Implementing a Microgrid Using Standard Utility Control Equipment

Tom Fenimore
Duke Energy

Andy Gould and Larry Wright
Schweitzer Engineering Laboratories, Inc.

Overview

- Microgrids and distributed generation
- Goals and objectives
- Engineering challenges
- Design philosophy
- Examples
- Lessons learned

What Is a Microgrid?

"…a group of **interconnected loads** and **distributed energy resources** within clearly defined electrical boundaries that acts as a **single controllable entity** with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both **grid-connected** or **island-mode**."

—Summary Report: 2012 DOE Microgrid Workshop

Microgrids and Distributed Generation Trend

- 28 U.S. states have pledged 10% renewable resources
- North Carolina is ranked 4th in U.S. solar capacity with 397 MW (2nd-fastest growth of solar capacity nationwide)

Integrating Distributed Generation

Can utilities seamlessly integrate distributed generation sources with standard utility equipment?

Test Site: Duke Energy McAlpine Creek Microgrid

Charlotte, NC

McAlpine Creek Substation

- Duke Energy McAlpine Creek Substation has served as test bed for smart grid and renewable generation since 2006
- Substation includes
  - 50 kW photovoltaic (PV) system
  - 240 kW, 500 kWh battery energy storage system (BESS)

Goals and Objectives

- Provide resiliency to critical facility
- Seamlessly disconnect and reconnect
- Use utility-owned and utility-sited assets
  - No alterations behind customer meter
  - Standard utility equipment

Goals and Objectives

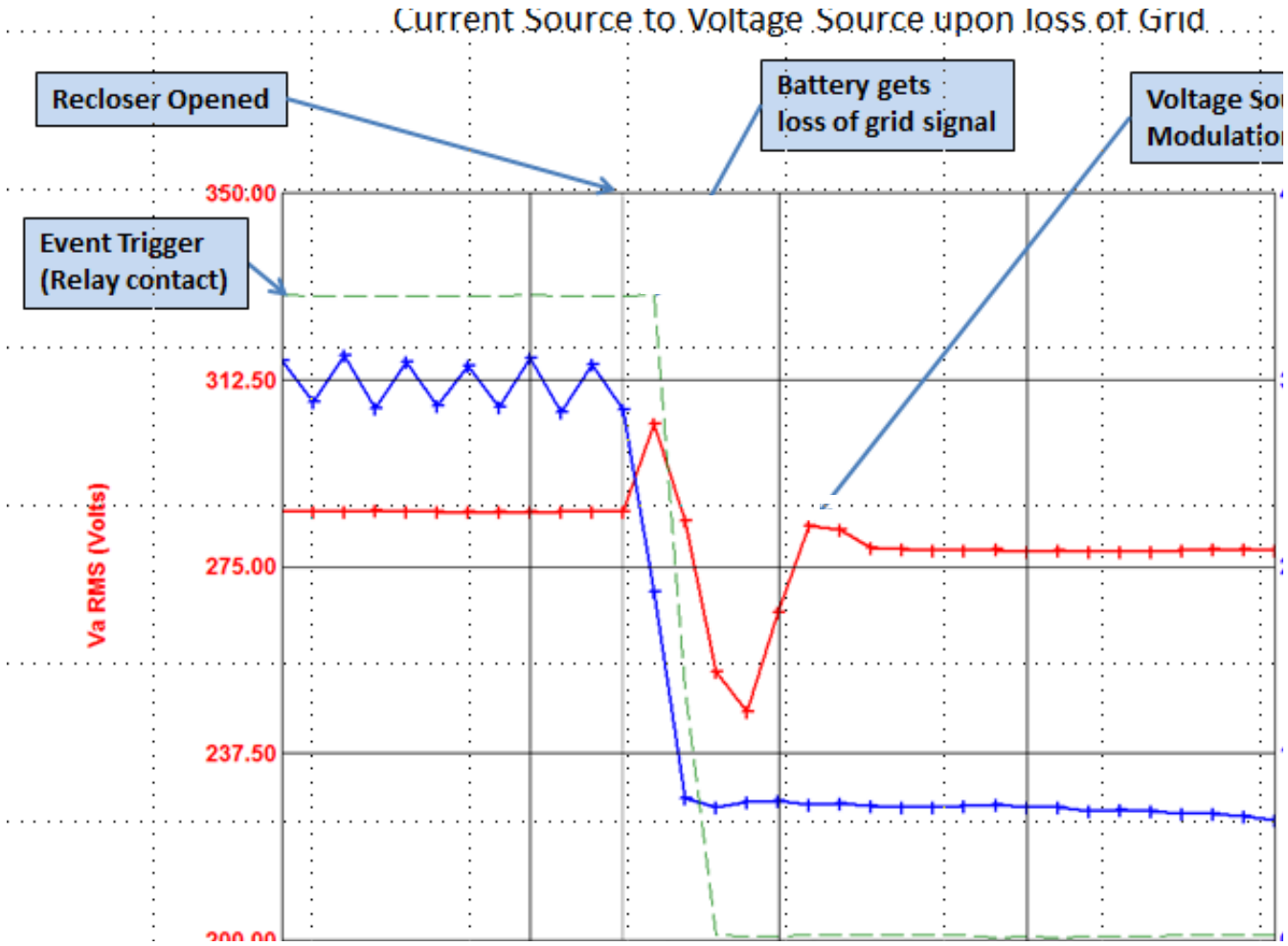
Demonstrate Ancillary and Grid Stability Services

