Lessons from Field Damage Assessments about Communication Networks Power Supply and Infrastructure Performance during Natural Disasters with a focus on Hurricane Sandy

Alexis Kwasinski, PhD
The University of Texas at Austin

Overview

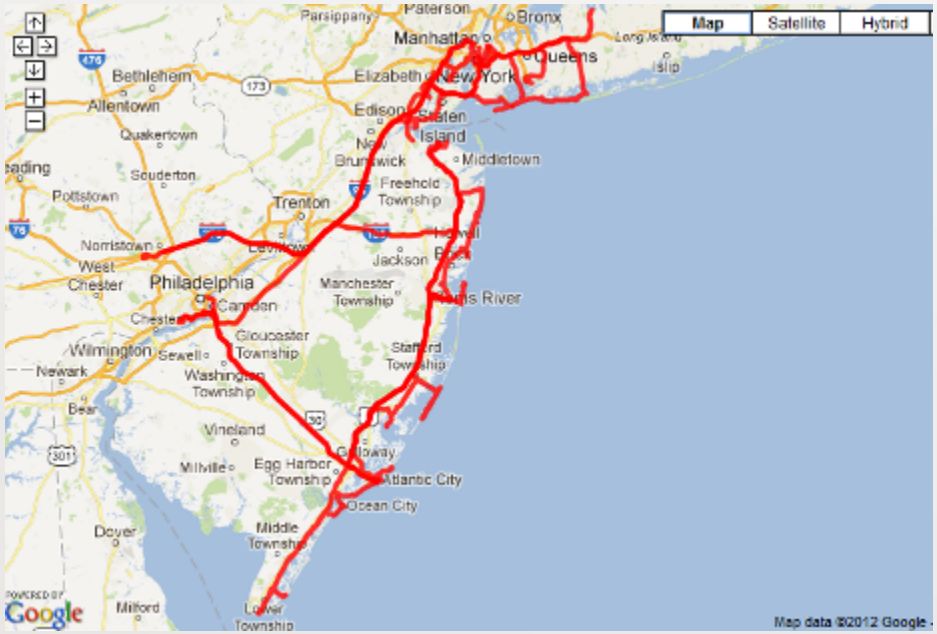
- Introduction
- Wire-line communication networks
- Wireless communication networks
- Cable TV telephony
- Power grids and power alternatives
- Conclusion

- Additional details, information and analysis at:
  - http://users.ece.utexas.edu/~kwasinski/research.html
  - http://users.ece.utexas.edu/~kwasinski/1569715143 Kwasinski paper FCC-NR2013.pdf

Introduction

- **Field damage assessments**

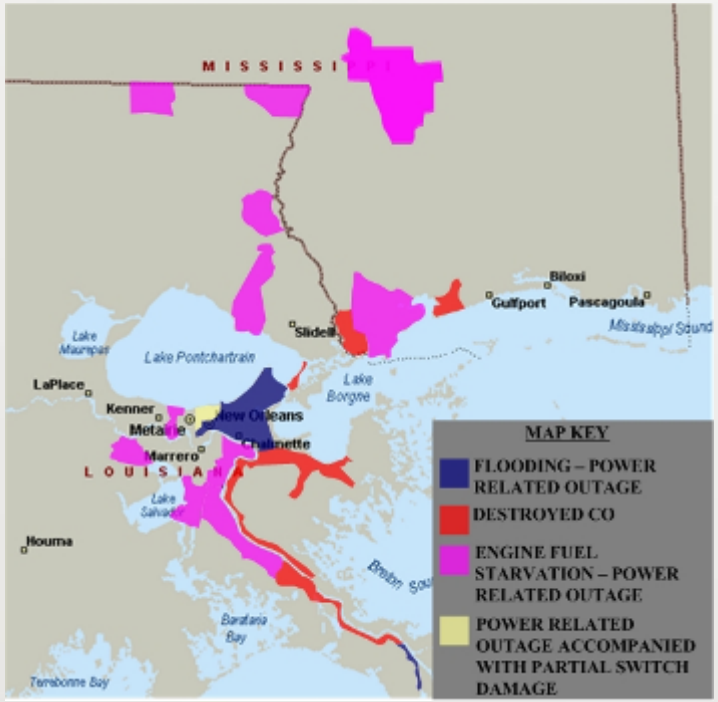
- They provide empirical data and records.
- Photos become evidence of issues and successes in a forensic process. If it is not in photo it may not have happened.
- Allow avoiding the “fog of restoration after a disaster”

