Energy Resilience with Distributed Energy;

CHP with Other Resources

Isaac Panzarella
Director,
DOE Southeast CHP TAP
NC Clean Energy Technology Center
NC State University
Raleigh, NC

DOE CHP Technical Assistance Partnerships (CHP TAPs)

- **End User Engagement**
  Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.
- **Stakeholder Engagement**
  Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.
- **Technical Services**
  As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.

www.energy.gov/chp

CHP Technical Assistance Partnerships

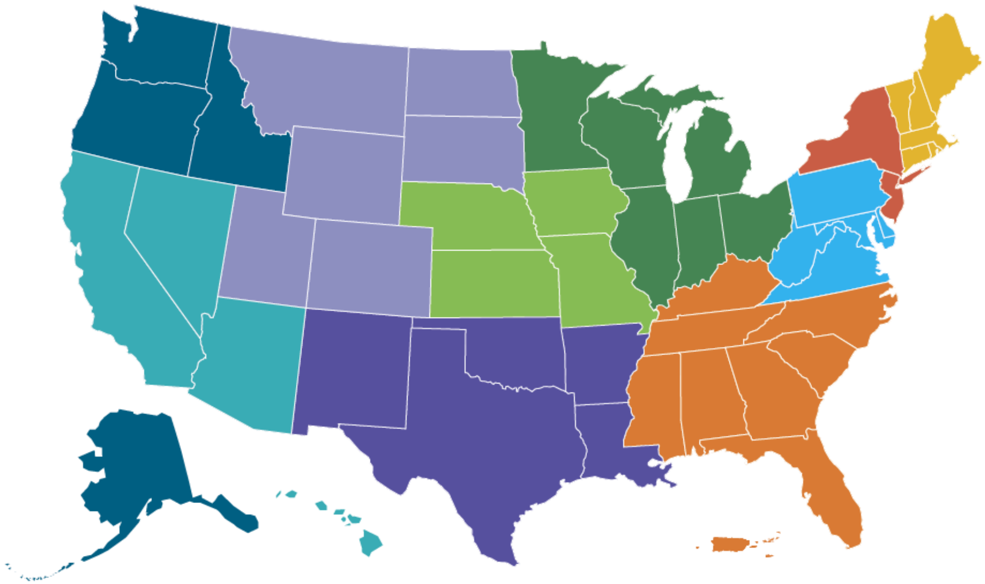
DOE CHP Technical Assistance Partnerships (CHP TAPs)

Northwest WA, OR, ID, AK
www.northwestCHPTAP.org
David Van Holde, P.E.
Washington State University
360-956-2071
VanHoldeD@energy.wsu.edu

Upper-West UT, CO, WY, MT, ND, SD
www.upperwestCHPTAP.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Midwest MN, WI, MI, IL, IN, OH
www.midwestCHPTAP.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefk1@uic.edu

New England VT, NH, ME, MA, RI, CT
www.newenglandCHPTAP.org
David Dvorak, Ph.D., P.E.
University of Maine
dvorak@maine.edu
207-581-2338



New York-New Jersey NY, NJ
www.newyorknewjerseyCHPTAP.org
Tom Bourgeois
Pace University
914-422-4013
tbourgeois@law.pace.edu

Mid-Atlantic PA, WV, VA, DE, MD, DC
www.midatlanticCHPTAP.org
Jim Freihaut, Ph.D.
The Pennsylvania State University
814-863-0083
jdf11@psu.edu

Southeast KY, TN, NC, SC, GA, FL, AL, MS
www.southeastCHPTAP.org
Isaac Panzarella, P.E.
North Carolina State University
919-515-0354
ipanzarella@ncsu.edu

Western CA, NV, AZ, HI
www.westernCHPTAP.org
Gene Kogan
Center for Sustainable Energy
858-633-8561
gene.kogan@energycenter.org

Southcentral TX, NM, OK, AR, LA
www.southcentralCHPTAP.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Central NE, IA, KS, MO
www.centralCHPTAP.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefk1@uic.edu

