



GE VERNOVA

CYBER-RESILIENT CONTROL FOR THE DER-RICH ELECTRIC DISTRIBUTION SYSTEM

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GE Vernova Portfolio of Businesses: One-of-a-Kind



CONVENTIONAL POWER

Gas Power



- Heavy Duty Gas Turbines
- Aeroderivative Gas Turbines
- Steam Turbines/Generators
- Services

Steam Power



- Post Rochambeau
- US Nuclear, Global Coal
- Steam, Generators, Boilers
- Services

Hydro



- Hydro Turbines/Generators
- Pumped Storage

Nuclear



- Boiling Water Reactors
- Fuel
- Small Modular Reactors

WIND

Onshore Wind



- 2 -3.5 MW platform
- 5 – 6 MW platform
- Services & repowering

Offshore Wind



- Haliade-150 (6 MW)
- Haliade-X (14 MW)

LM Wind Power



- Onshore wind blades
- Offshore wind blades
- (Haliade-X)

ELECTRIFICATION

Grid Solutions



- Transmission
- Power Transformers
- Grid Automation

Power Conversion



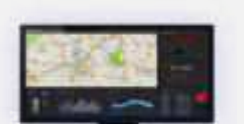
- Oil & Gas electrification
- Naval electrification
- Microgrids

Solar & Storage Solutions



- Inverter platform
- Energy storage system
- Plant controls

Digital



- Grid Software
- Opus One Platform
- Manufacturing
- Power, Oil & Gas

ACCELERATORS

Advanced Research

- Fundamental and applied research
- Funded internally and externally

Consulting Services

- Energy consulting services to GE Vernova & external customers
- PSLF platform owner

Financial Services

- 3rd party financing support e.g., Export Credit Agencies (ECAs)
- Direct financing through equity
- Tax equity (US)

Technology supports ~30% world's electricity

140+ Countries

80k Global Employees

GE Vernova participation in GFM related activities



Specification writing

- UNIFI GFM specifications
- NERC GFM BESS functional specifications
- GC0137 – precursor to Great Britain Grid Code
- IEEE P2988 Virtual Synchronous Machine
- Technical papers and publications

Membership in industry GFM forums

- UNIFI
- GPST
- ESIG

GFM DOE projects

- GRID-READY WIND (Award No. DE-EE0010652)
- GRID Services Demonstration of a hybrid (wind, solar, BESS) plant (Award No. DE- DE0009024)

Testing at National Labs

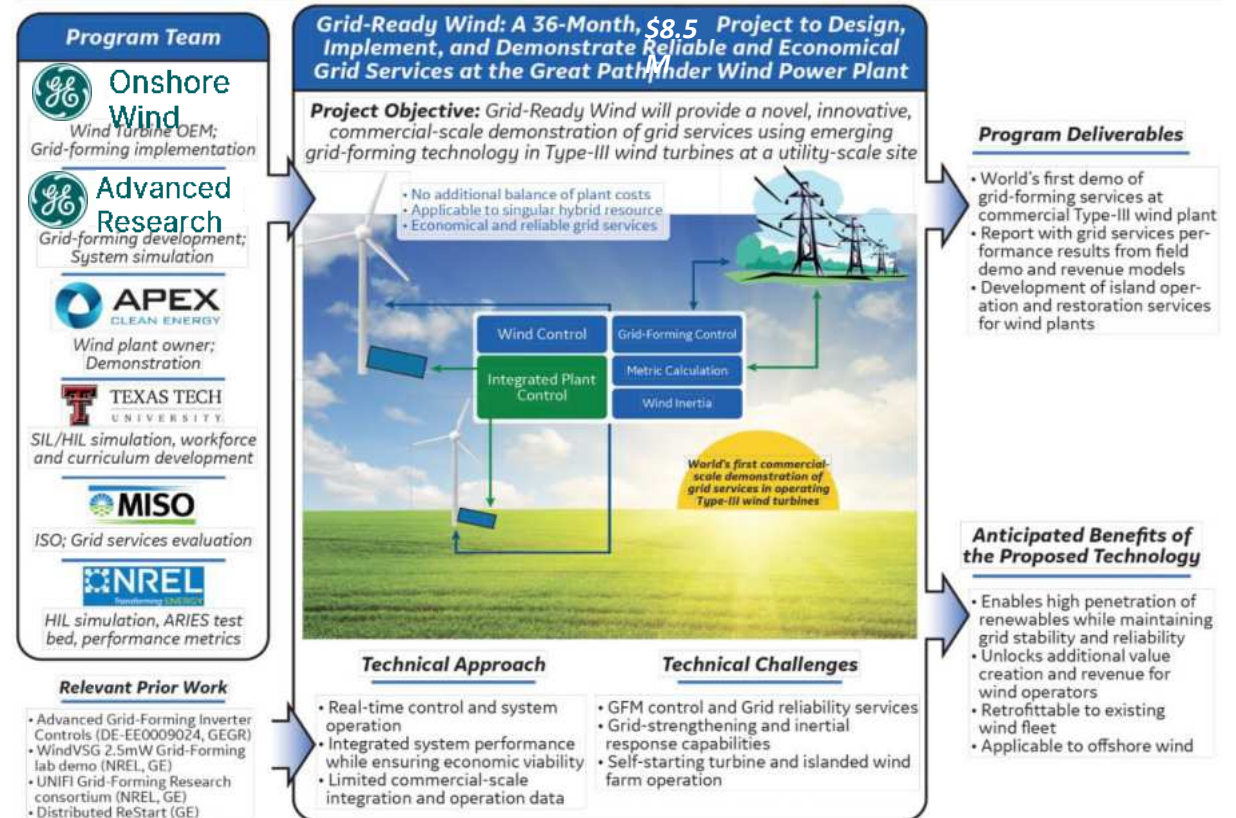
- NREL

GRID-READY WIND: Reliable and Economical Grid Services

Design, Implementation, and Demonstration at the Great Pathfinder Wind Power Plant

