



Renewable Hybrids GE Renewable Energy

Tuesday, March 17, 2020

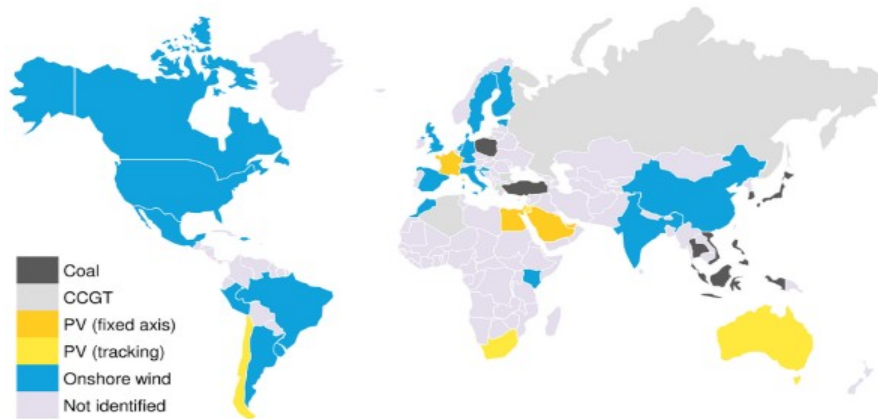


Luiz Fernando Biagini - Solar Sales leader LATAM

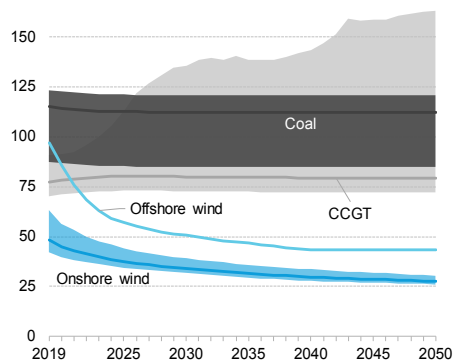
Renewable Energy is Mainstream

WIND & SOLAR CHEAPEST ENERGY SOURCES FOR 2/3 OF THE WORLD

Most competitive source of new bulk generation in 2019

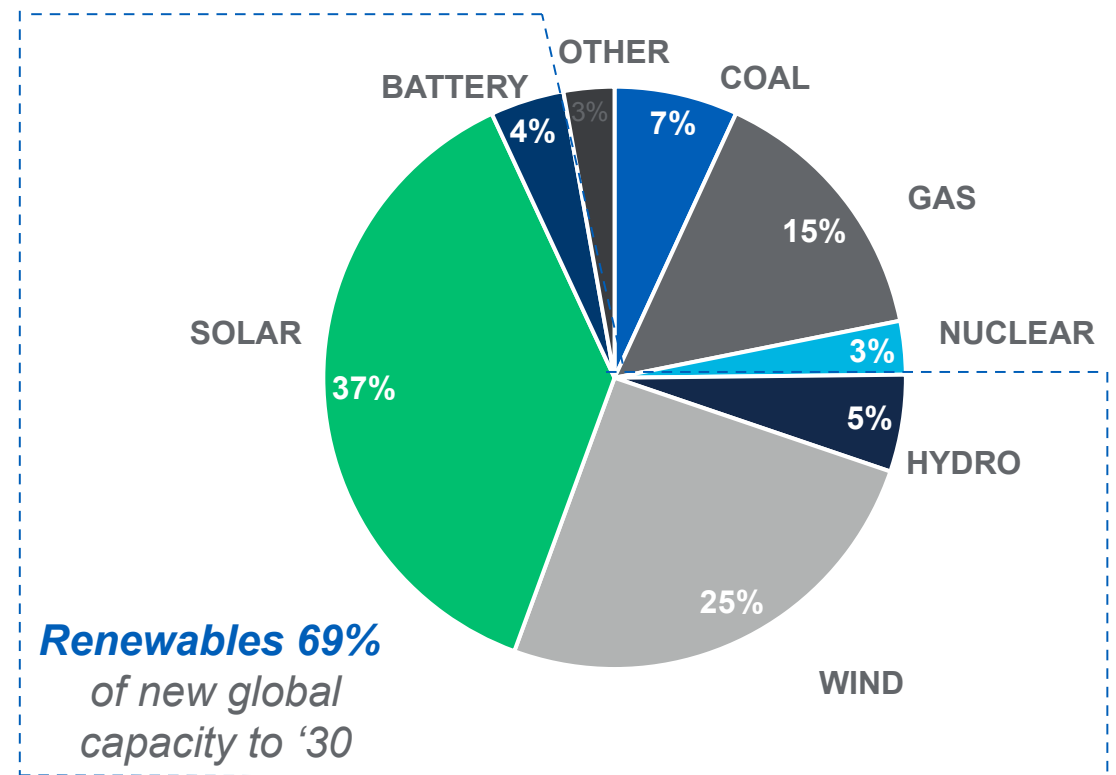


Wind and Solar projected LCOE (\$/MWh, 2018 real)



