Combined Heat and Power for Energy Savings, Environmental Responsibility, and Resiliency

CHP Workshop

Augusta, ME

April 3, 2019

S. David Dvorak, Ph.D., P.E.

CHP Technical Assistance Partnerships

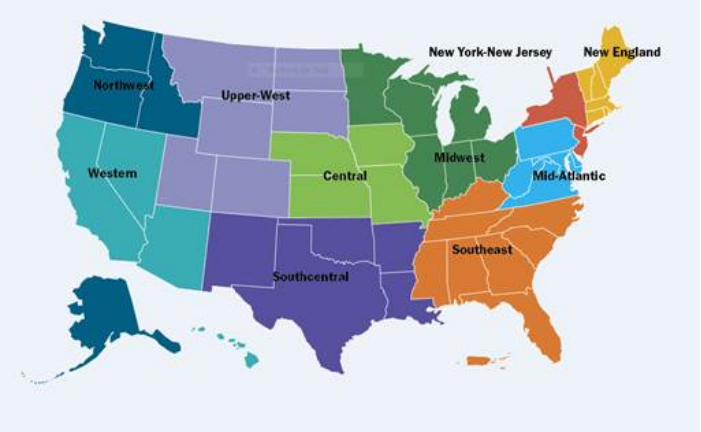
NEW ENGLAND

Outline

- Who we are, what we do
- CHP basics
- Existing Installations and Technical Potential
- Project Profiles
  - Energy Cost Reduction & Energy Efficiency
  - Environmental Responsibility
  - Reliability & Resiliency
- Technical Assistance
- Resources
- Next Steps

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

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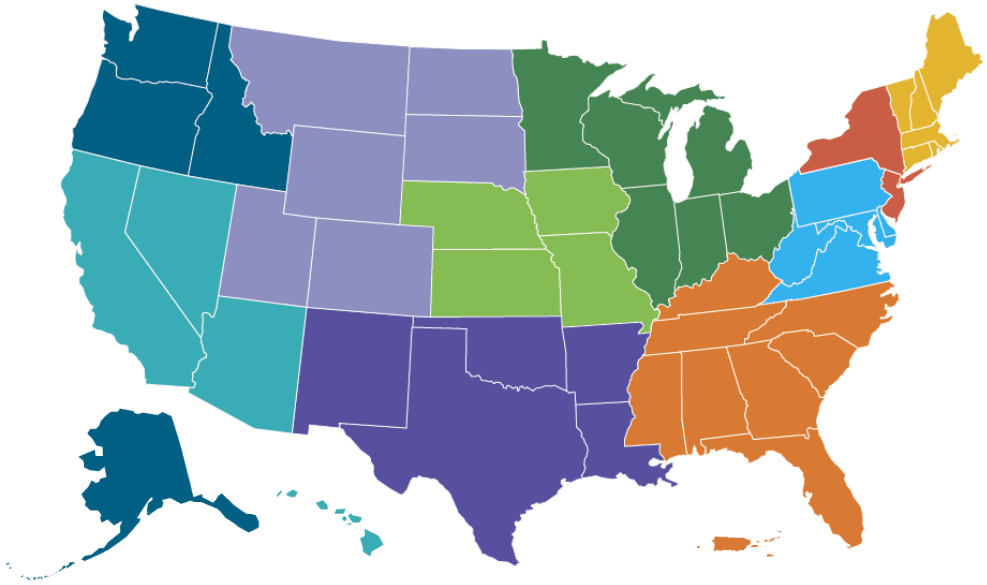

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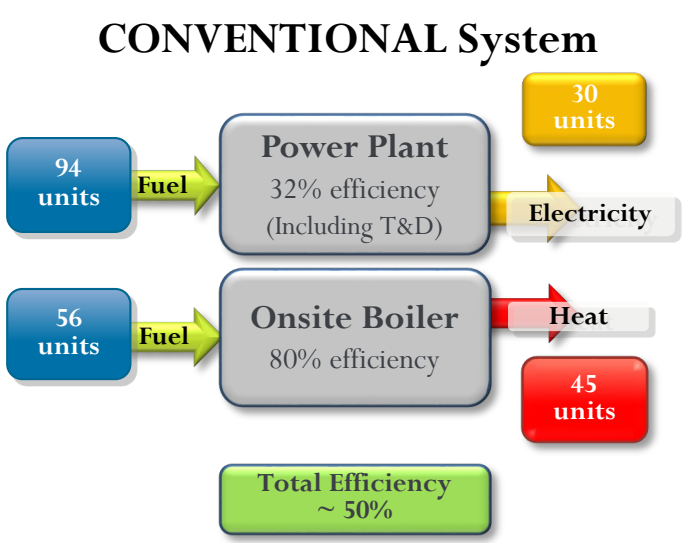
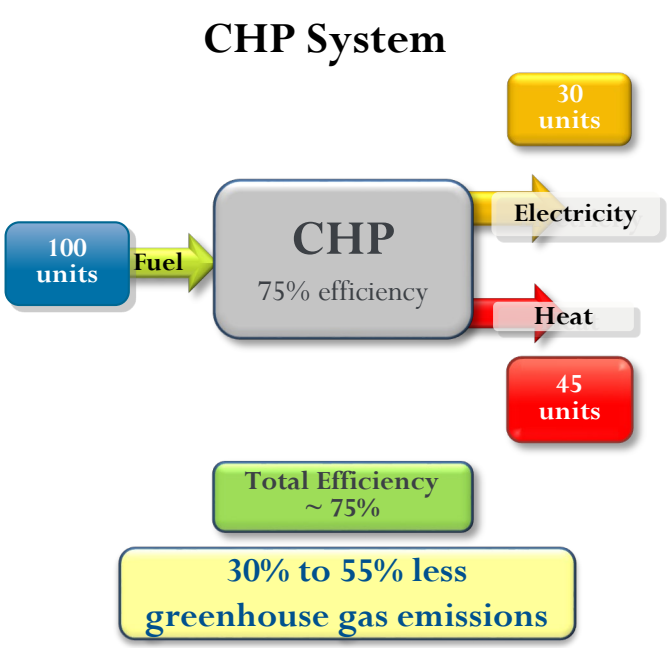
CHP: A Key Part of Our Energy Future





