RESILIENT POWER

A project of Clean Energy Group

Hydrogen and Fuel Cells for Resiliency: Fuel Cells for Telecom (Renewable H2)

March 17, 2016

Clean Energy Group

Innovation in Finance, Technology & Policy

Northeast Electrochemical energy storage Cluster

Housekeeping

All participants are in "Listen-Only" mode. Select "Use Mic & Speakers" to avoid toll charges and use your computer's VOIP capabilities. Or select "Use Telephone" and enter your PIN onto your phone key pad.

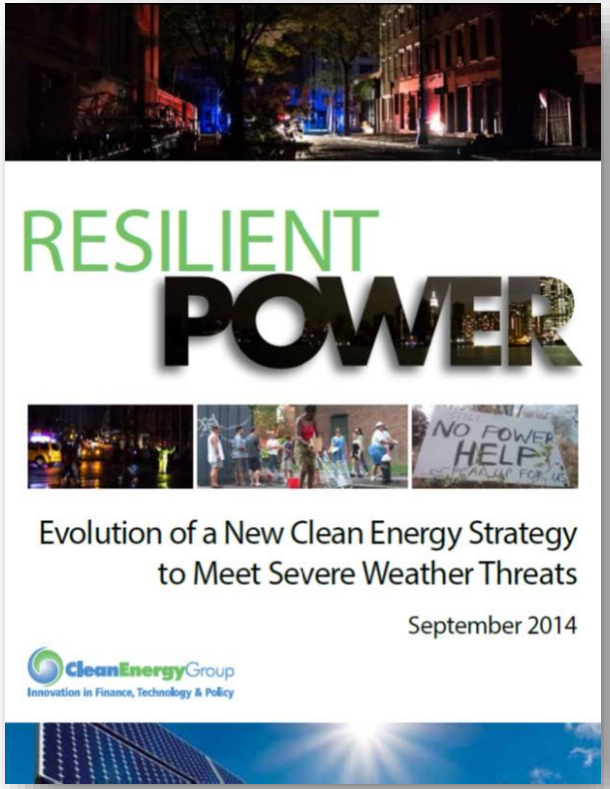
Submit your questions at any time by typing in the Question Box and hitting Send.

This webinar is being recorded.

You will find a recording of this webinar, as well as previous Resilient Power Project webinars, online at:

www.resilient-power.org

Who We Are



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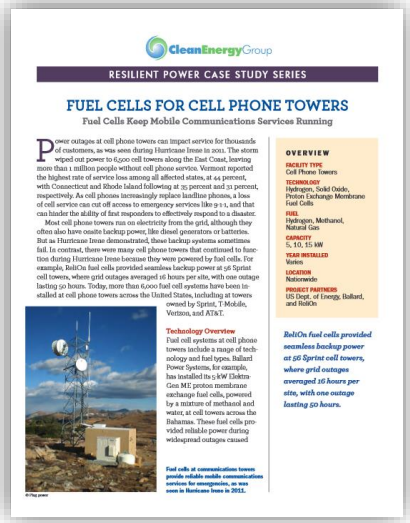
Fostering sustainable communities in the United States

Resilient Power Project

- Increase public/private investment in clean, resilient power systems
- Engage city officials to develop resilient power policies/programs
- Protect low-income and vulnerable communities
- Focus on affordable housing and critical public facilities
- Advocate for state and federal supportive policies and programs
- Technical assistance for pre-development costs to help agencies/project developers get deals done
- See www.resilient-power.org for reports, newsletters, webinars, and more.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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR CELL PHONE TOWERS

Fuel Cells Keep Mobile Communications Services Running

Power outages at cell phone towers can impact service for thousands of customers, as was seen during Hurricane Irene in 2011. The storm wiped out power to 6,500 cell towers along the East Coast, leaving more than 1 million people without cell phone service. Vermont reported the highest rate of service loss among all affected states, at 44 percent, with Connecticut and Rhode Island following at 35 percent and 31 percent, respectively. As cell phones increasingly replace landline phones, a loss of cell service can cut off access to emergency services like 9-1-1, and that can hinder the ability of first responders to effectively respond to a disaster.

Most cell phone towers run on electricity from the grid, although they often also have onsite backup power, like diesel generators or batteries. But as Hurricane Irene demonstrated, these backup systems sometimes fail. In contrast, there were many cell phone towers that continued to function during Hurricane Irene because they were powered by fuel cells. For example, ReliOn fuel cells provided seamless backup power at 56 Sprint cell towers, where grid outages averaged 16 hours per site, with one outage lasting 50 hours. Today, more than 6,000 fuel cell systems have been installed at cell phone towers across the United States, including at towers owned by Sprint, T-Mobile, Verizon, and AT&T.

