White Paper

Supporting Grid Modernization with Flexible CHP Systems

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Shareables

- Combined heat and power (CHP) can provide valuable grid services in applications that go beyond baseload power to support grid modernization objectives.
- Flexible CHP systems – like the one at Princeton University – enable renewable energy integration and real-time adjustments to balance the needs of the electric grid.
- Electric utilities are starting to gain value from CHP by using it in energy efficiency portfolios, procuring it as a distribution resource, and owning it as a generation asset.

Executive Summary

Most combined heat and power (CHP) installations are designed to produce onsite, baseload power and thermal energy for a facility, with value streams focused on energy bill savings. However, CHP's benefits extend beyond bill savings to include reliability, resilience, and valuable grid services that align well with grid modernization objectives. In the future, flexible CHP systems will be leveraged to support grid modernization and provide maximum value to the grid in use cases that go beyond baseload power generation.

Defining Grid Modernization

The term "grid modernization" can have a range of meanings. In some states, it is narrowly defined and focuses on how new technologies, such as advanced metering infrastructure (AMI) and other smart sensors and controls, can improve how the grid functions. In other states, it is broadly defined to include a range of actions aimed at making the electric grid more reliable, resilient, and capable of integrating an increasing number of DERs.

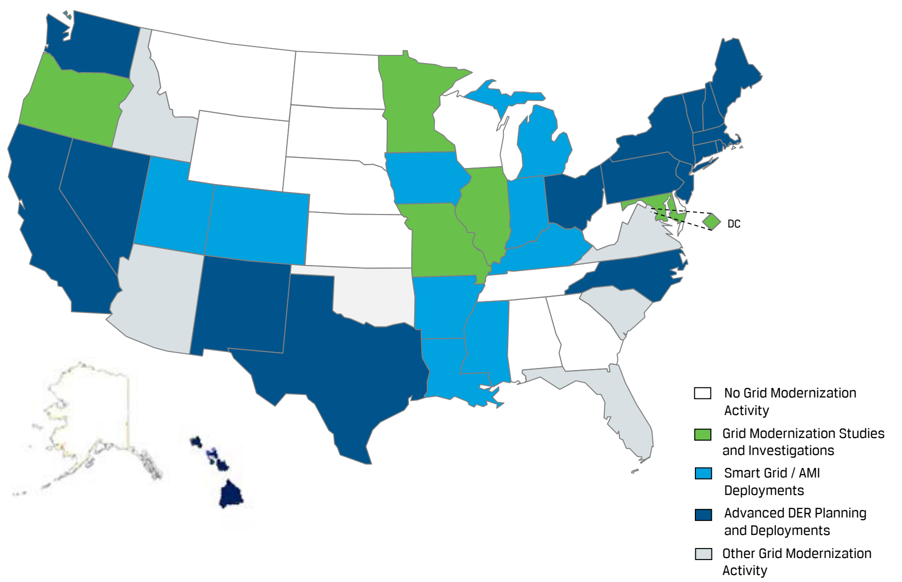
In general, grid modernization activities can be observed through a series of stages from beginning to advanced:

1. Initiating studies and investigations on DERs
2. Deploying smart grid technologies and AMI
3. Planning for and deploying advanced DER strategies, including microgrids and storage

Grid Modernization is Gaining Momentum

Most states are taking action to update aging electric grid infrastructure and institute new planning approaches to meet modern grid needs while managing an increasing number of DER deployments. In the first half of 2017, more than 36 states and the District of Columbia had policy activities related to grid modernization. Figure 1 shows a range of recent grid modernization activities at the state level, highlighting 16 states that are currently engaged in planning and deployment efforts for advanced DER installations including microgrids and energy storage systems.[1]

FIGURE 1. STATE ACTIVITY IN FIRST HALF OF 2017 RELATED TO GRID MODERNIZATION



Source: ICF with data from NCCETC.