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

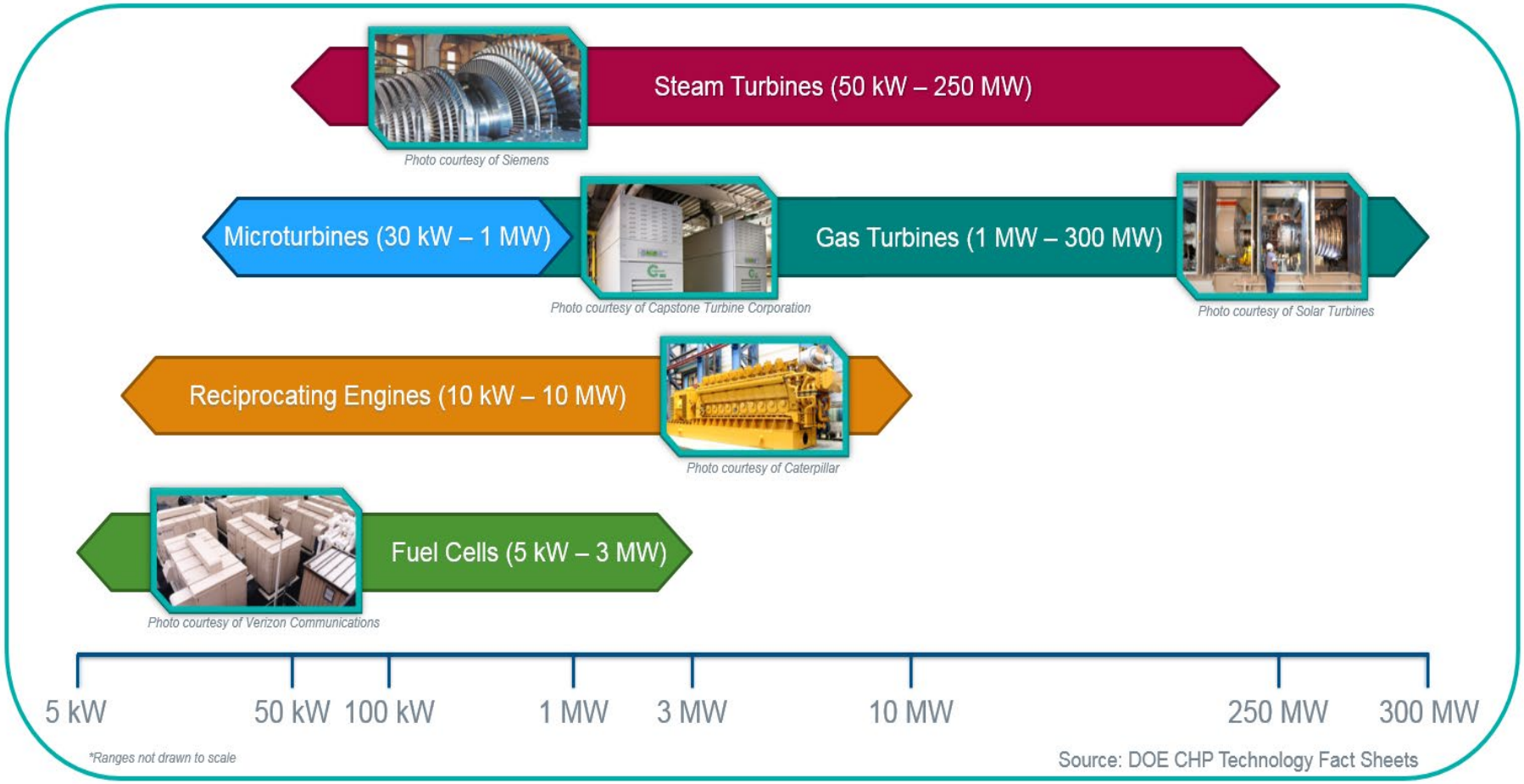
CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: www.energy.gov/chp

What Are the Benefits of CHP?