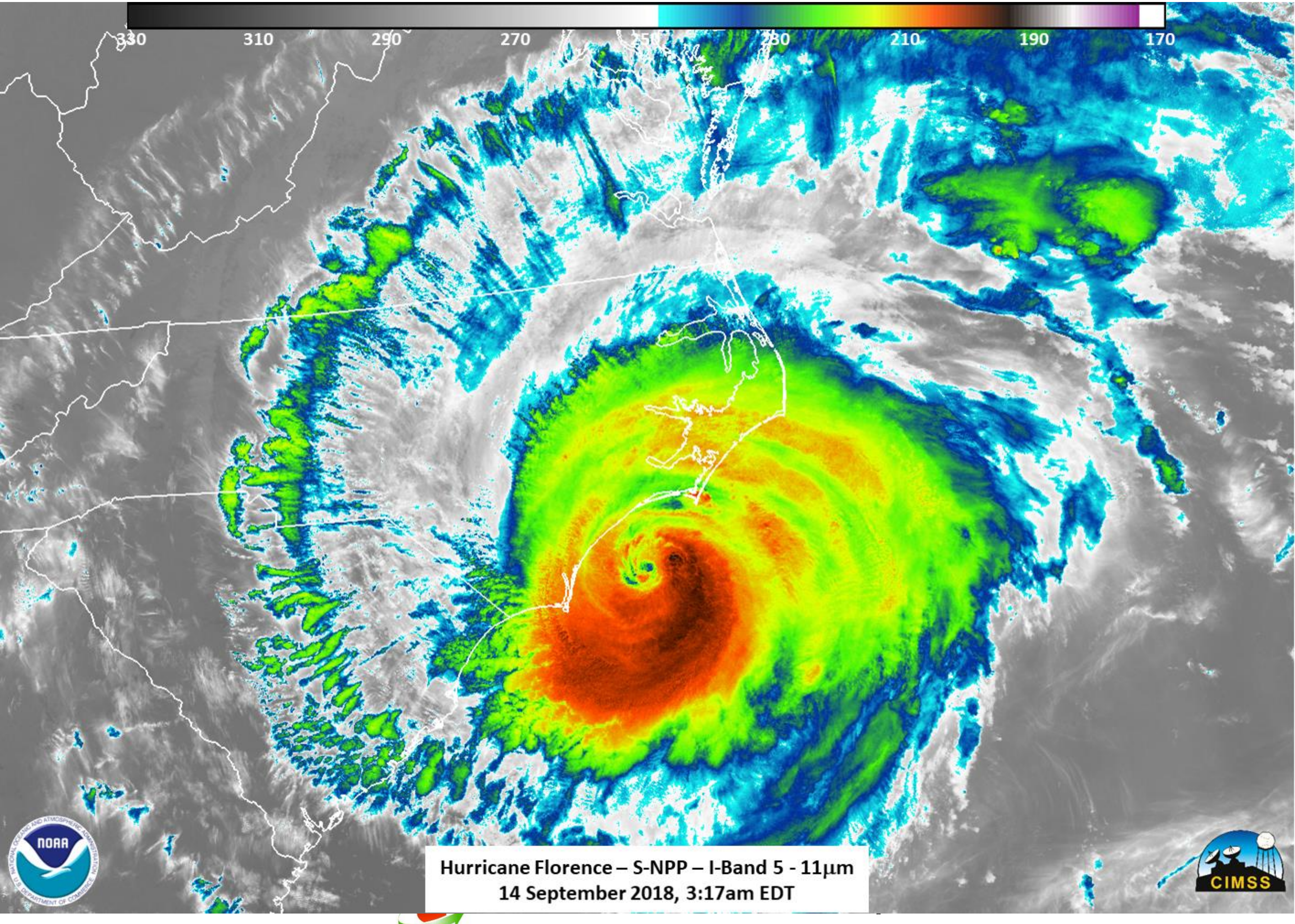
DOE CHP Deployment Program Contacts

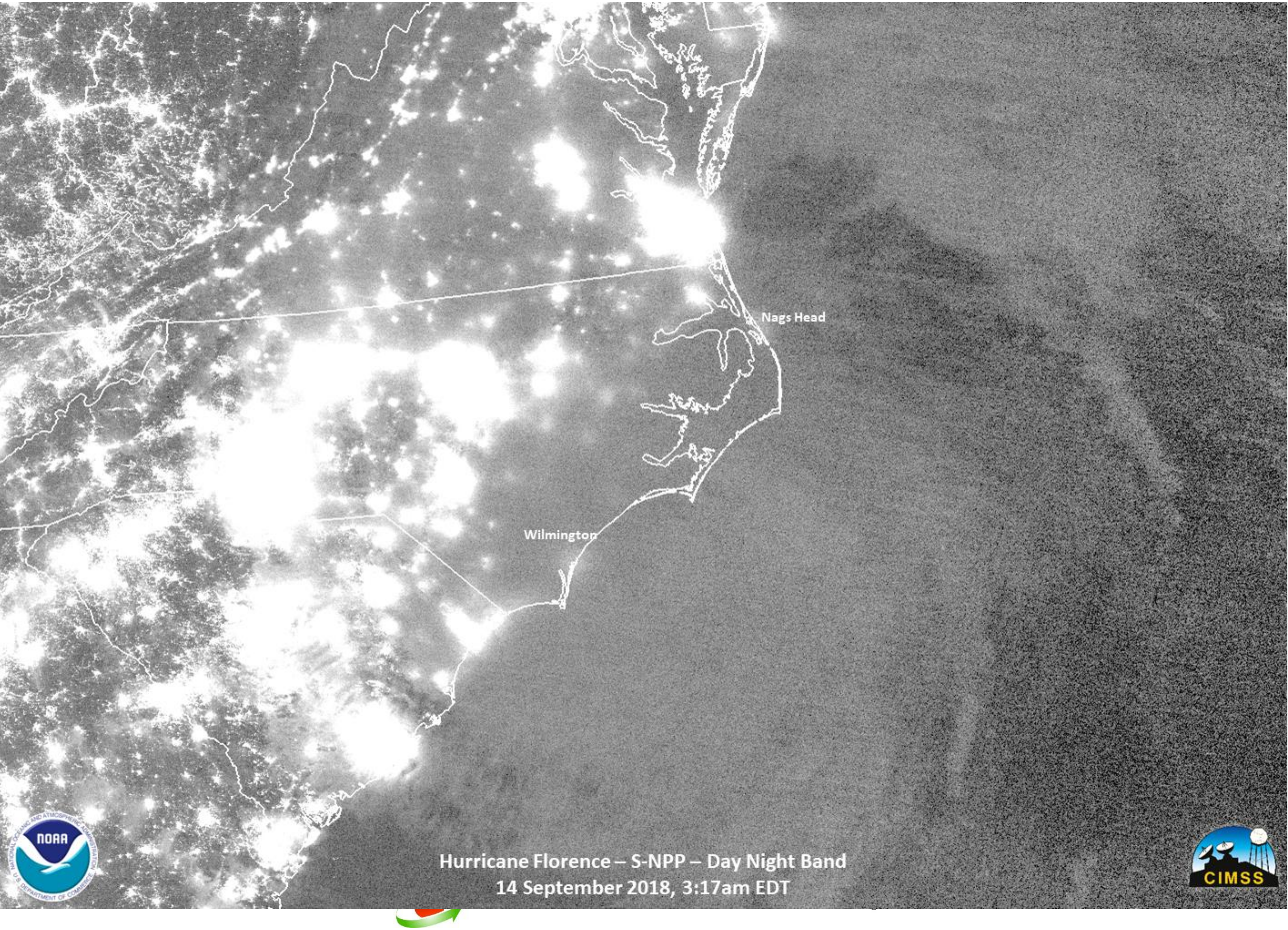
www.energy.gov/CHPTAP

Tarla T. Toomer, Ph.D.
CHP Deployment Manager
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Tarla.Toomer@ee.doe.gov

Patti Garland
DOE CHP TAP Coordinator [contractor]
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Patricia.Garland@ee.doe.gov

Ted Bronson
DOE CHP TAP Coordinator [contractor]
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
tbronson@peaonline.com


330
310
290
270
250
230
210
190
170
Hurricane Florence – S-NPP – I-Band 5 - 11µm
14 September 2018, 3:17am EDT
CIMSS


