BURNS McDONNELL

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

# *"It's Just a Couple of Wires"* Interconnecting CHP Assets with the Electrical Grid

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# What Could Go Wrong?

- Damage Onsite Generation
- End up with an Unreliable Plant
- Get a Large Bill for Utility System Upgrades
- Construct a Project the Utility Won't Accept
- Lose Money on Power Transactions

# Agenda

- Voltage Level
- Utility Protection Requirements
- Import/Export Restrictions
- Relay Coordination
- Generator Islanding
- Loading and Load Shedding
- Available Short Circuit Current
- Case Studies

# Interconnection Voltage Level

- Transmission
  - >69,000V
- Primary Distribution
  - 12,470V – 34,500V
- Secondary Distribution
  - 480V – 4,160V

# Utility Protection Requirements

- Protection Requirements Differ by Utility
- IEEE 1547 Requirements
  - An Attempt to Standardize <10MVA
  - Primary and Secondary Interconnections
- Islanding Protection
  - Direct Transferred Trip
  - Reverse Power 32

  (Non-Export Applications)

# Utility Protection Requirements

- Additional Protection
  - Over/Under Voltage 27/59
  - Over/Under Frequency 81O/U
  - Directional Overcurrent 67, 67N
  - Ground Overvoltage 59N
    - Utility Interconnection Delta-Wye
  - Sync Check 25

# Import/Export Restrictions

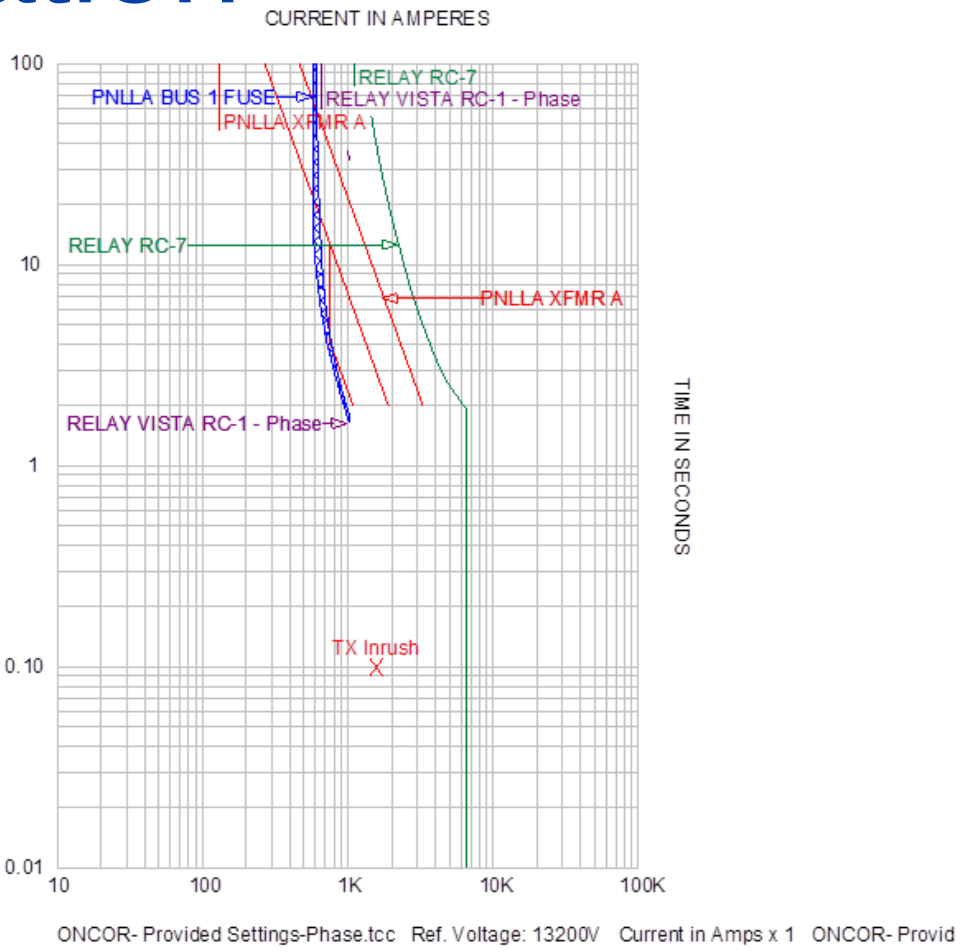
System Minimum Load > Generator Output = Import
System Minimum Load < Generator Output = Export

- Exporting (Even on a Rare Occasion) Requires Market Participation
  - Additional Metering Requirements
  - Subject to Market Rules and Pricing
  - Location Dependent – Rules Vary