OVERVIEW

FACILITY TYPE
Cell Phone Towers

TECHNOLOGY
Hydrogen, Solid Oxide, Proton Exchange Membrane Fuel Cells

FUEL
Hydrogen, Methanol, Natural Gas

CAPACITY
5, 10, 15 kW

YEAR INSTALLED
Varies

LOCATION
Nationwide

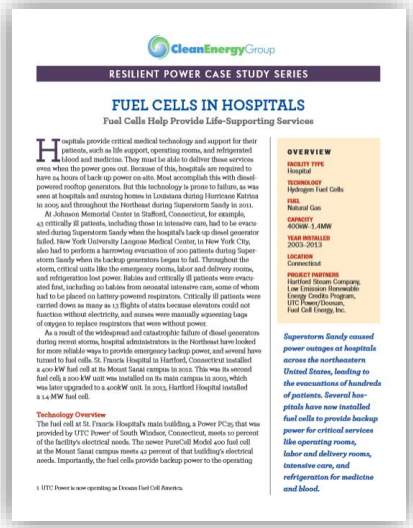
PROJECT PARTNERS
US Dept. of Energy, Ballard, and ReliOn

Technology Overview

Fuel cell systems at cell phone towers include a range of technology and fuel types. Ballard Power Systems, for example, has installed its 5 kW Elektra Gen ME proton membrane exchange fuel cells, powered by a mixture of methanol and water, at cell towers across the Bahamas. These fuel cells provided reliable power during widespread outages caused

ReliOn fuel cells provided seamless backup power at 56 Sprint cell towers, where grid outages averaged 16 hours per site, with one outage lasting 50 hours.

Fuel cells at communications towers provide reliable mobile communications services for emergencies, as was seen in Hurricane Irene in 2011.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FUEL CELLS IN HOSPITALS

Fuel Cells Help Provide Life-Supporting Services

Hospitals provide critical medical technology and support for their patients, such as life support, operating rooms, and refrigerated blood and medicine. They must be able to deliver these services even when the power goes out. Because of this, hospitals are required to have 24 hours of back up power on-site. Most accomplish this with diesel-powered rooftop generators. But this technology is prone to failure, as was seen at hospitals and nursing homes in Louisiana during Hurricane Katrina in 2005 and throughout the Northeast during Superstorm Sandy in 2012.

At Johnson Memorial Center in Stafford, Connecticut, for example, 43 critically ill patients, including those in intensive care, had to be evacuated during Superstorm Sandy when the hospital's back-up diesel generator failed. New York University Langone Medical Center, in New York City, also had to perform a harrowing evacuation of 200 patients during Superstorm Sandy when its backup generators began to fail. Throughout the storm, critical units like the emergency rooms, labor and delivery rooms, and refrigeration lost power. Babies and critically ill patients were evacuated first, including 20 babies from neonatal intensive care, some of whom had to be placed on battery-powered respirators. Critically ill patients were carried down as many as 13 flights of stairs because elevators could not function without electricity, and nurses were manually squeezing bags of oxygen to replace respirators that were without power.

As a result of the widespread and catastrophic failure of diesel generators during recent storms, hospital administrators in the Northeast have looked for more reliable ways to provide emergency backup power, and several have turned to fuel cells. St. Francis Hospital in Hartford, Connecticut installed a 400 kW fuel cell at its Mount Sanai campus in 2012. This was its second fuel cell, a 200 kW unit was installed on its main campus in 2005, which was later upgraded to a 400kW unit. In 2013, Hartford Hospital installed a 1.4 MW fuel cell.

OVERVIEW

FACILITY TYPE
Hospital

TECHNOLOGY
Hydrogen Fuel Cells

FUEL
Natural Gas

CAPACITY
400kW- 1.4MW

YEAR INSTALLED
2003-2013

LOCATION
Connecticut

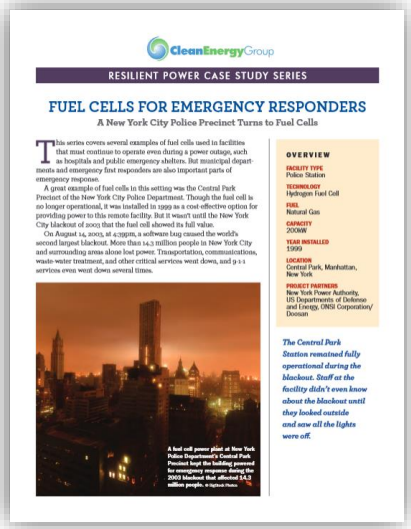
PROJECT PARTNERS
Hartford Steam Company, Low Emission Renewable Energy Credits Program, UTC Power/Doosan, Fuel Cell Energy, Inc.

Technology Overview

The fuel cell at St. Francis Hospital's main building, a Power PC25 that was provided by UTC Power[1] of South Windsor, Connecticut, meets 10 percent of the facility's electrical needs. The newer PureCell Model 400 fuel cell at the Mount Sanai campus meets 42 percent of that building's electrical needs. Importantly, the fuel cells provide backup power to the operating

1 UTC Power is now operating as Doosan Fuel Cell America.

Superstorm Sandy caused power outages at hospitals across the northeastern United States, leading to the evacuations of hundreds of patients. Several hospitals have now installed fuel cells to provide backup power for critical services like operating rooms, labor and delivery rooms, intensive care, and refrigeration for medicine and blood.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FUEL CELLS FOR EMERGENCY RESPONDERS

A New York City Police Precinct Turns to Fuel Cells

This series covers several examples of fuel cells used in facilities that must continue to operate even during a power outage, such as hospitals and public emergency shelters. But municipal departments and emergency first responders are also important parts of emergency response.