Project Impact

- Equipped and Empowered System Operators
- Risk mitigation and uncertainty management for resources dispatch and market product development for grid services
- Understanding of cost vs benefit of grid services from WPPs (GFL and GFM)
- Increased adoption of WPPs and standalone IBRs: removes instantaneous penetration limits imposed on WPPs
- Increased pace of decarbonization



World's first demonstration of grid-forming services at commercial Type-III wind plant

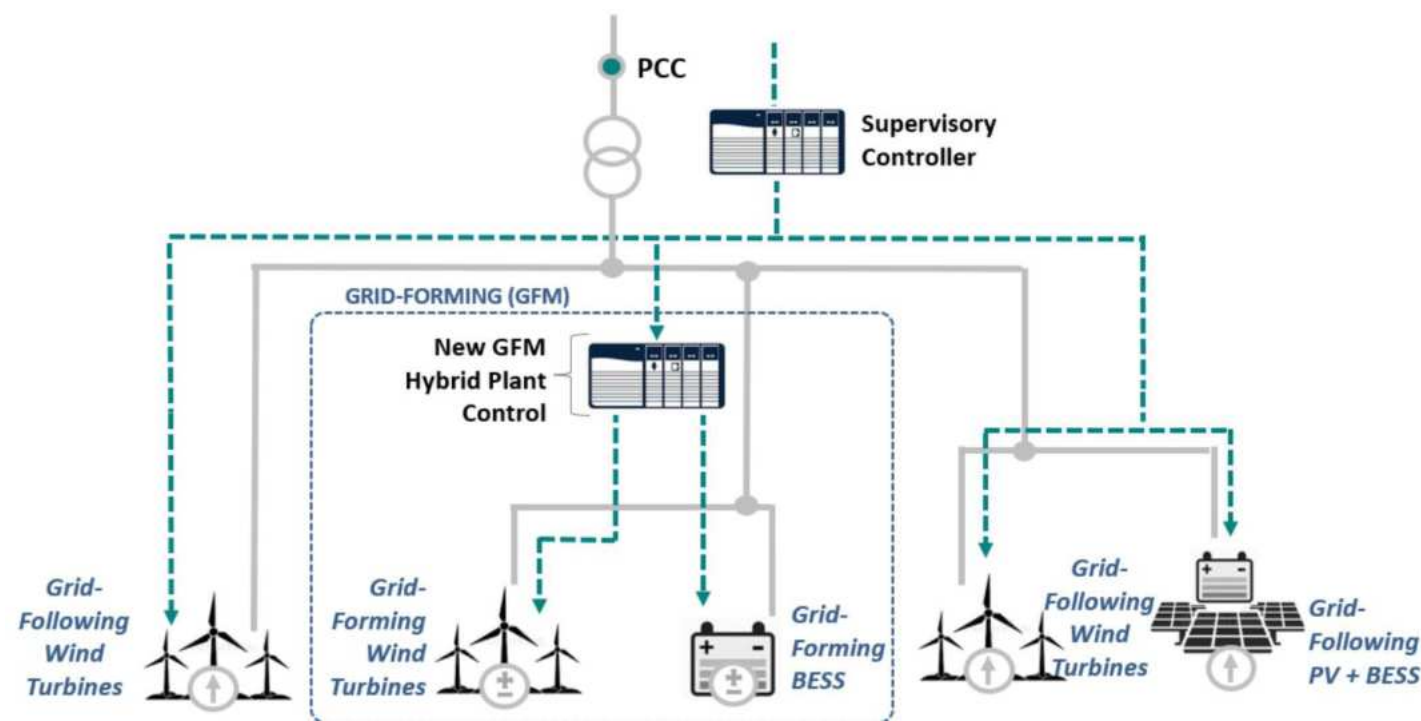
GE Demonstration of Grid Services by a 380 MW Wind, Solar and Battery Storage Combined Power Plant with Mixed Grid-Forming and Grid-Following Technologies

Team:

- Portland General Electric (**prime**)
- GE Research
- GE Renewables
- NextEra
- Bonneville Power Administration (BPA)
- Pacific Northwest National Laboratory (PNNL)
- University of Texas-Austin
- Portland State University

PGE/NextEra’s Wheatridge Plant in Morrow County, Oregon:

North America's first energy center to combine wind, solar, and energy storage systems (ESS) in one location, with 300 MW of wind, 50 MW of solar, and 30 MW of ESS. Jointly owned by PGE and NextEra