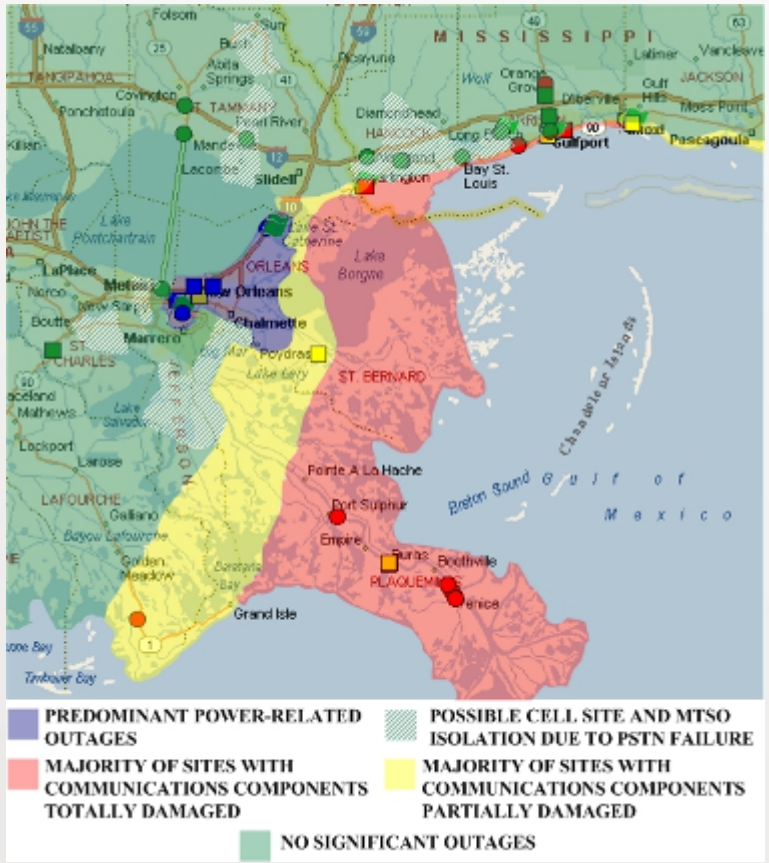


Introduction

- **Power supply during natural disasters**

- Power issues is one of the main causes of communication outages after natural disasters.
- E.g. Hurricane Katrina

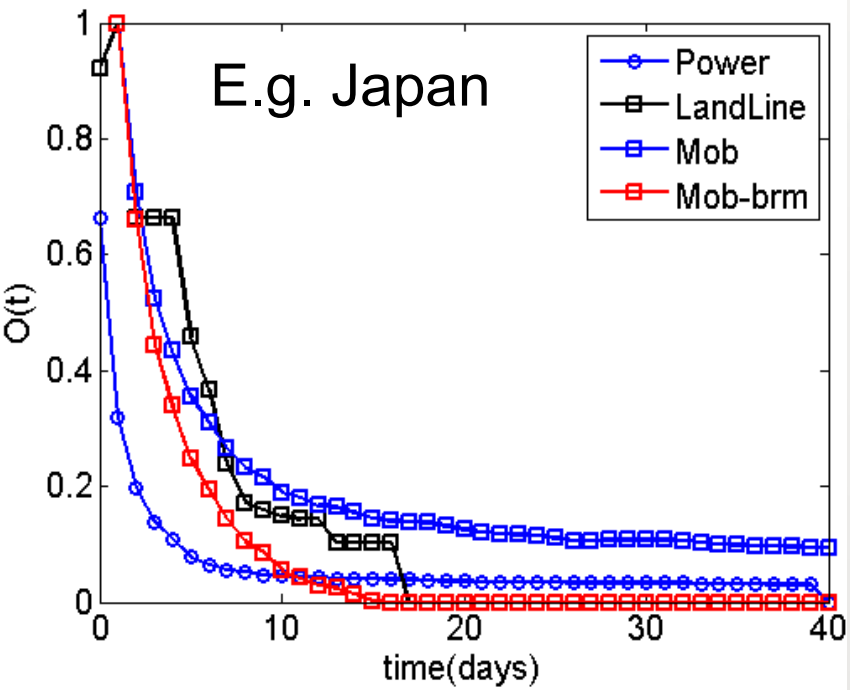




Introduction

- **Power supply during natural disasters**

- Correlation between power outages and communication outages is stronger in cases where there are insufficient number of onsite and deployable gensets.
- Due to energy storage at communication sites, communication outages lags power outages.



Miyako, Japan, 4/2011

Wire-line Telephony

- **Hurricane Sandy**

- Flooding affected service in a few central offices.
- Most central offices did not present power issues

140 West St, NYC, 11/3/2012

Wire-line Telephony

- **Flood mitigation strategies**

- Placing all power infrastructure on higher floors.
- Structural concerns with batteries placed on higher floors can be addressed.

