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Microgrids

U.S. Department of Energy Electricity Advisory Committee

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DER Technologies

Dispatchable Sources

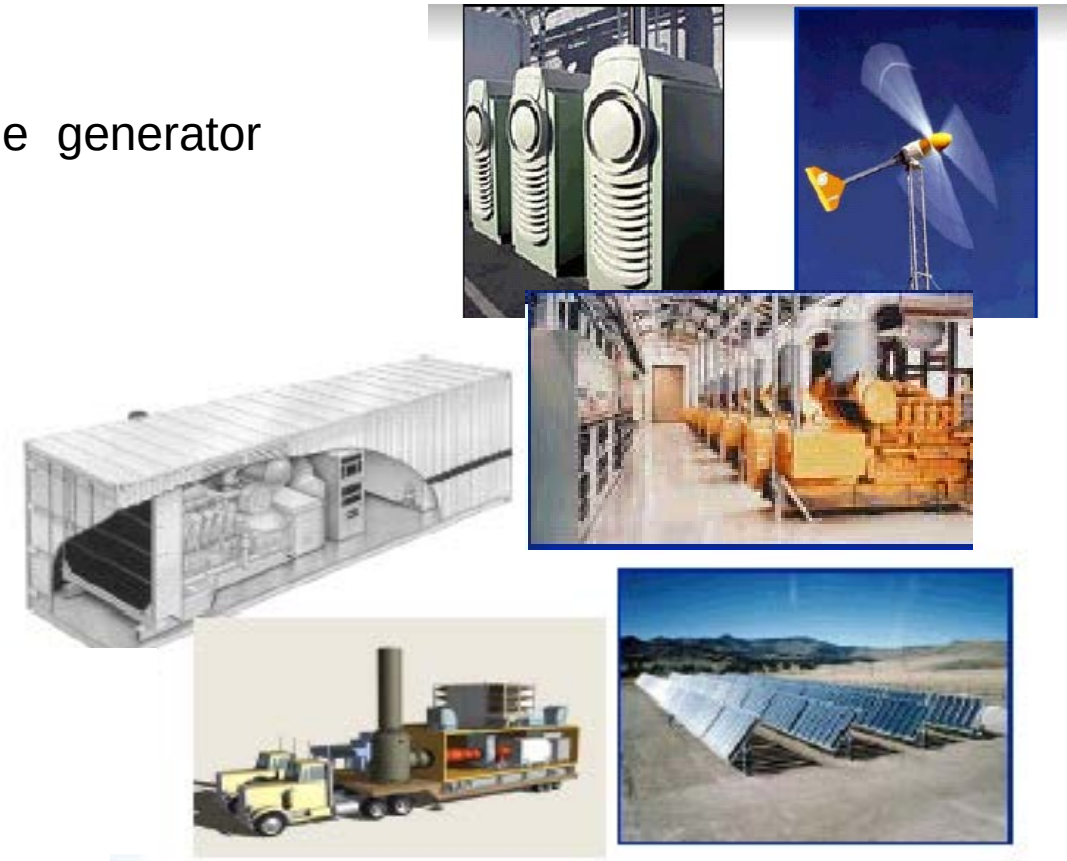
- Small internal combustion-engine generator
- Small gas turbines generators
- Microturbines
- Fuel cells

Intermittent Sources

- Wind turbines
- Photovoltaic

Storage

- Batteries, Ultra-capacitors
- Fly-wheels



How do we deal with 100,000+ DER units?

