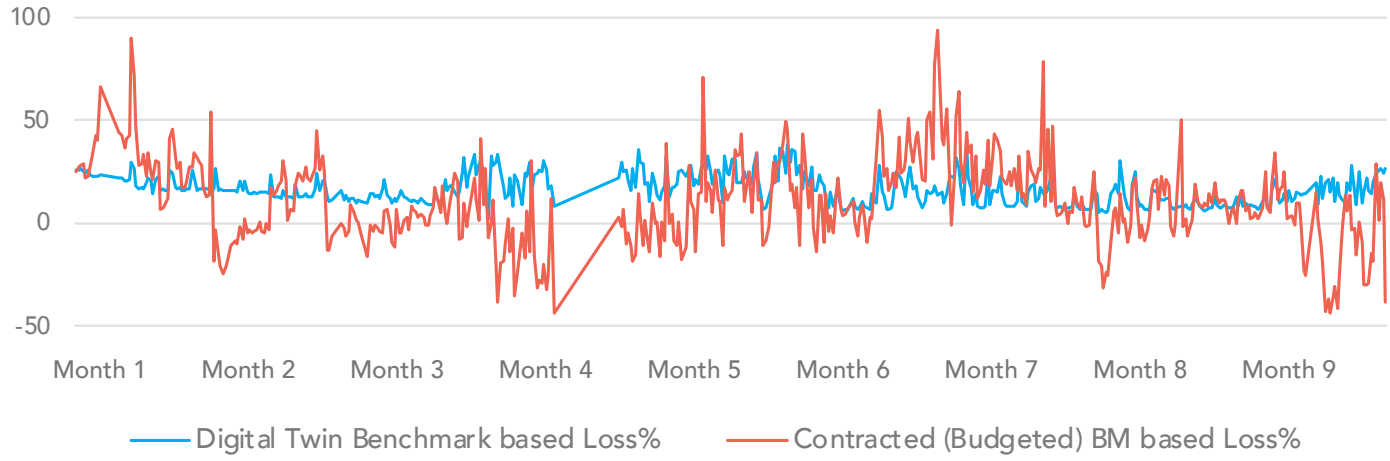
Contracted (Budgeted) Benchmark Variance = -43% to +100%

