CampusEnergy2021

BRIDGE TO THE FUTURE

Feb. 16–18 | CONNECTING VIRTUALLY

WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16

CEM ENGINEERING

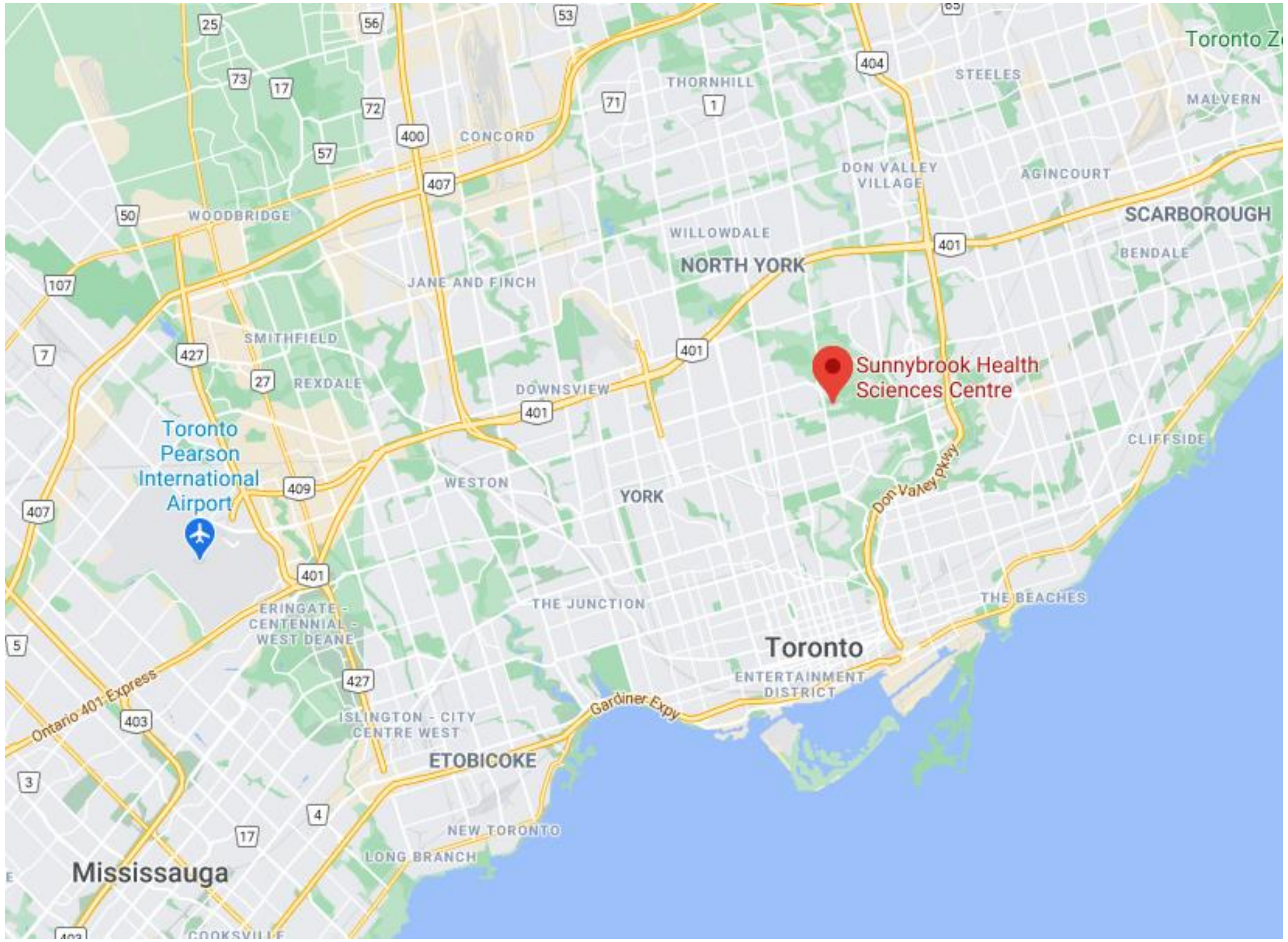
CHP Saves Lives:
A Case Study of CHP on a Toronto Hospital Campus

Q&A Will Not Be Answered Live

Please submit questions in the Q&A box.
The presenters will respond to questions off-line.

Overview

1. Introduction
2. Combined Heat & Power (CHP) Project
3. Challenges
   - Technical
   - Non-technical
4. Critical Success Factors
5. Lessons Learned



Sunnybrook Health Sciences Centre

- Largest Trauma Centre and largest Veterans Centre in Canada
- Teaching, Research, Brain Sciences, Heart, Cancer, Women & Babies (high-risk neonatal), Veterans
- 1.3 million patient visits per year
- 7-16 MW Electrical Load (4-5 MW emergency)
- 100,000 lb/hr steam peak, 125 psig

The Catalyst

- Feasibility studies, energy/cost savings, capital incentive
- Ice storm in December 2013
- Two years of freezing rain hit the city within two days
- 300,000 customers in Toronto without power
- Both supply feeders to Sunnybrook interrupted for 39 hours
- Emergency generator issues, precautionary NICU evacuations

