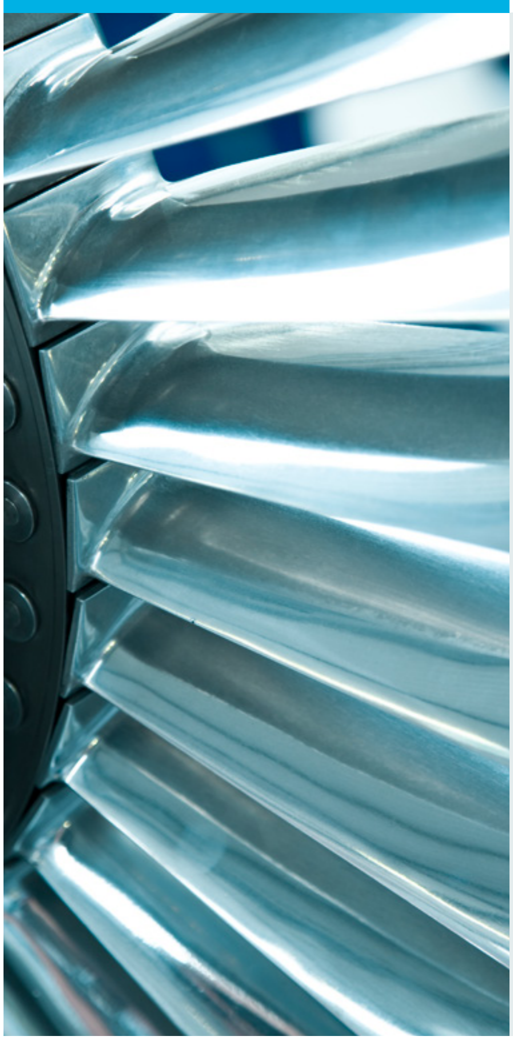
White Paper

Gas-Fueled Distributed Generation and Combined Heat and Power: Driving Forces for Beneficial Market Growth

By David Jones, ICF



Shareables

- Low gas prices and emerging market drivers like resiliency are expected to push considerable growth of gas-fueled distributed generation (DG) and combined heat and power (CHP).
- Gas-fueled DG and CHP systems can help utilities meet their energy-efficiency and emissions goals while providing cost-effective and reliable energy to customers.
- New packaged CHP offerings will lead to market growth for small commercial and institutional applications with more than 10 GW of economically viable CHP potential at more than 100,000 U.S. locations.

Executive Summary

Fuel-based DG technologies are well-established, but the markets and drivers for customer-sited DG are starting to change. While renewable DG options are becoming mature, cost-effective, and widely deployed, gas-fueled DG and CHP systems are positioned for growth.

DG and CHP installations fueled by natural gas can help utilities and states meet resiliency, emissions, and energy-efficiency goals while supporting electric utilities through locational benefits that relieve grid congestion and defer transmission and distribution investments. Packaged CHP offerings will reach new potential customers with standardized equipment, simplified installation processes, and flexible financing options. As renewable DG technologies mature and proliferate, gas-fueled DG and CHP deployments will continue to grow, playing vital roles for utilities and their customers.

Gas-Fueled DG Technologies:

- Reciprocating engines
- Gas turbines
- Microturbines
- Steam turbines
- Fuel cells

All of these DG technologies can recover and utilize waste heat in a CHP configuration.

Renewable DG Technologies:

- Photovoltaics
- Wind turbines
- Hydroelectric
- Geothermal
- Fueled DG/CHP technologies using renewable fuels

Fuel-based DG technologies have been providing reliable and efficient power to thousands of commercial and industrial facilities for more than 30 years. Fueled DG growth was strongest in the 1990s and early 2000s, as large industrial CHP installations took advantage of favorable federal energy policies and low natural gas prices. As gas prices increased in the mid-2000s, fueled DG installations slowed down, and the demand for renewable technologies like photovoltaics (PV) and wind turbines started growing exponentially. Environmental and policy initiatives, cost-effective incentives, and research and development breakthroughs have made PV and renewable DG options commercially viable. However, in the last few years, lower stabilized gas prices and new, more efficient DG and CHP options have made fuel-based generation more appealing, cost effective, and environmentally friendly than ever before.