Nags Head
Wilmington
NOAA
CIMSS
Hurricane Florence – S-NPP – Day Night Band
14 September 2018, 3:17am EDT

Examples of Damage Caused By Hurricane Florence

Wilmington, NC

Wilmington, NC

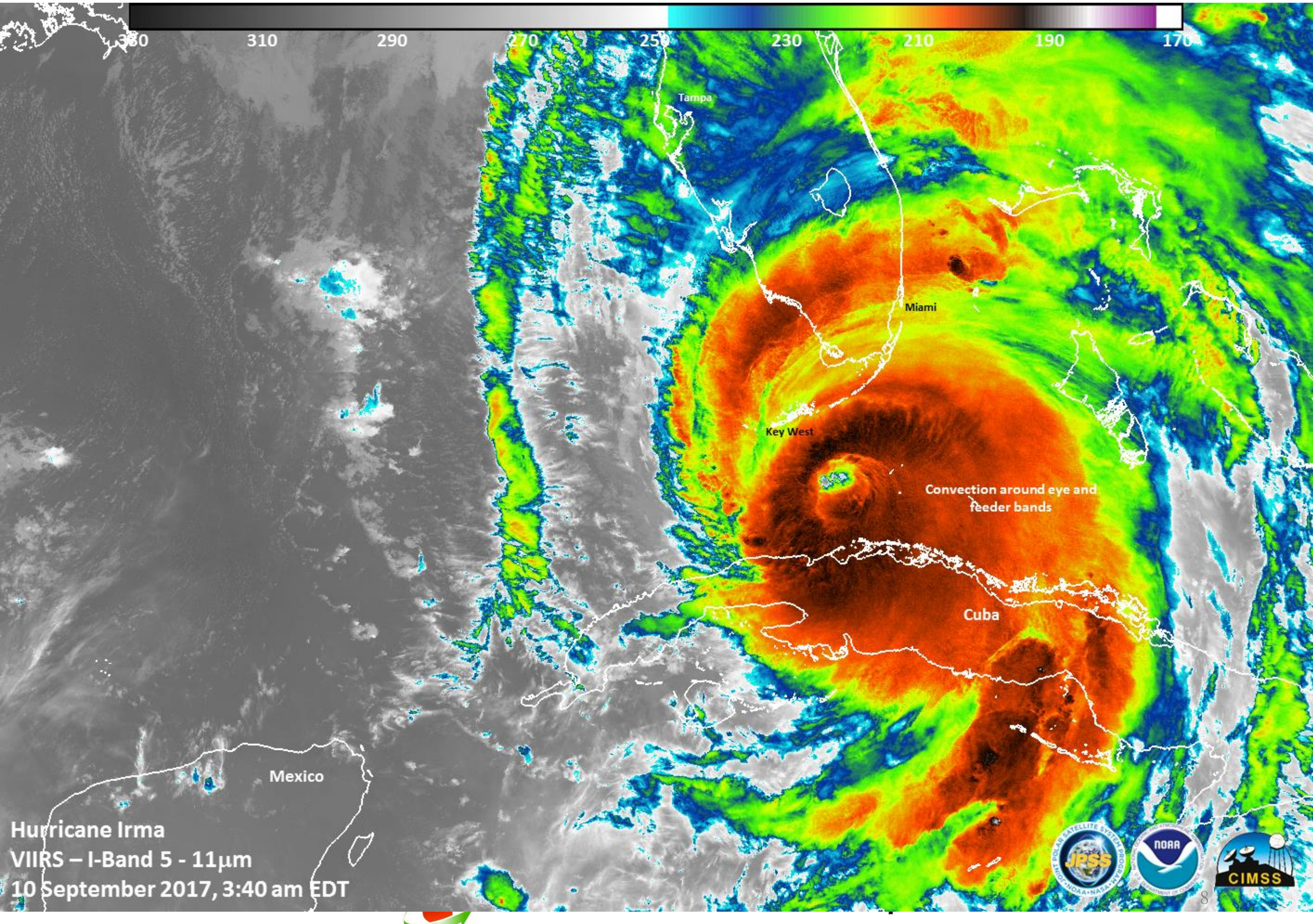
Lumberton, NC

Conway, SC

Images: National Oceanic & Atmospheric Administration / National Hurricane Center

Examples of Damage Caused By Hurricane Florence

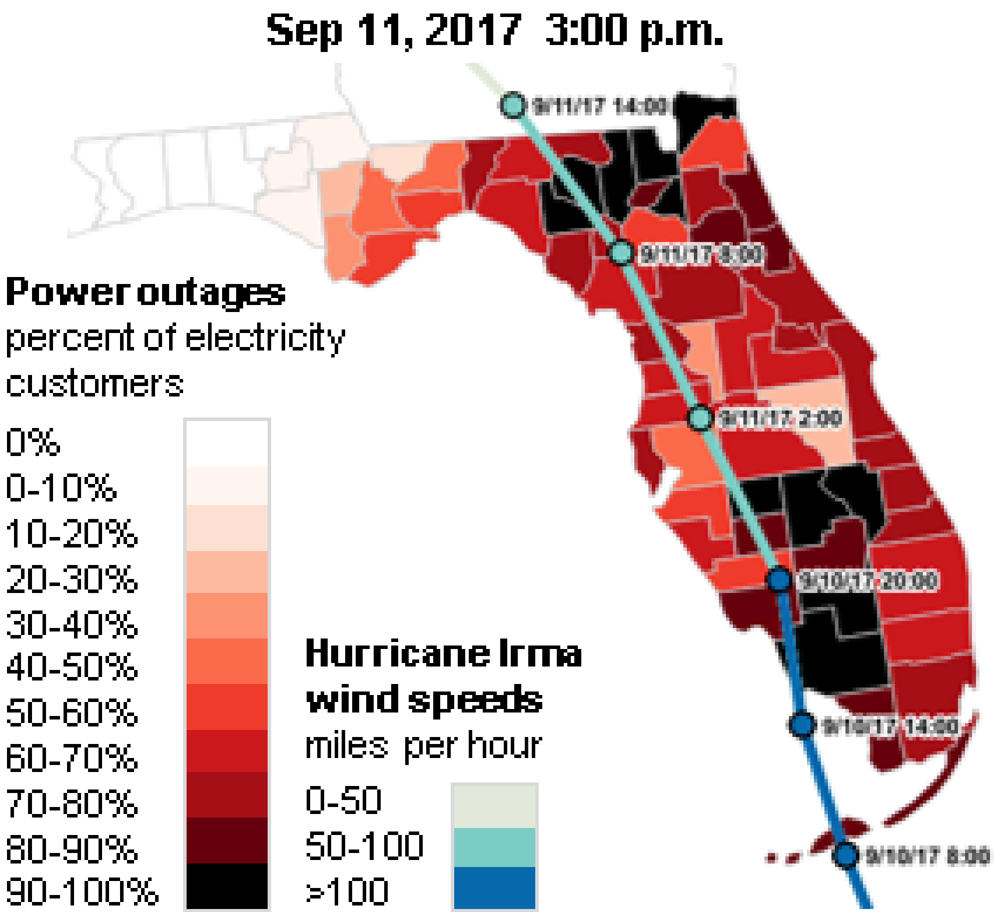
Images: Duke University Marine Lab / Curtis Construction


