



# Solar Asset Management Platform

Secret Sauce - Digital Twins at the Core



We start by building a detailed digital replica of your plant, by creating and adding up digital twins of each node. The bottom-up addition of yield expectations for each string in RealTime, produces the most accurate estimate of your plant's generation capacity at any time with unprecedented granularity and accuracy.

This means **not one Digital Twin, but Twins, Triplets, often 500 Mini Twins for a 50MW Plant.**

Next, we leverage these special purpose mini twins for identifying and quantifying shading, soiling, insulation, long term degradation, anomalies, due diligence etc. This lets us arrive at the most precise benchmark for your plant.

This true Condition based Maintenance guidance, with alerts, are benchmarked to our proprietary Digital Twin baseline. They help you **improve plant generation by 2 - 4% and O&M efficiency by 15%**

Seamlessly integrating with your plants, our cloud-only solution causes zero disruption to your existing systems.

We then optimize your asset performance as our Digital Twins learn and adapt to your plant's inherent characteristics over time. You can call these iterations and their compounding effect *stitch-in-time*, or *daily improvements* like the *Toyota way*. It all means increased profitability today, and better plant monetization even in 2027 and 2034.

## Digital Twin based CMMS

1 Source of Truth. Centralized Cloud Data Platform - for RealTime Monitoring, Reporting and Visualization

Quadrical helps you gain absolute control on production losses by going beyond Predictive Maintenance to Condition based Maintenance. This means we systematically address the issues which are leaking and not visible yet. Mean time to fixation comes later after the problem has been discovered - we find the problem earlier with Digital Twins.

Our system issues **Revenue quantified Daily Automated Tickets**, to prioritize resolution first for what has the most impact - optimized ticket scheduling based on revenue, intra-distance, count clusters along with what traditional systems offer, built into our RealTime Monitoring Platform

- Remediations, alerts, and outages
- Preventative Maintenance schedules
- Condition based Maintenance
- Predictive Maintenance

**Deployed on 3064MW Solar + 667MW / 2433MWh Storage / 200MW Wind**

## Centralized Cloud Data Platform

Plant operating data gathered from all data acquisition systems like SCADA, SMART IoT devices, weather forecast providers etc is surfaced on a **Data Platform** that updates in RealTime. All in one centralized cloud location – clean and analysis-ready!

**Open access to Raw Data** in a Cloud Data Lake, plug & play via Power BI, Tableau, Jupyter-notebooks etc

**Predictive O&M Guidance.** View and act on Revenue Quantified Automatic Tickets across:

- Alerts & Outages
- Preventative Maintenance & Predictive Maintenance
- Condition based Maintenance
- Accurate Needle-In-Haystack

**Track Equipment & Plant Level Performance Data** through customizable dashboards for role specialization – site engineering, operations, finance, management etc

**Reliable Sets of Plant Operating Data** with improved data quality, for truly informed decision making

**Flexible Data Analytics** to find untapped energy production and cost optimization potential

Together they provide real intelligence built into a **Monitoring Platform**, to guarantee maximum RoI for you.

## RealTime Monitoring with Embedded Predictive O&M

Cut through noise with Digital Twin powered Condition based Maintenance for personalized portfolio performance tracking

Extract more value from your assets with a Platform custom built to help you analyze underperformance, and pinpoint issues. We use features like loss waterfall charts, loss buckets etc to categorize leaks and losses at plant level which can be drilled down to underlying equipment at granular level

**Customizable Dashboards & Flexible widgets** designed for RealTime status of portfolio wide KPIs, alerts & guarantees by site

