White Paper

Hurricane Sandy & the Emperor's New Clothes: Microgrids as a Risk Mitigation Strategy for Extreme Weather Events

Michael Roach
CEO, MicroGrid Horizons
Michael@microgridhorizins.com
917-596-1950

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"Sight becomes insight, which, in turn, prompts action."

Jack Zipes
Hans Christian Andersen, 2005

A Fairy Tale for a Hurricane

In 1837, one hundred and seventy-five years ago, Hans Christian Andersen published a children's tale that epitomizes impervious leaders and still has much relevancy today as we reevaluate the leadership and structure of the modern electric utility industry in the aftermath of Hurricane Sandy.

The plot of Andersen's tale is simple:

> "A vain Emperor who cares for nothing hires two swindlers who promise him the finest, best suit of clothes from fabric invisible to anyone who is unfit for his position or "hopelessly stupid." The Emperor cannot see the clothing himself, but pretends that he can for fear of appearing unfit for his position; his ministers do the same. When the swindlers report that the suit is finished, they mime dressing him and the Emperor marches in procession before his subjects, who play along with the pretense, until a child in the crowd, too young to understand the desirability of keeping up the pretense, blurts out that the Emperor is wearing nothing at all and the cry is taken up by others. The Emperor cringes, suspecting the assertion is true, but continues the procession." (Wikipedia)

In today's real world, Hurricane Sandy "blurted out" what we can all see but do little to change - that the electric utility companies are naked to extreme weather events and have no credible alternative other than what they have done for the last one hundred years: wait for the storm to blow over; sequentially respond to customer complaints calls about loss of power; and then send line crews out to repair the distribution grid as fast as possible. In the 20th century, this strategy worked because our lives and businesses were less dependent upon electricity and we were passive, voiceless consumers that that accepted our fate like animals going to the slaughterhouse.

Some critics have recommended various prevention measures to improve the old utility disaster model, including:

- Better vegetation management (i.e., cutting down more trees so that fewer lines are broken by falling trees);
- Installing smart meters so that the utility company doesn't have to wait for customer complaint calls;
- Burying electric cables to get them out of harm's way.

Each of these measures has value and attendant costs. These measures may ameliorate some impact of extreme weather events, but with a storm of the size and power of Hurricane Sandy, these measures are quite literally "a drop in the bucket."

Only "hopelessly stupid" people will understand that no matter how "smart" the grid becomes under normal operating conditions, the "smart grid" is no match for the ferocity of extreme weather events, especially at the distribution level.

After Hurricane Sandy, the Emperor (i.e., utility companies, government leaders, regulators and corporations) has no clothes on!

How have our leaders and agencies responded to this crisis?

Tactically, many government emergency response agencies responded very well in many instances. The National Hurricane Center and the National Weather Service provided very accurate forecasts of where and when the storm would make landfall and what its human and property consequences would be. Local media pounded the drums to warn people of the imminent danger, to prepare for the wide power outages and to evacuate the most endangered zones. First Responders had a full week to prepare equipment and crews and then they leaped into the storm chaos with immense dedication and courage. FEMA quickly set up disaster recovery operations in the worst hit areas. NGOs and many individuals filled in the gaps with essential supplies and human comfort.

The horrendous scale of the damage overwhelmed the utility companies, our government leaders and our personal contingency plans. Over eight million people were without electricity from days to weeks. Right after the storm, 85% of Long Island was dark.

For many people in the urban Northeast, Hurricane Sandy brought the unimaginable, especially for well-to-do classes that thought they were totally secure in their suburban McMansions. It is one thing to sit in your media room with your large screen TV and pooh, pooh how terrible the people in New Orleans suffered with Hurricane Katrina and another thing entirely when a hundred year old oak tree smashes through your bedroom or two feet of ice-cold seawater flows through your living room.