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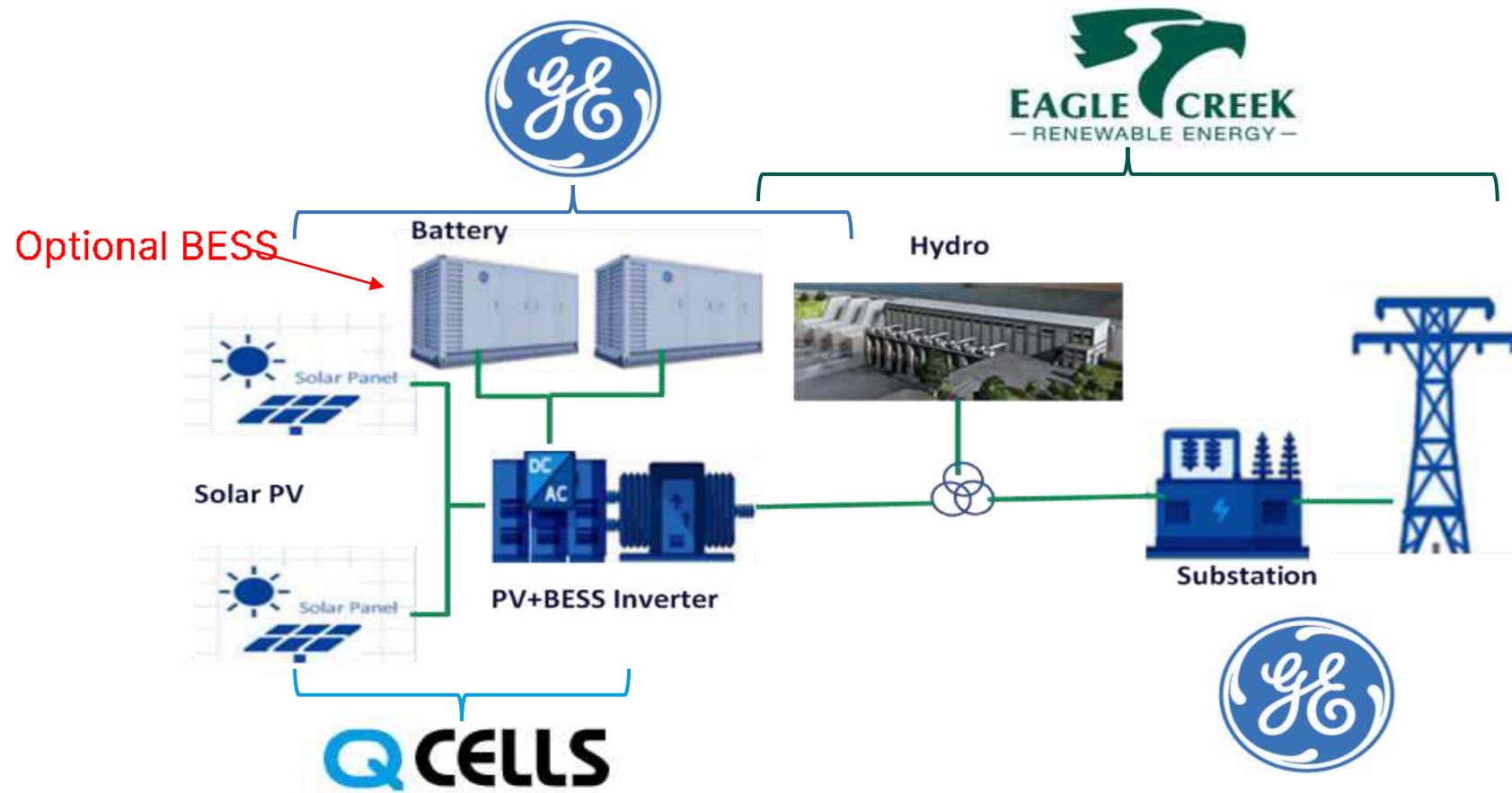
Increasing Renewable Generation and System Reliability through Coupling PV and Hydropower



Presenter: Arvind Tiwari

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Hybrid Plant Architecture



Multi-disciplinary team is architecting building blocks to evaluate and demonstrate at scale a robust, reliable and cost-effective PV/Hydro Hybrid System (PHHS).