- Frequency regulation
- Circuit voltage support (VAR dispatch)
- Coordinated control of battery inverter
- Mitigation of solar intermittency
- Real-time status monitoring

Engineering Challenges

- PV and battery system integration
- Understanding of off-grid operation
- Changes in fault current due to no inertia
- New protection and control schemes
- Power limit testing
- Integration with SCADA

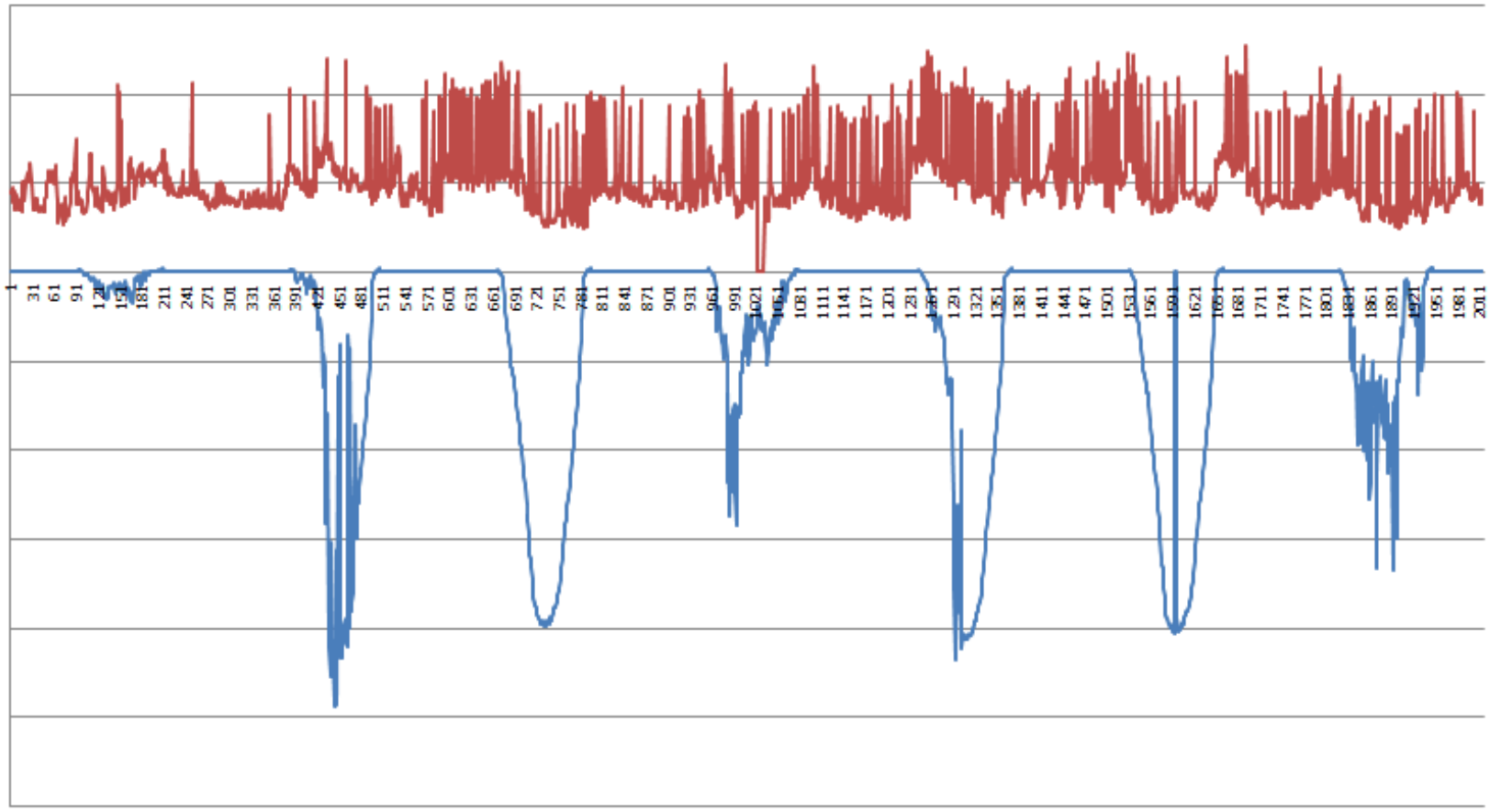
Testing Stage

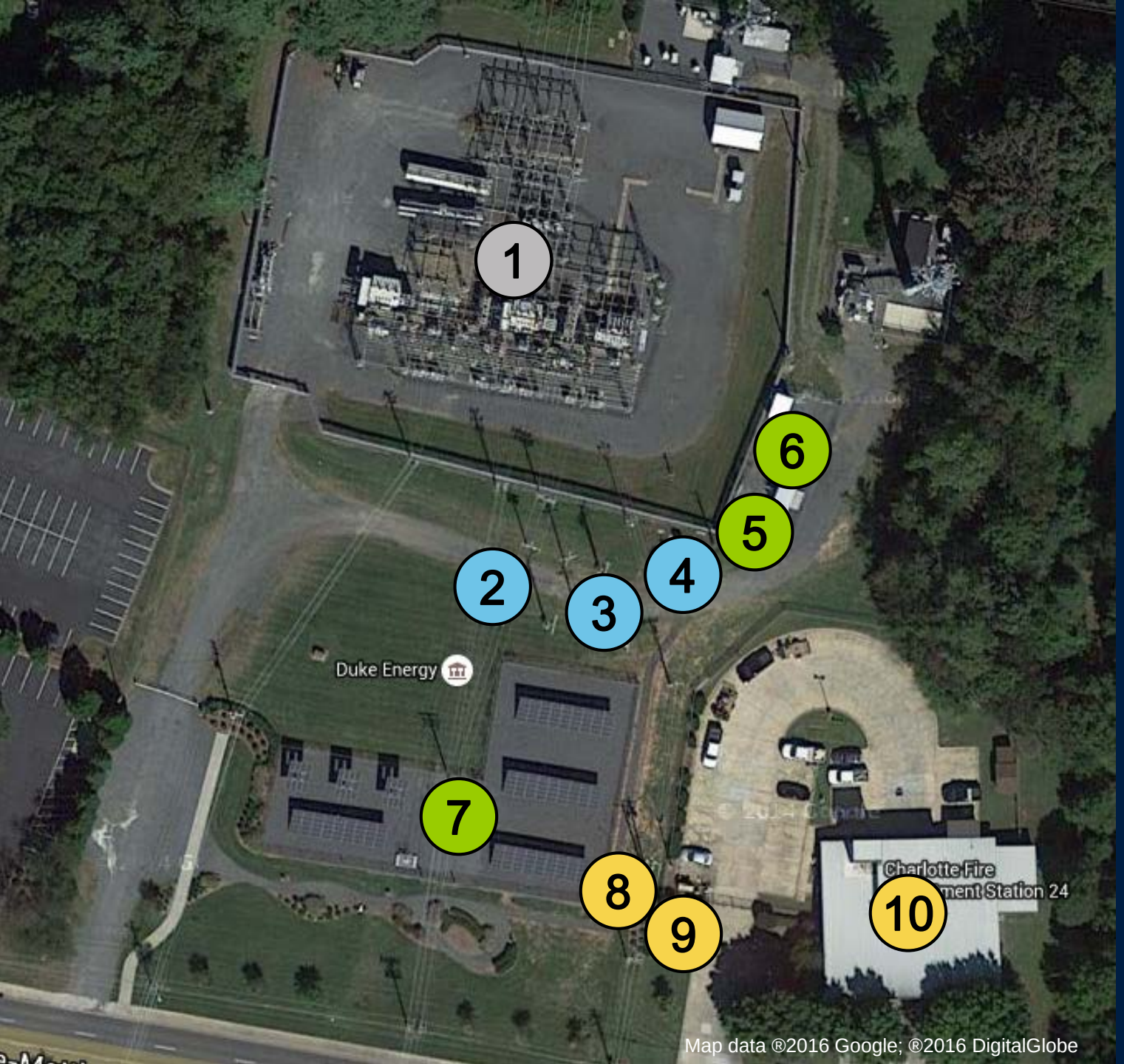


Fault Protection Study

- Microgrid has reduction in fault current during island mode
- Fire Station 24 (FS24) breaker was not sensitive enough
- Main FS24 breaker was replaced with electronic breaker with adjustable trip points