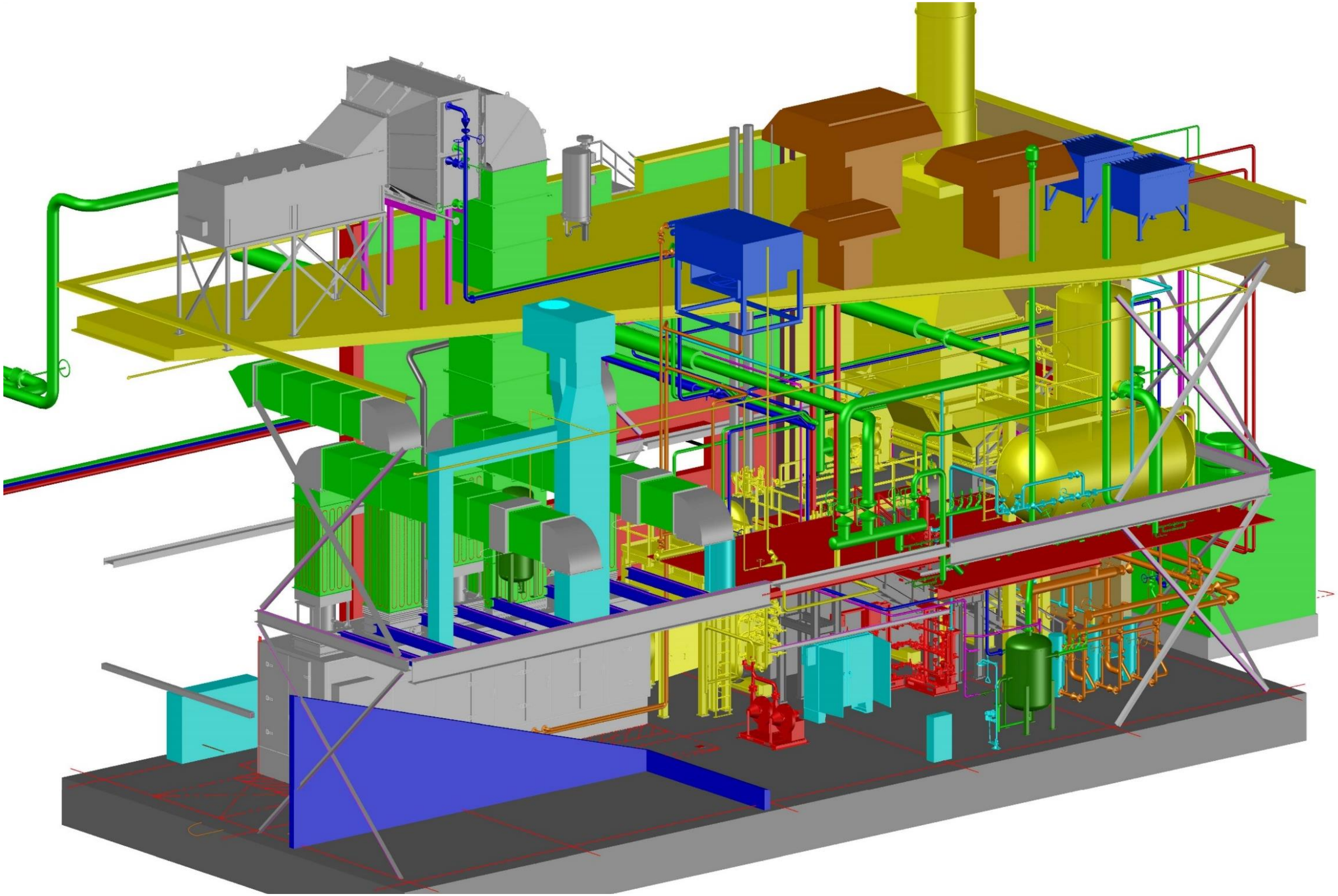
What provides backup to the backup to the backup?

