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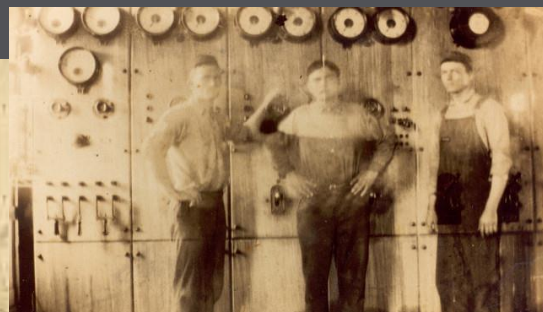
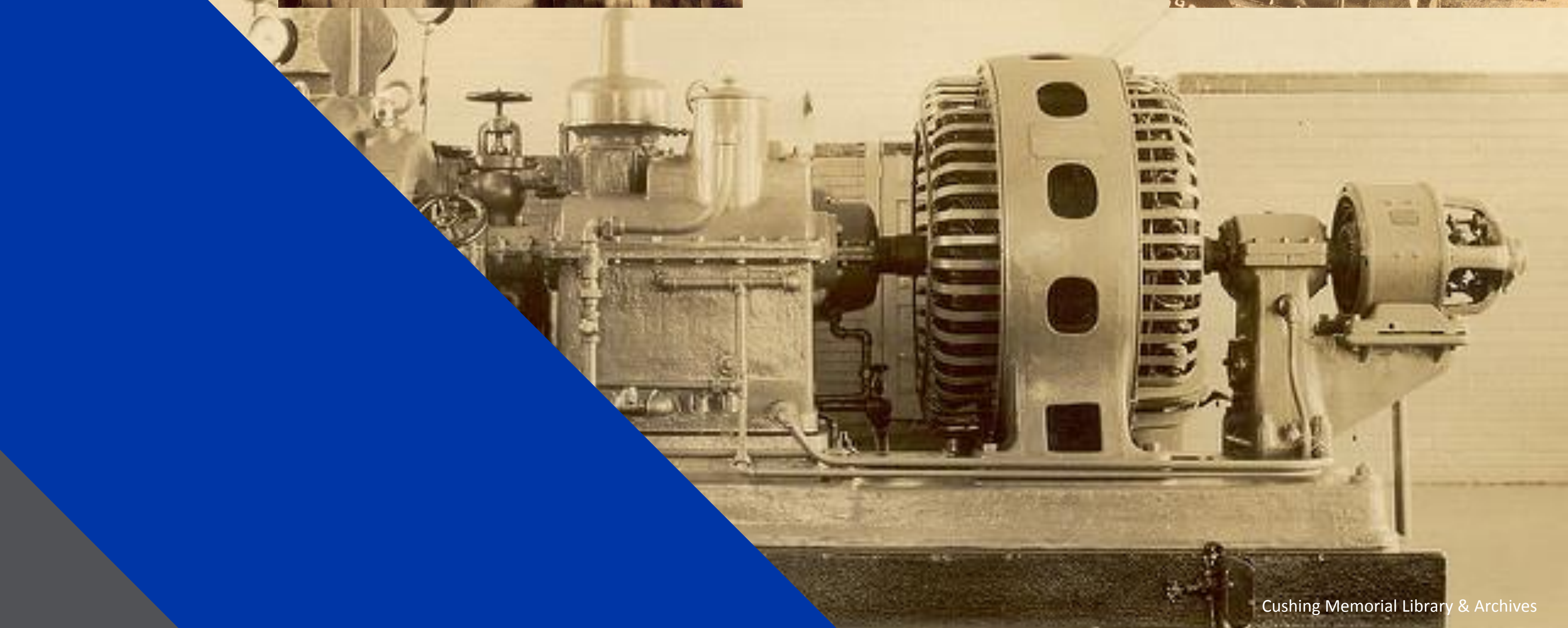
Texas A&M Microgrid and Electrical System Study





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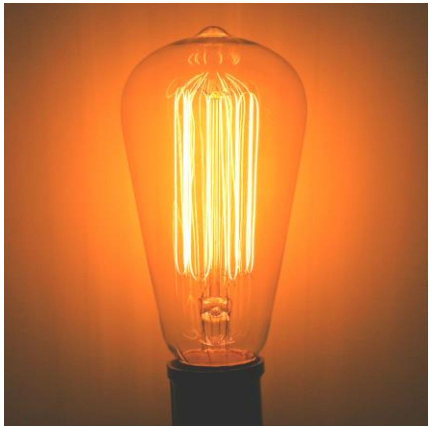
Introduction of Texas A&M Microgrid Study

- Purpose – Why are we studying the TAMU electrical system?
- Process – How do we want the distribution system to react?
- Plan – What is the application of the data we saw?



<u>Presenter:</u>

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  - Sr. Electrical Engineer – Burns & McDonnell

<u>Thanks to:</u>

- Tyler Hjorth, P.E., Class of ‘91
  - Manager, Electrical Services – TAMU UES

Question: How many Aggies does it take to screw in a light bulb?