Load Profile Analysis





Test Site Layout

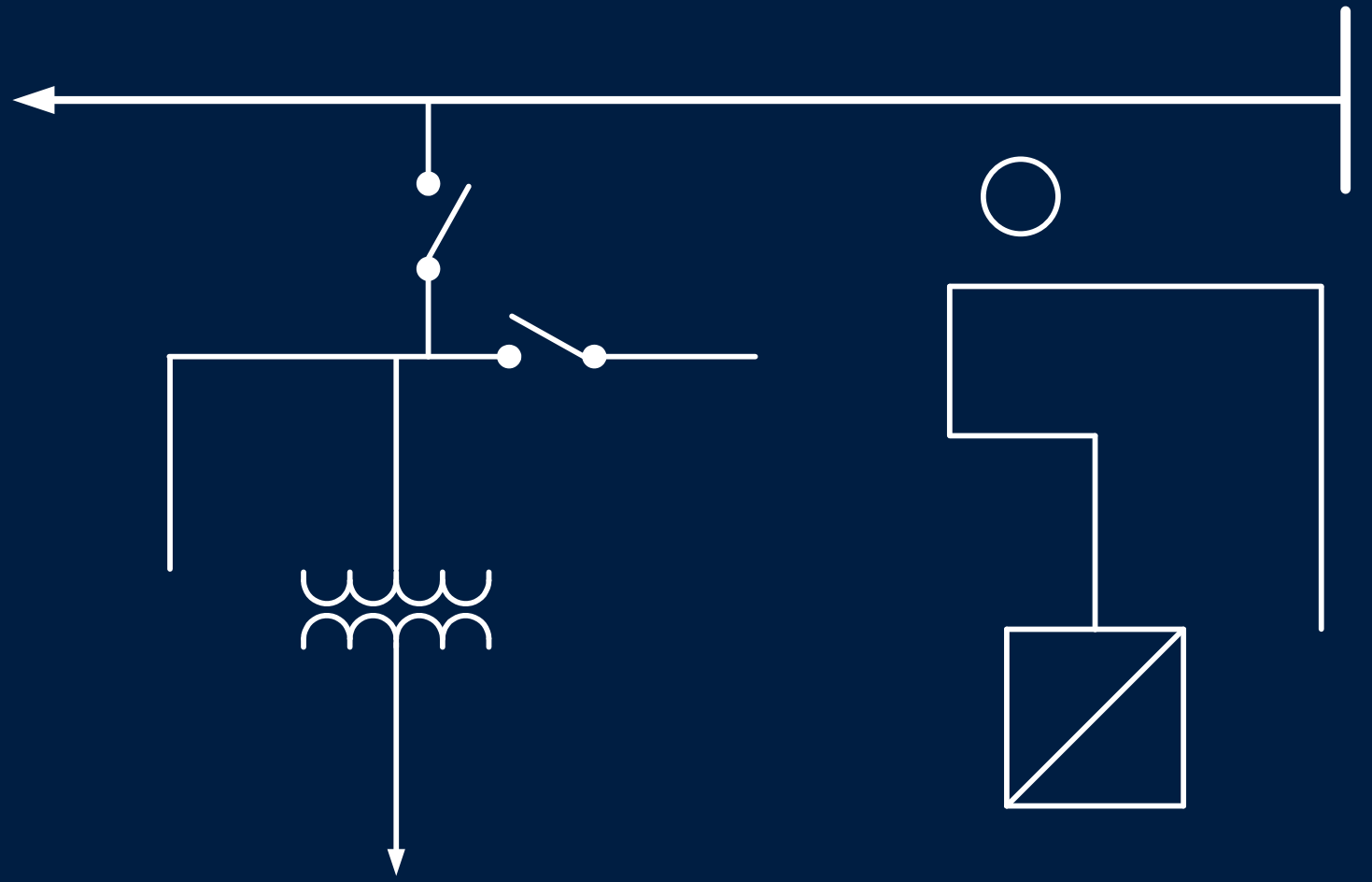
1. Existing substation

2. ISO switch
3. DER switch
4. DER transformer

5. Solar inverter
6. BESS and control house