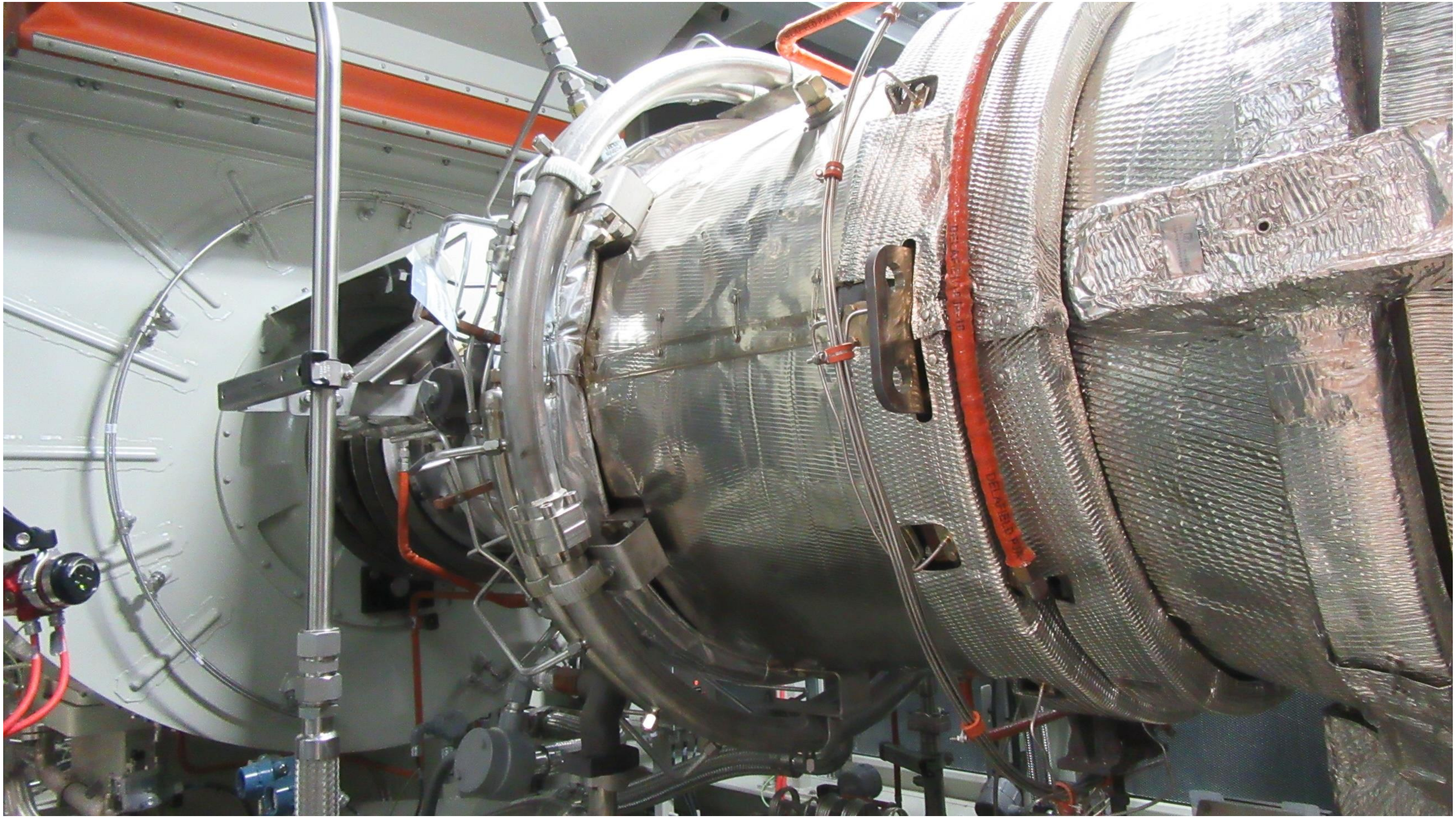
Energy Supply Resiliency Projects

- Emergency Generator Plant Renewal – 4 x 2 MW Diesel Generators
- Load Management System (LMS)
- 27.6 kV Substation Renewal
- Utility Feeder Upgrade
  (dedicated underground)
- Fuel Oil Storage Relocation/Upgrade
- **Combined Heat and Power (CHP)**
- Boiler Renewal (future)
- Battery Energy Storage (BES) (future)

CHP Project Description - Overview

- New CHP Building, connected to existing Central Utilities Building
- Gas Turbine Generator (GTG), Natural Gas, Nominal 8 MW, 13.8 kV, inlet air cooling (chilled water)
- Heat Recovery Steam Generator (HRSG), 90,000 lb/hr, 130 psig, duct burner, provision for future condensing economizer
- Deaerator
- Fuel Gas Booster Compressor (FGBC), 60-170 psig to 385 psig, outdoor acoustic enclosure, after/oil coolers
- Generator Step-Up (GSU) Transformer, 10 MVA, 13.8-27.6 kV
- Generator Breaker, 13.8 kV, 1200 A, revenue metering, generator protection
- 27.6 kV and 4.16 kV Substation Extensions





CHP Project Description - Schedule

Initial Early Feasibility Study
2010

Detailed Engineering Study & Incentive Applications
2013-2015

Preliminary Design & Impact Assessment
2016

Detailed Design Engineering
2018-2019

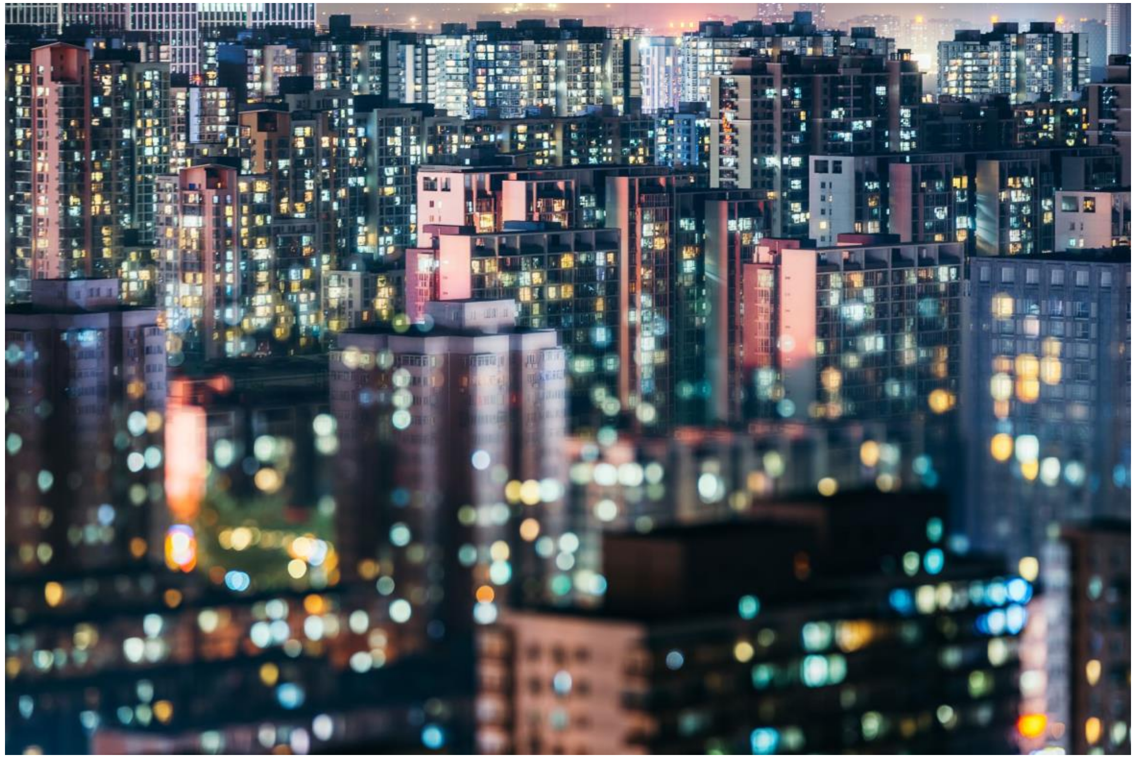
Construction & Commissioning
2019-2020

Government Capital Incentive / In-Service Date December 31, 2020

CHP Project Description – Operating Modes

- **Grid-connected**
  - Electrical load following
  - Minimum import limit
  - Export prohibited

