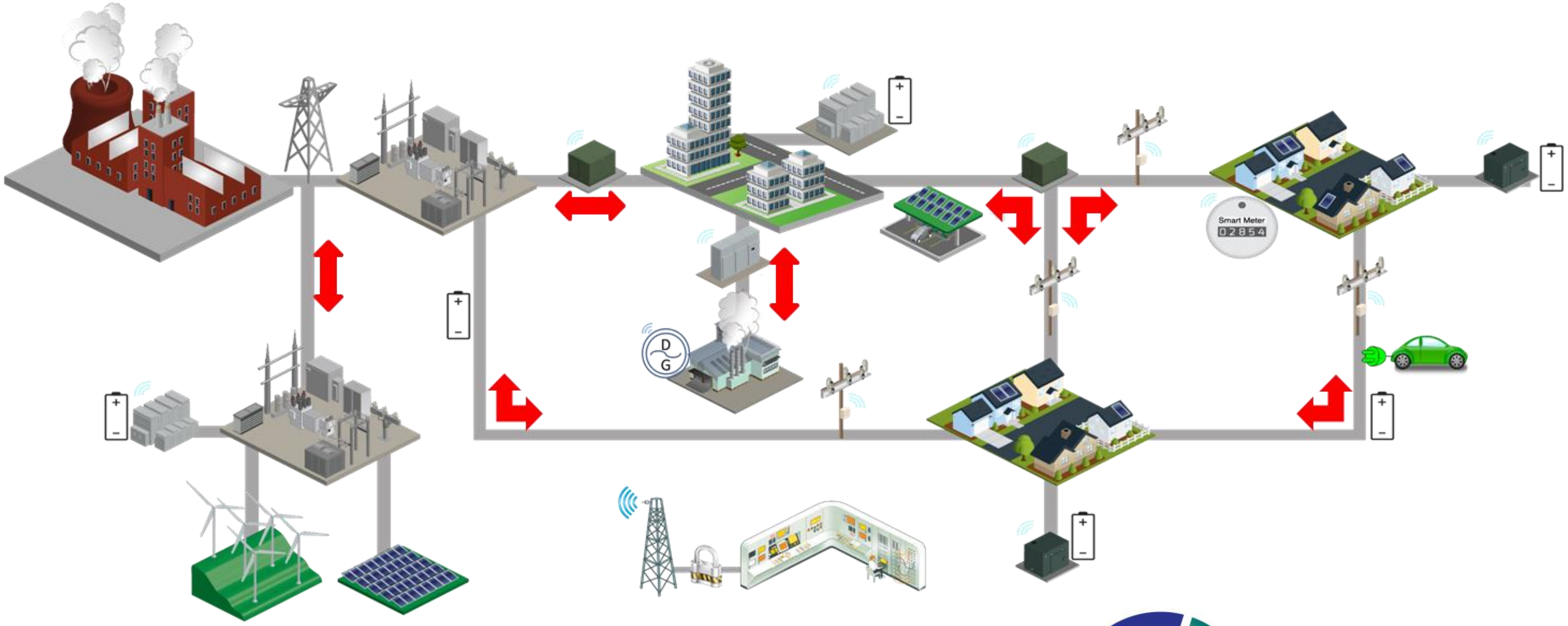
Adapting Existing Electrical Systems for Modern Microgrids



Chris Evanich, S&C Electric
Erika Weliczko, Case Western Reserve University

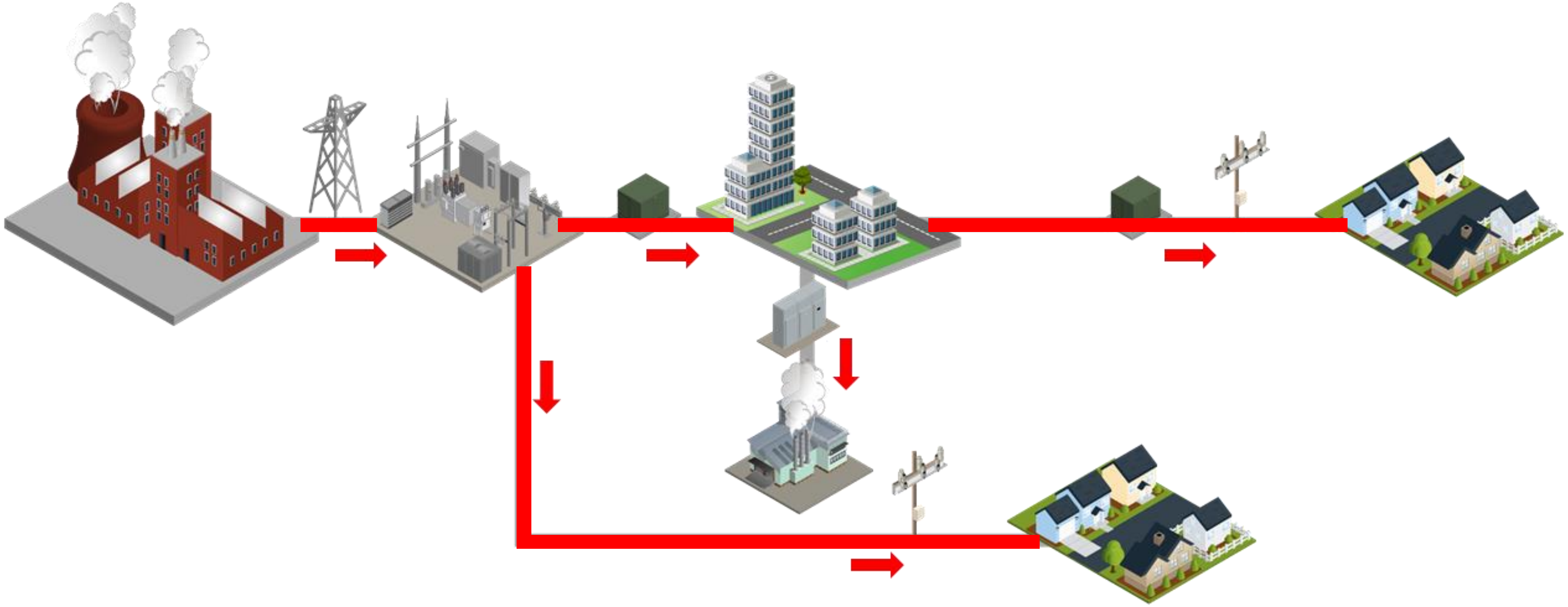
Microgrid 2.0
Advancing Industry Growth
OCTOBER 29-31, 2018 ▼ BALTIMORE, MD

