

Resilient Community Microgrids Concepts, Operations & Maintenance

International **D**istrict **E**nergy **A**ssociation

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Edward “Ted” Borer, PE

etborer@princeton.edu

Power Grid Energy Transport Characteristics

- Electricity is a “high grade” energy
 - Clean
 - High density
 - Quiet
 - Mature technology
 - Vast array of applications
 - Well-developed infrastructure
 - easier to handle and transport than thermal energy
 - more efficient and cost-effective to transport over long distances than thermal energy
- A power grid can draw from many diverse energy sources: hydro, nuclear, solar, wind, tidal, coal, oil, gas, biomass, waste...

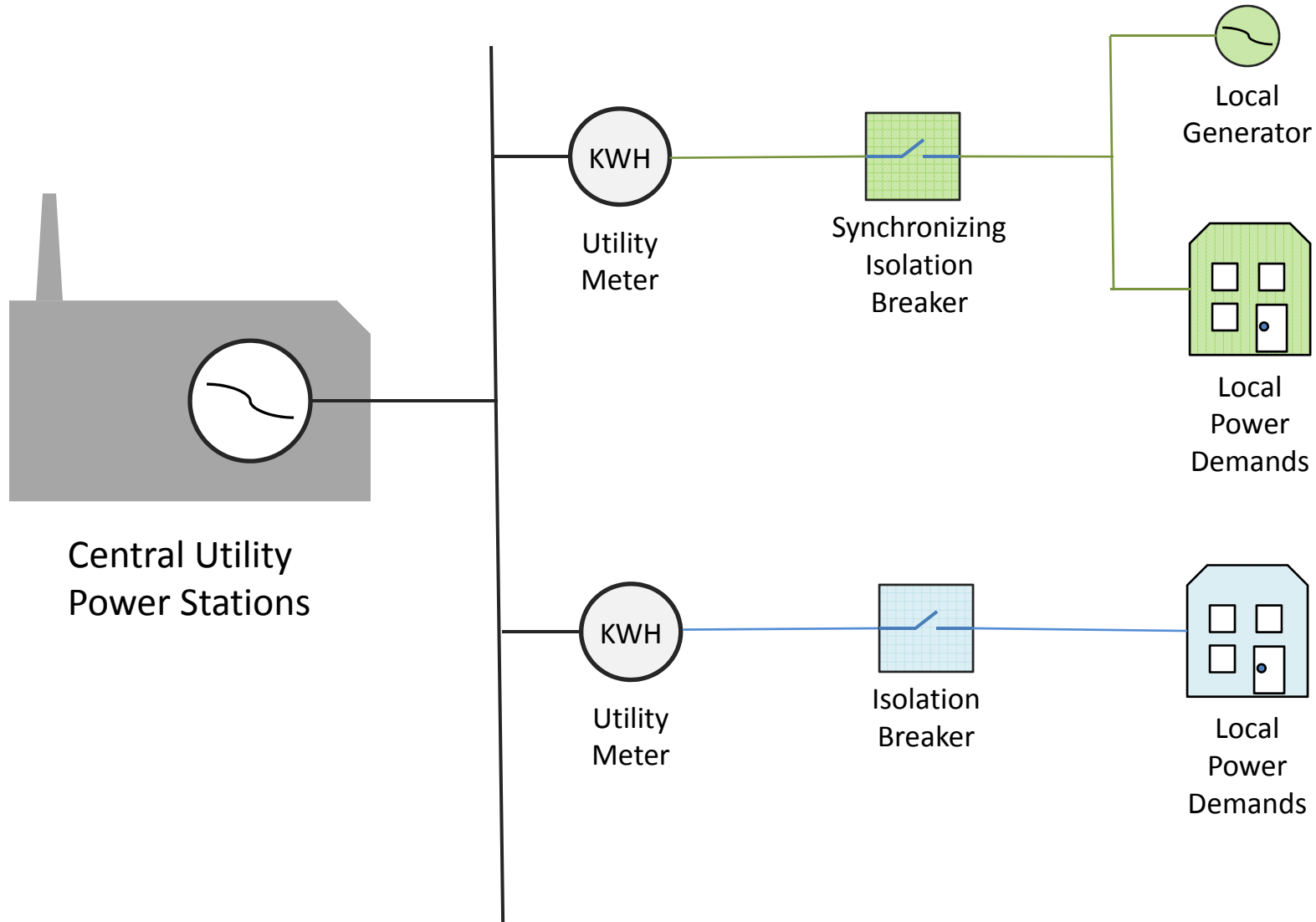


Wisdom From Experience:

Anticipate Decay

- Everything we build needs maintenance.
- Everything we build will fail.
- You can improve outcomes if you think, plan, and act in advance.

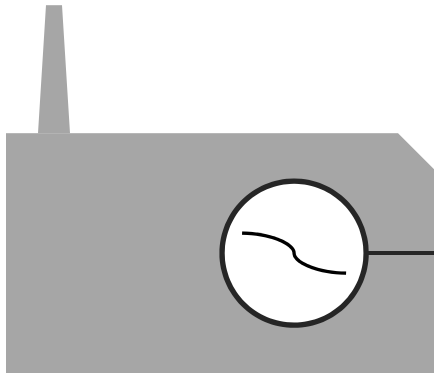
Basic Microgrid



Simplified Vocabulary

- **Available** – ready when you want it
- **Capacity Factor** – % of time something actually runs
- **Power Quality** – voltage, frequency, wave shape...
- **Reliable** – does not fail often
- **Resilient** – able to restore normal operation quickly following a failure