# Relay Coordination

## Interconnection Protection Settings Driven by Utility and System - Reclosing

- Transmission
  - Coordinate with Line Relays
- Primary Distribution
  - Coordinate with Substation Feeder
- Secondary Distribution
  - Coordinate with Transformer Protection



# Generator Islanding

- Planned Islanding
  - Deliberately Separate from Utility
  - Generator Capacity Must Exceed Load
  - Generators Operate in Frequency Control (Isochronous) Mode
    - Maintain 60Hz
    - Share Load if Multiple Generator Installation
  - Manual or Automated Initiation

# Generator Islanding

- Unplanned Islanding
  - Generation Energizes a Portion of the Utility System Following a Utility Outage
  - Generation Must Automatically Separate from Utility
  - Separation Must Occur Before Utility Reclosing
    - Separate Entire System and Operate in Island Mode
      - Trip Utility Interface Breaker(s)
    - Separate Generator(s) Only
      - Trip Generator Breaker(s)

# Loading and Load Shedding

- Islanding with Load > Generator Capacity Requires Load Shedding
  - Automated Load Shedding Required – Options:
    - Frequency Based
      - Shed Load Until 60Hz can be Maintained
      - Rate of Frequency Decline
      - Prioritized
    - Load/Capacity Based
      - Monitor Load and Online Generator Capacity
      - Shed Load to Below Online Generator Capacity

# Available Short Circuit Current

- Onsite Generators Contribute Short Circuit Current
  - On the Customer Side
  - On the Utility Side
- Protective Equipment Interrupting Ratings Must Exceed Available Short Circuit Current
- Mitigation Techniques
  - Upgrade Switchgear/Breakers
  - Add Impedance
    - Transformers
    - Reactors
  - Limiters