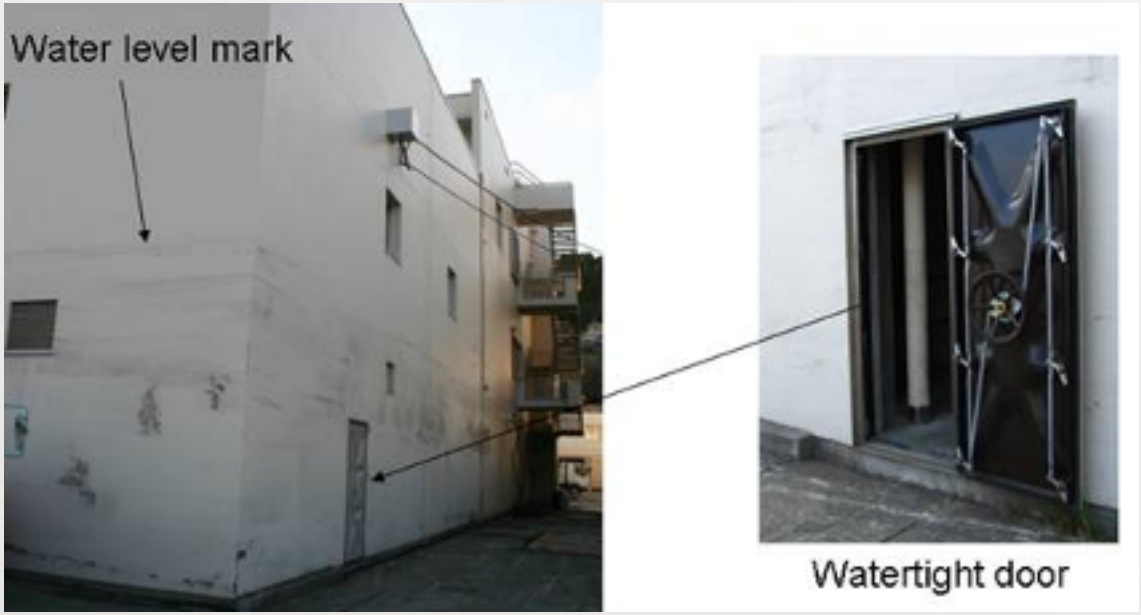
Lavallette, NJ, 11/2012

Onagawa, Japan, 4/2011

- **Flood mitigation strategies**

- Sandbags are not a very effective solution.

- Effective strategies include watertight doors and perimeter walls with floodgates.



Kamaishi, Japan, 4/2011

Unusomai, Japan, 4/2011

Wire-line Telephony

- **Flooding and power outages impact on copper cable facilities**

- Power and/or flooding may make cable pressurization equipment to fail.
- Without pressurized air multi-pair copper cables are damaged or have higher failure rates (even when they are filled with gels).

140 West St, NYC, 11/3/2012

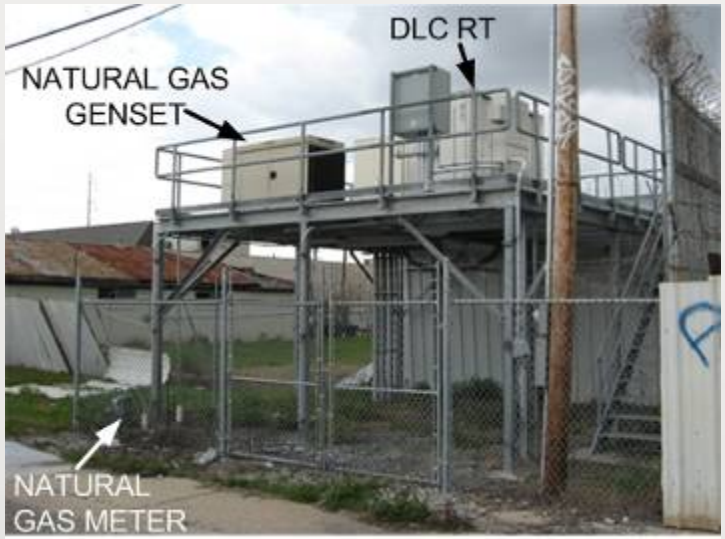
Wire-line Telephony

- **Fiber-optics remote terminals (e.g. DLC RTs and FTTx)**

- They are used to restore service to damaged copper cables or central offices.
- Main advantage: planning flexibility amid uncertain demand
- Main disadvantage: Need for local power supply