CHP Supports State Goals for Grid Modernization

While states are at different stages in their grid modernization efforts, most states have very similar operational needs and common objectives for building a modern grid. In a report earlier this year, the US Department of Energy reviewed a sample of policy approaches from 10 states and the District of Columbia on grid modernization and identified an emerging consensus among states around certain key concerns.[2] Common issues in state visions for grid modernization included reliability, resilience, integration of newer technologies, environmental responsibility, and response to more complex customer demands, including distributed generation and smart services.

[1] Data was assembled from quarterly reports from the North Carolina Clean Energy Technology Center (NCCETC) that summarize grid modernization actions taken in the first half of 2017. NCCETC, The 50 States of Grid Modernization: Q1 2017 Quarterly Report, May 2017, https://nccleantech.ncsu.edu/wp-content/uploads/GridMod_Q12017_FINALREPORT.pdf. NCCETC, The 50 States of Grid Modernization: Q2 2017 Quarterly Report, August 2017, https://nccleantech.ncsu.edu/wp-content/uploads/GridMod_Q22017_Final-1.pdf

[2] US DOE. Modern Distribution Grid: Volume I, 2017, http://doe-dspx.org/wp-content/uploads/2017/02/Modern-Distribution-Grid_Volume-I_01312017-1.pdf.

Despite the ability for CHP to support state grid modernization goals, few utilities have explored including CHP as part of their grid modernization strategies. Table 1 shows how CHP systems can meet grid modernization goals that are commonly identified in state policy documents.

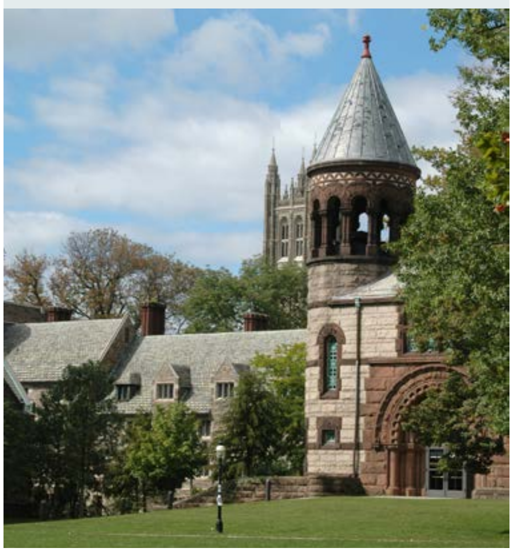
TABLE 1. HOW CHP CAN SUPPORT GRID MODERNIZATION

Grid Modernization Goal	How CHP Supports Goal
Grid Reliability	CHP installations can improve power quality, provide ancillary services, and relieve grid constraints
Customer Resilience	CHP systems can provide baseload power for microgrids, allowing critical loads to continue operation during grid outages
Energy Efficiency	CHP uses less fuel and is more efficient, which saves energy compared to conventional generation and separate heat production
DER Integration	CHP can help utilities integrate new renewable DER deployments and balance variable loads
Locational Value	CHP can be deployed at strategic locations on the system where it is needed most
Affordability	CHP can often meet system needs more cost-effectively than investments in traditional assets, thus lowering costs for ratepayers across the utility system
Emissions Reductions	Efficient CHP systems have lower emissions than conventional grid resources, and can be used to meet emissions reduction targets (ex: states w/ GHG goals)

CHP can help states and utilities meet each of these grid modernization objectives while producing several different value streams. When configured as a microgrid, CHP installations can provide resilience for host facilities, allowing them to continue operation during grid outages. This improves power reliability for the host facility, but it can also increase reliability for the surrounding utility grid by reducing congestion and improving power quality. Additionally, CHP can provide essential grid services through frequency response, voltage control, and ramping capabilities. For example, a CHP system at Princeton University helps balance the campus microgrid and provides ancillary services to the broader electricity grid (see sidebar). With these qualities that improve grid reliability, CHP can help

Princeton University CHP System Enables Renewable Integration and Flexible Operation

Princeton University installed a 15 MW gas turbine CHP system in 1996 to support the campus' electricity, heating, and cooling needs. Today, the CHP system runs at the center of a sophisticated microgrid that integrates 4.5 MW of solar energy and is flexible enough to make real-time operational adjustments. The CHP system can quickly ramp up and down generation as needed, and is regularly dispatched into the PJM Interconnection's frequency regulation markets to support grid frequency and voltage optimization.



utilities increase their scores for metrics such as System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI) and Customer Average Interruption Duration Index (CAIDI).