- **Islanding**
  - Automatic (unplanned)
  - Manual (planned)
  - Intelligent load shedding
  - Black Start: Auxiliary load transfer scheme

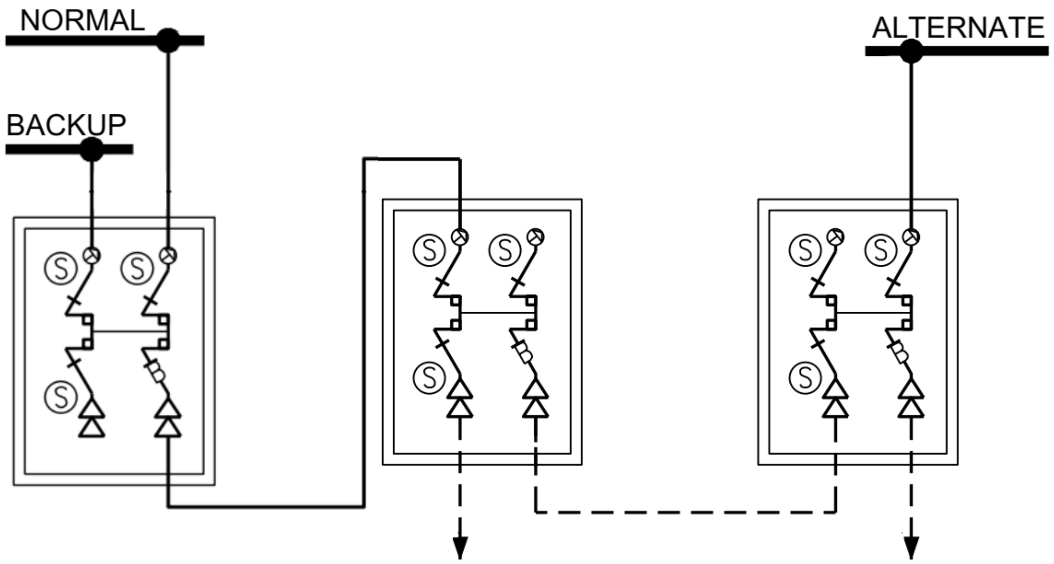


Challenges

- **Technical Challenges**
  - Complexity of many possible operating modes
  - Balancing redundancy, flexibility, simplicity
  - Integration with new and existing systems
  - Consideration/mitigation of failure modes
- **People Challenges**
  - Permitting - Electrical Utility, Municipal, AHJ, Air & Noise
  - Overlap or lack thereof between projects, consultants, vendors, contractors

Technical Challenge – Supply Feeders

- Three (3) utility feeders supply the site:
  - Dedicated (new underground feeder)
  - Alternate
  - Backup (generation not permitted)



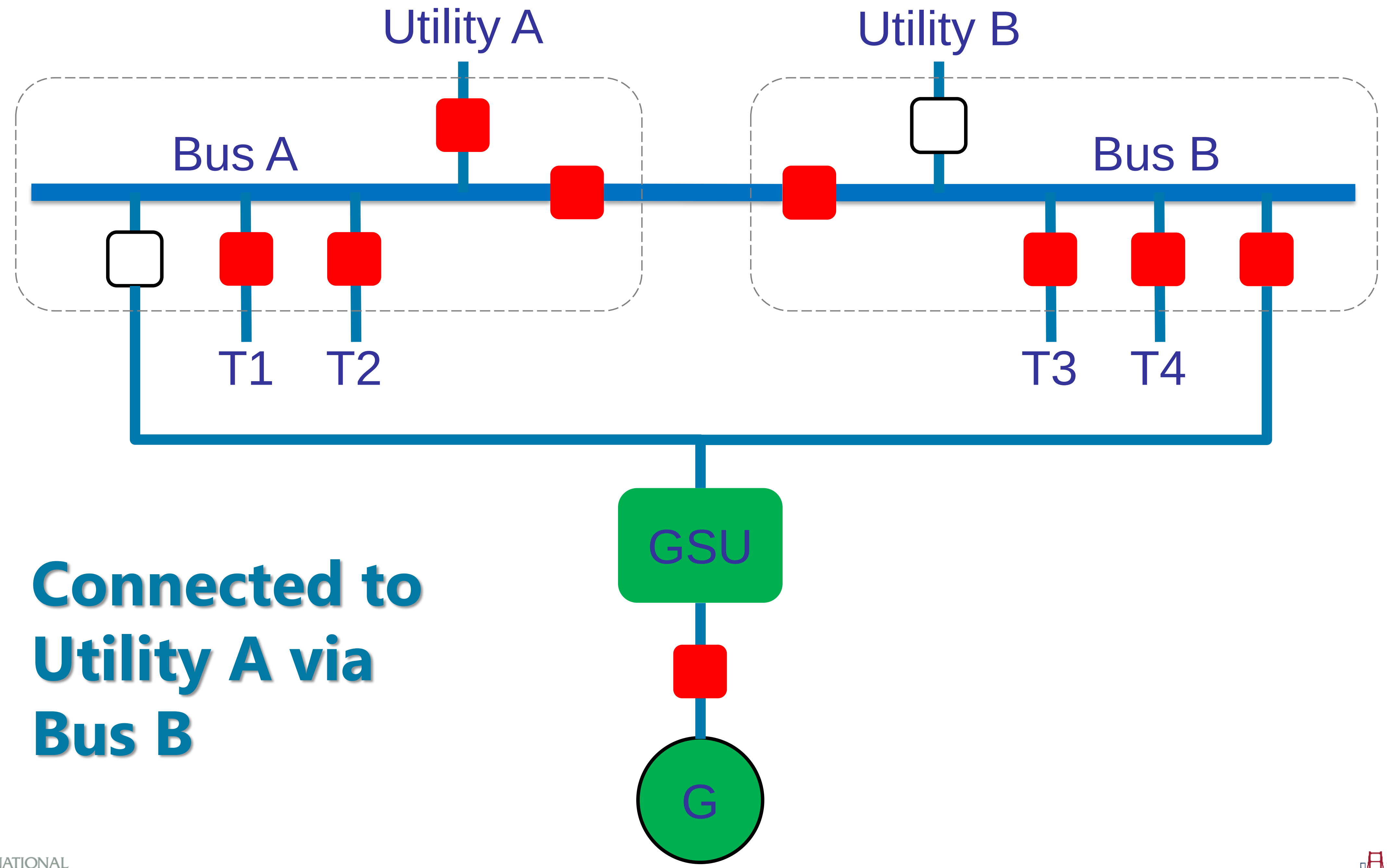
- Utility can closed-transition between all feeders without notice