Location



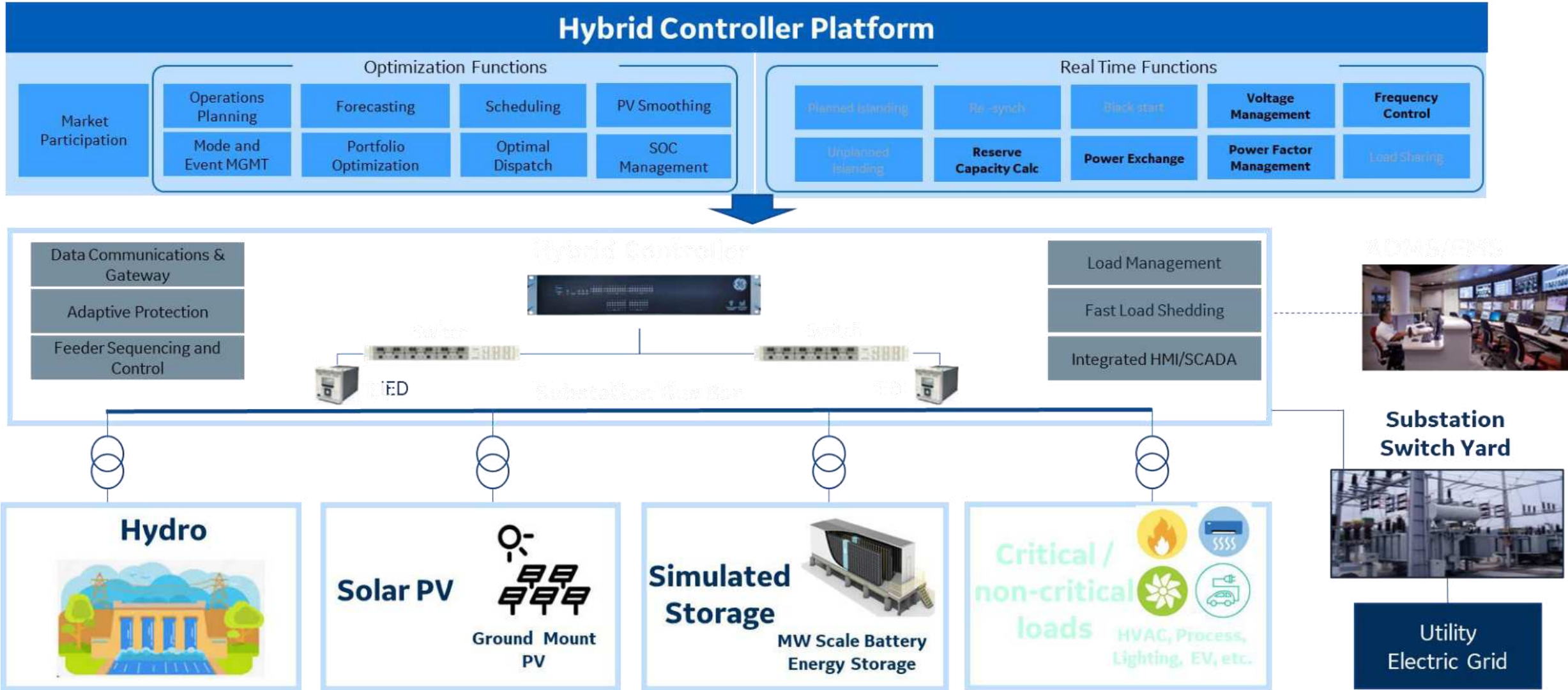
- Yadkin Project, a series of four hydroelectric stations, dams and reservoirs along a 38-mile stretch of the Yadkin River approximately 75 miles outside of Charlotte, North Carolina.
- The four stations are High Rock, Tuckertown, Narrows (Badin Lake) and Falls.
- The chosen station is Tuckertown



- Tuckertown is a 38.04 MW facility
- Commercial operations began in 1962
- It has three 12.68 MW Kaplan turbines



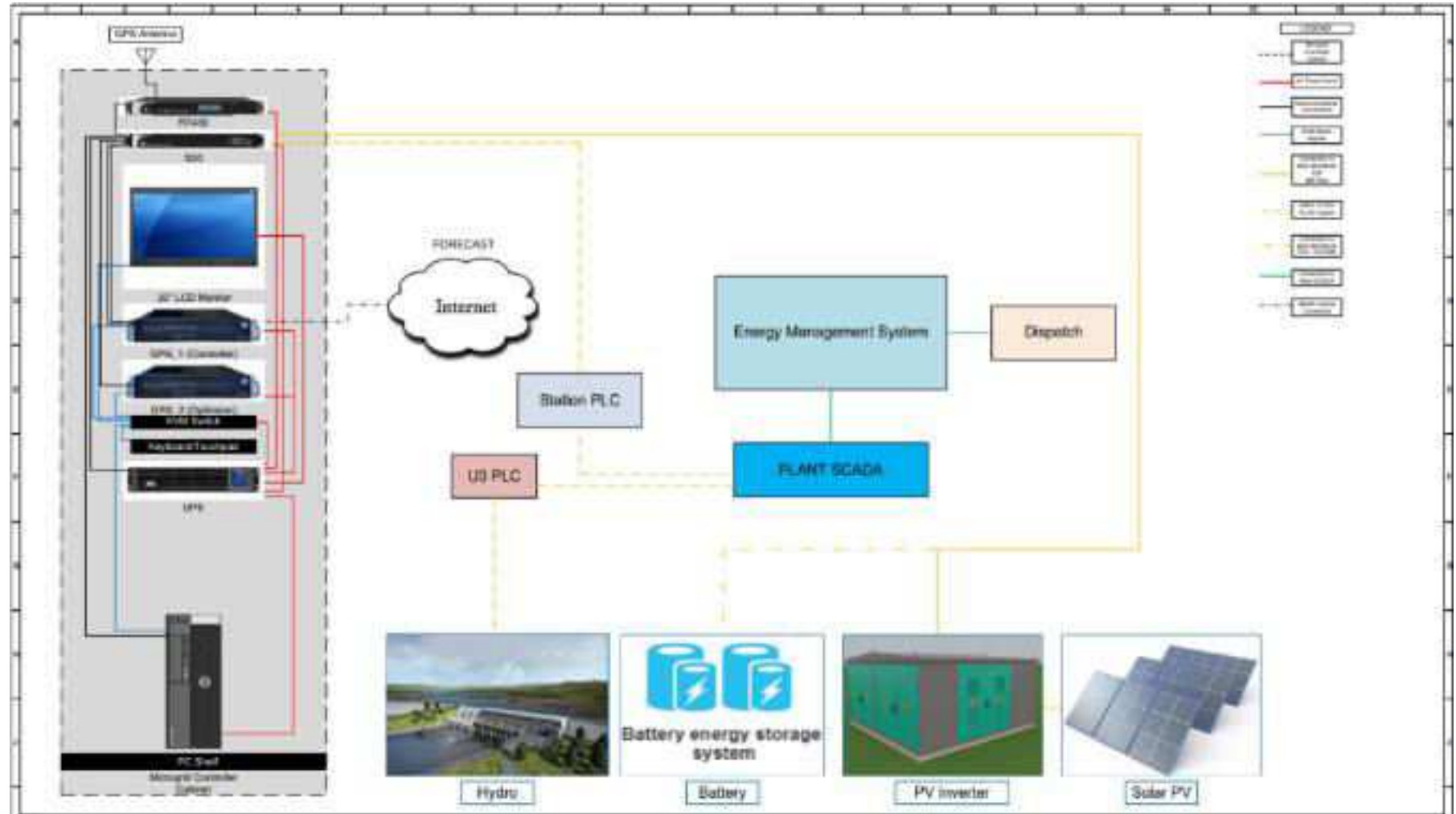
Down Selected Hybrid Controller Overview