CHP installations can also be used to help utilities meet their energy efficiency or emission reduction targets. Incentive programs that include CHP as an energy efficiency measure, like those offered by Baltimore Gas & Electric and Commonwealth Edison, encourage CHP deployments to cost-effectively reach energy savings targets. A single CHP installation can produce more energy savings than thousands of buildings employing traditional efficiency measures. CHP systems also tend to produce significantly fewer greenhouse gas emissions compared to traditional generation, so CHP can be used to help states and utilities meet their emission reduction goals.

CHP systems can facilitate the integration of renewable technologies like wind and solar while providing locational value to utilities. In the U.S., gas-fired engine power plants with fast ramp rates have been deployed in states like Texas and Kansas to balance renewable loads from wind turbines.[3, 4] Systems like these could operate more efficiently by capturing and utilizing available thermal energy in a CHP configuration. In Europe, where renewable output is substantially higher than the U.S., models show that flexible gas-fired CHP systems may be the most affordable and practical option to balance increasing renewable loads with variable output.[5]

A recent study from the US Department of Energy examined the future impact that flexible CHP systems could have on California's electricity grid as the share of renewable energy increases.[6] The study identified a number of key benefits:

- **Reduced Grid Operating Costs:** System-wide cost reductions for California utilities could reach $265M per year with the addition of flexible CHP systems.
- **Increased Generation Capacity:** The deployment of additional CHP units would increase generation capacity in California, with an estimated capacity value between $79M and $106M per year.
- **Reduction in Grid Stress:** In the Flexible CHP scenario, CHP would nearly eliminate "high stress hours," and help maintain stability when the grid needs it most, such as the evening solar ramp.

This study focused on California, but flexible CHP systems could potentially deliver these same benefits to utilities and their customers throughout the U.S. while supporting grid modernization efforts.

[3] Overton, Thomas W., Power Magazine, "Reciprocating Engines Expand Roles", September 1, 2014.; http://www.powermag.com/reciprocating-engines-expand-roles/.

[4] Power Magazine, "Wärtsilä supplies 225 MW power plant to the City of Denton, Texas, USA", Press Release, September 21, 2016, http://www.powermag.com/press-releases/wartsila-supplies-225-mw-power-plant-to-the-city-of-denton-texas-usa/.

[5] Decentralized Energy, CHP's Future in a Sustainable Energy Market, January 22, 2015, http://www.decentralized-energy.com/articles/print/volume-16/issue-1/features/chp-s-future-in-a-sustainable-energy-market.html.

[6] U.S. Department of Energy, Modeling the Impact of Flexible CHP on California's Future Electric Grid, January 2018, https://energy.gov/eere/amo/downloads/modeling-impact-flexible-chp-california-s-future-electric-grid-january-2018.

