THE SMART EMS
FOR THE
SMART DATA CENTERS

Prepared by: Kumar M
13 May 2025

INDEX

Abbreviation

Acronym	Full Form
AGC	Automatic Generation Control
BESS	Battery Energy Storage System
DG	Diesel Generator
EMS	Energy Management System
ESG	Environmental, Social, and Governance
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine
IEC	International Electrotechnical Commission
IP	Internet Protocol
ISO	International Organization for Standardization
IT	Information Technology
KPI	Key Performance Indicator
MG Project	Microgrid Project
PCS	Power Conversion System
PPC	Power Plant Controller
PQ	Power Quality
PQM	Power Quality Meter
PUE	Power Usage Effectiveness
PV	Photovoltaic (Solar)
Q(V)	Reactive Power vs. Voltage Droop Control
RBAC	Role-Based Access Control
RE	Renewable Energy
SCADA	Supervisory Control and Data Acquisition
SCSADA	Secure SCADA (Contextual term; ensure this is not a typo)
SGA	Smart Grid Analytics
SLA	Service Level Agreement
SOC	State of Charge

TCP/IP	Transmission Control Protocol / Internet Protocol
Tier III	Uptime Institute Tier III Data Centre (Concurrent Maintainability)
Tier IV	Uptime Institute Tier IV Data Centre (Fault Tolerant)
UPS	Uninterruptible Power Supply
VSG	Virtual Synchronous Generator

1. SUMMARY

Data centers in today's digital economy can't afford to have any downtime whatsoever. Increasing environmental laws, financial concerns, and the requirement for real-time adaptation are posing new challenges to the traditional backup infrastructure, which consists of uninterruptible power supplies (UPS) coupled with diesel generators (DGs).

An Energy Management System (EMS) integrated with a Power Conversion System (PCS) and Battery Energy Storage System (BESS) was successfully implemented by a leading micro-grid project in the Kingdom of Saudi Arabia (MG Project) using Smart Grid Analytics' (SGA) controller architecture. The end result is an optimal backup solution for contemporary data centers that is entirely robust, integrates renewable energy, and interacts with the grid.

2. PROJECT OVERVIEW

Solar photovoltaic (PV) arrays, combined with internal combustion engines (ICEs), third-party energy management systems (EMS) which is supplied by a Vendor with PCS and BESS, and power point converters (PPCs), as well as several grid interconnection points across separate zones, necessitated a powerful controller for the MG Project's hybrid power system.

SGA's responsibility was to provide a controller platform that could coordinate the real-time distribution of energy, function in both grid and island modes, predict the future one day in advance, and interact without any hitches with diverse assets.

3. ARCHITECTURE & FUNCTIONAL OVERVIEW

Layer	Components
Physical Layer	PV, BESS, ICEs, PQMs
Control Layer	SGA EMS + PCS Logic, SCADA
Communication Layer	IEC 61850, Modbus TCP/IP, IEC 104
Forecasting Layer	Load, PV, SOC prediction logic
Resilience Layer	Islanding, Black Start, VSG switching

Important Building Blocks

1. Day-Ahead Scheduling:

EMS generated dispatch plans using PV forecasts (Digital Twin for Solar Power Plant—patented technology), load trends, and available SOC, dynamically updating for intraday changes.

2. Multi-Mode Power Flow Control:

Grid-connected: followed PQ set-points with AGC logic's.

Islanded: operated in autonomous mode, maintaining frequency & voltage using VSG droop logic.

Black Start: BESS or ICE initiated site recovery via SGA coordination.

3. Frequency Regulation Logic:

Primary by BESS with fast droop response.

Secondary by EMS using control curves.

Tertiary/AGC pulse control managed through forecast deviation compensation mechanism's.

4. SOC Alignment Post-Islanding:

Post-reconnection, SGA rebalanced SOC across micro-grids using planned import/export cycles. without risking overshoot.

5. Load Shedding & Prioritization:

Load hierarchy is managed via threshold logic and real-time SOC levels, with user-defined override zones.

4. RESULTS FROM MG PROJECT

Millisecond response times in islanded operations

1. Coordinated control of PV, BESS, ICE, and grid in multiple zones (each zone connected at a distance from the other zone). Every zone has a DG/ICE, BESS, and PV farm.)
2. Automatic black start sequencing and SOC reset logic. 3.
3. 25–30% fuel reduction during test cycles by shifting ICE runtime.
4. 100% EMS availability in all control modes

This validated the logic, stability, and deployment model for highly resilient, scalable infrastructure—exactly what future-facing data centres demand.