- 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 resiliency** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.

Common CHP Technologies and Capacity Ranges



CHP in the U.S. Represents a Variety of Fuels, Technologies, Sizes, and Applications

Industrial

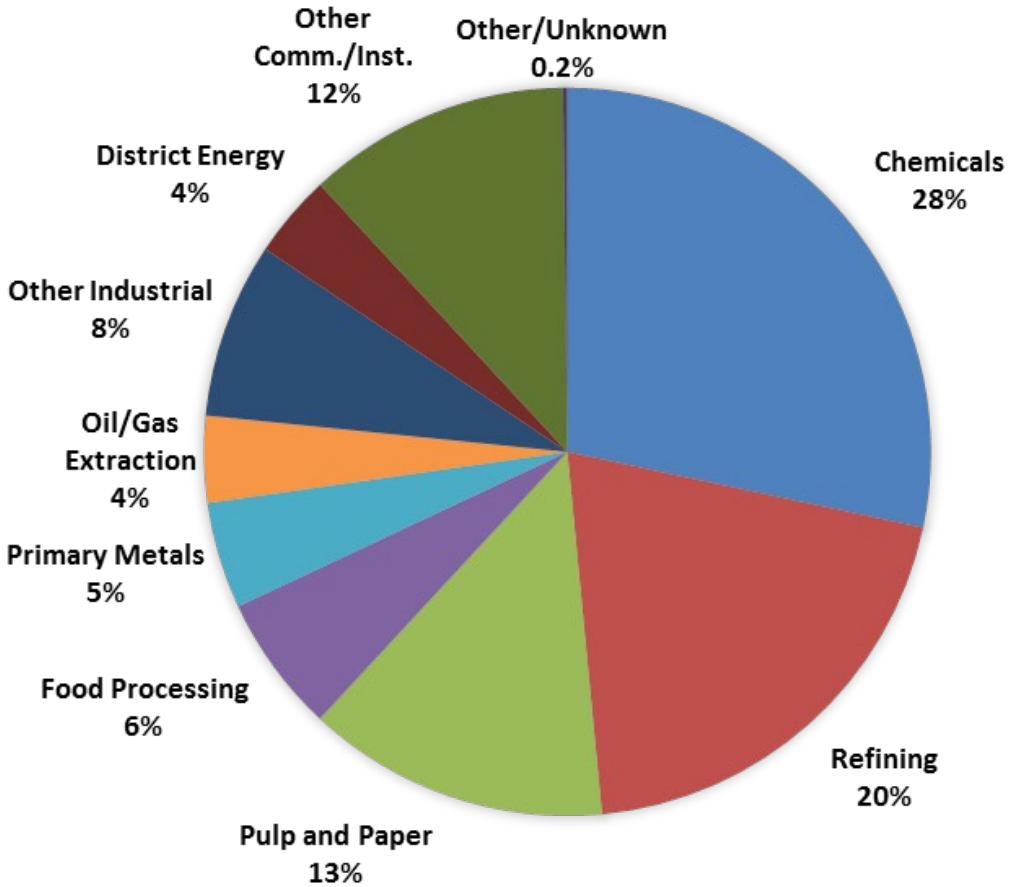
Institutional

Residential

Utility Scale