- Only respond to transfer trip command from the connected feeder

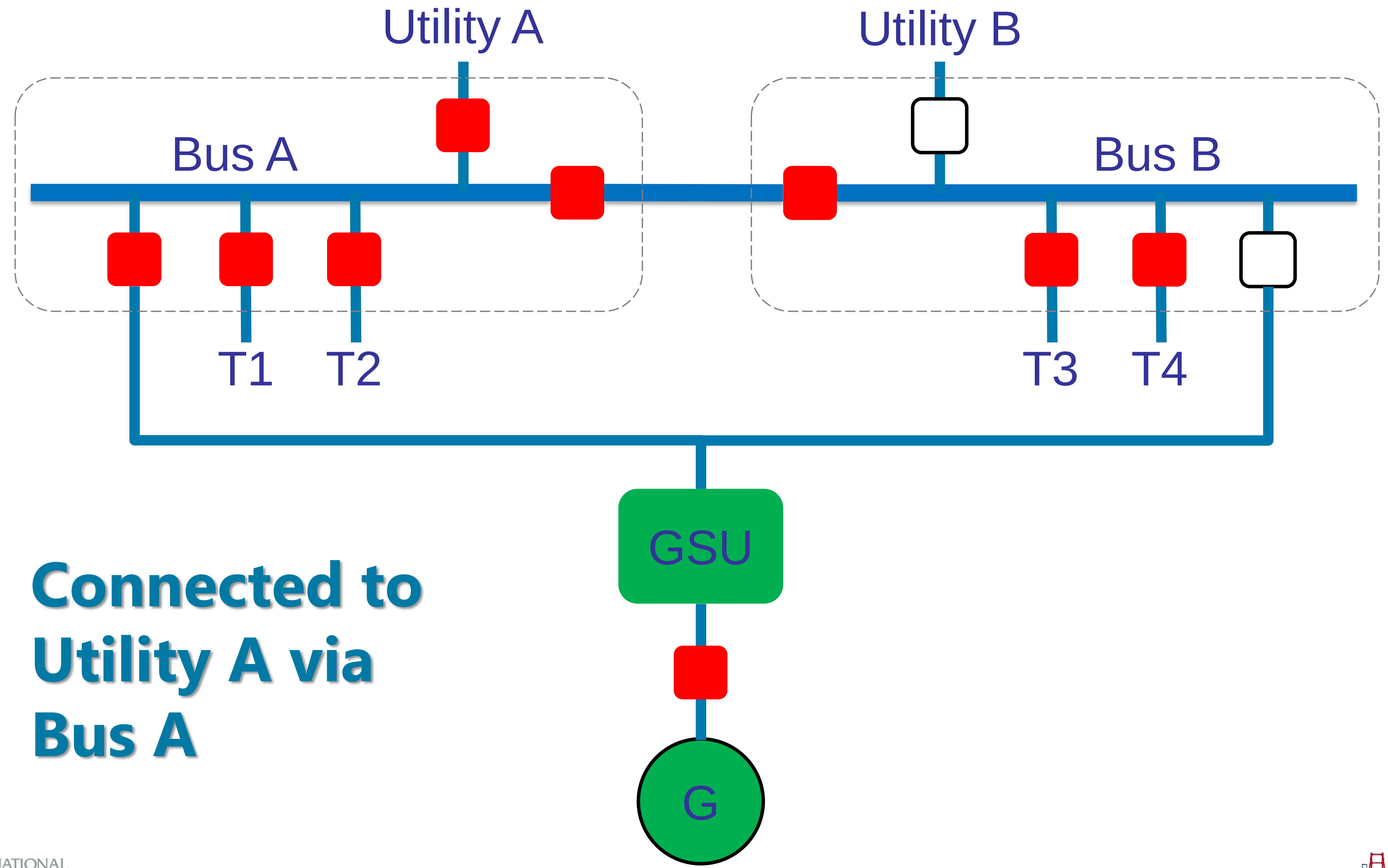
How do we know what we're connected to?