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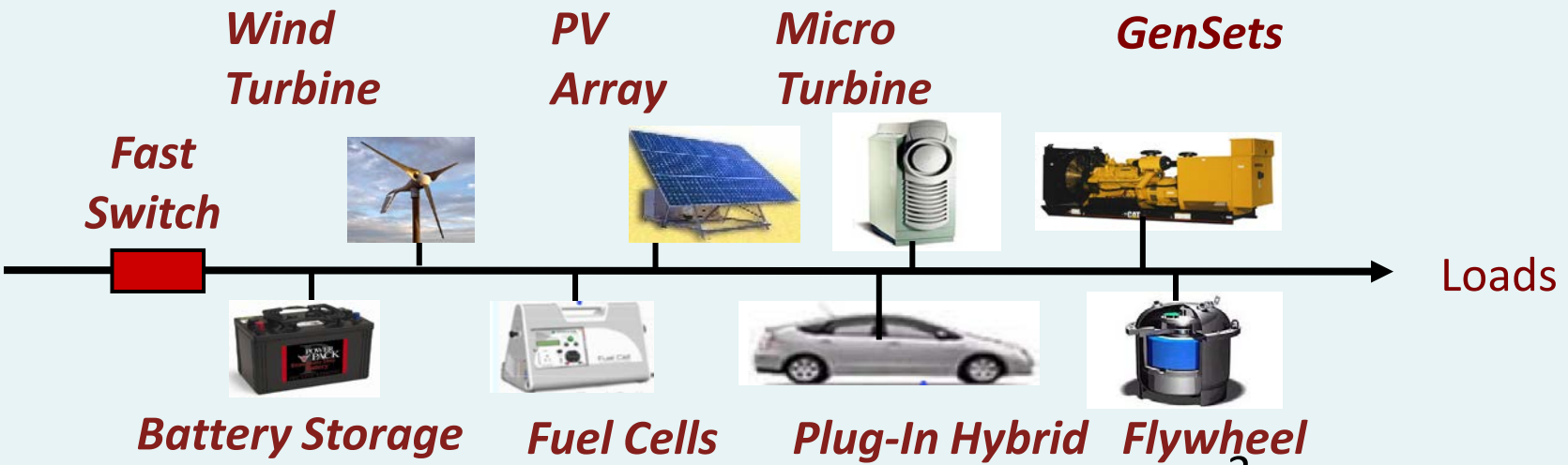
Cluster Loads & DER

(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



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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)

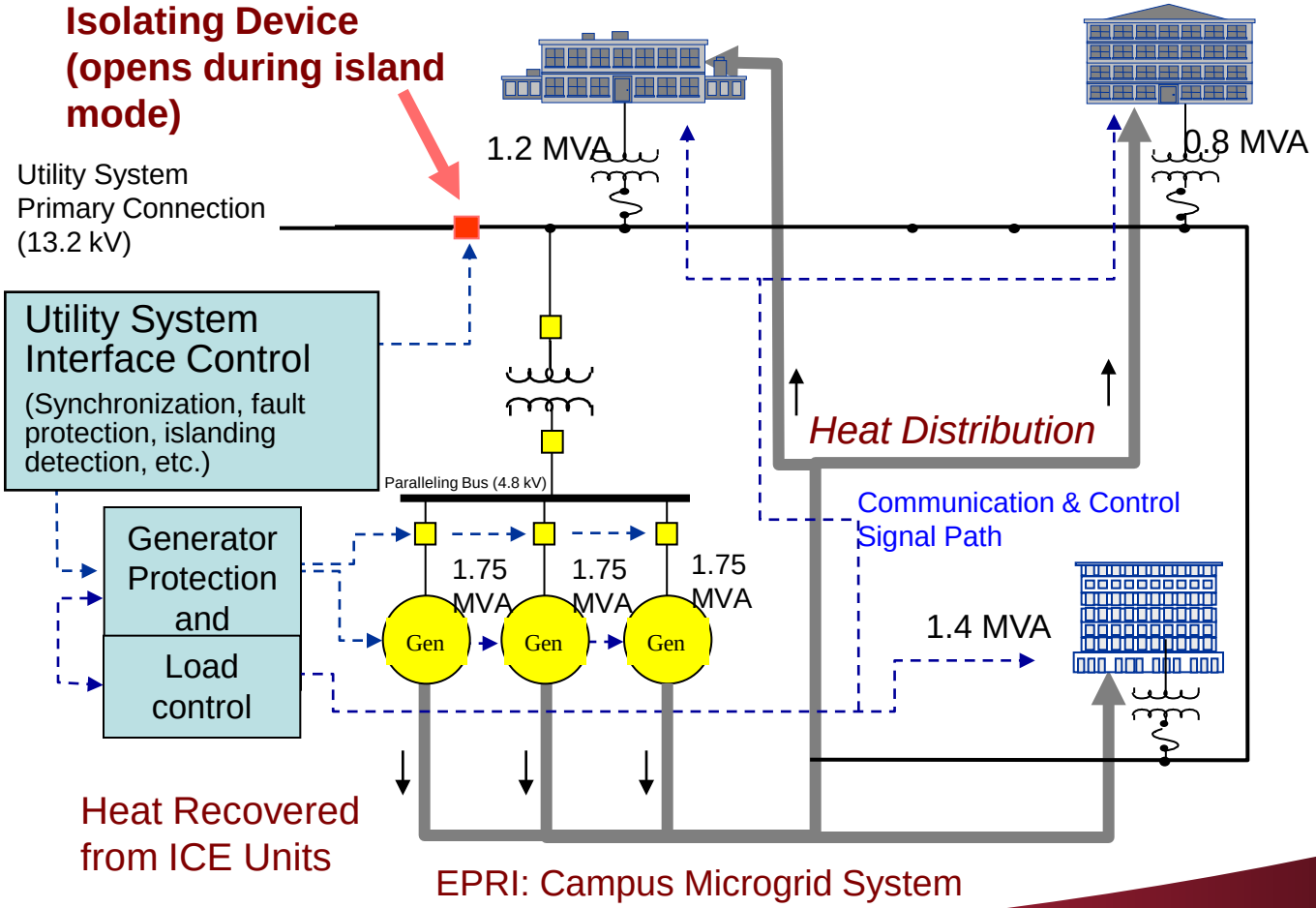
Reduced emissions and improve energy efficiencies

