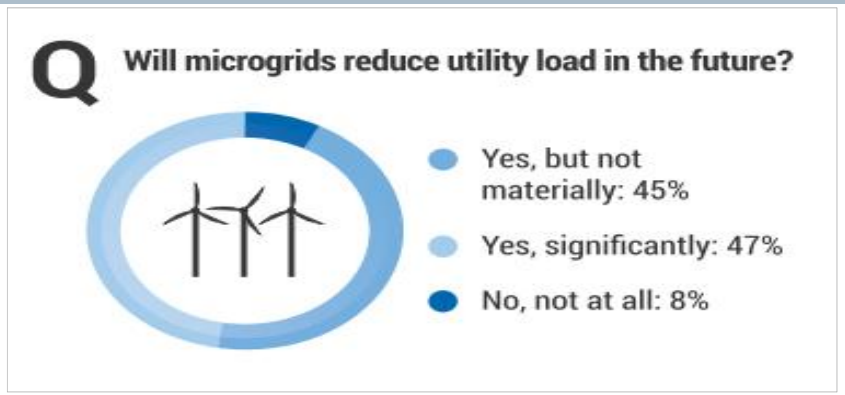
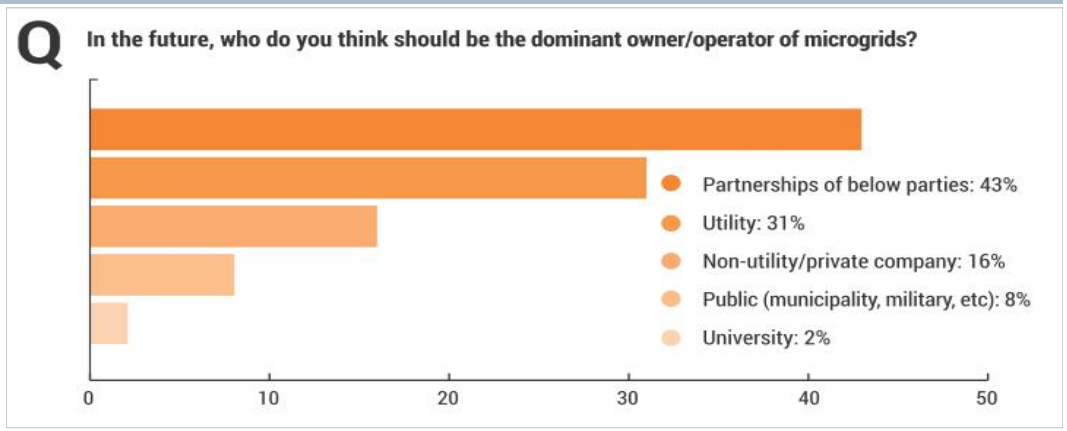
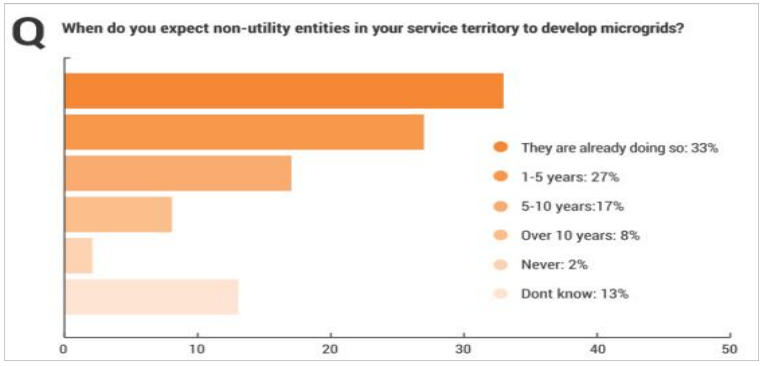
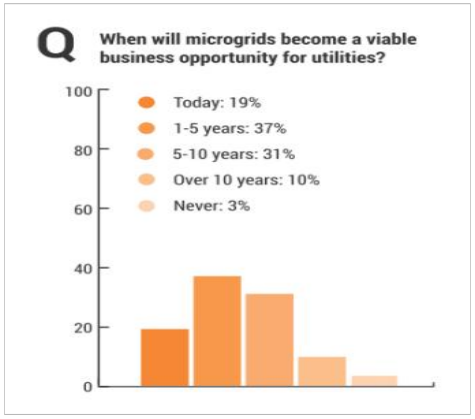
Introduction to Microgrids & Control Solutions

Industry Perspective on Microgrid

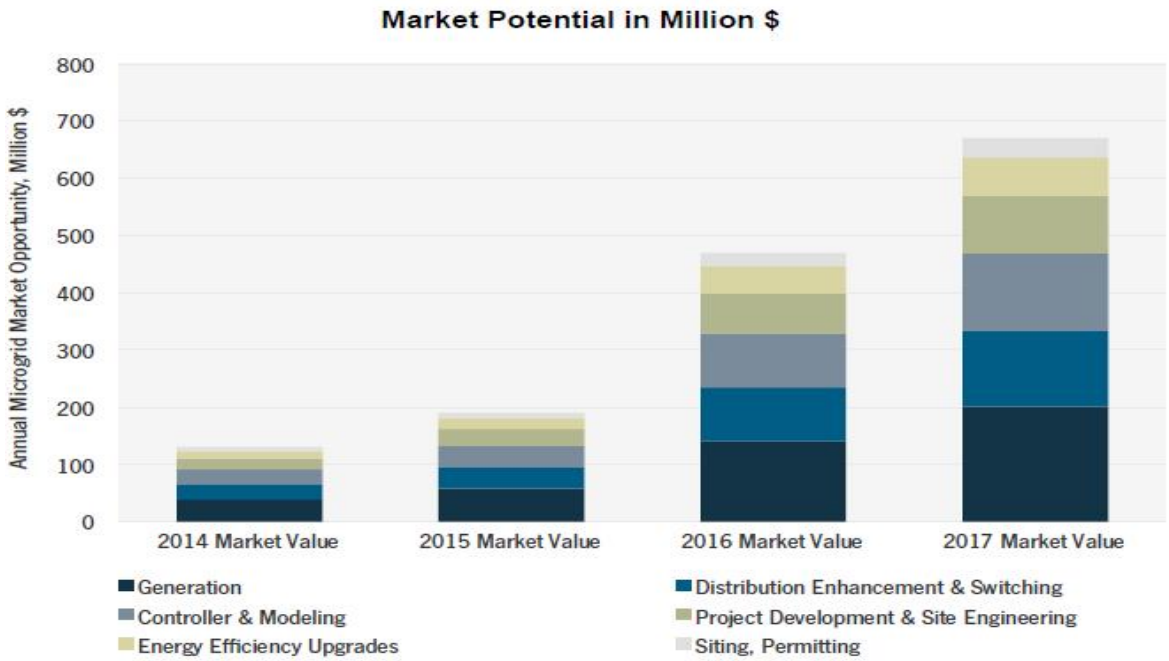








Microgrid Market Potential to Exceed $670 Million



Take Away

- A Five increase from 2014 ($133 million) to 2017 ($671 million)
- Project cost $/kW to decrease by cost efficiency gains in controller development and project development
- Beside generation vendors, the biggest opportunities will be controller, modeling and switching providers

Source: GTM Research 2014

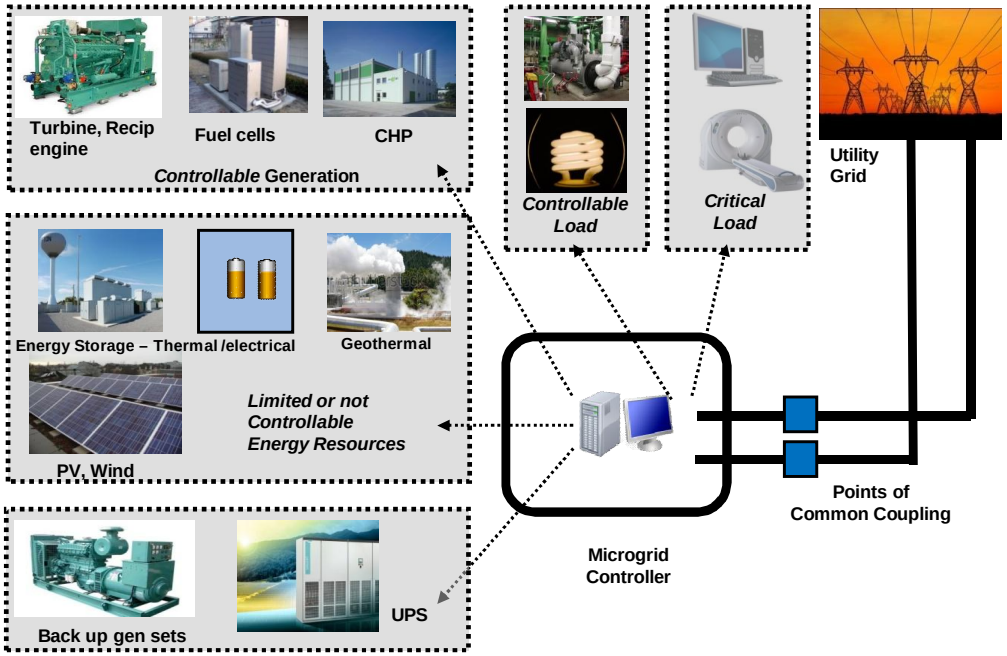
Consumers Initiatives towards Microgrid and More