A great example of fuel cells in this setting was the Central Park Precinct of the New York City Police Department. Though the fuel cell is no longer operational, it was installed in 1999 as a cost-effective option for providing power to this remote facility. But it wasn't until the New York City blackout of 2003 that the fuel cell showed its full value.

On August 14, 2003, at 4:10pm, a software bug caused the world's second largest blackout. More than 14.3 million people in New York City and surrounding areas alone lost power. Transportation, communications, waste-water treatment, and other critical services went down, and 911 services even went down several times.

A fuel cell power plant at New York Police Department's Central Park Precinct kept the building powered for emergency response during the 2003 blackout that affected 14.3 million people. © Peyton Hoyt

OVERVIEW

FACILITY TYPE
Police Station

TECHNOLOGY
Hydrogen Fuel Cell

FUEL
Natural Gas

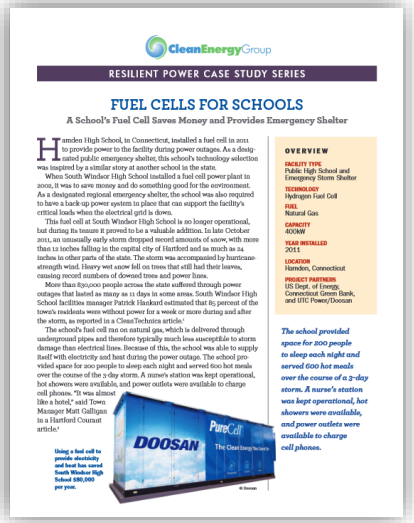
CAPACITY
200kW

YEAR INSTALLED
1999

LOCATION
Central Park, Manhattan, New York

PROJECT PARTNERS
New York Power Authority, US Departments of Defense and Energy, ONSI Corporation/ Doosan

The Central Park Station remained fully operational during the blackout. Staff at the facility didn't even know about the blackout until they looked outside and saw all the lights were off.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FUEL CELLS FOR SCHOOLS

A School's Fuel Cell Saves Money and Provides Emergency Shelter

Hamden High School, in Connecticut, installed a fuel cell in 2011 to provide power to the facility during power outages. As a designated public emergency shelter, this school's technology selection was inspired by a similar story at another school in the state.

When South Windsor High School installed a fuel cell power plant in 2010, it was to save money and do something good for the environment. As a designated regional emergency shelter, the school was also required to have a back-up power system in place that can support the facility's critical loads when the electrical grid is down.

This fuel cell at South Windsor High School is no longer operational, but during its tenure it proved to be a valuable addition. In late October 2011, an unusually early storm dropped record amounts of snow, with more than 12 inches falling in the capital city of Hartford and as much as 24 inches in other parts of the state. The storm was accompanied by hurricane-strength wind. Heavy wet snow fell on trees that still had their leaves, causing record numbers of downed trees and power lines.

More than 830,000 people across the state suffered through power outages that lasted as many as 11 days in some areas. South Windsor High School facilities manager Patrick Haskard estimated that 85 percent of the town's residents were without power for a week or more during and after the storm, as reported in a CleanTechnica article.[1]

The school's fuel cell ran on natural gas, which is delivered through underground pipes and therefore typically much less susceptible to storm damage than electrical lines. Because of this, the school was able to supply itself with electricity and heat during the power outage. The school provided space for 200 people to sleep each night and served 600 hot meals over the course of a 3-day storm. A nurse's station was kept operational, hot showers were available, and power outlets were available to charge cell phones. "It was almost like a hotel," said Town Manager Matt Galligan in a Hartford Courant article.[2]

Using a fuel cell to provide electricity and heat has saved South Windsor High School $80,000 per year.

OVERVIEW

FACILITY TYPE
Public High School and Emergency Storm Shelter

TECHNOLOGY
Hydrogen Fuel Cell

FUEL
Natural Gas

CAPACITY
400kW

YEAR INSTALLED
2011

LOCATION
Hamden, Connecticut

PROJECT PARTNERS
US Dept. of Energy, Connecticut Green Bank, and UTC Power/Doosan

The school provided space for 200 people to sleep each night and served 600 hot meals over the course of a 3-day storm. A nurse's station was kept operational, hot showers were available, and power outlets were available to charge cell phones.

www.resilient-power.org

Northeast Electrochemical Energy Storage Cluster (NEESC)

NEESC is a network of industry, academic, government and non-governmental leaders working together to help businesses provide energy storage solutions.

Northeast Electrochemical energy storage Cluster

www.neesc.org

Today's Guest Speakers

- **Corinne Vita**, Sales Director, Major Accounts, Altergy
- **Thomas Browning**, Sr. Manager, Engineering Field, T-Mobile