330
310
290
270
250
230
210
190
170
Tampa
Miami
Key West
Convection around eye and feeder bands
Cuba
Mexico
Hurricane Irma
VIIRS – I-Band 5 - 11μm
10 September 2017, 3:40 am EDT
JPSS
NOAA
CIMSS

Examples of Damage Caused By Hurricane Irma in Florida

Images: National Oceanic & Atmospheric Administration / National Hurricane Center

Power Outages in Florida from Hurricane Irma



Utility	Customers Affected in Excess of
Tampa Electric	425,000
Florida Power & Light	4,400,000
Duke Energy	1,000,000
Gulf Power	13,000
Florida Electric Cooperatives	760,000
Municipal Utilities	800,000

Source: US DOE EIA / Florida Division of Emergency Management

Hurricane Irma Impacts on Healthcare Facilities

As of 15 Sep 2017, 5 days after landfall

Assisted Living Facilities:

- 193 are utilizing generators
- 1,978 have power
- 182 have reported as being closed
- 177 have reported post-storm evacuations

Nursing Homes:

- 34 are utilizing generators
- 669 have power
- 10 have reported being closed
- 40 have reported post-storm evacuations

Hospitals:

- 2 are utilizing generators
- 299 have power
- 8 have reported being closed
- 7 have reported post-storm evacuations

Source: Florida Division of Health - http://www.floridahealth.gov/newsroom/2017/09/091517-health-care-facility.html

Recent Assessments of the Cost of Power Outages

Study author	Parameters	Annual cost
Galvin Electricity Initiative (Rouse and Kelly 2011)	Cost of losses due to power outages	$150 billion (about 4 cents for every kWh consumed nationwide)
Lawrence Berkeley National Laboratory (LaCommare and Eto 2006)	Cost of poor energy reliability and poor power quality	$79 billion
Hartford Steam Boiler and Atmospheric and Environmental Research (AER and HSB 2013)	Cost of power outages	$100 billion
Executive Office of the President (2013)	Cost of weather-related outages over five minutes	$18–33 billion
Institute of Electrical and Electronics Engineers (Bhattacharyya and Cobben 2011)	Cost of poor power quality	$119–188 billion
Electric Power Research Institute (EPRI) (Hampson et al. 2013)	Cost of outages to “industrial and digital economy” businesses	$45.7 billion
EPRI (Hampson et al. 2013)	Cost of outages to entire US economy	$120–190 billion
US Congressional Research Service (Campbell 2012)	Cost of weather-related outages longer than five minutes	$25-70 billion

Source: ACEEE (2017) Valuing Distributed Energy Resources: Combined Heat and Power and the Modern Grid

Distributed Energy Resources Disaster Matrix

Ranking Criteria

Four basic criteria were used to estimate the vulnerability of a resource during each type of disaster event. They include the likelihood of experiencing:

1. *a fuel supply interruption,*
2. *damage to equipment,*
3. *performance limitations, or*
4. *a planned or forced shutdown*

○ *indicates the resource is unlikely to experience any impacts*

◒ *indicates the resource is likely to experience one, two, or three impacts*

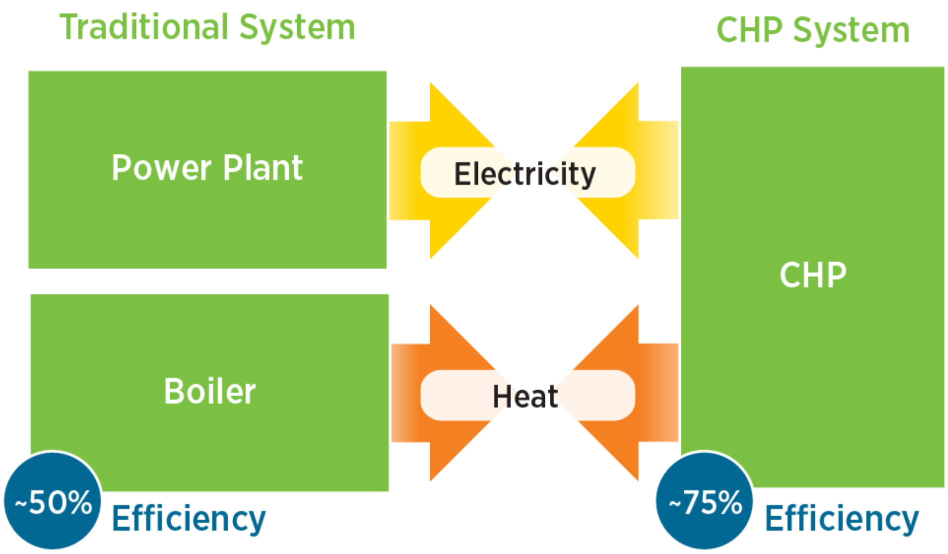
● *indicates the resource is likely to experience all four impacts*