Outline

- Review traditional electrical distribution system
- Describe modern electrical system requirements
- Identify microgrid implementation challenges
- Review examples
- Identify how to get started

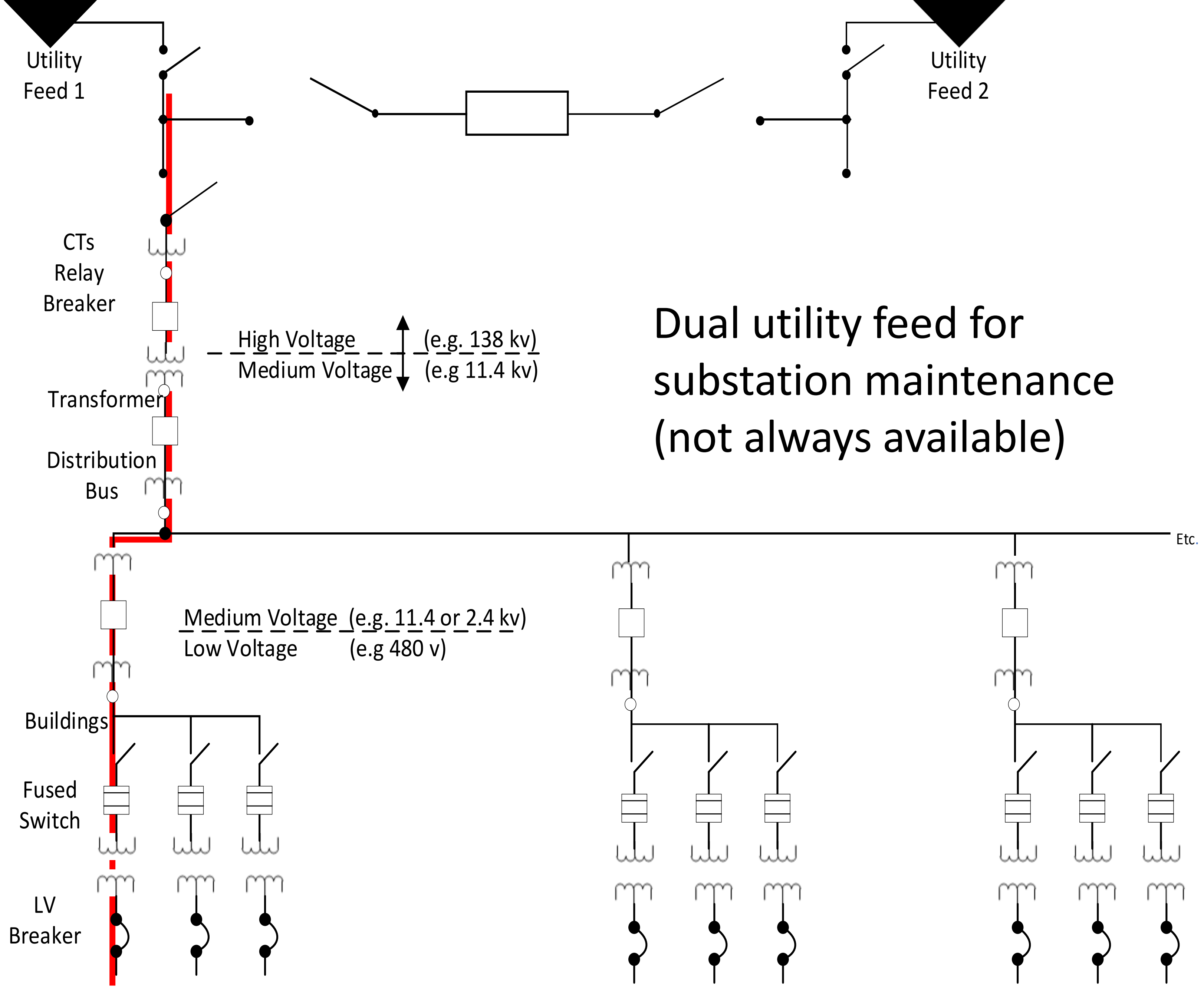
Traditional Grid

Central generation, one way power flow



Typical Radial Distribution to Buildings

- One supply path
- No onsite generation to feed loads



Dual utility feed for substation maintenance (not always available)