9 Massive US Companies Pledge To GO 100% Renewable

- ✓ Goldman Sachs *(2020)*
- ✓ Johnson & Johnson *(2050)*
- ✓ Nike *(2025)*
- ✓ Procter & Gamble
- ✓ Salesforce
- ✓ Starbucks
- ✓ Steelcase
- ✓ Voya Financial *(2015)*
- ✓ Walmart

Microgrid Definition

- ✓ Scaled-down power system
- ✓ Local generation and consumption of power
- ✓ Typically connected with main grid via coupling point
- ✓ Manage decentralized energy, including renewables & storage, in a local environment
- ✓ Allow for optimizing controllable loads and building automation



Three Pillars of a Microgrid System

Mixed Generation Assets

- Wind, Solar, other RES
- GT, ST, CHP, Fuel Cell, Diesel Gen-sets
- Battery, UPS, Other ESS

Complicated Load Profile

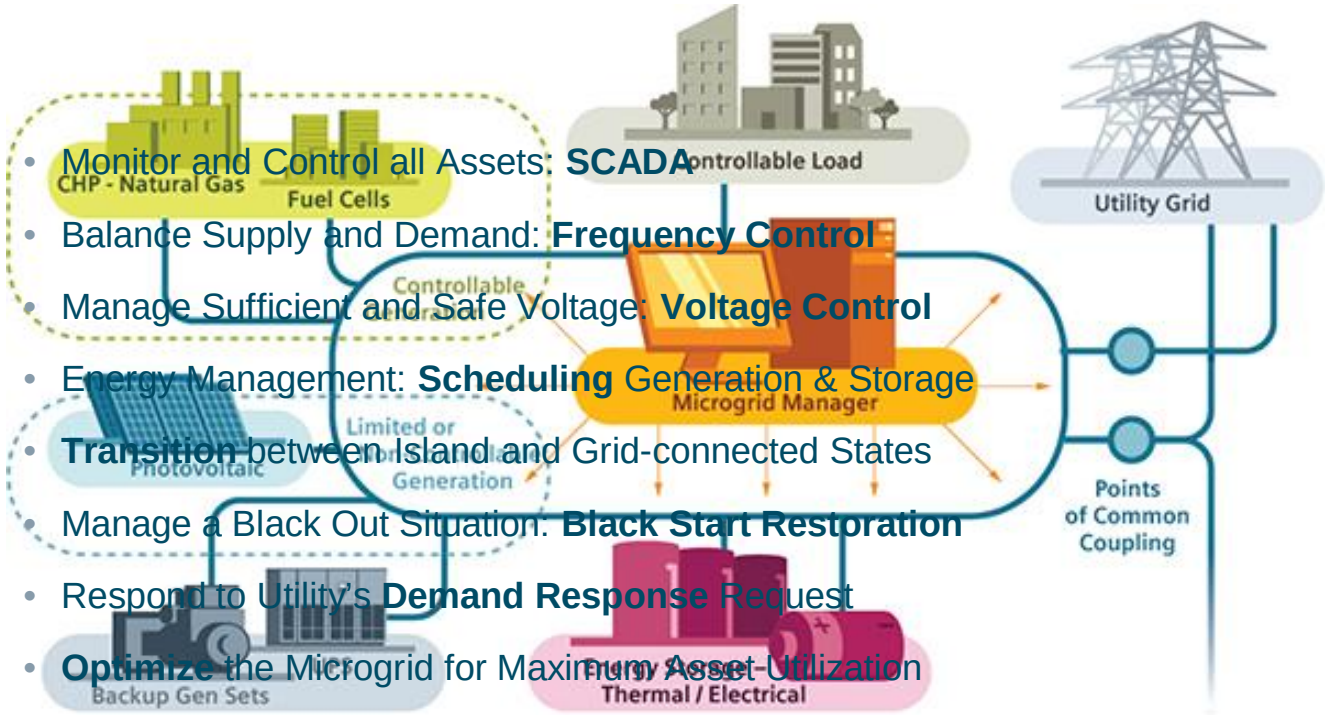
- Critical vs. Non-Critical
- Controllable vs. Non-Controllable
- Sheddable vs. Non-Sheddable

Complex Modes of Operations

- Grid-Connected vs. Off-Grid
- Black start
- Re-synchronization to the Grid

Role of a Microgrid Controller

SIEMENS



- Monitor and Control all Assets: **SCADA**
- Balance Supply and Demand: **Frequency Control**
- Manage Sufficient and Safe Voltage: **Voltage Control**
- Energy Management: **Scheduling** Generation & Storage
- **Transition** between Island and Grid-connected States
- Manage a Black Out Situation: **Black Start Restoration**
- Respond to Utility's **Demand Response** Request
- **Optimize** the Microgrid for Maximum Asset Utilization

Components (SW and HW):

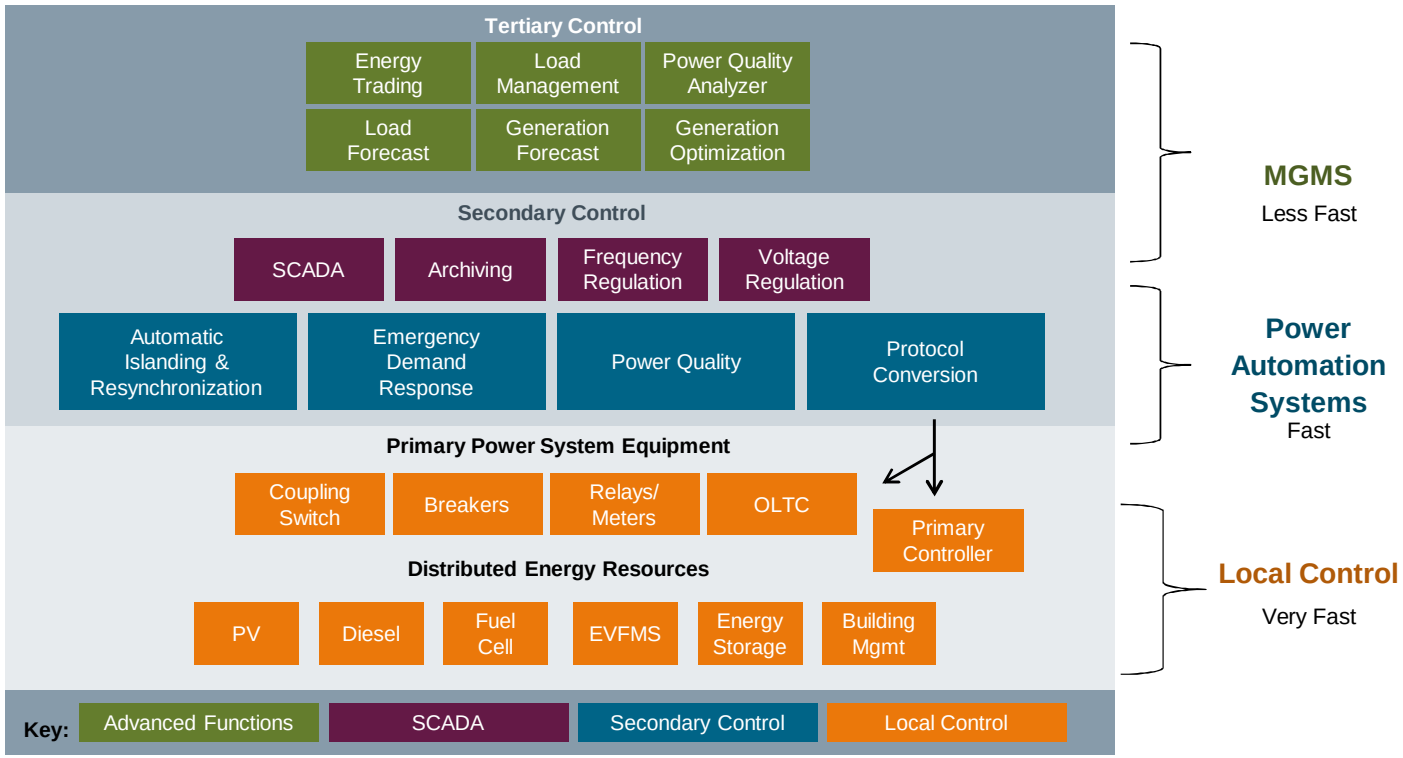
Control & supervisory
- Central mgmt. & control comp.
- Operation tool for baselining & decision logic (e.g. weatherforecast)