On a strategic level, neither the utility companies nor most of our government leaders have offered any real system alternatives other than business as usual. Governor Cuomo formed the Moreland Commission to assess the emergency preparedness and management response to the storm by utility companies in New York State. This commission may be another a classic “cooling out” mechanism designed to demonstrate immediate concern and leadership. Unfortunately, these types of commissions are often better at buying time until the event gets out of the headlines and delaying strategic action to the indefinite future.

What are the fundamental system problems of the utility industry under extreme weather events and how are risks managed? Are there historical precedents for analyzing catastrophes of this scale and fixing “the system”?

The engineering world has long used ‘Probabilistic Risk Analysis’ (PRA) to understand the probabilities of different system failure scenarios occurring and to analyze failures after the fact. Prof. Elisabeth Pate-Cornell of Stanford University has spent her career analyzing catastrophic system failures in various sectors such as: commercial aviation, oil platforms, medical anesthesiology, space shuttle Challenger, and insurance companies. In her view, “probabilistic risk analysis” is a counter to the excuse that “stuff happens”:

> Risk analysis is thus an alternative to the “stuff happens” philosophy – ignoring signals or deciding that accidents are “normal” events or are too unlikely to be accounted for.

We can apply Prof. Pate-Cornell’s general risk management methodology (without the rigor of probabilistic mathematics) to the electric utility industry. In her recent paper, *On “Black Swans” and “Perfect Storms”*, she describes the two basic types of uncertainties that risk managers face:

> “Perfect storms” involve mostly aleatory uncertainties (randomness) in conjunctions of rare but known events. “Black swans” represent the ultimate epistemic uncertainty or lack of fundamental knowledge, where not only the distribution of a parameter is unknown, but in the extreme, the very existence of the phenomenon itself… In reality, most scenarios involve both types of uncertainties.

Pate-Cornell stresses the power of systems analysis and probability to face these uncertainties:

> Engineering risk management requires an in-depth analysis of the system, its functions and the probabilities of its failure modes. The PRA method was designed to address cases in which failure statistics at the global level were not sufficient to assess the failure risks, including conjunctions of unlikely and often dependent events… A critical feature of the probability of a scenario is the level of dependence among factors involved… Most accidents are rooted in errors, often several of them in the same chain of events, and these behaviors, in turn, are often influenced by the structure, procedures and culture of the organization.

What is the Objective of Probabilistic Risk Analysis?
Pate-Cornell summarizes the goal:

> “The objective is to find and fix system weakness and reduce the risks of failure as much as possible within resource constraints.”

What Are the Risk Components to Analyze Regarding the Utility Industry?
We have three basic components to analyze in the failure scenario wrought by Hurricane Sandy:

- Extreme Weather Event – Hurricane Sandy;
- Technology – the electric grid;
- Utility Structure – the business model and attendant regulatory framework that enables it.

What is the First Step in the Analysis?
Pate-Cornell looks to precursors to give guidance in analyzing the current situation:

> “Precursors provide invaluable signals that action has to be taken, sometimes quickly, to prevent an accident. A probabilistic risk analysis coupled with a measure of the quality of the signal (rates of false positives and false negatives) can be a powerful tool for identifying and interpreting meaningful information, provided that an organization is equipped to do so, appropriate channels have been established for accurate communications, and mechanisms are in place for filtering information and reacting to true alerts.”

The First Risk Factor: Did we have signals or warnings that Hurricane Sandy could cause the scale of physical devastation that it did?
Large hurricanes have hit the New York City area in the past. The most unforgettable ones were the 1821 storm that made landfall at Jamaica Bay and brought with it a 13-foot surge and the “The Long Island Express” of 1938

pushed a surge of 25-35 feet on shore and killed nearly 700 people across New England. In 2011, Hurricane Irene blew through the area without a lot of damage in the New York City area and, unfortunately, gave many people a false sense of security.