Natural Disaster or Storm Events	*Flooding*	*High Winds*	*Earthquakes*	*Wildfires*	*Snow/Ice*	*Extreme Temperature*
Battery Storage	◒	○	◒	●	○	◒
Biomass/Biogas CHP	◒	◒	◒	●	○	○
Distributed Solar	○	◒	◒	●	◒	◒
Distributed Wind	○	◒	◒	◒	◒	◒
Natural Gas CHP	○	○	◒	◒	○	○
Standby Generators	◒	○	◒	●	◒	○

Source: DOE Better Buildings (2018). Issue Brief: Distributed Energy Resources Disaster Matrix

CHP: A Key Part of Our Energy Future

- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



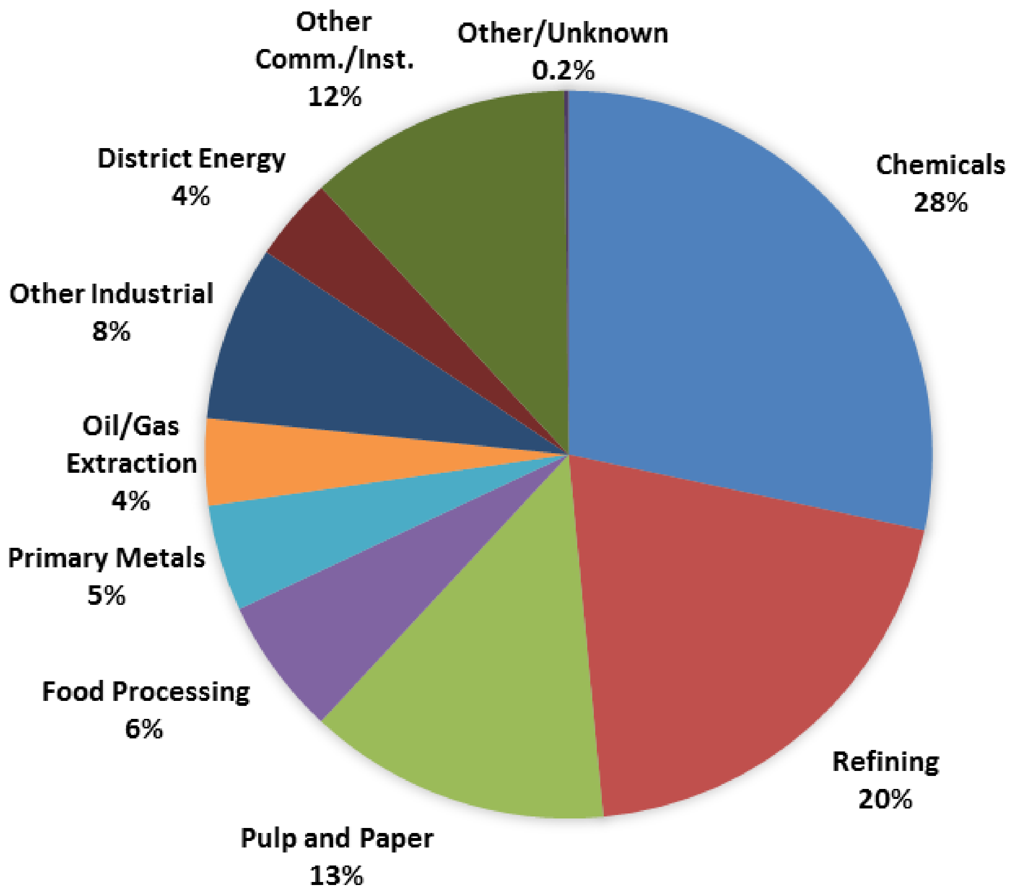
CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: www.energy.gov/chp

What Are the Benefits of Combined Heat and Power?

- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- Higher efficiency **reduces emissions** of pollutants
- CHP can also increase **energy reliability** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.

CHP Today in the United States



- **81.3 GW** of installed CHP at more than 4,400 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

Source: DOE CHP Installation Database (U.S. installations as of December 31, 2017)

Critical Facilities in Florida that Maintained Operations during Hurricane Irma with CHP

GRU South Energy Center / Shands Hospital

Miami-Dade South District WWTP

St. Josephs Hospital, Tampa

Eight Flags Energy Center, Fernandina Beach

Critical Facilities in Puerto Rico that Maintained Operations during Hurricane Maria with CHP

CARIBBEAN BUSINESS Thursday, June 21, 2018 PUERTO RICO 11

Turn on the Heat at Hospital de La Concepción, Empire Gas

Cogeneration or CHP Provided Electricity, Useful Heat After Hurricanes; Olein Refinery Operates Off-Grid

BY EVA LLORÉNS VÉLEZ
e.llorens@cb.pr

Hurricane Maria destroyed Puerto Rico's electrical system, leaving everyone in the dark. However, several facilities continued to operate after the storm simply because they had their own power systems.

These companies were Empire Gas, Hospital de La Concepción in San Germán and Olein Refinery & Lubricants Corp. in Yabucoa. The companies' facilities have cogeneration or combined heat & power (CHP) systems to generate electricity and useful heat at the same time. Empire Gas has a trigeneration system that simultaneously produces electricity and useful heating and cooling through fuel combustion, in this case propane.

Ramón González Simounet, vice president of Empire Gas, said that for the past few years, the company has not only provided propane gas but has also transformed into a power company by helping design power systems that use propane gas. "We also expect to be able to generate power with liquefied natural gas when it becomes efficient for the market," he said. Empire Gas, which has more than 500 workers, and its partners helped the hospital and Olein set up their CHP systems.

Marlon Cabrera, a mechanical engineer at Empire Gas, noted that these three facilities are examples of resiliency. Empire Gas not only provided them gas after the 2017 hurricanes but also continued to supply [gas] to allow them to operate. "The hospital was the only one that remained 100 percent operational.... Olein Refinery began to operate and distribute its oil barely two days after the hurricane [Maria]," he said.

The experience of these three facilities demonstrates Puerto Rico's need to move from a centralized energy system in which power generation is located in one area of the island to a distributed energy system in which energy generation is close to the consumer.

But cogeneration or CHPs provide more reliability. That is because these efficient systems also capture heat and turn it into energy.

González said Olein Gas is "operating as an island" because it no longer is connected to the Puerto Rico Electric Power Authority (Prepa) grid. The company opted to build a CHP because it was losing money from power interruptions.