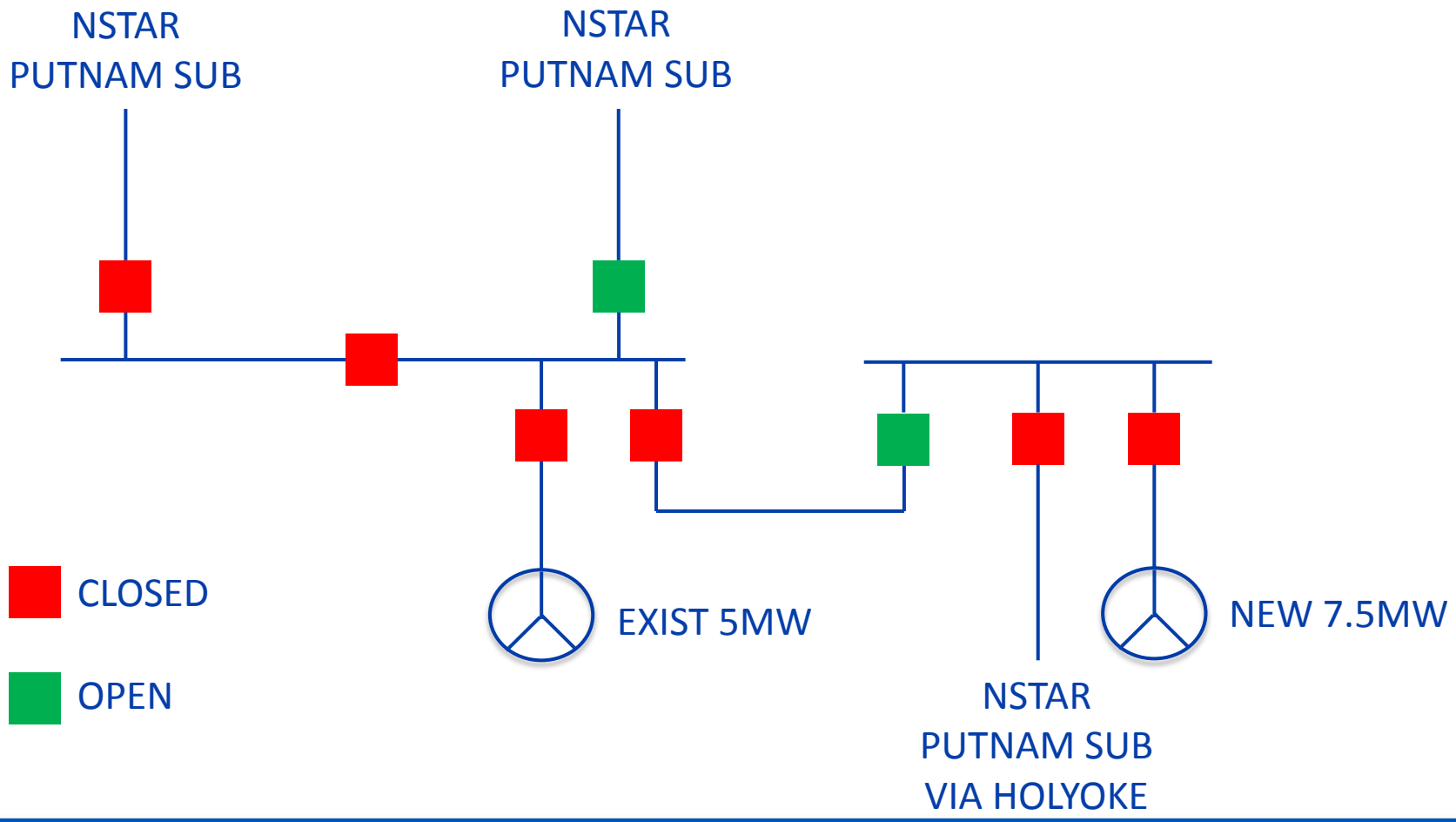
# CASE STUDIES

# Harvard Blackstone Plant – Cambridge, MA

- Existing Steam Turbine Generator – 5MW
- New Combustion Turbine Generator – 7.5MW
- Primary Distribution Interconnection
- Serves Harvard Campus
  - Locally connected to Business School
  - Remotely connected to Holyoke Substation

# Harvard Blackstone Plant – Cambridge, MA

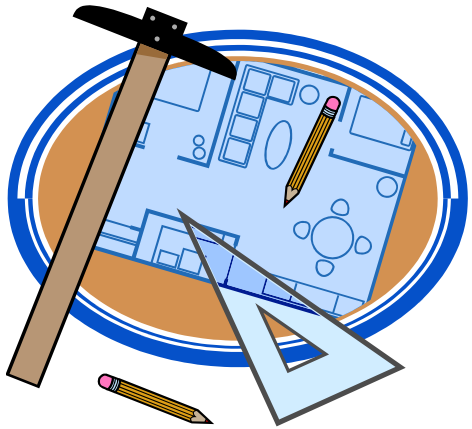
## Initial Proposed Interconnection



# Harvard Blackstone Plant – Cambridge, MA

## Initial Proposed Interconnection

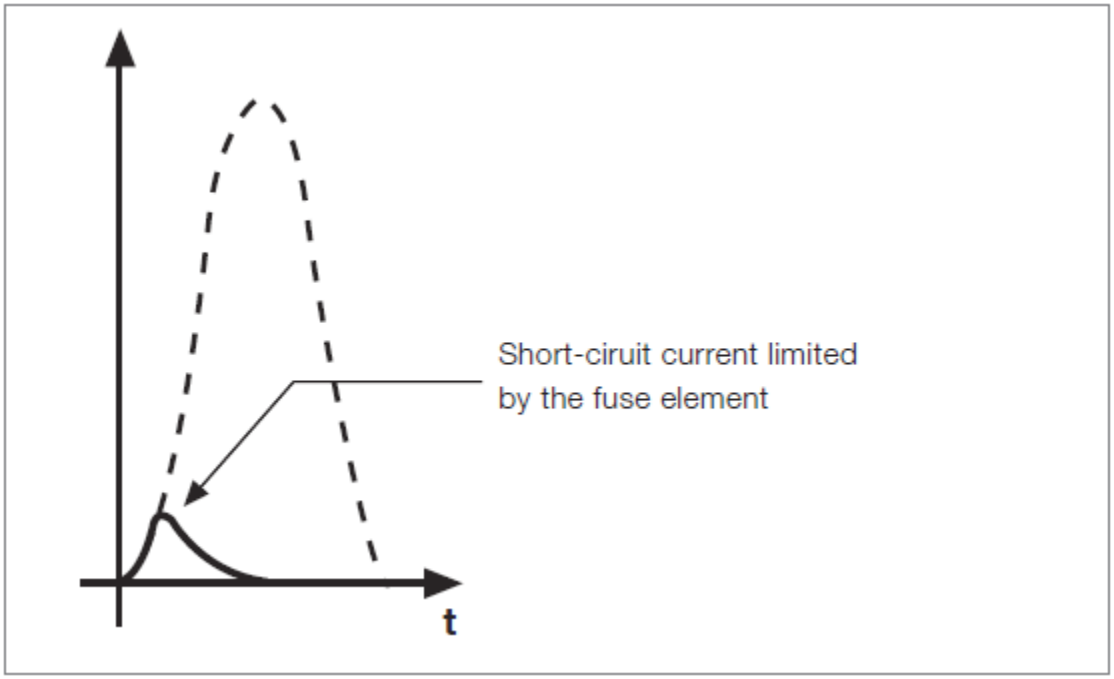
- Utility Interconnect Study Results
  - Unacceptable short circuit contribution
  - Putnam substation contingency alignment – tie breaker closed
- **No Additional Short Circuit Current Contribution Allowed**
  - STG and CTG contributions approximately equal
- Now What????  Back to the Drawing Board