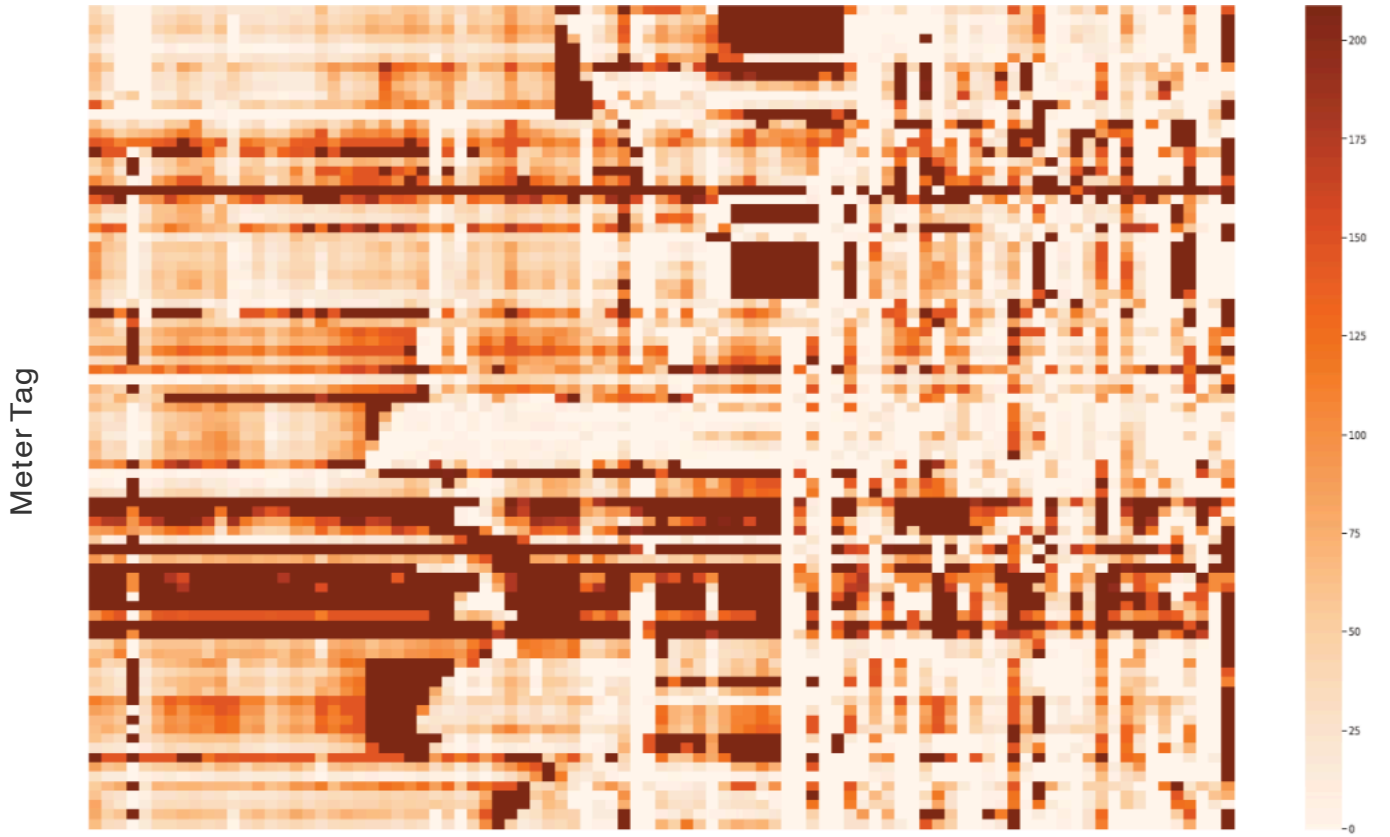
Digital Twin Benchmark Variance = +2.29 to +15%

A Stable Benchmark (3x lower sigma) = More Precise Loss Tracking & Remediation

James Abraham
Founder & Director, SolarArise

We are deeply focused on energy uplift and believe our plants can produce more than the budget targets.



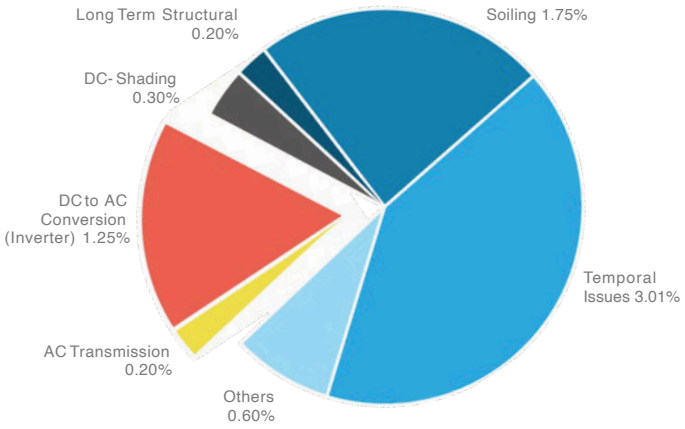


Shading Loss– 301 MWh (3 Months)

Actual Energy Produced
= 31,267 MWh

(Contracted) Expectations
= 32,072 MWh

With Right Conditions, Plant May Produce Even More
= 33,730 MWh



Examples of Needle-in-Haystack / Temporal Issues

Category of Loss	# of tickets	Loss %	Loss (MWh)	Comments
Slacker SCBs	5	0.10%	26.8	Check for structural issues, shading, and wire heating during various times of day
Others (SCBs uncorrelated with Digital Twin Benchmark)	3	0.03%	9.8	Out-of-Sync SCB's for additional observation
SCBs with Long Term Issues	21	0.30%	113	Investigate from structural perspective
SCBs with Shading Loss	87	0.90%	302	Table-to-Table Morning/Evening Shading