Purpose: Electrical System Study Need

Why study the campus electrical distribution system?

- No defined response for system contingencies
  - Goal is automated system response
  - Answer the “What if” question
- ETAP model not updated for new loads
  - New equipment and buildings have been added to campus recently
- No comprehensive relay protection philosophy
  - Various methods of system protection methods are used
- Manual control of substation capacitors
- Building generators not tested and underutilized

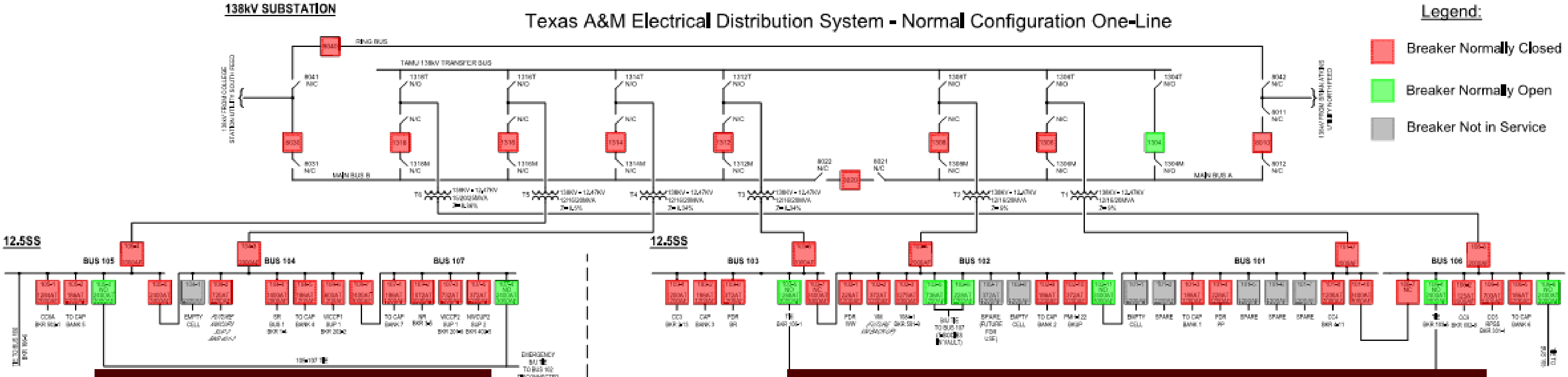
Microgrid Definition:

“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. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.”

U.S. DOE MEG

Overview of TAMU Electrical Distribution System

- 138kV to 12.47kV Substation
  - Separation of Utility Plants and Campus Buildings
- Utility Plants
  - Central Utility Plant: CUP
  - Satellite Utility Plants: SUP1/SUP2/SUP3
- Campus Distribution
  - Switchgear Distribution Points
  - Building Feeders
- Control Systems
  - Ovation
  - SCADA
  - Distribution Automation