"They were supposed to payback for the project in three years, but because of the high sales volume and they had no power interruptions, they will now be able to pay off the loans for their equipment in a year," he said.

Roberto Acosta, president of Accurate Solutions, designed the CHP system at La Concepción Hospital, a 167-bed healthcare facility in San Germán. "CHP systems in hospitals are not new," he said.

Hospital La Concepción not only continued to perform surgeries when all other hospitals became inoperable after losing power but also provided dialysis services to patients in the island's western region and conducted more than 60,000 laboratory tests.

> "Besides saving money on energy costs, the hospital was also able to save lives.
>
> —Roberto Acosta, president of Accurate Solutions

"The hospital served as a base because the Regional Hospital in Mayagüez had to shut down," he said.

Acosta said La Concepción's CHP generates about 1,200 kilowatts (kWh) of energy per hour and operates at 83 percent energy eff*iciency. "We are operating at 8.67 cents per kWh, but when we recuperate the heat, we save two more cents," he said.

The hospital is expected to see its return on investment in six years because it made additional upgrades. The equipment uses propane gas to operate because it is the cheapest fuel available.

"Besides saving money on energy costs, the hospital was also able to save lives," he said.

Empire Gas, according to González, implemented a "redundancy plan" that allowed it to continue to receive supplies at two terminals in the island's southern and northern regions. The company has the Pro-Caribe terminal, which he described as the heart of the company, where a CHP plant is also located. Pro-Caribe's operations, which he described as a "virtual gas duct," allowed the company to fill trucks with propane gas for distribution across the island after the hurricane. "We always have supplies for four months," he said.

Hospital de la Conceptión, San Germán

Matosantos Commercial, Vega Baja

Project Snapshot:
Resiliency and Cost Savings

UFHealth
UNIVERSITY OF FLORIDA HEALTH

GRU
More than Energy

Shands Hospital at University of Florida / Gainesville Regional Utilities

Gainesville, FL

Application/Industry: Hospitals

Capacity: 12 MW

Prime Mover: Gas turbine + Recip engine

Fuel Type: Natural gas

Thermal Use: Steam for heating and steam turbine chiller

Installation Year: 2009, 2017

Environmental Savings: Eliminates SO2 emissions, reduces NOx by 95%, and reduces CO2 by 58%

Highlights: GRU financed, owns and operates the South Energy Center as part of a 50 year agreement to provide electricity, steam, and chilled water to the hospital. The hospital accrued $30M in capital savings from not building its own central plant.

Project Snapshot:

Utility–Industry Partnership, Critical Infrastructure Resiliency

Eight Flags Energy Center
Chesapeake Utilities /
Florida Public Utilities Corp
Fernandina Beach, FL

Application/Industry: Utility/Industrial
Capacity: 22 MW
Prime Mover: Gas turbine
Fuel Type: Natural gas
Thermal Use: Steam for Rayonier plant
Installation Year: 2014
Efficiency: 78%
Net Annual Savings: $7.3 million

Testimonials: *“We’re excited to launch the Company’s first CHP plant as we continue to expand our footprint and develop smart energy offerings, further diversifying our business.”*
- Michael P. McMasters, President and Chief Executive Officer, Chesapeake Utilities Corporation

“The Eight Flags Energy CHP system is a welcome addition to the Fernandina plant, improving our reliability and the robustness of our operations.”
- C.A. McDonald, Plant Manager, Rayonier Advanced Materials

Source: http://www.chpk.com/eight-flags-energy/

Project Snapshot:

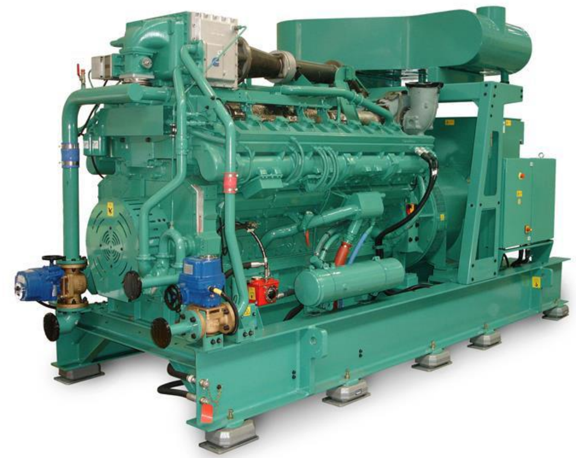
Multi-fuel Resiliency for Critical Infrastructure

Miami Dade Water & Sewer Dept.
South District WWTP
Miami, FL

Application/Industry: Wastewater Treatment
Capacity: 8 MW
Prime Mover: 4 reciprocating engines
Fuel Type: Digester, landfill or natural gas
Thermal Use: Digester process heat, absorption cooling
Installation Year: 1991, expanded 2014
Energy Savings: $2.16 million per year in electricity cost savings

Testimonial: *"Using all biogas provides a cost savings of approximately $650,000 per year per 2 megawatt cogeneration unit operating on biogas and natural gas. Not only would we be less dependent on purchasing electricity, thus realizing a cost-savings, but utilizing the methane gas in this method is also an environmental benefit."*
- Lester Sola, Miami-Dade WASD Director

MIAMI-DADE COUNTY



Cummins C2000 Engine-Generator

Aerial View of South District WWTP

Source: Miami Dade Water & Sewer, Brown & Caldwell

What do we mean by a Microgrid?

