Environmental and Energy Study Institute

Fact Sheet

Combined Heat and Power:

Pathway to Lower Energy Costs, Reduced Emissions, Secure and Resilient Energy Supply

May 2013

Combined heat and power (CHP) technologies provide industries, commercial businesses, institutions, and communities with ways to reduce energy costs and emissions while also providing more resilient and reliable thermal energy and electric power. CHP systems combine the production of heat (for both heating and cooling) and electric power into one process, using much less fuel than when heat and power are produced separately. CHP systems can achieve energy efficiencies of 70 percent or more, compared to producing heat and power separately, which is on average less than 45 percent efficient. Further, CHP systems (appropriately designed) can provide resilient, reliable, around-the-clock thermal and electrical energy even when the local power grid is down.

CHP is a proven technology. There are more than 4,100 CHP systems in use in the United States today. More than two-thirds are fueled with natural gas, but renewable biomass, process wastes, and coal are also used. The U.S. Department of Energy (DOE) reports that the United States has more than 82 gigawatts (GW) of installed capacity, representing about eight percent of total U.S. electric power generation capacity.[1]

CHP systems can be used in many different settings and many different scales, ranging from the micro, residential scale to large-scale industrial systems that produce more than 20 megawatts (MW) of power. Applications include:

- Industrial (chemicals, refineries, pulp and paper, food processing, pharmaceuticals, biorefineries…)
- Critical infrastructure (emergency services facilities, hospitals, water and wastewater treatment plants…)
- Institutional (retirement homes, research institutions, government buildings)
- Commercial (hotels, airports, office buildings)
- District energy (colleges and university campuses, urban centers, military bases)
- Residential (individual and large multi-family units) [2]

The chemical industry has the largest share of CHP capacity in the United States today (29 percent), followed by the petroleum refining industry (18 percent), and the pulp and paper industry (14 percent).[3]

CHP BENEFITS

CHP saves energy, saves money, improves competitiveness, reduces emissions

CHP technology provides a way for all of the above sectors to benefit significantly from reduced energy costs while also reducing other harmful emissions. The DOE and EPA estimate that by installing 40 GW of new CHP capacity, U.S. businesses and industry could save $10 billion per year in energy costs and reduce overall national energy demand by one percent. The $40 to $80 billion of new investment in CHP could be paid back within four to eight years.

When less fuel is used to meet thermal and electric power needs, fewer air pollutants and greenhouse gases are emitted. Similarly, when natural gas or renewable, sustainably-produced biomass fuels displace the use of fossil coal or petroleum, emissions can be further reduced. DOE estimates that the current fleet of CHP systems saves about 1.8 quads of energy annually and reduces U.S. carbon dioxide emissions by 240 million metric tons, the equivalent of removing 40 million cars from the road. Installing another 40 GW of CHP could further reduce CO2 emissions by 150 million tons per year, the equivalent of removing another 25 million cars from the road.[4]

CHP is secure, resilient, distributed energy by design

Having assured access to reliable heat and power 24/7 is critical for the functioning of a modern economy. Uninterrupted thermal and electric power supplies are especially critical for hospitals, nursing homes, water supply and wastewater treatment plants, research facilities, and large refineries and chemical plants. An interruption in heat and power at these types of facilities could cause significant economic harm, injuries, and/or threaten public health.