Along with stabilized low gas prices, four primary drivers are expected to contribute to market growth for gas-fueled DG and CHP:

- **Resiliency.** Gas-fueled DG and CHP systems can provide reliable baseload power 24 hours a day, which is important for microgrids and energy resiliency during extended power outages.
- **Packaged CHP Offerings.** New standardized packages provide onsite power options for small customers with a simplified installation process.
- **Environmental Benefits.** Modern CHP equipment is extremely efficient; overall efficiencies can exceed 80%. Gas-fueled CHP installations have the potential to contribute to energy efficiency and greenhouse gas reduction targets set by states and utilities.
- **Utility Support.** Gas-fueled DG and CHP systems can work to support utilities, with locational benefits that can relieve grid congestion, provide ancillary services, and defer transmission and distribution investments.

Due to these drivers, the markets for gas-fueled DG and CHP are expected to grow considerably in coming years, alongside renewable power markets.

The Importance of Resiliency

Gas-fueled DG systems offer reliability and resiliency to facilities, allowing them to continue critical operations during extended power outages. The dependability of gas-fueled DG has become an important driver for adoption, especially since Superstorm Sandy left millions in the Northeast without power for several days in 2012. During this storm, facilities with CHP were able to continue operation, generating electricity and heat to provide essential community services. Urgent care centers like South Oaks Hospital in Long Island and Greenwich Hospital in Connecticut used their CHP systems to maintain critical operations and continue to accept patients during the multiday blackout. Wastewater treatment facilities such as New Jersey's Bergen County Utilities Authority used biogas-fueled CHP systems to provide critical sanitation services to their communities. Bergen County Utilities Authority, for instance, was able to safely process sewage for all 47 of its municipalities during the

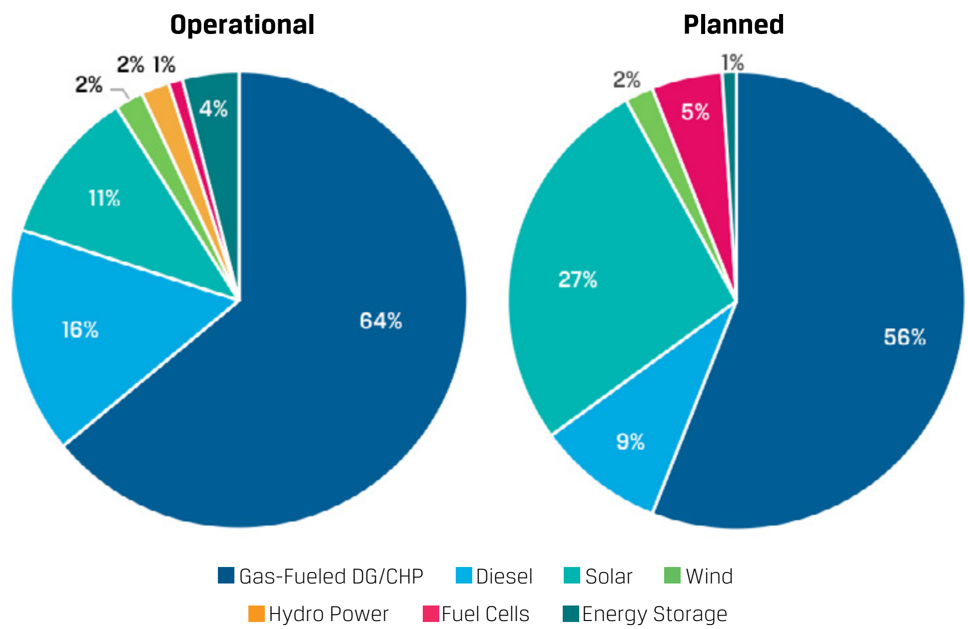
Gas-Fueled DG and CHP Systems Provide Resiliency During Power Outages

The South Oaks Hospital in Long Island, a 245-bed facility, was able to disconnect from the grid just before Superstorm Sandy made landfall on October 28, 2012. The hospital's 1.1 MW CHP system allowed it to stay isolated for 15 days, powering the hospital both during and throughout the aftermath of the storm. The hospital was not only able to serve its own patients but could also admit patients from other sites and act as a community center during the power crisis.