Communication layer
- IT-communication
- Smart meters, sensors

System layer
- **Power electronics**: Smart inverter, smart connection
- **Smart controller** (DG, storage, loads)

Field layer
- **DG**: Solar PV, Wind turbine, combustion engine, CHP, CCHP
- **Energy Storage**: Battery, ultra capacitor, flywheel, E-car
- **Grid components**: switchgear, distribution line, transformer, protection
- **Power consumer mgmt.**

Microgrid Control Hierarchy



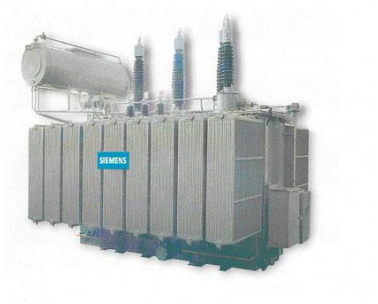
Microgrid Control Hierarchy – Local Control

SIEMENS

Primary Power System Equipment

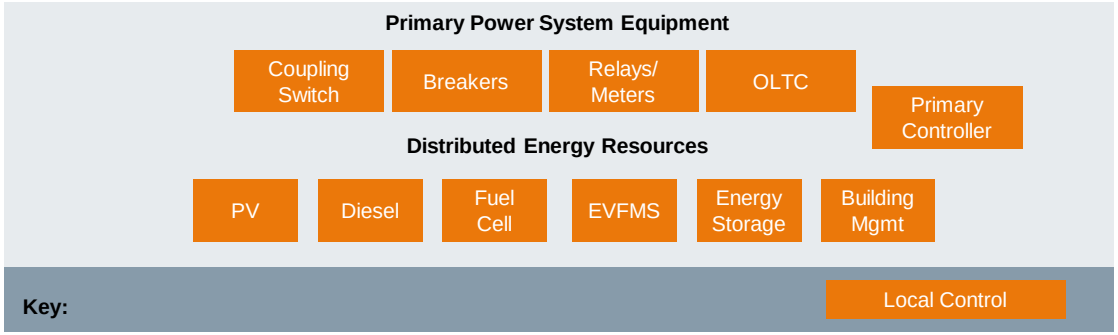
Switch/Circuit Breakers

Protection and Control Devices and Power Meters



On-load Tap Changer Controller

Genset Controller



Microgrid Control Hierarchy – Local Control

SIEMENS

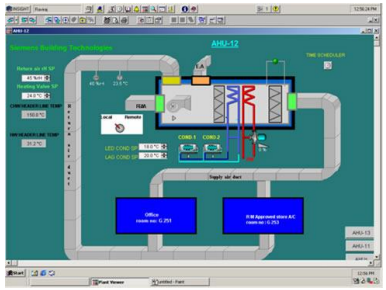
Distributed Energy Resources

PV Cells / Solar Inverter

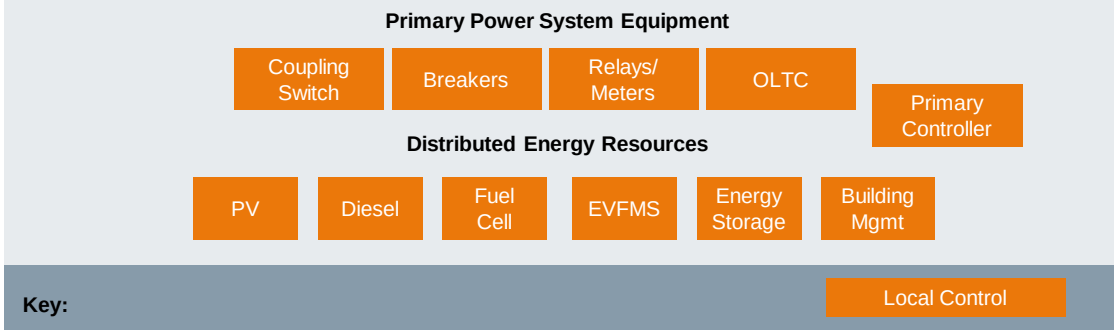
Diesel Generators

Fuel Cells

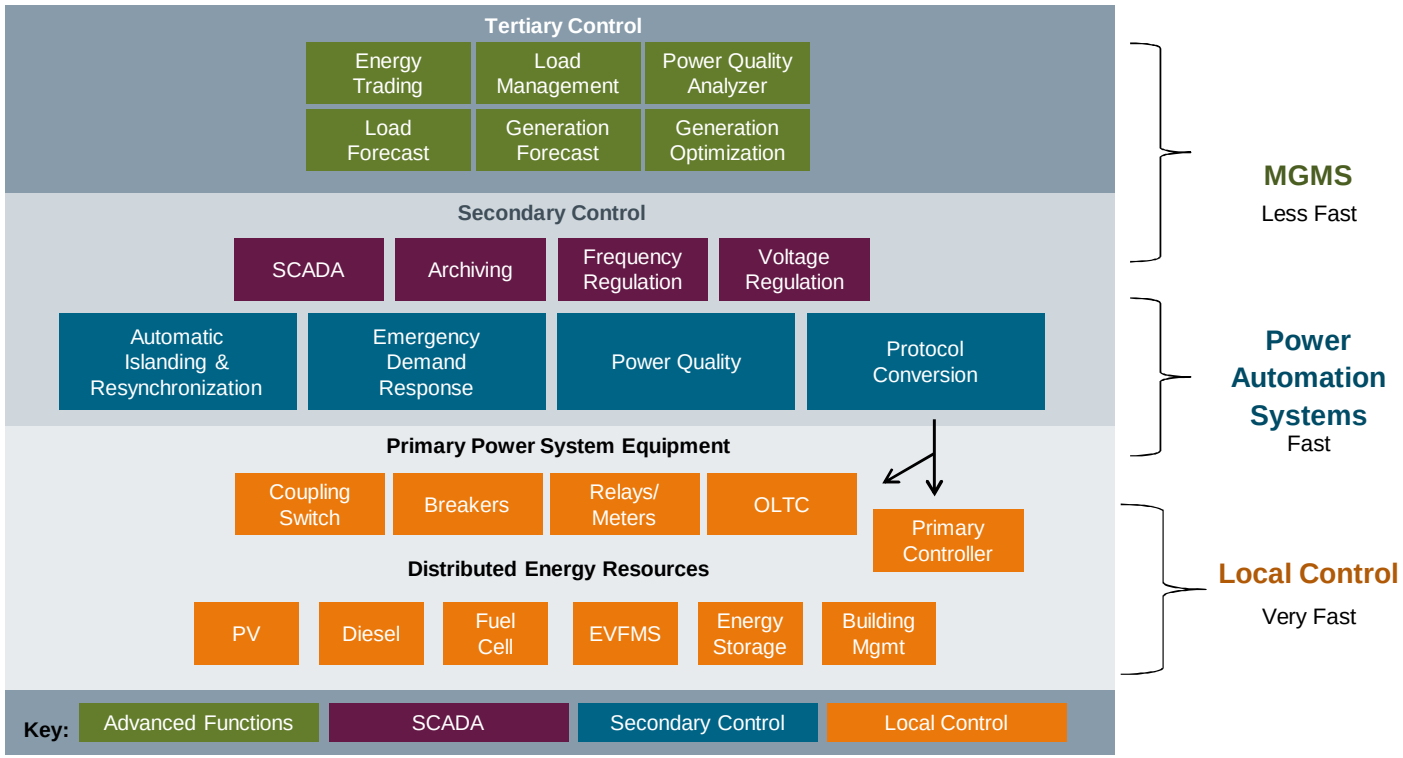
Energy Storage (Batteries)