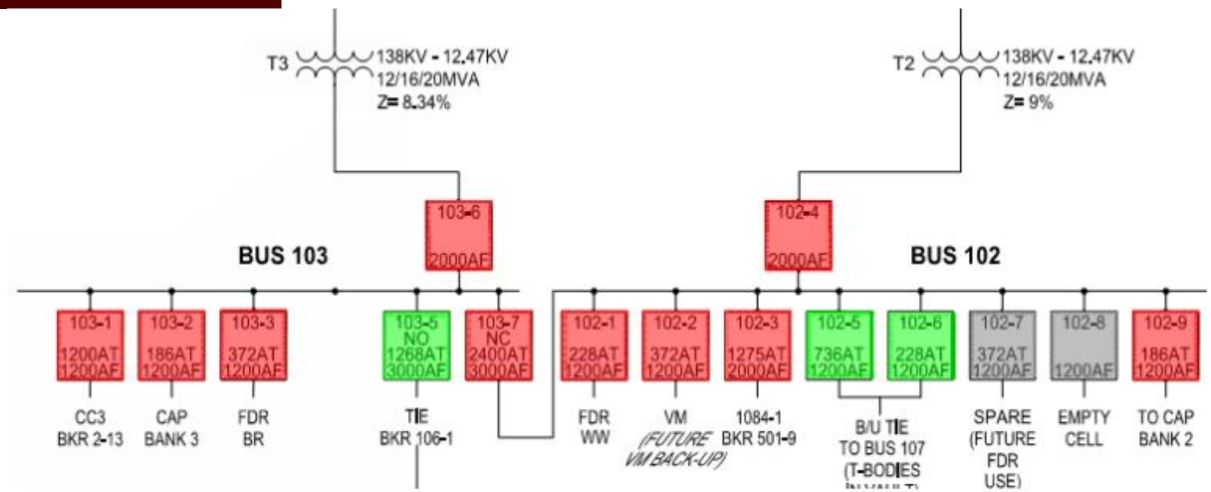


UTILITY PLANTS

- GTG1=34MW
- STG2=11MW
- STG4=5MW

CAMPUS DISTRIBUTION

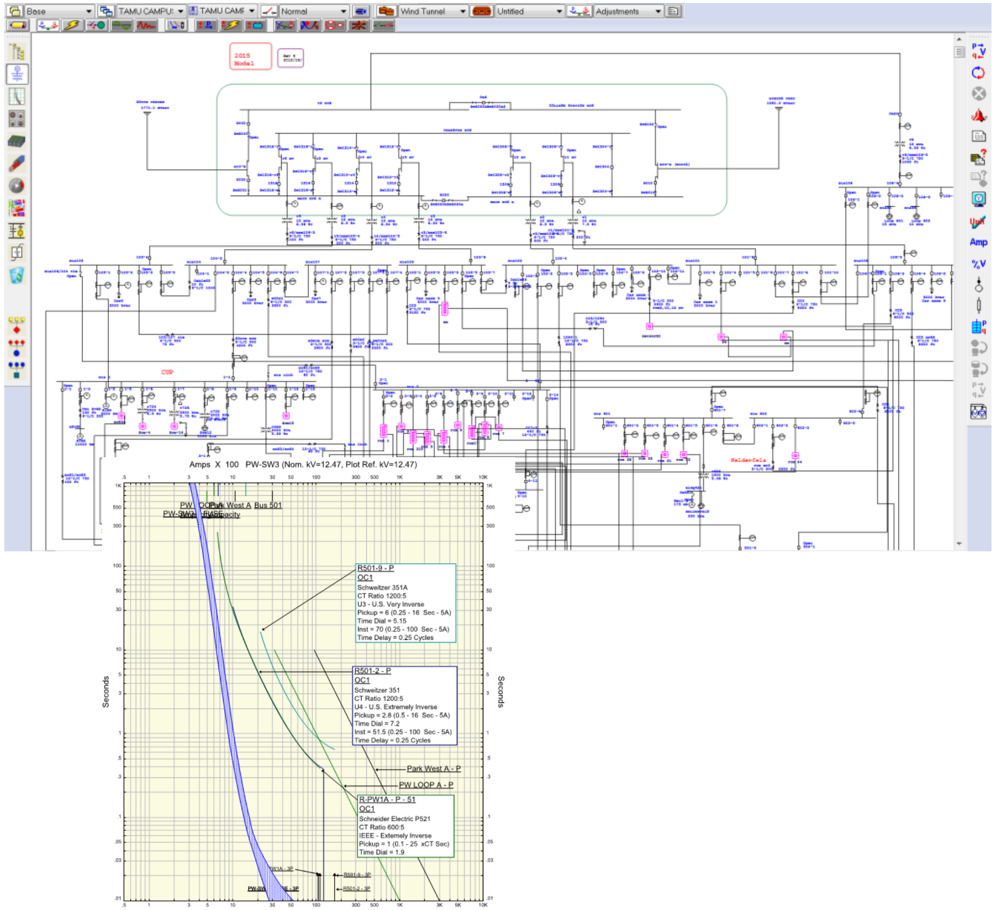
- Heldenfels Switching Station
- Research Park Switching Station
- West Campus Switching Station



Process: System Study Approach

How do we improve on the electrical system?

- Analyze and define system response options
  - Utilize available meter data
- Update ETAP model
  - Short circuit study
  - Arc-Flash study
- Document relay settings philosophy
  - Correct coordination issues
  - Propose standards for new relays
- Analyze substation capacitors
- Investigate generators for paralleling



Plan: Automate Electrical System Response

The "What If" Scenarios

- 138kV-12.47kV Substation Transformer Loss
- 12.47kV Bus Loss
- 138kV Bus Differential Trip
- Loss of Utility Power (Island Mode)
- Total Campus Power Loss