WIND, SOLAR & STORAGE INSTALLS CONTINUE TO GROW

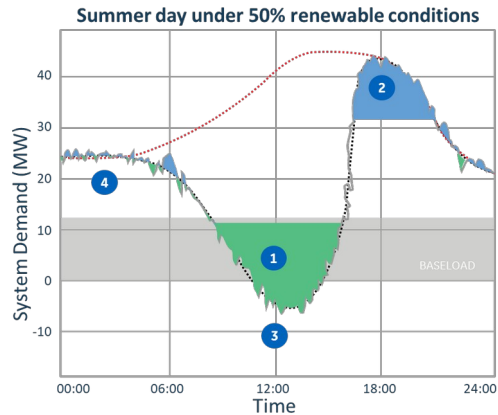
Projected Capacity Additions 2019-2030



Source: BNEF

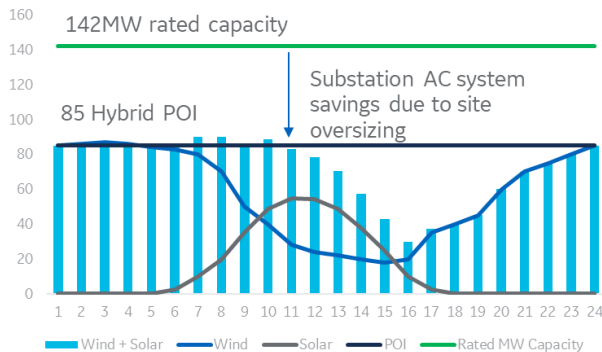
Increased RE penetration requires improved dispatchability, grid stability & efficiency/affordability that Hybrid Systems can provide

Integrating Storage



- 1 | **Renewables curtailed** - ES charged with free or negative priced energy
- 2 | **Peak Load** - ES discharged during peak demand
- 3 | **Spinning Reserve** – ES discharged during dynamic events
- 4 | **Frequency Regulation** – ES continuously charged and discharged to maintain grid stability

Integrating Wind and Solar



Leveraging complementarity of Wind and Solar to:

- Increase Capacity Factor
- Optimize EBOP and interconnection
- Optimize use of land
- Improve combined LCOE



Hybrids System Design Process

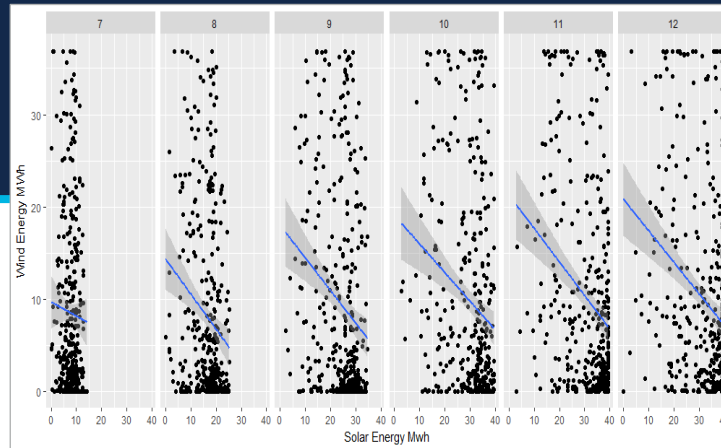
SITE CONDITIONS AND OPTIMIZATION RESTRICTIONS



- Resource data
- Topography
- Energy demand/load profile
- Restrictions: POI size, land availability, required return