Central Generating Plant Characteristics

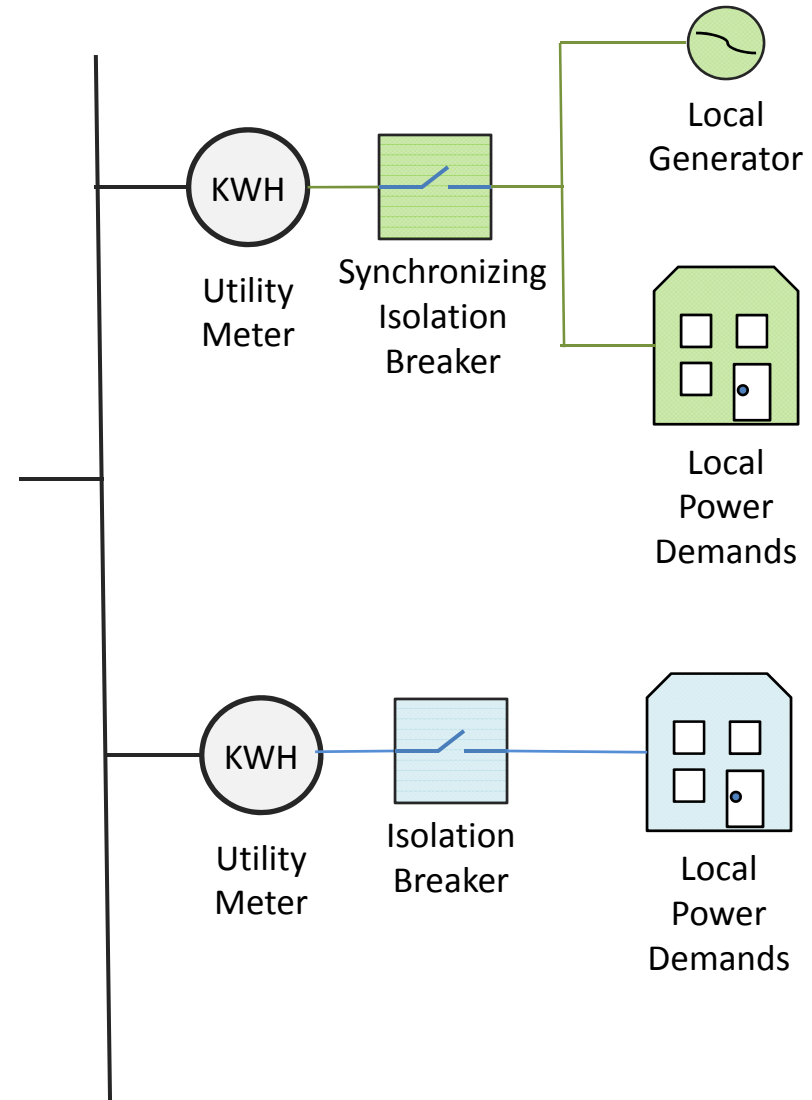


Central Utility
Power Station

- Close to fuel & water sources
- Lower value real-estate
- Efficiency *of scale*
- Hidden aesthetics
- Less obvious environmental impact
- Single point waste (solid, liquid, noise, thermal...)

Microgrid Characteristics

- Smaller scale
- Close to energy *users*
- Efficiency through ***diversity of use.***
- Local labor & fuel supplies.
- User-prioritized triage (choices)
- More complex systems
- More “stuff” local to energy users
- Aesthetic/environmental impact is local



Nanogrid Example

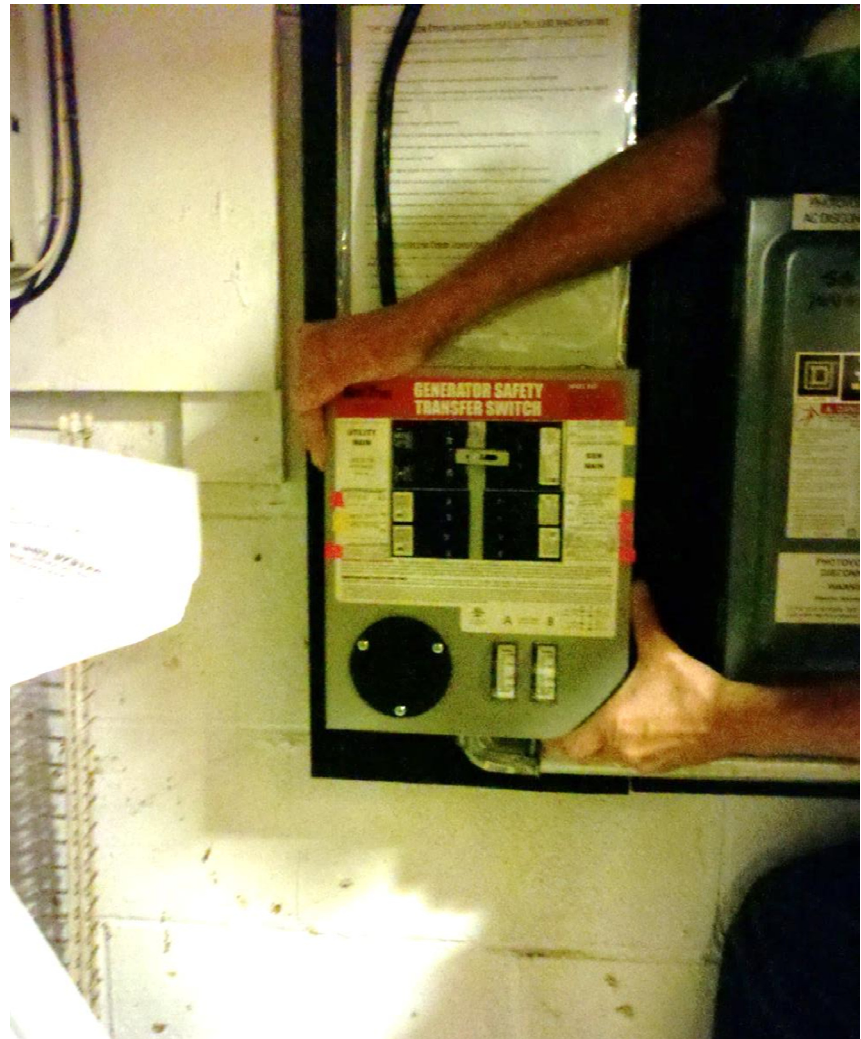
- Utility power failure → operate as an island



Nanogrid

Mission Critical Circuits are on a Transfer Switch

- Main panel is dark
- Critical circuits only



Nanogrid

Manual Transfer To Local Generation

- Requires
 - Training
 - Documentation
 - Local investment
 - Local operation
- Manage
 - Fuel, emissions, noise, safety, maintenance...



With Limited Power Availability “Triage” is necessary

- Non-critical or deferrable loads lose power
- Users like to be involved in these decisions



Nanogrid

With Limited Emergency Power

- Mission-critical and “expensive consequence” loads are still supported



Nanogrids Can Include Renewables



Nanogrids Can Couple With Thermal Energy



Nanogrids Can Improve Local Power Resilience



Nanogrid Summary

Benefits

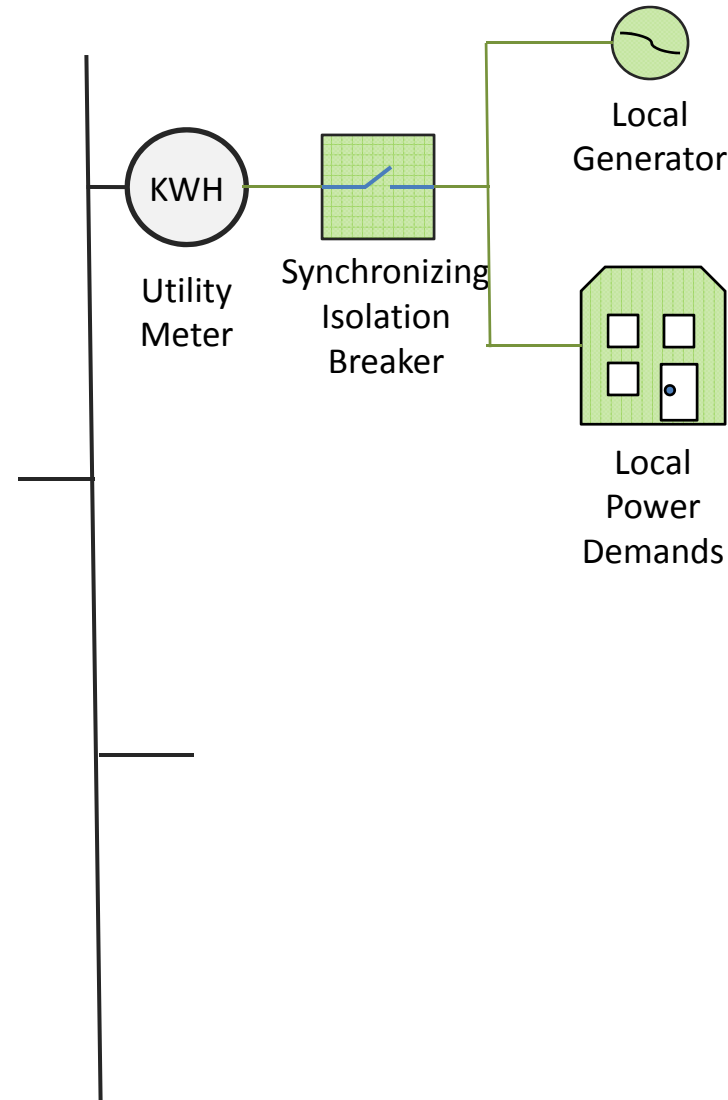
- Resilience
- Customized to user needs
- Can take advantage of local labor & fuel
- Can include renewable and thermal energy
- Can support local community