<u>TAMU Electrical Goals:</u>

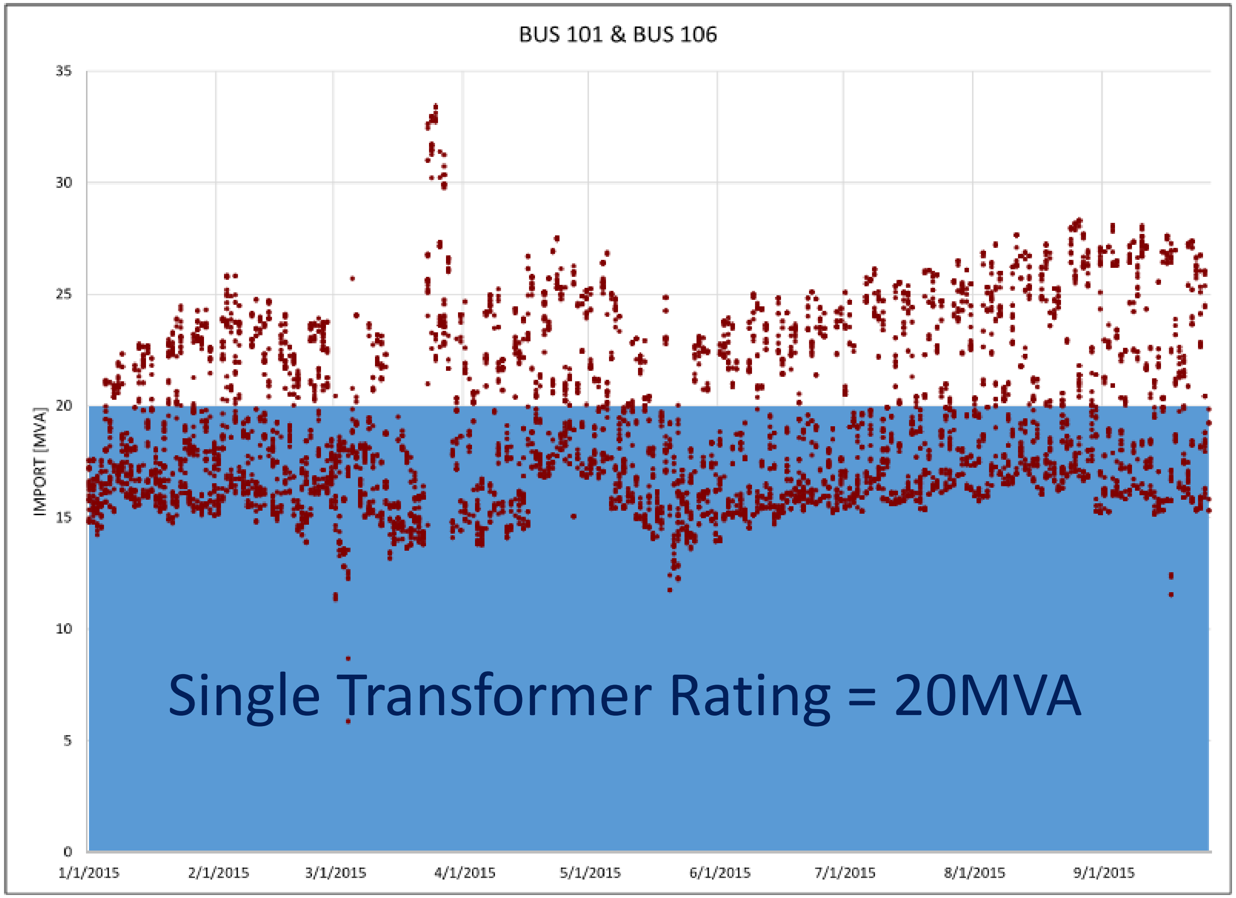
1. Keep the lights on.
2. Parallel transformers as needed.
3. Utilize on-site generation.
4. Shed campus load as last option.