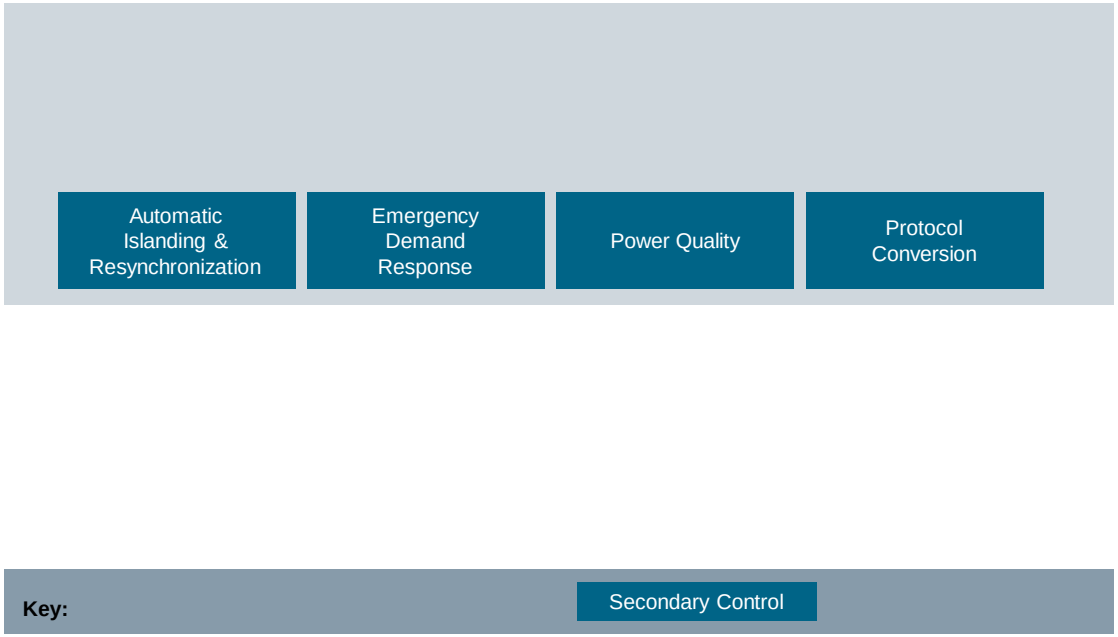
Building Management System



Microgrid Control Hierarchy



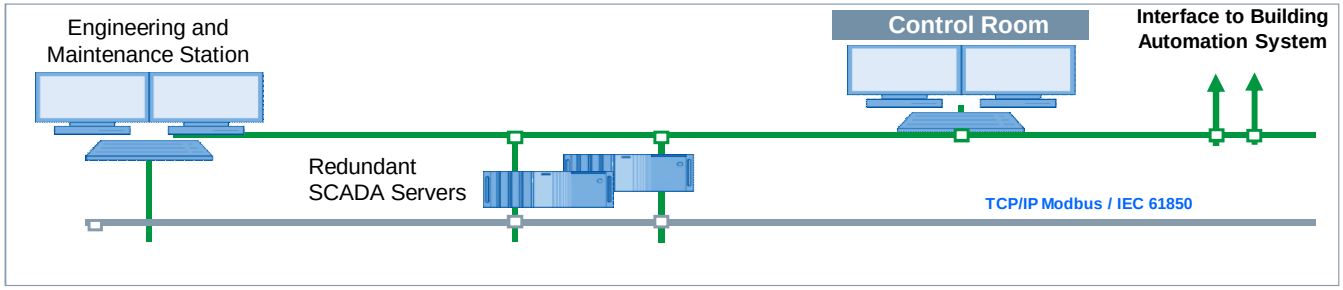
Microgrid Control Hierarchy – Secondary Control

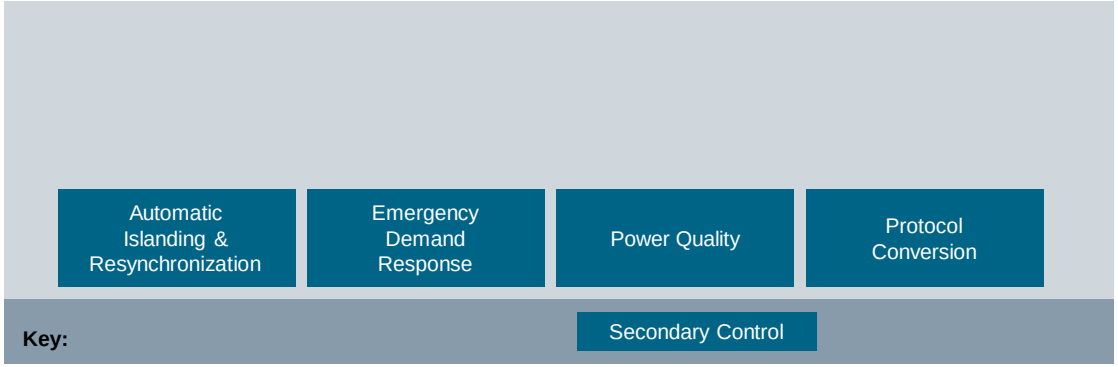


Microgrid Control Hierarchy – Secondary Control

SIEMENS

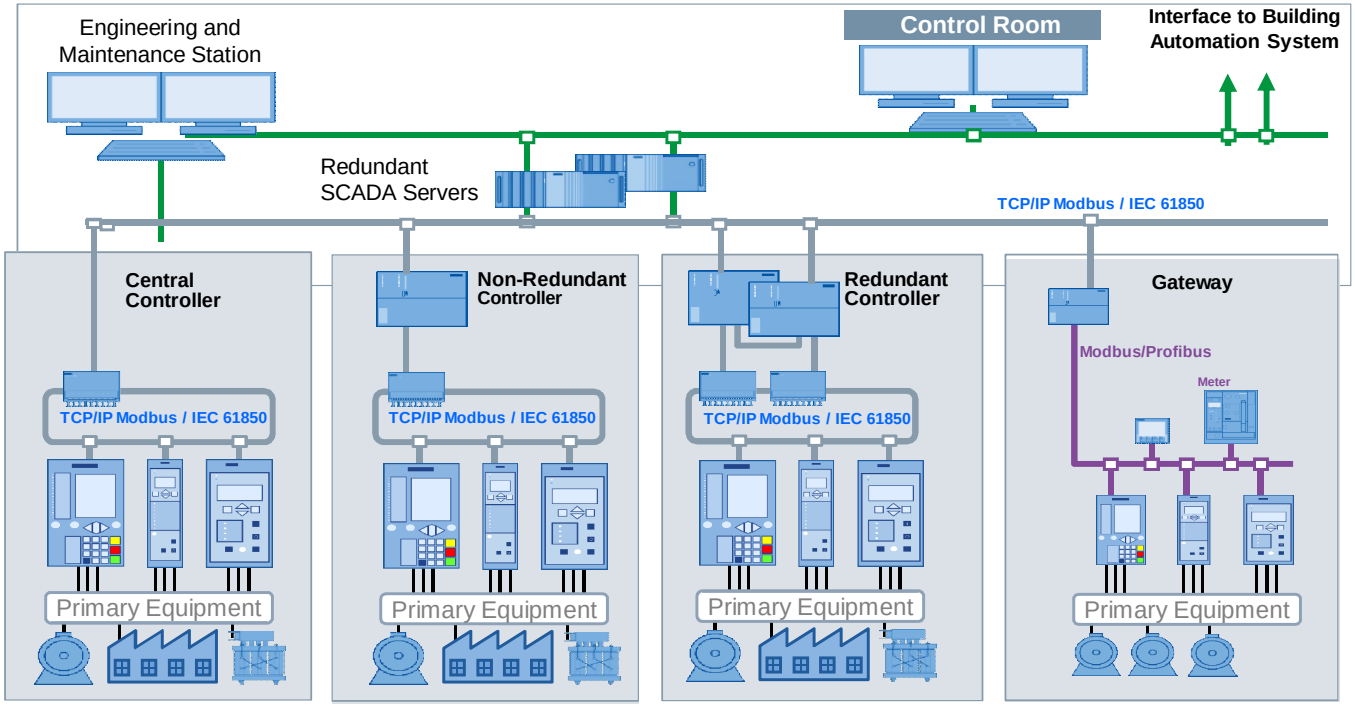
Secondary Control





Microgrid Control Hierarchy – Secondary Control

Secondary Control – Communications Network



Microgrid Control Hierarchy – Power Quality

SIEMENS

Power Quality

IEEE States:

" ***Power quality is the concept of powering and grounding sensitive equipment in a matter that is suitable to the operation of that equipment*** ".

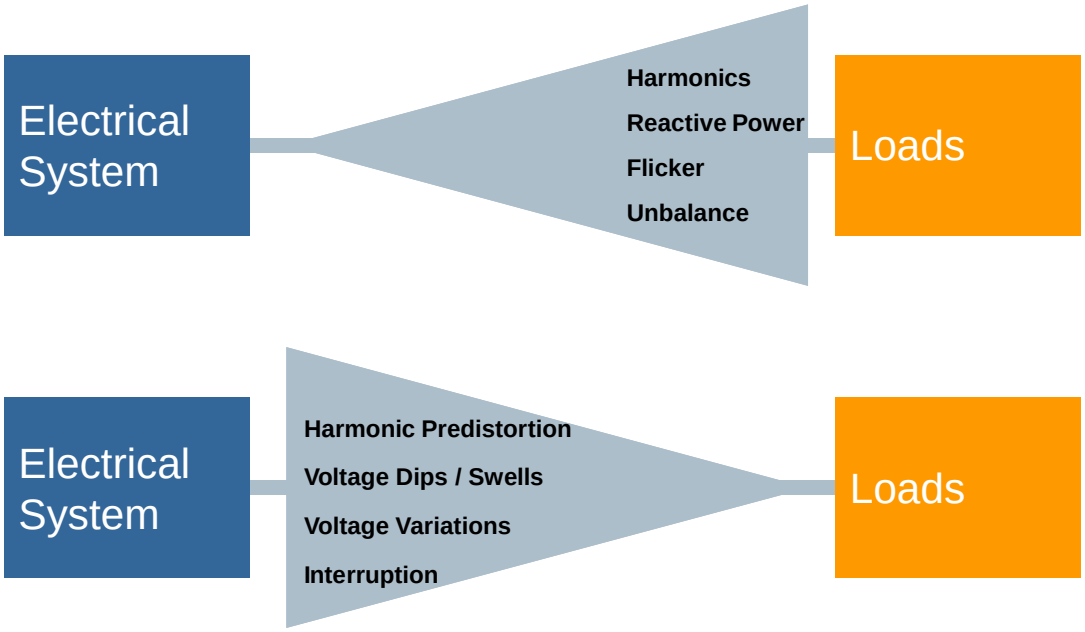
The need for Quality Power - Every market is exposed by financial losses due to power availability and voltage quality. Minimizing losses due to power quality issues starts in identifying and understanding the problem.