7. PV Array

8. Customer transformer
9. Customer generator
10. FS24

Microgrid One-Line Diagram

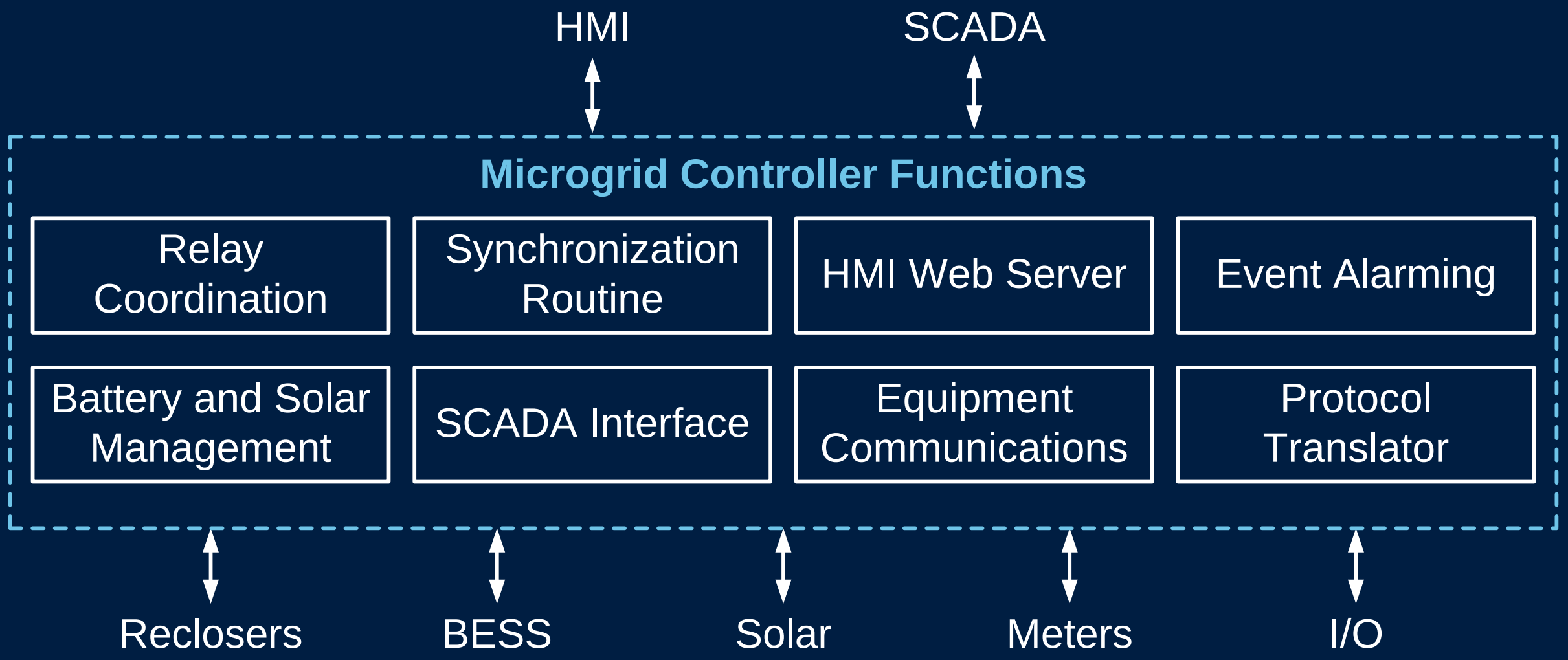


Standard Recloser and Control Devices Chosen

Recloser (triple-single)