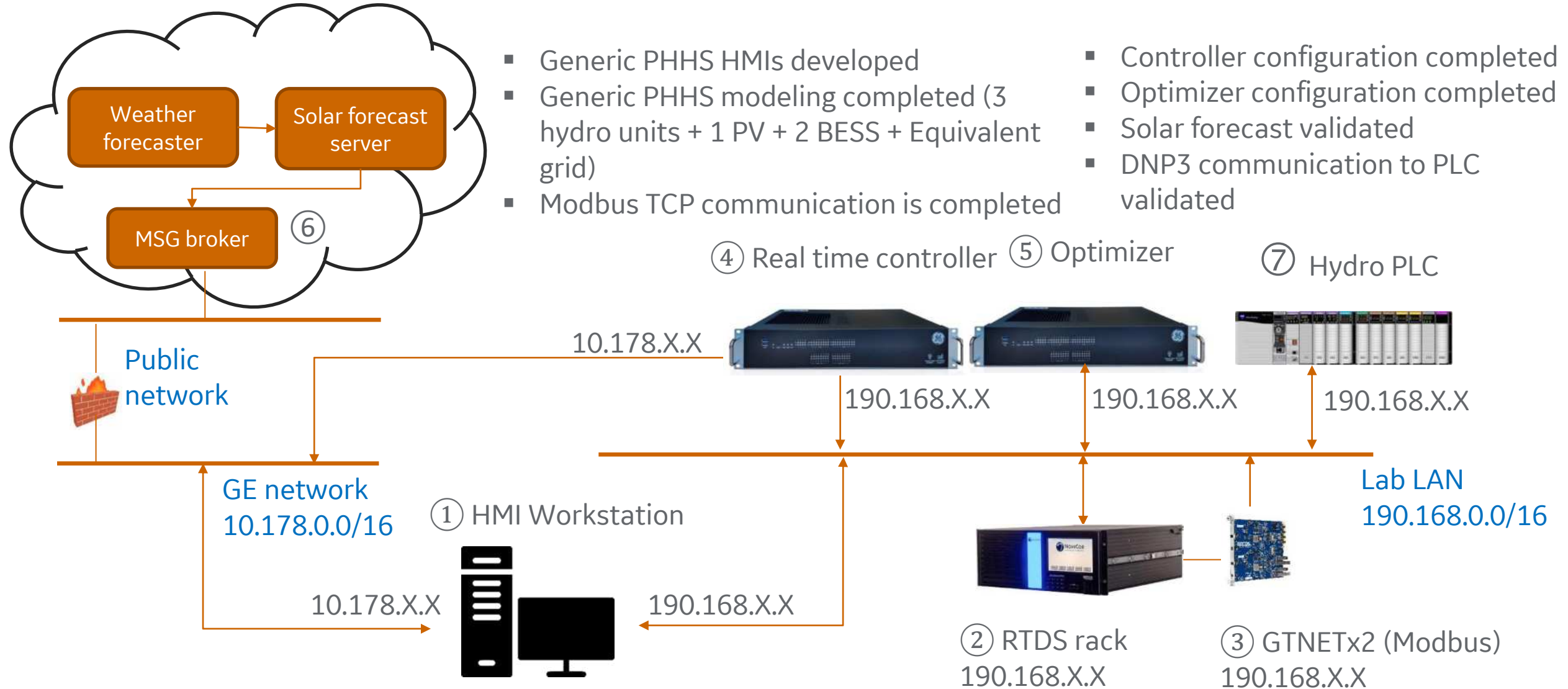
Controller provides fundamental communication and control capabilities and additionally, offers high flexibility and scalability to customize the plant control for PHHS.

On site installation

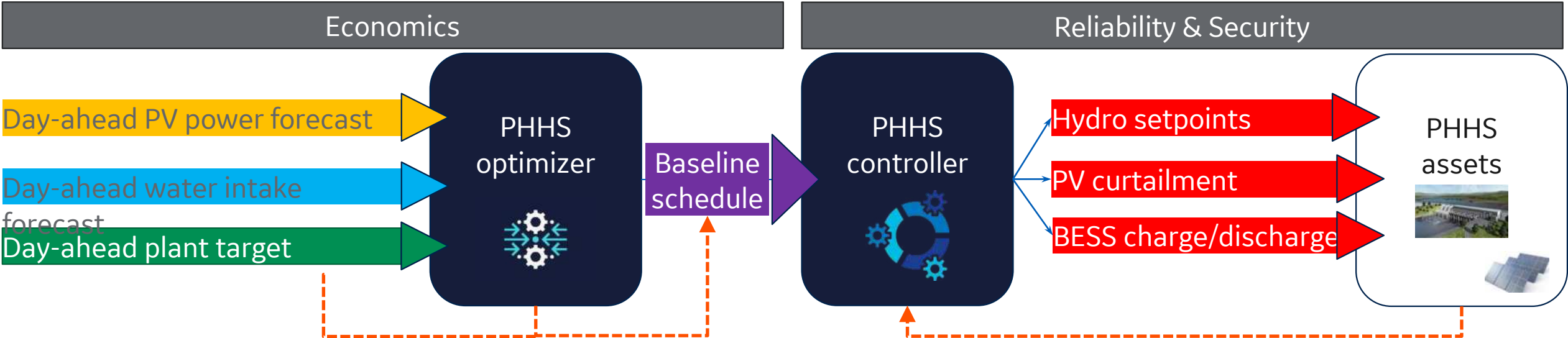
- Isolated from NERC CIP network
- Non routable DNP connection
- Data configured on both sides of DNP connection
- Secure VPN remote access
- GE OT network restricted to MQTT and VPN server.