Commercial

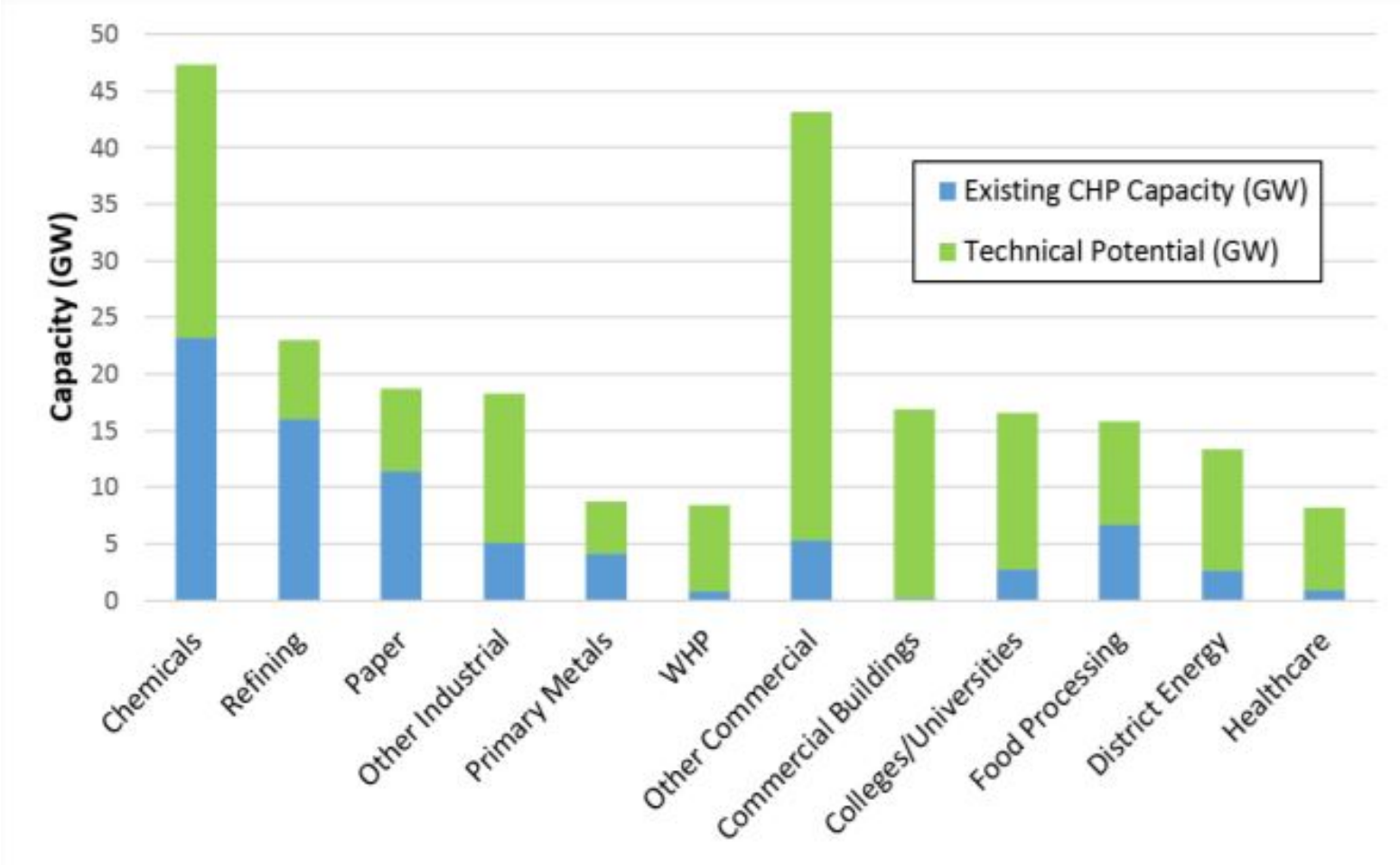
CHP Today in the United States



- **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)

Where is the Remaining Potential for CHP?



CHP Technical Assistance Partnerships
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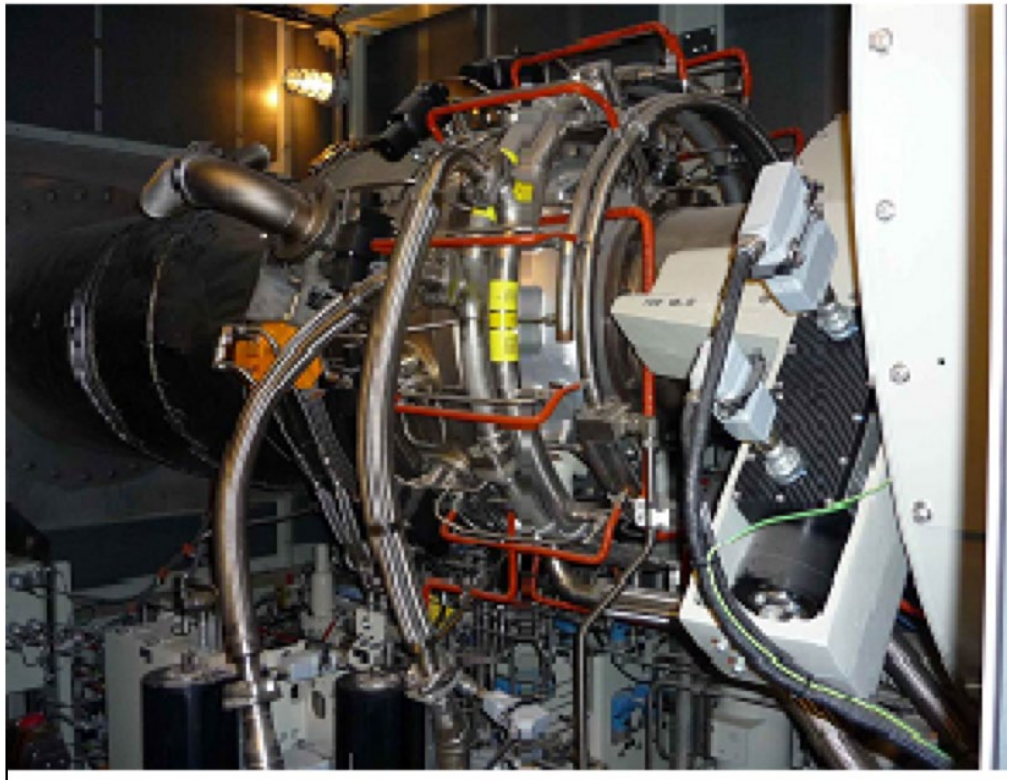
Project Snapshot:

Environmental Responsibility

- Smith College
- Northampton, MA
- Application/Industry: College
- Capacity: 3.5 MW
- Prime Mover: Combustion turbine
- Fuel Type: Natural gas
- Thermal Use: Heating, cooling & hot water
- Installation Year: 2008
- Testimonial: *"For several years, Smith has sought ways to reduce and manage the college's environmental impact. This new cogeneration system is a significant step in Smith's efforts to remain at the forefront of environmental responsibility."*
  - Carol T. Christ, former Smith College President



Source: http://northeastchptap.org/Data/Sites/5/documents/profiles/SmithCollege3.5MWCHPApplication.pdf

Project Snapshot:

Energy Security

Bradley Airport
Windsor Locks, CT

Application/Industry: Airport
Capacity (MW): 5.8 MW
Prime Mover: Reciprocating engines
Fuel Type: Natural gas
Thermal Use: Heating, cooling & hot water
Installation Year: 2002

Highlights: The primary motivation for establishing the combined heat and power energy (CHP) center was to increase energy security, as the airport was encountering numerous power outages from its central power supplier. Additionally, the airport wanted to lower its operating costs and decided that a CHP plant would allow for substantial operating cost savings when compared to conventional central heating/cooling plant.

Source: http://northeastchptap.org/Data/Sites/5/documents/profiles/BradleyAirportpp.pdf

Project Snapshot:

Power Reliability

Toray Plastics America
North Kingstown, RI

Application/Industry: Manufacturing
Capacity: 20 MW
Prime Mover: Gas turbine and reciprocating engines
Fuel Type: Natural gas
Thermal Use: Space heating, steam and chilled water for industrial processes
Installation Year: 2002 and 2014

Highlights: A brief disruption in power supply can cause manufacturing to go down for as long as eight hours, and that lost production time is very costly. Now in the case of instability or an outage on the power grid, the facility goes automatically into island mode to operate independently using the CHP system. CHP has reduced operating costs and improved the reliability of the facility's electric supply.

TORAY
Innovation by Chemistry
Toray Plastics (America), Inc.

Source: http://www.northeastchptap.org/Data/Sites/5/documents/profiles/ToraycHP.pdf

Project Snapshot:
Resiliency and Disaster Relief

South Oaks Hospital
Amityville, NY

Application/Industry: Healthcare

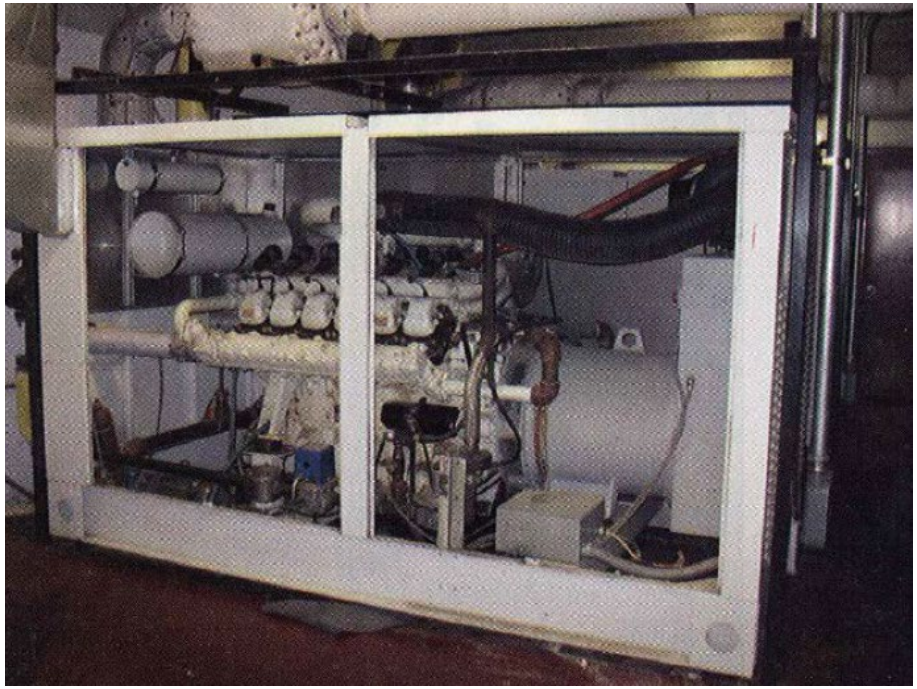
Capacity: 1.25 MW

Prime Mover: Reciprocating engines

Fuel Type: Natural gas

Thermal Use: Steam, cooling, hot water
Installation Year: 2007

Highlights: After Superstorm Sandy, South Oaks continued to provide critical health services for two weeks relying solely on its CHP system. They admitted patients displaced from other sites, refrigerated vital medicines, and welcomed staff and local community to recharge electronic devices and shower. South Oaks' previous CHP system operated continuously through the Northeast Blackout of 2003 as well. South Oaks' leadership, management team, and staff agree that CHP has served them well for more than 20 years.