Sandy blackout, while in neighboring cities, raw sewage seeped into local watersheds due to treatment plant failures.[1]

Reliability and resiliency are important drivers for microgrids, which combine different DG resources into single controllable entities that can operate independently of the larger utility grid. Gas-fueled DG systems have a distinct advantage over renewable energy for reliable baseload power generation. While electricity output from solar and wind resources can be intermittent and difficult to predict, gas-fueled DG technologies are highly reliable in all weather conditions. Natural gas DG and CHP are the most commonly deployed technologies for existing and planned microgrids in the United States largely because of their resiliency benefits. The capacity for operational and planned U.S. microgrids is broken down by DG technology type in Exhibit 1.

EXHIBIT 1. U.S. OPERATIONAL AND PLANNED MICROGRID CAPACITY, Q3 2016

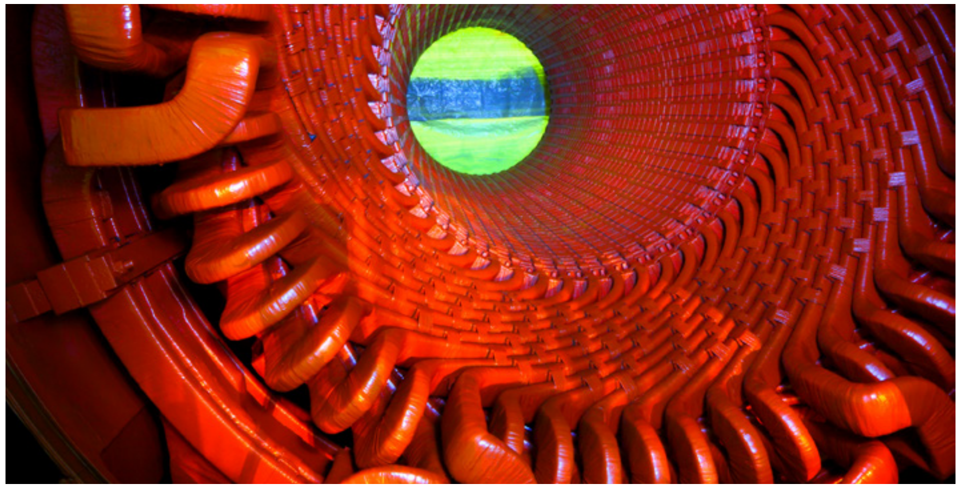


Source: GTM Research

GTM Research estimates that the total U.S. microgrid capacity will increase from 1.65 GW in 2016 to 4.30 GW in 2020, a growth of 260% in a four-year timeframe.[2] Gas-fueled DG and CHP will continue to play an important role in these microgrid deployments, providing an anchor of resilient baseload power as solar PV systems become more heavily incorporated.

[1] American Council for an Energy-Efficient Economy, *How CHP Stepped Up When the Power Went Out During Hurricane Sandy*, http://aceee.org/blog/2012/12/how-chp-stepped-when-power-went-out-d, December 6, 2012.

[2] GTM Research, *U.S. Microgrid Market Growing Faster Than Previously Thought: New GTM Research*, http://microgridknowledge.com/us-microgrid-market-gtm, August 29, 2016.



Expanded Markets for CHP with Packaged Systems

Historically, most CHP installations required customized engineering and design, with the systems being constructed at the installation site. However, with the advancement and maturation of CHP technologies, manufacturers have recently developed standardized packaged CHP systems. These packages eliminate many site-specific design requirements, as they are engineered and assembled offsite, with heat exchangers, electronics, and controls assembled in a complete package.

Packaged CHP systems have helped to facilitate third-party ownership and replicable financing models for CHP. These offerings can provide customers with bill savings and energy resiliency without the burden of operation and maintenance responsibilities or capital investments.

