INTERNATIONAL DISTRICT ENERGY ASSOCIATION

DESIGNING MICROGRIDS

Michael Dempsey

June 20, 2016

Agenda

- Define Microgrid
- Discuss Typical Attributes
- Common Platforms
- Typical Customers and Applications
- Design Considerations
- Case Study

Microgrid Definition

A microgrid is

“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

[and can] connect and disconnect from the grid

to enable it to operate in both grid-connected or island-mode.”

*- the **U.S. Department of Energy***

Microgrid Definition

A microgrid is

"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

[and can] connect and disconnect from the grid

to enable it to operate in both grid-connected or island-mode."

*- the **U.S. Department of Energy***

Common Features

- Decoupling of Generators from Loads
- Seamless Transitions to/from Utility
- Increased Redundancy of Generation

Historical View of Microgrids

- Strictly for Customer Energy Reliability / Independence
- Heavily Dependent on Diesel Generation
- Bi-State Systems

Microgrid Evolution

- Microgrids Now Contain Assets which are Installed Primarily for Utility-Tied Operation
- No Energy Source is Out of Bounds
- Multiple Modes of Operation - Both Grid Tied and Islanded

Where We are Headed

- Microgrids Designed to be an IPP 99.99% of the Time with Customer Energy Security
  as a Secondary Requirement
- Utilities Adopting New Rate Structures and Capital Plans to Profit from Microgrid Capabilities
- Cyber Security is
  one Big Hurdle to Clear

Microgrid Platforms

Combined Heat & Power

- Central Energy Plant Approach
- Focused on Highly Efficient Utility Tied Operation
- Common on University Campuses

Traditional Critical Infrastructure

- Central Backup Power Plant Approach
- Only Operate in Absence of Utility
- Common at Data Centers and Hospitals

Next Gen Critical Infrastructure

- Distributed Generation Approach
- Focused on Flexibility and Sustainability
- Emerging Technology

Universities

- Energy is a Significant Portion of Total Operating Costs
- Loss of Research can be Very Costly
- Students Expect Uninterrupted Utilities

Hospitals

- Codes Only Require “Triage Quality” of Care
- During Disasters, People Migrate to Hospitals, Police Stations, Etc. as Places of Refuge
- High Efficiency Buildings and Technology-Based Care do not Permit “Limp Mode” Operation

Manufacturing

- Automation has Increased Susceptibility of Overall Manufacturing Process to Electrical Issues
- Just in Time Inventory Practices Reduce or Eliminate Cushion of Already Manufactured Products
- Rolling Blackouts can Result in Dramatic Costs of Lost Production and Lost Material

Department of Defense

- Greater Dependence on Electronics at all Levels of Military
- Leaner Military has Resulted in a Great Deal of Theater Command and Control being Located in US
- Very Large Renewable Generation Installations which Are Unavailable During Outages

Design Considerations

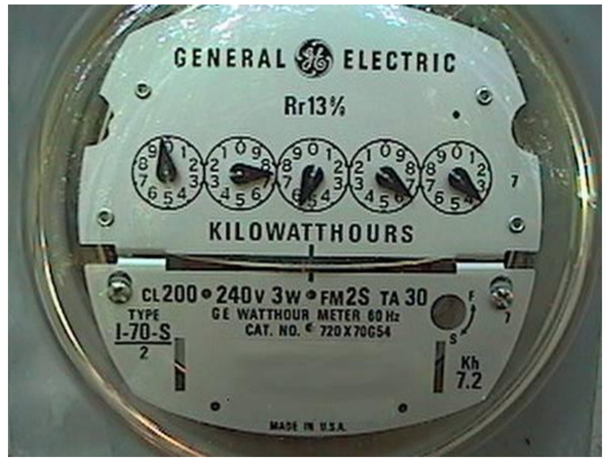
- Existing or New Facility/System
- Loads
- Sources
- Distribution System
- Control
- Cost