Weekly Remediation Reports

Category of Loss	# of tickets	Loss %	Loss (MWh)
Failures- Y-Connectors, Cable (Others)	179	1.12%	26.7
Inverter (DC to AC)	20	0.84%	20.0
Slackers - Late Starters / Early Finishers	15	0.44%	10.6
Uncorrelated to Benchmark	13	0.38%	9.1

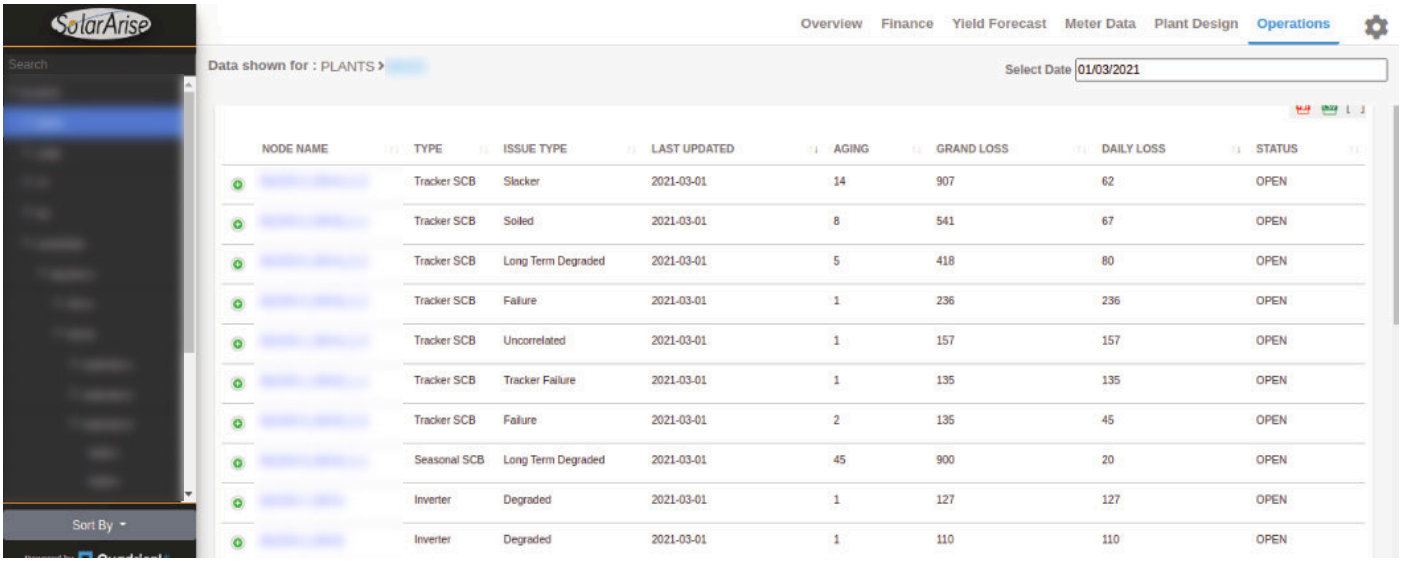
Long Term Structural Losses = 21 SCB's 113 MWh (0.3%)

Identified 7 SCB's which contributed to 44 MWh (0.3%) for Further Investigation and Manufacturer Escalation

Soiling Analysis

Continuously investing in new feature additions, Quadrical Ai developed Digital Twins to detect Soiling Losses. During our Case Study window, we found additional Soiling Loss of 372 MWh and identified 3 Blocks which required more frequent cleaning.