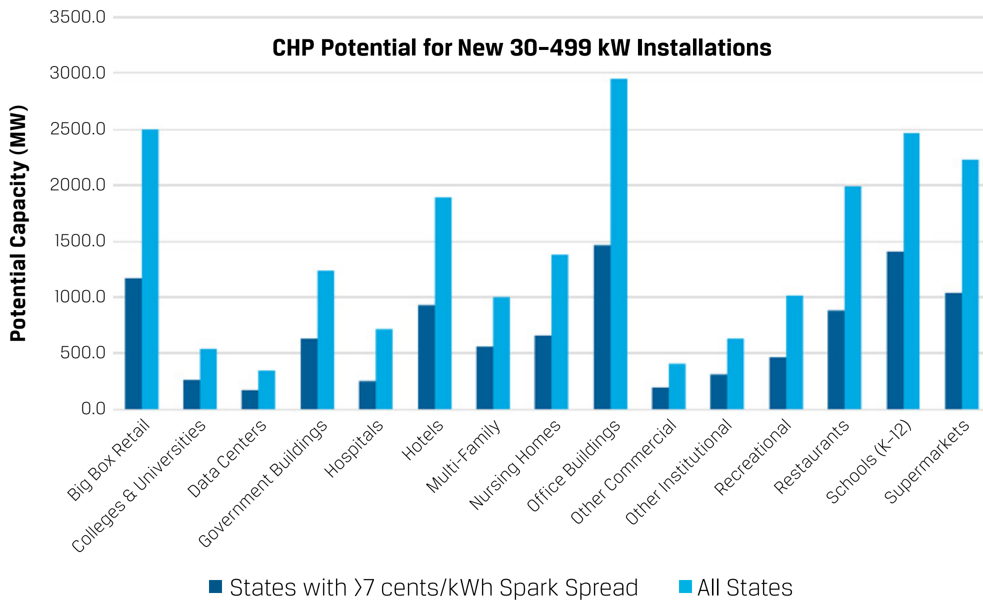
Most packaged CHP units range from 30 kW to 2 MW, with the vast majority falling under 500 kW in size. More than 216,000 commercial and institutional facilities in the United States are capable of supporting onsite CHP in the 30-499 kW size range, with an estimated 21 GW of technical potential. Exhibit 2 shows the potential[3] for <500 kW CHP systems by commercial/institutional facility type.[4] Nearly half of the 21 GW of technical potential comes from states with commercial spark spreads more than seven cents/kWh, indicating favorable economics for CHP.[5]

3 ICF CHP Technical Potential Database, 2016.

4 ICF prepared a detailed report for the Dept. of Energy on the CHP Technical Potential for all system size ranges throughout the United States in 2016. https://www.energy.gov/eere/amo/downloads/new-release-us-doe-analysis-combined-heat-and-power-chp-technical-potential

5 Spark spread calculated with 2014 state average commercial electricity and natural gas prices from the U.S. Energy Information Administration.

EXHIBIT 2. TECHNICAL POTENTIAL FOR <500 KW CHP IN THE COMMERCIAL AND INSTITUTIONAL SECTORS



Source: ICF CHP Technical Potential Database, 2016.

Packaged offerings are expected to expand the CHP market, with more than 10 GW of economically viable potential for <500 kW CHP at more than 100,000 commercial and institutional facilities.

Baltimore Gas & Electric Smart Energy Savers Program

To meet Maryland state energy-efficiency goals set by the EmPOWER Maryland Act, Baltimore Gas & Electric created the Smart Energy Savers Program. Under this program, CHP is included as a supported energy-efficiency option for businesses. Qualified projects (reciprocating engines or gas turbines with efficiency ≥65%) can be awarded incentives of up to $2.5 million, depending on the size of the system.

Meeting Efficiency and Emissions Goals

Reciprocating engines can achieve more than 40% electric efficiency (HHV), with total CHP efficiencies sometimes exceeding 80%.[6] Modern gas turbines are nearly as efficient, and they produce high-quality steam that can be used for industrial processes. Total efficiencies for gas-fueled CHP tend to be about 50% higher than separate heat and utility power, and these efficiency gains can contribute to energy-efficiency targets for utilities and end users.

