

Advanced Distribution

(A Blueprint for Change: Local Reliability)

Rethinking T&D Architecture for DER: HOW?

IEEE PES T&D Conference & Exposition
24 April 2008
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University of Wisconsin

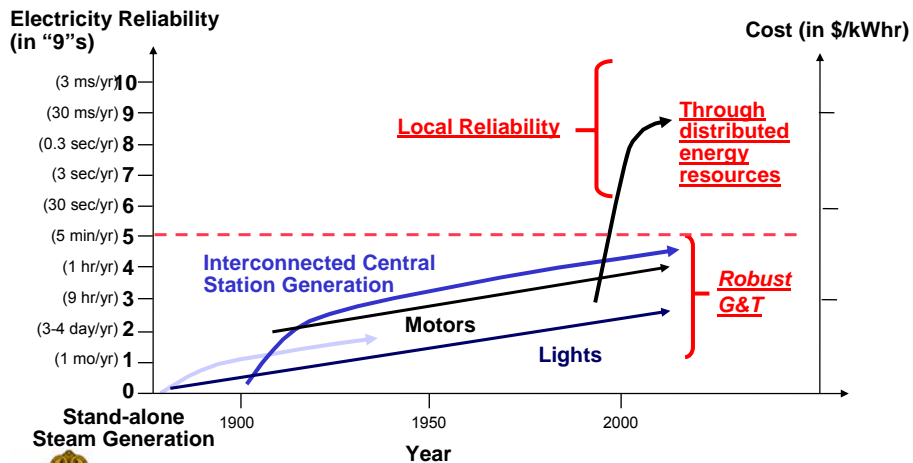


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1



A Blueprint for Change: Local Reliability

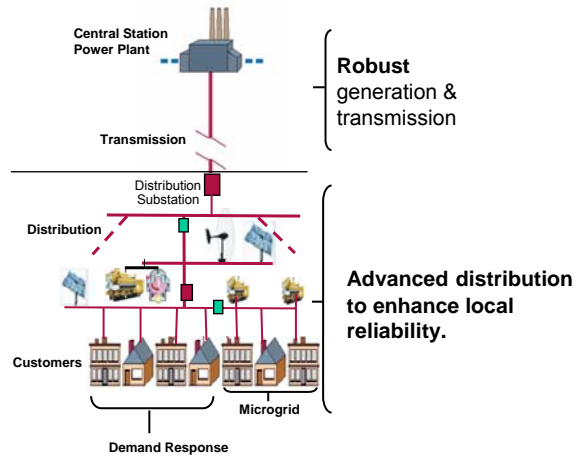


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2



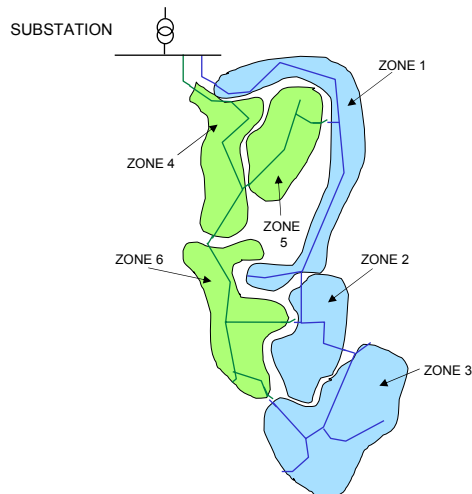
Advanced Distribution: A Blueprint for Change



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Typical Distribution Feeder

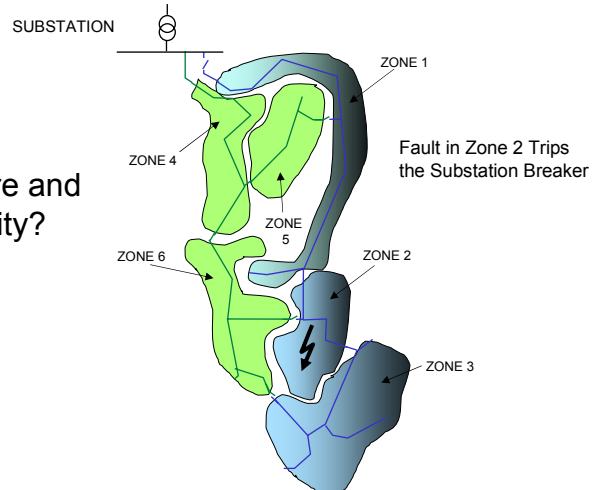


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Fault in Zone 2

How do we reconfigure and provide higher reliability?