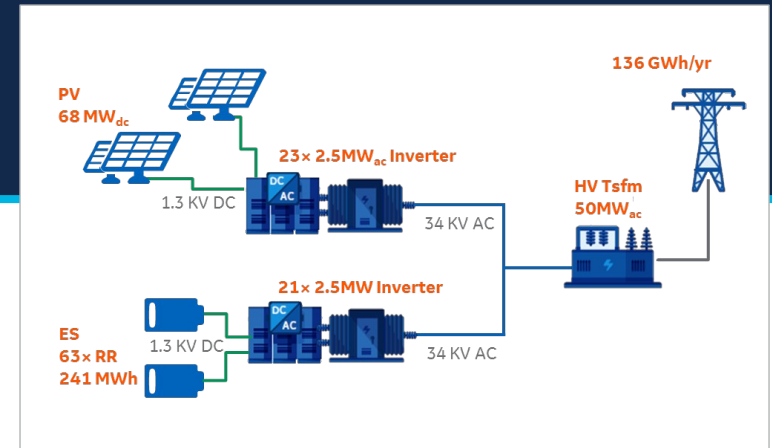
VALUE ANALYSIS



- Energy resource assessment
- Curtailment analysis
- Correlation analysis
- Economic evaluation
 - CAPEX Synergies
 - OPEX Synergies