RealTime RevenuePrioritized Operation Dashboard

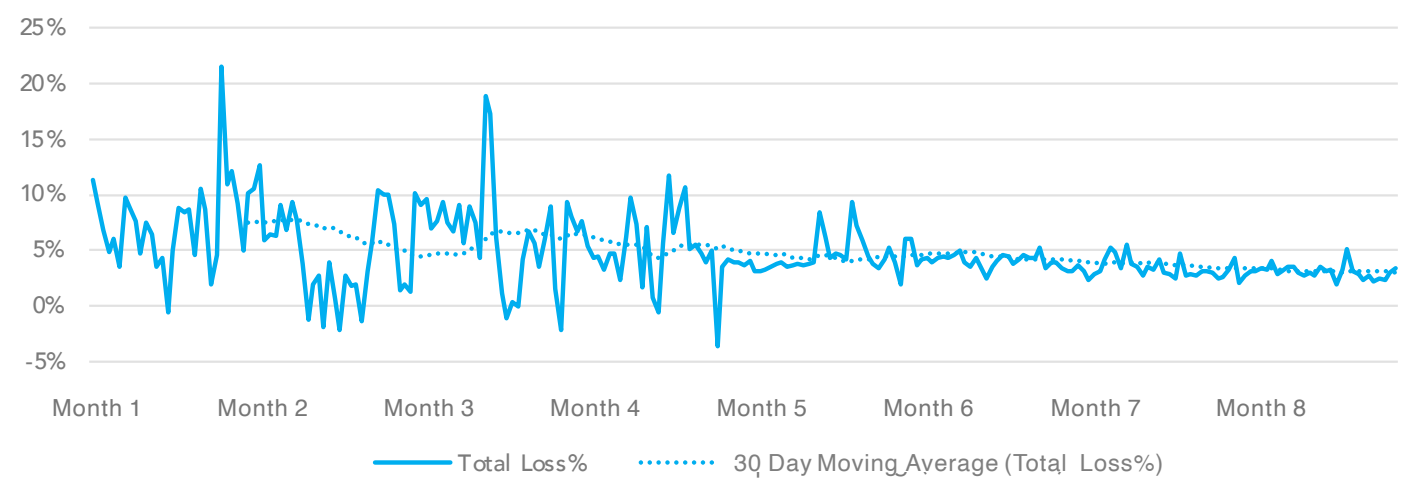


NODE NAME	TYPE	ISSUE TYPE	LAST UPDATED	AGING	GRAND LOSS	DAILY LOSS	STATUS
	Tracker SCB	Slacker	2021-03-01	14	907	62	OPEN
	Tracker SCB	Soiled	2021-03-01	8	541	67	OPEN
	Tracker SCB	Long Term Degraded	2021-03-01	5	418	80	OPEN
	Tracker SCB	Failure	2021-03-01	1	236	236	OPEN
	Tracker SCB	Uncorrelated	2021-03-01	1	157	157	OPEN
	Tracker SCB	Tracker Failure	2021-03-01	1	135	135	OPEN
	Tracker SCB	Failure	2021-03-01	2	135	45	OPEN
	Seasonal SCB	Long Term Degraded	2021-03-01	45	900	20	OPEN
	Inverter	Degraded	2021-03-01	1	127	127	OPEN
	Inverter	Degraded	2021-03-01	1	110	110	OPEN

Post-Quadrical Ai Check-In

		18-Mos Baseline	Reductions
Generation Loss	Shading:Fixations around Fixing	0.3%	0.1%
	Structural Losses: Degraded Panels	0.2%	0.2%
	Temporal Losses: MC4, Y-Connector, Insulation, Ground Fault Reductions and Panel Errors	3.0%	1.6%
	Soiling	1.7%	1.4%
	Other (Site Outages)	0.6%	0.1%
Invertor Loss	Clipping		
	Temporal Losses (Fan failures, Overheating etc)	1.0%	0.7%
	Other	0.2%	0.0%
AC Loss	Curtailment		
	Temporal losses		
	Temporal losses	0.2%	0.0%
Total		7.3%	4.2%

Total Loss%



James Abraham
Founder & Director, SolarArise

Quadrical Ai's Digital Twin approach was instrumental in setting realistic expectations and then pinpointing areas of underperformance that focused our teams' efforts.