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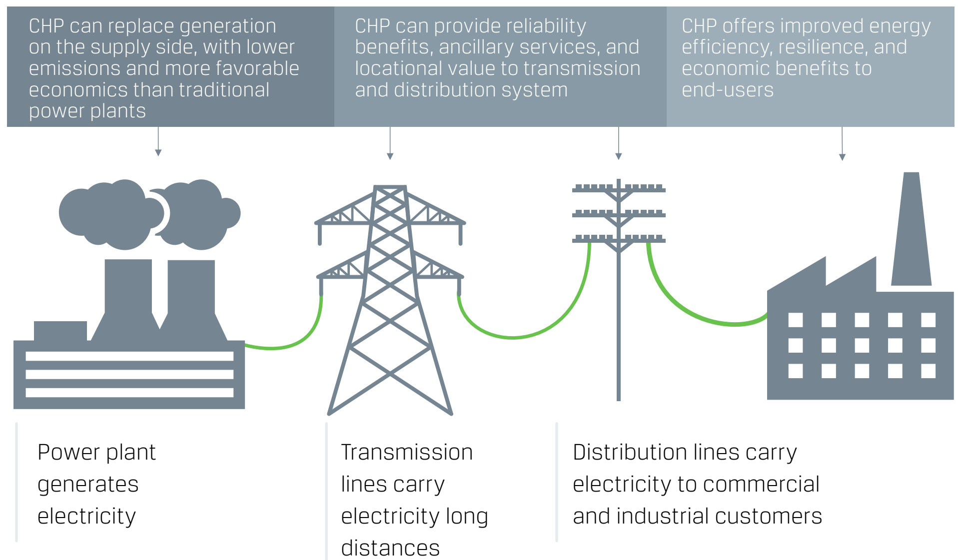
Utilities Can Realize the Full Value of CHP through Grid Modernization

When developing plans for grid modernization, utilities can gain value from incorporating CHP as an energy efficiency resource on the demand-side or as grid resource on the supply-side. As shown in Figure 2, CHP can replace more expensive, higher emitting generation, alleviate constraints along the distribution system, and improve efficiency and lower costs for end-users of the electric grid.

FIGURE 2. CHP CAN PROVIDE VALUE FROM THE POINT OF UTILITY GENERATION TO THE CUSTOMER SITE



In recent years, a common way utilities have gained value from CHP is through energy efficiency programs that incentivize and count energy savings from CHP systems located at customer sites to meet state requirements. However, with the need for more grid services and emphasis on broader adoption of DERs, utilities are gaining value from CHP in new ways, by procuring CHP as a distribution system resource, or investing in CHP systems on the generation side.

CHP in Utility Energy Efficiency Portfolios—Utilities that have developed CHP programs as part of their energy efficiency portfolios are able to meet large portions of their mandated energy efficiency targets at a significantly lower cost than other efficiency measures. For example, Baltimore Gas & Electric (BGE) anticipates that 19.5% of total Commercial and Industrial kWh program savings will come from behind-the-meter CHP. This large amount of savings comes from only a handful of customers, which lowers the utility's costs of acquiring and tracking these savings compared to traditional energy efficiency measures.[7] ICF has worked closely with BGE to launch their CHP program, assess their market, and develop a targeted outreach approach, which is essential for implementing a successful CHP program.

[7] Shipley, Anna and Anne Hampson. Utility Combined Heat and Power Programs—the Hot New Trend in Efficiency. ICF 2017. https://www.icf.com/resources/white-papers/2017/utility-combined-heat-and-power-programs-the-hot-new-trend-in-efficiency.

Policy Actions on Utility Ownership of DERs in Deregulated Markets

In deregulated electricity markets, new laws could allow utilities to own and operate DER assets.

- A new law in Connecticut allows distribution utilities to build and own fuel cells, including CHP, but must show how projects improve the reliability of the distribution grid, such as avoiding capacity upgrades or improving voltage, frequency or other grid functions.
- Legislators in Pennsylvania are debating a bill that would allow utilities to own and recover costs for energy storage and microgrids, which are often supported by CHP systems, on the condition that they can demonstrate they are in the public interest.
- Regulatory staff in Washington, DC found utility ownership of DERs could be allowed as long as the electricity generated is not sold, but instead used by the utility to support reliable operation of the distribution system.

CHP as a Distribution System Resource—Utilities in some states have gained value by investing in DERs, including CHP, fuel cells, solar, and energy storage, instead of spending ratepayer dollars on traditional grid infrastructure. Con Edison's deferral of a $1.2 billion substation upgrade through the Brooklyn Queens Demand Management (BQDM) Program is a popular example of how utilities can procure customer resources to meet distribution system needs at the lowest cost.