Belle Chasse, LA, after Isaac

Long Island, after Sandy

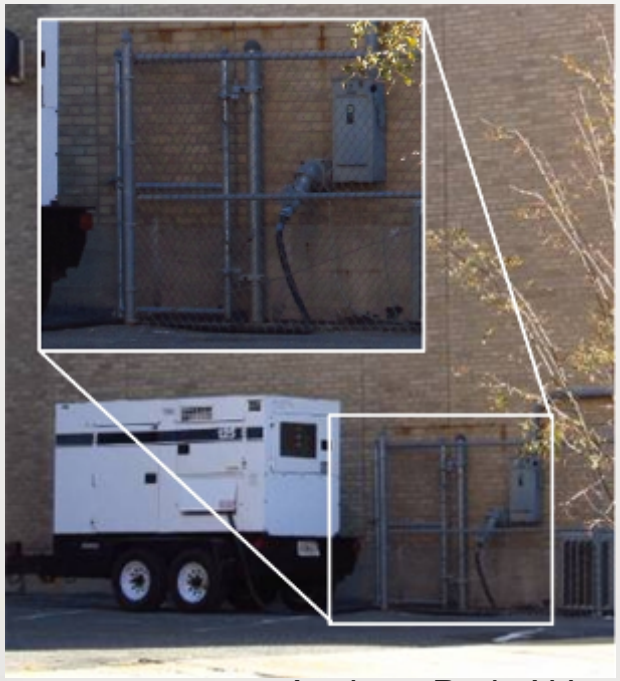


New Orleans

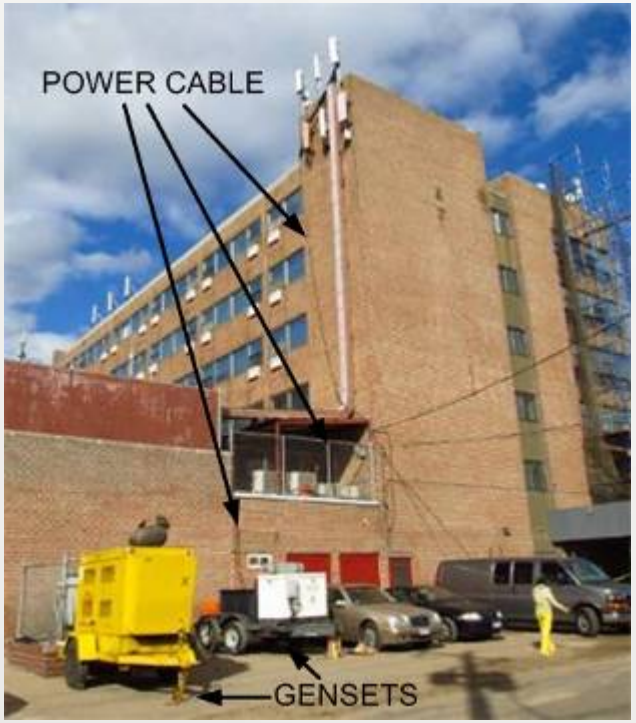
Algiers, LA after Isaac

- **Power supply to cell sites**

- Power supply for cell sites is a main outage cause during disasters.
- Site access coordination may make cells on rooftops more vulnerable to power outages



Ausbury Park, NJ after Sandy



Rockaway Park, NY after Sandy

- **Power supply to cell sites**

I-95 and I-195, NJ, after Sandy

- Power supply options:
  - Diesel gensets
  - Propane gensets
  - Fuel cells

Double Bayou, LA, after Isaac

New Orleans after Isaac

Cable TV

- **Power supply to distributed network elements**
- Observed approaches:
  - Natural gas pad-mounted generators
  - Camping gensets on pole mounted equipment (unsafe)

After Gustav

After Sandy

Chalmette, LA after Isaac

After Katrina

Near Yscloskey

After Isaac

Networks Evolution

- Communication networks are more distributed

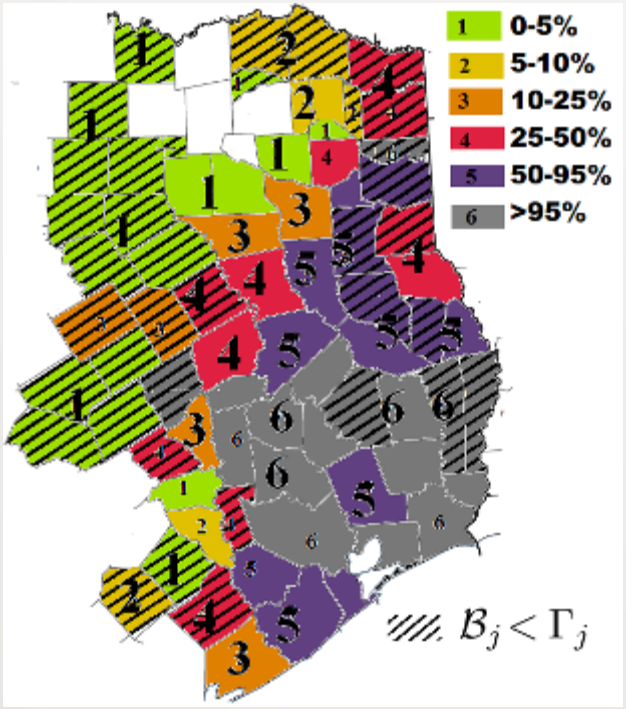
- Concern: increased need for reliable power for customers' devices