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Advanced Distribution: Concepts

Interconnected Loads and DER in each Zone

- Each zone is an integrated system which can operate in parallel with the grid or as an intentional island.

Autonomous Source

- Local load balancing control (power vs. freq controller).
- Local Voltage vs. Q control.

Smart Switch

- Seamless separation & automatic re-synchronizing on local information.

Autonomous Load Dropping

- Use local information to drop non-critical loads



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6

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Smart Switch

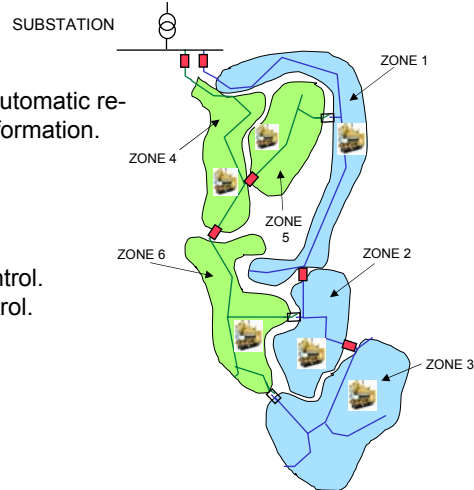
Seamless separation & automatic re-synchronizing on local information.

-  Closed Smart Switch
-  Open Smart Switch

Autonomous Source

- Local load balancing control.
- Local Voltage vs. Q control.

 Autonomous Source



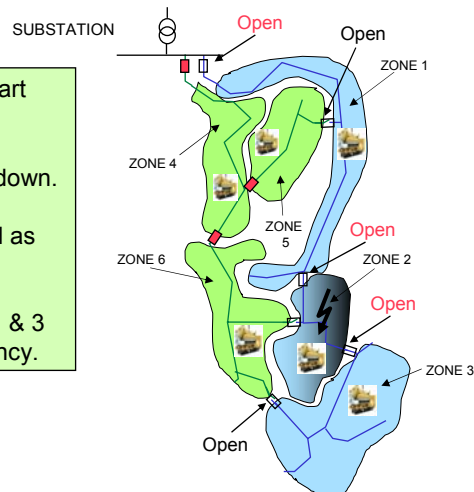
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- Fault in Zone 2 opens Smart Switches in Zone 1, 2 & 3.
- Zone 2 Generation shuts down.
- Zone 2 & 3 stay energized as islands.
- Excessive loads in Zone 1 & 3 are dropped on low frequency.



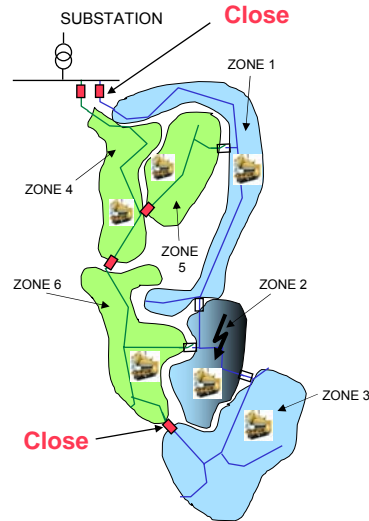
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8

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1. Smart Switch closes after detecting that the substation's voltage and frequency are within a "normal" range
2. Smart Switch closes after detecting that the Zone 6 voltage and frequency are within a "normal" range
3. Dropped Loads are energized after reconnection to the substation.
4. Smart Switches to Zone 2 do not close since the voltage is not within "normal" range



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9

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These concepts have been tested at the AEP/CERTS Microgrid test site



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Autonomous Sources

Promote islanding

- Islanded sources balance load.
- Insure stability for multi-sourced systems.
- Provide for load dropping

Design for high reliability

- Avoid dependence on central controllers
- Minimize engineering errors/cost using plug-and-play peer-to-peer models