Recloser Controller

Design Phase



Protection

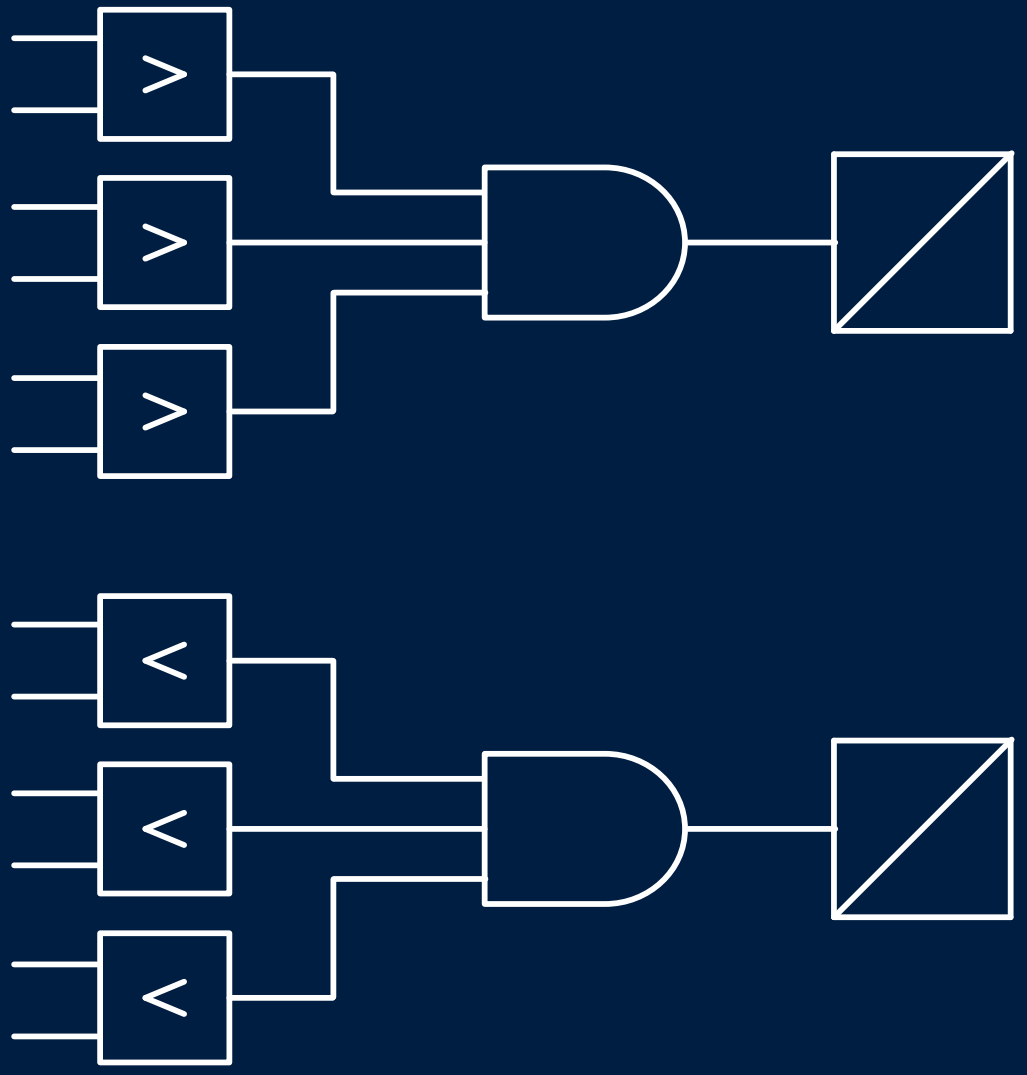
- Isolation (ISO) switch protection
  - Undervoltage elements (27)
  - Synchronism check (25)
- Distributed energy resource (DER) switch protection
  - Undervoltage elements (27)
  - Overvoltage elements (59)
  - Underfrequency element (81)