5. THE SIGNIFICANCE TO DATA CENTERS

The architecture proven at the MG Project is directly transferable to Tier III/IV data centre's, particularly those operating in -

- In areas with unstable grid supply
- Under stringent ESG mandates
- With a need for diesel-free backup architecture

Key Benefits for Data Centres

Functionality	Benefit
Instant Black Start with BESS	Zero switch-over time
VSG Mode	Inertia-like stability during outages
SOC Forecasting	Guaranteed runtime visibility
Load-Based Scheduling	Optimized energy use and reduced PUE
Island Mode Control	Autonomous operations with no human intervention
Regulatory Readiness	Eligible for green incentives, ESG scoring, ISO & Tier compliance

6. ADAPTATIONS FROM MG PROJECT

The architecture deployed in the MG Project is not only proven in a complex micro-grid environment but is also readily adaptable to mission-critical data centre operations.

Modern Tier III/IV data centre's require real-time power management, diesel-free resilience, and full SCADA visibility—all of which were implemented and validated through the SGA EMS + PCS + BESS platform.

Adaptation Framework: Data Centre Application

MG Project Element	**Data Centre Equivalent**
Solar PV Generation	Grid Power and or with Solar PV generation
BESS + PCS	Energy Storage + Fast Switching Backup
ICE (for peak shaving with DG Sync. Controller	Optional ICE or PCS + BESS with EMS Controller
EMS Controller	Already built in above.
SCADA Layer in EMS	Already built in EMS
Load Prioritization	Server Rack Tiering, HVAC, Fire/Access Control load domains

Power System Intelligence Integration

The SGA platform includes advanced power systems logic tailored for high-availability operations:

- Real & Reactive Power Set-Point Management via Droop Curves and Q(V) Logic.
- VSG control mode simulates inertia during islanding.
- AGC Set-Point Reception & Distribution in Grid-Supporting Configurations.
- Dynamic SOC Limit Management based on forecasted load, downtime exposure, and HVAC loads.

These features allow data centres to:

- Run autonomously during grid failure
- Seamlessly transition between UPS/BESS/ Mains or Grid
- Forecast runtime capacity based on IT and HVAC demand patterns
- Prioritize critical infrastructure (e.g., core server racks over low-priority loads)

Design Integration with Existing Infrastructure

1. Parallel with Existing UPS: BESS + PCS can be installed in parallel to existing UPS as a backup override or ride-through extension.
2. DG Replacement: DG's can be retained as tertiary backup or replaced entirely depending on ESG goals.
3. Rack-Level Coordination: SOC and dispatch logic can be informed by rack heat loads and IT task priority using BMS input.
4. Grid Interactive Mode: Participate in demand response or grid export for facilities with large RE/BESS systems.

Cybersecurity and Compliance

The system is IEC 62443-aligned, offering full:

- Role-based access control (RBAC)
- Patch management support
- Encrypted data exchange
- SCADA firewall segregation

This makes it compliant with ISO/IEC data centre standards, Tier certifications, and emerging ESG audits.

7. CONCLUSION: FUTURE-READY BY DESIGN

The MG Project in the Kingdom of Saudi Arabia, implemented by Smart Grid Analytics, demonstrates a clear and tested alternative to legacy UPS + DG power architectures. With the integration of EMS + PCS + BESS, this system provided sub-second backup response, multi-mode operation (grid-connected, islanded, VSG), intelligent dispatching, and cyber-secure SCADA control, all while maintaining uptime, reducing fuel dependency, and enabling predictive energy management.

This is precisely what modern data centers now require.

The increasing complexity of workloads, edge computing, and AI models calls for energy systems that are not just resilient but intelligent. Traditional DG systems, while reliable in the past, cannot meet the real-time demands, regulatory scrutiny, or carbon reduction targets of today's digital infrastructure.

By adapting the MG Project architecture:

- Data centers gain autonomous, fuel-free power continuity.
- Integrate easily into existing power systems and IT environments.
- Meet ESG mandates and green certification standards.
- Improve operational KPIs like PUE, SLA uptime, and carbon offset eligibility.

8. REINVENTING DATA CENTER BACKUP INFRASTRUCTURE

Whether you're operating a hyperscale cloud hub, a financial data center, or a Tier IV colocation facility, Smart Grid Analytics offers:

- A proven architecture
- A modular deployment framework
- A team with deep power systems and EMS expertise
- And a commitment to delivering clean, intelligent, and compliant energy orchestration

Let's reimagine your backup power system—diesel-free, delay-free, and future-proof.

End of Document