NICHOLAS INSTITUTE
FOR ENVIRONMENTAL POLICY SOLUTIONS
DUKE UNIVERSITY

case study

NI CS 12-01 | April 2012 | nicholasinstitute.duke.edu

Combined Heat and Power in the Southeast

Identifying Commercial and Institutional Opportunities

Etan Gumerman, Amy Morsch, Sarah Plikunas, Kenneth Sercy, and Whitney Ketchum

Combined heat and power (CHP) maximizes the usable energy from a fuel source by simultaneously generating thermal and electric outputs. CHP can achieve operating efficiencies of up to 80%, compared to the 45% efficiency typically achieved by conventional energy production.[1] CHP is not a specific technology; rather, CHP applications are customized, site-specific energy systems that may consist of reciprocating engines, combustion or steam turbines, microturbines, generators, and heat-recovery systems.[2] This flexibility allows project engineers to choose the appropriate fuel and products that meet their needs.

When to Consider Combined Heat and Power

WHAT'S INSIDE

For more information, visit nicholasinstitute.duke.edu/se-chp-swh.

The U.S. Department of Energy's Federal Energy Management Program recommends that facility energy managers consider installation of a CHP system when several of the following conditions apply:[3]

- a centralized heating or cooling system already exists
- the site's thermal and electric demand levels are closely matched
- the ratio of average electric load to peak load is high
- the average electric load is more than 1 megawatt (MW)
- the system will operate most of the year
- the cost of CHP system fuel is favorable relative to the cost of grid-derived heat and power
- energy security is critical

CHP can achieve operating efficiencies of up to 80%, compared to the 45% efficiency typically achieved by conventional energy production.

CHP offers a variety of benefits. It improves business competitiveness by utilizing energy that would otherwise be wasted, it ensures that critical systems remain powered in the event of disruptions to grid power,[4] it helps meet greenhouse gas (GHG) reduction and sustainability goals, and it provides educational opportunities for the academic community and public sector.

BENEFITS IN ACTION

A CHP system at Mississippi Baptist Medical Center allowed the facility to remain 100% operational for 52 of the 57 hours the City of Jackson was without power following Hurricane Katrina; the Center was the only hospital in the Jackson metro area able to remain open during the disaster. The system currently saves the Center $700,000 in energy costs annually.[5]

Potential in the Southeast

Although most studies on CHP potential focus on applications in the industrial sector—which currently make up 88% of installed capacity nationwide[6]—CHP systems can also provide benefits to schools, hospitals, government facilities, airports, wastewater treatment facilities, hog farms, landfills, grocery stores, and other commercial operations. A study released by ICF International identified an additional 68 gigawatts of nonindustrial CHP potential nationally,[7] and the U.S. Environmental Protection Agency has identified 14 MW of potential

1. Anna Shipley et al., "Combined Heat and Power: Effective Energy Solutions for a Sustainable Future" (Oak Ridge, TN: Oak Ridge National Laboratory, 2008).
2. U.S. Department of Energy Southeast Clean Energy Application Center, "CHP Electric Technologies," accessed April 18, 2012, http://www.southeastcleanenergy.org/cleanenergy/chp/technologies.aspx.
3. U.S. Department of Energy Federal Energy Management Program, "Combined Heat and Power Applications," accessed April 18, 2012, http://www1.eere.energy.gov/femp/technologies/derchp_chpapplications.html.
4. Shipley et al., "Combined Heat and Power."
5. Louay Chamra and Keith Hodge, "CHP at the Mississippi Baptist Medical Center" (Starkville, MS: Mississippi State University), accessed April 18, 2012, http://www.chpcenterse.org/reports/CHP-MBMC.pdf.
6. U.S. Department of Energy Southeast Clean Energy Application Center, "About Combined Heat & Power," accessed April 18, 2012, http://www.southeastcleanenergy.org/cleanenergy/chp/.
7. ICF International, "Effect of a 30 Percent Investment Tax Credit on the Economic Market Potential for Combined Heat and Power" (2011), accessed April 18, 2012, http://www.uschpa.org/files/public/USCHPA%20WADE_ITC_Report_FINAL%20v4.pdf.