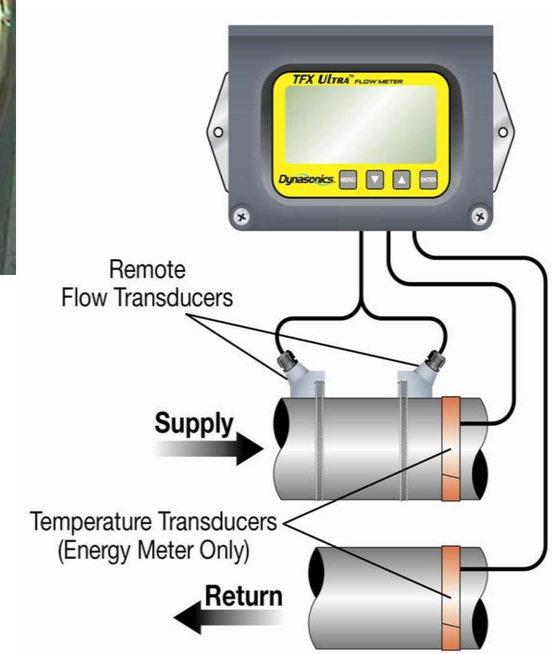
Design Considerations Existing/New

- Existing Facility or Asset(s)
  - Required Modifications
    - Loads
    - Sources
  - Load/Source Balance
  - Partial of Full Operation
  - Budget
- New Facility or Asset(s)
  - Projected Load/Source Balance
  - Partial of Full Operation
  - Budget

Design Considerations Loads

- Load Magnitude
  - Peak Load
  - Average Load
  - Critical Load
  - Load Factor
- Load Segregation
  - Load Step Size
  - Starting Methods
- Thermal/Electrical Load Balance
  - CHP Applications





Design Considerations

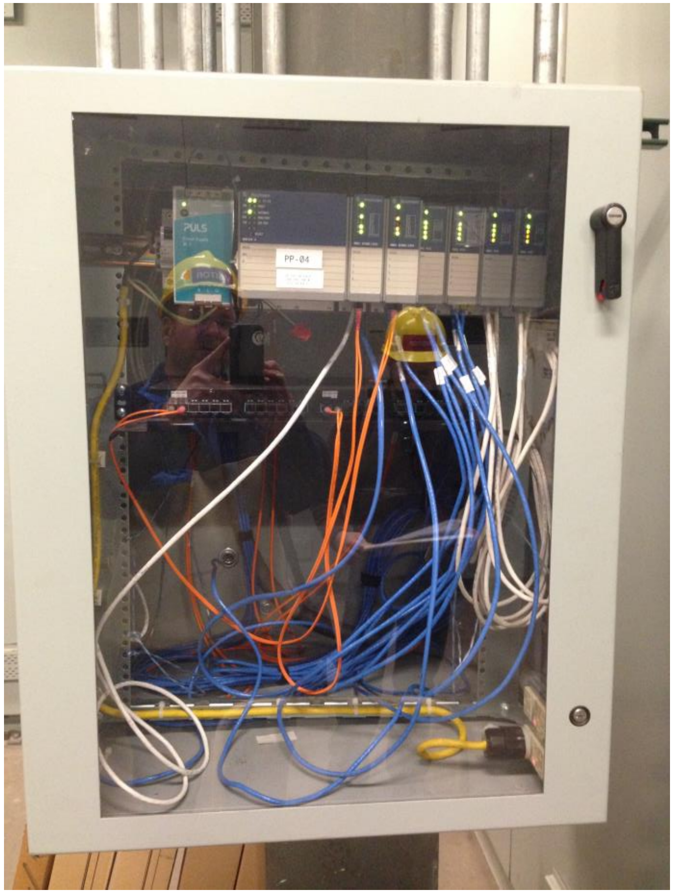
- Normal Deployment Mode
  - Grid Tied
  - Island Capable
  - Import/Export
- Source Capacity
- Fuel Source Reliability
- Renewables
- Load Control/Load Share
  - Multiple Sources Operating in Parallel
  - Transient Responsiveness

Design Considerations Distribution System

- System Configuration
  - Source Location
  - Load Location
  - Access to Load
- System Protection
  - Utility interconnection Protection
  - Islanded Protection

Design Considerations Controls

- Distribution Automation
- Source Control
  - Isochronous
  - Parallel Only
  - Islanding
- Load Control
  - Load Switching
  - Load Shed
  - Load Sequencing/Starting



Design Considerations Cost

- Existing Assets
- New Assets
- Magnitude of Operation Supported
- Distribution System Modifications
- Automation Level