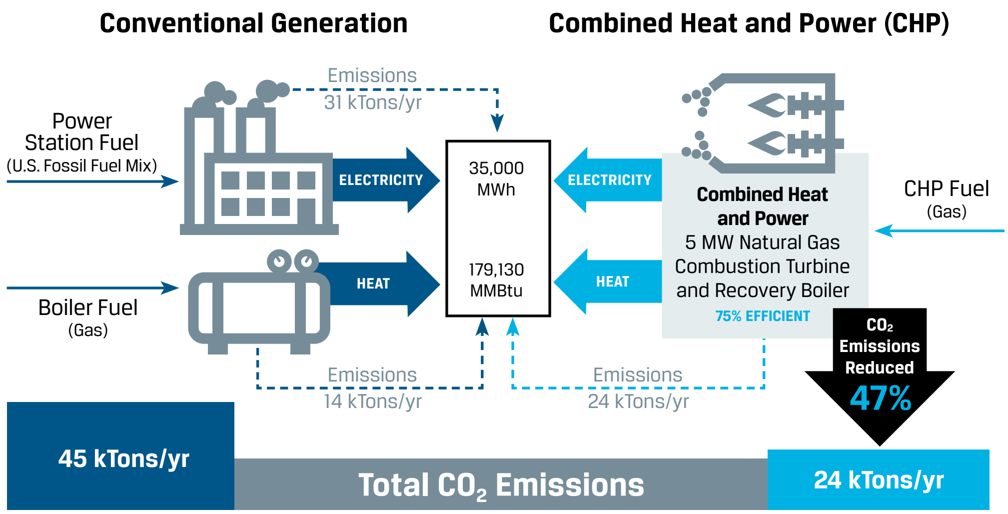
For a utility, the administrative burden of implementing CHP programs is relatively low, with only a handful of customers needed to achieve significant results. For example, Baltimore Gas & Electric has an energy-efficiency program under the EmPower Maryland initiative, one of the first in the country to include CHP as an energy-efficiency measure. Baltimore Gas & Electric anticipates in its 2015–2017 EmPower Maryland Program Filing that 23% of the total commercial and industrial energy savings will come from CHP. Only 24 total CHP participants are required to achieve these savings, compared to thousands of participants for other energy-efficiency measures.[7]

6 While CHP engines are capable of exceeding 80% efficiency (HHV), this can only be accomplished in practice if all of the recoverable waste heat from the system is completely utilized by the host facility.

7 Baltimore Gas and Electric Company 2015–2017 EmPower Maryland Program Filing (Case No. 9154), submitted August 28, 2014.

In addition to economic and energy-efficiency benefits, CHP systems can also significantly reduce greenhouse gas emissions compared to separate heat and power. In the Environmental Protection Agency's proposed Clean Power Plan, CHP systems will receive credits for net avoided greenhouse gas emissions. According to the latest eGRID data, the U.S. average carbon dioxide emissions for a fossil fuel power plant combined with a gas boiler could be reduced by half with a typical CHP installation[8] (see Exhibit 3).

EXHIBIT 3. NATURAL GAS CHP SYSTEMS CAN CUT CO_2 EMISSIONS IN HALF



If the Clean Power Plan goes into effect, gas-fueled CHP could potentially be used to help states reach their emission targets. Additionally, DG and CHP systems can be fueled by biogas resources, which are considered renewable fuels.[9] The use of these resources can prevent methane emissions, and many states currently include biogas and biomass fuels in Renewable Portfolio Standards and related incentive programs.

Locational Benefits for Utilities

With the recent proliferation of PV and other DG resources, utilities have made efforts to streamline their interconnection procedures and reduce barriers to DG integration. Utilities have developed sophisticated control systems to accommodate and manage these resources for optimized operation across the grid. Engineers have created models to better understand how strategically located DG resources can be used to alleviate long-standing grid issues like congestion and aging infrastructure. As a

[8] U.S. Environmental Protection Agency, 2012 eGRID (Emissions and Generation Resource Integrated Database) data, https://www.epa.gov/energy/egrid, released October 2015. Baseload CHP systems are most likely to replace fossil fuel generation sources, so this is used as the basis for comparison. Emission savings depend on the type of CHP system, emission controls, and utility generation sources.