Typical Protection in Radial Distribution

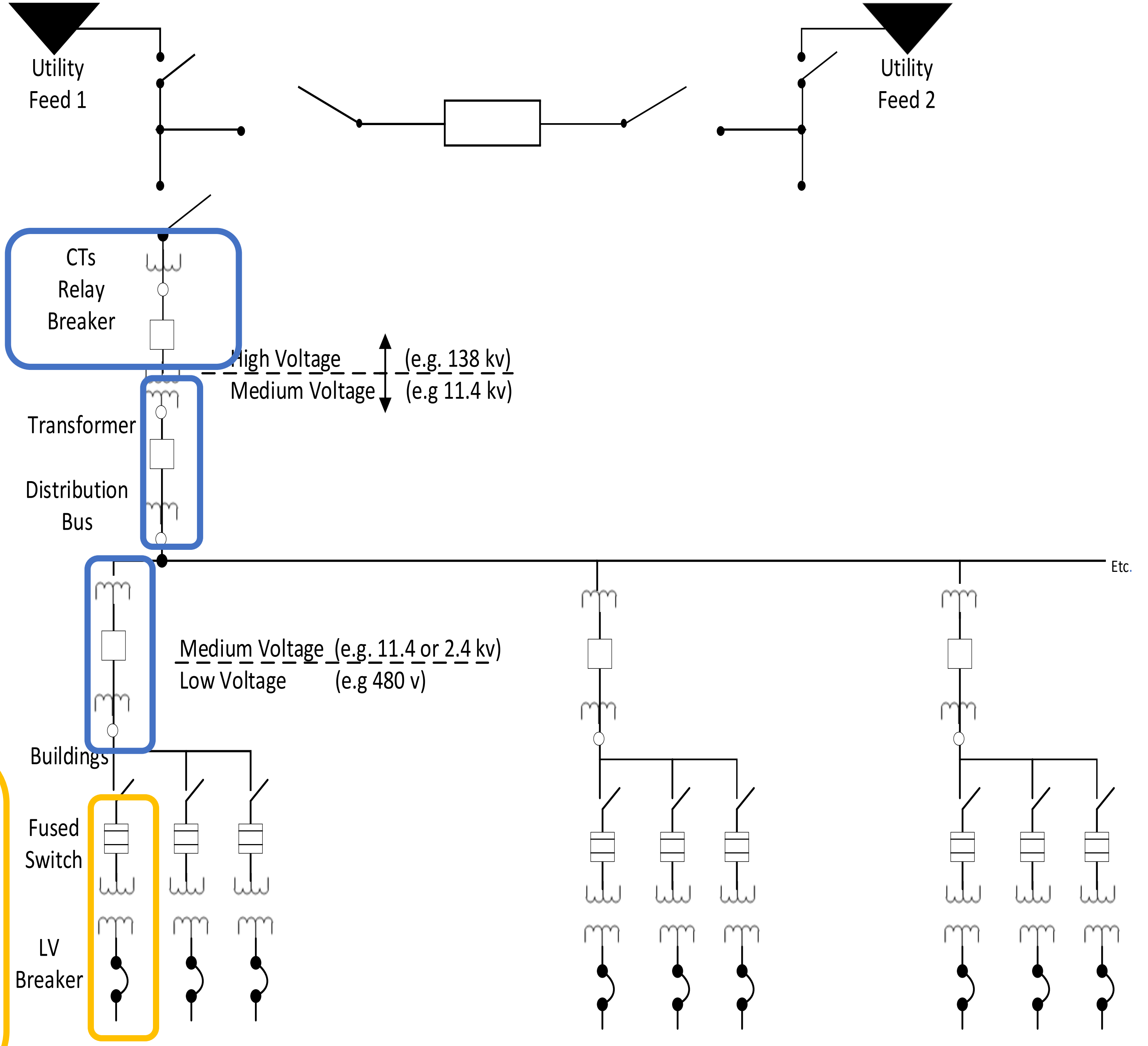
Relays protect based on:

- Overcurrent
- Differential current
- Reverse current
- Fault to ground

Typical Protection in Radial Distribution at Building

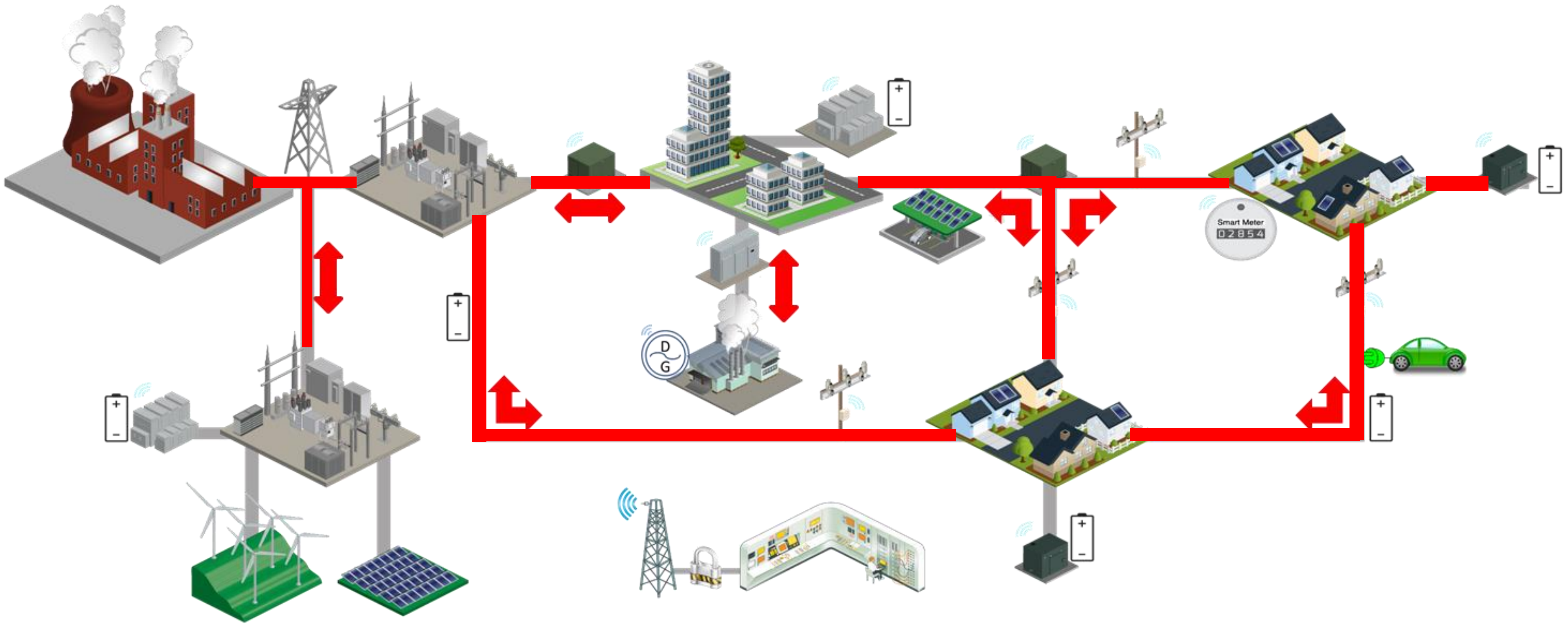
Breakers and fused switches protect based on:

- Overcurrent



Grid of the Future

Distributed generation, multidirectional power flow

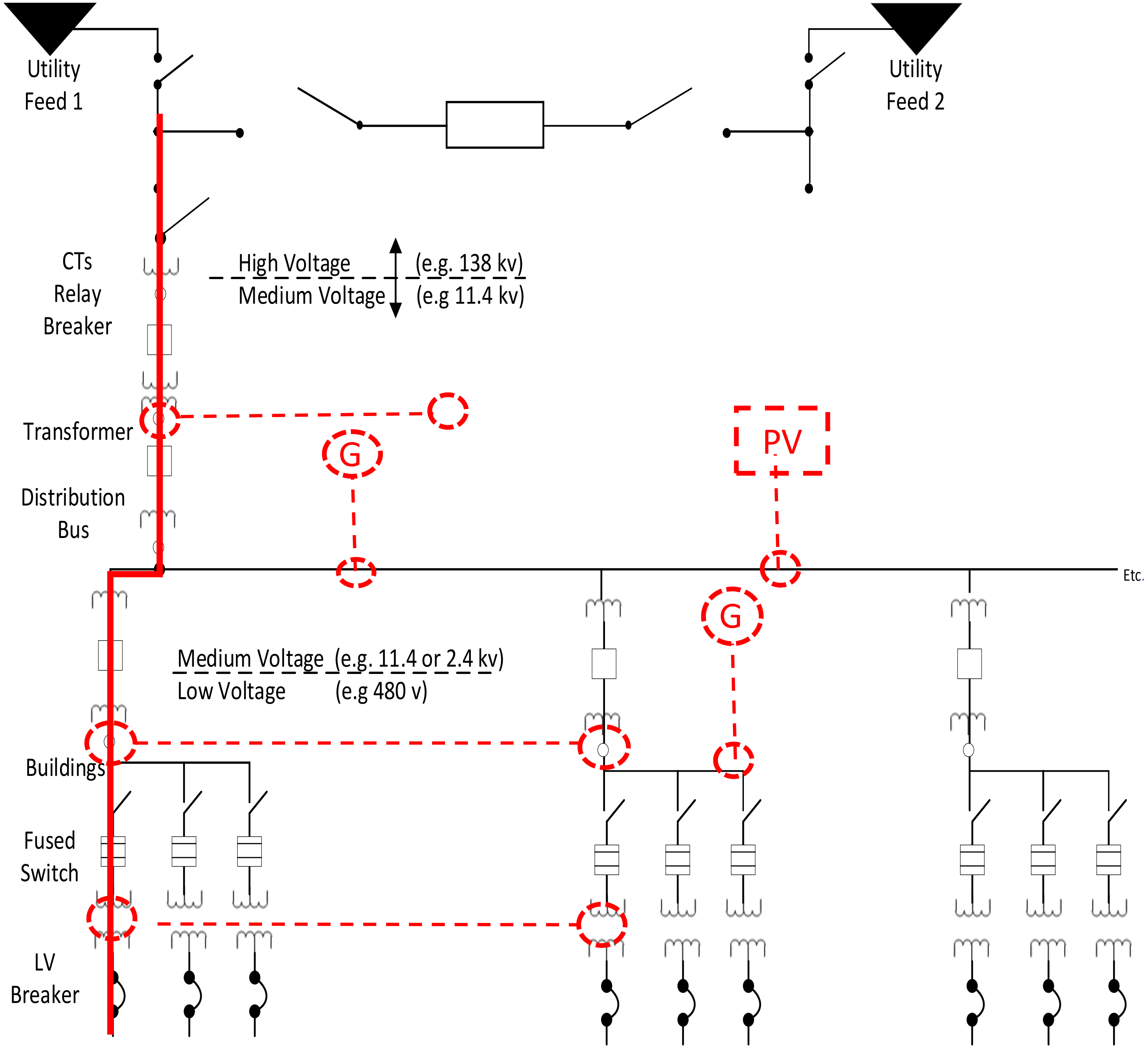


Modern Electrical System Requirements

- Enhance restoration capabilities
- Increase backup for critical loads
- Manage demand costs
- Incorporate renewables

Redundancy and Resilience Opportunities

- Include new interconnection points
- Incorporate onsite generation



Microgrid Implementation Challenges

- Protection adjustments
  - Varying topologies
  - Fault sources
- New hardware requirements
  - Breakers and switches
  - Feeders
- Additional communication requirements

Example Microgrid Scenarios

- 12.47 kV System
- 250 kW BESS
- 1 MW Natural Gas Generator
- Renewable resources