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Altergy Systems

Fuel Cells for Onsite – On Demand Telecom Power

Corinne Vita

NEECS Webinar

March 2016

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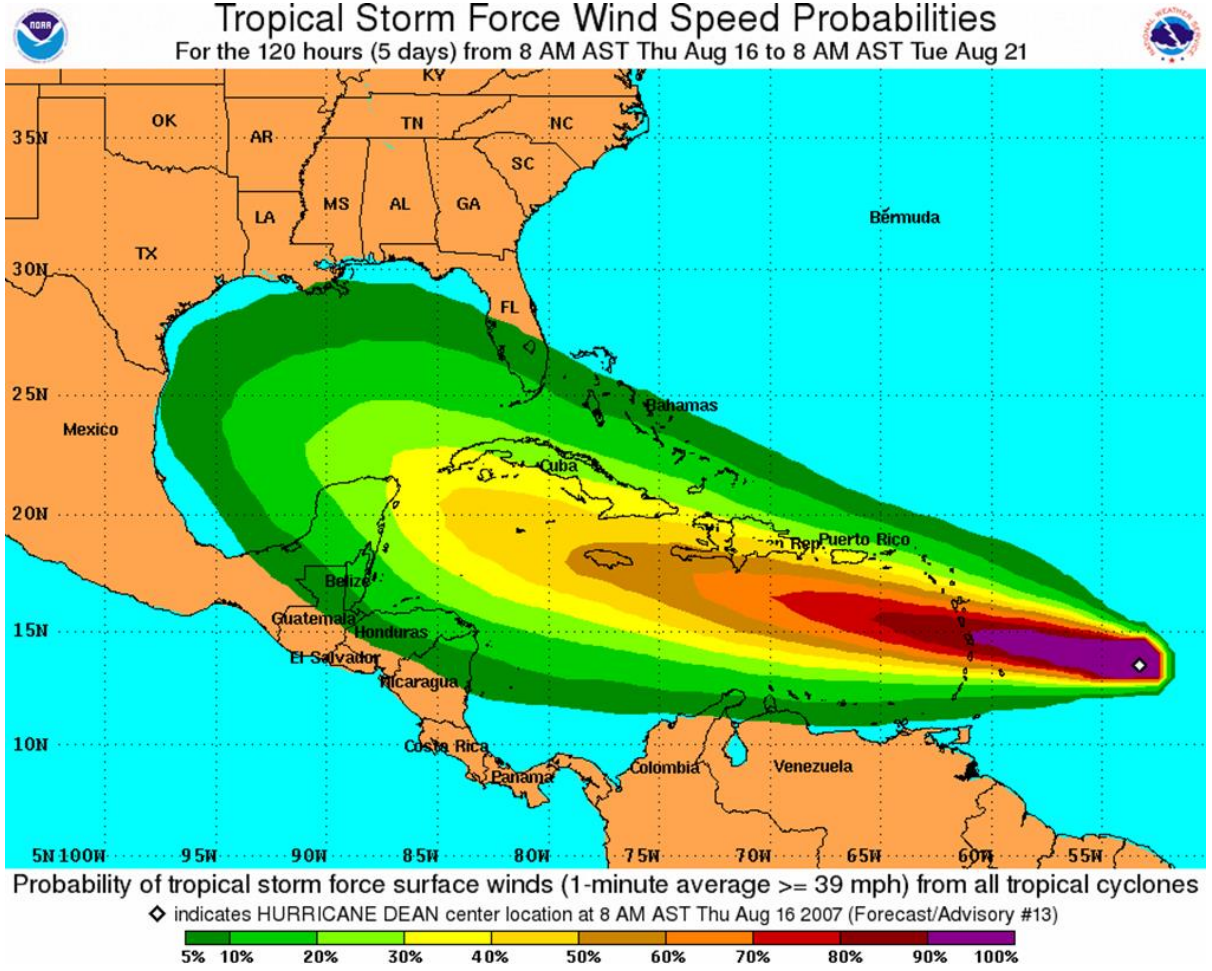
Climate Change Brings More Severe Weather

- **In New York, 60 Altergy Systems fuel cells successfully backed up cell sites after hurricane Sandy knocked out utility power to 8.1 million customers.**
- **Snowstorms, tornados, thunderstorms**
- **Earthquakes – 20 Altergy fuel cells provided cell site power during Napa earthquake**



Challenges for Telecom and Cable Networks

- Avoid power outages and disruption of service to customers
- FCC 8 hour backup power regulations after Katrina for cell sites, broadband networks for internet and VoIP phones
- Long runtime needs to fit site space/weight requirements
- Attractive Total Cost of Ownership
  - Federal Investment Tax Credits
  - State utility incentives
- Sustainable, clean, low environmental impact
- No Maintenance – reduce operational costs

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What Are Industry Professionals Saying?

- **Reported issues with batteries**
  - Unpredictable and short run times
  - Prone to capacity and performance degradation
  - Temperature sensitivity
  - Power output is mass-dependent
    - High capacity batteries are extremely large and heavy
    - Weight/space limitations
  - High disposal costs
  - Recurring costs for replacement cycles

Compared with battery systems, fuel cells offer longer continuous run times. They also don't need to be recharged, and they're more durable in harsh environments.

Photo courtesy of the National Renewable Energy Laboratory

What Are Industry Professionals Saying?

- **Reported issues with generators**

- **High maintenance costs**
- **Toxic emissions**
- **Noise**
- **Mechanical failure**
- **Reliability/Failure to start**
- **Permitting difficulties for rooftop deployments**
- **Emissions/Regulatory Permits and costs**

Compared with generators, fuel cells are easier to maintain because they have fewer moving parts and can be monitored remotely. They're also quiet and produce fewer emissions.