Establish Basis of Design

- Establish Functional Criteria
  - What the System Can Do
  - What the System Can't Do
- Document Key Design Decisions
- Obtain Stakeholder Buy-in
- Carefully Plan Level of Automation
- Mind the Budget

Case Study

UT Southwestern Medical Ctr

Project Background

- Transmission Interconnect
- Customer owned substation
- 21.8MW Distributed Peak Shaving Generation
  - Only designed to operate grid connected
- Campus Load Exceeds Generation Capacity
  - Campus peak load 60MVA+

Design Considerations

- Existing or New Facility/System - EXISTING
- Loads – 60MVA+
- Sources - <22MW
- Distribution System – 13.8kV MANUAL
- Control – NO OVERALL AUTOMATION SYSTEM
- Cost – MINIMIZE $$

Loads

- Load Significantly Greater Than Source
- Develop Process to Prioritize Critical Load
  - Campus Management
  - Stakeholder Involvement
  - Build Consensus
  - Rotate Power Periodically
  - Significant Operator Involvement
- Define Load Step Size

Sources

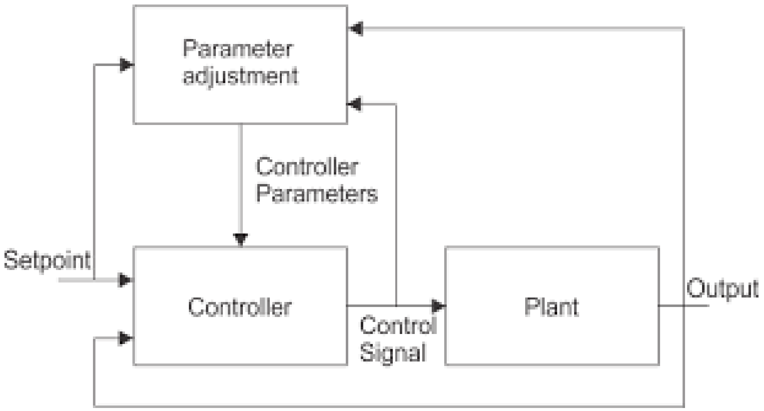
- Existing onsite generation
  - North Campus - 3 CAT NG Recip – 3MW Each
  - South Campus - 4 Deutz NG Recip – 3.2MW Each
- Multiple Building-specific Emergency Diesel Generators
- University Hospital – Separate Diesel Generator System
- Added Small DG for Starting Air

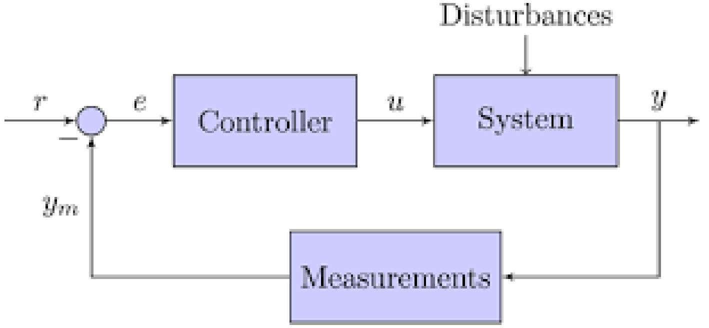
Distribution System

- 13.8kV Campus Owned
- Access to All Load
- Utility Interconnection Protection Modifications Required
- Relay Setting Changes
- Manual System Operation