**Trend Analysis for Production Loss Categorization**, identification of leaks & underperforming nodes

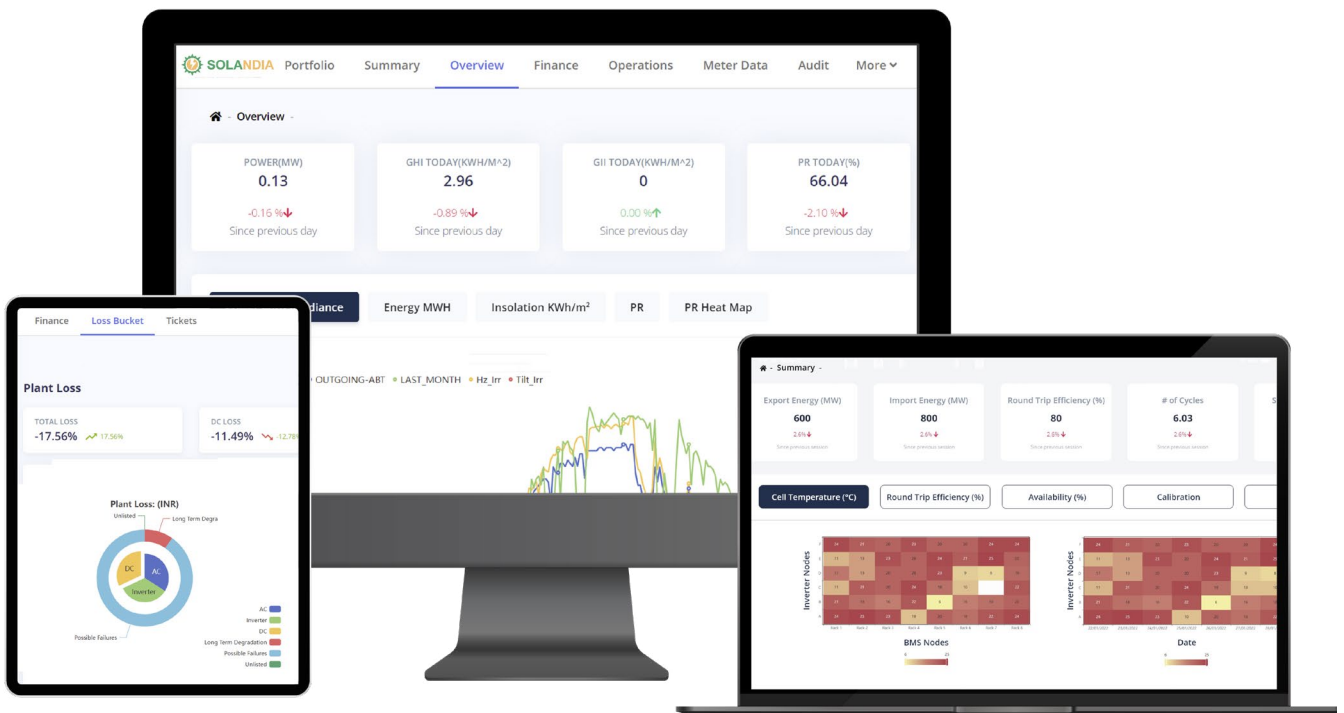
**Prioritization Rules & Customizable Alerts** to highlight critical events and potential performance issues, with instantaneous notifications via email & SMS

**Streamlined Reporting & Data Communication Workflows:** Standardized business and operational reports with out-of-box visualizations supported by data views + exports

Move away from time-based work orders to **performance-based work orders.**

- Consistent portfolio wide Ticket Management System covering configured alerts, AI CBM (Condition based Maintenance) Degradation and Anomalies, and Preventative Maintenance schedules
- Advanced insights on loss bucketing, anomaly & outage prevention, degradation instances (auto detection of early signatures of soiling, shading, string-level outage related underperformances), Needle-in-Haystack/temporal degradation issues
- Optimized tickets prioritization and dispatch based on revenue impact, distance clusters, & ticket count
- Proactive site O&M mobilization with revenue prioritized daily task lists, intuitive workflows, flexible resource allocation, notification, & escalation by site
- Track the effectiveness and capability of your teams by analyzing custom reports like O&M efficiency and optimizing their workflow accordingly
- Quadrical ROC (Remote Operations Center) to manage and coordinate tickets directly with your field O&M staff

Leverage RealTime Monitoring/Reporting and O&M Guidance to increase field force efficiency and productivity.