Drawbacks

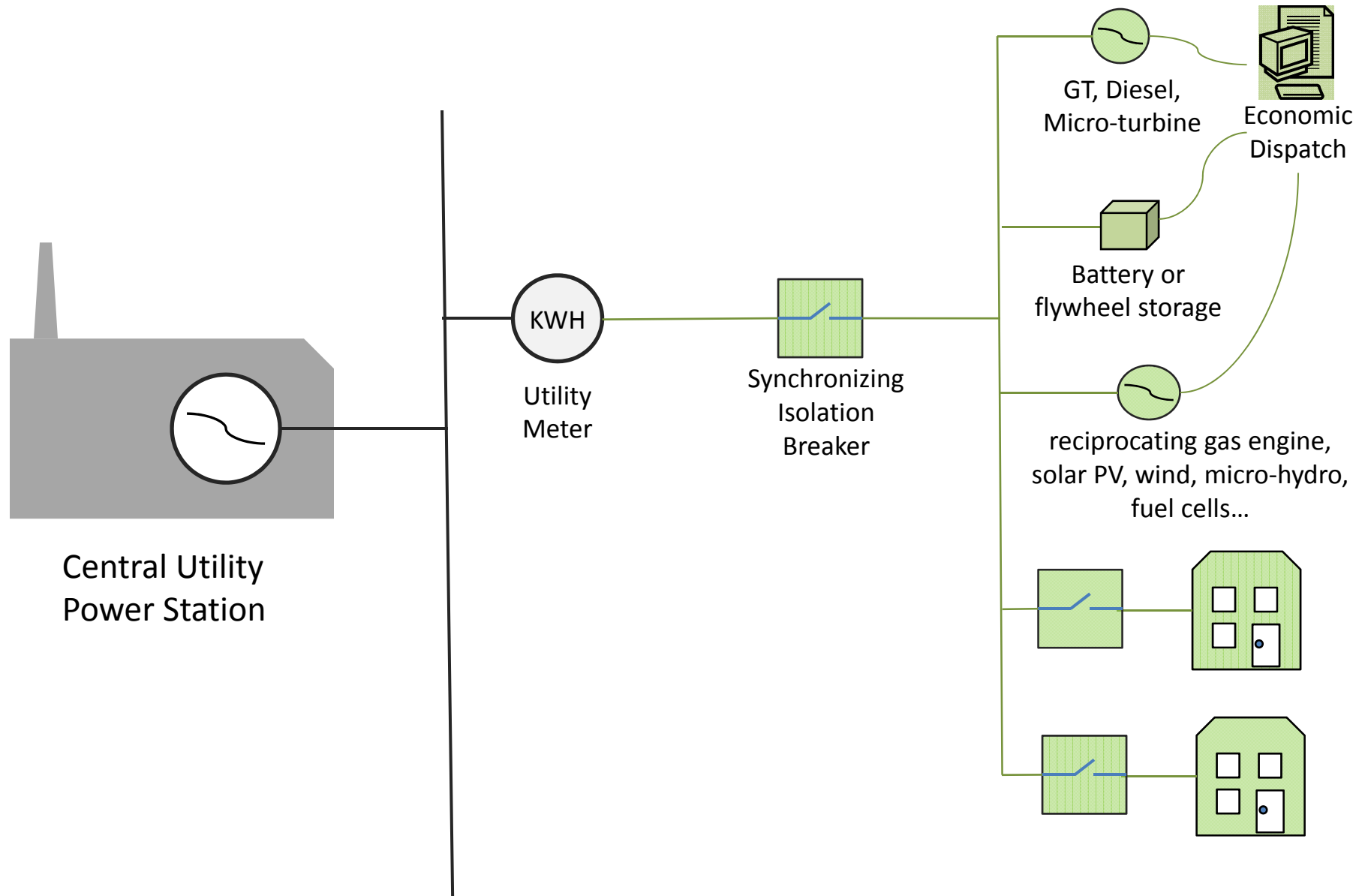
- First cost
- Operating cost?
- Training/competence
- Staffing
- Maintenance
- Complexity