Power reliability is truly a business and operations issue rather than merely an inconvenience.

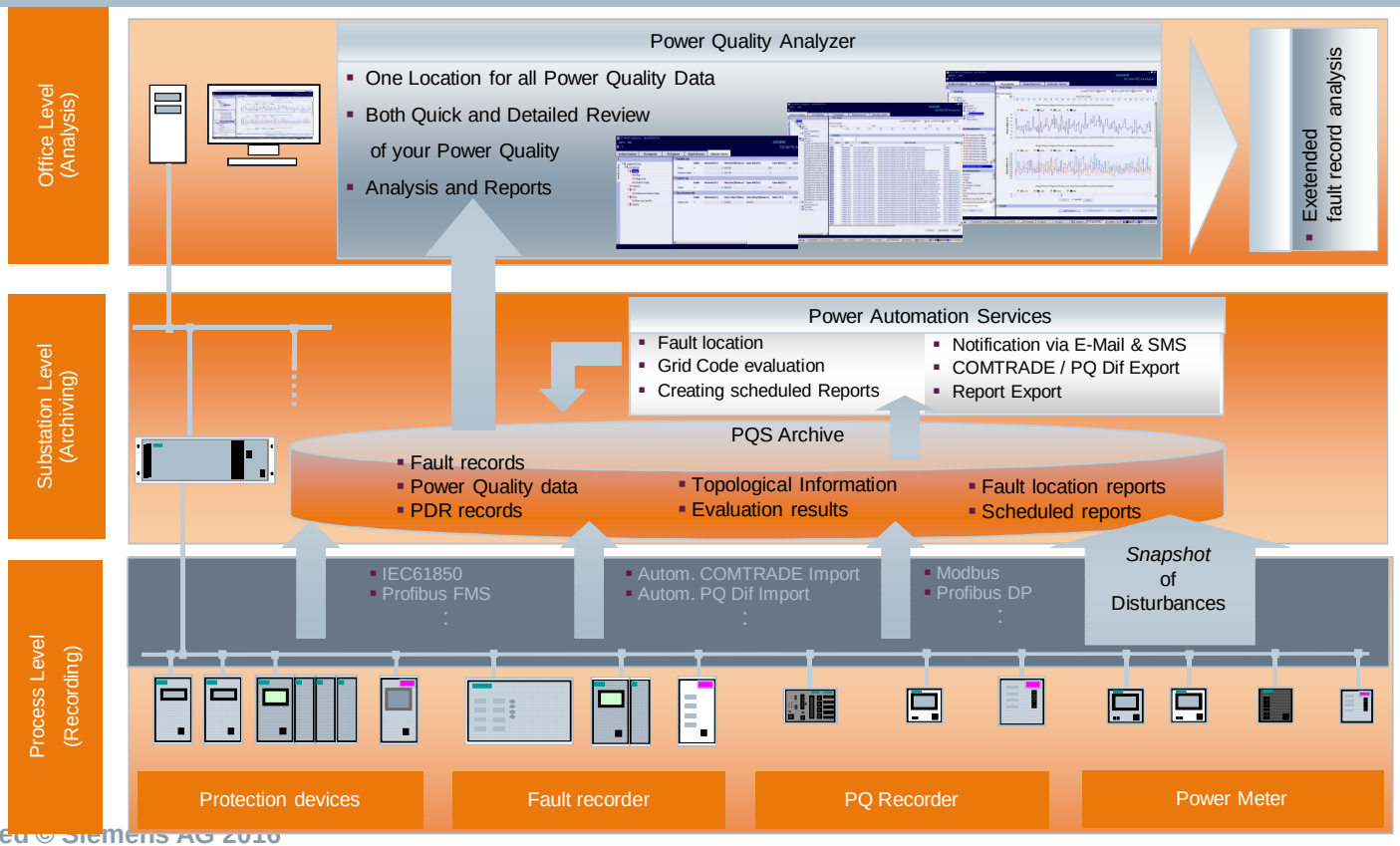
Microgrid Control Hierarchy – Power Quality