Technical Challenge – Bus Configuration

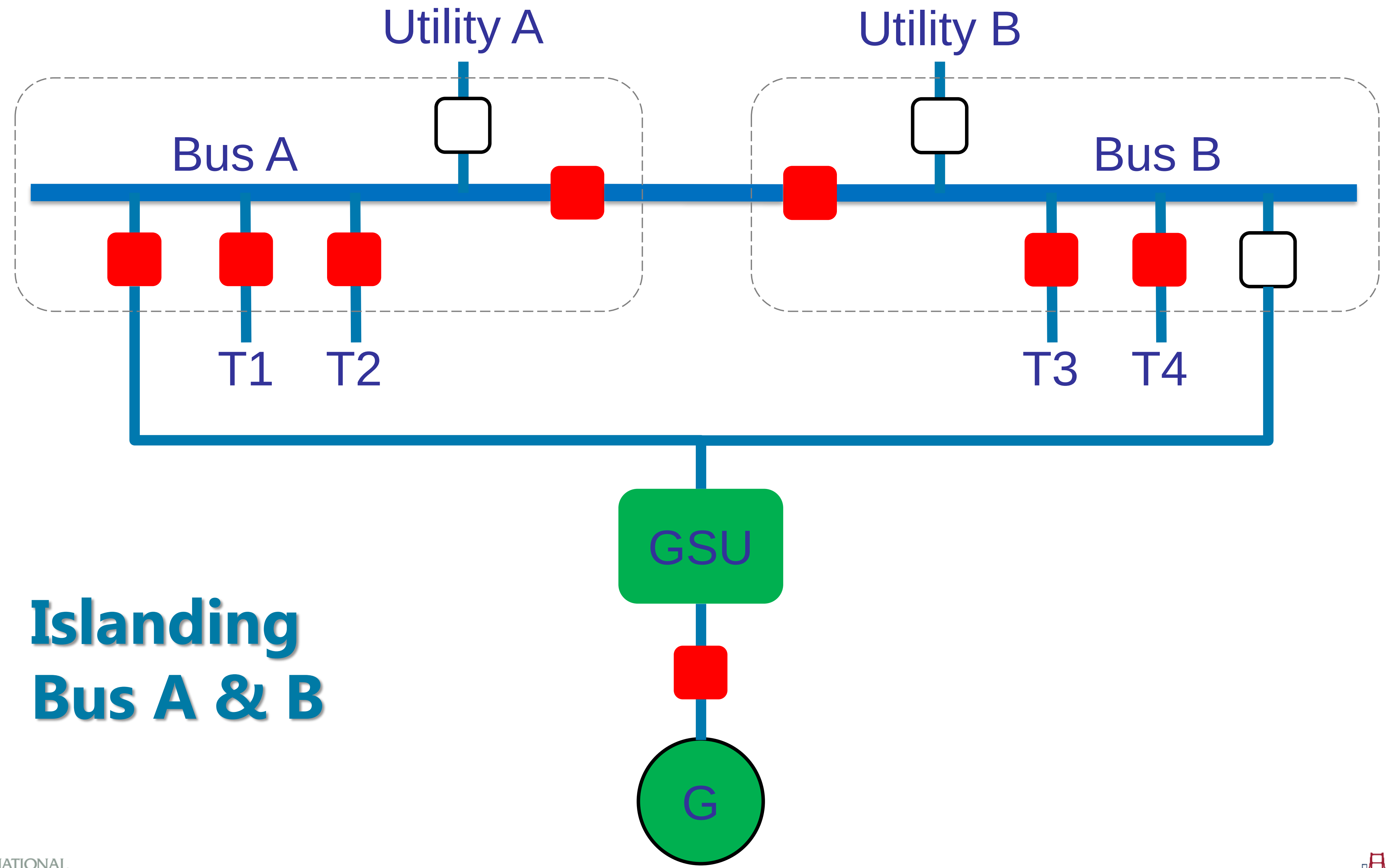
- Campus load divided into A and B buses
- ***What if Bus A or B is out of service?***
- Allow GSU to connect to both sides with interlock
- Single-bus operating mode: islanded or grid-connected
- Complex protection logic automatically identifies mode
- Generator can synchronize across three (3) different breakers