Benefits Of Microgrids

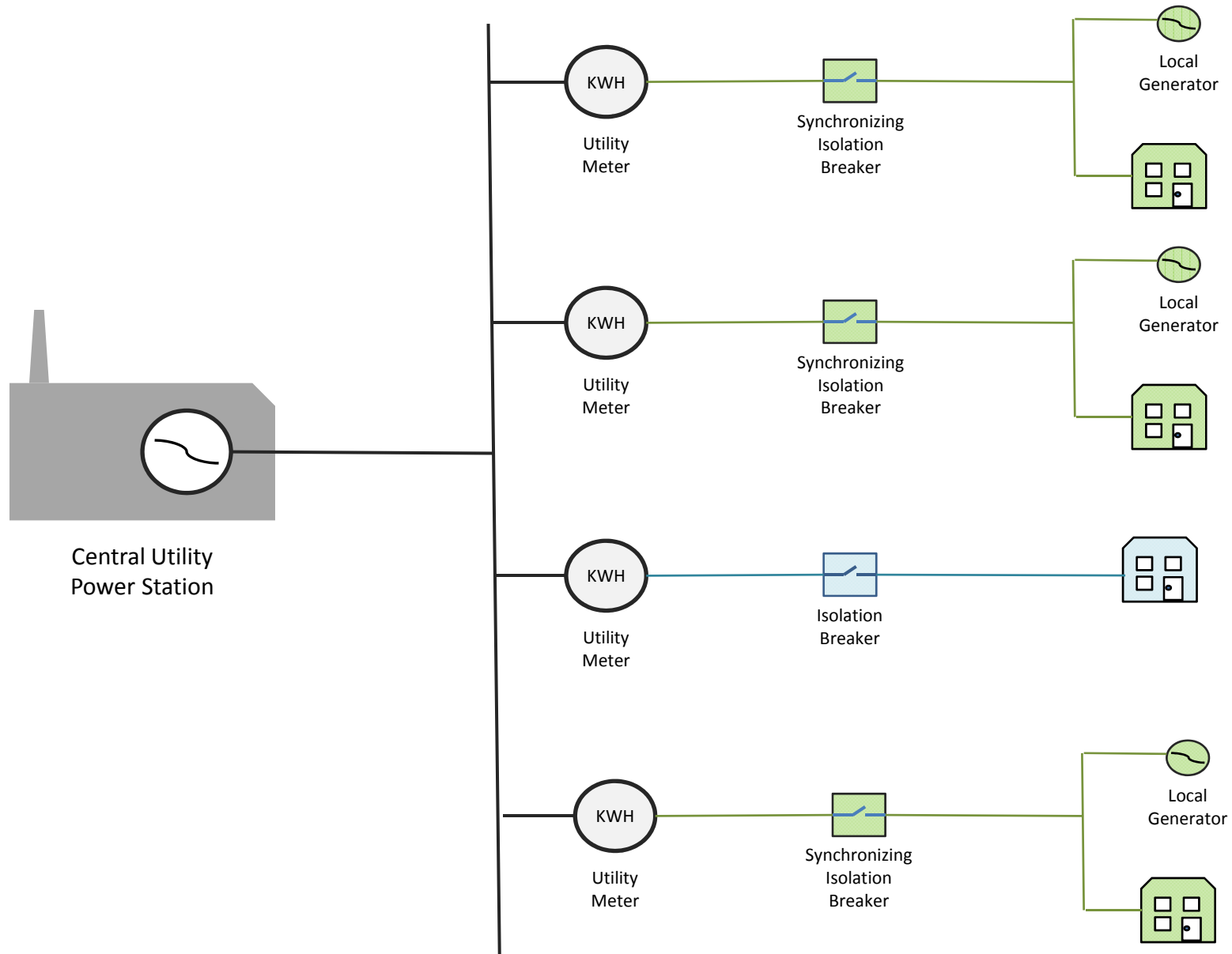
- Life-cycle cost
- Environmental Impact
- Reliability
- Resilience
- Security/self-sufficiency
- Grid “services”
- Better use of capital
- Customized to needs
- Power quality