Long Beach, NY, after Sandy

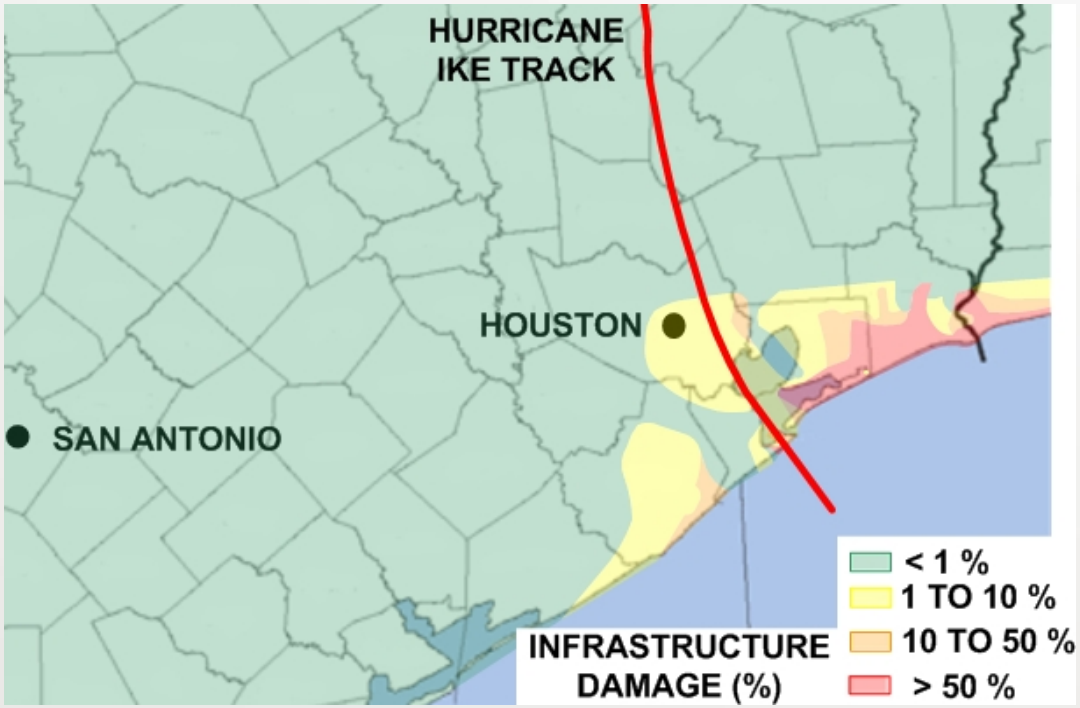
Power Grids

- **Power grids performance during natural disasters**

- Due to their predominately centralized control and power generation architectures, power grids are very fragile systems in which little damage may lead to extensive outages.



Power outage incidence after Ike

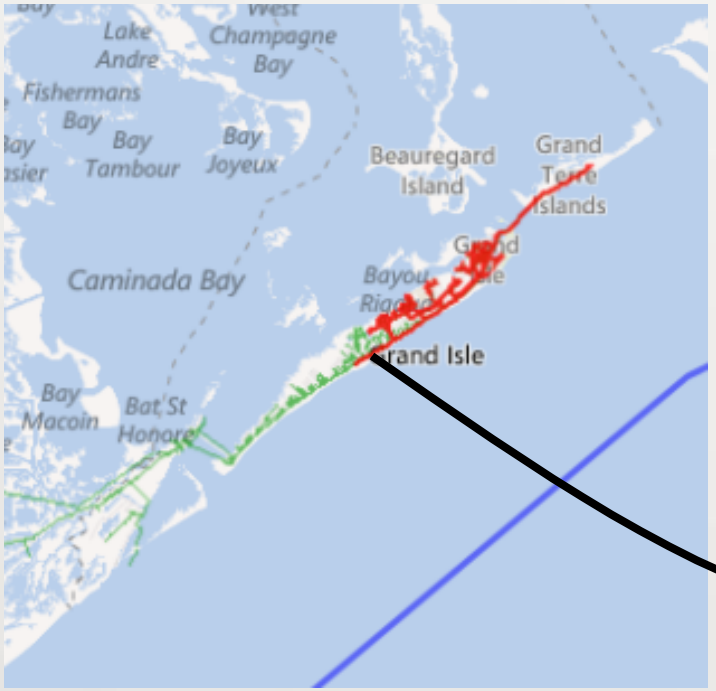


Percentage of power grid damage after Ike

Power Grids

- **Power grids performance during natural disasters.**
- **General observations exemplified with Hurricane Isaac:**

- Severe damage is limited to relatively small areas.
- Only one damaged pole among many undamaged causing most of the island to loose power.



Grand Isle, about 1 week after Isaac

Entergy Louisiana

Power Grids

- Proposed solutions for improved power supply

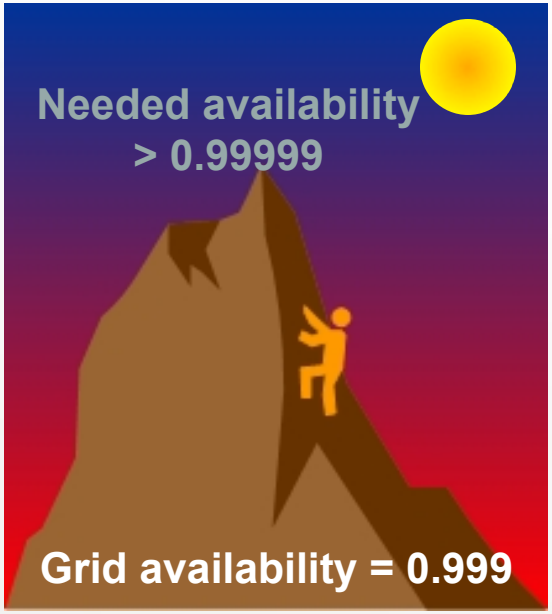
- Solutions domain:
  - Utility (e.g. mobile transformers, smart grids): limited effectiveness
  - Network operators (e.g. microgrids): may be more flexible
- Network operator solutions:
  - Microgrids
  - Standby systems