[9] Biogas resources include landfill gas and anaerobic digester gas from wastewater treatment plants and farms with anaerobic digesters. These resources can be used to economically generate renewable power and heat with minimal fuel costs.

Replacing Net Energy Metering

In many states, net energy metering (NEM) laws allow renewable DG owners to sell excess electricity to the utility at the full retail rate. This has been an important driver for PV adoption. However, NEM arguably implies a value for customer-generated electricity that is not representative of the true locational value of the energy and other grid services provided.

Due to the proliferation of PV with NEM in Hawaii—and the resulting technical and operational challenges—the state's public utilities commission had to close the NEM program to new participants.

States including New York and California are developing alternative compensation mechanisms for customer generators that more accurately reflect the locational value of electricity. While NEM has traditionally been limited to renewable technologies, new regulations could potentially be applicable to gas-fueled DG and CHP systems.

result of these efforts to accommodate and utilize new DG installations, utilities are starting to recognize the full set of locational grid benefits that distributed energy resources can provide.

New York and California are leading the way to develop programs that will encourage beneficial DG deployments. As part of New York's 2014 Reforming the Energy Vision initiative, the joint utilities of New York have developed policies that will promote efficient use of energy and encourage deployment of distributed energy resources (DER), including identification of beneficial locations for DER deployment and analysis of hosting capacity to help guide DER placement. Policy makers are also developing new rules that will compensate customer generators for the locational value of electricity.

Similarly, in 2014 California launched a rulemaking proceeding that requires the state's investor-owned utilities to develop distribution resource plans to better integrate DG systems onto the grid. These plans require utilities to incorporate DG into grid-planning and investment strategies, with transparent monetization practices for customers providing grid services.

As New York and California utilities develop policies to incentivize customer-owned DG, other utilities are considering the benefits of owning and operating CHP systems at strategic grid locations. Duke Energy and Duke University recently reached an agreement for a 35-year contract where Duke Energy will install and operate a 21 MW natural gas combustion turbine on campus. The CHP plant will provide electricity and steam to Duke University, with excess electricity being supplied to the Duke Energy electric grid. The university will not receive a price break on their electricity, but they will benefit from efficient and reliable onsite generation that will reduce greenhouse gas emissions. Meanwhile, Duke Energy will use this CHP installation to defer the need for local transmission and distribution upgrades. This initiative is expected to be the first of many large-scale rate-based CHP projects for Duke Energy, with plans for the equivalent of four similar plants between now and 2021.[10]

The Future of Gas-Fueled DG

With emerging market drivers and the various benefits that gas-fueled DG and CHP systems can provide, U.S. installations are expected to grow significantly over the next decade. While the growth will not be as explosive as the recent surge in PV deployments, it is expected to have long-lasting and positive impacts for both utilities and end users.

[10] International District Energy Association, How a $55M Duke Energy CHP Plant Could Cut Duke University's Carbon Emissions, May 18, 2016, http://www.districtenergy.org/blog/2016/05/18/how-a-55m-duke-energy-plant-could-cut-duke-universitys-carbon-emissions/

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About the Author

David Jones has over 13 years of experience modeling the performance of distributed generation (DG) applications and analyzing potential markets for clients in the energy industry. He has modeled the hourly operation of several on-site power technologies including PV, storage, fuel cells, and combined heat and power (CHP) systems. Prior to joining ICF, Mr. Jones served as Senior Engineer at Resource Dynamics Corporation and Engineering Aide for the Defense Information Systems Agency. He also obtained a Mechanical Engineering degree at the University of Virginia, with a concentration in energy systems. At ICF, Mr. Jones leads efforts to evaluate potential DG/CHP applications and markets, while communicating findings to clients and managing project teams.

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