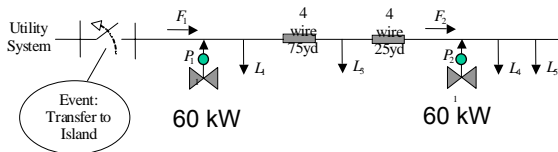
The controls on each source needs to use **local information**; provide for **automatic power balance** through a Power vs. Freq controller; use frequency droop to drop load, and provide **local voltage control** to enhances stability;



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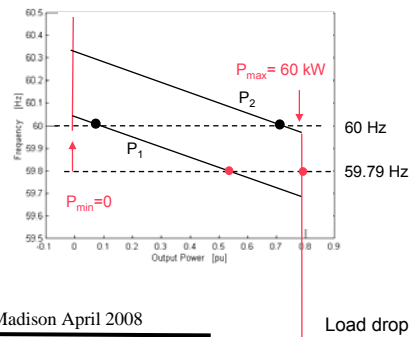


AEP/CERTS Field Test: Power vs. frequency



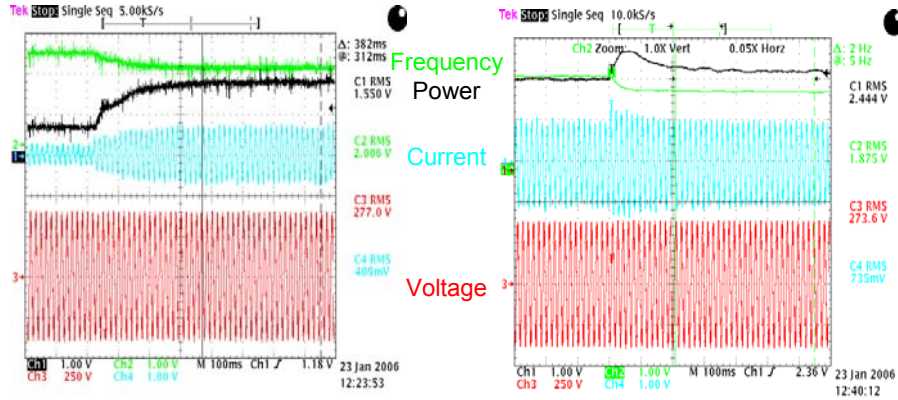
- Loads and sources are clustered
- Islanding power balance provided by DG
- Use frequency droop (P vs. Fq.)
- Load drop on low frequency

	A: Grid	B: Island
P_i [pu]	6 kW	42 kW
f_{pu}	54 kW	60 kW
Frequency [Hz]	60.00	59.79
Load	102 kW	102 kW
Grid Flow	42 kW	0.0



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AEP/CERTS field test traces



Unit 1

Unit 2



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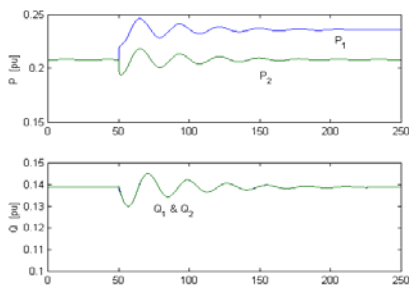


Local voltage control to *enhances stability*

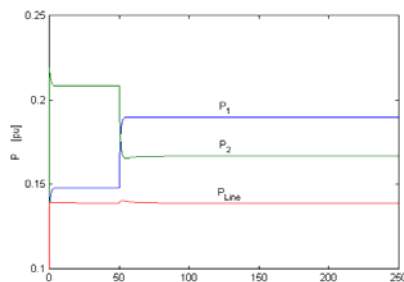
Interactions between 2 DG units & the Utility

P/Q control can cause local oscillation problems

P/V control helps local stability



P/Q control of two sources on the end of a long feeder line.



P/V control of two sources on the end of a long feeder line.



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Local Control of Smart Switch

Promote islanding

- Seamless separation from the utility & automatic re-synchronizing.

Uses **local information** for all operations; rapid and **seamless separation for**, faults, power quality and IEEE 1547 events; and **automatic re-closer** when system returns to normal.

Key is to use the **frequency difference** between the grid and islanded system to determine the re-synchronizing point. Re-closer is done when the **voltage phase difference become zero**.