In recent years, scientists from NASA and Columbia University have published several scholarly reports on how climate changes raise sea levels and may impact the surge levels of hurricanes hitting the New York City area. It's simple mechanics, if the sea level is higher when a storm surge arrives in the area, it will penetrate further inland and to higher elevations. In 1995, a transportation study evaluated the vulnerability of the transportation system to hurricane surges and estimated that a category three storm would send a surge of up to 25 feet at JFK Airport and 21 feet at Lincoln Tunnel. A 2001 study projected sea levels rises of 11.8 to 37.5 inches in the New York City area by the 2080s. The 2006 study projects sea level rises of 15 to 19 inches by the 2050s. Vivien Gornitz, one of the authors of that study said:

> "With sea level at these higher levels, flooding by major storms would inundate many low-lying neighborhoods and shut down the entire metropolitan transportation system with much greater frequency."

A 2012 study concludes that:

> "The combined effects of storm climatology changes and a 1 m (meter) SLR (sea level rise) may cause the present NYC 100-yr surge flooding to occur every 3-20 yr and the present 500-yr flooding to occur every 25-240 yr by the end of the century."

Ocean temperatures have also been rising and warm oceans are the super fuel of hurricanes. Chris Mooney writes:

> "Surface sea temperatures off the Mid-Atlantic coast were near record high in September and 2.3 degrees Fahrenheit above the long term average. In fact, averaged across the globe, ocean temperatures in September were the second highest on record, surpassed only by 2003 – and with much of the excess heat occurring in the Atlantic region."

New York City government took these climate change warnings to heart and a panel commissioned by the City produced "Climate Change Adaptation in New York City: Building a Risk Management Response." Unfortunately, only 2 pages out of the total 354 pages are devoted to the dependency of the entire infrastructure on energy. The vulnerability is clearly identified though:

> "Production facilities for electric power are concentrated in a relatively few locations relative to the customer base they serve. Presently, about two dozen power plants of varying sizes are operating in New York City, and

> over a dozen more were proposed as of 2005. These facilities are owned and/or operated by half-dozen entities. Traditional power plants have required shoreline or close to shoreline locations for water intake structures and cooling water discharges; thus a number of the city's existing production facilities are located at lower elevations and potentially sensitive to flooding due sea level rise."

The city's report fully acknowledges the obvious vulnerability of the infrastructure upon the city grid:

> "Most infrastructure in the city relies on the city's power grid for energy, thus if it fails the other infrastructures that depend upon it fail."

Did the city's energy grid fail during Hurricane Sandy? Yes, 650,000 customers in New York City were without power after the storm.

Did the surge reach part of the critical grid infrastructure? Yes, the 14th Street Con Edison substation blew up (click here for video) and knocked out power for most of lower Manhattan below 34th Street.

Did the report offer possible alternatives? None at all! The authors threw up their hands and wrote the energy risk off as an intractable challenge beyond their humble scope and without practical solution.

> "The electric power industry is subject to a variety of regulations which presents a challenge to incorporating any new demands, such as climate change information, into its portfolio. Limited resources and multiple demands on those resources present another challenge to meeting energy needs. This situation is not only specific to New York City but also is common to the energy sector in general, occurring in many urban areas as well."

Other leaders have responded with more prudently and foresight. The State of Connecticut, under the leadership of Governor Malloy, reevaluated the state's energy risk after last year's pounding by Hurricane Irene and the "Halloween Storm" that left huge swaths of the state without power for weeks. In the "Report of the Two Storm Panel" report of January 2012, Connecticut got its first call for microgrids as a means to prevent power outages. In June, the General Assembly created a microgrid pilot program with funding of $20 million to test microgrid development at selected municipalities. The Governor warned the utilities that if that didn't cooperate with the program: "I think they understand they're playing with fire if they don't get on board."

The Second Major Risk Factor: What is the technology of the electric grid and how risk prone is it?
At the generation level, the grid in the United States has been very reliable, as long as you exclude accidents like Three Mile Island. In Japan, although the historical record clearly indicated that earthquakes and tsunamis had previously destroyed much of the area where the Fukushima nuclear power plants were built, the risk was not even included in the scenario analysis due to power industry political influence.