# Features

<p><b>Integration Capability</b></p>	<p>Hardware/Software agnostic. Support for most inverter, transformer, battery, and panel manufacturers. Support for: FTP, ODBC, Modbus, SCADA, OPC protocols</p>
<p><b>Onboarding Speed</b></p>	<p>Plant onboarding with historical data in 2 days</p>
<p><b>Advanced Analytics Tools</b></p>	<p>Advance Performance Analysis leveraging Digital Twin AI for extremely accurate and granular expectation from every device, at any location, weather conditions, and time            Quick Audit: Comprehensive Audit of last 6-mos data for actionable analysis (and revenue based tickets) of Temporal Loss and Short-term Degradation            Deep Audit: Multi-year due diligence Audit for granular and quantified view of Structured and Long-term Degradations            Alarm &amp; Event Analysis            Grid Outage, Inverter Clipping, Curtailment, Pyranometer Calibration, Tracker seasonal fixed tilt align            Trend Analysis            Ad hoc analysis (XY Analysis)            Basic RT Analysis            Data Quality, Daily Generation Report (reconciled with equipment errors), Specific Yield Report            Heat Map and GIS Visualization            Comparative Analysis (Peer analysis)            Soiling Loss Analysis (Beta)            Loss Analysis (Loss Funnel includes weather, grid, structural losses, and degradation for Inverter and SCB)</p>
<p><b>Operations &amp; Maintenance Tools</b></p>	<p>Rich no-code framework for user-defined alerts including multivariate rules, statistical rolling-windows, instance and daily aggregates, peercomparisons, and Digital Twin comparisons            Maintenance Dashboard            Operations Dashboard            Maintenance Management - Predictive, Preventative, Breakdown, Condition based Maintenance  <b>Portfolio-wise Auto &amp; Manual Ticketing</b>  <ul style="list-style-type: none"> <li>Comprehensive Ticketing Management: Breakdown, Alerts, Condition based Maintenance, Predictive maintenance, and Preventive Maintenance</li> <li>Assigning of Jobs and maintenance log-sheet</li> </ul>           Alert &amp; Alarm Management (MTBF/MTBI/MTTR, Top 10 Alarms)            Rule Based Alert / Adhoc alerts            Priority and Dispatch Management Revenue-impact, distance clusters and ticket count based            Work Flow or Force Management / Incident Management            ROC team to manage and coordinate tickets directly with customer's O&amp;M field staff            Flexible, site-wise Resource allocation, notification, and escalation            Health &amp; Safety Management            Track Contractual Guarantees            Budget Vs Actual (Annually &amp; Monthly)</p>
<p><b>Reporting &amp; Notification Tools</b></p>	<p>Standard Scheduled Reporting (Monthly &amp; Weekly Reports)            Flexible visualization of any parameter across peers and time            RealTime, on-demand ad hoc reports            Auto Schedule of Reports            Email &amp; SMS Notifications            Centralized Data Platform  <ul style="list-style-type: none"> <li>With integrated capabilities for site-digitization, satellite weather, yield forecast, and custom report via PowerBI, Tablaeu, and Jupyter notebooks</li> <li>Notification on the portal</li> </ul>           Open schema for extensibility with PowerBI, Tableau, and Jupyter-notebooks            Seamless data exports of visualizations</p>
<p><b>Additional Tools &amp; Capabilities</b></p>	<p>Digital Twin based Audit Platform (for comprehensive view of historical and current losses)            Audit Management            Progressive Mobile Web App: Management Revenue Dashboards by Site, Field Assigned Tickets, Ticket Action/Resolution Flows            Third-party data integration (Drones, CCTV, DustIQ, Other Sensors)            GIS based Asset Tracking            Custom Dashboard - Drag and Drop widgets            Data Uploading            Enterprise Search Engine            Scalability            Manage large portfolio by region, customer, any other clustering approach            Data Storage &amp; Archival            Data Migration Management            Data Security</p>
<p><b>Asset Management</b></p>	<p>Budget Vs Actual Contractual &amp; Financial KPI Guarantee Tracking            Plant Digitization and GIS based Asset Tracking and O&amp;M management</p>
<p><b>Financial Tools</b></p>	<p>Financial KPIs            Financial Accounting</p>
<p><b>Enterprise Scale Monitoring Capabilities</b></p>	<p>Manage large Fleet/Portfolio of sites by region, customer, and configurable clusters            Security and Access: User Management (Role and Site based access and Permissions)            Flexibility of Resource Allocation, KPI, escalations, and notifications by site            Centralized Portfolio Management: RealTime Monitoring &amp; Visualization of Global Asset portfolio (CMMS)            Portfolio view, Map view, Plant view, Inverter View &amp; SMB View (With RT key KPI tracking)            Availability Analysis of Critical components, KPIs            Executive Dashboard (Summary Page)            Integration with Weather providers for weather-data and satellite / drone providers for plant digitization            Mobile app for select dashboard and field experiences (in roadmap)</p>

# The Software

## Seamless Onboarding

- Cloud agnostic. Your cloud or ours based on customer preference
- Data Engineers deploy standardized data migration process from ground to cloud in record time.\*
- Flexible, infinitely scalable architecture, with expert support for your teams
- Swift, open architecture integration with all major OEMs: Secure, remote connections any critical source – from SCADA data to power forecasts – regardless of hardware manufacturer or 3rd party service

\*Recently we onboarded 40 Plants (850MW) in 45 days.