Microgrid Control Modes

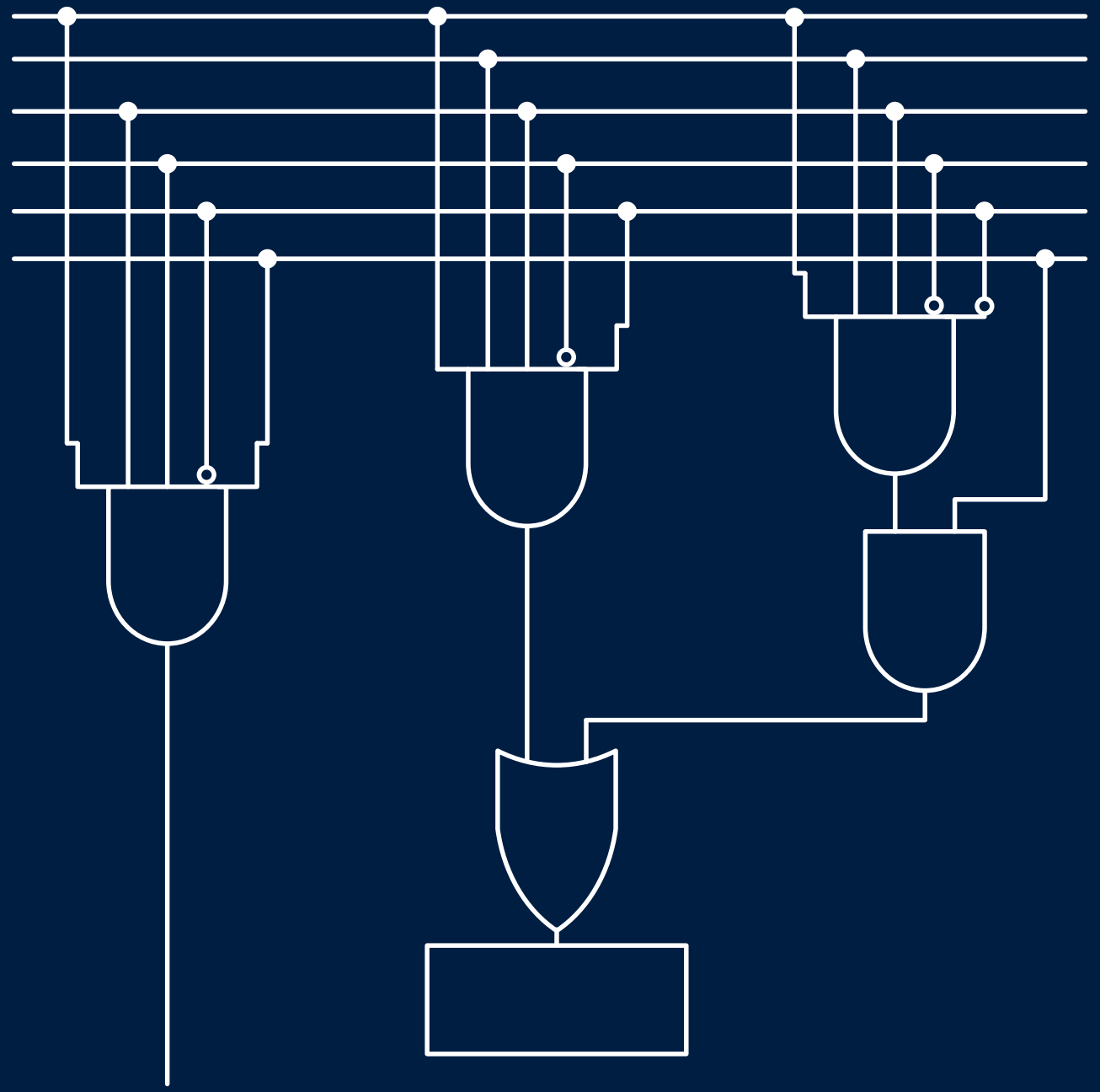
Duke Energy Developed Three Modes

- Mode 1 – automatic mode with manual resynchronization
- Mode 2 – automatic mode with automatic resynchronization
- Mode 3 – manual mode

