Assembling a Grid Resiliency Toolbox: The Tools That Make it Possible

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Stefano Galiasso

Energy Resources Center

ERC is an interdisciplinary public service, research, and special projects organization that works to improve energy efficiency and the environment

- Founded in 1973, part of the College of Engineering at the University of Illinois-Chicago

Domain of expertise:

- Combined Heat and Power
- Energy Efficiency
- Bioenergy and Sustainable Landscapes
- Utility Billing Data Management

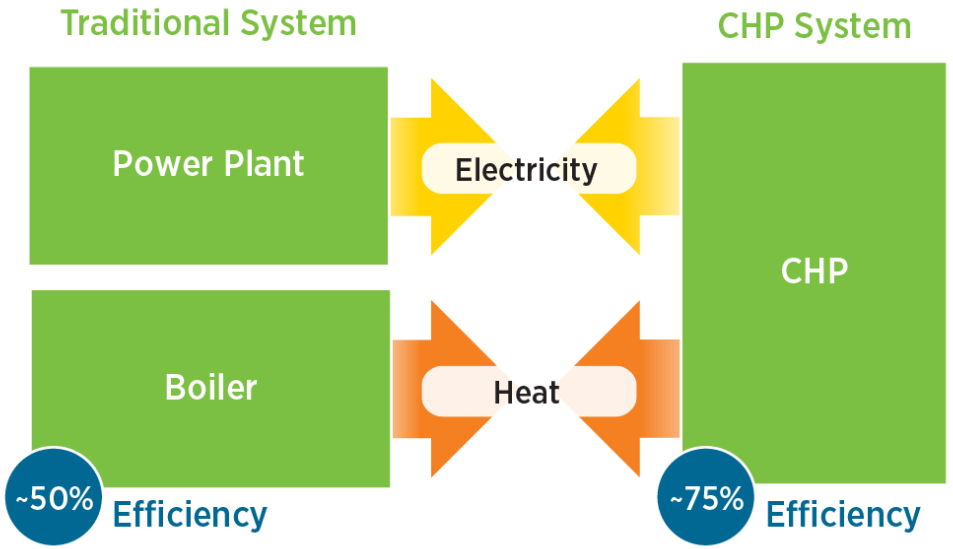
Primary services:

- Energy efficiency analysis, portfolio planning and potential studies
- Energy assessments and retro-commissioning
- Program implementation (niche markets, new technologies and pilot programs)
- Training program for engineering students: 10-15 students currently enrolled and in training

CHP for Grid Resiliency

Combined Heat and Power (CHP)

- 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: http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