Photo courtesy of the National Renewable Energy Laboratory

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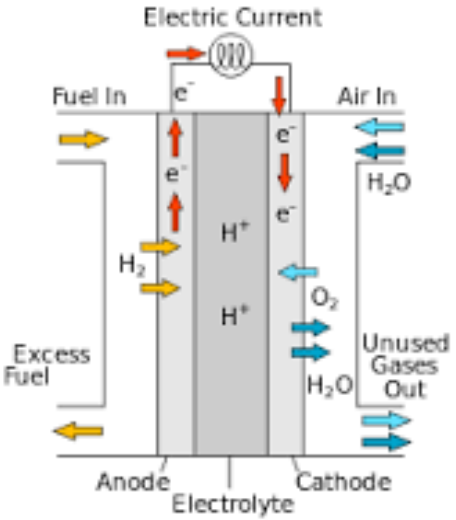
Fuel Cells - Abundant Clean and Green Power

- **Fuel Cell - An electrochemical device that combines hydrogen and oxygen to produce electricity - PEM Proton Exchange Membrane**
  - **No combustion, no emissions**
  - **Clean, Quiet**
- **Reliable - No moving parts**
- **Quick start operation – used in data centers, telecom, cable networks, and cars Toyota, GM, Honda, fork lifts, buses**
- **Low Maintenance, much lighter and compact than battery generator equivalents, install on rooftops**
- **Environmentally Friendly – hydrogen is simplest most abundant element in the universe**
- **No temperature sensitivity like batteries, runs -40oC to +40oC**
- **Long runtime, small footprint**
- **Incentives, Grants, Rebates**

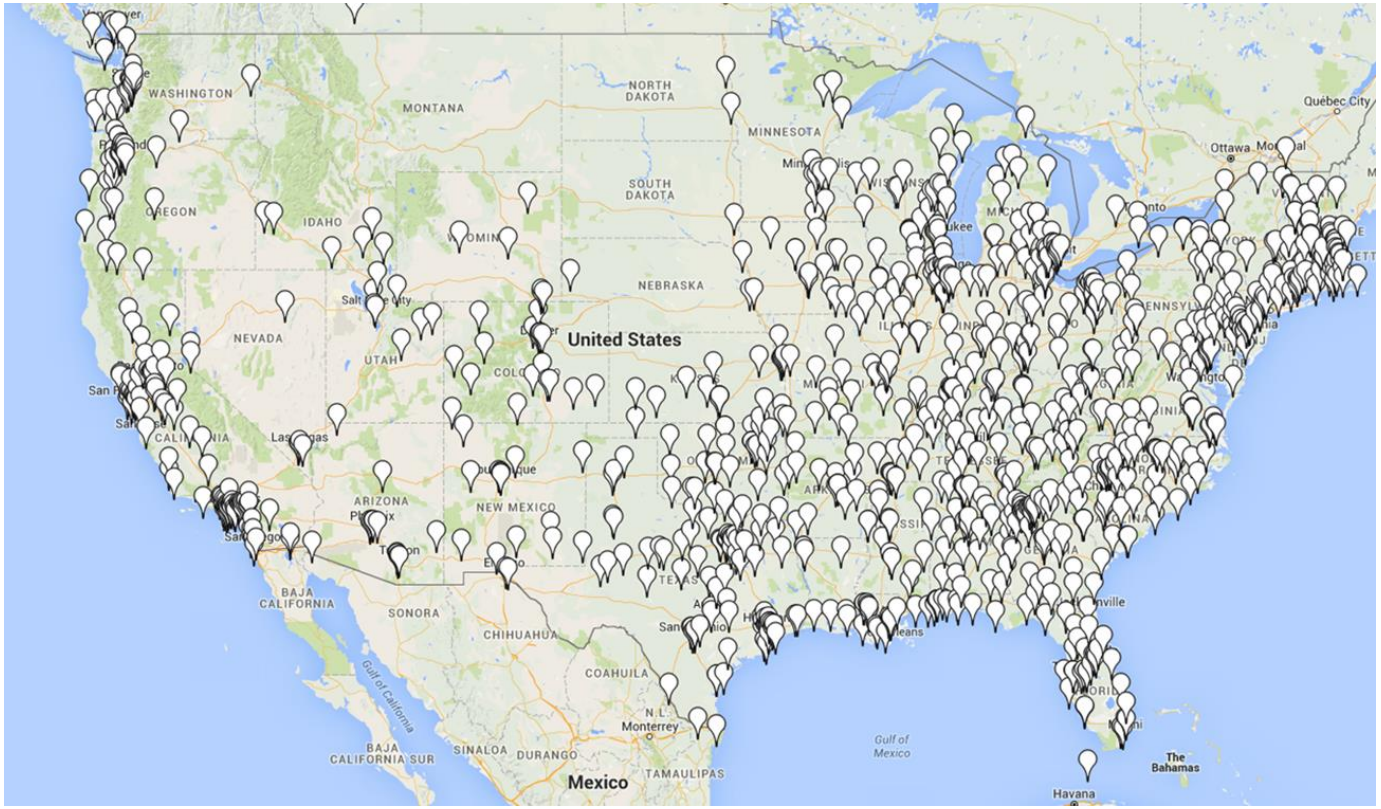


Hydrogen – Simplest, Most Abundant Element

- **A clear, odorless gas. Excellent energy carrier**
- **Non polluting - when consumed its only emission is pure water**
- **Lightest element - highest energy content per weight**
  - Pound for pound, it contains almost three times as much energy as natural gas
- **Economically competitive – can be 60% less expensive than diesel fuel**
- **Safe - 50 year use history and safety record**
  - Diffuses rapidly -14 x lighter than air
  - Gasoline 22X more explosive, natural gas 5X
- **Produced in any country, from variety of sources**
  - Renewable: Solar, wind, geothermal, hydro, biomass, algae
  - Traditional: Natural gas, gasoline, nuclear, coal, water
- **Used in oil production, chemical, foods, electronics industries**
- **Transported by truck, rail, barge and pipeline**