138kV-12.47kV Substation Transformer Loss

Campus Distribution: XFMRs T1, T2, T3, T6, T8

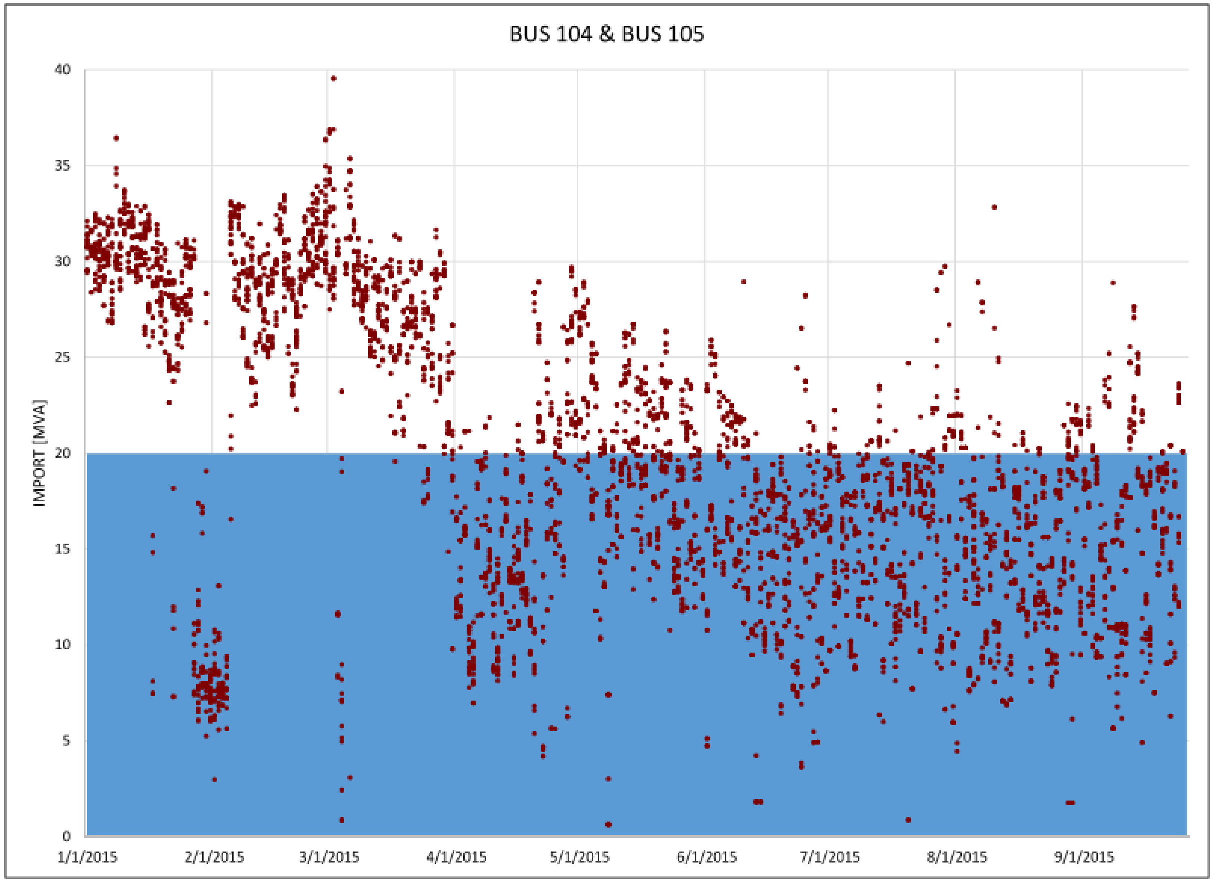
<u>System Reaction:</u>

1) One XFMR/ Two Bus
2) Three XFMR / Four Bus
3) Overload XFMR
4) Shed Load



138kV-12.47kV Substation Transformer Loss

Utility Plants: XFMRs T4, T5

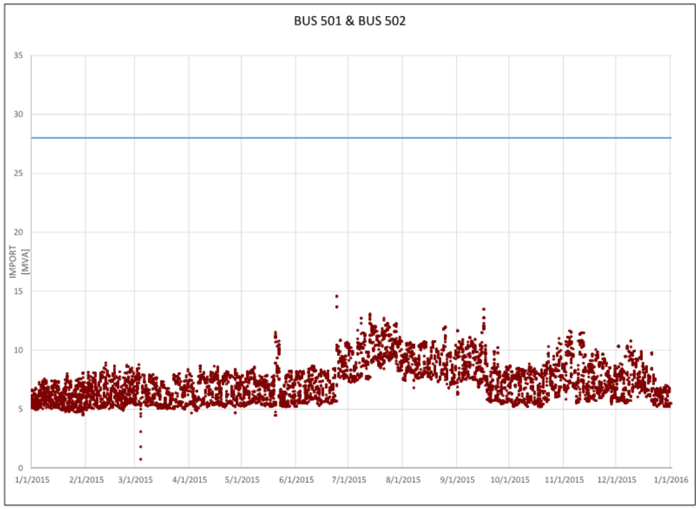


System Reaction:

1) One XFMR/ Three Bus
2) Bus 106 Backup

12.47kV Bus Loss

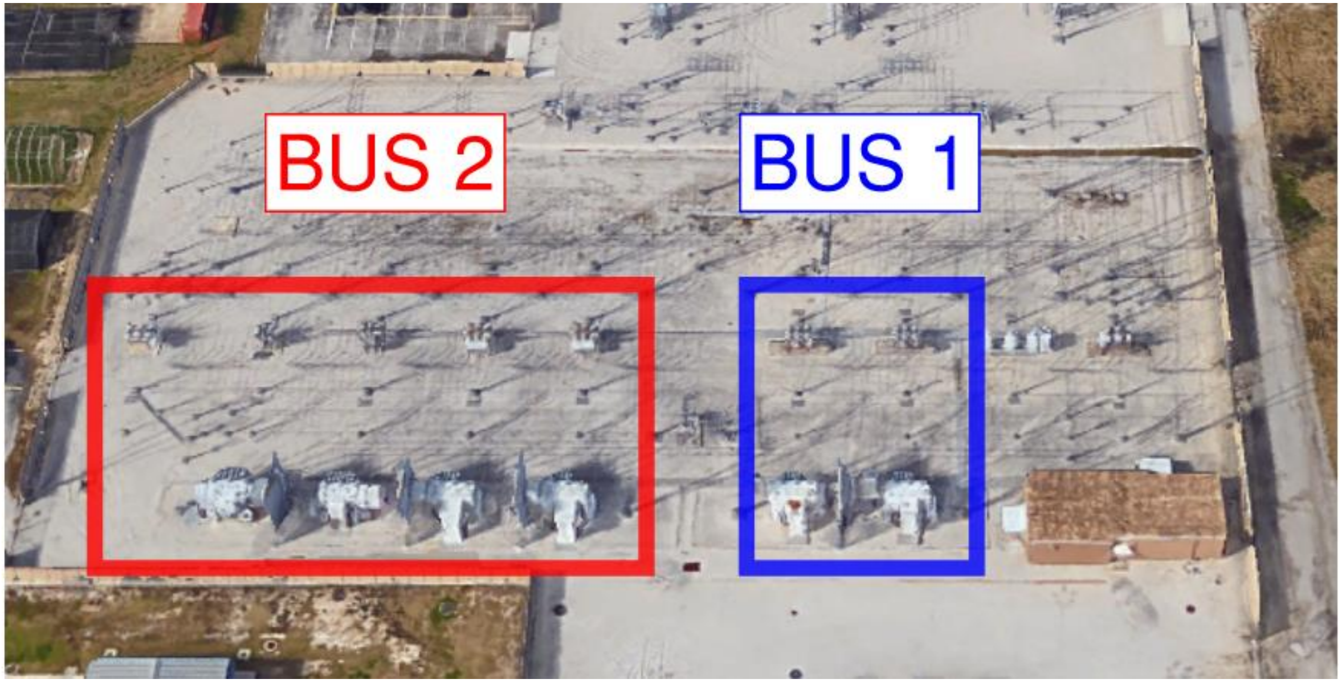
- Cause: Bus Differential Trip
- Analyzed downstream switchgear meter data
- Campus Distribution: Bus 101, 102, 103, 106, 108
  1) Switch Downstream Switchgear Breakers
  2) Shed Load
- Utility Plant: Bus 104, 105, 107
  1) Switch Downstream Switchgear Breakers
  2) Reduce Power Output of Generation