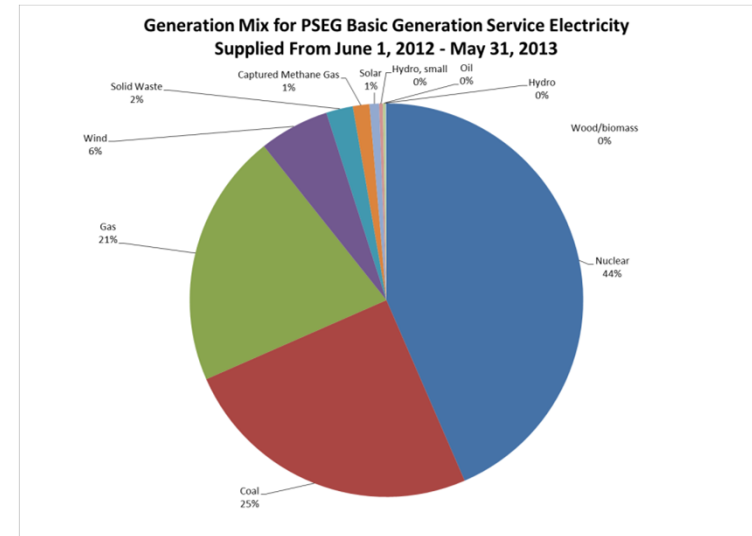
Microgrid Options



Microgrids Add Reliability



Large Utility Generating Plants Are Far Apart



Central Atlantic coal and
nuclear plants are shown

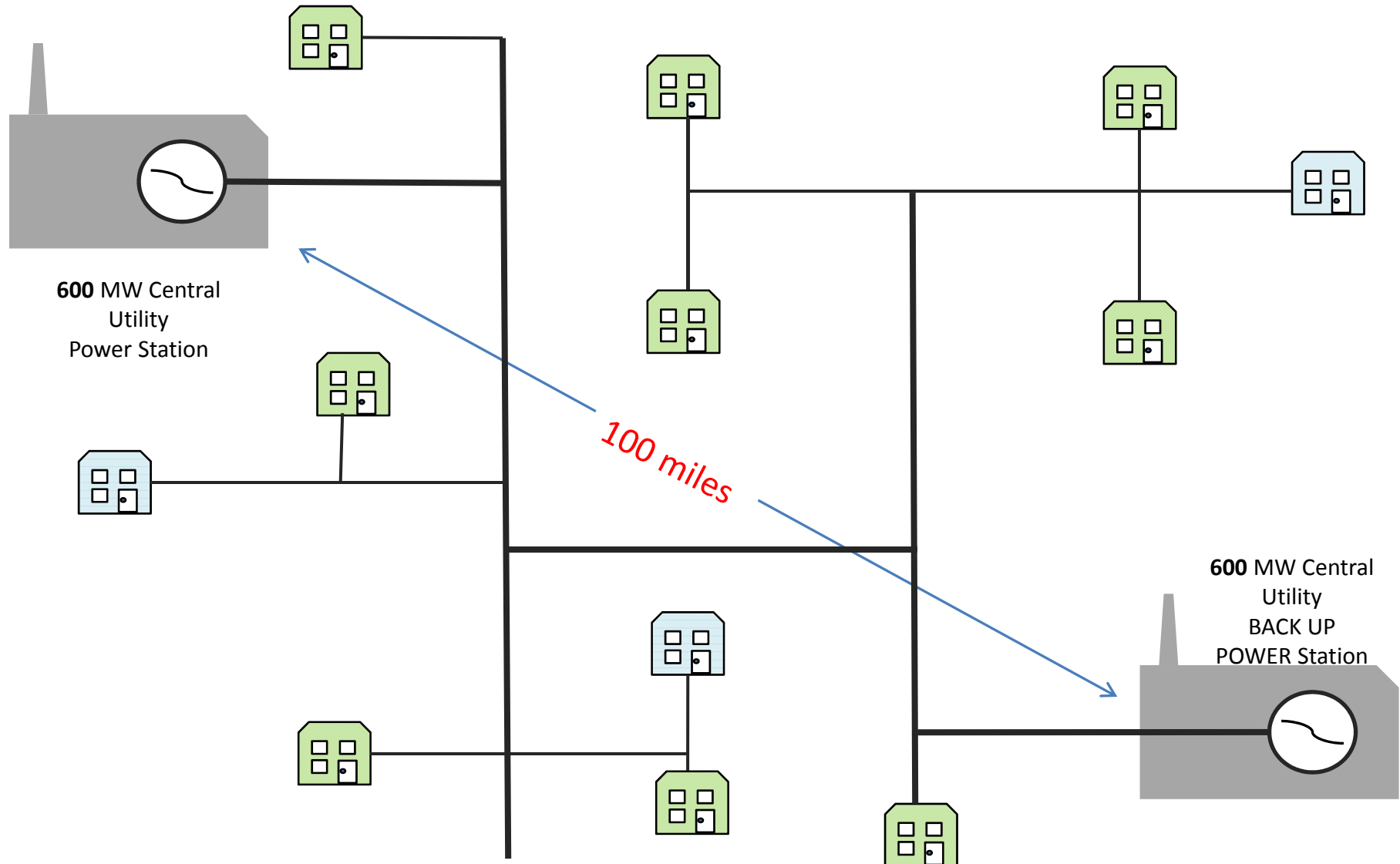


Utility Grid With Simple Redundancy

12 x 50 MW = **600 MW Demand**