- 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

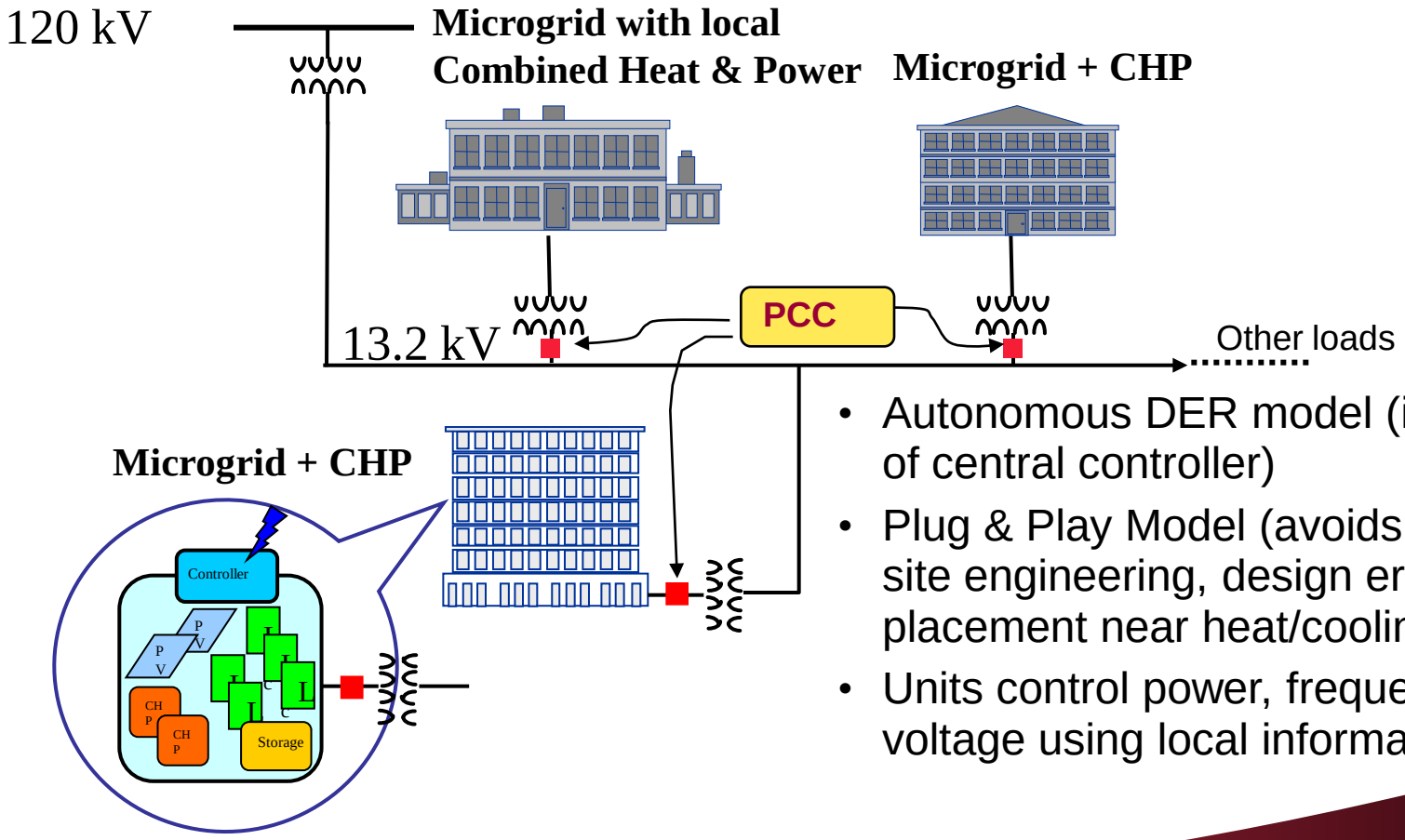


EPRI: Campus Microgrid System

Issues:

- Loss of control & communication
- Extensive site engineering
- Costly heat distribution system.
- Difficult to scale

CERTS Microgrid: Autonomous components



- 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

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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)*

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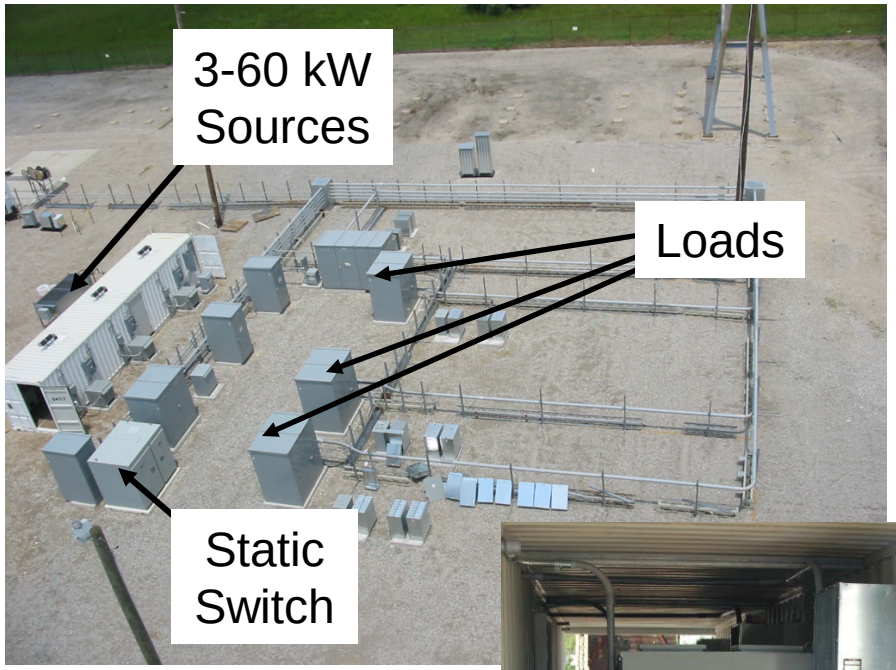
AEP/CERTS Microgrid Test Bed

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.



- CEC PIER 2001-2006
- DOE RDSI 2006-2009
- DOE Smart Grid/HQ 2009-present

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First CERTS Compliant CHP Systems

- 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

TecoGen

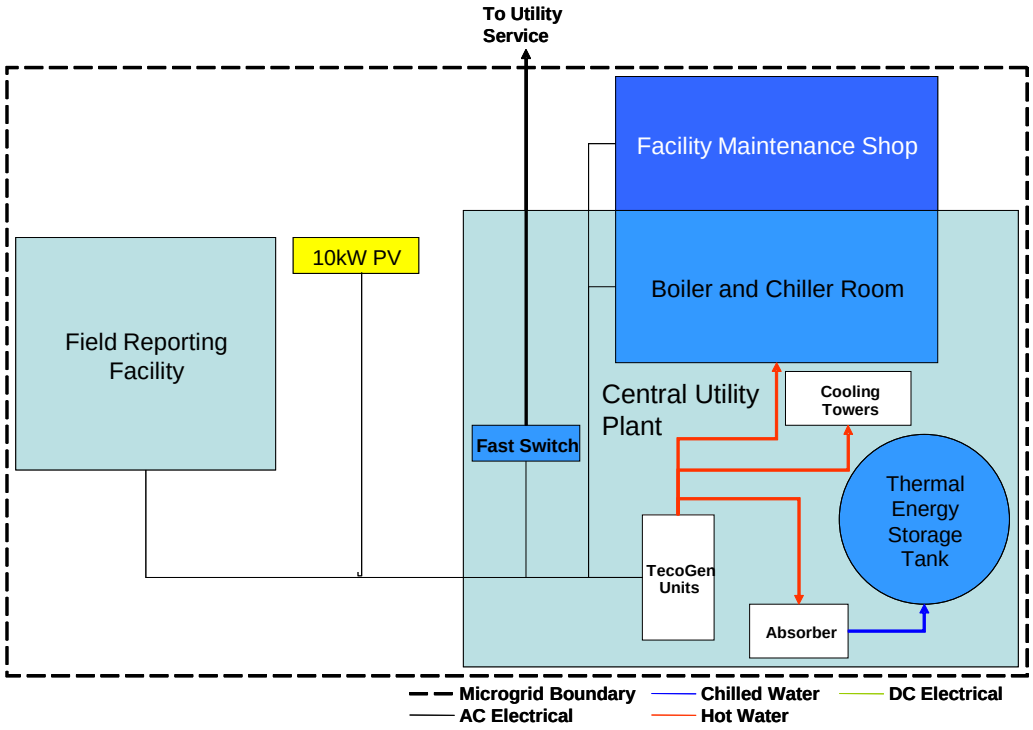
SMUD Microgrid Project

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

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CERTS Microgrid Demonstration