138kV Bus Differential Trip

- 138kV Bus #1 – XFMRs T1, T2
  - Only campus distribution affected
  1) One XFMR/Two Bus (T8 backup)
  2) Two XFMR/Four Bus
  3) XFMR Overload
  4) Load Shed

- 138kV Bus #2 – XFMRs T3, T4, T5, T6
  - CUP generation transfers to island mode
  1) One XFMR/Two Bus (T8 backup)
  2) Two XFMR/Four Bus
  3) XFMR Overload
  4) Load Shed



Loss Of Utility Power

Island Mode

- Automated Grid Separation
  - GTG-1, STG-2, STG-4 switch to island mode
  - Campus generators provide power to buildings
  - Thermal process coordination

- Island Mode Operation
  - Generation = Load
- Return to Utility
  - Automatically Synchronize to BTU

Loss Of Utility Power

No Utility Power or Campus Generation

- Zero Voltage Start (ZVS) Sequence
  - CUP Diesel Generator starts GTG1
  - GTG1 supplies power to CUP
- Mechanical Systems Interaction
  - Steam production balance
  - Automation through Ovation system
- Energize select campus loads through breaker operation
- Return to Utility
  - Automatically synchronize

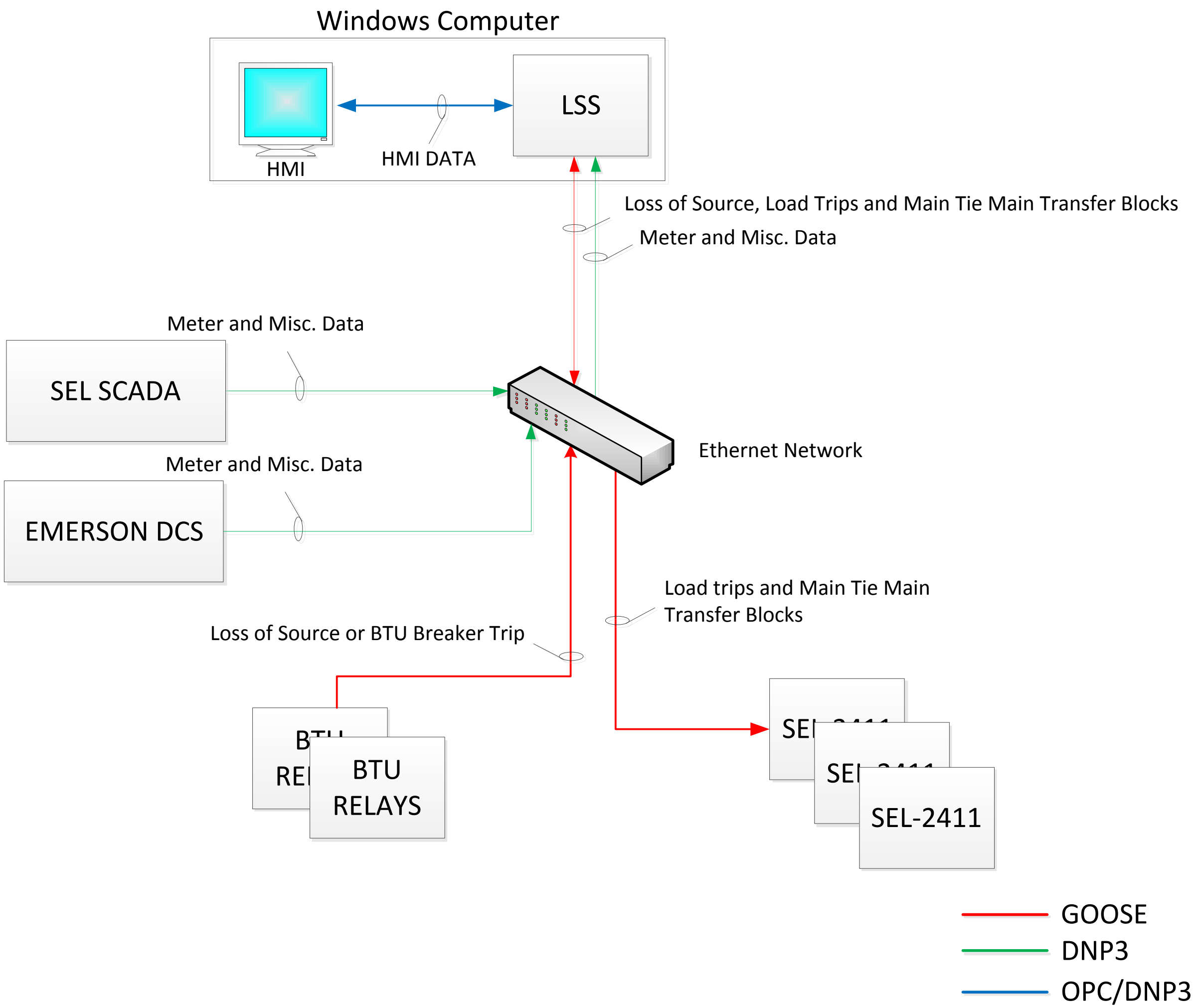
Microgrid Control Solution

Main Functions

- Breaker Control
  - Switch breakers according to proposed response
- Automatic Islanding/Fast Load Shedding
  - Detection before generator trip
- Automatic Generator Synchronization
- Power Factor Control
- Emergency Generator Integration
- Control System Interaction