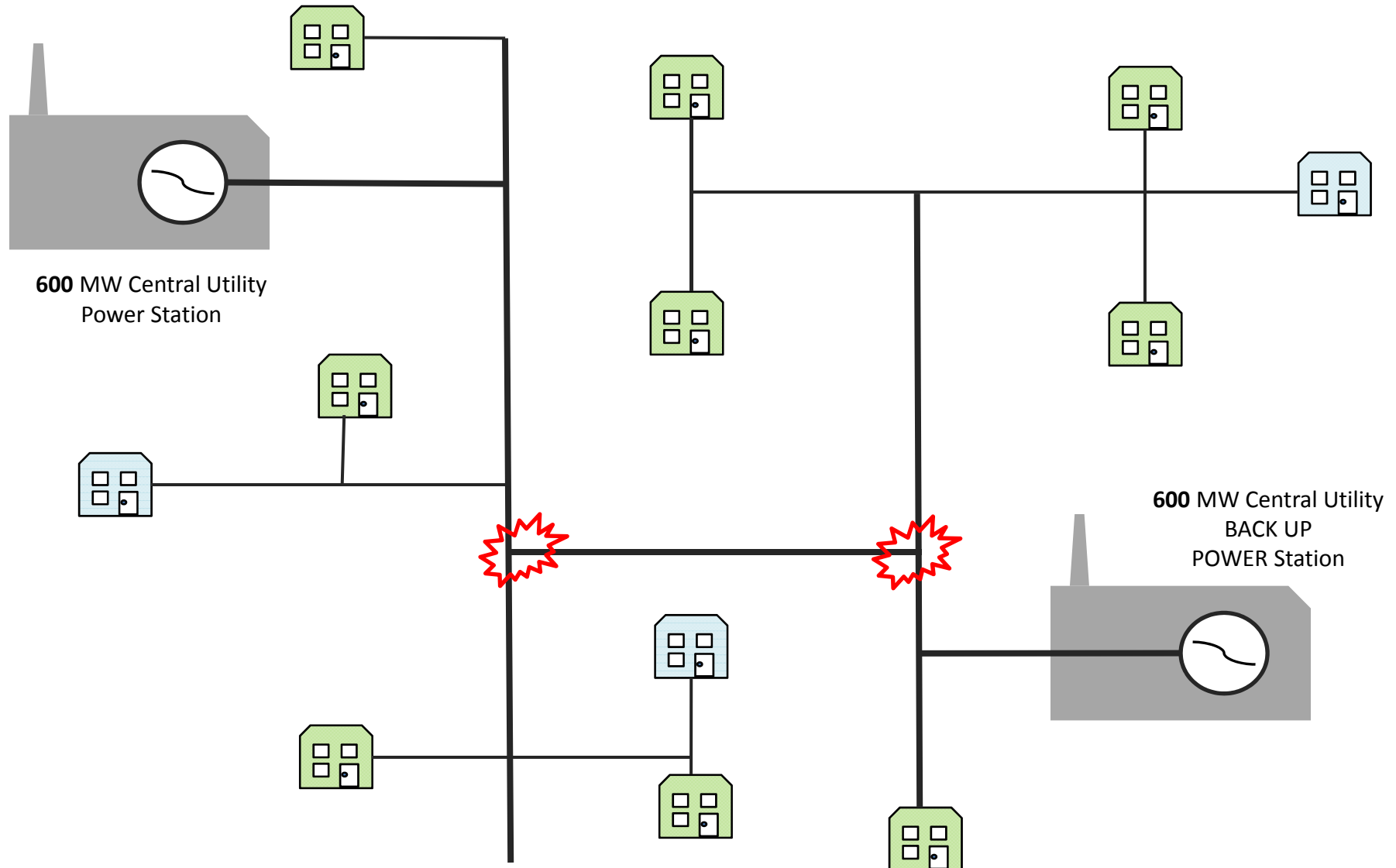
600 MW + 600 MW Back-Up = **1200 MW Installed Generation**

"N-1 Redundancy"



Utility Grid Vulnerability Points

12 x 50 MW = 600 MW Demand, 600 MW + MW Back-Up



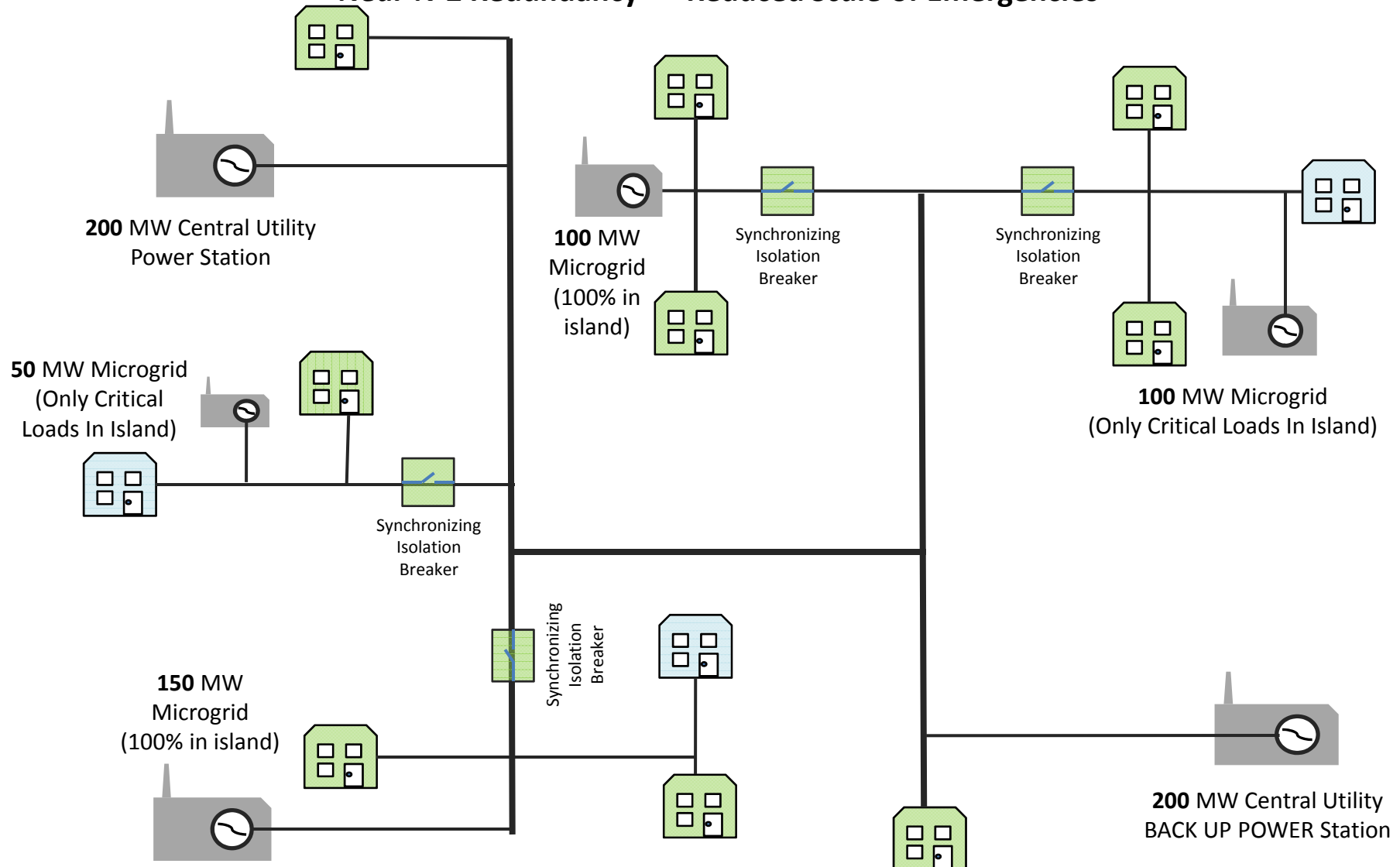
Utility + Distributed Microgrids = Diversity