Fuel cell-based microgrid in Garden City, NY after Hurricane Sandy

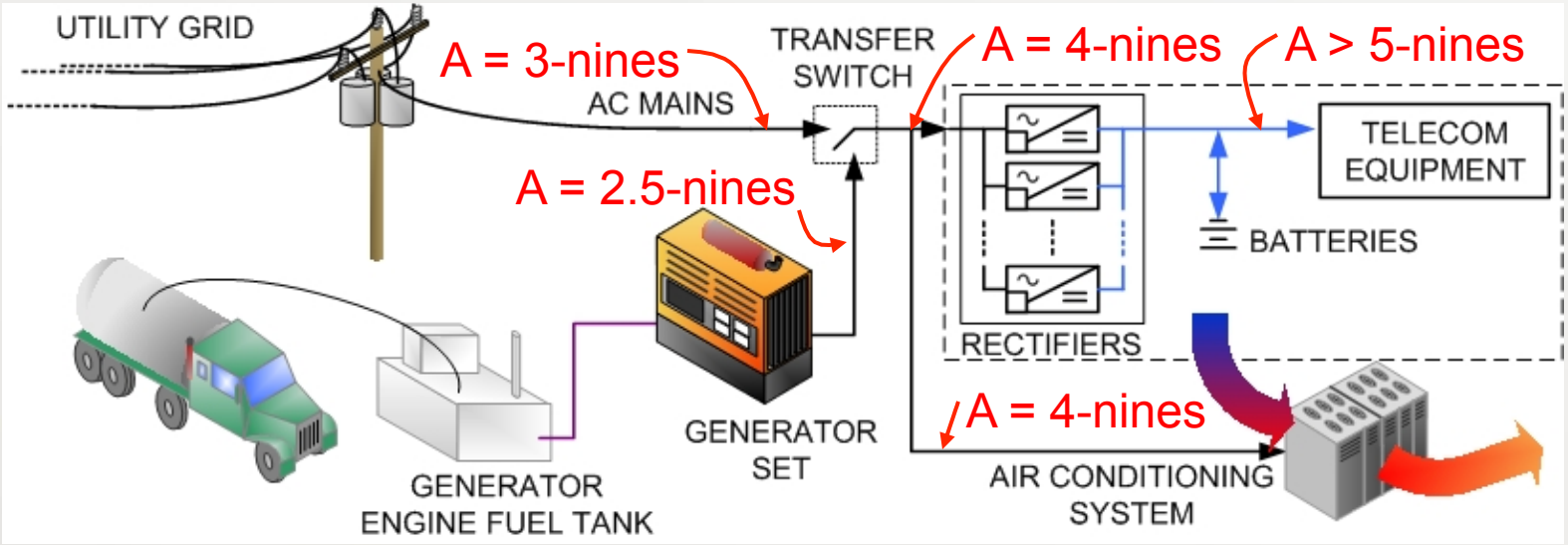
Cell site with a standby diesel genset after Hurricane Ike

Solutions for Improved Power Supply

- **Network operators-based: conventional standby power plants**



- Telecom power plants are needed in order to overcome grid's low availability
- Battery energy storage is essential in order to reach telecom-grade availability levels
- Power availability for air conditioners is below the minimum required in telecom applications