# Harvard Blackstone Plant – Cambridge, MA

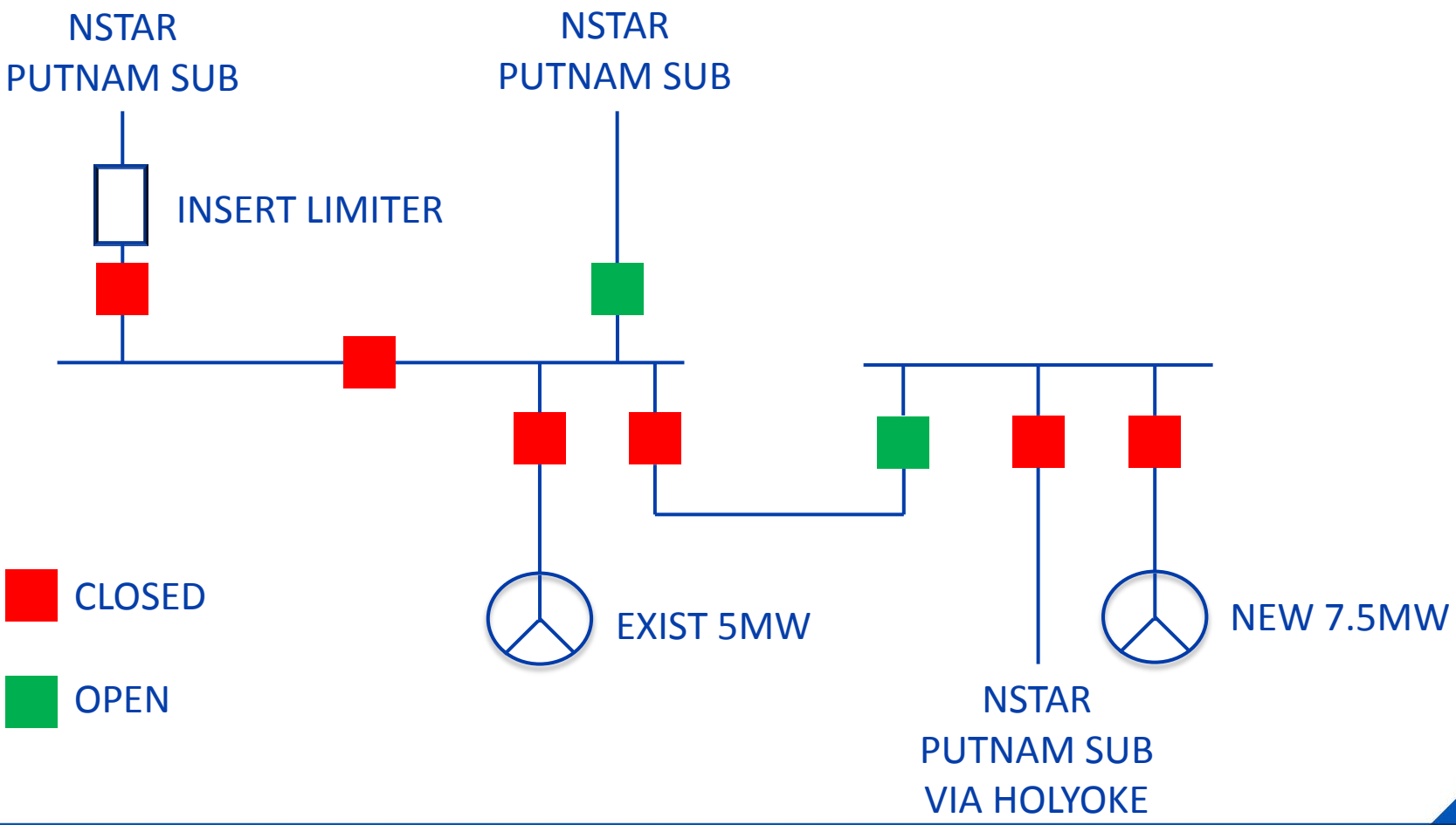
## Proposed Interconnection Modification

- Eliminate Additional Short Circuit Contribution
- Inserting Impedance – Unacceptable Voltage Drop
  - Reactors
  - Transformers
- Solution – Limiter