OPTIMIZED HYBRID PROJECT

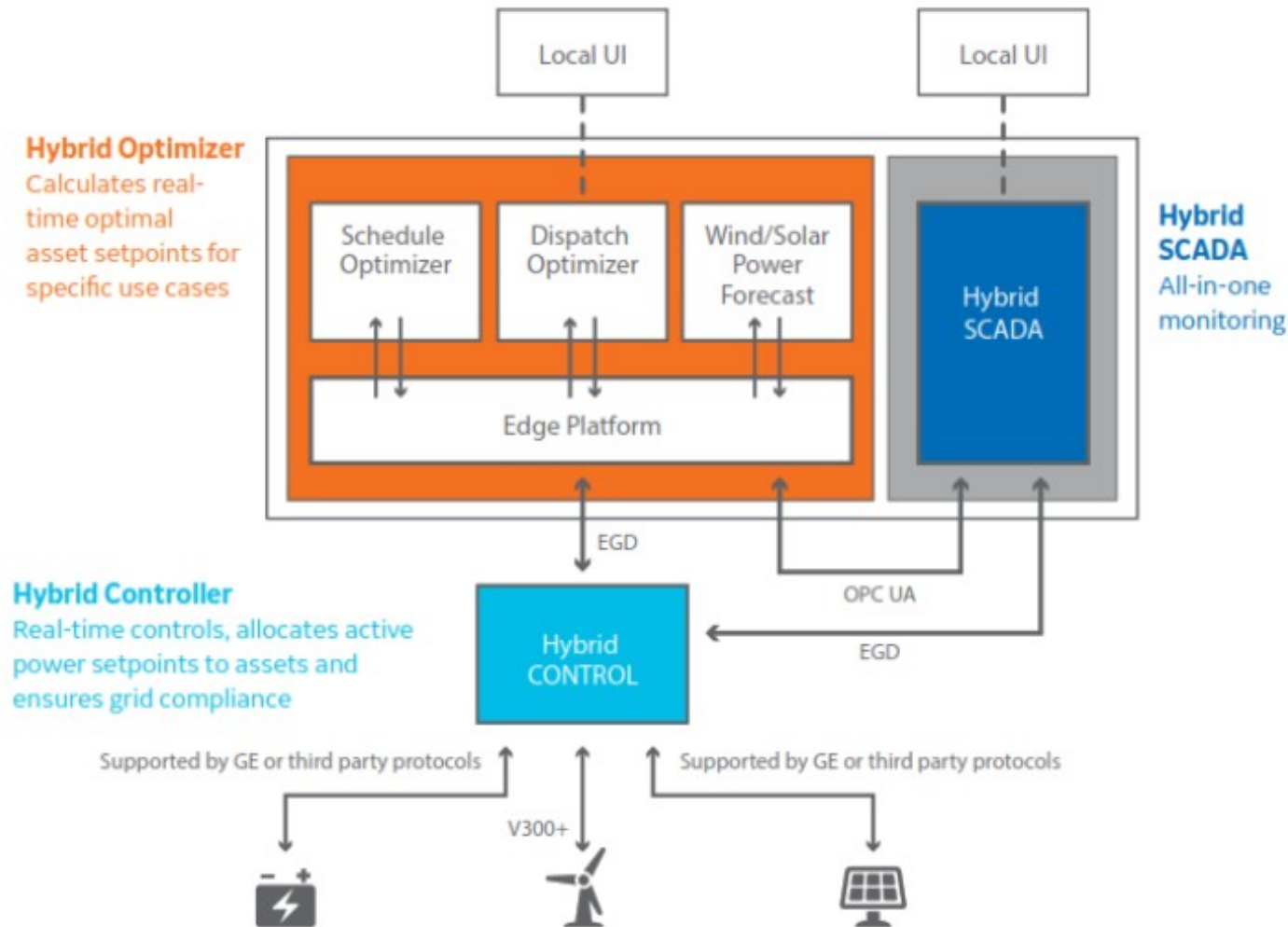


- Hybrids sizing
- System design
- Operational strategy

Continuous customer feedback



Hybrid Control Systems



The Hybrid Control System is a multi-layer supervisory controller by which co-located **wind, solar, storage** and/or other generation assets are **integrated at the farm level** to meet their **desired use cases** e.g. power firming, load following and energy shifting.



GRID COMPLIANT



LOWER CAPEX & FASTER RESPONSE



FLEXIBLE

Integrated controls to maximize Customer revenue and/or battery life



GE has all the components to play in Hybrids



Value
Modelling



Control
s



Digital
Service
s



Grid
Solution
s



Wind



Hydro



Solar



Hydro
Pumped
Storage
(PSP)



Battery
Energy
Storage
(BESS)

ENABLERS

RENEWABLE SYSTEMS

STORAGE SYSTEMS

GE PARTNERS

- GE Power
- GE Global Research Center
- GE Energy Consulting
- GE Energy Financial Services

How?

- Hybrid site configuration, design, engineering, optimization
- Provision of hybrid hardware (wind turbines, solar modules, inverters etc.) and related operations & maintenance services
- Provision of engineering, procurement and commissioning services, when required
- Design of a Hybrid Controls architecture / GE Hybrid Controller incl. Hybrids Dashboard and reporting
- A single contract and set of guarantees



Solar Plant APM

*Improve Solar Asset Performance &
Reliability and Reduce Operating Cost & Risk*

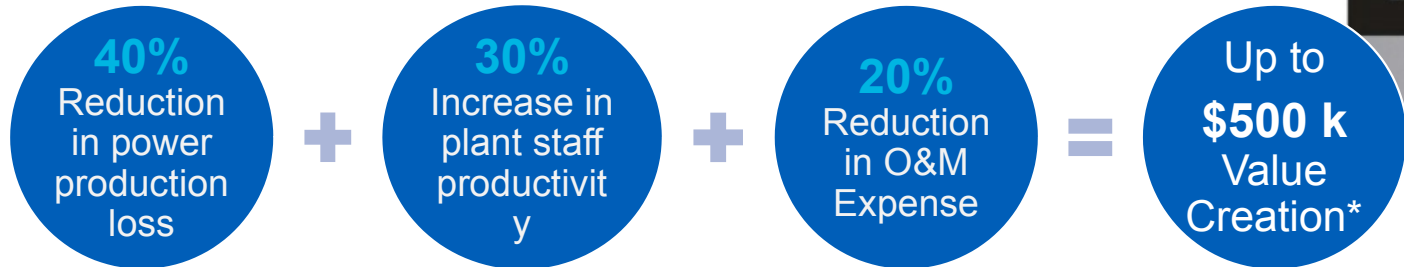
Solar Plant APM

Improve Solar Asset Performance and Reliability, Reduce Operating Cost and Risk

With power purchase agreement (PPA) prices dropping rapidly, reducing maintenance costs and maximizing power production is critical for PV plant profitability. How do you determine if your assets are performing at their full potential and what are the right maintenance strategies to sustain viable ROI for your PV assets and reduce operating risk

With GE's Solar Plant APM, you will be able to:

- Understand Performance Gaps
- Identify Areas for Improved Performance
- Adopt Predictive, Proactive Maintenance Strategies



*Based on a case study for a 100 MWac site at \$10k annual O&M cost, \$35/MWh PPA rate and other data sources

Solar Plant APM Features

OEM Agnostic Features

Connectivity & Data Management

- Connectivity solution
- Edge analytics
- Asset hierarchy
- Asset registry
- 2 Year Data storage
- Data mining and analysis

Monitoring & Diagnostics

- Persona-based dashboards
- Asset status and KPIs
- Condition monitoring
- Benchmarking
- Faults analysis
- Alert/Alarm management
- Case management
- Recommendation management
- Standard & Customized Reports

Advanced Analytics

- Comparative analytics
- Performance modeling
- Production loss breakdown
- Forecasting analytics
- Soiling analytics
- Optimized cleaning schedule