Unlike traditional models which rely on an "ideal component" formula, we use a Machine Learning model of efficiency and behavior. Based on data collected from 100's of input parameters and actual inverter and plant yields, these merged individual and average performances create sophisticated special purpose models. This makes them fine tuned to capture sensor data, degradation to create forecasts and foresee future anomalies. Adapting to tolerances, the environment and history, the Quadrical Ai Digital Twins tune continuously, resulting in steady optimization of the aging plant.

Future Performance

Loss percentages will continue to be further improved as timely actions are taken on O&M guidance. With on-site O&M feedback, the Quadrical Ai system is also trained to become more intelligent with time. Globally, almost every solar company faces similar challenges. As assets age, prices paid per MWh are decreasing, while scale and complexity are increasing. This makes holistic long-term planning essential for asset owners and managers.

We know that a Digital Twin AI solution can tell natural variances in the system apart from problematic performance. With Quadrical Ai's ability to adapt with time and learning, they'll be optimizing your plant assets even at Year 25.

Benefits

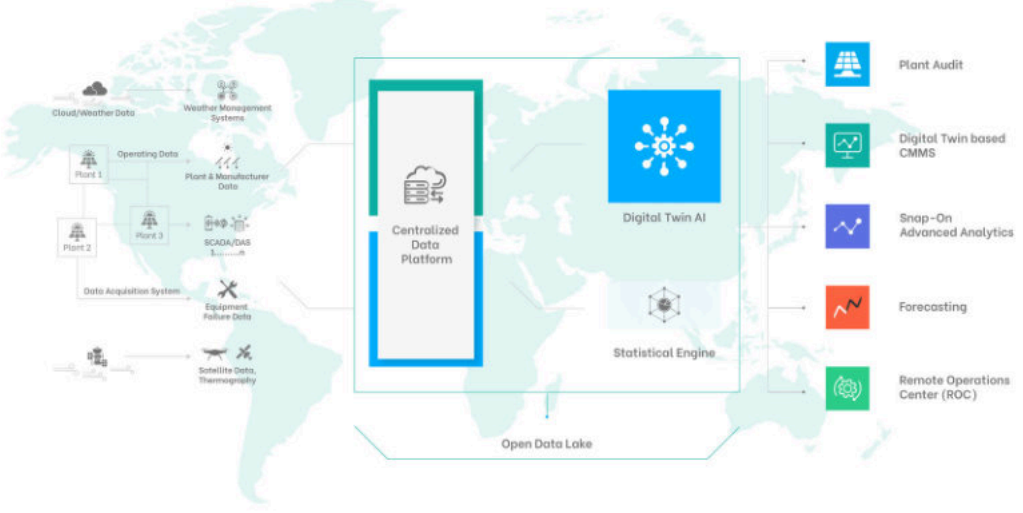
Management
Real Time Portfolio Performance Monitoring & Revenue Impact.
O&M Team
Corrective, Preventive, & Predictive O&M Directions & Ticketing Workflow.
Internal Data Science Team
Real Time Structured Schema Based Data of Actual as well as Reliable System Benchmark – Digital Twin data and all of it available on a Real Time dashboard.

Digital Twin Based AI for Complete Solution

- Robust Metrics and Benchmarking
- Energy Forecasting with Storage, Trading, and Pricing Optimizations
- Monitoring with Accurate Needle-in-Haystack Identification
- Predictive Maintenance for Outage Prevention
- O&M Guidance with Revenue Prioritized and Actionable Tickets
- Plant Audits

Sharat Singh
Quadrical Ai, CEO

Our partnership with SolarArise has been fruitful as they think in KWh, not just KW. Looking at technology as a revenue generation tool, not a cost center, makes it a value addition and the foundation of organic growth.



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Quadrical Ai

Deployed on 3000 MW Solar + 5000 MWh Storage + 200 MW Wind