Increased Resiliency, Less Idle Capacity

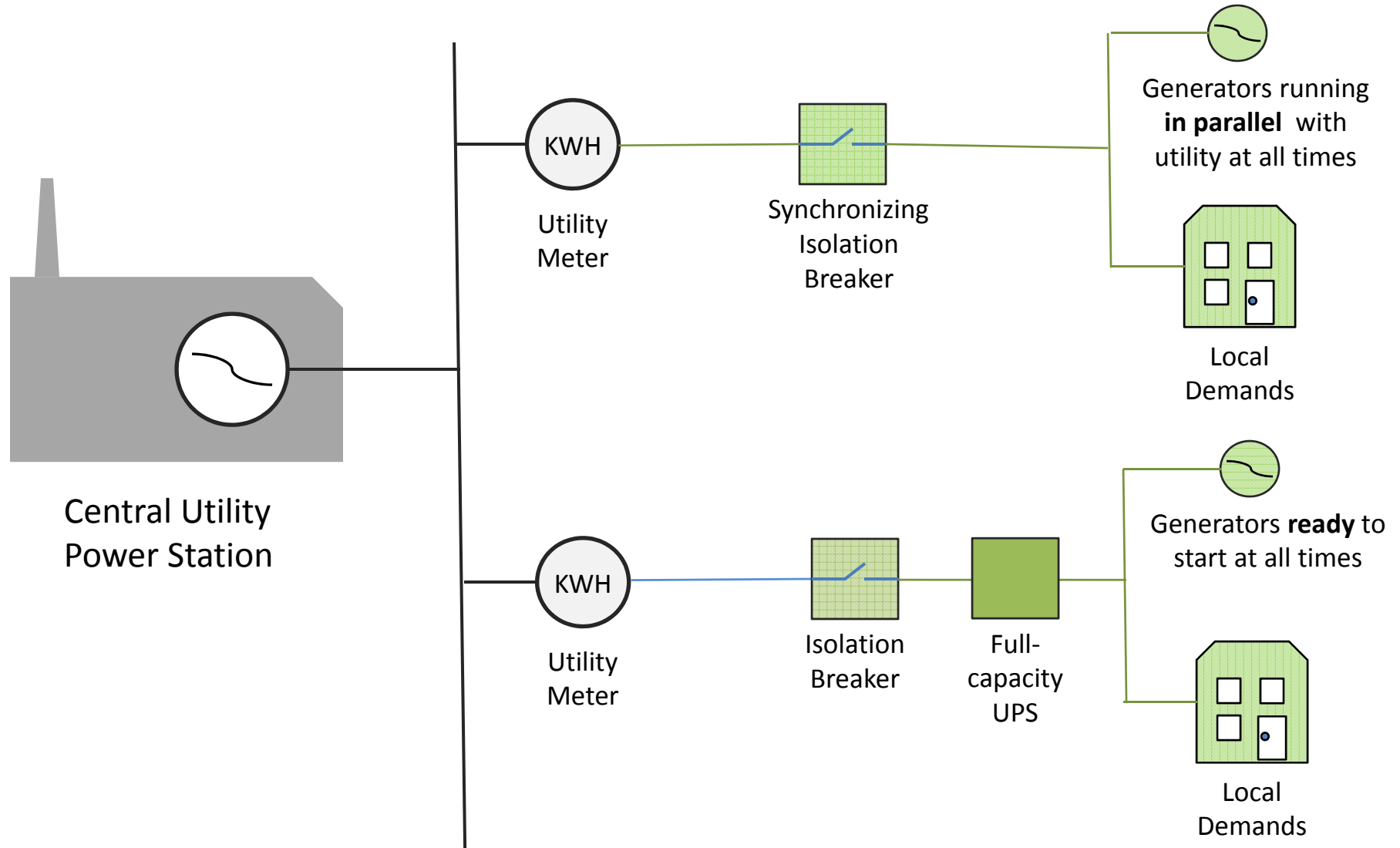
12 x 50 MW = **600 MW Demand**

400 MW Utility + 400 MW Microgrids = **800 MW Installed Capacity**

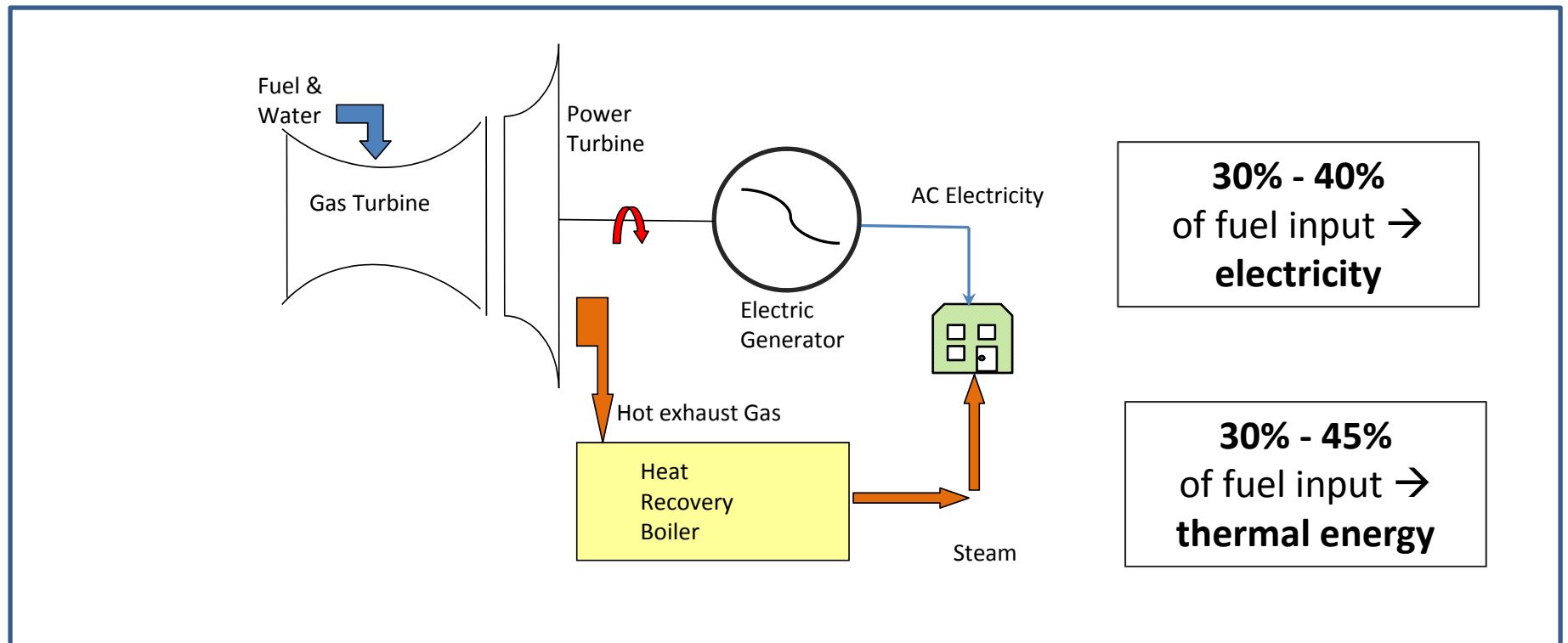
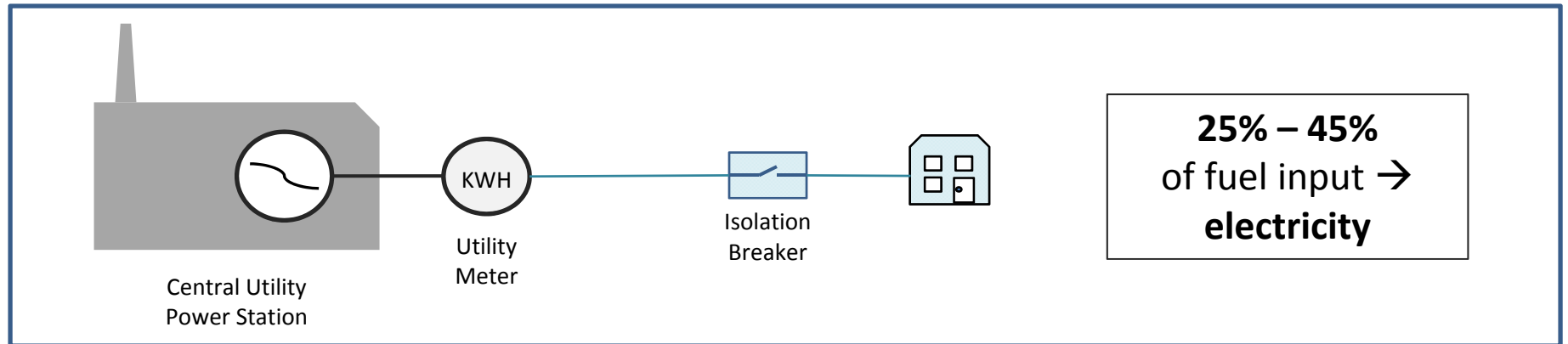
"Near N-2 Redundancy" + Reduced Scale of Emergencies