OEM Specific Features

Predictive Analytics

- IGBT thermal analytics
- Cooling system health analytics
- Capacitor lifetime analytics
- Predictive alert dashboard
- Predictive alert notifications
- Intelligent asset strategy

Product Offering Tier 1

Product Offering Tier 2



Predix Cloud

Mobility | Cloud Services & Applications | IT Security | Software Development Kit



Predix Edge

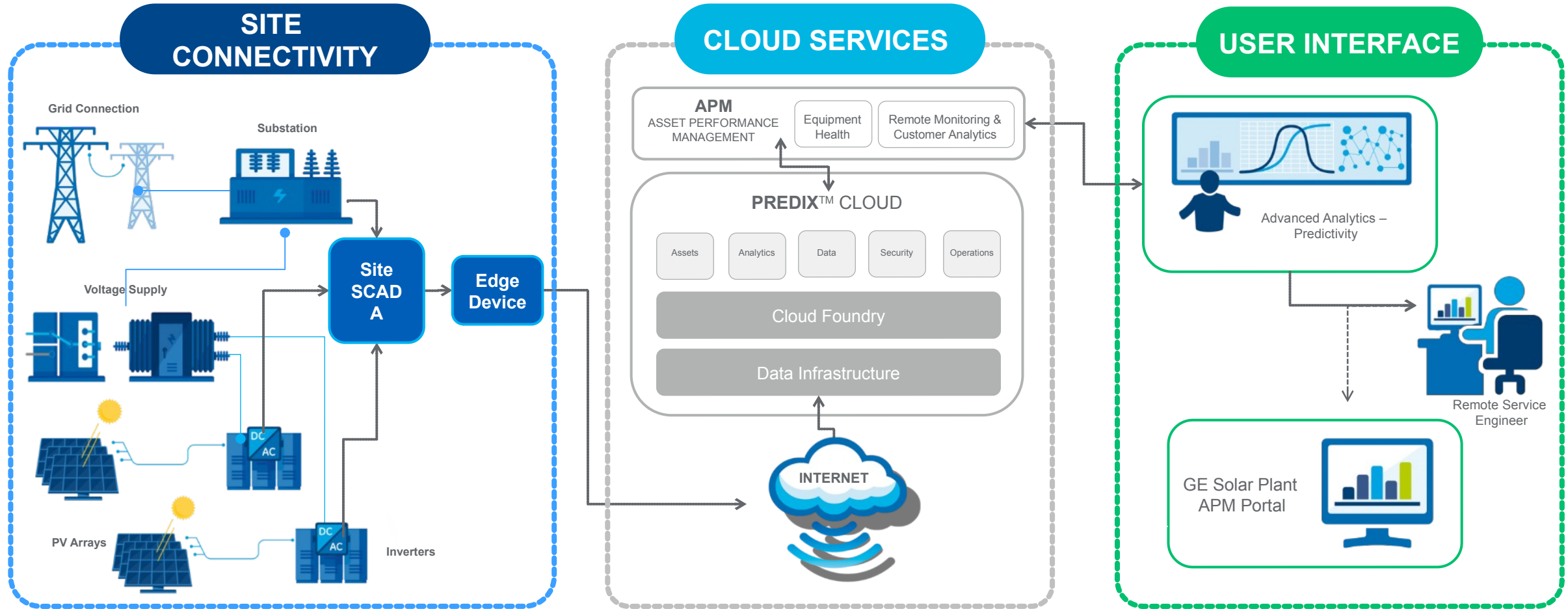
Optimizing Controls Applications
Edge Applications



Cyber Security

Identify | Defend | Protect

Connectivity Architecture



Solar Plant APM

Understand Performance Gaps

Solar Plant APM performs analysis on digital twins of site assets in real-time to determine deviations from expected KPIs at any operating point and environmental condition.

40%

Reduction in power production loss



Solar Plant APM

Identify Areas for Improved Performance

Machine learning-based signature detection algorithms automatically quantify and categorize each cause of production loss, providing insight to enable better maintenance strategies.

~70% of the utility-scale power plants production loss is due to inverter failure*

40%

Reduction in power production loss



*Data from NREL PVQAT TG 11 PV Systems - Subgroup on Power Electronics



Solar Plant APM

Adopt Predictive, Proactive Maintenance Strategies

With the use of machine learning, as data is processed, alerts are generated well before component failures, reducing unplanned downtime and costly emergency repairs.