GEV ARC CHIL Lab Validation Update



A Global Optimizer + Real Time Controller Solution



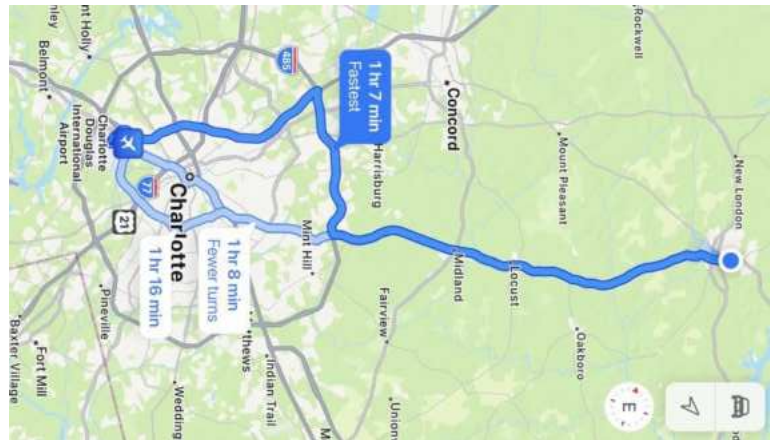
Updated every 15min

Real time monitoring

Atlas

Map Quest

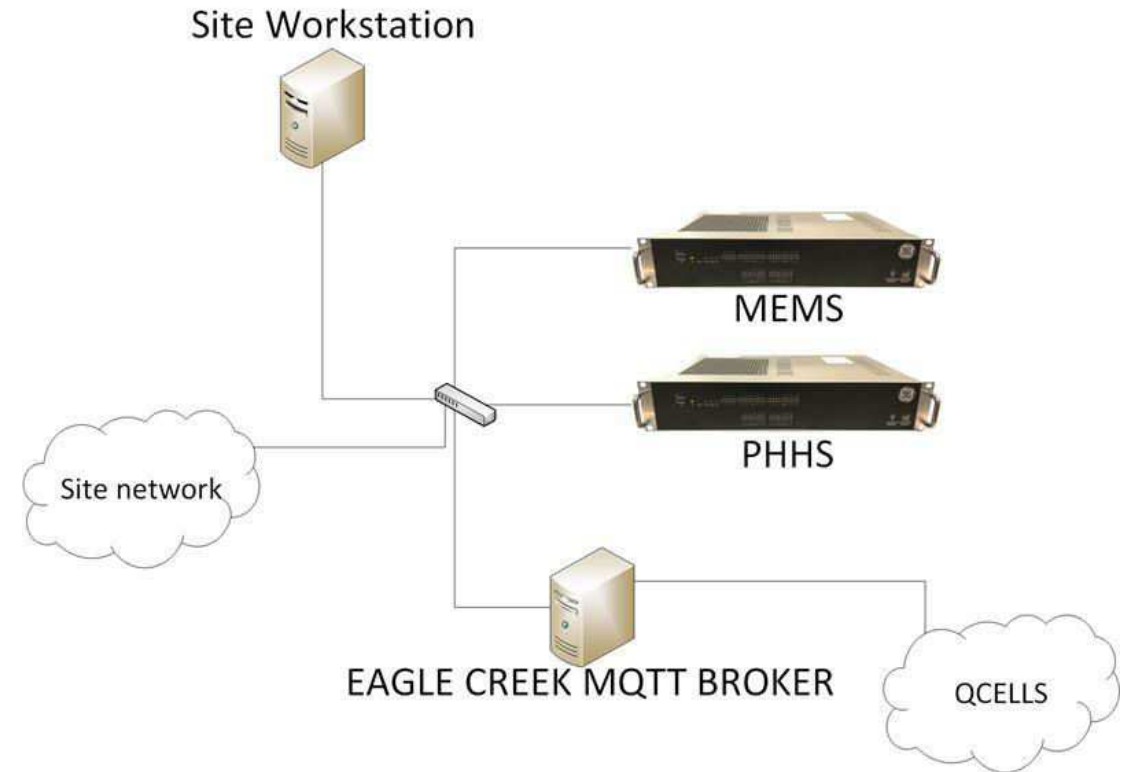
Waze plus



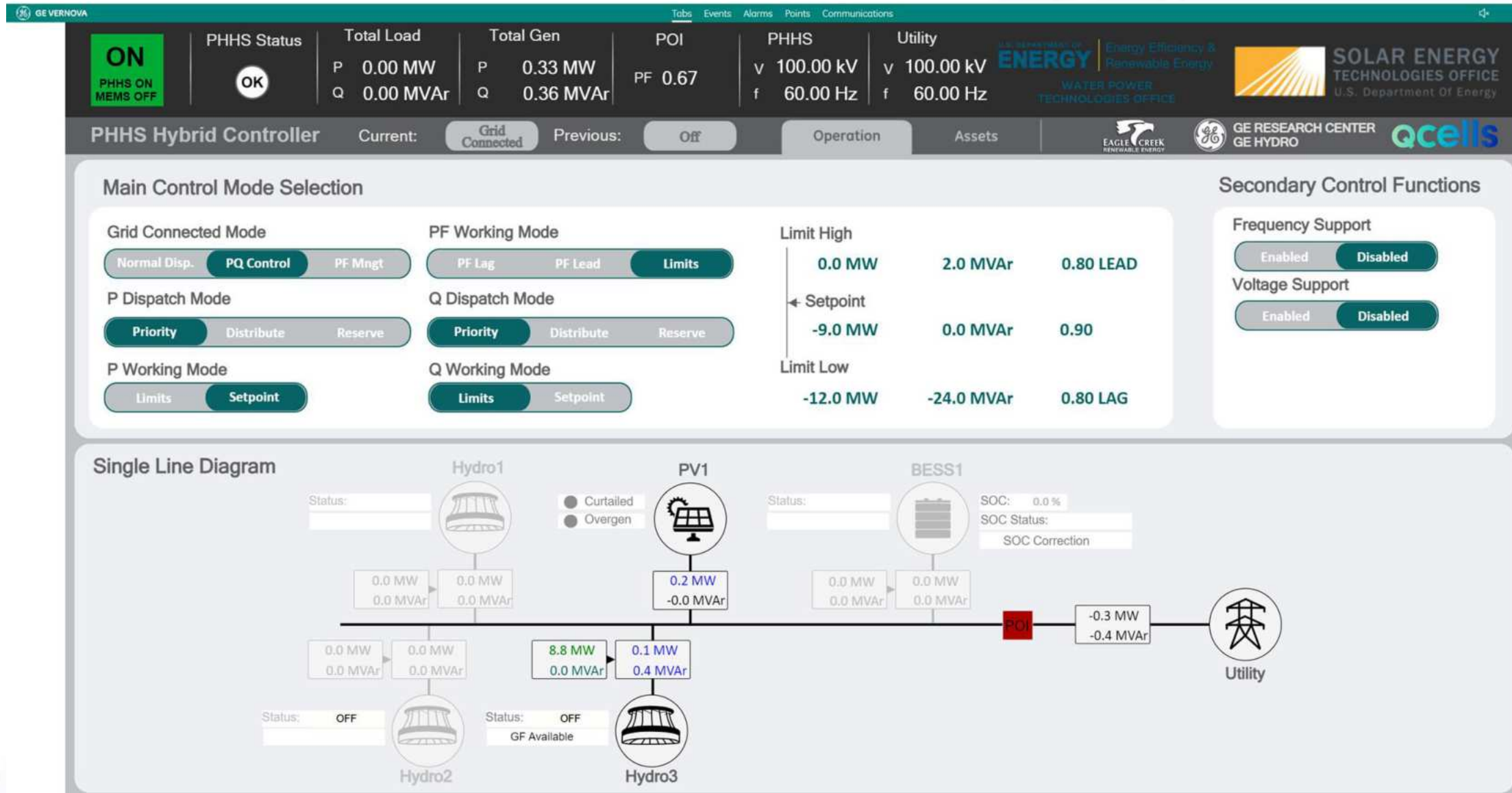
MQTT Message broker architecture

