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OFFICE OF
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Sandia National Laboratories

Laboratory Demonstration of Microgrid Power Electronics and Energy Storage

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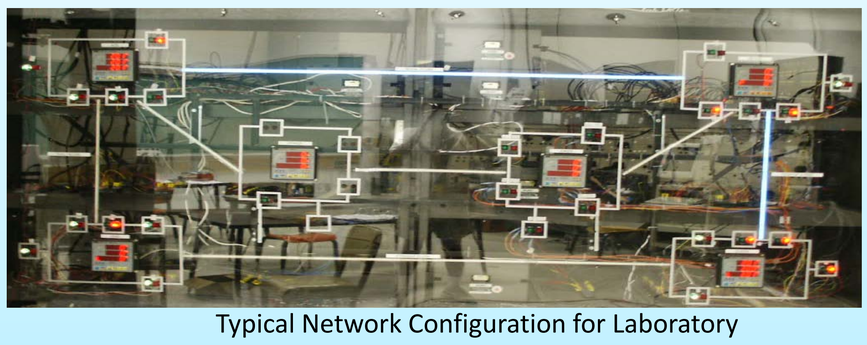
Purpose

A laboratory scale customer driven microgrid is being developed to investigate the application and management of distributed storage, investigate power electronics integration and provide a venue for students to gain hands-on experience through senior design projects.

Impact on DOE-OE ESS Mission

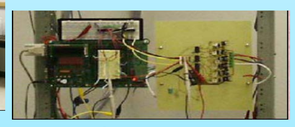
The residential and small commercial sector can represent as much as 35% of electric load. The development of electrical distribution systems as microgrids with energy storage presents an opportunity for increasing application of distributed storage.

- **Develop laboratory capability for configuring microgrids with energy storage components**
  - *Reconfigurable network with rotating generators, loads, renewables and storage*
  - *Developed a decentralized, multi-agent system, with only neighbor to neighbor communication*
  - *Manages autonomous operation of a distribution feeder*
  - *Interfaces to laboratory hardware are being completed*



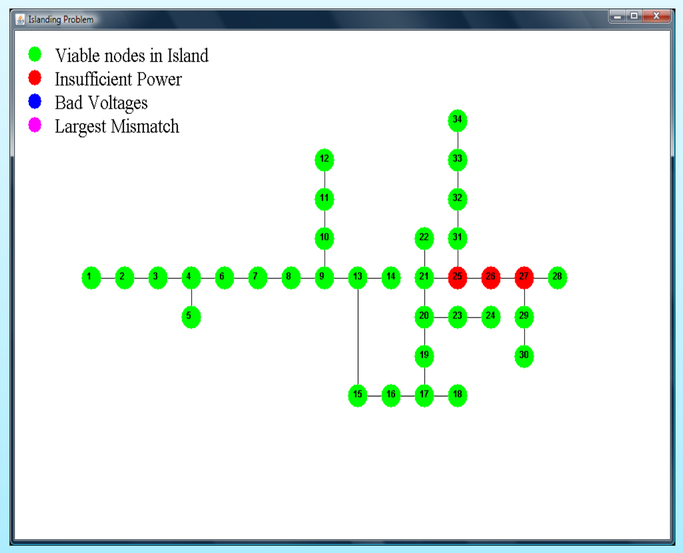
Typical Network Configuration for Laboratory

Generators and Loads



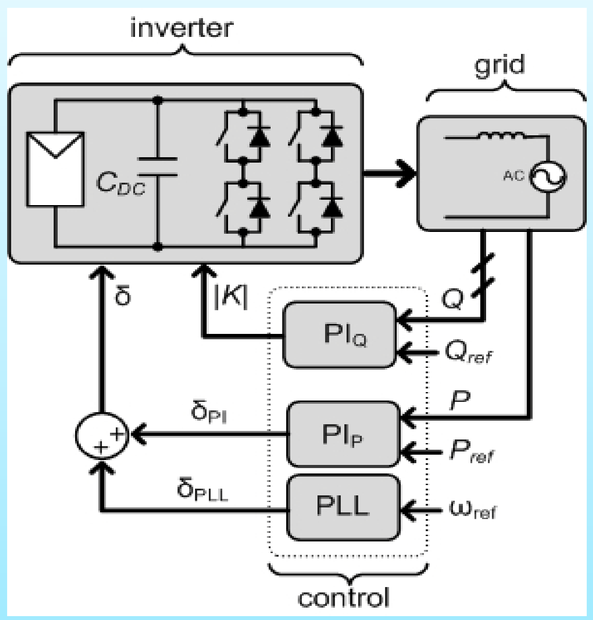
Storage/Power Electronics

PV System



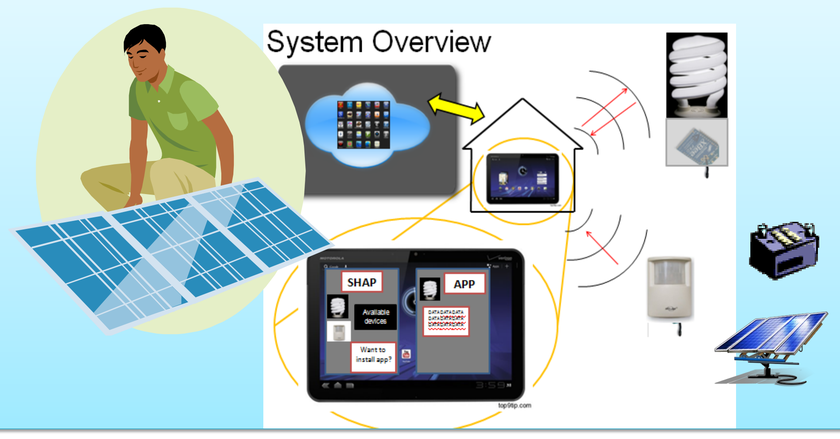
Illustrating Islanded Operation of a Feeder

- **Examine role of power electronics and energy storage in customer-driven microgrids**
  - *Developed general dynamic model of inverter to describe how a generic inverter reacts to ac side disturbances. Model will be used to examine*
    - *How inverter reacts to faults*
  - *What is the role of dc side storage in providing 'inertia'*



$$\frac{d^2\delta(t)}{dt^2} = K_3A_1\left[\cos[\delta(t)]\cdot v_{dc}(t)\cdot\frac{d^2\delta(t)}{dt^2}\right] - K_3A_1\left[\sin[\delta(t)]\cdot v_{dc}(t)\cdot\left[\frac{d\delta(t)}{dt}\right]^2\right] + 2\cdot K_3A_1\left[\cos[\delta(t)]\cdot\frac{d\delta(t)}{dt}\cdot\frac{dv_{dc}(t)}{dt}\right] + K_3A_1\left[\sin[\delta(t)]\cdot\frac{d^2v_{dc}(t)}{dt^2}\right] + K_4A_1\left[\cos[\delta(t)]\cdot v_{dc}(t)\cdot\frac{d\delta(t)}{dt}\right] + K_4A_1\left[\sin[\delta(t)]\cdot\frac{dv_{dc}(t)}{dt}\right] + A_2\cdot\left[\frac{d^2\omega'(t)}{dt^2}\right] - A_3\cdot\left[\frac{d\delta_{PLL}(t)}{dt}\right]$$

- **Provide Senior Design classes for undergraduate students**
  - *Students are designing a platform to allow simple integration of end user technologies including renewable sources, storage and demand response.*



When the user invests in hardware, the platform recognizes the hardware and downloads appropriate 'applications' to manage the hardware. If the user's renewable energy system includes storage, the application would manage daily charge and discharge profiles based on load profile and real time price

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