# Harvard Blackstone Plant – Cambridge, MA

## Proposed Interconnection Modification

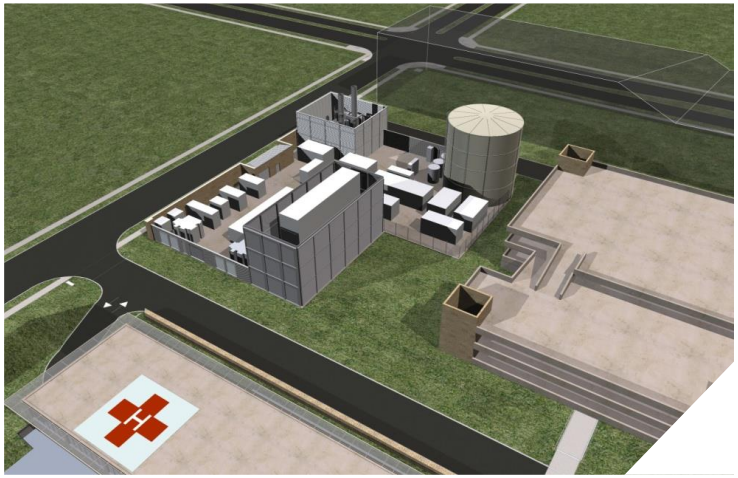


# Harvard Blackstone Plant – Cambridge, MA

## Proposed Interconnection Modification

- Limiter Effectively Eliminates Short Circuit Contribution from STG
- Trip Setting
  - Current magnitude
  - AND
  - Current rate of rise
- Minimize Nuisance Tripping
- Only Enable When Utility Substation Ties are Closed
- No Impact to Operations

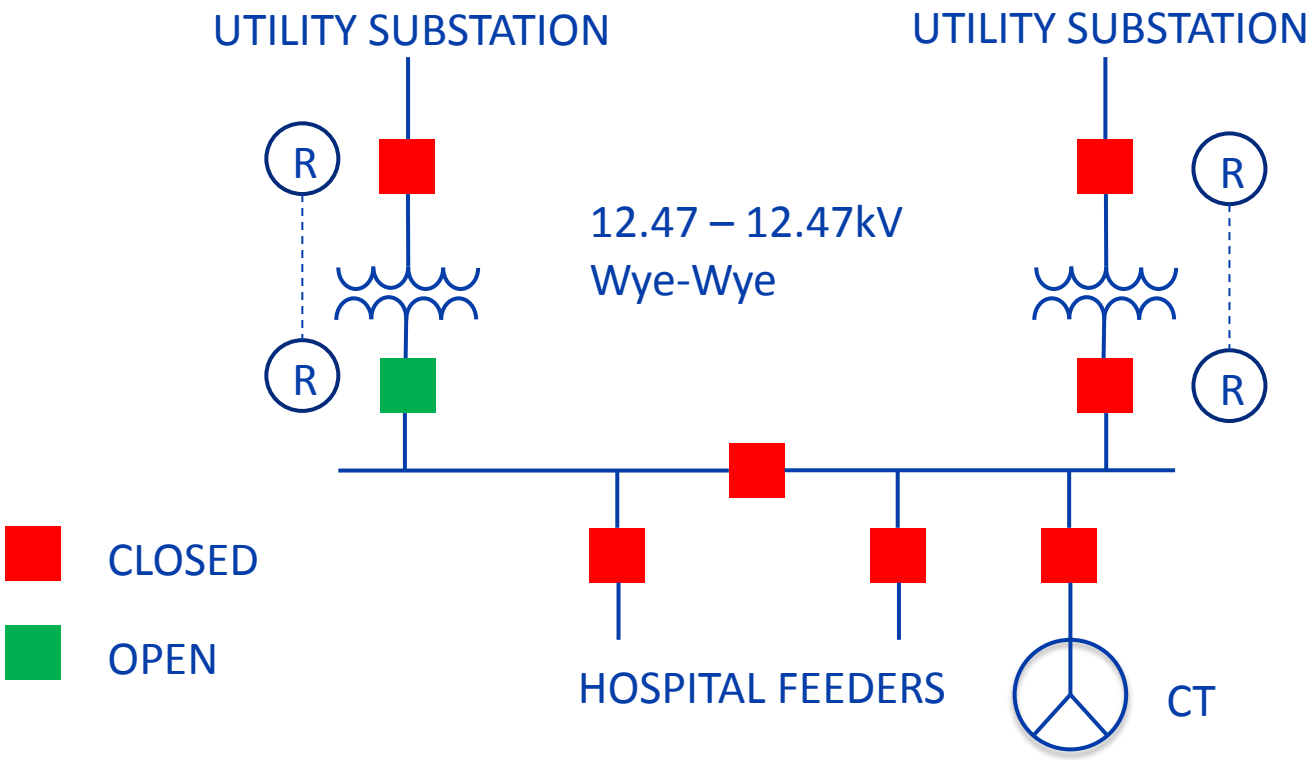
# Austin Energy Robert Mueller Energy Center – Austin, TX