at wastewater treatment facilities in the Southeast.[8] To help increase understanding of the potential for CHP in these less-studied sectors, the following case studies explore CHP installations at a university (Vanderbilt) and a wastewater treatment plant (RM Clayton facility in Atlanta, GA). These examples show that CHP can also make sense for public and private institutions, and can be a real consideration for the region's many universities, wastewater treatment facilities, and other similarly situated energy consumers.

Case Study: Vanderbilt University Power Plant[9]

Given the large thermal and electric loads of most universities, CHP can be an attractive option for facilities managers seeking to replace or repair aging central plants. Vanderbilt University in Nashville, Tennessee, began developing cogeneration plants to produce energy and steam with its first installation in 1988, which introduced steam-producing boilers and a turbine that can produce electric power when needed. This increased efficiency, reduced costs, improved the reliability of the campus's steam and electricity service, and maintained fuel flexibility at the campus's central plant.

WHAT MAKES IT WORK

- Achieves the goals of reliability and financial savings, with the co-benefit of sustainability
- System design avoids standby rates and interconnection
- Flexible dual CHP configuration can be continuously optimized according to fuel prices, energy demand, and the price of grid power

Growing demand for steam and power led the university to install a second CHP system in 2000. After entering into a demand-side management agreement with TVA, backup power capacity became more important, so engineers chose a CHP configuration that would generate electricity with a steam byproduct—rather than the 1988 configuration that generates steam with an electricity byproduct. The $30 million system includes natural gas–fired combustion turbines with a total capacity of 10 MW, plus heat-recovery steam generators with a capacity of 200,000 lbs/hr.[10] Vanderbilt estimated the payback period for the 2000 expansion to be 10 years, but with lower-than-projected campus demand and utility-program changes, actual payback turned out to be longer. Vanderbilt approved the system in light of the significant co-benefits of expanding backup power capacity and creating a dual CHP configuration that can be optimized according to factors such as fuel prices, demand, and the price of grid power.

After two positive experiences with CHP, Vanderbilt is currently looking into a third system.

Vanderbilt has also benefited by avoiding the prohibitive interconnection standards and standby rates that compromise the economics of many CHP projects. Because the university generates only about 30% of the power it uses, it continues to use grid power, thereby avoiding the need to sell excess power or engage in difficult standby rate negotiations with the utility.

Facilities managers are happy with the system: the nonfinancial benefits of having a reliable backup power source, operational flexibility, and reduced GHG emissions have made the longer payback period acceptable. After two positive experiences with CHP, Vanderbilt is currently looking into a third system—further testament to the flexibility and benefits this technology may provide to university communities.

Case Study: R.M. Clayton Wastewater Treatment Plant[11]

The R.M. Clayton Wastewater Treatment Plant in Atlanta, Georgia, currently flares excess methane gas produced by an anaerobic digester—wasting a high-energy fuel—but the city's Division of Sustainability and the Department of Watershed Management are collaborating to solve this problem. By the summer of 2012, the plant will be equipped with a combustion engine that turns waste biogas into nearly 13 million kilowatt-hours of useful energy annually. The system will also capture more than 39,000 million Btu of waste heat and use it as process energy for the anaerobic digesters.[12]

The project stemmed from a city goal to produce 5% of municipal energy from renewable sources by 2015. The system