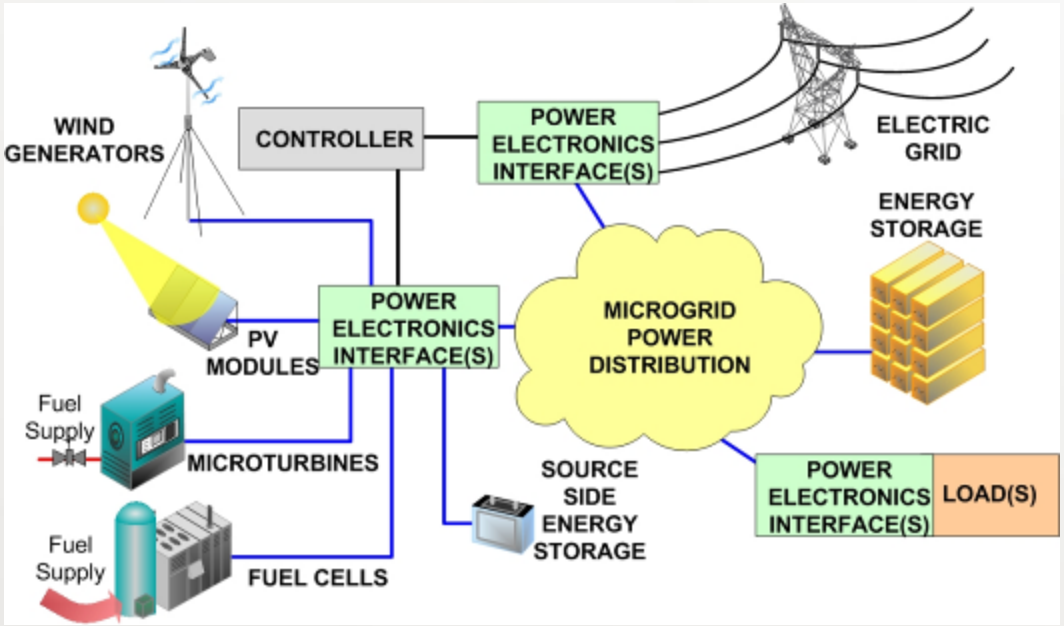
Solutions for Improved Power Supply

- Microgrids

• Microgrids are locally confined and independently controlled electric power grids in which a power distribution architecture integrates loads and distributed energy resources—i.e. local distributed generators and energy storage devices—which allow the microgrid to operate connected or isolated to a main grid.

• Combined heat and power absorption chillers help to address air conditioning low power supply availability.

• Microgrids have operated satisfactorily after Irene, Sandy and the 2011 earthquake in Japan



Solutions for Improved Power Supply

- **Key observation that leads to microgrid-based solutions:**
- During disasters damage distribution is inhomogeneous

Bolivar Peninsula after Ike

Solutions for Improved Power Supply

- Solution: microgrids
- Lifelines and energy storage

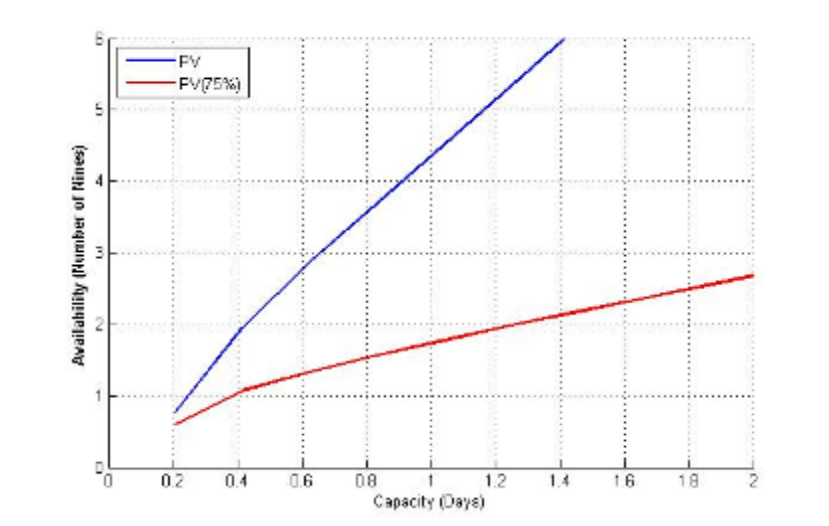
- Most local generators depend on other infrastructures, called lifelines (e.g. natural gas distribution networks or roads) to receive energy
- But lifelines can be affected by the natural disaster like conventional grids.

- Approaches to address lifeline dependencies:
  - Diverse power source technologies
  - Local Energy Storage

Solutions for Improved Power Supply

- Solutions: microgrids
- Photovoltaic (PV) systems in microgrids

- Most renewable energy sources do not require lifelines, but…..
- PV systems have large footprints. Solution:
  - Size PV arrays for less of the required load and use it to support another power source rated at full capacity.
  - Reduce the size of the PV array and increase local energy storage capacity



50 kW PV array

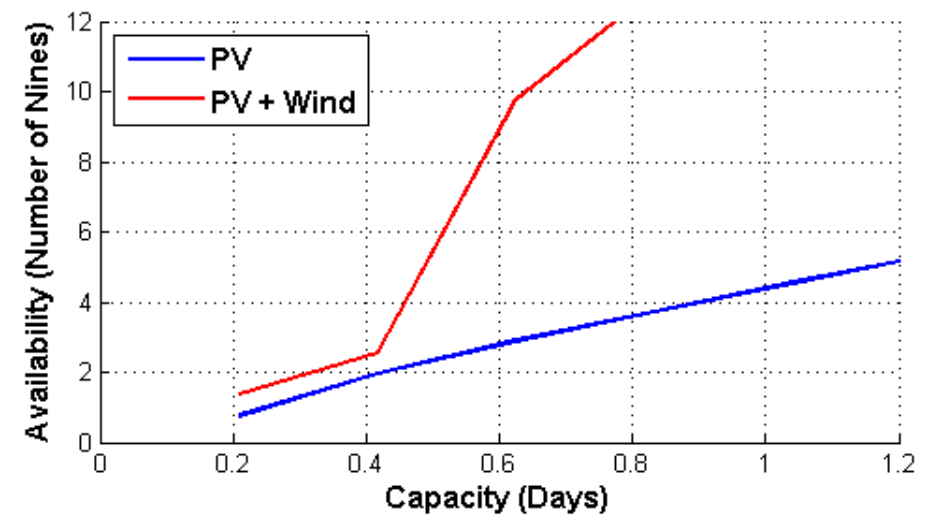
2x350 kW natural gas generators

Nedo/NTT Sendai Microgrid

Solutions for Improved Power Supply

- Solutions: microgrids
- Photovoltaic (PV) systems in microgrids

- Most renewable energy sources do not require lifelines, but…..
- Renewable energy sources have, typically, variable output. Solutions:
  - Local energy storage (e.g. batteries)
  - Source diversification