Controls

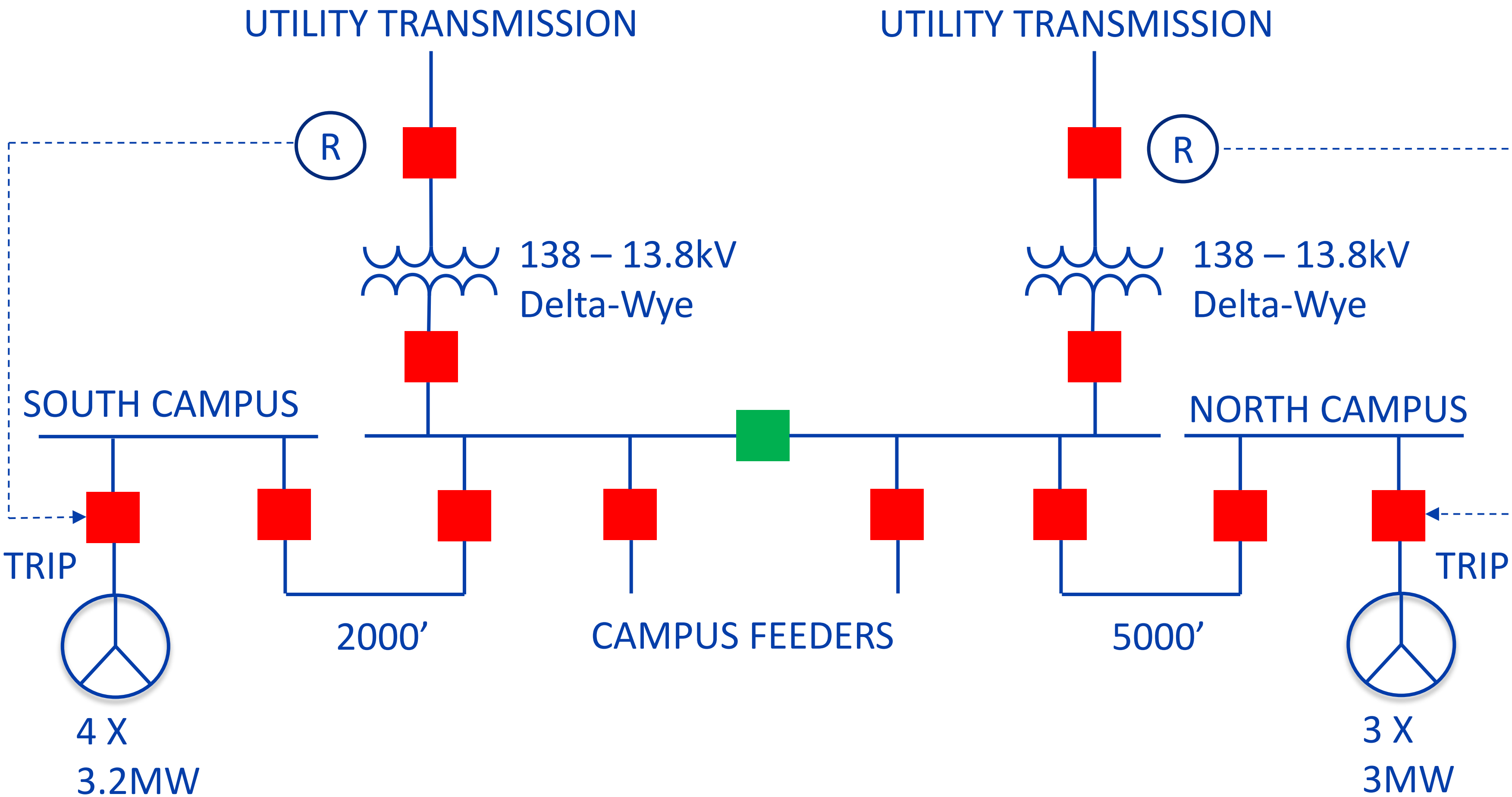
- North Campus
  - Modify CAT Switchgear System – Facilitate Export to Campus
  - Enable Test Mode – Isochronous Load Share Mode
- South Campus
  - No Changes Required
- New Microgrid Operational Mode