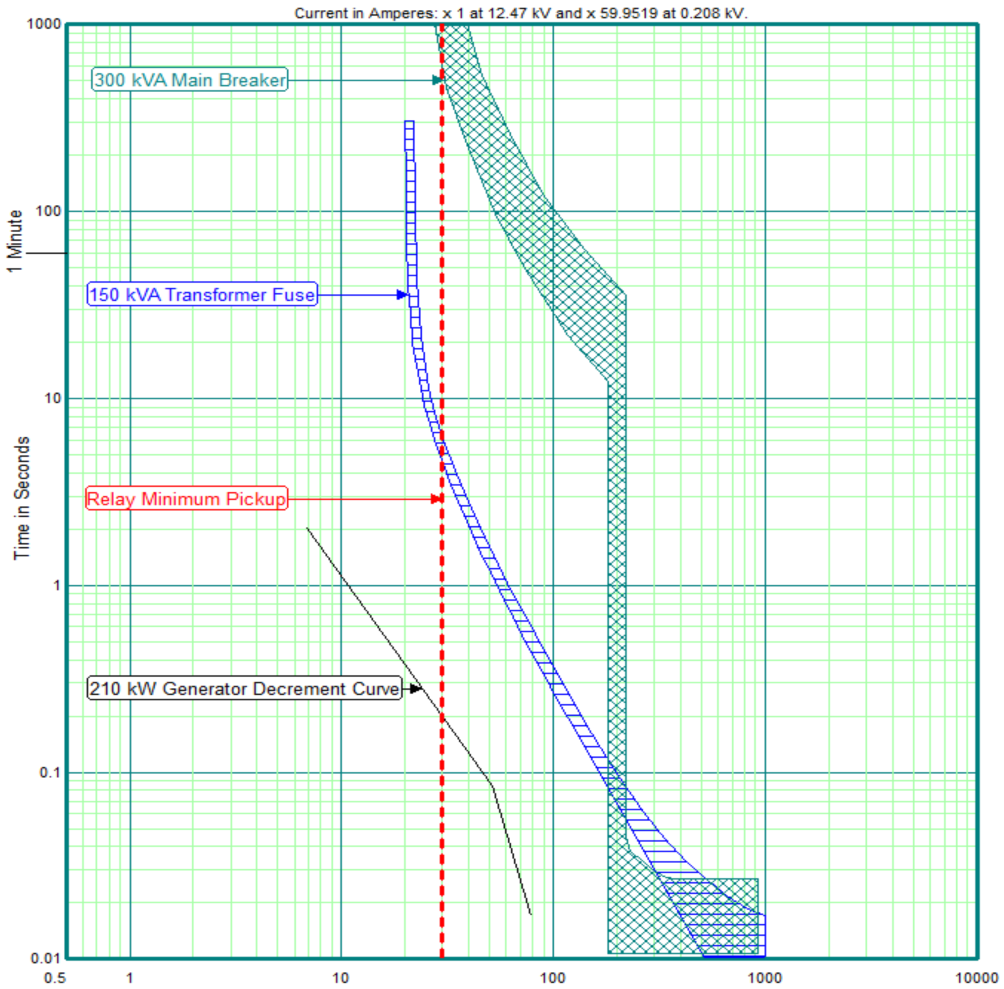
Grid-Tied Fault Current (kA)	Islanded Max Fault Current (kA)	Islanded Min Fault Current (kA)	Max Load Current (kA)
5.0	0.5	0.02	0.05

Coordinating with Existing Devices

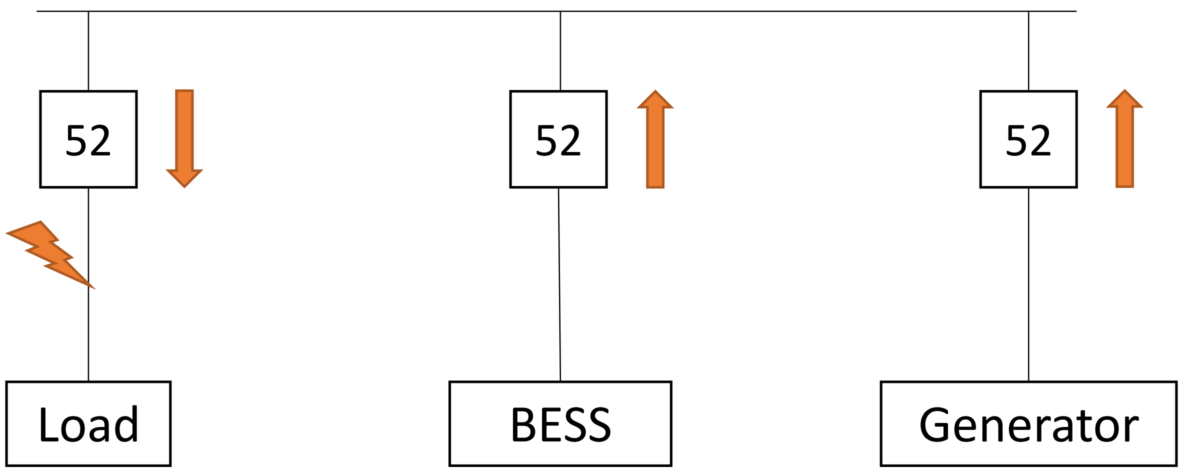
- Existing devices on system are likely overcurrent protection
  - Lateral and transformer fuses
  - Low-voltage breakers
  - Generator + inverter breakers

- Some devices may not operate while islanded

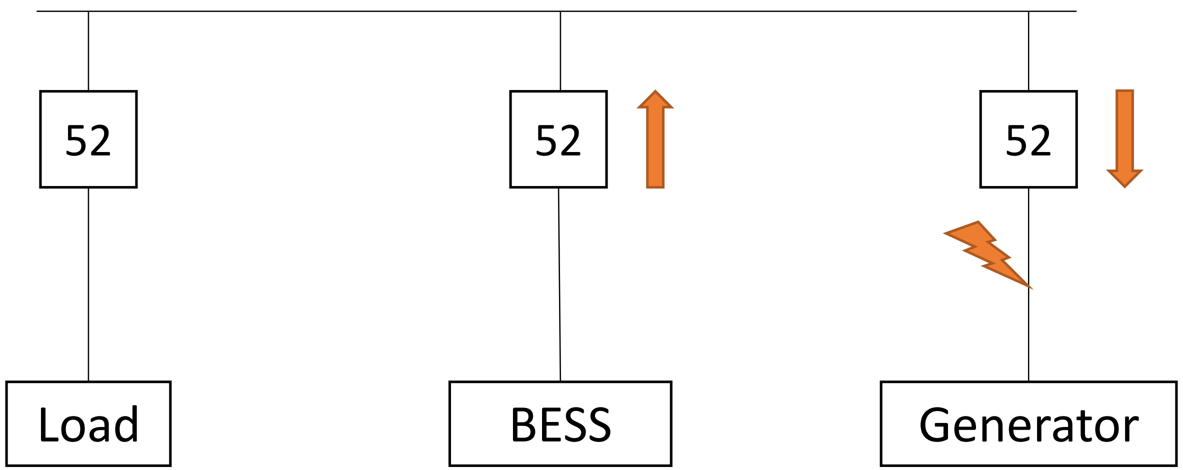
- If selected carefully, breakers can be coordinated for many fault scenarios