Total O&M cost: 6k/MW/year - 10k/MW/year*

30%

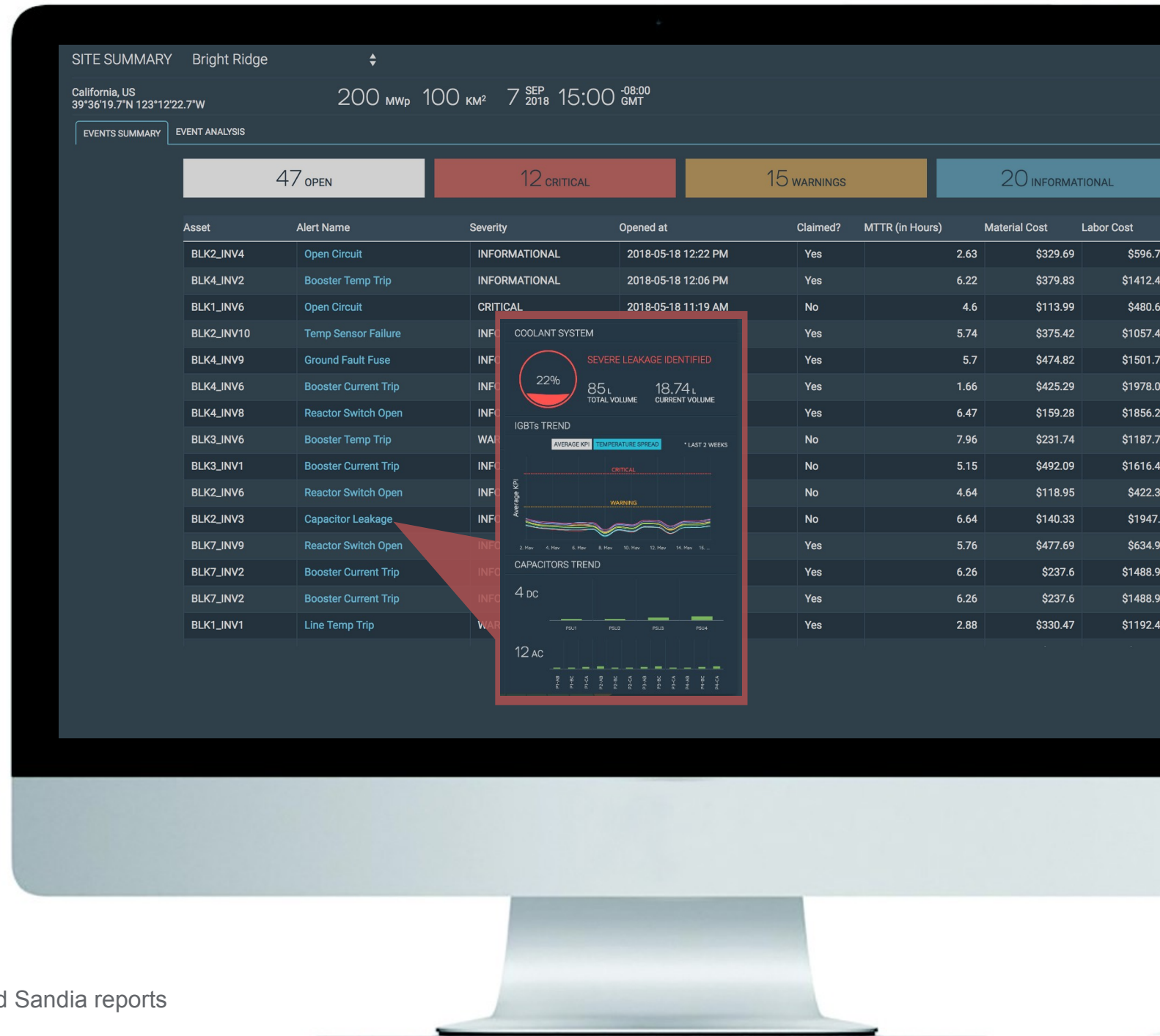
Increase in Plant Manager productivity

20%

Reduction in O&M costs



*Data from US Department of Energy, GTM, EPRI and Sandia reports



Solar Plant APM Predictive Analytics