Two Zero-Interruption Strategies

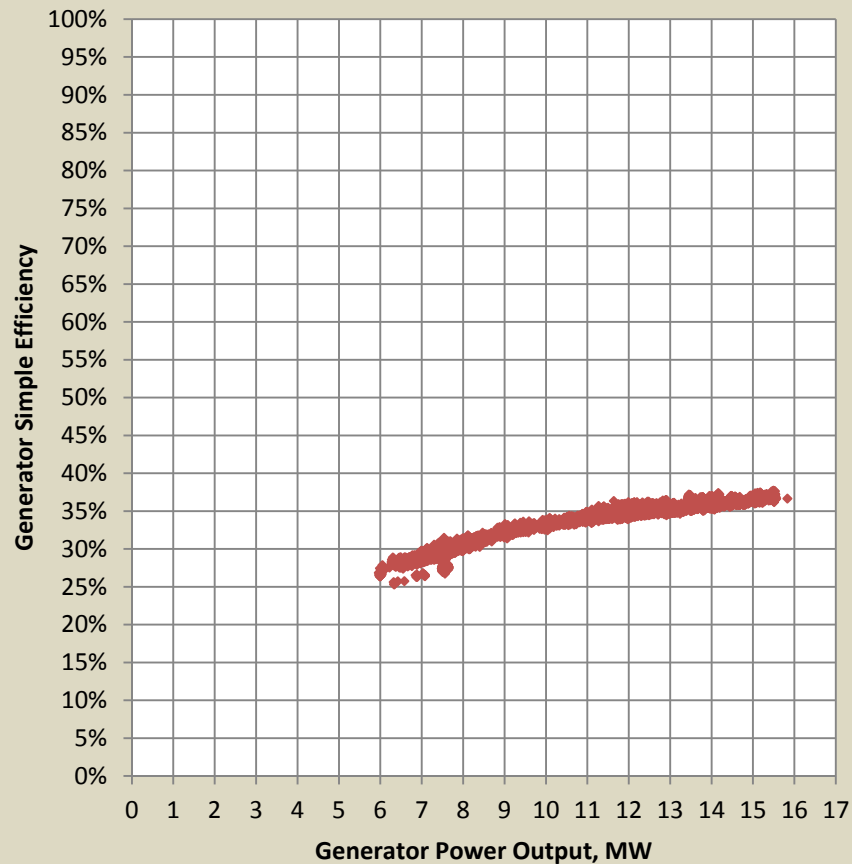


Efficient Use Can Beat Efficiency of Scale

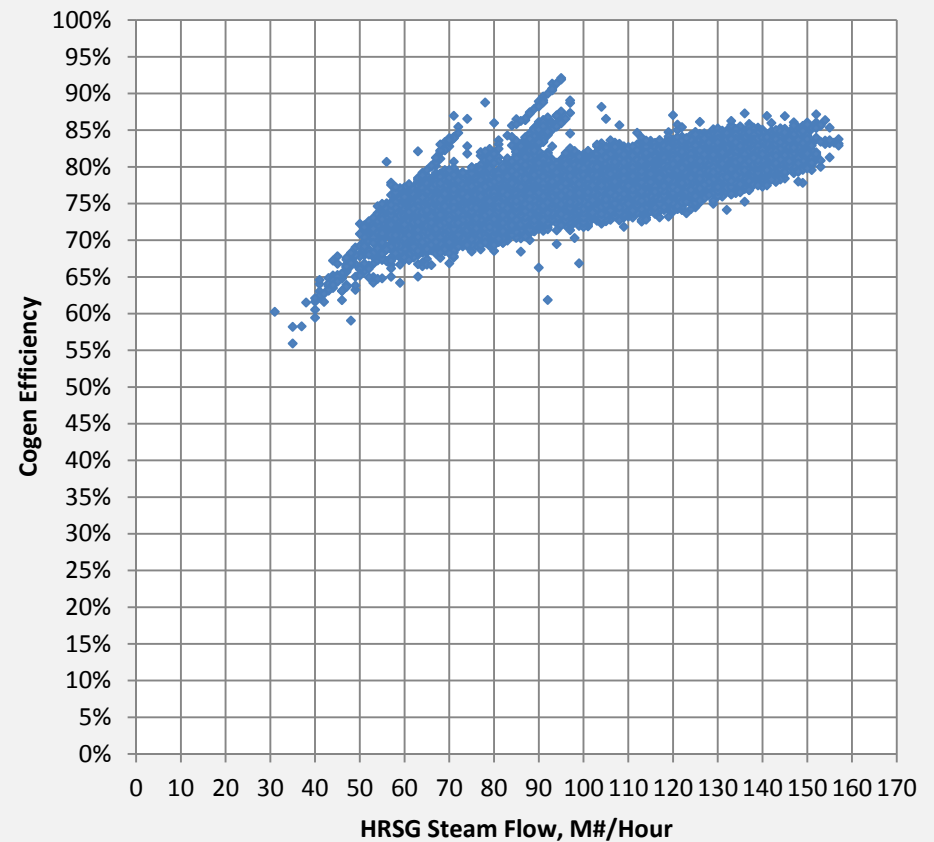


How Much More Efficient is Combined Heat & Power?

Gas Turbine Simple-Cycle Efficiency
Oct 1, 2013 - Feb 14, 2014



Cogeneration System Total Efficiency
Oct 1, 2013 - Feb 14, 2014



Types of Engines in Microgrids

- Diesels
- Reciprocating Gas Engines
- Gas Turbines
- Micro-turbines
- Boilers with steam turbines



Must Do

For Microgrid Reliability

- Distributed base-load generator(s)
- Ability to run isochronous
- Ability to isolate generator-load combinations
 - Skilled, manual, in-person effort, not automatic
- Underground utility distribution
- Black start capability
- Gross load-shed capability
- Understand fuel and water reliability

Should Do

For Microgrid Reliability

- Fully commission complete systems
- Re-test periodically
- Test using realistic conditions
- Building-level load-shed capability
- Multiple fuel options
- Use emergency response teams periodically
- Plan for human needs

Should Do

Plan for Human Needs During Emergencies

- Emergency Response Teams will be successful in proportion to how well their needs are planned for and how realistically and regularly they are exercised during non-emergency conditions



Emergency Human Need Questions



- Minimum staff to operate microgrid?
- What troubleshooting/maintenance can they perform?
- What % of staff must prioritize family during a regional emergency?
- Where will emergency op's center be if the power is out?
- What if the planned location is unavailable?
- Is the team dependent on phone, internet, radio...?
- How will emergency team communicate with their families?
- Where will they shower?
- Where will food come from if roads are impassible?
- What events could interrupt municipal water supply?
- Who is capable of leading an emergency response team and making competent decisions in an unpredicted, stressful, evolving situation?
- What authority will they have?

Less Than You'd Expect In An Emergency

- **5 MW Solar PV**
 - Uncontrollable, volatile output
 - Off at night and extreme weather
 - Utility-interactive inverters – can't run in isolation
- **½ MW Backpressure Steam Turbines**
 - Not significant scale
 - Not controlled power output
 - No black start
 - Induction generators – can't run in isolation
- **5 – 6 MW Emergency generators**
 - Serve emergency circuits only
 - Usually carry much less than design load
 - Most can't be synchronized
 - Not permitted for non-emergency

Wed 10/29	Thu 10/30	Fri 10/31
66° 45°	59° 41°	58° 37°
		
Chance of Rain	Clear	Partly Cloudy

(Nanogrid manual transfer switch works like this)

Make Life Better Every Day

- **CHP or combined cycle**
 - not necessary in emergency response
 - make the equipment more cost-effective
 - Run more often, thus more reliable
 - Most problems happen in non-emergency situations
- **Permitting for non-emergency use**
 - not necessary for emergency response
 - more cost-effective by increasing capacity factor
 - run more often, thus more reliable
 - usually adds emissions controls
- **Energy storage**

Emergency vs. Continuous Power Generation

EMERGENCY ONLY

- No ROI, emergency only
- Simple permitting
- Limited emissions controls
- < 500 hrs/year
- Simple controls
- Often not built for parallel operation
- Limited use can lead to less attentive maintenance
- Often diesel fuel only

CONTINUOUS/ELECTIVE

- ROI in avoided operating costs
- Complex permitting
- Emissions controls
- Unlimited hours
- More expensive controls & contracts if import/export is desired
- More economic opportunity
- Parallel operation
- Equipment that delivers steady economic benefit gets good maintenance
- Gas, diesel, dual fuel, or other options

Benefits of Microgrids

- Lower life-cycle costs
- Options
 - generate or buy based on economics and/or carbon footprint
- Reduce both energy ***use*** and peak ***demand***
- Work well with CHP to greatly increase energy efficiency
- **Self-sufficiency** in emergencies
- Support **places of refuge** in an emergency
- Real-time power costs are set by the most expensive plant.
 - Microgrids **lower energy cost for all** customers.
- Microgrids distribute risk into smaller pieces
 - grid **reliability is improved**.

Some Microgrids Who Got Through Hurricane Sandy With the Lights On

- **Co-Op City, Bronx NY**
 - 45 MW CHP
- **Hartford Hospital, CT**
- **Bergen County Wastewater Treatment Plant, NY**
- **Fairfield University**
- **Nassau County Cogen (supports hospital)**
- **New York University**
 - 10-MW CHP plant
- **Danbury Hospital, CT**
 - 4.5 MW CHP
- **Hunterdon Developmental Center Clinton, NJ,**
 - 4.5 MW CHP
- **Pepco Midtown Thermal Energy Plant- Atlantic City, NJ,**
 - 5.7 MW CHP

Microgrid Resources Coalition



- <http://www.microgridresources.com/>
- The purpose of the MRC is to advance microgrids as energy resources.
- The MRC promotes the widespread implementation of microgrids through advocacy for laws, regulations and tariffs that support their access to market, compensate them for their services, and provide a level playing field for their deployment and operations.

Hurricane Sandy Student Video

- <http://youtu.be/Wtjlj91imSQ>