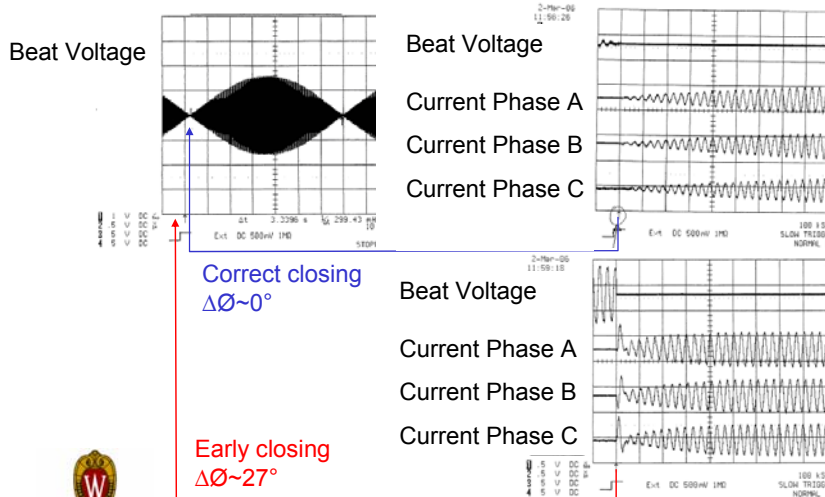


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15



Smart Switch Factory Test: Seamless Re-closing



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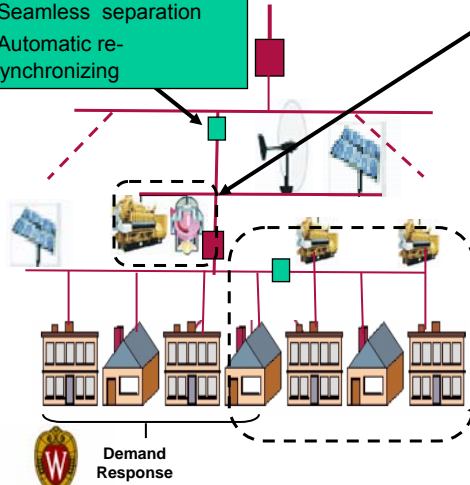
16



Advanced Distribution

Smart Switch

- Seamless separation
- Automatic re-synchronizing



Use combined generation and storage with microgrids concepts to:

- Enhance G&T by use of plug-and-play DER for *peak shaving*
- Arbitrage of energy price differentials
- Firm *intermittent resources*
- Enhance reliability with *Intentional islanding*
- Use *frequency drop for demand response*.

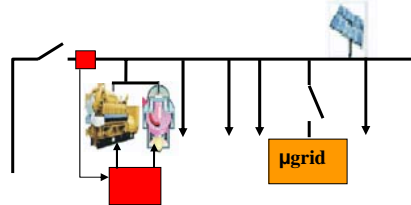
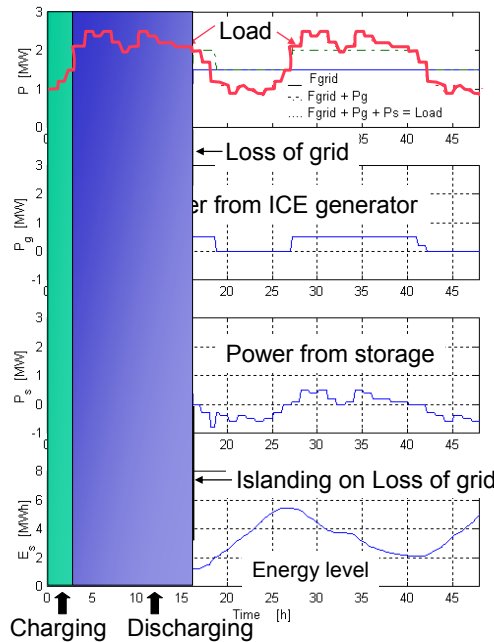
Use CERTS microgrids to provide high *Local Reliability* with *CHP*



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Simulated advanced distribution



- Power from grid is constant 24/7.
- Storage is charged during low load periods.
- Generation is run at optimum level during high loads.
- Storage follows load and provides fast power balance during islanding.