The team has set up MQTT message broker to facilitate data exchange.

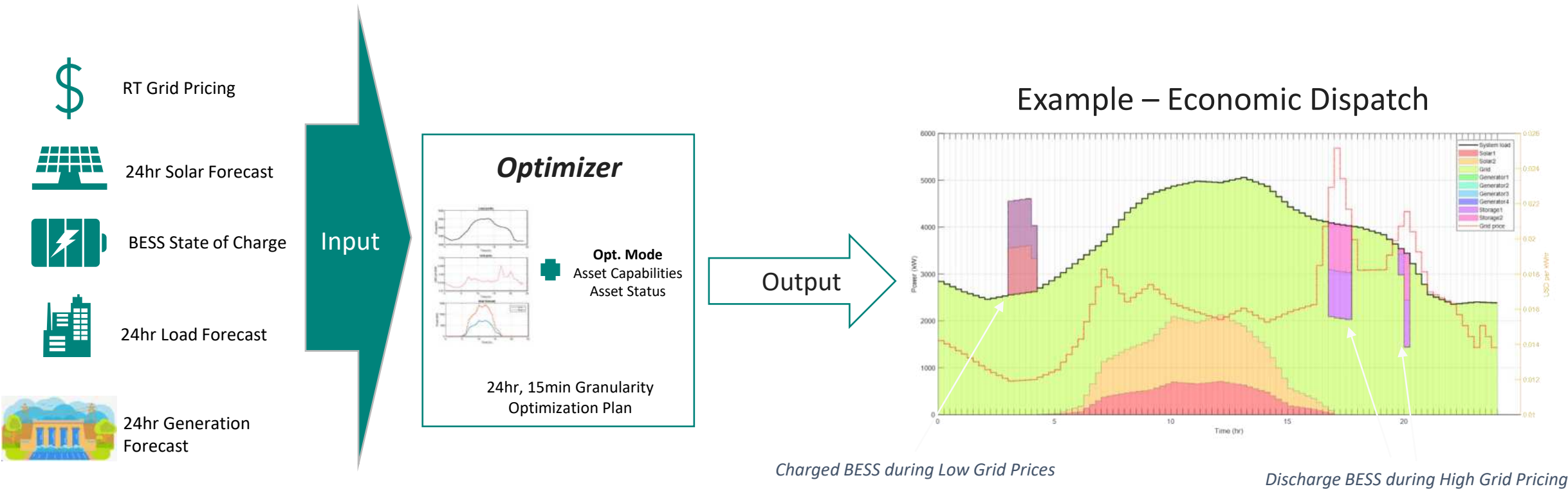
- PV forecast data collection:
QCELLS server (publisher) -> broker -> PHHS controller -> Optimizer
- Site data collection:
PHHS controller (publisher) -> broker -> QCELLS server