Example Fault Scenario



Example Fault Scenario

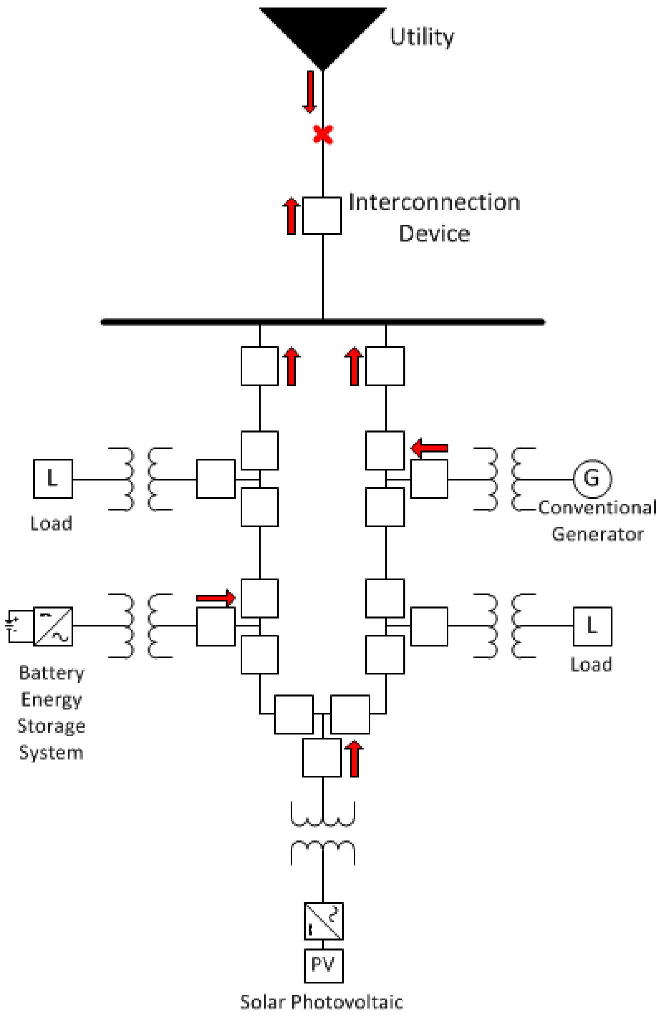


Challenges in Identifying Direction

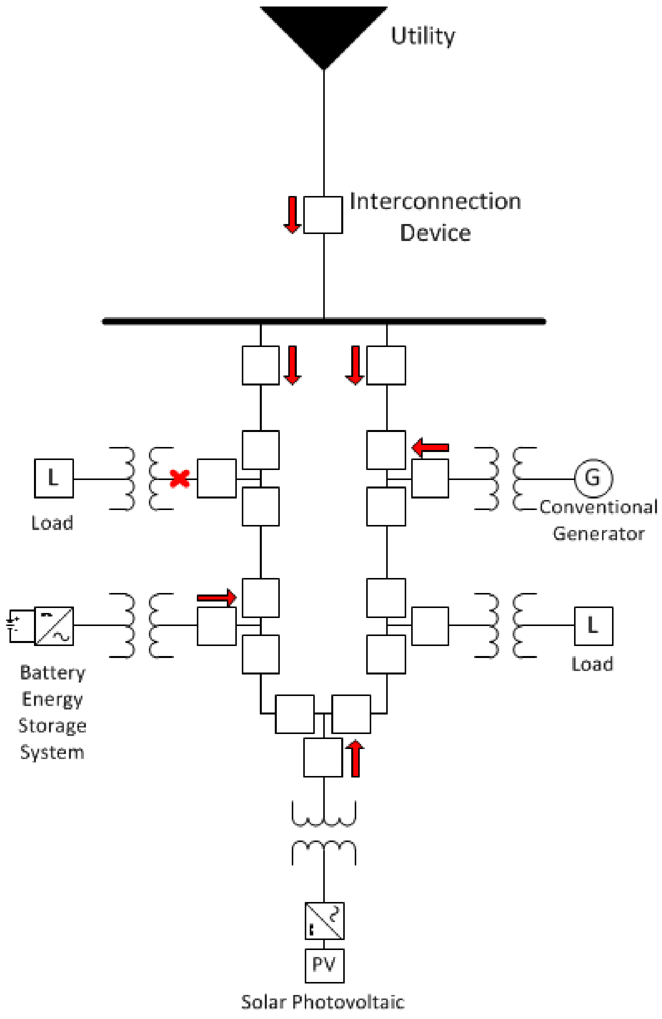
- Delay in relay
- System frequency changes
- Inverter output waveforms
- CT saturation