Yet, increasingly, extreme weather events are bringing the power grid down across the country – sometimes for days or weeks at a time. Extended power outages from Hurricane Sandy in the Northeast and other recent hurricanes on the Gulf coast caused billions of dollars worth of economic losses and threatened public health and safety.[5]

With sufficient public planning, investment, and public/private partnerships, CHP systems can increasingly play a critical role advancing homeland security in the face of extreme weather and other threats. New York State Emergency Services and NYSERDA have been identifying and developing strategies to increase the use of CHP in key facilities to advance disaster preparedness, business continuity, and community sustainability.[6] CHP played a critical role keeping the lights and heat on in New Jersey, New York, and Connecticut in the wake of Hurricane Sandy.[7] Hospitals, apartment complexes, nursing homes, and wastewater treatment plants with CHP were able to continue meeting the basic needs of their communities when other energy services (including back-up electric generators) failed.[8]

The DOE Gulf Coast Clean Energy Application Center reports that CHP systems have proved to be resilient in the wake of many other natural disasters across the country as well – such as in the aftermath of hurricanes Katrina and Rita in Louisiana. CHP proved to be far more reliable than emergency electrical back-up generators in case after case.[9]

SIGNIFICANT CHP POTENTIAL

The amount of energy lost in wasted heat in the United States – just from the electric power sector – exceeds the total amount of energy used in Japan.[10] In the United States, CHP is relatively underutilized compared to other advanced economies, representing only about eight percent of total U.S. power production, compared to 30 percent or more in countries such as Denmark, Finland, and the Netherlands. CHP systems offer the potential to more than double the overall efficiency of U.S. electric power production by capturing and using this thermal energy. The DOE and EPA estimate that there is untapped CHP potential of about 130 GW at industrial, institutional, and commercial facilities across the country – facilities that have an optimal combination of year-round on-site thermal and electric power needs.[11]

CHP could make a significant contribution in the years ahead as old, inefficient, polluting coal-fired power plants are retired. The American Council for an Energy-Efficient Economy (ACEEE) reported in a recent study that CHP systems could theoretically replace more than 100 percent of the anticipated retirements of coal-fired power plants across a dozen states by 2020 – if critical policies are put in place that encourage it. The report finds that "while CHP is not positioned to fully replace the lost capacity, it can play a substantial role in meeting these needs, especially in certain states." ACEEE believes that electric utilities, with favorable regulatory environments, are best positioned to make these substantial long-term investments. [12]

KEY BARRIERS TO CHP

The ACEEE report also notes, however, that, "*given current policies and recent installation trends, it appears taking advantage of that [CHP] technical potential could be a challenge*." "*Policies and regulations do not always encourage CHP deployment, though, and this report finds that almost all of the states that are facing higher levels of potential coal retirements do not have most of the critical policies in place that yield a healthy investment environment for CHP*." [13]

Another ACEEE report details some of the existing regulatory and legal barriers to CHP, which vary state-to-state and utility-to-utility. Issues include setting favorable CHP-utility interconnection standards, establishing favorable supplemental and backup power rates, developing output-based emission standards, and providing proper valuation of additional energy and environmental ancillary services provided to ratepayers and utilities by CHP facilities.[14]

CHP POLICY

Federal Policy

In August 2012, President Obama ordered federal agencies to work jointly to increase the use of CHP in the United States by 40 GW (50 percent) by 2020. The Executive Order "*directs certain executive departments and agencies to convene national and regional stakeholders to identify, develop, and encourage the adoption of investment models and State best practice policies for industrial energy efficiency and CHP; provide technical assistance to States and manufacturers to encourage investment in industrial energy efficiency and CHP; provide public information on the benefits of investment in industrial energy efficiency and CHP; and use existing Federal authorities, programs, and policies to support investment in industrial energy efficiency and CHP."*[15]

State Policy

Many states are beginning to address the barriers to the deployment of CHP. The EPA recently released a report inventorying what states are doing now to address many of these barriers.[16] The Energy Information Administration reports: *"Twenty-three states recognize CHP in one form or another as part of their Renewable Portfolio Standards or Energy Efficiency Resource Standards. A number of states, including California, New York, Massachusetts, New Jersey, and North Carolina, have initiated specific incentive programs for CHP."*[17]