SIEMENS

Power Quality

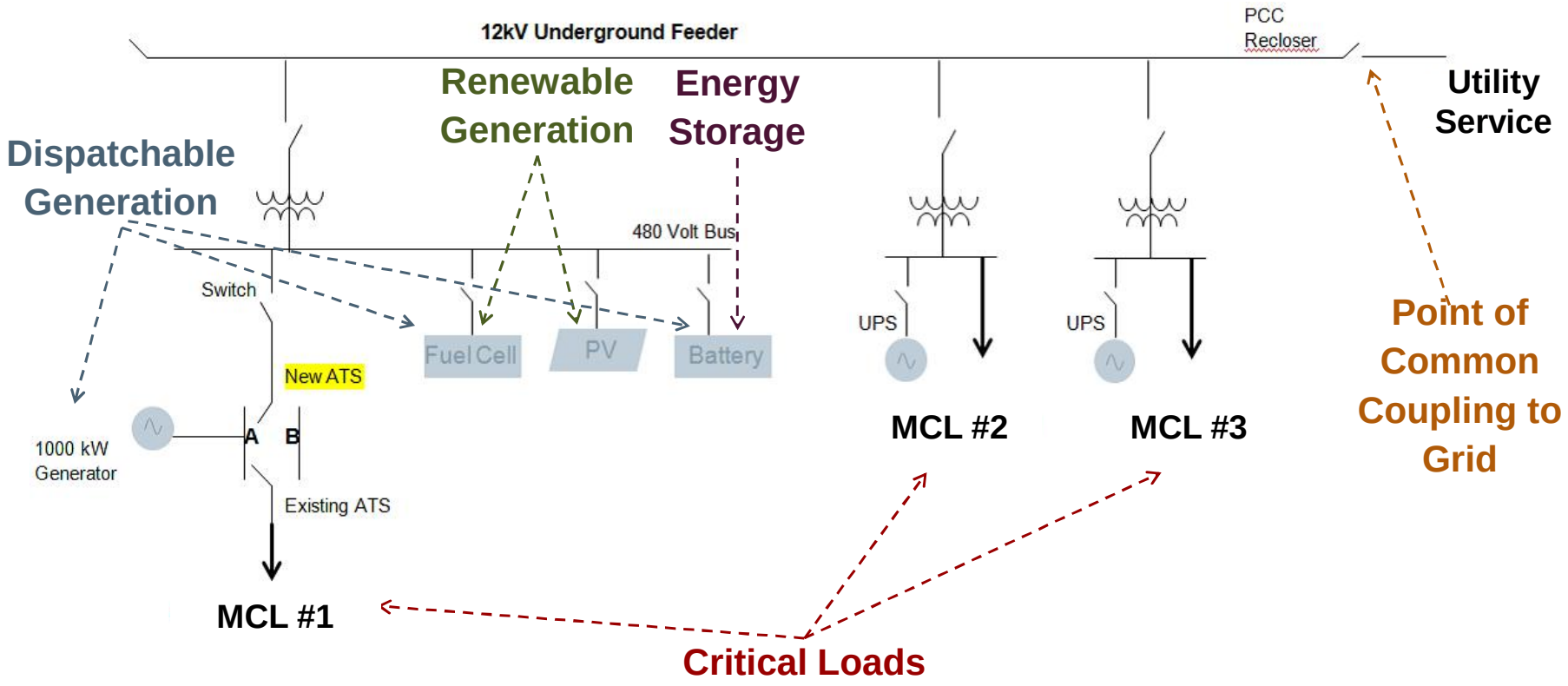


Microgrid Control Hierarchy – Power Quality

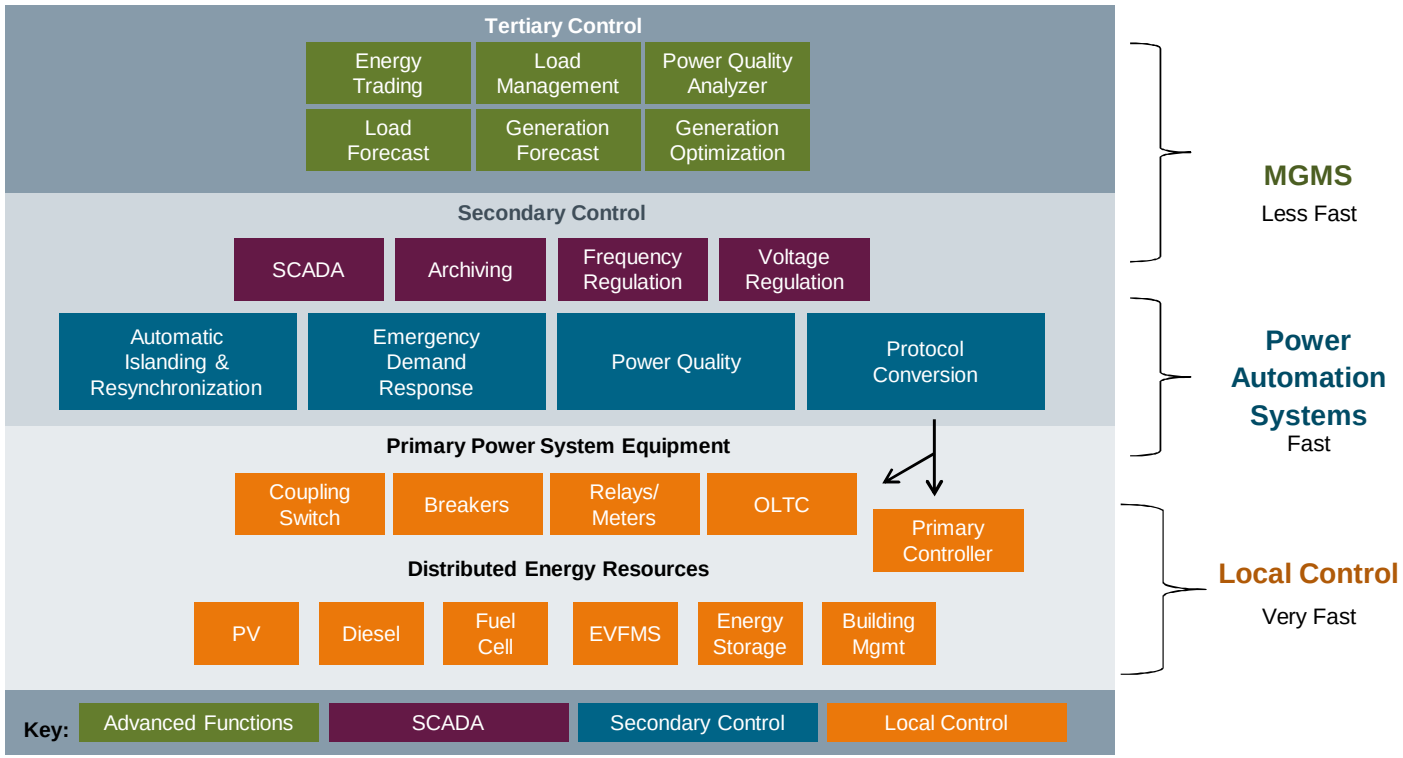


Page 17

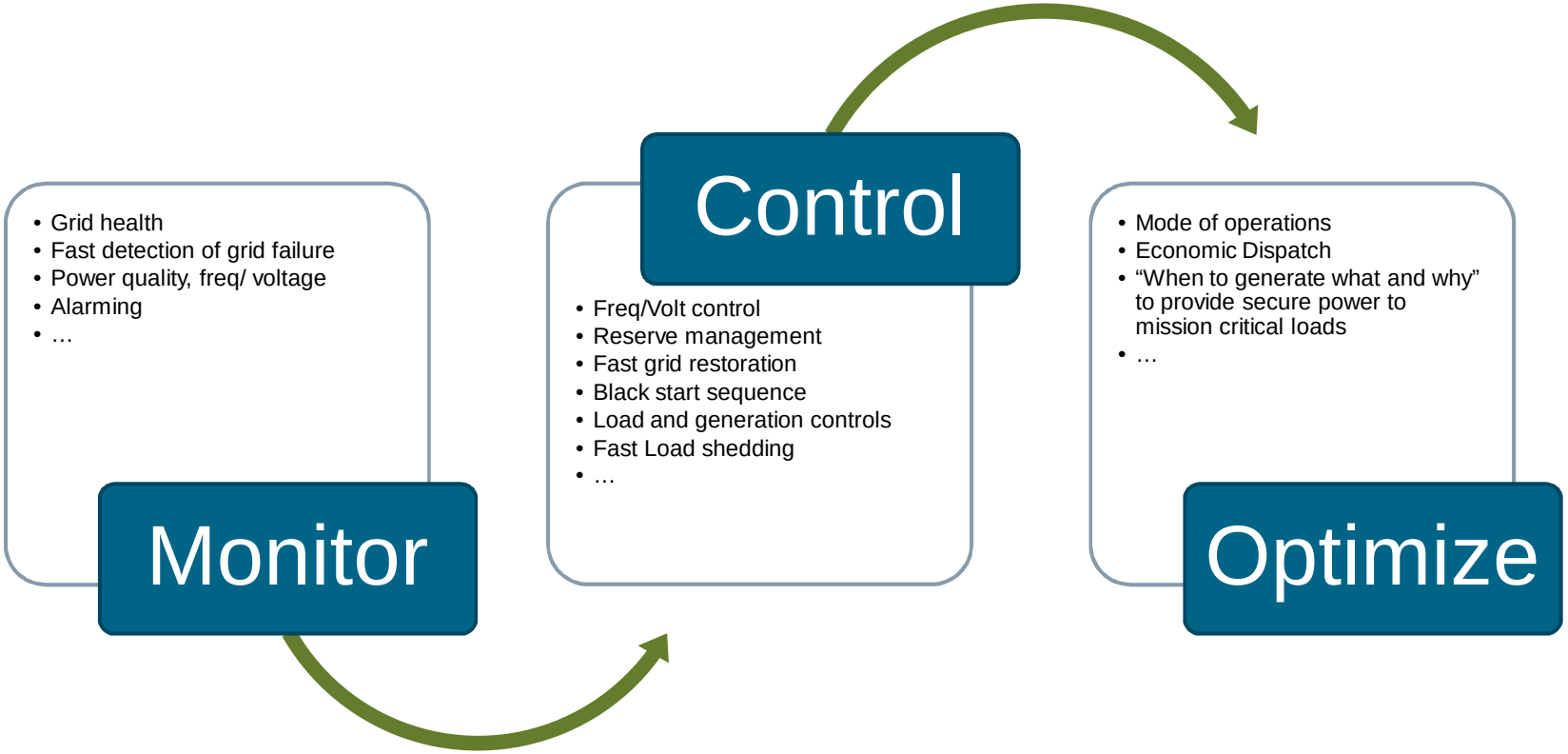
Typical Design Example



Microgrid Control Hierarchy

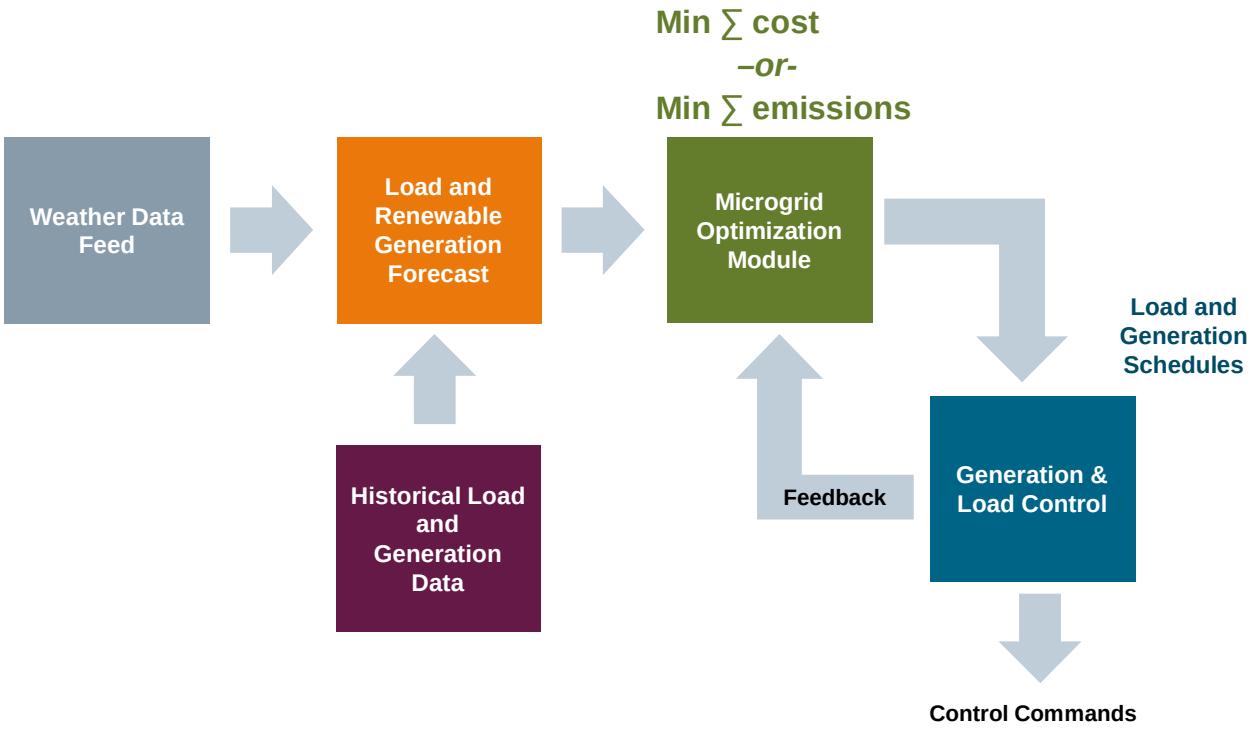


Microgrid Control Solutions

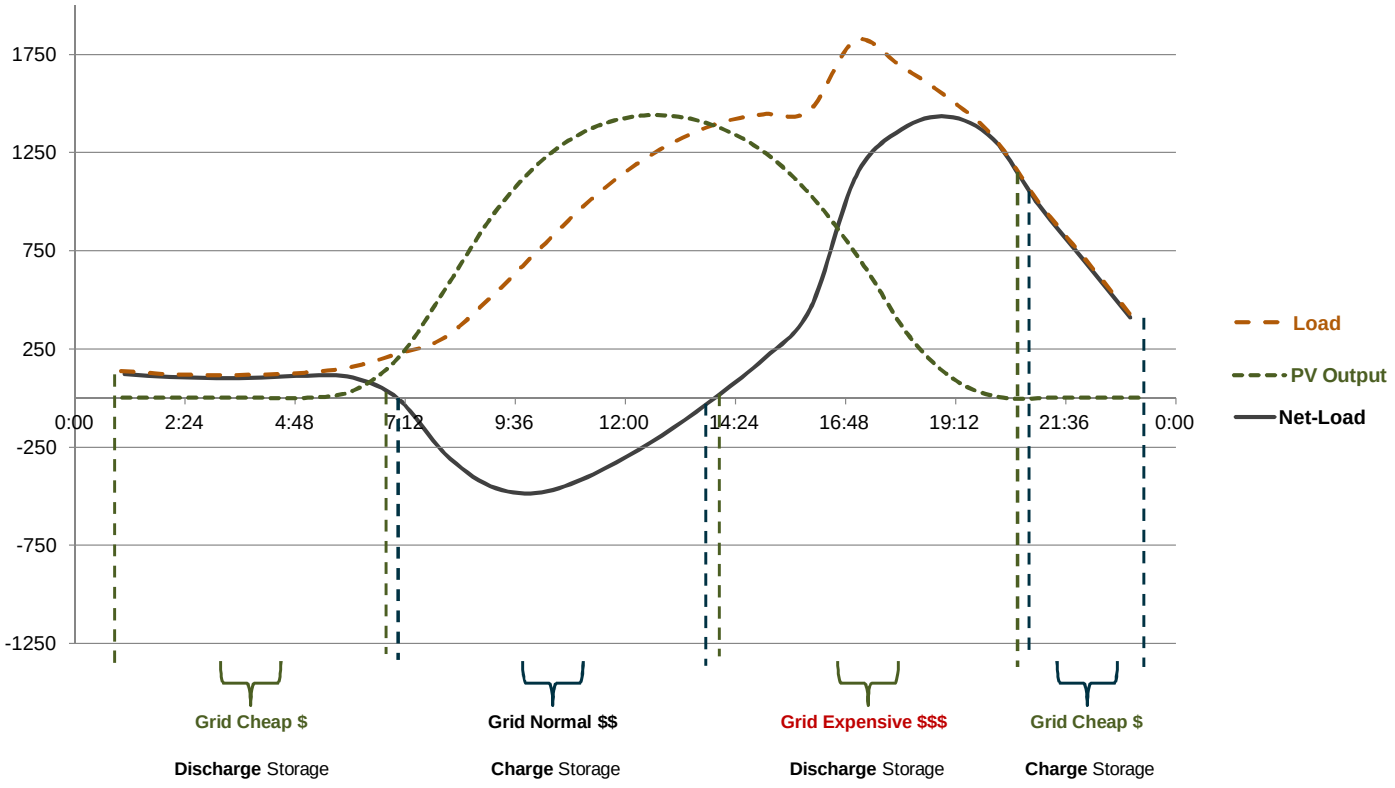


Advanced Microgrid Control Solutions

SIEMENS



MGMS Overview
Day-ahead Forecast and Scheduling based on Optimization



Advanced Microgrid Control Solutions

SIEMENS

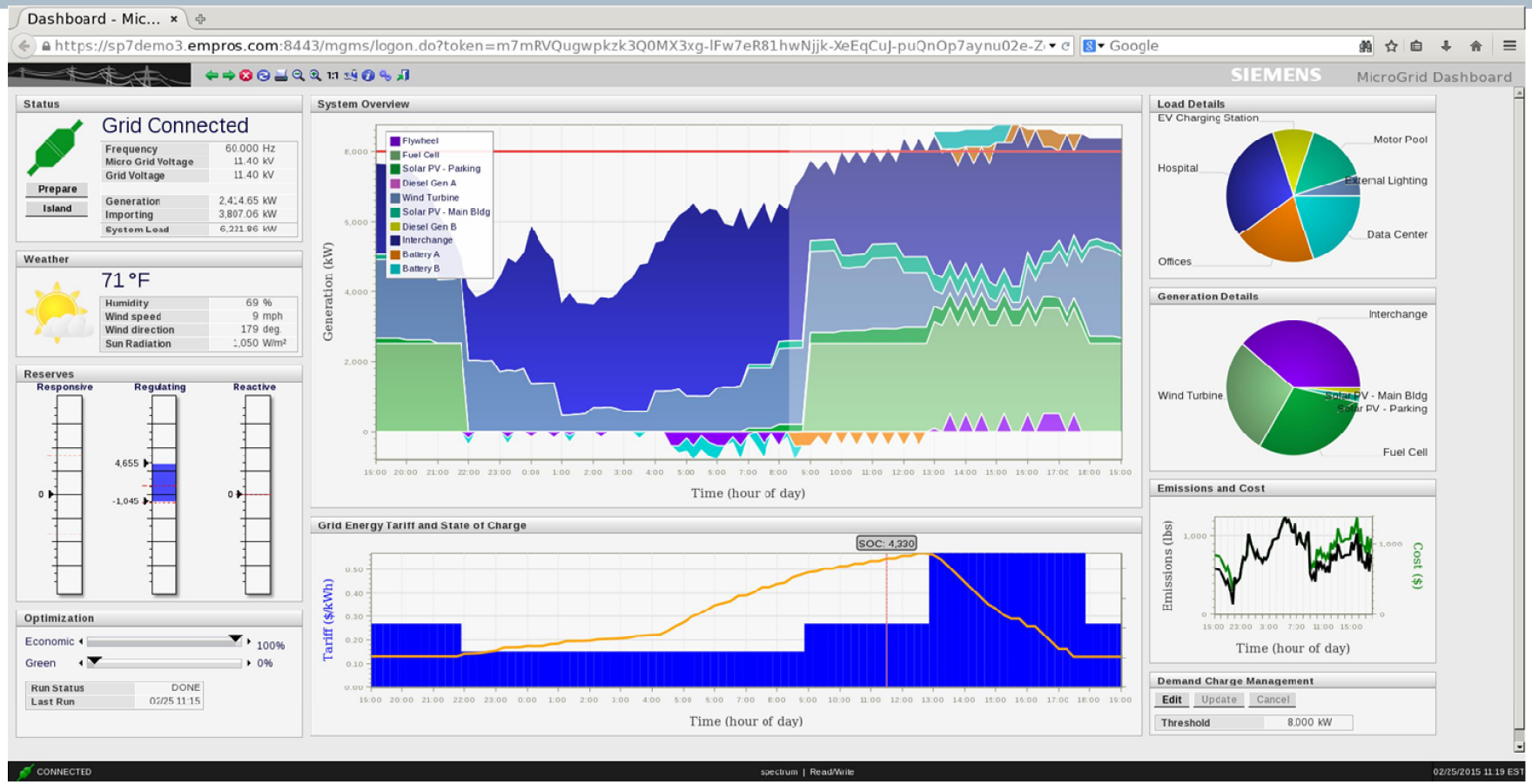
Needs	Reliable Power Renewable Integration	Cost Savings Emission	Security Resiliency
Benefits	**Reliable**	**Efficient**	**Sustainable**	**Secure**
Functions	• Alarming • Frequency Control • Voltage Control • Reserve Management • Grid to Island Transition • Fast Load Shed • Island to Grid Resynch • Black Start Restoration • Power Quality Analysis	• Optimal economic dispatch & Unit commitment • Simple Deployment • Autonomous or Simple Operation • Demand Charge Management • Bid energy markets or ancillary services • Interface/optimize energy storage	• Emission Optimization • Solar & wind forecasting • Maximum penetration of renewables via storage optimization	• Strong security, platform based on utility-level system • Patch management • Security architecture & design • Cyber vulnerability assessment • Access control • Security in lifecycle • Information security governance