Control Logic

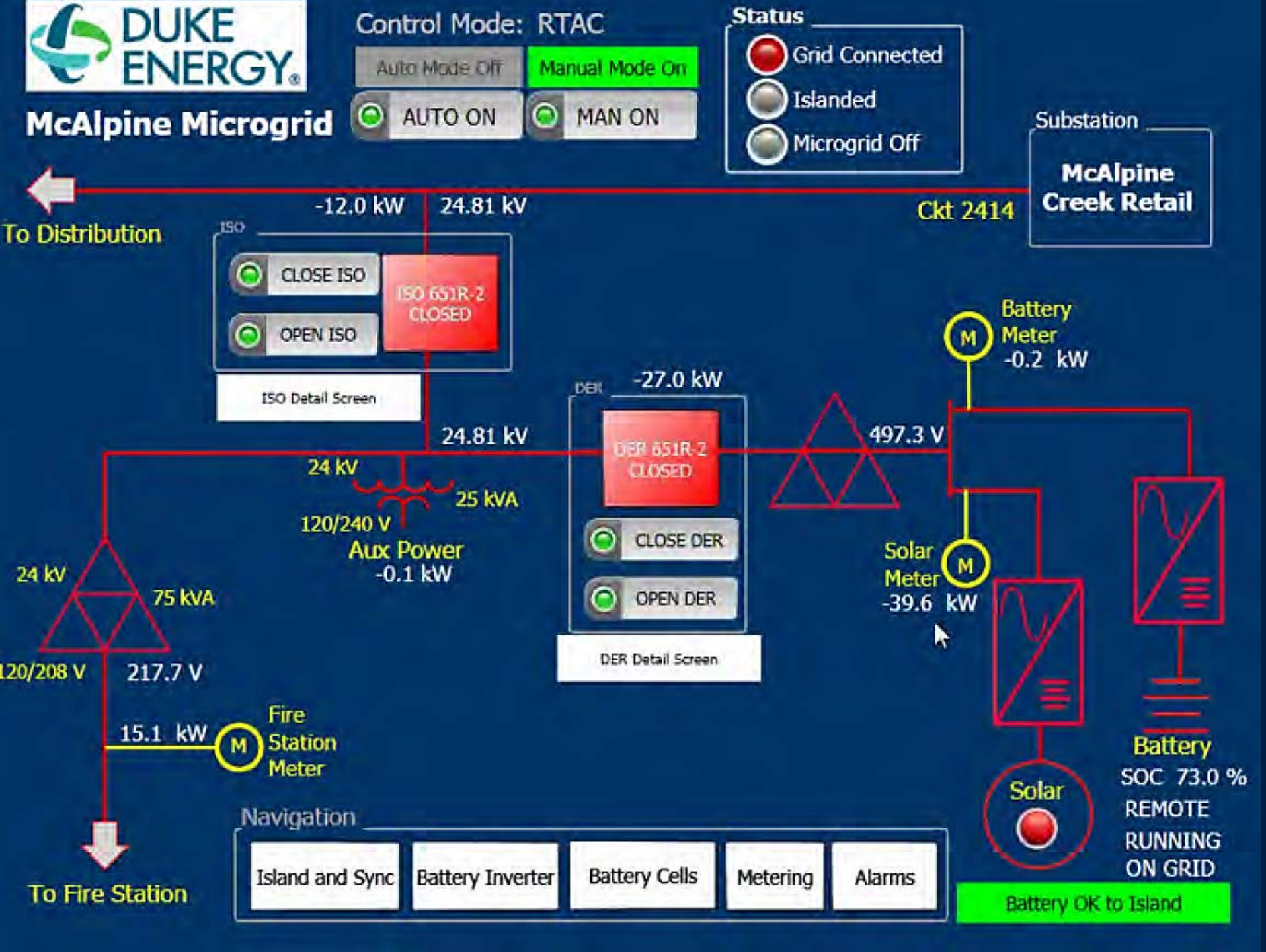


Control Logic



Controlled Synchronization Routine

- Grid is healthy
- Time delay has elapsed
- ISO breaker is open



HMI Overview Screen

Lessons Learned

- Microgrids can be valuable grid assets
- Inverter-based technology is challenging to adopt
- Auxiliary power considerations are required
- Power quality metering is crucial
- Safety and operational considerations are different

Control House Exterior and BESS

Control House Interior

Questions?