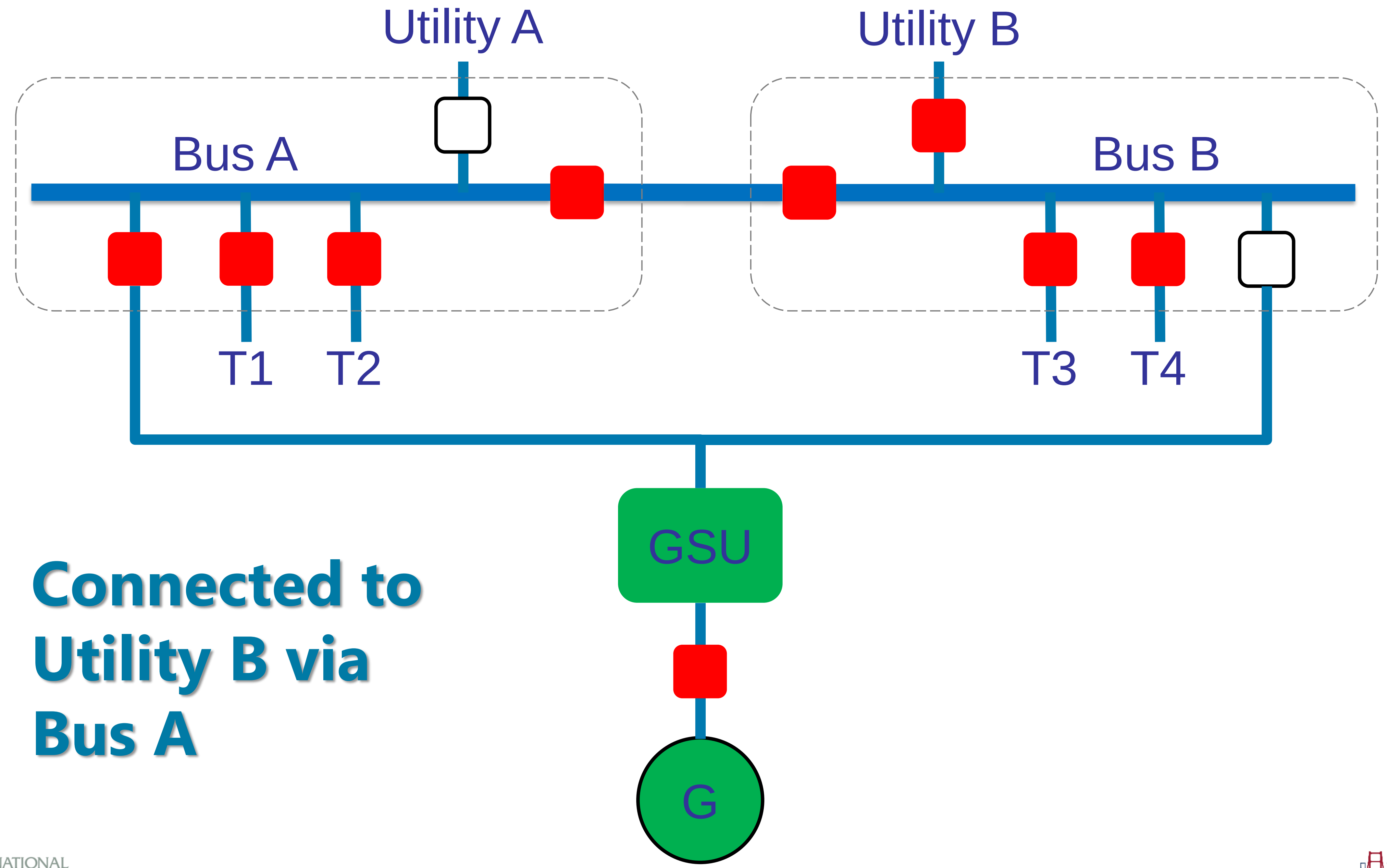
Connected to Utility A via Bus B



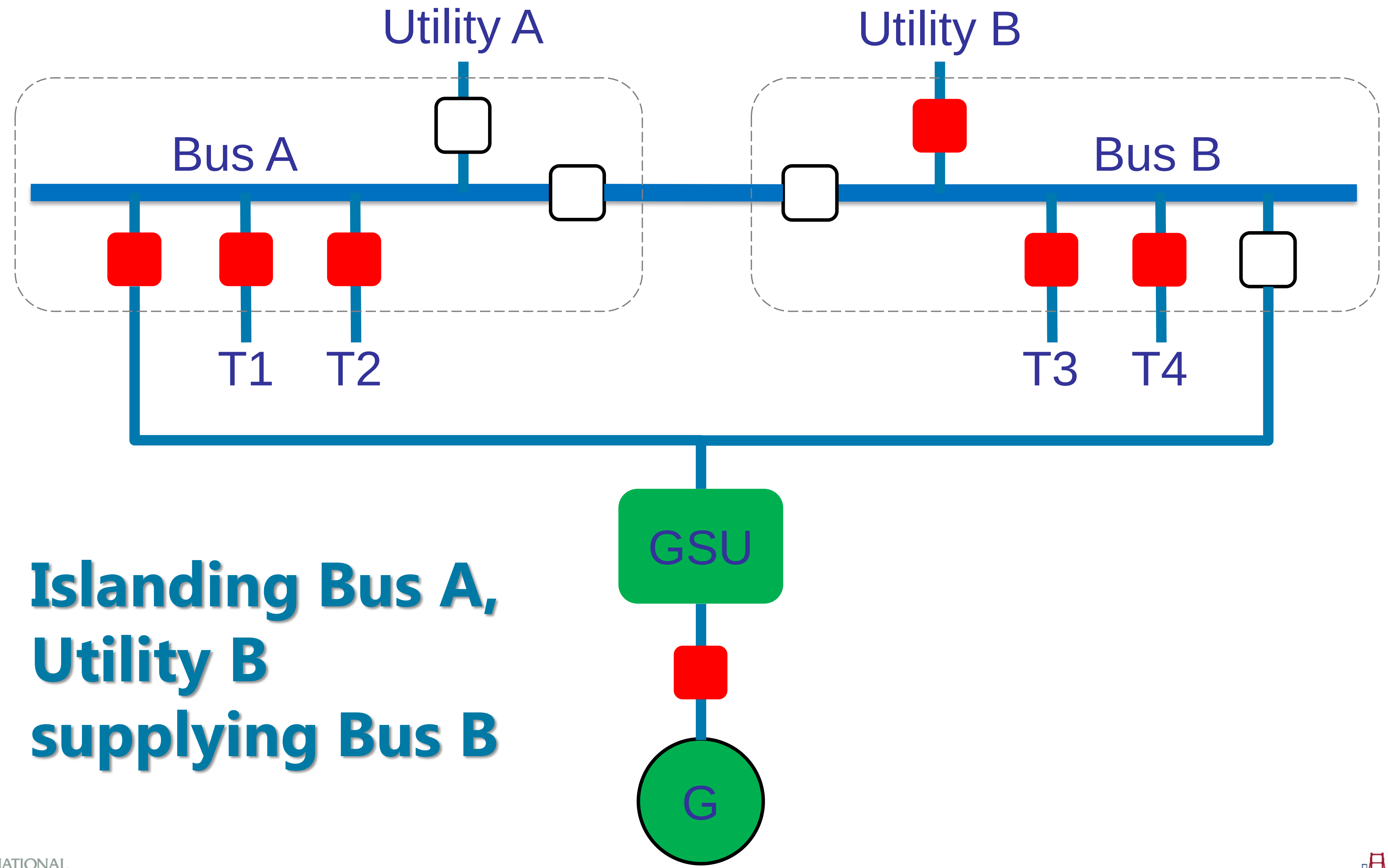
Connected to Utility A via Bus A



Islanding
Bus A & B



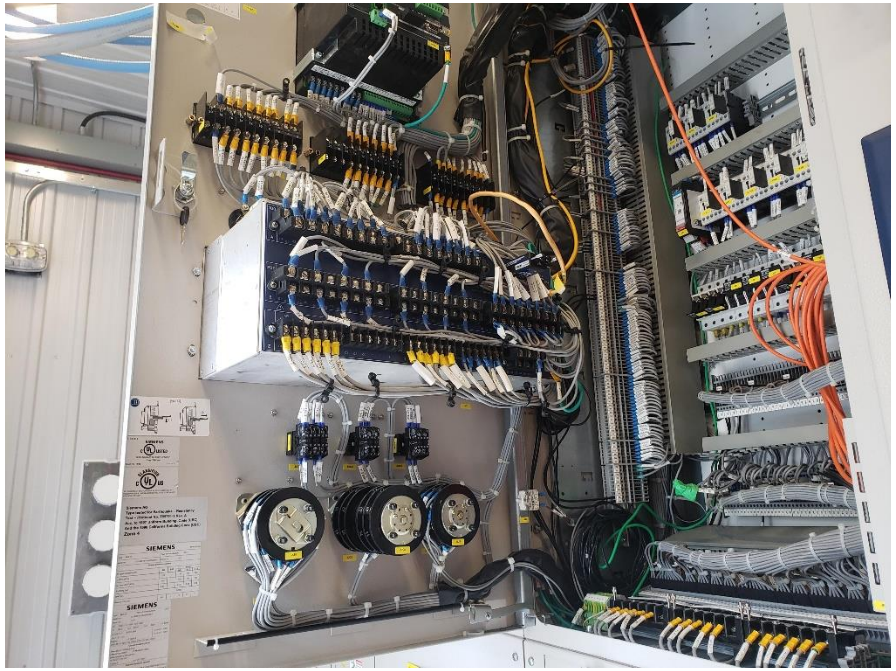
Connected to Utility B via Bus A



Islanding Bus A, Utility B supplying Bus B

Technical Challenge – Switchgear Modifications

- New 27.6 kV substation project coordination
- Hardware modifications required for CHP
  - Protection relay replacement
  - Interlocks, remote control, sync check
- Modification to automatic transfer scheme
  - Maintain transfer scheme while CHP offline
  - Block transfer if CHP online



Technical Challenge – Emergency Generators

- Minimize changes to essential electrical systems
- Ensure compliance with CSA Z32
  Essential Electrical Systems in Health Care Facilities
- Auto-start and seamless transfer upon islanding
- Prevent re-transfer to normal when islanding, especially black start

Technical Challenge – Load Management

- Response to grid interruptions must:
  - Act immediately to avoid overload
  - Maintain continuous supply to essential loads
  - Minimize interruption to non-essential loads
  - Prioritize between non-essential loads
- Integration with new Load Management System (LMS)
- Integration with existing breakers and chillers; limited documentation
- Continuous monitoring of load, generation, capacity; load shed table
- Prevent inadvertent auto-restart

People Challenge – Electrical Utility – Approvals

- Original connection application completed **in 2016**
- Consultations held at beginning of project **early 2018**
  - New Dedicated Feeder
  - Battery Energy Storage (BES)
- Revised application review time: **7 months**