- **Alameda County,** Santa Rita Jail

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

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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

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AEP/CERTS Microgrid: Mixed System

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.

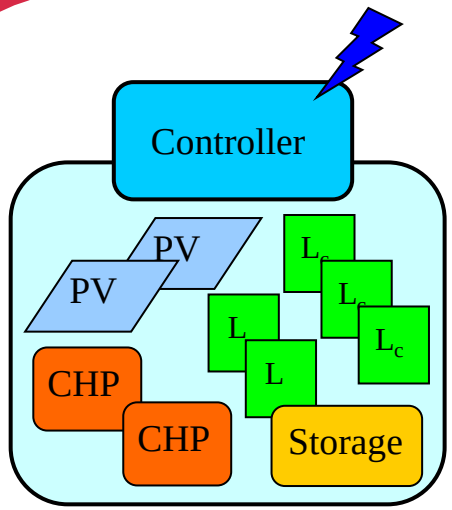
3-cycle mechanical interface switch

- Lower the overall microgrid system costs through less expensive interface switches

Intelligent load and source shedding

- Promote graceful degradation

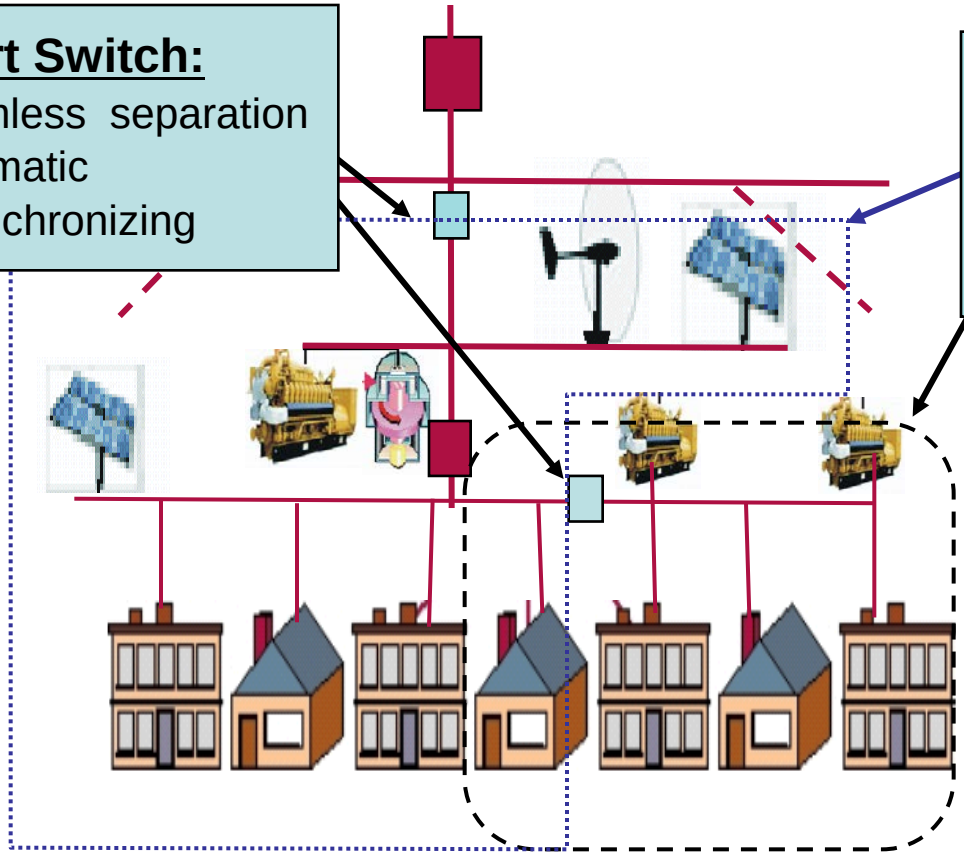
What is Next?
Microgrid as a Grid Resource



- 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"

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Questions?

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