DER Technologies

Dispatchable Sources
- Small internal combustion-engine generator
- Small gas turbines generators
- Microturbines
- Fuel cells

Intermittent Sources
- Wind turbines
- Photovoltaic

Storage
- Batteries, Ultra-capacitors
- Fly-wheels

How do we deal with 100,000+ DER units?
Cluster Loads & DER
(interfaced to the grid using a fast switch)

- Microgrids provide the most promising means of integrating large amounts of distributed sources into the power grid
- Microgrids open the door to significant system efficiency reliability improvements
## Microgrid Drivers

### Provides system approach to high penetration issues

#### Reduce load outages by ~ 98% (UPS like system)
- Fast islanding (~1 cycle)
- Provides for a stiff voltage during events (SVC)

#### Reduced emissions and improve energy efficiencies
- Effective use of Combined Heat & Power (CHP)
- No transmission and distribution losses
- Facilitates demand side management
- Support renewable sources

### Provides higher reliability & modularity
- Autonomous local control (independent of loss of central controller)
- Graceful degradation
- Minimize engineering errors/cost/and maximizes flexibility
- Plug-and-play & peer-to-peer models
Microgrids with Fast Controls and Communications

Issues:
- Loss of control & communication
- Extensive site engineering
- Costly heat distribution system.
- Difficult to scale
CERTS Microgrid: Autonomous components

120 kV

Microgrid with local Combined Heat & Power Microgrid + CHP

13.2 kV

PCC

Other loads

- Autonomous DER model (independent of central controller)
- Plug & Play Model (avoids extensive site engineering, design errors & allows placement near heat/cooling loads)
- Units control power, frequency & voltage using local information
CERTS Microgrid Concept

Each DER unit is a grid forming component (*controls ac voltage and frequency*).

- Autonomous load following
- Insures multi-unit stability (*local voltage control*)
- Autonomous load transfer from overloaded source to other sources
- Intelligent load and source shedding

The interface switch provides for autonomous islanding and re-synchronizing to the network (*opens on IEEE1547 & power quality events*)
AEP/CERTS

Microgrid Test Bed

Demonstrated at Site
(inverter based, no communications & no storage)

✓ Autonomous load following
✓ Seamless separation & automatic re-synchronizing with the grid.
✓ Autonomous load transfer from overload source to other sources
✓ UPS level power quality
✓ Stable operation for multi-sourced systems.

3-60 kW Sources

Loads

Static Switch

• CEC PIER 2001-2006
• DOE RDSI 2006-2009
• DOE Smart Grid/HQ 2009-present
First CERTS Compliant CHP Systems

TecoGen

- First product to commercially offer CERTs controls algorithms for microgrid operation
- Features:
  - Low emission NG engine
  - Operated over wide speed range to optimize fuel efficiency
  - 700,000 BTUh recoverable heat
  - 82.4% (LHV) overall efficiency
SMUD Microgrid Project

Phase-1
- 3-100 kW InVerde systems
- Collect CCHP & UPS data over 12 months
- Feeder peak load reduction
- Test technical and operational implications of exporting power from a microgrid

Phase-2
- Add 500 kW-3hr Premium Power battery

310kW demo of CEC/DOE/CERTS Microgrid concept at SMUD’s central utility plant
Objective

- Demonstrate the commercial implementation of the CERTS concept
- Reduce peak electricity demand & demonstrate demand response
- Improve the security and reliability of the power supply
- Improve the fuel cell’s performance

Equipment

- 4 MW-hr Lithium Ion battery
- Two 1 MW diesel generators
- Smart switch
- 1 MW fuel cell with CHP
- 1.2 MW solar on rooftops
- 12 kV feeder

DOE & CEC funded project

Alameda County, Santa Rita Jail
## Military Microgrids

| Fort Sill Energy Efficient Microgrid | • Hybrid CERTS Microgrid  
| | • 500 kW hr battery  
| | • 2-200 kW NG gen-sets  
| | • 30 kW PV  
| | • 2.5 kW wind  

| Advanced Distribution and Control for Hybrid Intelligent Power Systems: | • Meshed microgrid with a reliable wireless communication system  
| | • Intelligent distributed controls to promote graceful degradation  

| MAXWELL Air force base | • Interconnecting two buildings  
| | • Demonstrate CERTS advanced controls  
| | • 2- existing MW gen-sets  

Directed connected synchronous generators  
- Demonstrate that CERTS concepts can be applied to the governor and exciter of conventional machines

AC Storage  
- Management of stand alone storage as a peer in the microgrid

Photovoltaic  
- Investigate the use of PV as a peer in the CERTS microgrid.

3-cycle mechanical interface switch  
- Lower the overall microgrid system costs through less expensive interface switches

Intelligent load and source shedding  
- Promote graceful degradation
What is Next?

Microgrid as a Grid Resource

- Provides a standard building block for “Smart Distribution”.
- Dispatchable bi-directional real & reactive power.
- Demand side management.
- Multiple points of electrical coupling.
- Islands & re-synchronizes autonomously.
- Controller interfaces with system controllers and locally optimizes the microgrid operation.
- Can have custom features
What's next?
Coupled Microgrids

**Smart Switch:**
- Seamless separation
- Automatic re-synchronizing

**Two coupled microgrids:**
- Distribution level
- Customer level with high *Local Reliability & CHP*

Standard building block for “Smart Distribution”
Questions?

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