» Widely available

Hydrogen is widely available



- **The availability profile for Air Gas**
- **There are at least 4 other national suppliers with even greater distribution**

Altergy Freedom Power –The New Standard

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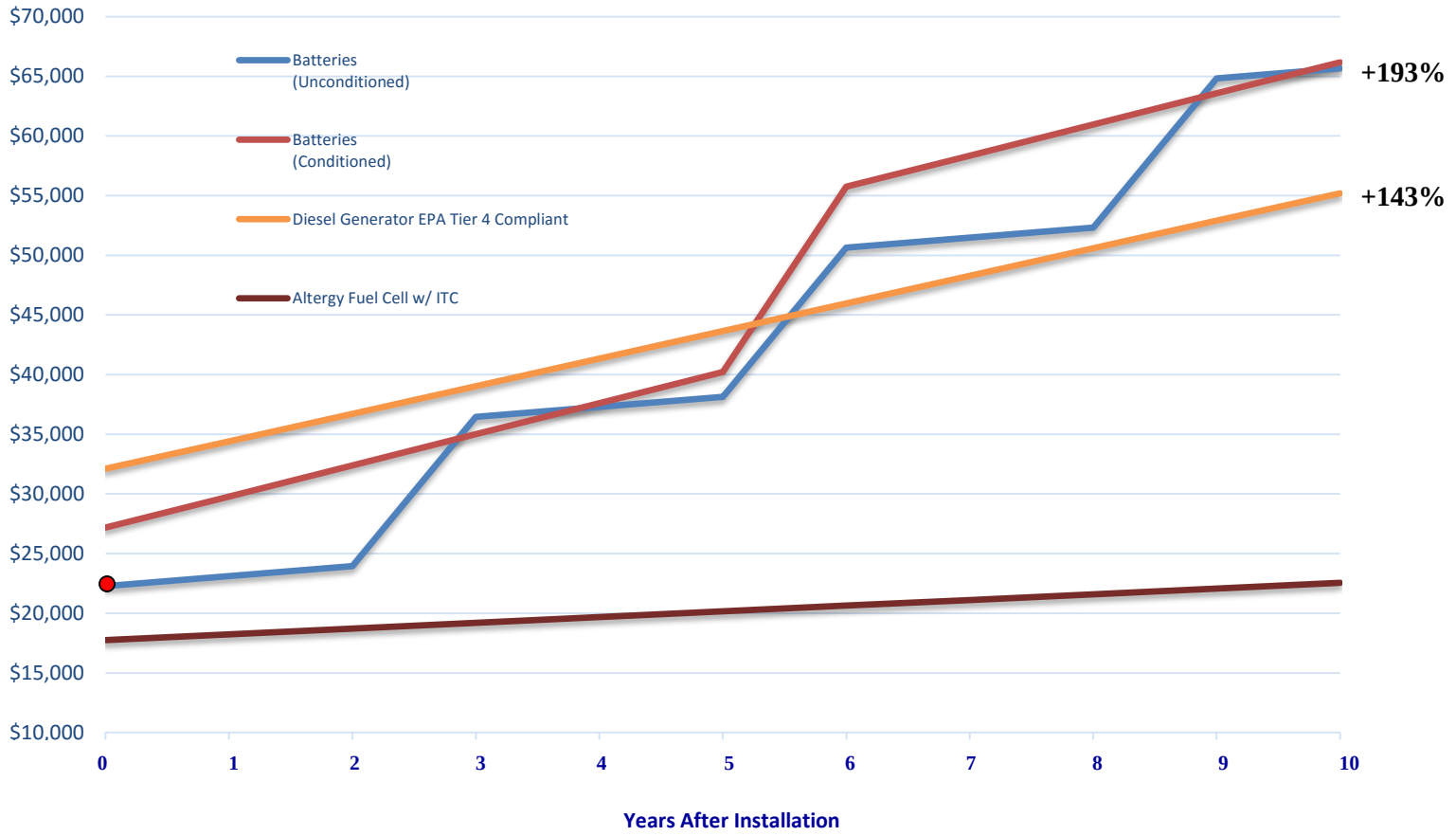
Data Center & Life Safety - California Institute of Technology

55kW Rooftop Placement of Fuel Cells and Hydrogen Storage

Data Center Powered by Multiple Altergy FPSs

Altergy's *Freedom Power* System mounted to top of rack replaces grid and eliminates backup, infrastructure and conversion