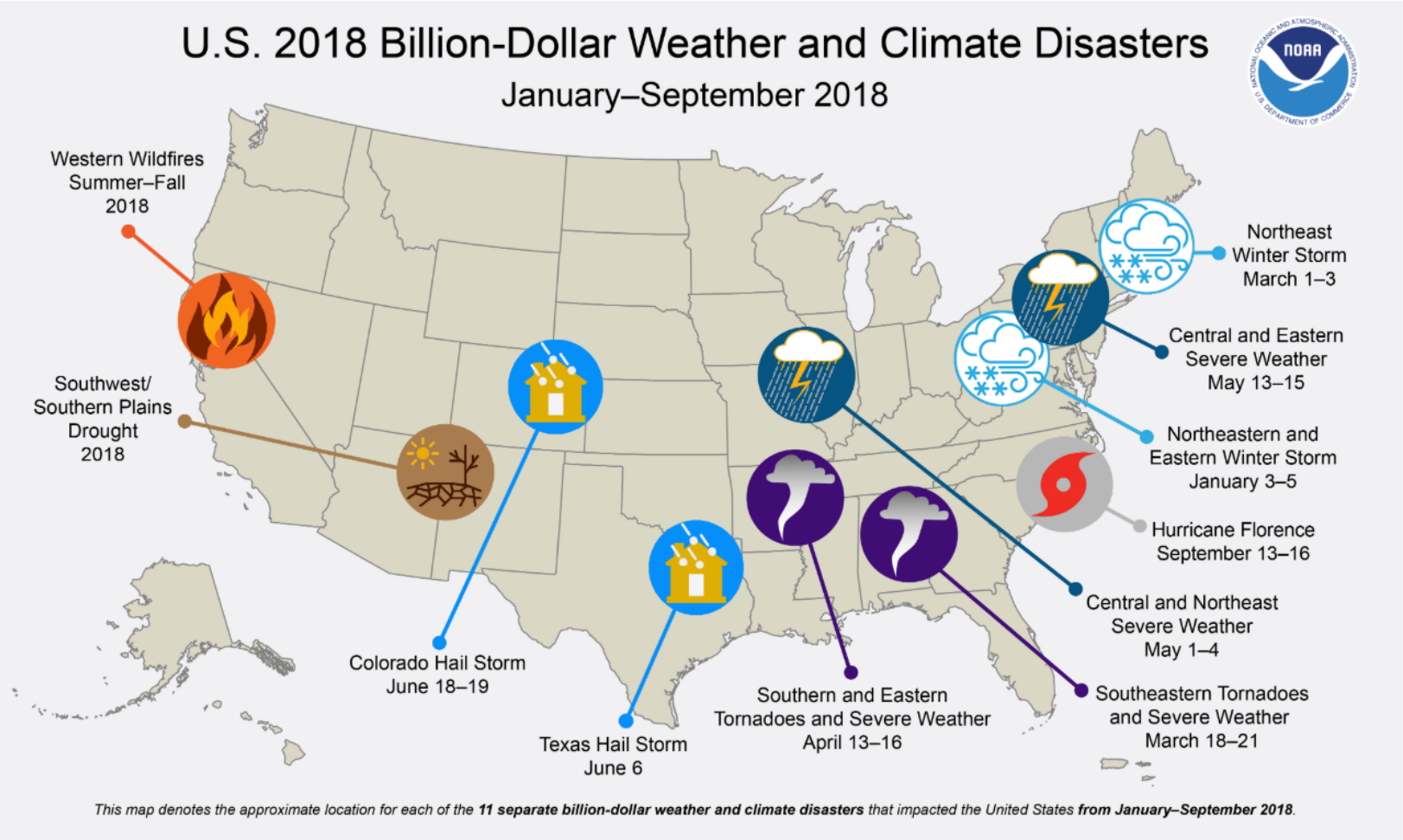
Source: http://energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march

Defining Resilience and Reliability

- **Resilience:** the ability of an entity—e.g., asset, organization, community, region—to anticipate, resist, absorb, respond to, adapt to, and recover from a disturbance
  - Reducing the magnitude and duration of energy service disruptions
- **Reliability:** the ability of the electric power system to deliver the required quantity and quality of electricity demanded by end-users

Source: State Energy Resilience Framework, Argonne National Laboratory (2017)

Power Outages are Costly



Valuing Resiliency and Reliability

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 – Valuing Distributed Energy Resources – CHP and the Modern Grid 2018

What was the cost of the August 2003 Northeast cascading blackout? What would be the cost today?