High-Level Customer Requirements

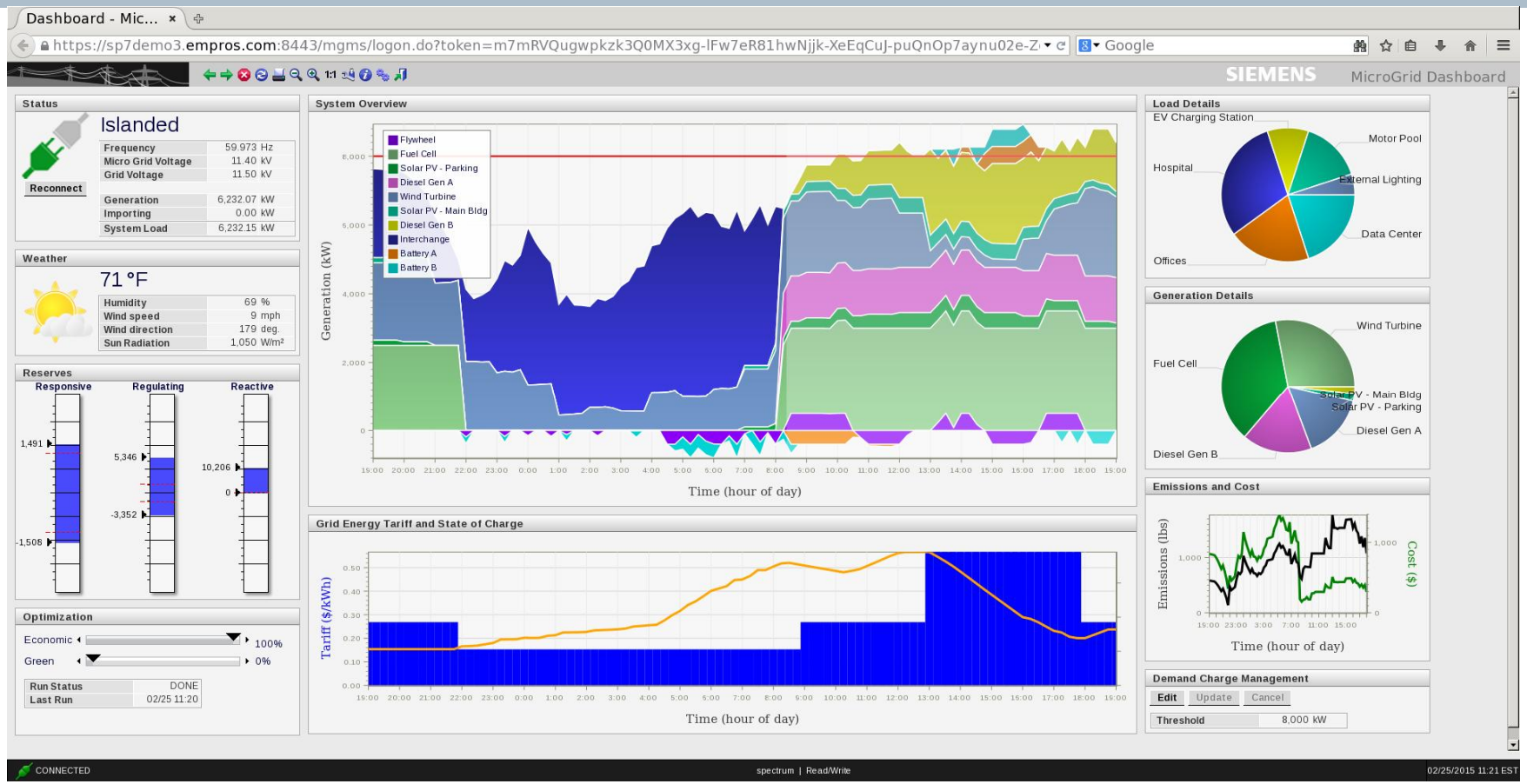
Advanced Microgrid Control Solution Benefits

Specific Functional Requirements

MGMS: Grid Connected



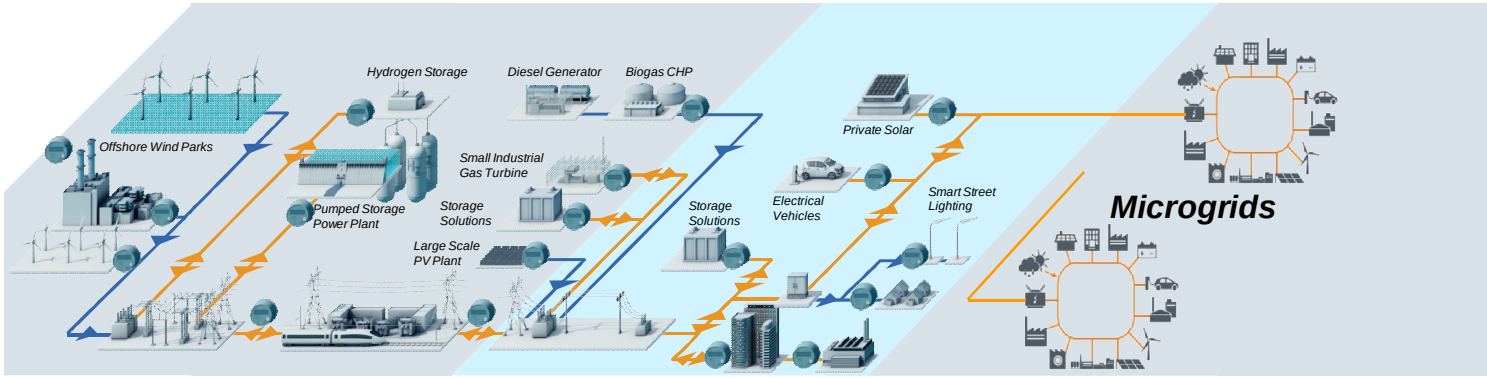
MGMS: Islanded



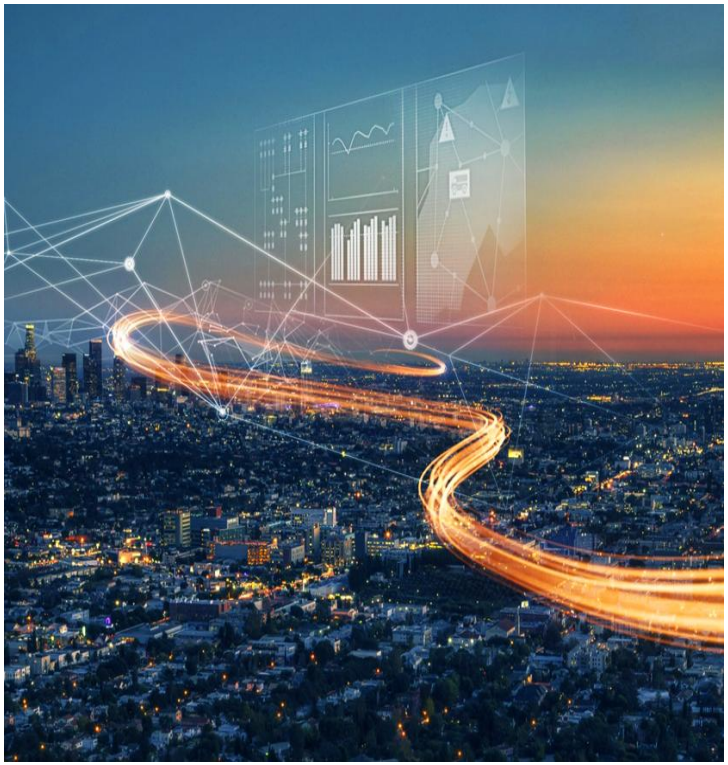
Advanced Microgrid Controls Enables Integrated Grid

- Interconnected Grid to Integrated Grid
  - Better integrate renewables, storage and other DER
  - Grid recovery and healing
  - Optimization of system energy and load management

- Advanced Microgrid Controls enable:
  - Transparency and data accessibility
  - Prosumers
  - Distribution-level power markets
  - Grid stability
  - Safety and protection



Contact



Maggie Clout
Business Development Manager
Microgrid
Mobile: 404-426-3068
Email: maggie.clout@siemens.com