Microgrid Protection Challenges

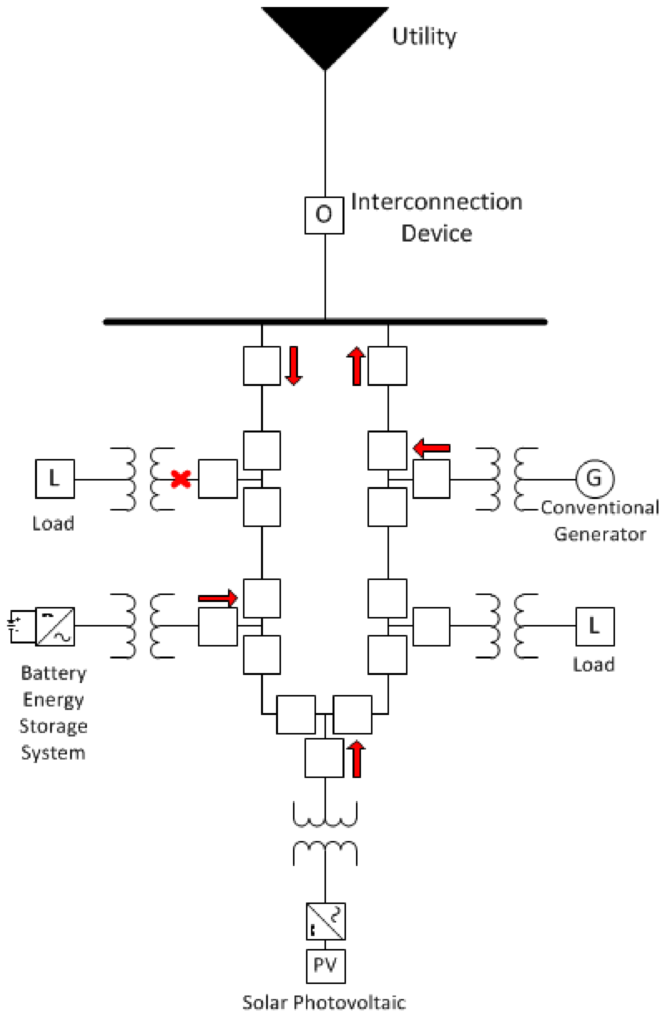
Fault from utility



Fault in MG, connected to utility



Fault in MG, islanded

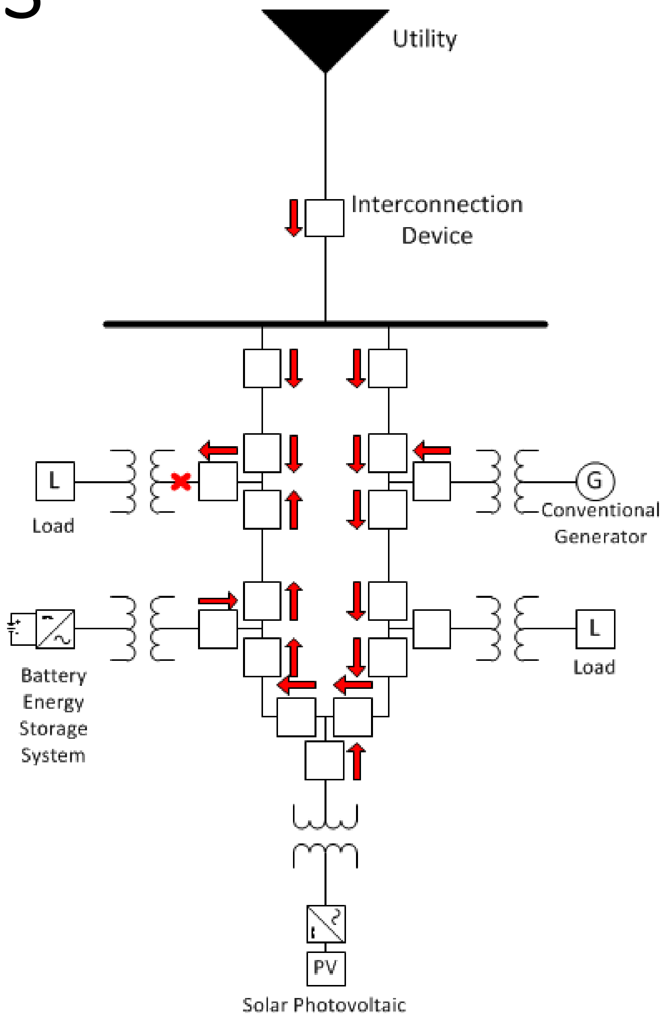


Microgrid Protection Solutions

- Define separate interconnected and islanded settings
  - What device determines setting group?
  - How is the setting group determined?
  - When do the relays transition setting groups?
- Protect against undesired paralleling
  - Synchronization check
  - Blocking close

Microgrid Protection Options

- Zone Interlocking: Uses relays to share direction of current, upstream provide authorization for downstream breaker to trip
- Differential: Utilizes Kirchhoff's Current Law to evaluate if fault is in equipment
- Directional: Uses relays to share direction of current, upstream blocked by downstream experiencing fault with delay



Microgrid Protection: Key Takeaways

Differentiate between load, inrush, and fault current through all configurations

Design selective coordination with directionality in microgrid protection

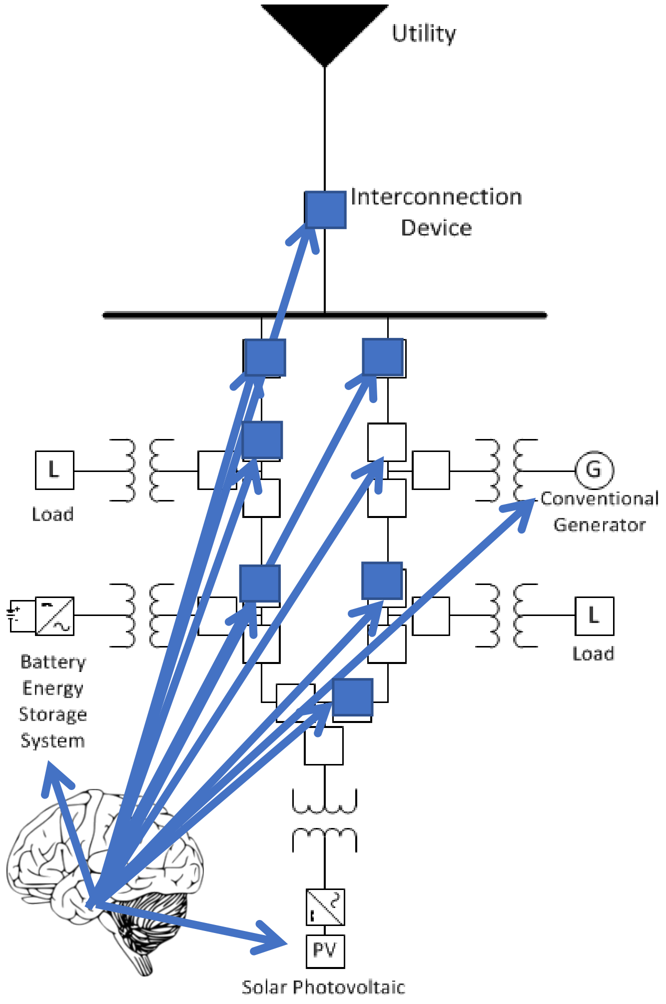
Coordinate with downstream overcurrent devices

New Hardware Requirements

- Self-Healing Electrical Grid
  - Interrupt fault current with breaker
  - Segment load with switch
- Point of Interconnection Device
  - Detect loss of source
  - Detect power quality events
    - Single or open phase
    - Unbalanced voltage
  - Protect distribution system equipment
- Microgrid Control System
  - Address legacy and new equipment
  - Execute sequence of events
  - Manage cybersecurity