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. - *DOE Microgrid Exchange Group 2010*

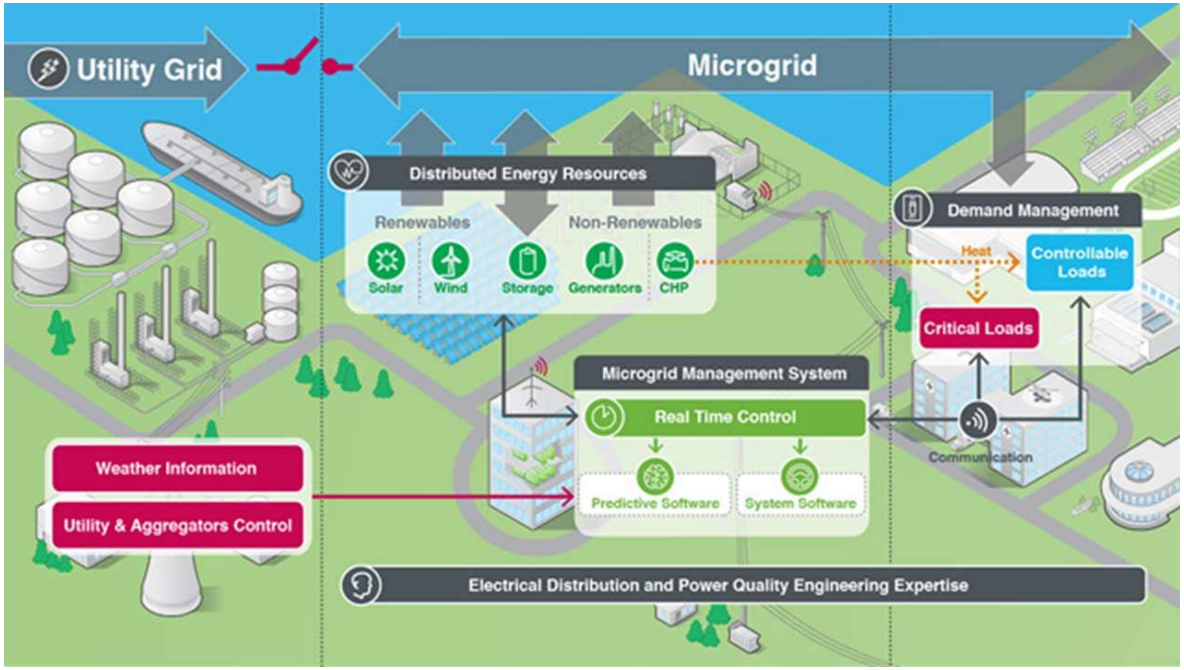


Diagram: Schneider Electric, Montgomery County, MD

Montgomery County, MD
Public Safety Headquarters Microgrid

- Storms in the summer of 2012 left police and emergency workers without power
- Solution: Microgrid with CHP, solar & storage
- Financing Partnership with Schneider Electric & Duke Renewables
- Components:
  - 800kW CHP
  - 2 MW Canopy Mounted Solar
  - Absorption Chillers – thermally powered from CHP
  - Battery Storage
- 2nd project at Correctional Facility planned
- http://www.montgomerycountymd.gov/dgs-oes/

Image: Montgomery County, MD

Critical Infrastructure and Resiliency Benefits of Combined Heat and Power with Microgrids

"Critical infrastructure" refers to those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, national economic security, or national public health and safety."

Patriot Act of 2001 Section 1016 (e)

Applications:

- Hospitals and healthcare centers
- Water / wastewater treatment plants
- Police, fire, and public safety
- Centers of refuge (often schools or universities)
- Military/National Security
- Food distribution facilities
- Telecom and data centers

CHP (if properly configured):

- Offers the opportunity to improve Critical Infrastructure (CI) resiliency
- Can continue to operate, providing uninterrupted supply of electricity and heating/cooling to the host facility

State and Local Role in Policies for CHP

CHP adoption can also be supported by state and local action

Policy Actions

- State public utility commissions can facilitate CHP installations by:
  - Including CHP as a qualified resource in EE or renewable resource standards
  - Including CHP in utility or state ratepayer-funded efficiency programs
  - Standardizing interconnection requirements
  - Assess standby rates for impact on CHP projects
  - Pursuing models of utility ownership, including CHP in utility resource plans
  - Incorporating the non-energy benefits of CHP into cost-effectiveness calculations, including resiliency and grid stability
- Local policymakers can streamline CHP installations by including CHP in local permitting codes and inspector training.

Implementation Actions with help of CHP TAPs

State and local CHP implementation is supported by offering:

- Training, outreach, and enforcement of building efficiency policies and codes
- Outreach and technical assistance regarding the energy efficiency and non-energy benefits of CHP

Examples of State CHP Policy Implementation for Resilience

Following Superstorm Sandy in 2012,

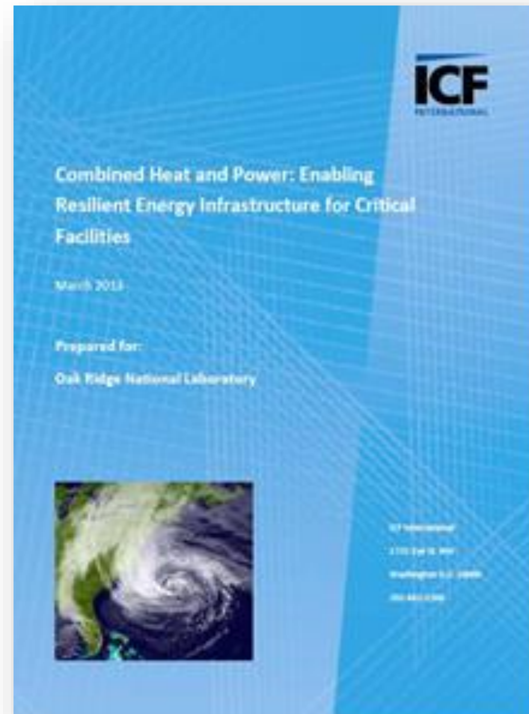
- New Jersey created the Energy Resilience Bank which is operated by New Jersey's Economic Development Authority to provide a grant/loan product that covers 100% of the cost of implementing resilient CHP systems. There are ten hospitals in NJ approved to move forward with projects.
- The New York State Energy Research and Development Authority (NYSERDA) CHP Program provides incentives for New York CHP installations. Following issues with some initial designs identified during the 2003 Northeast blackout, NYSERDA required that to qualify for incentives, future installations must have islanding capability so that the CHP system would operate and support operation during blackouts.
- Connecticut initiated a first in nation Microgrid Pilot Program, and conducted information and outreach webinars, explaining the central role of CHP in an economically successful microgrid.
- The Northeast CHP TAP contributed to NYC Mayor Bloomberg's June 11, 2013, report "A Stronger, More Resilient New York", "a comprehensive plan that contains actionable recommendations both for rebuilding the communities impacted by Sandy and increasing the resilience of infrastructure and buildings citywide."