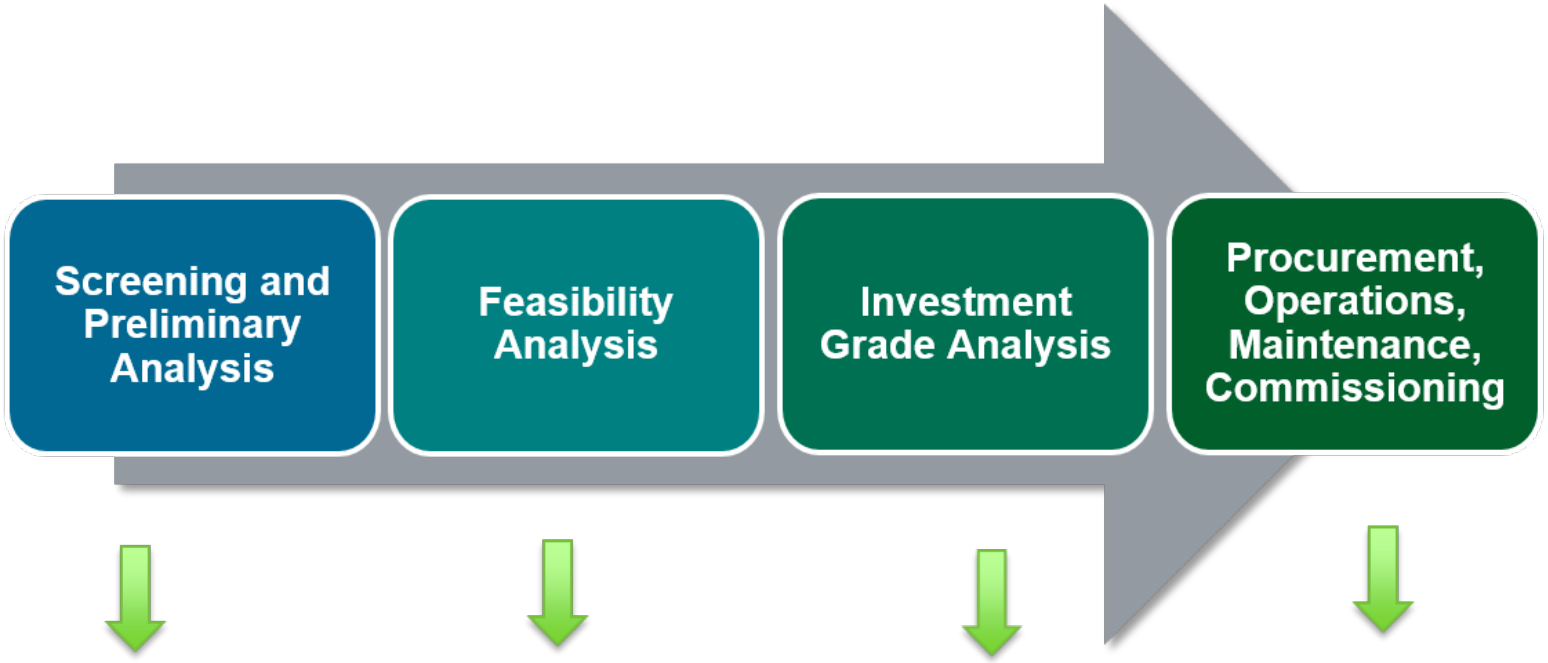
CHP Increases Resilience and Reliability

- For end users:
  - Provides continuous supply of electricity and thermal energy for critical loads
  - Can be configured to automatically switch to “island mode” during a utility outage, and to “black start” without grid power
  - Ability to withstand long, multiday outages
- For utilities:
  - Enhances grid stability and relieves grid congestion
  - Enables microgrid deployment for balancing renewable power and providing a diverse generation mix
- For communities:
  - Keeps critical facilities like hospitals and emergency services operating and responsive to community needs

Packaged CHP Systems

- CHP technology advancements allow for standardized packaged CHP systems
  - Most systems range from 10 kW to 2 MW
- Packaged systems expected to expand the CHP market to new customers
  - Avoid costs and delays associated with customized engineering and design
  - 26 GW of CHP technical potential in the 50-499 kW size range
- Packaged systems are increasingly including solar PV in addition to CHP equipment
- DOE Packaged CHP eCatalog seeks to increase package options up to 10 MW

CHP TAP Role: Technical Assistance



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

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

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

Review specifications and bids.