At the transmission level, the U.S. grid has been continually struck by major collapses of the transmission system caused by cascading failures, such as the 2003 Blackout that knocked out power to 60 million people in the Northeast and most recently, the September 2011 Blackout in the San Diego Gas & Electric territory that shut down all of southern California around San Diego. The grid system is designed to prevent these cascading failures, but they seem to happen will a regularly that disproves the supposed assurances of the technological safeguards.

The grid is most vulnerable at the distribution level where pole-strung electric lines deliver the “final mile” to customers. Trees, electric wires and hurricane winds just don’t get along with each other no matter how “smart” the grid is. At the distribution level, the grid is inherently vulnerable and impossible to fix without truly massive investments burying lines and elevating distribution gear. By design, “all of the eggs are in one basket.”

The Third Risk Factor: The structure and business model of the existing investor-owned utility companies.
The business-as-usual (BAU) utility model is clear to everyone: the company receives explicit regulatory authority to be the monopoly electric provider in a designated territory in exchange for a guaranteed rate of return on its investment subject to state oversight; power generation is at central plants owned by the company or independent power providers (IPP); fuel is sourced from an oligarchy of suppliers; regulatory oversight varies by the degree of political influence the company musters; large business customers receive preferential discounted rates; retail customers are passive and powerless consumers.

This BAU model worked throughout the 20th century. In the 21st century, the model is undergoing extreme stress, internally from unstable customer markets, financial pressures and often highly volatile energy supply commodity markets. Externally, new competitors are rising at both the technological level and the business level. Most utility companies resist structural change and continually fall back on their vestigial monopoly position to fight competition. For the last decade, utility companies have grudgingly integrated more renewable resources

and distributed systems, and, usually, only because they were required to comply with legislative mandates.
The structural model of the utility business has been considered sacrosanct. Defenders say that nothing can be changed because any change would endanger the reliability of the grid.

Hurricane Sandy has finally exposed the reckless and extreme level of risk of maintaining the BAU utility model.

Do Business Models Change?
Models don't changed easily, especially if they have vast forces of vested interests in support of the model. Structures and business models, no matter how entrenched, do change, though, and sometimes very quickly. We have numerous examples from civilian business sectors switching from one dominant business model/technology to another:

- Whale oil - petroleum
- Pony Express – telegraph lines
- Ma Bell landline companies – wireless communications companies
- Horse-drawn carriages – automobiles
- Sailboats – steamships
- Steamships - airplanes
- Mainframe computers – distributed computing
- Express mail – fax machines
- Fax machines - email

Classic Example of the Military Changing Technologies – Col. Billy Mitchell and Air Power vs. Battleships
The military has also had similar crises and radical technology transformations, such as the change from 19th century style cavalry charges against 20th century machine guns to tank warfare assaults. The most dramatic military example comes from the tribulations and trial of Col. Billy Mitchell in the 1920s. General Mitchell was a U.S. Army General with superb leadership characteristics and a fine combat record. He led all American air forces in World War 1.

Unlike most of his contemporaries, he felt that World War 1 was not the "War to End All Wars." In fact, he believed that unless America invested heavily in air power after the war, the country would be at a strategic disadvantage in the conflict he saw coming in Europe in the next decade. In his view, this strategic realignment of American military forces would require the development of an independent branch of the military devoted solely to air power.

From a pure economic efficiency perspective, Mitchell also felt that it was much cheaper to build and maintain a fleet of one thousand airplanes to defend the Eastern coast of the U.S. than to build one battleship for its defense. Even more, he resolutely believed that the supremacy of battleships as the most powerful expression of military might was over. To prove it, he fought for several years with the military brass to show them that airplanes could easily sink battleships. They finally agreed to “Project B,” a demonstration test of his philosophy. Even though the Navy rigged the test in their favor with lopsided rules of engagement, Mitchell’s airplanes sunk the ships as predicted. The public loved him but the brass were so outraged that they went on an all out campaign to drum him out of the military service.