More Example State CHP Policies

- After Hurricane Ike in 2008, to reduce power outage and losses during a natural disaster event, the Texas state legislature passed HB 1831 and HB 4409 in 2009. This legislation requires the state to identify all critical infrastructure assets conduct an economic feasibility analysis of CHP for all major renovations and new construction.
- The Louisiana legislature passed a similar law (Resolution No. 171) in 2012.
- In October 2015, the Missouri Department of Economic Development, Division of Energy, published the "Missouri Comprehensive State Energy Plan" which includes recommendations to incorporate CHP based on energy savings, meeting state energy goals, and providing energy security benefits.
- The Missouri Department of Economic Development, Division of Energy joined the US DOE CHP Resiliency Accelerator and identified hospitals as a target market sector for its outreach. The Illinois State Energy Assurance Plan supports the use of CHP in creating resiliency benefits for critical infrastructure and the grid as a whole.
- The Michigan Agency for Energy sponsored the "CHP Roadmap for Michigan," research paper. This report models future CHP penetration given a number of different scenarios and possible policies including efficiency incentives, utility rate reform and resiliency benefits.

DOE Report - Combined Heat and Power: Enabling Critical Infrastructure

- Provides context for CHP in critical infrastructure applications.
- Contains 14 case studies of CHP operating through grid outages.
- Policies promoting CHP in critical infrastructure.
- Recommendations on how to design CHP for reliability

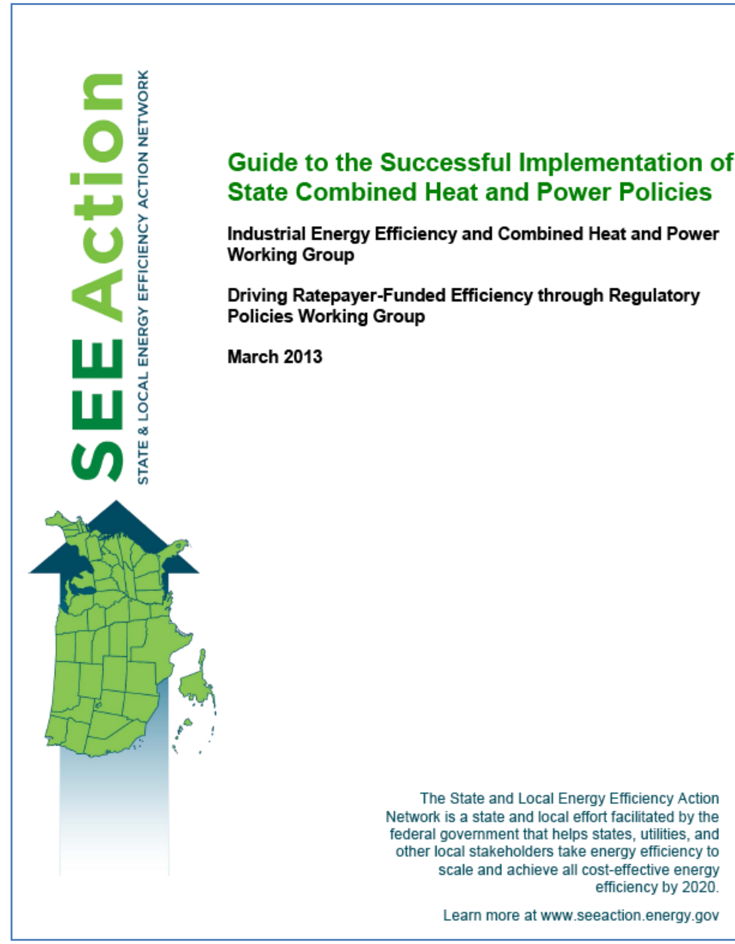


http://www.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf

SEE Action Guide to…State CHP Policies

The Guide provides state policy makers with actionable information regarding:

- Design of standby rates
- Interconnection standards for CHP with no electricity export
- Excess power sales
- Clean energy portfolio standards
- Emerging market opportunities: CHP in critical infrastructure and utility participation in CHP markets


SEE Action
STATE & LOCAL ENERGY EFFICIENCY ACTION NETWORK

Guide to the Successful Implementation of State Combined Heat and Power Policies

Industrial Energy Efficiency and Combined Heat and Power Working Group

Driving Ratepayer-Funded Efficiency through Regulatory Policies Working Group

March 2013

The State and Local Energy Efficiency Action Network is a state and local effort facilitated by the federal government that helps states, utilities, and other local stakeholders take energy efficiency to scale and achieve all cost-effective energy efficiency by 2020.

Learn more at www.seeaction.energy.gov

CHP TAP Role: Technical Assistance

Screening and Preliminary Analysis

Quick screening questions with spreadsheet payback calculator; Advanced technical assistance to explore equipment or operational scenarios.

Feasibility Analysis

Perform 3rd Party reviews of site feasibility assessments: Estimates on savings, installation costs, simple paybacks, equipment sizing, and type.

Investment Grade Analysis

Perform 3rd Party reviews of Engineering Analysis. Review equipment sizing and choices.

Procurement, Operations, Maintenance, Commissioning

Review specifications and bids.

Summary

- CHP gets the most out of a fuel source, enabling
  - High overall utilization efficiencies
  - Reduced environmental footprint
  - Reduced operating costs
- CHP is the key component in **critical infrastructure microgrids**, which can be configured to include solar PV and other distributed generation
- CHP offers **proven applications** with commercially available technologies that cover a range of needs
- **DOE CHP TAPs** are a resource for policy information and technical assistance to critical infrastructure facilities interested in CHP

Next Steps

Contact the Southeast CHP TAP for assistance if:

- Interested in having a Qualification Screening performed to determine if there is an opportunity for CHP at your site
- If you already have an existing CHP plant and interested in expanding it
- Need an unbiased 3rd Party Review of a proposal
- Interested in further information on best practice state policies for CHP to support energy resilience, including through a webinar or face-to-face meeting

Thank you!

Isaac Panzarella
Director,
DOE Southeast CHP TAP
NC Clean Energy Technology Center
NC State University
Raleigh, NC
email: ipanzar@ncsu.edu
tel: 919 515 0354