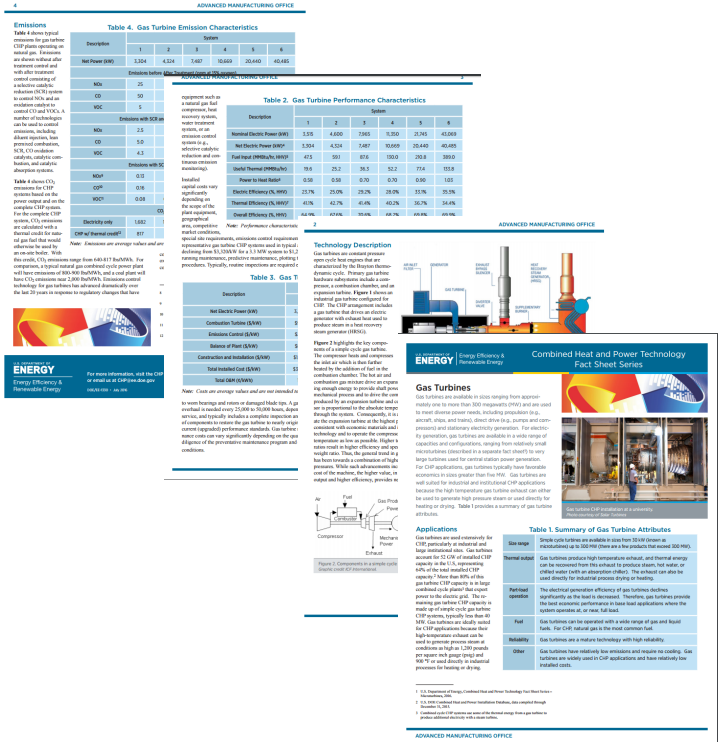
DOE TAP CHP Screening Analysis

- **High level assessment to determine if site shows potential for a CHP project**
  - **Qualitative Analysis**
    - Energy Consumption & Costs
    - Estimated Energy Savings & Payback
    - CHP System Sizing
  - **Quantitative Analysis**
    - Understanding project drivers
    - Understanding site peculiarities

Annual Energy Consumption	Base Case	CHP Case
Purchased Electricty, kWh	88,250,160	5,534,150
Generated Electricity, kWh	0	82,716,010
On-site Thermal, MMBtu	426,000	18,872
CHP Thermal, MMBtu	0	407,128
Boiler Fuel, MMBtu	532,500	23,590
CHP Fuel, MMBtu	0	969,845
Total Fuel, MMBtu	532,500	993,435
Annual Operating Costs		
Purchased Electricity, $	$7,060,013	$1,104,460
Standby Power, $	$0	$0
On-site Thermal Fuel, $	$3,195,000	$141,539
CHP Fuel, $	$0	$5,819,071
Incremental O&M, $	$0	$744,444
Total Operating Costs, $	$10,255,013	$7,809,514
Simple Payback		
Annual Operating Savings, $		$2,445,499
Total Installed Costs, $/kW		$1,400
Total Installed Costs, $/k		$12,990,000
Simple Payback, Years		**5.3**
Operating Costs to Generate		
Fuel Costs, $/kWh		$0.070
Thermal Credit, $/kWh		($0.037)
Incremental O&M, $/kWh		$0.009
Total Operating Costs to Generate, $/kWh		**$0.042**

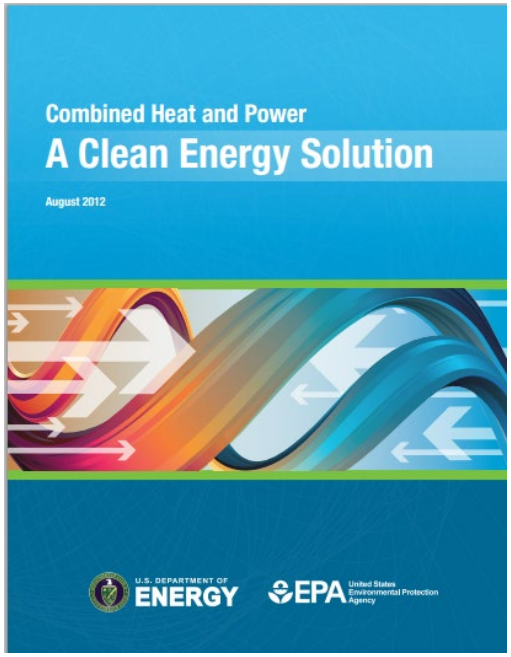
CHP Project Resources

DOE CHP Technologies Fact Sheet Series



www.energy.gov/chp-technologies

Good Primer Report



www.eere.energy.gov/chp

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Summary

- CHP gets the most out of a fuel source, enabling
  - **High overall utilization efficiencies**
  - **Reduced environmental footprint**
  - **Reduced operating costs**
- CHP can be used in different strategies, including **critical infrastructure resiliency** and emergency planning
- **Proven technologies** are commercially available and cover a full range of sizes and applications

Next Steps

Contact your Regional CHP TAP for assistance if:

- You are interested in having a "no-**cost"** Qualification Screening performed to determine if there is an opportunity for CHP on-site.
- If you have an existing CHP plant and are interested in expanding **the plant**.
- **If you need** an unbiased 3rd Party Review of a proposal.

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CHP
TECHNICAL ASSISTANCE
PARTNERSHIPS

Thank You

Questions?

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https://betterbuildingssolutioncenter.energy.gov/chp/chp-taps

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