To date, approximately 3.1 MW of behind-the-meter CHP has been procured by Con Edison through BQDM, and more is expected over the next few years.[8] Through initiatives like BQDM, utilities can have greater control over how and where CHP and other DERs are deployed within their service territory. ICF has helped several utilities evaluate their distribution networks and assess the potential benefits of NWAs. We expect that utilities across the country will soon be implementing NWA programs to meet their evolving distribution system needs.

Utility-Owned CHP—For utilities doing business in a more traditional regulatory structure, ownership of CHP systems located at customer sites with continuous thermal loads is a promising approach to gaining new value from CHP. With high efficiencies and credit from steam sales, CHP is often the least-cost resource compared to other generation options, and it can be deployed at strategic grid locations in a shorter timeframe than large utility power plants.[9] After working with utilities to identify and evaluate ownership opportunities, ICF has found that utility-owned CHP can be extremely beneficial as a rate-based asset, especially when local distribution system investments can be deferred.

Earlier this year, Duke Energy received regulatory approval to recover costs for building, owning, and operating a 16 MW CHP system at Clemson University in South Carolina. The system will provide low-cost steam to meet campus thermal requirements and reliable electricity to all grid customers by April 2019. Duke Energy is actively pursuing additional CHP investments, and incorporating CHP into their integrated resource plans.

Utility-owned CHP can be deployed as a distribution system asset, even in deregulated states where utility companies are typically prohibited from owning generation resources. Policy makers are starting to explore the potential for deregulated utilities to own DERs in certain instances, especially when they serve the public interest by enhancing the grid's resilience and flexibility (see sidebar).[10]

[8] Subramony, Gita. ERS. "Packaged CHP Systems and Non-Wires Solutions." Presentation at ACEEE Energy Efficiency as a Resource Conference. Phoenix, AZ. October 2017.

[9] Hampson, Anne; Hedman, Bruce; Duvall, Ken. ICF and Sterling Energy, Utility CHP: A Least-Cost Baseload Resource, https://www.icf.com/resources/white-papers/2017/utility-chp-ownership, June 1, 2017.

[10] Citations for sidebar: Wood, E. "New Connecticut Law Opens Door to More Fuel Cell Projects." Microgrid Knowledge. July 10, 2017. https://microgridknowledge.com/fuel-cell-projects/; Wood, E. "Pennsylvania Tackles a Big One: Who Pays for Utility Microgrids?" Microgrid Knowledge. June 2, 2017. https://microgridknowledge.com/utility-microgrids-pennsylvania-hb1412/.; MEDSIS Staff Report. Formal Case No. 1130, Modernizing the Energy Delivery System for Increased Sustainability. January 25, 2017. http://www.dcpsc.org/getmedia/6048d517- 1d9d-4094-b0f4-384f19a11587/MEDSISStaffReport.aspx.

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With CHP systems deployed by utilities in strategic grid locations, utilities can maximize system benefits and have more control over CHP operations to ensure delivery of reliable grid services.

CHP Can Be the Solution

Grid modernization and increased DER integration require new planning approaches and updated processes to meet future electricity needs. As states develop their visions to build a more modern grid, they can include CHP as a flexible and cost-effective resource that provides grid services. Considering and placing value on the full range of benefits CHP can offer resilience and reliability attributes, avoided costs of traditional distribution investments, and efficiency/emissions improvements could help overcome traditional barriers to CHP deployments. Utilities can incorporate CHP into energy efficiency portfolios, utilize CHP as a distribution system asset, or invest in CHP generation assets as part of their resource planning and grid modernization efforts. Utilities that consider the flexible attributes and potential grid benefits of CHP are likely to find a useful solution that lowers costs and provides value to both utilities and their customers.

About the Authors

David Jones is a Project Manager at ICF with over 14 years of experience analyzing markets and modeling the performance of DG and CHP applications for government clients and energy industry stakeholders. He leads ICF's efforts to evaluate CHP technologies and markets, while communicating findings to clients and managing project teams. Prior to joining ICF, Mr. Jones served as Senior Engineer at Resource Dynamics Corporation.

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