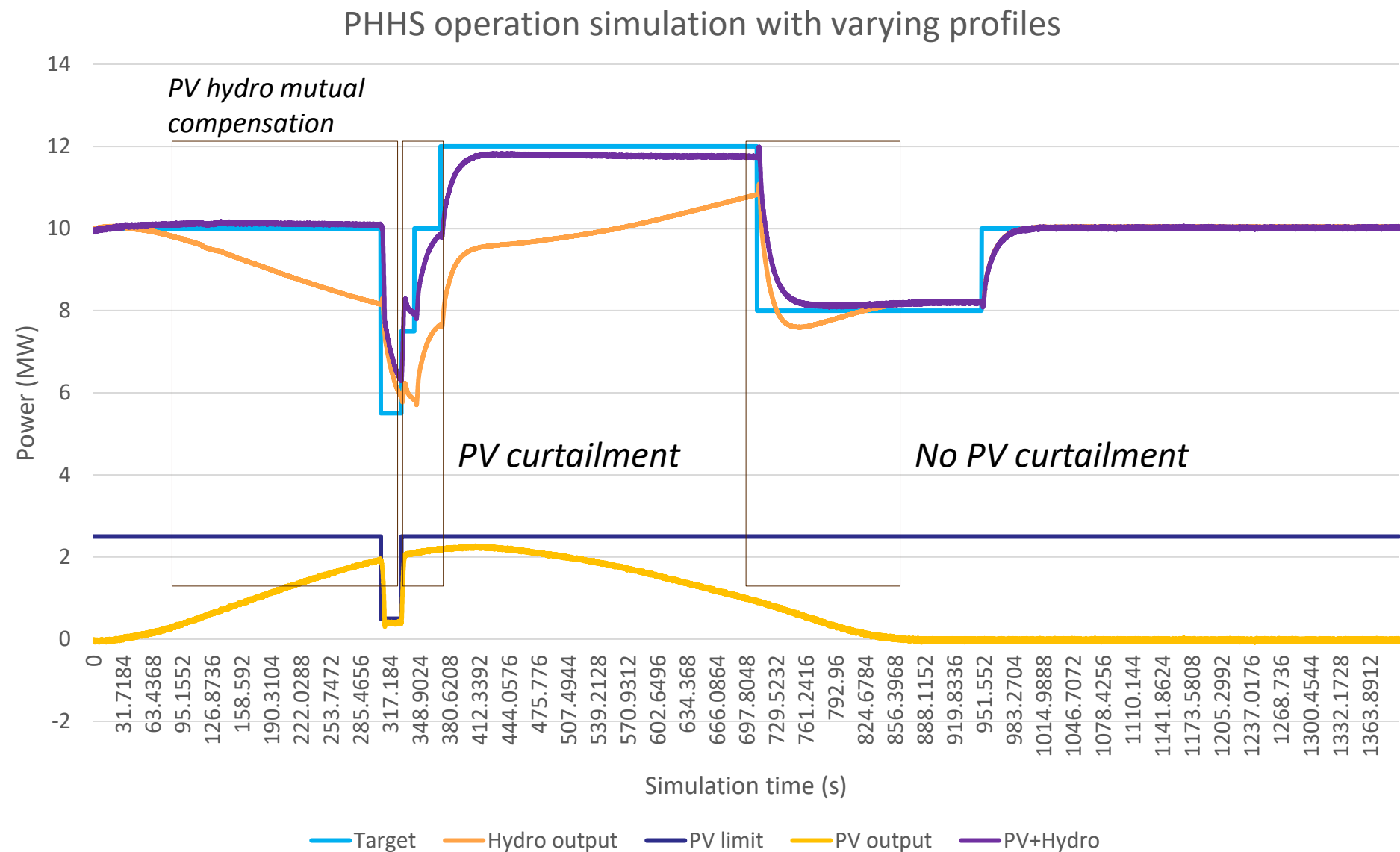
Human Machine Interface (HMI)



Typical Hybrid Control application - Energy Optimization



Varying solar irradiance, temperature, and target profiles



Hybrid controller dispatches PHHS following power target observed and responds to PV intermittency within the operation constraints

PHHS Control Setup in the Powerhouse

Rack placed in Tuckertown plant power



Controllers powered up and customized HMI



Secure remote access and connection to station PLC is set up and under tested

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Increasing Renewable Generation and System Reliability through Coupling PV and Hydropower

Eagle Creek RE, Award #: DE-EE0009342



Optimal Dispatch and Scheduling

- Economics, maximize renewables, energy shifting, and maximize battery life
- Ability to incorporate real-time asset status and operating values
- Event driven optimization
- Reduced operations & maintenance