Altergy – The Best Value in Backup Power



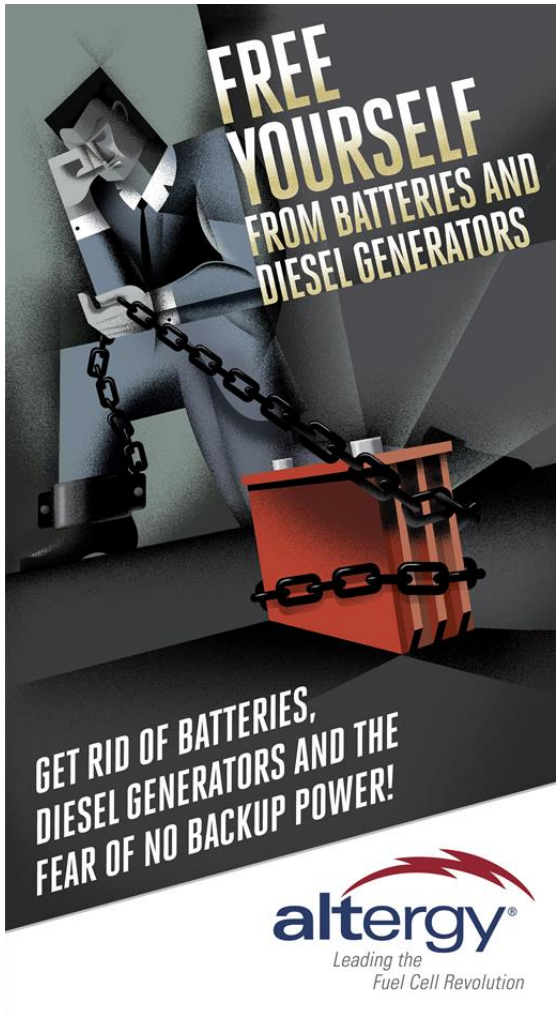
Altergy's Market Leading Freedom Power Systems

- **Revolutionary Fuel Cell Design and Robotic Assembly:**
  - Design breaks the reliability and cost barrier to commercialization
  - Robotic factory assembled and tested
  - Provides for durable, robust construction
  - Allows production on world's first and only automated, robotic fuel cell assembly line
    - Individual cell every ~ 30 seconds
    - Complete fuel cell engine in minutes
    - Assures consistent high quality
    - Assures capacity for your needs

  - Meets stringent US/International certification and listing requirements
  - Modular design powers kW to MW
  - Trusted in critical applications

Thank You!

- We have the largest deployed fleet in telecom
  - More than 8.3 million watts deployed
  - Field operating time exceeds 32 million hours



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The most reliable, cost effective power solution available

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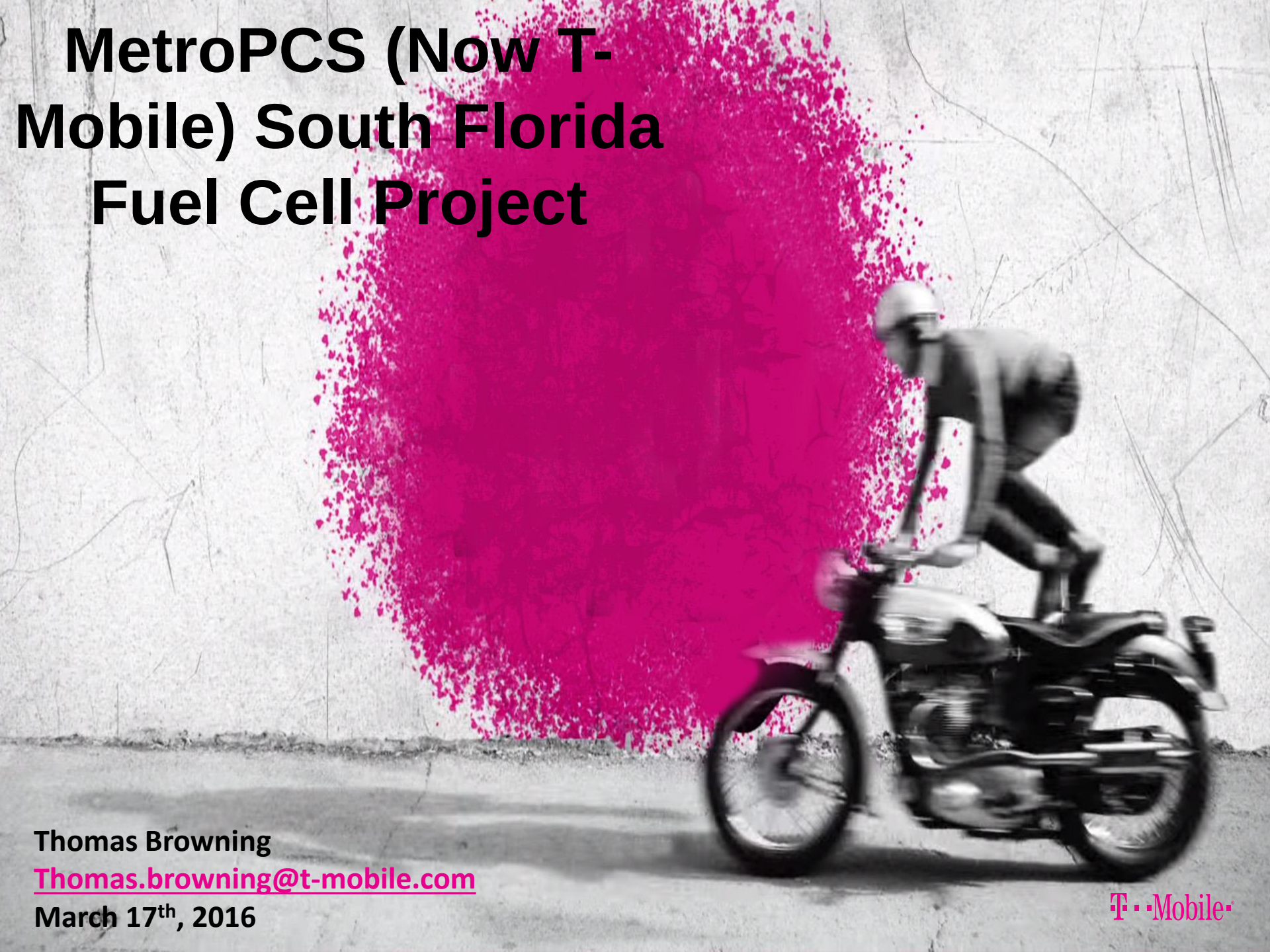
MetroPCS (Now T-Mobile) South Florida Fuel Cell Project