- Solar Mercury 50 Combustion Turbine – 5MW
- 35,000 lb/hr Steam Capacity
- Primary Distribution
  - Two 12,470 Utility Feeders
- Emergency Generation
- Serves Dell Children's Hospital

# Austin Energy Robert Mueller Energy Center – Austin, TX

## Initial Operation – Single Utility Feeder

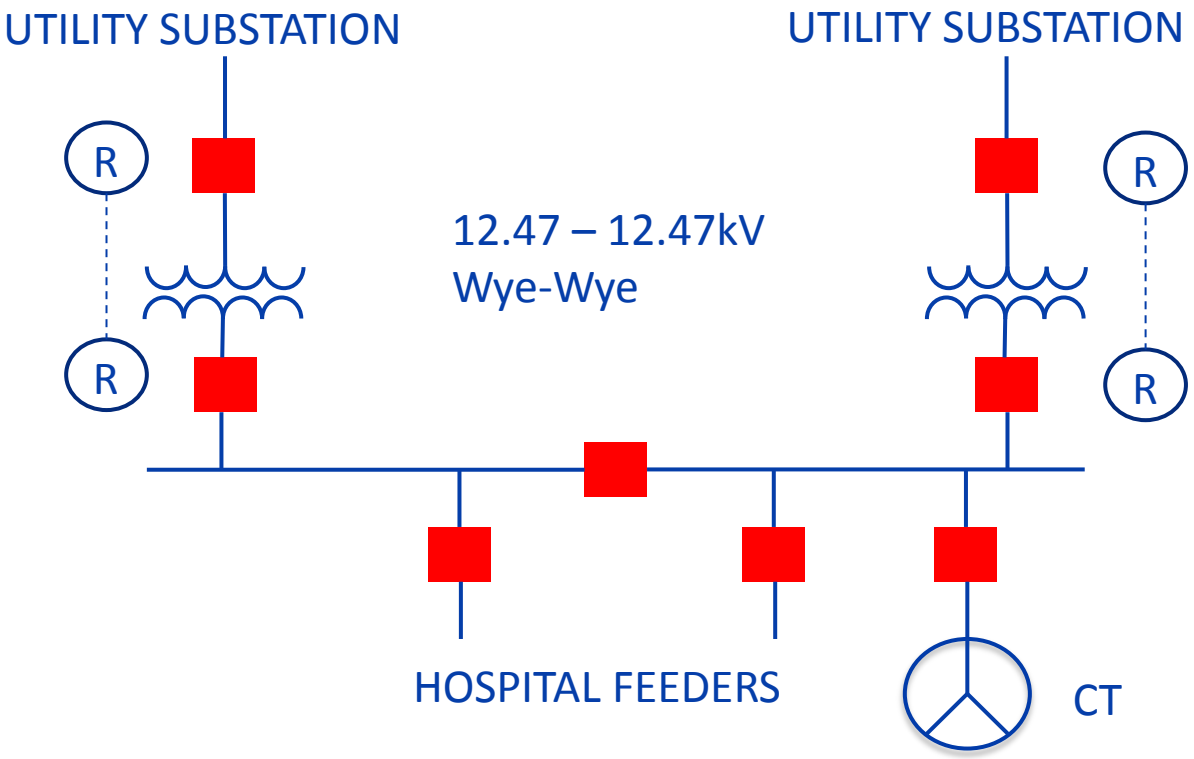


# Austin Energy Robert Mueller Energy Center – Austin, TX

- Reliability Issues
- Frequent Momentary Utility Outages
  - Overhead Exposure
- Transition to Island Mode Not Always Successful
- CT Contribution to Faults Caused Trips