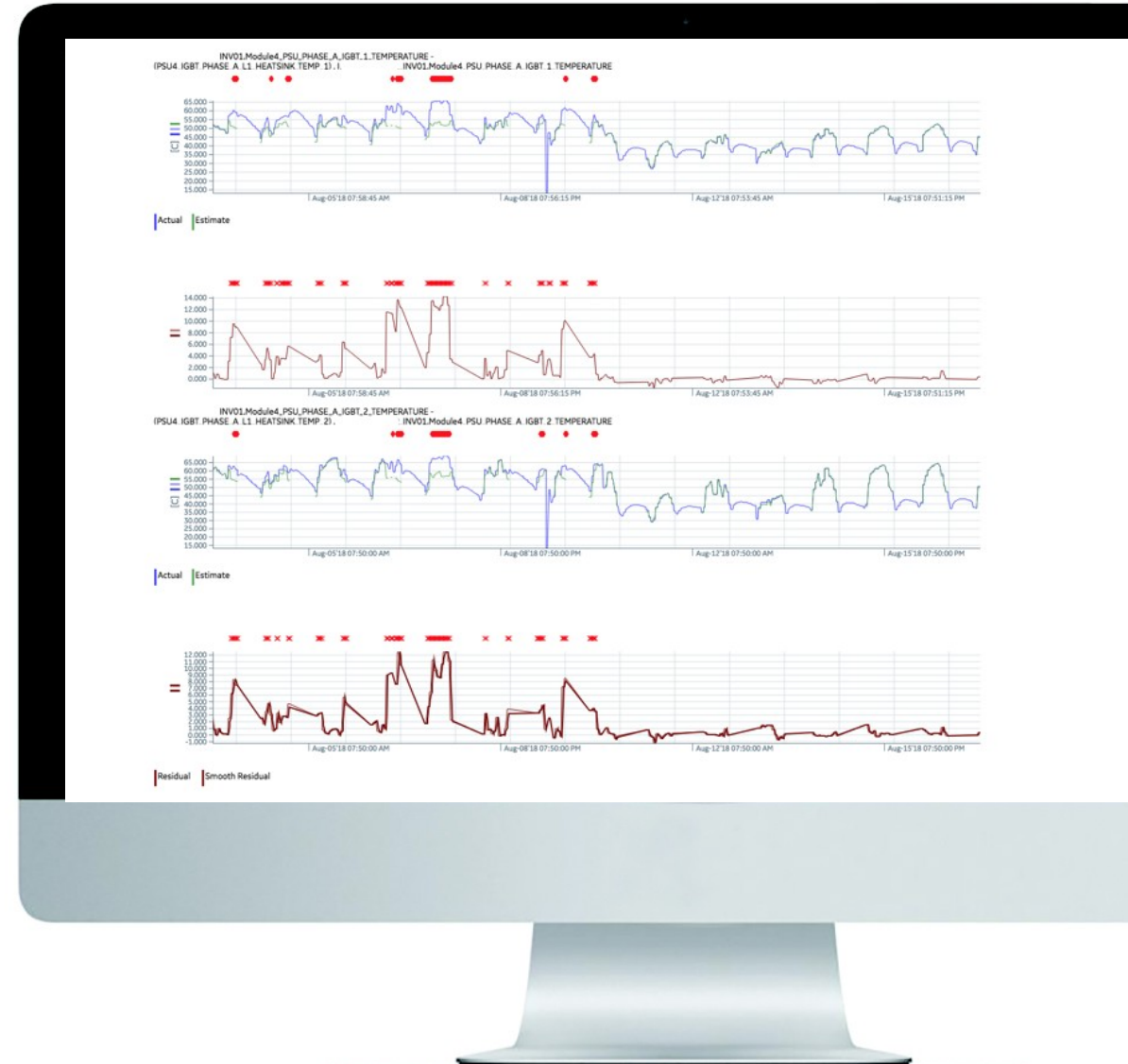
Eliminates unplanned downtime, optimizes maintenance
Increase revenue and lower O&M costs

Cooling system health

- System alerts on **Day 0**
- Severity increases on **Day 79**
- Inverter fixed on **Day 112** ← de-rated for **33 days**