Current Operational Mode

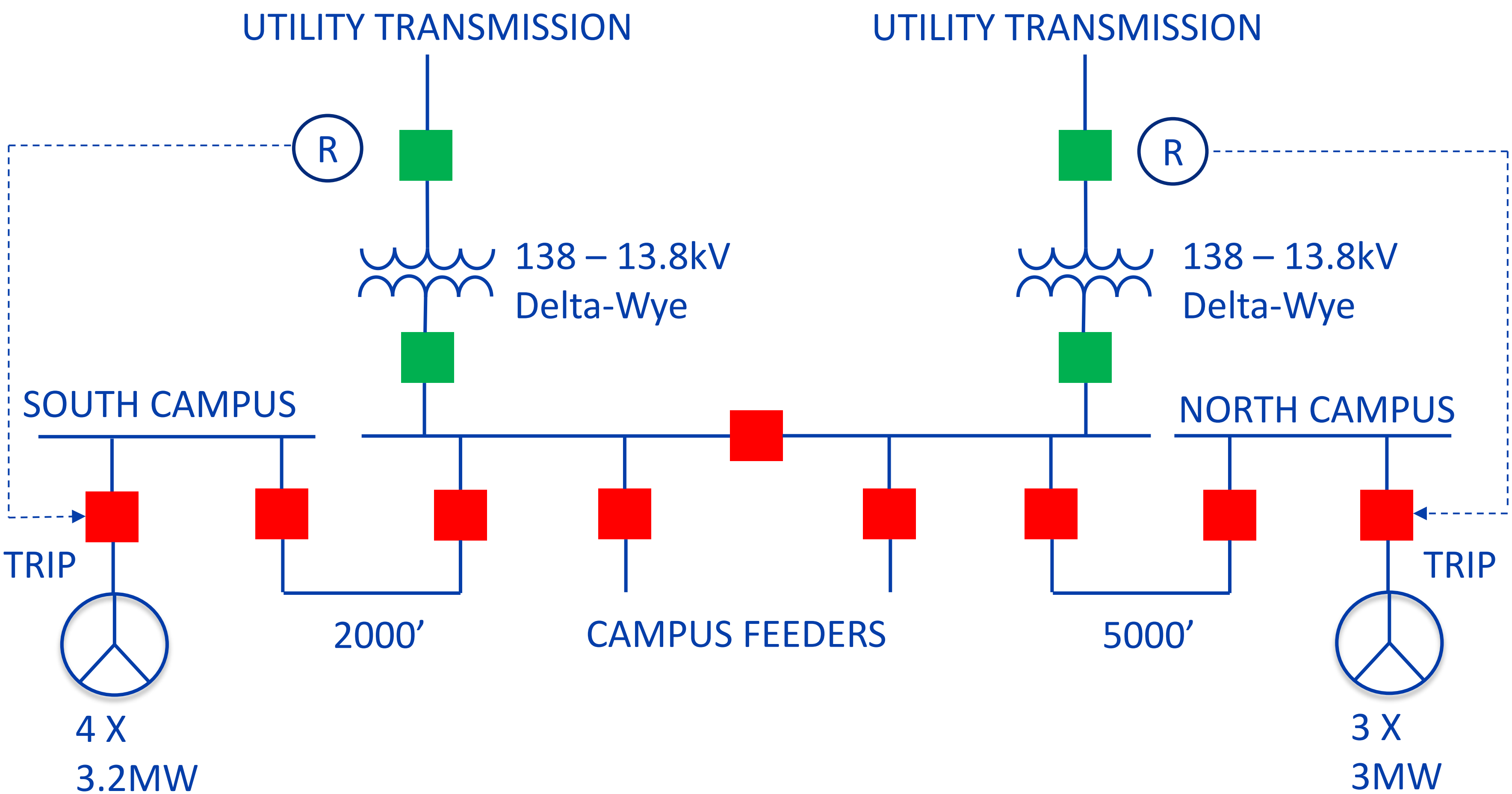
- Normal Mode
  - Grid connected
  - Generation only operates for:
    - Peak shaving (4CP avoidance)
    - Emergency load service (demand response)



NORMAL OPERATION

Added Operational Mode

- Microgrid Mode – Added Functionality
  - Island operation
  - CAT generators isochronous load share – act as source
  - Deutz generators base load mode – operator adjusts setpoint
  - Diesel generator maintains compressor for air start of CAT generators
  - CAT and Deutz generators controls do not communicate
  - Manual load add/shed by operators



MICROGRID OPERATION

Microgrid Mode

- Load swings absorbed by CAT generators only
- Manually transfer load to Deutz generators
  - Operator manipulate baseload setpoint
- Minimal modifications required to implement
  - Small starting air compressor DG
  - Substation relay settings modification
- Control systems unchanged
- Detailed operations procedure required

Summary

- No Two Microgrid Systems are Identical
- Multiple Platforms with Differing Requirements
- Similar Set of Design Considerations
- Competing Agendas Between Stakeholders
- More Automation – More Complexity – Higher Cost
- Establish and Document Design Basis

BURNSMCD.COM/ONSITE

CONTACT

Michael Dempsey, P.E.
Electrical Department Manager
P 817-733-8186
E mdempsey@burnsmcd.com