## Ingest Data from Multiple Sources

Data ingested from plants is correlated with relevant streams (production, weather, device IoT, expected performance ratios, and ongoing operations) for exhaustive operational efficiency

## Scalable, Flexible Data Management Strategy

- Data Aggregation  
Completely transparent and unbiased view of all your assets with a single, standard schema structured for each plant across the portfolio
- Data Accessibility  
Plant operating data is cleaned and harmonized and structured into an AI-first Data Platform
- Zero Sync Issues  
All data is fetched, processed, and can be utilized via the Data Lake in RealTime (OPC/CDC data clients enable this live sync)
- State-of-Art Cloud Storage & Data Archiving Solutions  
To provide unlimited scale, 99.99% data availability, 99.5% or more system uptime performance
- Highest standards of data security and secure encryption in-flight and at-rest

## Reliable, Trusted, Optimized Data Platform

Data from all plants, SMART devices (Block, MFM, Inverter etc.) is cleansed to enable intelligent filling of missing values, de-du-

plication and configurable time-synchronization, improving the data quality and reliability for RealTime reporting, and accurate forecasting and plant performance optimization

## Plug & Play

Connecting most SCADA compliant energy production sensors, standard IoT sensors for device information and weather feeds, our software goes to work. With easy integration supporting all manufacturer types – the Quadrical Ai Platform will ingest all relevant cross-plant data into a single standardized schema. You will benefit with out-of-the-box reports and visualizations

## Intuitive, Customizable Dashboards & Reporting

With proprietary advanced modelling techniques, we enable RealTime monitoring and O&M workflows in interactive dashboards with built-in extensive visualization and reporting capabilities custom & standard generation, operational reports identify and drive additional revenue opportunities

## Accurate Performance Forecasting

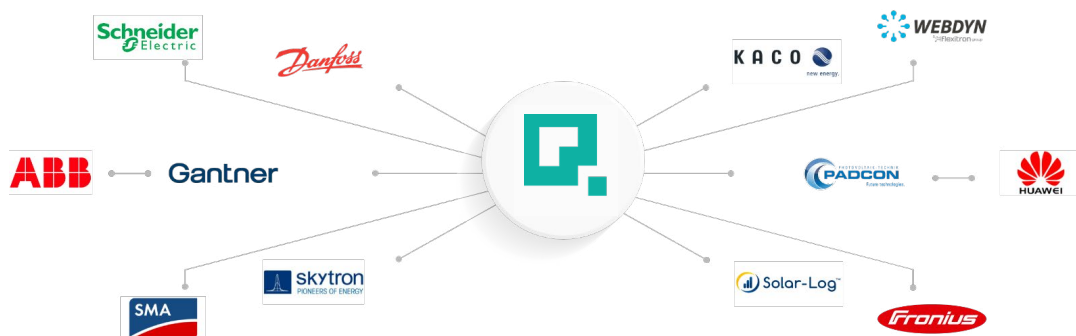
Our Customer Success Team helps you plan future production to align with predicted demand and optimize plant capacity with both planned and predictive maintenance strategies

## Open Architecture Integration (Public API)

Single standard schema for entire portfolio, so your team has open access to clean, raw data. Proprietary Digital Twin data is also accessible for your team to enrich your analytical scope, while we continue to build our advanced analytics

## Role-based & Network-based Access Controls

Plus, other specific controls such as encryption in SQL and other databases, so that data in transit stays protected against 'out of band' attacks (e.g., traffic capture)



We've successfully integrated with 10+ cloud APIs/data systems already using out-of-the-box frontend integrations.

## Extensible

- No code development required. Future-Proof with Extensibility to build new reports to track custom KPIs, and
- Combine internal information around operations/operational revenue data to further improve future reporting

## AI. Out-of-the-Box

With Digital Twin AI based Advanced Predictive Analytics, we are set up to truly benefit you. You can say we're simply out-of-the-box. First, Prediction AI will give you forecasts not only for regulatory compliance but also for budgeting, logistics and planning. Then, Anomaly Detection AI will make Preventative Maintenance become planned with a predicted and prioritized task lists of failures and degradations, based on their exact revenue impact. You will know exactly what to do to improve your portfolio's profitability, and what is worth doing first. Quadrical's Audit identifies losses with granular bucketization, and catches faults, failures, and degradations with much higher accuracy than traditional approaches.