8. U.S. EPA Combined Heat and Power Partnership, "Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market Analysis and Lessons from the Field" (2011).
9. This case study was developed through conversations with Mark Petty at Vanderbilt University Plant Operations in the fall of 2011.
10. The new system includes gas-fired combustion turbines (Nuovo Pignone for General Electric) and heat-recovery steam generators (Energy Recovery International). Vanderbilt University, "Plant Operations: The Cogeneration Plant and Utility Distribution System," accessed April 18, 2012, http://www.vanderbilt.edu/plantops/content.php?page=plant.php.
11. This case study was developed through conversations with Jean Pullen and Bill Hosken at City of Atlanta and Jason Bodwell at Georgia Environmental Finance Authority in the fall of 2011.
12. Jean Pullen, "R.M. Clayton CHP Project Status and Overview of Energy and Economic Performance" (City of Atlanta Division of Sustainability, 2011).

is designed to achieve 88% of that goal and will help the city avoid an estimated 12,700 metric tons of greenhouse gas emissions each year. While this kind of sustainability performance is important to the city, favorable economics are also a key requirement for city projects. In this case, the R.M. Clayton system will generate approximately $1 million in annual savings after a six-year payback period. The $7.1 million project is financed by a loan from the federal Clean Water State Revolving Fund at an interest rate of 3%, and a $1.5 million grant.

The project will bring Atlanta very close to achieving its goal of using renewable sources for 5% of municipal energy by 2015, and will save around $1 million every year.

WHAT MAKES IT WORK

- Achieves multiple goals: GHG reductions and financial savings
- Creative financing through the Clean Water State Revolving Fund
- Partnership between the divisions of Sustainability and Watershed Management
- System design avoids standby rates and interconnection

Much like Vanderbilt, the City of Atlanta will avoid prohibitive standby rates because the facility will continue to require a substantial supply of energy from Georgia Power. The city also controlled upfront costs by approaching the project as "design-build," meaning that the system was designed to meet the budget on a strict design and construction schedule with a unified contractor-engineer team.

Tips to Make It Work

Project managers at both facilities say they are satisfied with the investment, and each described plans to consider or pursue additional CHP projects. Based on their experiences, project managers assessing or planning new systems may want to consider the following tips.

Appreciate the variability of CHP. It is important for managers to consider their particular circumstances. CHP guidance documents can provide direction on project assessment and scoping, but these tools have their limits, given the variability of CHP configurations. To reduce the risk of overcalculating the benefits of the R.M. Clayton installation, the project manager used more conservative assumptions for capital and operational costs than those provided in guidance documents, ultimately achieving a more accurate estimate of the system costs.

Plan for uncertainties. The Vanderbilt CHP systems have operated through a number of fuel price and demand fluctuations. Although Vanderbilt did not originally plan to install two different CHP systems of opposite configuration to meet their overall thermal and electric demand, this setup has afforded facilities managers unique operational flexibility. System operation can be optimized continuously according to coal and natural gas prices, campus thermal and electric demand, and the price of grid power.

Policy Opportunities

Previous joint reports by the Nicholas Institute and Georgia Tech found that with supportive policies (1) renewable energy could provide a large portion of the region's electricity at competitive rates within a decade;[13] (2) aggressive energy-efficiency policies could reduce the need for new generation, reduce water consumption, moderate projected electricity-rate increases, and create jobs;[14] and (3) industrial CHP capacity could increase by 50% by 2030.[15] By lowering demand, clean energy projects like CHP mitigate the need for new generation, the demand for natural gas, the power losses and congestion associated with transmission and distribution, and the air pollution associated with conventional energy production.

OVERCOMING BARRIERS

Creative project managers are working around barriers by

- sizing the CHP system to avoid the need for interconnection
- tapping into creative funding sources, such as Georgia's Clean Water State Revolving Fund, which assisted the CHP project at a wastewater treatment plant
- valuing nonmonetary benefits, such as on-site energy security and sustainability

Creative project managers are finding ways around common obstacles and demonstrating that there are viable opportunities in the Southeast, but additional policies could reduce these obstacles. The following key entry points provide an opportunity for policy makers to encourage clean energy development—particularly CHP—by commercial and institutional entities.