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

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

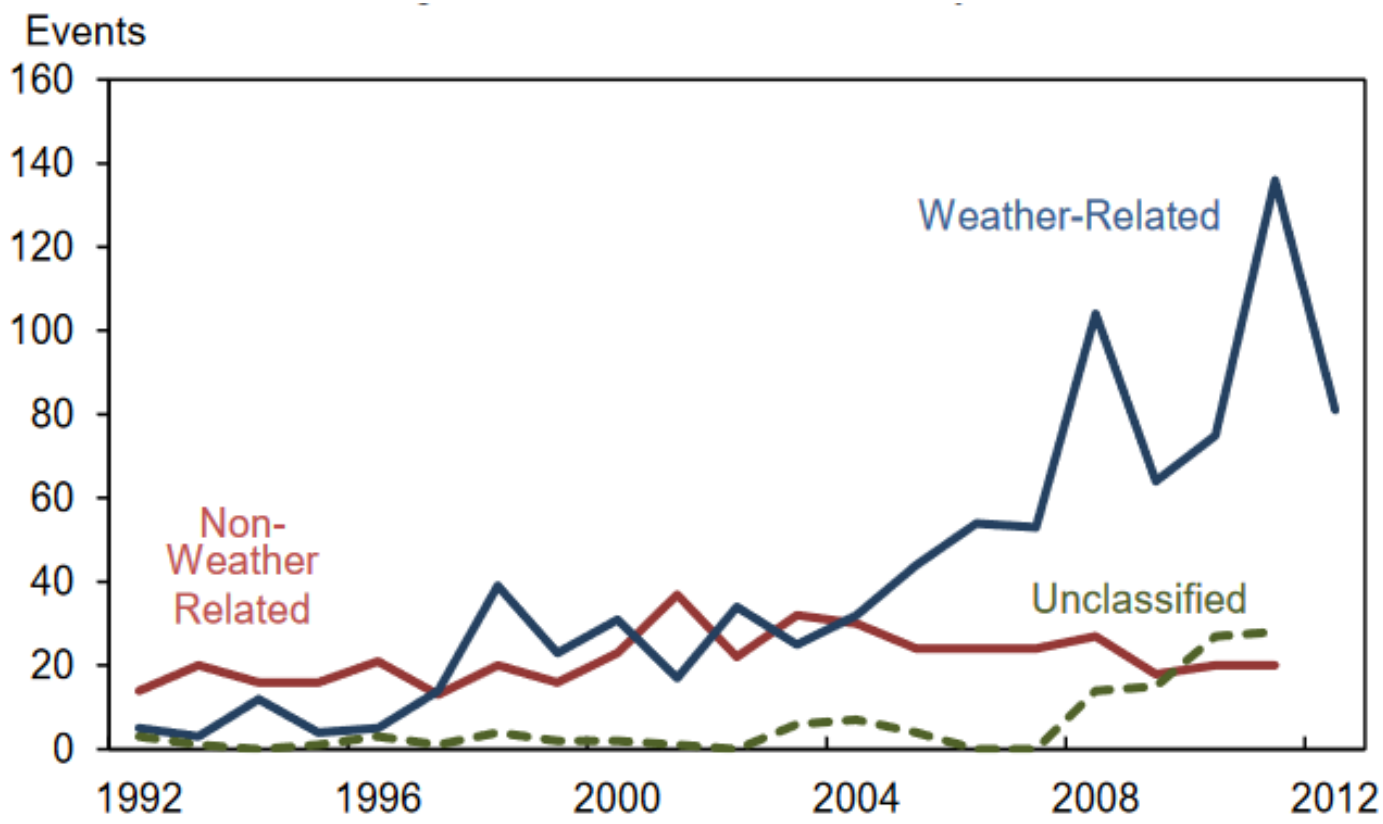
Uninterrupted Operation Requirements

- **Black start capability**
  - Allows the system to start up independently from the grid
- **Generators capable of grid-independent operation**
  - The system must be able to operate without the grid power signal
- **Ample carrying capacity**
  - System size must match critical loads
- **Parallel utility interconnection and switchgear controls**
  - The system must be able to disconnect from the grid, support critical loads, and reconnect after an event

CHP vs Backup Generation

	Backup Generator	CHP
System Performance	• Only used during emergencies	• Designed and maintained to run continuously • Improved performance reliability
Fuel Supply	• Limited by on-site storage	• Natural gas infrastructure typically not impacted by severe weather
Transition from Grid Power	• Lag time may impact critical system performance	• May be configured for “flicker-free” transfer from grid connection to “island mode”
Energy Supply	• Electricity	• Electricity • Thermal (heating, cooling, hot/chilled water)
Emissions	• Commonly use diesel fuel	• Typically natural gas fueled • Achieve greater system efficiencies (70+%) and lower emissions

Observed Outages to the Bulk Electric System, 1992 -2012



Source: Energy Information Administration

CHP in Microgrids

CHP, District Energy & Microgrids: Combined Benefits

- **Energy Assurance:** The need for stable and sustainable energy supply at sites
- **Reliability:** The need for greater resilience and reliability, risks, and financial costs
- **Clean Energy Development:** reducing greenhouse gas (GHG) and other emissions
- **Economic Development:** Imperatives for encouraging and facilitating economic development
- **Disruptive Technologies and Forces:** Transformative industry trends that make distributed generation (DG), energy storage, and energy management technologies more useful and cost-effective for a wider range of applications
- **Local Self-Reliance:** Energy end-users' interest in alternative service models, especially those that enhance local self-reliance, environmental quality, and economic health.

Microgrids & CHP

CHP can be the keystone of Resilient Microgrids:

- Reliable dispatchable power
- Provides thermal energy during grid outage
- Daily operating cost savings help offset costs of resilient microgrids
- CHP can reduce GHG emissions
- CHP can offset some capital costs associated with investments in traditional backup power

Resources

Case Studies for CHP and Critical Infrastructure:
https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf

Valuing DER: CHP and the Modern Grid:
https://aceee.org/sites/default/files/valuing-der.pdf

Alliance for Industrial Efficiency – 2 Page Fact Sheet: https://alliance4industrialefficiency.org/wp-content/uploads/2018/02/CHP-in-Disaster-Mitigation-Fact-Sheet.pdf

Guide to Using CHP for Enhancing Reliability and Resiliency in Buildings:
https://www.energy.gov/eere/amo/downloads/guide-using-combined-heat-and-power-enhancing-reliability-and-resiliency

Thank you!

Stefano Galiasso

Manager of Energy Efficiency Programs

Energy Resources Center (ERC)

University of Illinois at Chicago (UIC)

1309 S. Halsted Street, Chicago, Illinois 60607

O: 312.996.8646

sgalia2@uic.edu www.erc.uic.edu