Microgrid Communication

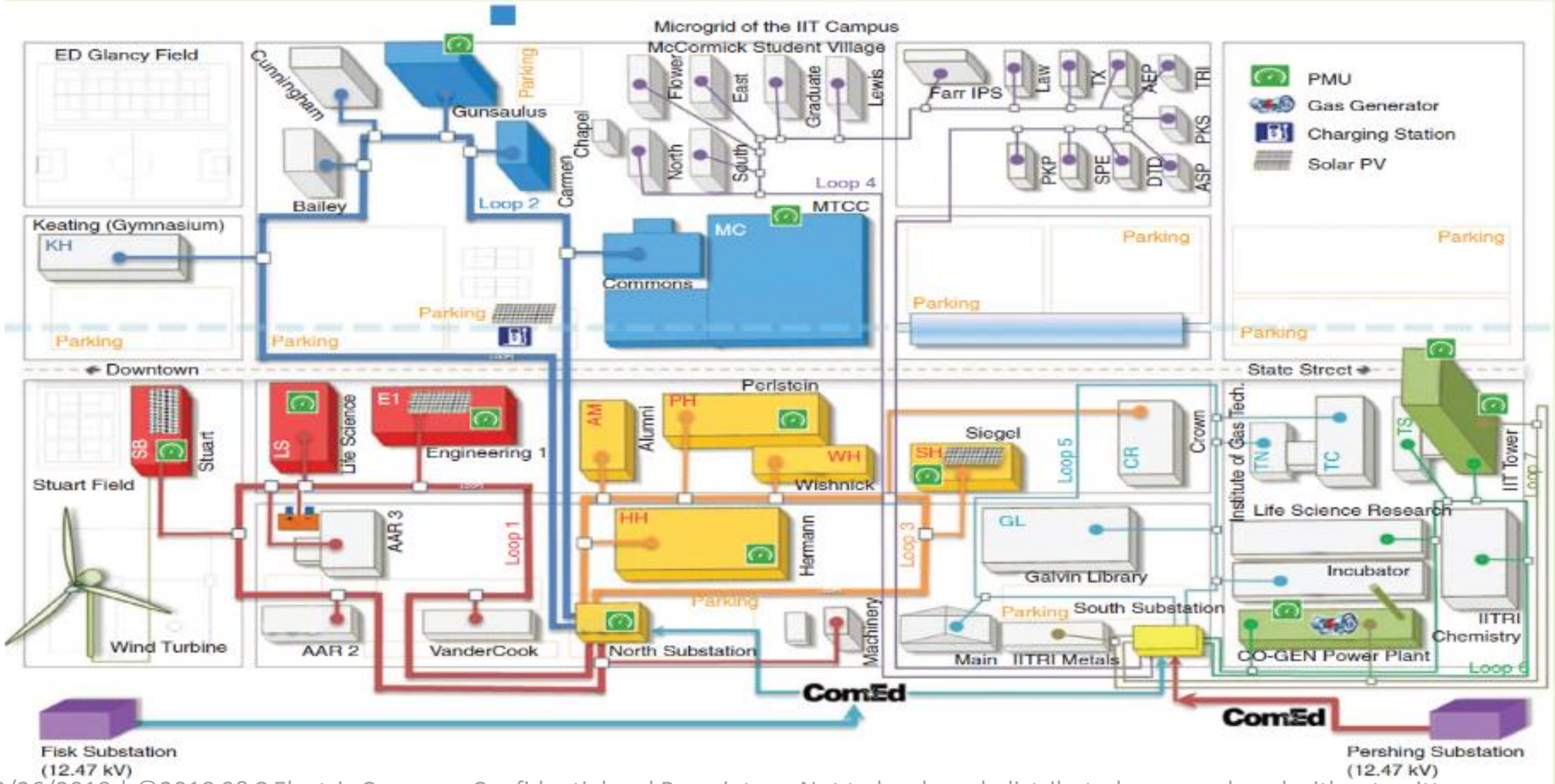
- Communication Medium
- Supervisory Control and Data Acquisition (SCADA)
- Protection



Microgrid Implementation - IIT

Illinois Institute of Technology – Chicago, IL

- Improved reliability, $1.3 million annually
- Reduced their peak demand charge
- T&D Deferral - $5 million substation



Microgrid Feasibility: Single Building

Medical Research

265,000 GSF, ~550 kbtu/sf

1995 construction

annual usage:

12,000,000 kwh ELE,

53,000,000 lbs STM

3,000,000 ton-hrs CHW

Served by double-ended substation

Fuses provide overcurrent protection

1MW diesel backup generator onsite

Other generators (2MW+) nearby

Microgrid Feasibility: Distributed Generation

Utility Distribution Hub

Steam and Electricity Infrastructure

serving 1.3M+ GSF

annual usage:

- 15,000,000 kwh ELE
- 81,000,000 lbs STM

2.4kV substation with electromechanical relay overcurrent protection

11.4kV switching hub

~1 MW backup generation at downstream buildings

2000-ton chiller plant downstream

Getting Started

- Assemble information about existing electrical system including:
  - One lines (including feeder information, utility configuration)
  - Existing relays and configuration
  - Fault study of existing configuration(s)
- Conduct initial feasibility assessment:
  - Existing onsite generation (type, location, size, and control)
  - Identification of critical loads (location, size, and controllability)
  - Load profiles of critical and secondary/shedable loads
  - Communication infrastructure across the facilities
  - Thermal loads to be included in a microgrid
  - Intended use of microgrid

Creating a microgrid presents many technical challenges

- Faults and Protection
  - Microgrid protection involves sophisticated use of communication-assisted schemes and adaptive relay settings
- Hardware Integration
  - Microgrids require careful selection of equipment to interconnect new and existing resources
- Control Infrastructure
  - Microgrid controller requires a communication network to manage the generation and load within the network

Questions?

Chris Evanich, S&C Electric
Chris.evanich@sandc.com

Erika Weliczko, Case Western Reserve University
emw3@case.edu

Microgrid 2.0
Advancing Industry Growth
OCTOBER 29-31, 2018 ▼ BALTIMORE, MD