13. Marilyn A. Brown et al., "Renewable Energy in the South" (Atlanta: Southeast Energy Efficiency Alliance, 2010).
14. Marilyn A. Brown et al., "Energy Efficiency in the South" (Atlanta: Southeast Energy Efficiency Alliance, 2010).
15. Ibid.

Policy Opportunities (continued)

MITIGATE UPFRONT COSTS

Investing in clean energy often means spending more now in order to save money later. CHP systems that generate 1 to 10 MW—the typical size for nonindustrial applications—cost between $1 and 10 million to install. This amount of capital can be difficult to secure. Recouping this investment through utility bill savings can take longer in the Southeast, where electricity prices are low. Policy tools, such as tax credits, loan programs, and energy portfolio standards, can address both of these issues by making it easier to access capital and spread out upfront costs. These types of policies and programs are less common and typically less aggressive in the Southeast than in other regions, presenting a key opportunity for policy makers to facilitate CHP development.[16]

FACILITATE ACCESS TO INFORMATION

Easy access to information that fosters comfort with new technology is critical to clean energy development. Because CHP is so customizable, it can take a lot of effort for a facilities team and other decision makers to familiarize themselves with the technology and its benefits. CHP is rarely discussed as an opportunity outside the industrial sector, so it is especially important to educate nonindustrial institutions.

By facilitating information sharing among all types of CHP users, policy makers can encourage more widespread adoption. For example, demonstration projects that are open to the public and that clearly track energy savings can increase familiarity and build confidence in the technology.

REMOVE REGULATORY HURDLES

Restrictions on excess power sales, costly standby rates, unfavorable interconnection standards, and burdensome permitting processes can all hinder project development. By removing these hurdles, policy makers can help more CHP projects move forward. For example:

Policy makers can establish well-developed interconnection standards. Such standards set a clear and uniform process for connection to the electric grid, which reduces uncertainty, prevents delays in project development, and sets out technology requirements that ensure safety and reliability. Many Southeastern states have yet to adopt interconnection standards, including Alabama, Arkansas, Georgia, Mississippi, South Carolina, Tennessee, and Louisiana.[17] Several of these states offer guidelines or net-metering standards, which can make interconnection easier for some small CHP applications, but these policies are less helpful than standardized rules.

Regulating bodies can set accurate and reasonable rates for utilities.[18] Owners of CHP systems that connect to the grid often pay "standby rates." These are flat monthly fees for the extra capacity the electric utility has to maintain in order to provide backup power in the event of an on-site system failure. These rates vary by utility, and if they are set too high, they can render CHP investments uneconomic. High standby rates have been particularly burdensome in Alabama, Georgia, Louisiana, North Carolina, and Virginia.[19]

16. Anna Chittum and Nate Kaufman, "Challenges Facing Combined Heat and Power Today" (Washington, D.C.: American Council for an Energy-Efficient Economy, 2011).
17. U.S. Department of Energy Southeast Clean Energy Application Center, "Policies for Clean Energy," accessed April 18, 2012, **http://www.southeastcleanenergy.org/policy.**
18. Ibid.
19. Chittum and Kauffman, "Challenges Facing Combined Heat and Power Today."

The **Nicholas Institute for Environmental Policy Solutions** at Duke University is a nonpartisan institute founded in 2005 to help decision makers in government, the private sector, and the nonprofit community address critical environmental challenges. The Institute responds to the demand for high-quality and timely data and acts as an "honest broker" in policy debates by convening and fostering open, ongoing dialogue between stakeholders on all sides of the issues and providing policy-relevant analysis based on academic research. The Institute's leadership and staff leverage the broad expertise of Duke University as well as public and private partners worldwide. Since its inception, the Institute has earned a distinguished reputation for its innovative approach to developing multilateral, nonpartisan, and economically viable solutions to pressing environmental challenges.
nicholasinstitute.duke.edu