Built to Scale, Iterative system in a SaaS Cloud makes it Future-Proof. Fully Extensible. Open Architecture. Our Plant Audit is a Proof of Concept (PoC), that can show the "what" of your solar plant. It acts as your reliable decision support tool, which you can use to deep dive into plant - inverter - SCB - string level performance analysis, supported by lists of initial failures and degradations flagged by our Audit.

With this state-of-the-art performance analysis and revenue prioritized ticket lists, you not only save significant amount of time in finding the right issues, doing root cause analyses and foreseeing impending failures, but also achieve O&M targets faster, as you proactively act on the issues.

Working with us means true data-driven decision making due to significantly improved data quality available in RealTime.

With time intrinsic learning capability of our Digital Twin algorithms allows our CMMS to provide more clarity on the types of issues, failures, and their root causes.

# Add-Ons to Digital Twin based CMMS

## Forecasting

Accurately forecasting future production with > 98.4% accuracy in head-to-head tests.

Digital Twin powered forecasted generation (> 98% daily accuracy in head-to-head tests): intra-day, day(s) ahead, week(s) ahead

- Optimized database tailored to every required location, based on globally available forecasts & weather data
- Ensemble multiple weather providers for converting yield models into final yield

- Storage, Trading and Pricing Optimizations for stronger internal planning and regulatory compliance

**Available ONLY as Add-On to Centralized Cloud Data Platform and RealTime Monitoring**

## Remote Operations Center (ROC)

Optimize O&M strategy and on-field execution by giving Quadrical responsibility for overall efficiency and impact.

ROC team supports 24/7, 365 days with continuous RealTime monitoring, in-house performance engineering and proactive services.

- Triage issues: Analyze ticket generated by our rules based and AI system to ensure 100% accuracy / confidence
- Coordinate ticket execution and follow-up for fixes, with site O&M teams
- Post fix follow-up to capture appropriate failure modes, for future prevention

We leverage learnings, live-site QA, operations and customer feedback - to iteratively tune site configurations for KPI improvements.

Scope limited to tickets captured in Quadrical Centralized Management Platform.

**Available ONLY as Add-On to Centralized Cloud Data Platform and RealTime Monitoring**

# Why Quadrical

## Proprietary Digital Twin Technology

**Personalized understanding of a plant's exact yield potential:** Extremely accurate, granular (PR/efficiency) expectations from each instrumented device, at any location, weather condition, & time

**Predictive capabilities:** Error-free, highly accurate O&M guidance that starts with pinpointing underperformance & root causes

**Specialized Digital Twins** purpose-built separately for identifying and quantifying shading, soiling, insulation, ground-faults, long-term degradation, due diligence, classifications etc.

### Condition based Monitoring

Degradation & Anomaly Detection

Better planning + Revenue prioritized execution

### Optimized Tickets

Condition based Monitoring, Alerts + Predictive Maintenance

Prioritization & dispatch based on revenue impact, distance clusters & ticket count

### Remote Operations Center (ROC)

Quadrical to manage ticket execution/closure directly with site O&M

## Fast Onboarding

Hit the Cloud running with **speedy and smooth onboarding**. Seamless integration with your current systems. **Plug & play cloud Products and Services** to swiftly integrate across portfolios of all sizes. Quadrical Ai Integration team is the fastest in the business with an average of ~1 GW installed in ~30 days

## Immediate Value & ROI Gains

Strong experience in establishing secure remote connections (>400 different types) to the full spectrum of manufacturers of renewable assets, associated devices and CMMS

## Standardized Data Migration Process

Independent of plants' hardware infrastructure and PV monitoring solutions. Flexible backbone architecture and technical expert support to surface RealTime current snapshots of portfolio performance, up and running on a custom-built dashboard

## Ease of Deployment

Platform fully compatible with all inverter, data-loggers, DAS, FTP and SCADA systems