# Austin Energy Robert Mueller Energy Center – Austin, TX

## Modified Operation – Dual Utility Feeders



# Austin Energy Robert Mueller Energy Center – Austin, TX

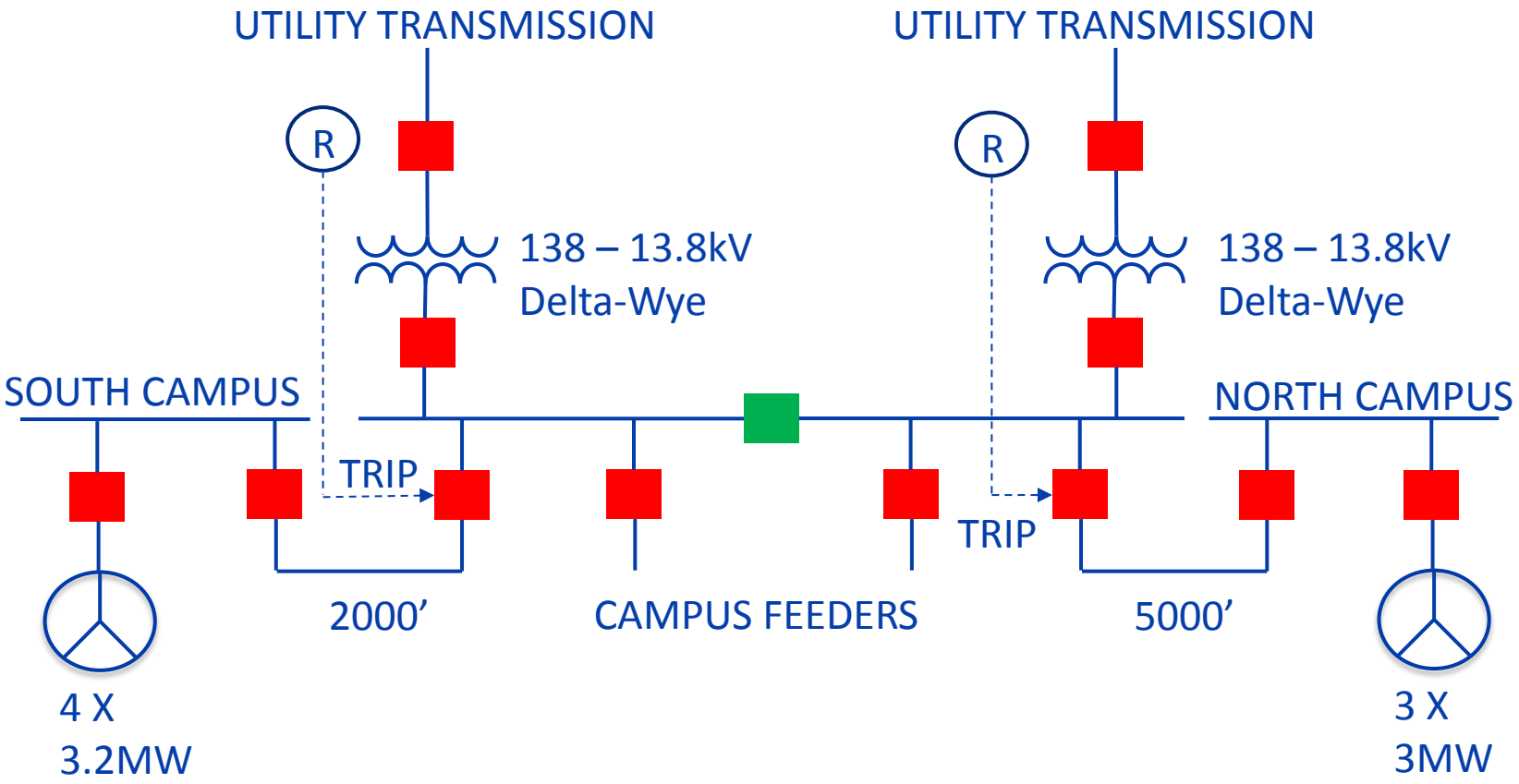
- Significant Reliability Improvement
- Same Number of Momentary Utility Outages
  - But Only One Feeder at a Time
  - Plant Remains Connected to “Healthy” Utility
- Faults Cleared Quickly
  - Reduced Impact on CT
- Automatic Reclose on Utility Return
  - Transparent to Plant Operators

# UT Southwestern Medical Center Dallas, TX


- 3 CAT NG Recip – 3MW Each
  - North Campus
- 4 Deutz NG Recip – 3.2MW Each
  - South Campus
- Transmission Interconnect
  - Two 138,000V Utility Lines
- 21.8MW Distributed Peak Shaving
- Campus Load Exceeds Generation Capacity

