What is needed for a microgrid?

• **Control of power and load balance**
  - Controllable power source
  - Controllable load demand
  - Power storage.

• **Control of power quality**
  - Voltage support
  - Frequency support
  - Power factor (var) support.

• **System controls**

• **Ability to synchronize with grid.**
Microgrid function

• Currently microgrids are being developed for improving reliability or in some cases reducing power cost.
  o Commonly used for hospitals, fire stations, police, colleges, server farms, etc.

• They can be financially attractive especially if waste heat is useful and power is expensive.

• Primarily fossil-fuel based (natural gas and diesel are common).
Where does renewable energy (RE) fit in?

• RE can be anything from a major part, to a minor feature, to not included at all.

• Financial impact of RE can be very complicated
  o On the first level it is just a fuel saver.
  o It can be a fuel supply extender.
  o It can be used to enable power or grid support services sales.
What features are valuable in the system?

• Power control is desirable for both load and generation components.
• Power quality support services are essential in at least some components.
• Integrated controls that prioritize and control loads will reduce storage and inverter requirements.
• RE input forecasting and load forecasting capability for controls will optimize assets.
What is going on in demand response?

• Technologies for behind-the-meter demand response and aggregation are being developed and reaching the market.
  o Three-stage water heaters
  o Refrigerators
  o Heating and air conditioning systems.

• Staging is another form of demand response.
  o Clothes washer and dryer
  o Dishwasher.
Add it all together and what is available?

• Community or home microgrid or off grid
  o Power by RE possibly with natural gas supplemental input
  o Affordable storage used to stabilize grid quality
  o Smaller inverters will be needed due to staging and demand response.

• All of these technologies can be integrated at the home, community, or larger level.
How does distributed wind fit?

• Microgrid or off-grid communities with photovoltaic and wind or small hydro and wind or other combinations
  o Individual homes could have wind generators.
  o The community could have wind generators.

• Wind generators will need to be flexible players with power-limiting capability and the ability to contribute to power quality.