To get him out of the headlines, Mitchell was sent on a long tour of the Asian Pacific. He returned with a 324-page report that identified Japan as the source of the next war threat in the Pacific and he also believed that the Japanese would attack Pearl Harbor as part of their initial assault.

Battles between Mitchell and the brass escalated until he criticized Army and Navy leadership for incompetence and “almost treasonable administration of national defense.” He was court-martialed for insubordination in the fall of 1925 and, after a seven-week trial, he was found “guilty of all specifications and of the charge.” Mitchell was suspended from active service and spent the next decade of his life preaching about the strategic importance of the new aviation technology in changing the world. Ironically, he was later honored by modern military brass as having the courage and foresight to prepare America for the turbulent times later in the 20^{th} century. He is now regarded as the father of the modern U.S. Air Force.

Are there strategic alternatives to massive power outages from extreme weather events? Has anyone offered alternatives to the utility BAU model of disaster preparedness and resiliency?

Yes. The New York State Energy Research and Development Authority (NYSERDA) has devoted large resources to “studying” distributed generation and microgrids in particular. Very little action has resulted from their numerous, high quality reports.

Other parties have studied and taken action. The Consortium for Electricity Reliability Technology Solutions (CERTS) was founded in 1998 by a group of universities, government research laboratories and corporate partners. The U.S. Government sponsored the initial research program to improve the quality and reliability of the U.S. electricity grid.

The impetus for the program was that, although the grid had undergone continuous technological development for a century, it continued to experience intermittent, but catastrophic blackouts. Whether nature-made (e.g., hurricanes, lightning, snowstorms, fires, etc.) or man-made (operator errors, equipment malfunction, etc.), the results of an outage were the same for electricity customers – no grid electricity for extended periods of time and no backup. And,

customers have no guarantee that it won't continue to happen with the same results.
One of the priorities of the CERTS program was to qualitatively improve grid reliability by integrating distributed energy resources (DER). Very early in the program it was realized that if DER and load management systems were integrated at the facility level, then the vulnerabilities of the grid could be greatly reduced or eliminated entirely. Small scale electrical systems, that later came to be called "microgrids," could resolve many seemingly intractable technical problems identified by the utility companies. These new microgrid designs could also make the integrated DER systems "good citizens" from the perspective of the grid operators.

Technical Challenges Faced by All Microgrids

Many of the technical problems that microgrids face were originally associated with problems encountered by grid operators as efforts to promote large-scale integration of DER, especially renewable energy technologies (e.g., solar and wind), gained momentum.

Every microgrid faces a set of technical challenges similar to those that the main grid encounters, including:

- **DER Component Connection to Microgrid** - How do DER units join the microgrid and whose responsibility is it to figure out how to make safe interconnections?
- **DER Component Output Balancing** - How does the microgrid balance the resources and technical operating constraints of different types of DER components (e.g., solar, wind, fuel cells, microturbines, combined heat and power generators, batteries, etc.)?
- **Facility Load Fluctuations** - How does the microgrid accommodate highly variable changes in the attached load?
- **System Electrical Stability** - How does the microgrid balance loss of voltage and frequency control?
- **Grid Interconnection & Islanding** - How do the DER units communicate with the microgrid during normal operation and when the main grid defaults (especially when it shuts down) how do the DER units reconnect?
- **System Performance** - How does the microgrid optimize the DER mix and the energy output or environmental performance of each DER unit relative to external conditions (e.g., weather conditions, electricity prices, environmental regulations)?

The CERTS Microgrid Concept

CERTS microgrid technologies have been in R&D stage for the last decade and are now entering the commercialization phase. The CERTS model of microgrids is based upon the pioneering research work of Prof. Robert Lasseter of the University of Wisconsin - Madison. Prof. Lasseter's solutions allow true "plug-n-play" and "peer-to-peer" implementations of distributed energy resources into an integrated on-site energy system without the need for a dedicated command and control system. (Please see the attached: Appendix B. "Compendium of CERTS Research" for details of the research program.)