## Cutting-Edge Satellite Weather Integrations

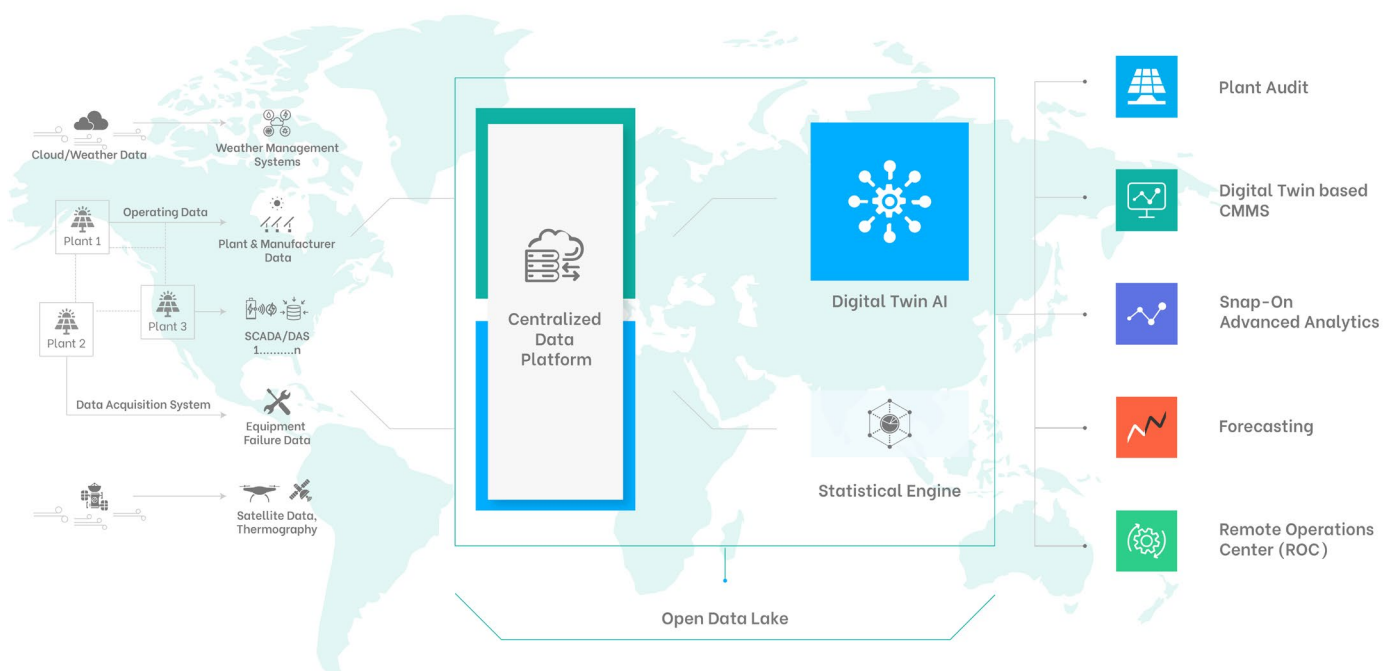
Alleviates need for (& quality issues from) weather station

## Reporting Extensibility (via Power BI, Notebooks)

## Active Innovation Roadmap

Near-term roadmap includes Storage Analytics and Renewable Energy Certificates:

- Satellite Imaging - University of Cambridge
- IoT Soiling Platform - University of Waterloo
- iREC platform
- Utility Scale Storage





# Our Clients say...



**James V Abraham**  
(Founder and Director - SolarArise)

We worked with Quadrical to build a data platform, consolidating our plant data onto a common schema. Quadrical built out the schema with AI capabilities to help O&M teams to identify and rectify anomalies, prioritised by revenue impact. There are many players who claim capabilities and tools in Artificial Intelligence, but none have the true depth of technical abilities that Quadrical brings to the table.



**Ramesh Kumar Modalavalasa**  
(Business Head - O&M, Vikram Solar)

As we onboarded 25 plants with Quadrical in 45 days, we've been impressed with their ability to fully own data quality and connectivity. With advanced Analytics-as-a-Service, we're already seeing the benefits with insights available for our operations team to identify the plant performance issues and possible breakdowns proactively. I am now confident that this platform has the potential to transform the way we do our operations. Look forward to us optimize our entire 100MW+ portfolio while monitoring it in near RealTime.



# Our Founders



Sharat has been a Global VP at Adobe Global, CTO at MMT (MakeMyTrip), and MD at Scale-Ups, prior to a career in the US with startups and companies like Microsoft. His sweet spot is building teams which do great things together and passion is making the benefits of AI and Big Data available to everyone. Sharat did his B. Tech at IIT Delhi, with an MBA from New York University.



Hugh has most recently been the CEO at Cognitive Systems, a hardware startup. Prior to that he was a VP and early employee at Blackberry, and is one of the people responsible for their superior security reputation. His interest in AI goes back to being a PhD student at Cambridge University. He also has an M. Eng from University of Waterloo.