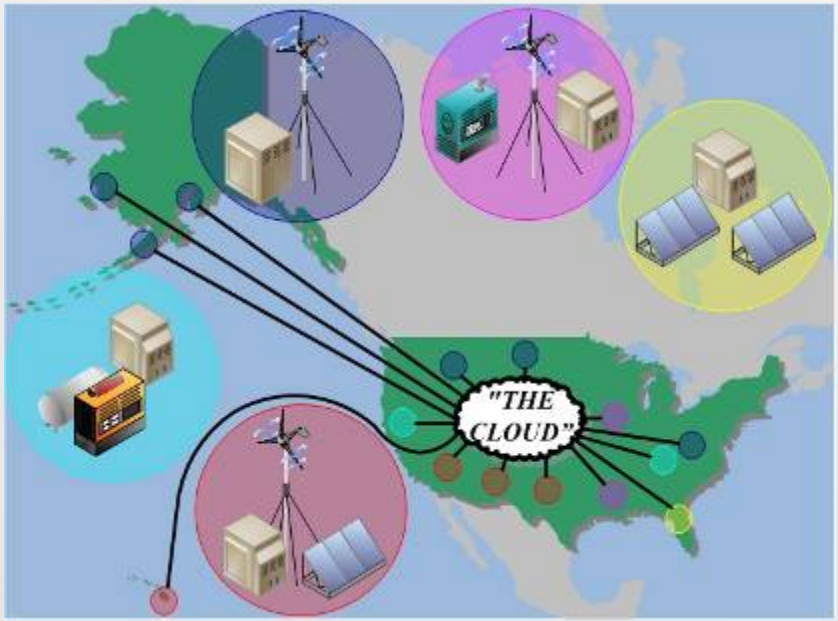


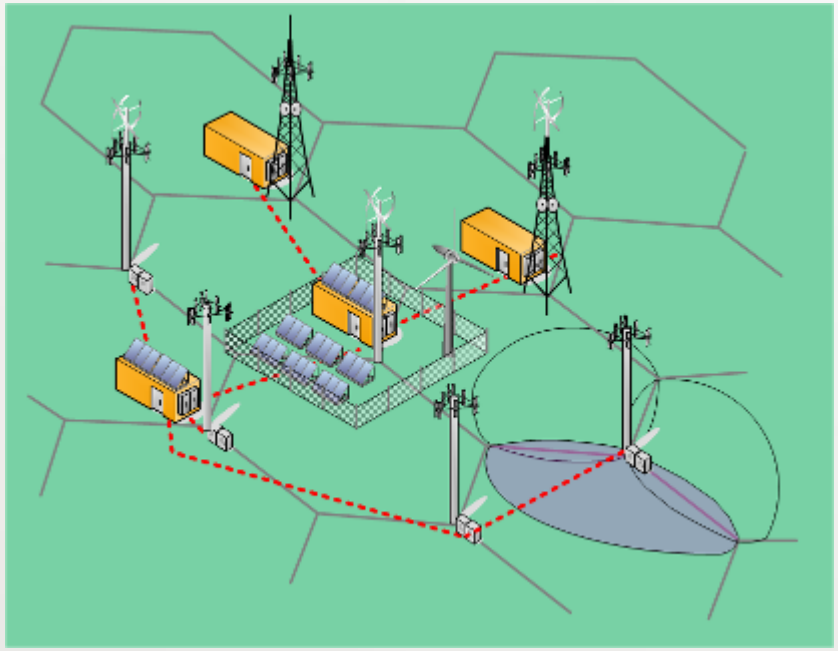
Kamaishi, Japan, 4/2011

Technical Solutions

- New approaches with integrated power and data/ communications management

- They address issues with renewable energy sources by managing traffic or data management depending on available local power generation and energy storage resources. Photons transmitted through fiber optic cables are used as a “proxy” for electrons that, otherwise, would be circulating though transmission lines.





Conclusions

- Final thoughts

- Power grids are fragile systems and a main source of communication networks outages during natural disasters.

- Communication networks distributed network elements are more vulnerable to power issues during natural disasters than centralized network elements.

- Conventional standby power plants provide a more reliable power supply approach but issues still exist due to grid's very low availability.

- Microgrids may be a better solution than conventional approaches.

Thank you very much

akwasins@utexas.edu