CERTS Microgrid DER Operational Functionality

Each DER unit is a microgrid forming component and does not require mode switching to operate on the microgrid electrical circuit. The key technical features of the CERTS microgrid include:

- Autonomous load following droop (local power vs. frequency)
- Insures multi-unit stability (local voltage control V vs. Q)
- Autonomous load transfer from overloaded sources to other sources (Pmax)
- Intelligent load and source shedding
- Intelligent and fast interface switch provides for autonomous islanding and re-synchronizing to the grid (automatically opens on grid power quality events or faults and seamlessly re-closes to re-join the grid)

CERTS Microgids Poised to Become the "Killer App" for Disaster Resilience

CERTS microgrid systems are scalable from a small facility to large multi-facility campuses. The robust system integrity and outstanding energy assurance performance of CERTS microgrids will radically transform existing utility industry as we know it today. At an exponential rate, CERTS microgrids will become the fundamental building block of the global "smart grid" industry due to their strategic technological advantages and dramatic impact on reducing the levelized cost of energy (LCOE).

CERTS microgrid technology is now being used in numerous demonstration sites (please see Appendix B.), including:

- AEP Dolan Center
- SMUD Corporate Headquarters
- Santa Rita Jail
- Military Installations (see Appendix C.)

For several years, Tecogen has incorporated CERTS algorithms into the control software in hundreds their CHP units. Their installations operate as microgrids except the inclusion of a static switch.

Chris Marnay, a lead microgrid researcher at the Lawrence Berkeley National Laboratory, assesses the technical advantages of the microgrid at the Santa Rita Jail and the most important impact of microgrids on the grid:

> “Of course, the microgrid can also function when it’s connected to the grid, allowing the Jail to reduce its electricity bill as well as lowering the load on the local electricity distribution network. Part of this grant is to demonstrate the ability to lower the electrical load on the neighboring PG&E feeder, which is the part of the of the electricity distribution system from the substation to the meter. So the Jail can coordinate with nearby loads such that the overall peak load on that feeder is reduced, which is another way of saying that it provides a big financial benefit to the utility because it postpones them having to upgrade their equipment to increase capacity.”
>
> “Besides reliability, microgrids offer several other advantages. One is that they can be tailored to take advantage of local resources, such as the sun or wind. Integrating small and uncontrollable renewables into our legacy grid is tricky because of the requirement that supply and demand must constantly be in balance while these resources vary continuously.”
>
> “This thinking leads to the most controversial advantage, by far, which is that we may be able to live with a less reliable grid because highly sensitive loads, such as the Jail, are served in a more localized fashion. To me, that’s where the huge advantage lies, in unshackling the traditional grid. With our current system, the grid has no feasible way to differentiate and prioritize between a recharging iPhone and hospital life-saving equipment.”

So the vision of our future may be a hybrid energy system whereby the BAU grid goes on as before (with improvements) and within it are pockets of hardened and resilient microgrid powered facilities. How the utility companies resist or embrace this new movement is still an open question but the movement is already well underway.

Exemplars of Resilience in the Face of Hurricane Sandy

During and after Hurricane Sandy, distributed energy systems across the Northeast demonstrated their reliability and resilience to the ravages of the storm. Thoughtful leaders who implemented systems before the storm were rewarded with power and heat when all about them was plunged into darkness and cold.

Exemplars of this new microgrid and cogeneration world include:

- **Brevoort Apartment Building, New York City** – The 20-story residential building used four natural gas-fired Tecogen cogeneration microgrid-based systems to supply power and heat for the permanent 720 residents as well as another 700 people who took refuge there.

