### Typical Distribution Systems

- **Passive**
  - System distributes power to loads
  - Unidirectional power flow
- **Overcurrent relaying**
  - Coordinated with fuses
- **Voltage regulation fairly simple**
  - Controlled at substation

### Distributed Generation Protection

- **What is DG (or DR)?**
  - Synchronous generators
  - Induction generators
  - Power electronically coupled generators
  - Connected to distribution circuit
  - Typically less than 5MVA (some bigger approaching 10MVA)
  - Supply owners load, not rest of circuit
- **Connection similar to a load**
### Impacts

- Addition voltage source not provided from substation
  - Fault current source
  - Backfeed to other circuits
  - Impact voltage regulation
- Restoration of feeder after outage
- Power quality

### IEEE Standards

- IEEE 1547-2003: Standard for Interconnecting Distributed Resources with Electrical Systems
  - Amendment 1, 2014
- 1547.1: Conformance test procedures
- 1547.2: Application Guide for 1547
- 1547.3: Guide for monitoring, information exchange and control
### IEEE Standards

- **1547.4** Guide for design, operation and integration of DR Island Systems
- **1547.6**: Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks
- **1547.7**: Conducting DR Impact Studies
- **1547.8** (draft): Supplemental support for implementation strategies for expanded use of IEEE 1547

### Protection Considerations

- **IEEE 1547-2003**: Standard for Interconnecting Distributed Resources with Electrical Systems
  - Defines protection at PCC/POI, not generator
  - Disconnect for voltages outside of range
  - Disconnect for frequencies out of range
  - Stay disconnected until feeder restored
Protection Considerations

- IEEE 1547-2003: continued
  - Voltage magnitude fluctuation on synchronization < 5%
  - Detect unintentional islanding
  - DG doesn’t cause overvoltages
  - DG doesn’t cause miscoordination of protection
  - Disconnect for faults on feeder

Utility perspective

- Protect system from DG
- 51P/51G impacts
- Coordinate with DG protection for facility faults
- Transfer trip (if necessary—more likely with higher ratings)
- Don’t reclose with DG connected
### Utility perspective: Back feed issues

- Downstream loads see larger currents
- Transfer trip to avoid having it feed faults
- Directional protection
- Communication aided protection

### DG owner perspective

- Protect generator from grid
- Stay connected while meeting IEEE 1547
- Disconnect from utility for system level disturbances and supply on site loads
- Minimum set of standard generator protection
1547 requirements

- Sense VLL on feeder side of PCC/POI
  - Overvoltage (59)
  - Undervoltage (27)
    - Specific clearing time
- Disconnect for frequencies out of range
  - 810 and 81U

- Stay disconnected until voltage on feeder between 88% and 110%
  - And frequency 59.3-60.5 Hz
  - Both for 5 minutes
- Detect unintentional island
  - Disconnect within 2 sec
- Difficult as DG gets large relative to load
Transfer Trip (ANSI 25)

- From Utility to DG
- Comms
  - Radio
  - Direct Fiber
  - Telecom
  - Data network