# UT Southwestern Medical Center Dallas, TX

## Initial Operation – Trip Campus Feeder

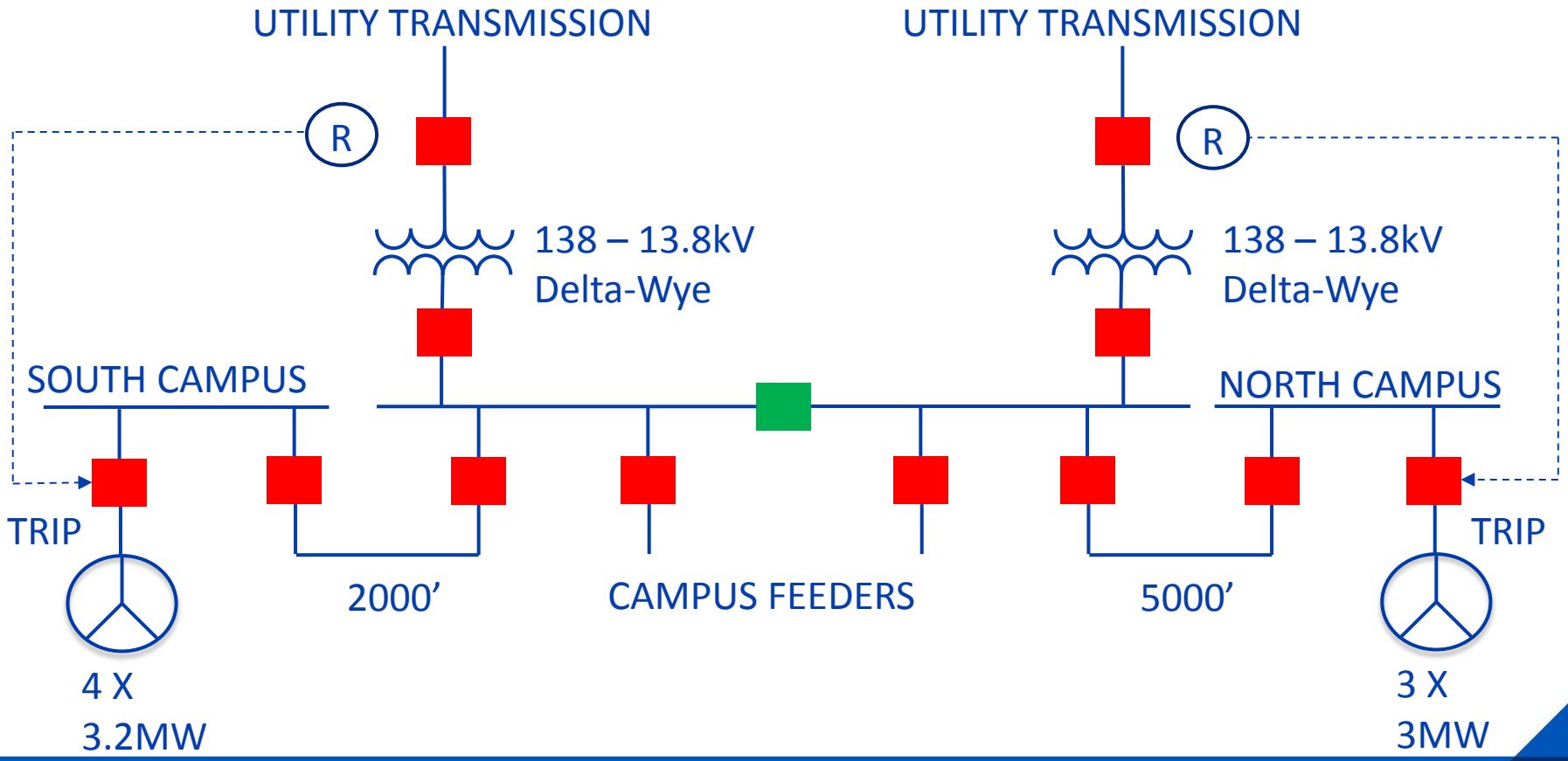


# UT Southwestern Medical Center Dallas, TX

- Reliability Issues
- Directional Overcurrent 50 Element Always Asserted
  - Load Current Above Pick-up
  - Pick-up and Directional Decision Not Linked
  - Transmission System Faults Several Buses Away Caused Trips
- Load Exceeds Generator Capacity – Generators Trip
- Campus Wide Outage with Utility Available

# UT Southwestern Medical Center Dallas, TX

## Modified Operation – Trip Generator Breakers Directly



# UT Southwestern Medical Center Dallas, TX

- Significant Reliability Improvement
- Added Load Encroachment Relay Supervision
- Eliminate Campus Wide Outages
- Transmission System Very Reliable
- Generator Deployment Economic Only

# Conclusions

- CHP Generator Interconnection is Critical
  - No Two Installations are Identical
  - Utility Involvement is Required
    - Protection and Metering Requirements
  - Develop CHP Design Basis Early in Project
    - Loading vs. Capacity
    - Islanding
    - Load Shedding
    - Import/Export
    - Interconnection Studies
    - Available Short Circuit Current

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