

ECE 444 / ECE 544 /

CS 444 / CS 544

Supervisory Control and Critical Infrastructure Systems

Session 27

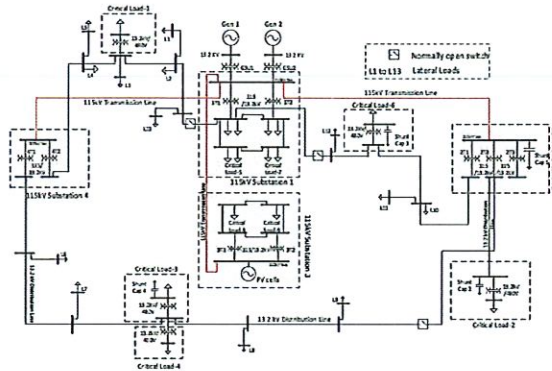
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Possible Classifications of Microgrids (1)

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- Several different views:
 - » 50/60 Hz AC distribution systems
 - » 50/60 Hz AC transmission and distribution
 - » DC
 - » High or low frequency AC



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Possible Classifications of Microgrids (2)

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- Single owner
 - » University campus, industrial facility, base, etc.
 - Coordinated control is easier
 - Appear as a single entity to utility already
- Geographically tied group
 - » Agree to work together
 - Financial (pricing)
 - Coordinated control
 - Act as a single controlled entity
 - » Increased challenges for communication

} aggregators



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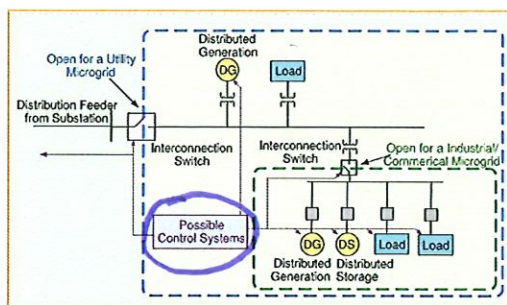
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Generic Microgrid

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Source : Making Microgrids work , IEEE Power and Energy Magazine, 2008



Components

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- Power generation resources (variety, includes renewables)
- Electrical loads (controls)
- Energy storage system (optional)
- **Microgrid controller**
- **Communications**
 - » Communication standards
 - » Interoperability



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Other early examples

- Early applications: uninterruptible power supplies
- Isolated distribution systems fed by inverters/batteries
- Microgrids dominated by inverters
- VSC HVDC to:
 - » islands, off-shore oil platforms, or other wind platforms
 - » Black start

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Present Status

- Microgrids are moving from niche applications to utilities systems
- Improved power system resilience—from end user perspective
- Support increased renewable generation penetration
- Enable new business models

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DOE Definition of a Microgrid

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- “A group of interconnected loads and distributed energy resources within a clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid connected and island mode”



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Early Applications

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- Quickly became a very active area for research/papers
- Early field installations largely niche cases that already had significant distributed generation
 - » Isolated loads
 - » Industrial facilities
 - » Military bases
 - » University campuses
 - » Supporting high value loads—super UPS



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Rotation
Machines
- nat. gas
- diesel
- coal

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Operations

- Data historian *(now - multiple databases)*
 - » Reports
 - » Data for simulations—snap shots, forecasts
- Geographic information system (GIS)
 - » Translating model data
 - » Device location/names/tags/parameters
 - » Parameters for different analysis tools
- Operator training
 - » Real scenarios in closed environment

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→ Replica control center for training

Historical data or simulated data

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Communications

- Cybersecurity
- Alarm configurations
- Telemetry
- Configuration mappings
- Drill down HMI views of equipment

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Distribution Management System (DMS)

- To an extent, advances are moving grid energy management system environment to distribution systems
 - » State estimation
 - » Load flow
 - » Contingency analysis
- More challenging in a distribution system
 - » Since unbalanced need three phase solution
 - » Topology analysis
 - » Network model – validation
 - » Change management
 - » User interface
 - – Displaying planned or unplanned outages for operators

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data is from SCADA (some PMU)

distributed

EMS ~ Transmission system as a whole

multiple databases

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Some Other DMS Functions

- Fault calculations
- Capacitor/voltage regulator placement (planning)
- Efficiency/loss estimates
 - » Volt/VAR optimization
- Load forecasting → power consumption (energy) → supply (PV, wind)
- Reliability/resilience
- Network reconfiguration (manual and autonomous)
 - » FLISR
- Clients for field crews—system for visiting, mutual aid crews.

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- Power market - real time price info - automation in meters

- Hosting capacity (congestion, voltage)

- Load management / generation (DER) management
↳ demand response curtailment

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Advanced Distribution Management Systems (ADMS)

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- ADMS can have a broad range of topics
- Some exist now in distribution systems, some are emerging
- Key is bringing to together range of functions that now have their own communications and data bases
 - » And possibly separated staff
- Software tools emerging in market to fit this niche → ADMS
- The next slides discuss functions that can be fit into to ADMS

ADMS



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Outage Management System (OMS)

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- Call management
- Incident management
- Customer management
- Providing information in web apps
 - » To public
 - » Internal users
- Can also include
 - » Crew management: status of crews, assignment management
 - » Switching management: plans, work requests
- All of these require communicating information
 - » Some that is normally outside the OT environment

IT
OT




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| | | |
|--|---|--|
| <h1>Communication Requirements</h1> | | <i>CS&ECE 444/544</i> <i>Lecture 26</i> |
| <ul style="list-style-type: none">• Measurements with controller• Controller to actuators<ul style="list-style-type: none">» Generators» Loads<ul style="list-style-type: none">– Responsive loads—Demand Response– Load shedding...» Storage» Protection and control• With larger grid<ul style="list-style-type: none">» Grid connected versus isolated mode | | |
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| | | |
|--|---|--|
| <h1>Power Sources</h1> | | <i>CS&ECE 444/544</i> <i>Lecture 26</i> |
| <ul style="list-style-type: none">• Rotating machines<ul style="list-style-type: none">» Diesel» Gas» Some utilize steam from other processes» Small to medium sized hydro• Power electronic controlled or interfaced (mostly voltage sourced converters)<ul style="list-style-type: none">» Photovoltaic (1 or 3 phase)» Wind» Energy storage | | |
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