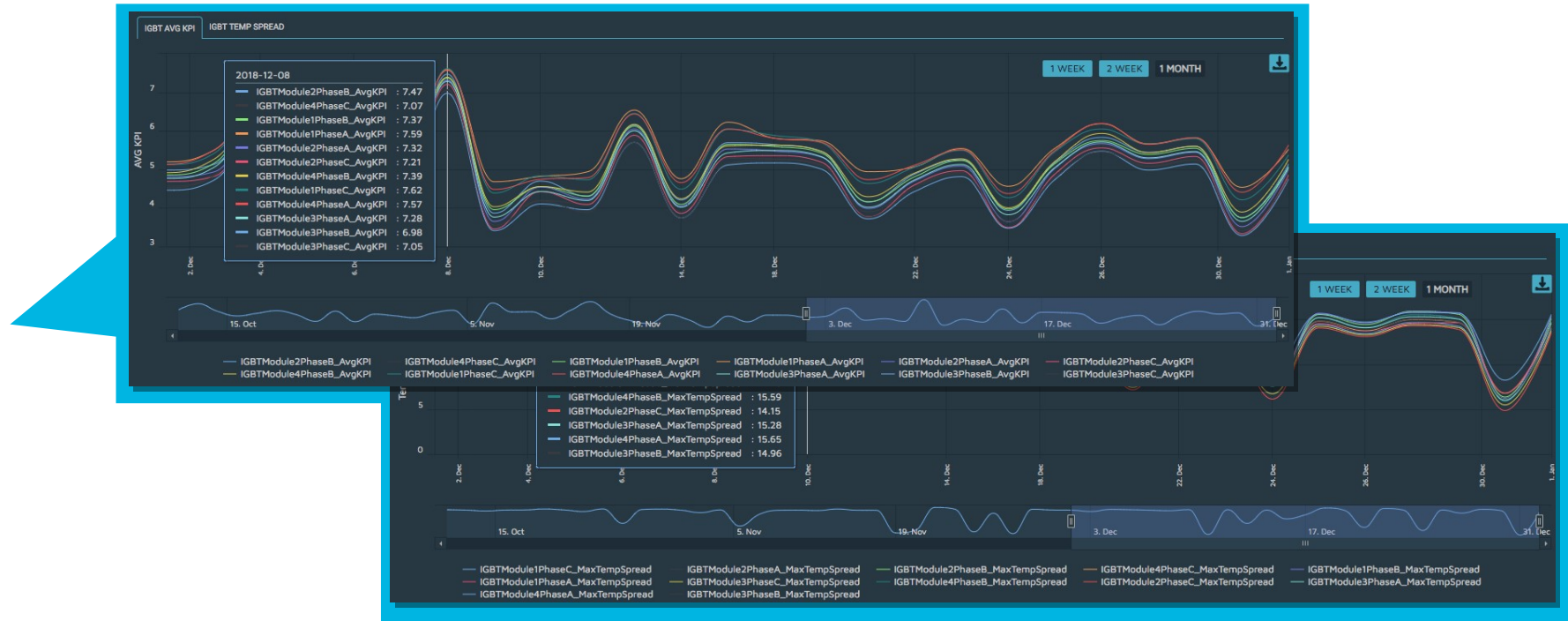
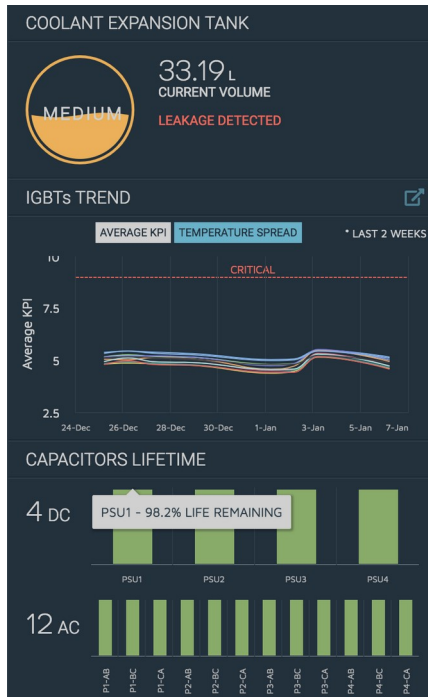
IGBT Heat Stress

- System alerts on **Day 0**
- Severity increases on **Day 16**
- Inverter derated on **Day 50**



Solar Plant APM Predictive Analytics

Eliminates unplanned downtime, optimizes maintenance
Increase revenue and lower O&M costs



Predictive Analytics Covered (specific to GE inverters):

- AC Cap lifetime
- DC Cap lifetime
- IGBT overheat
- IGBT lifetime - thermal cycles
- IGBT lifetime - power cycles
- Coolant leakage
- Low coolant volume
- Inverter Efficiency or Performance Problem
- DC Cabinet Cooling Problem
- Loss of AC power output
- Loss of DC Power
- AC Cabinet cooling problem
- AC reactor winding Temperature problem
- Auxiliary Problem
- Overcurrent Problem
- Phase Current Imbalance
- Line Current Imbalance
- Power Electronics Issue