- **New York University, New York City** – A combined cycle generator kept the core buildings around Washington Square supplied with power and heat for days.
- **One Penn Plaza** – Cogeneration units kept essential functions at the facility running throughout the disaster.
- **Co-op City, Bronx, New York** – The huge housing complex used its cogeneration systems to ride through the citywide outages.
- **Princeton University, Princeton, NJ** – A large gas-fired turbine keep essential campus facilities (i.e., 4000 apartments, 35 high-rise buildings, townhouses, garages and more) operating for two days until grid power was restored.
- **U.S. FDA White Oak Research Center, Maryland** – Its cogeneration system keep the huge facility running for two days until grid power was restored.
- **South Windsor High School, Connecticut** – The school, which usually uses its large fuel cell system to offset daily power costs, switched over to grid power independence after the storm and served as an emergency shelter.

Will the Utility Companies Change Their Business Model?
Some utility companies may fight just as tenaciously as the old Generals and Admirals did in denying the importance of a new world-changing energy technology on their business model. But, others utilities are slowly embracing the new technology. American Electric Power, Sacramento Municipal Utility District, PG&E, and Con Edison all have testing programs underway to integrate new distributed energy systems.

Whether the majority of utility companies will embrace microgrid technology is currently an open question. They may have no choice because of political mandates, such as Connecticut's microgrid program. Even more important than political mandates or its energy resiliency capabilities, CERTS microgrid technology is designed at its core to easily incorporate cheaper and cheaper distributed energy systems from different manufacturers. The cost of solar technology has dropped 75% over the last few years. Other DER technologies will follow suit as the microgrid market grows. The economic efficiency (i.e., lower price) of microgrids in generating and managing loads locally will be the most formidable challenge faced by the utility companies. Mere technical superiority isn't enough to radically change markets. But, huge prices declines in energy costs are!

Microgrid Challenge for Governments Around the Globe
Price declines for microgrid-generated electricity are the real "tipping point." Due to Hurricane Sandy and other extreme weather events, American government leaders have been warned to make to make a rapid and orderly transition to a

new energy world or continue to suffer the consequences. In many high-priced U.S. markets, this transition may only take three years and in cheaper markets five years.

This microgrid-enabled energy market transition is not only imminent for government but also for business. In short order, “To Be or Not to Be” will be a fundamental issue of corporate governance. Should the company bring microgrid power generation and management in-house at potentially higher short-term costs and management responsibilities and long-term savings and benefits or just continue to ride along with the BAU utility company whatever the risks.

American government and business leaders have to take microgrids seriously right now and take action because microgrid technology is not the exclusive domain of the USA. Countries all over the world are facing the same grid resiliency and energy cost issues. Many of those countries already understand that the American grid design is obsolete, especially in many developing countries. Their leaders want to embrace the most efficient technology that brings the greatest benefits at the lowest cost and they will embrace microgrids very rapidly. Along with microgrid project development comes technology advances, manufacturing development, jobs and even export opportunities.

What Can We Do Now to Accelerate the Transition in the USA?
Several steps can be taken to build resilience into our power system before the next Sandy, including:

- **Fast Track Microgrid Development for Critical Infrastructure Facilities** – Identify appropriate sites, expedite interconnection, reward first movers;
- **Change Regulatory Environment** – Reevaluate the regulatory matrix to unencumbered microgrid development, especially for community microgrids where lines cross property lines or right of ways;
- **Incentivize the Development Process** – Devise innovative financing mechanisms to lessen risk for private investors; publicly support early adopters; form public-private partnerships to give the process a “Manhattan Project” priority.

The studying is done. The microgrid demonstrations have been completed. Now, it is time for our leaders to demonstrate that they are true leaders by taking charge and initiating the actions necessary to make the transition to a world of resilient power systems based upon microgrids.

Maybe when the next superstorm hits, it won’t be *deja vu* all over again!

(Please Note – The following Appendices demonstrate that there is no “excuse” for a lack of knowledge regarding the technical development of microgrids and their practical use for critical infrastructure facilities.)

Appendix A.

Hurricane Sandy & the Emperor's New Clothes:

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The Emperor's New Clothes

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Appendix C.

Net Zero Energy Approach to Microgrid Design

Summary

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