Thomas Browning
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March 17th, 2016

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The FCC Mandate

- The Katrina Panel
- The FCC Mandates 8 hours of backup
- Exceptions allowed, but not defined

The Problem

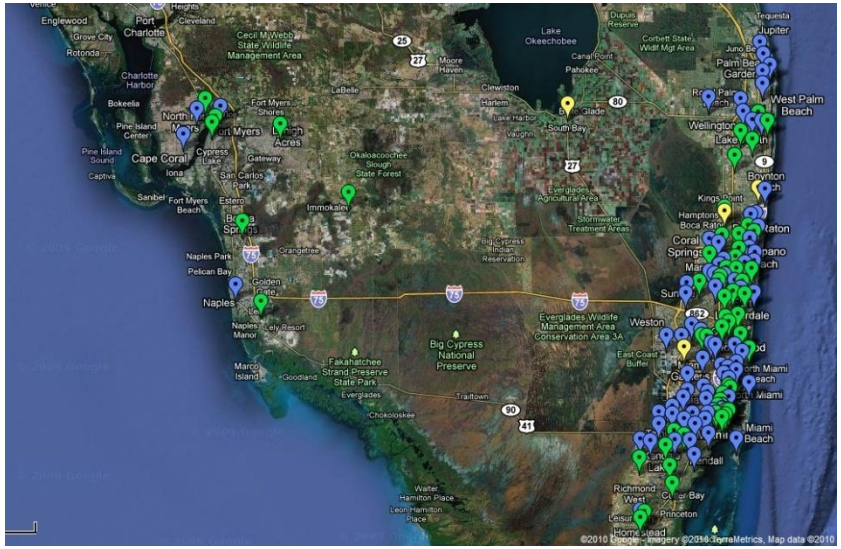
- High call volumes + Low cost service provider =
  - High power consumption
  - Space constraints
- Power consumption approaching 15KW
- Rooftop sites and the weight considerations
- 140 Mph Wind Load requirement (now 170+ Mph)
- 8 Hour mandate put on hold, but moved forward anyway

Challenging Dimmensions

- Requirements:
  - Must fit in two 26” x 26” spaces
  - Must provide 15KW of nominal power
- 100+ candidates identified
- Altergy Systems awarded contract
- 300+ hydrogen systems purchased for 100+ sites

Project Challenges

- One of the largest (if not the single largest) deployment of fuel cells at the time
- Educating the jurisdictions
- Getting the first permit through
- Moving candidates to friendlier jurisdictions
- You want me to put a lightning rod where?



T··Mobile·

Refueling Considerations

- Fill in place or bottle swaps?
- Rent or purchase bottles?
- High or low pressure?
- Composite or steel tanks?
- 6 and 9 bottle steel tank configurations
- What about the rooftops?
- Creating a bottle swap process

Operation Considerations

- Altergy alarmed at 40% fuel capacity
- Typical costs for maintenance and refueling have been low ($571 per site for 2010)
- Power outages have been primary contributor to fuel consumption
- Quite and seamless integration
- Generators have been considerably more expensive and significantly less reliable to maintain ($1,024 per site during 2010)
- Run times have been exceptional
- Worked with Altergy to train local contractors:
  - Repair / reconfigurations
  - Refueling and maintenance
- Completed 40+ reconfigurations without incident

Moving Forward

- Converted most sites to a dual voltage fuel cell that would support both CDMA and 4G LTE requirements
- Scalability and tank configurations
- Cell site power demands are generally declining
- More tax incentives please

Questions?

T··Mobile·

Q&A

Moderator: Todd Olinsky-Paul, Project Director, Clean Energy Group

- **Corinne Vita**, Sales Director, Major Accounts, Altergy
- **Thomas Browning**, Sr. Manager, Engineering Field, T-Mobile
- **Rick Burant**, Vice President of Sales, Altergy

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