  - Results received at end of design phase
- Requirements had to be anticipated from prior experience to maintain project schedule

People Challenge – Electrical Utility – Managing Change, Schedule

- Six months of design review and negotiations
- Frequent design modifications post-design phase
    - Allowable operating modes/scenarios
    - Protection logic, interlocks, transfer trip scheme
    - New utility-owned automation controller
    - SCADA points
    - New fiber lines added to replace existing wireless
- Minor changes continued through commissioning

Critical Success Factors

- Building relationships and trust
- Relationship with electrical utility
- Collaboration between consultants, Start-up Engineer, Commissioning Agent
- Contractor working closely with equipment technicians
- Pre-selection of major equipment
- Consideration for failure modes
- Thorough commissioning process

Lessons Learned – Utility

- Experience with local utility is essential
- Meet early and often – regular contact throughout project
- Thorough documentation of discussions, decisions
- Schedule tracking and follow-up
- Minimize costly changes and delays
  - Demonstrate expertise, build trust
  - Provide justification of design concepts
  - Understand constraints

Lessons Learned – Collaboration

- Close integration of multiple projects
- Collaboration between consultants, owner, contractors, utilities, vendors
- Relationship between parties is foundational for success
- Demonstrate expertise with evidence
- Mutual respect and fairness
- Share ideas, feedback, constructive criticism
- Project/customer success primary focus of all parties

Thank You!

For any questions, please contact:

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