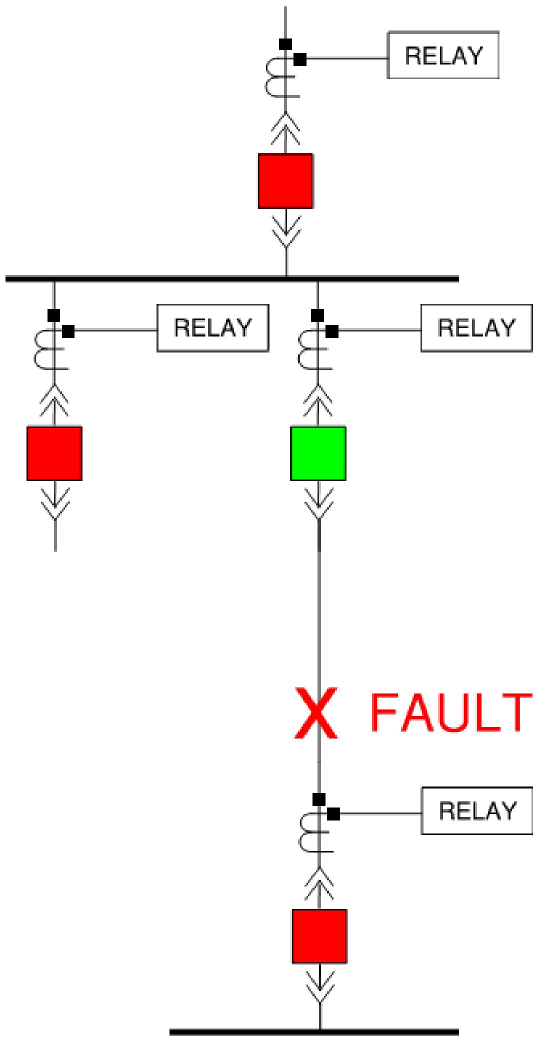
Microgrid Control Solution

System Diagram

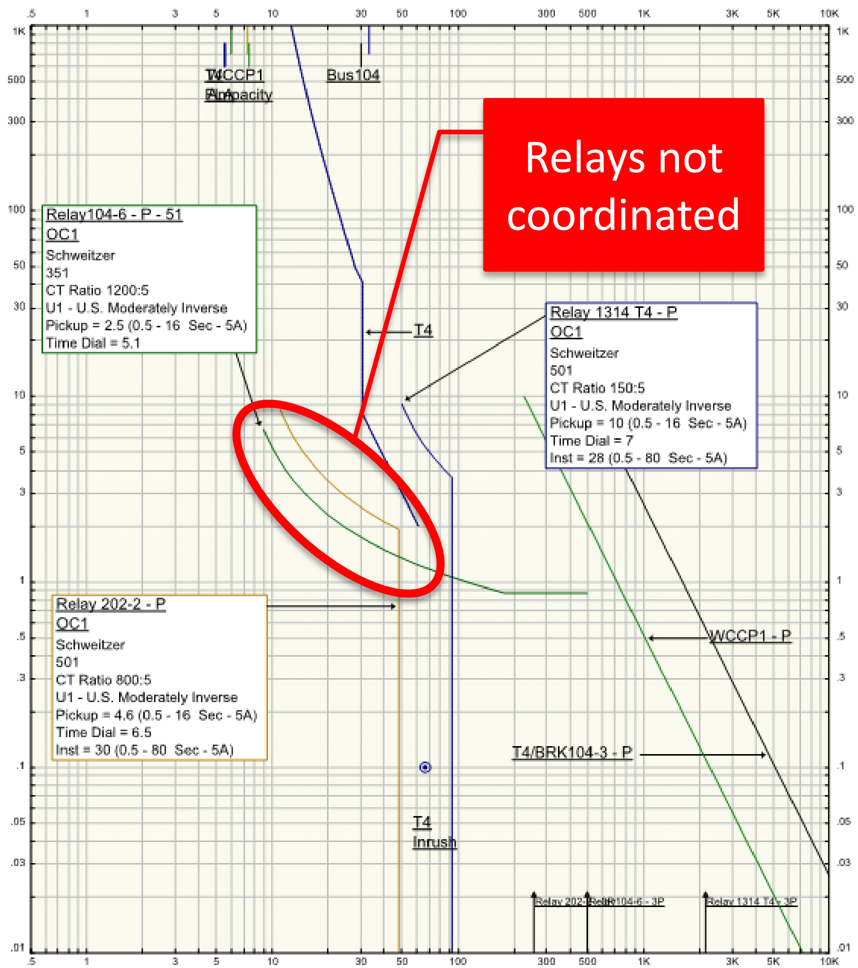


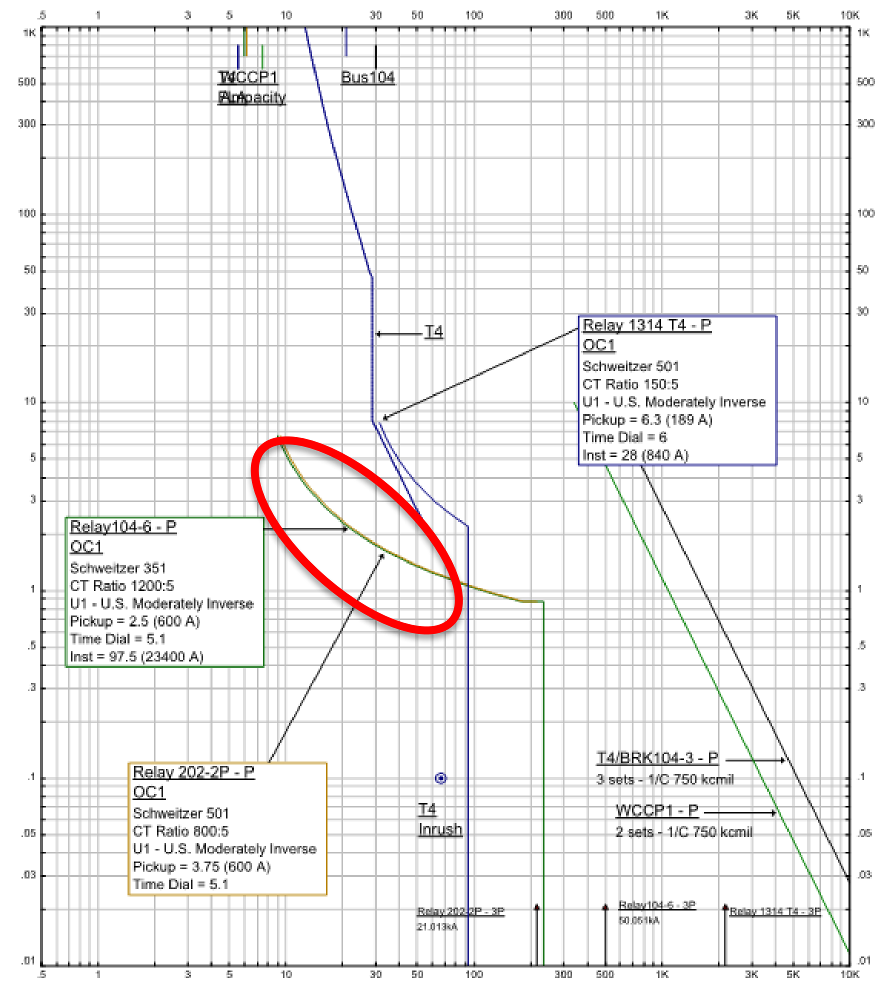
Relay Protection Philosophy

- Goal: Trip downstream relays before upstream
  - System coordination vs. equipment protection
- Analysis of 15kV relays
  - .rdb files
  - TCC curves
  - Trip equations
- Proposed changes
  - Improve transformer protection
  - Coordinate instantaneous on main feeders
  - Improve ground fault coordination
  - Simplify trip equations



Relay Coordination Curves Before/After





Substation Power Factor Control

- 3000kVAR units at each 15kV substation bus
  - Manually switched
- 3 of 7 units not functioning
  - Recommend new, staged units
- Goal: Maintain .97pf
- Interaction with control system

Generator Investigation

- Current Issue: How to test building generators using load?
- Future Issue: How to use excess generator capacity to provide power to campus in an outage?
- Analyzed ratings of equipment and ratings of generators 500kW and larger.

Result: Most generators can be paralleled to the system safely for testing and back up on a campus level.

Steps Forward and Application

- Next Steps
  - Detailed Design of the Microgrid Control System
  - Complete a detailed ZVS sequence
  - Install metering at main 15kV system buses

- What is the application for your system?
  - Know where power is flowing on your system
  - Maintain current electrical system model with relaying
    - Identify system coordination improvement
  - Ask the "What-if" questions about your equipment
    - Generation behind the meter
    - Roadmap of potential automation & island operation
  - Pro-active about system operation

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