CHP AND BIOMASS

When biomass is produced sustainably, biomass-fueled CHP systems can produce heat and power with very few net greenhouse gas (GHG) emissions, and thus can be much more climate-friendly than systems fueled with fossil natural gas, coal, or oil. By substituting biomass for fossil fuel, carbon emissions from non-renewable, finite fossil fuels can be avoided. Further, because almost all of the biomass used for biomass CHP today is derived from forestry or agricultural residues or urban waste streams, significant additional emissions of climate-changing methane, which would otherwise be released to the atmosphere from decomposition, are avoided. The avoided methane emissions can actually make some renewable biomass CHP systems net carbon negative on a life cycle basis.[18]

More than seven GW of biomass CHP capacity is on-line today.[19] For decades, forest products industries, such as pulp and paper mills, have used woody biomass residues – by-products of their production processes – to provide electric power and thermal energy for their operations. Other biomass CHP feedstocks, however, can include residues from agriculture, livestock manure, sewage, and other biogenic portions of urban waste streams. The potential is huge: up to 6,000 gigawatt-hours worth of usable biomass residues and wastes are discarded each year in the United States.[20]

Biomass CHP can help local economies by creating jobs, reducing vulnerability to volatile fossil fuel prices, increasing local self-reliance, and recycling energy dollars locally.

Biomass can be either direct-fired or gasified to produce heat and power. Direct-firing biomass is the most common method, but newer advanced biomass gasification systems are ideally suited for CHP applications, performing at higher levels of efficiency.[21] Biomass CHP plants have been developed that can run on municipal solid waste (MSW), with overall system efficiencies greater than 80 percent.[22]

Among the key advantages of renewable biomass CHP is that it can provide reliable baseload electric power and thermal energy on demand 24/7 (at a much higher capacity rate), compared to intermittent wind energy (available on average about 36 percent of the time) and photovoltaic solar (available about 22 percent of the time).[23]

The best opportunities for developing biomass CHP systems are:

a) in regions where there is an ample local supply of sustainably-produced biomass;
b) in regions where natural gas and heating oil prices are high and/or natural gas is unavailable;
c) in urban areas where there are existing urban biogenic waste streams and concentrated heat and power demand;
d) in small- to medium-sized agricultural, food processing, and forestry industries located near feedstock supplies which have sufficient on-site heat and power demand to warrant investment in small scale systems; and
e) in existing ethanol plants and future integrated biorefineries which have high heat and power demand 24/7 all year.[24]

This fact sheet is available electronically (with hyperlinks and endnotes) at *www.eesi.org/papers*.

Author: Ned Stowe
Editor: Carol Werner

*The **Environmental and Energy Study Institute** (EESI) is a non-profit organization founded in 1984 by a bipartisan Congressional caucus dedicated to finding innovative environmental and energy solutions. EESI works to protect the climate and ensure a healthy, secure, and sustainable future for America through policymaker education, coalition building, and policy development in the areas of energy efficiency, renewable energy, agriculture, forestry, transportation, buildings, and urban planning.*

[1] State and Local Energy Efficiency Action Network. *Guide to the Successful Implementation of State Combined Heat and Power Policies.* Prepared by B. Hedman, A. Hampson, J. Rackley, and E. Wong, ICF International; L. Schwartz and D. Lamont, Regulatory Assistance Project; T. Woolf, Synapse Energy Economics; J. Selecky, Brubaker and Associates. 2013. www.seeaction.energy.com

[2] For examples of the full range in scale and diversity of CHP applications, go to the EPA's Combined Heat and Power Partnership web page http://www.epa.gov/chp/index.html. The CHP Partnership is "*a voluntary program seeking to reduce the environmental impact of power generation by promoting the use of CHP. The Partnership works closely with energy users, the CHP industry, state and local governments, and other clean energy stakeholders to facilitate the development of new projects and to promote their environmental and economic benefits*." The Partnership sponsors annual Energy Star CHP awards. See the list and descriptions of recent awardees here http://www.epa.gov/chp/documents/past_award_winners.pdf.

[3] U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA). *Combined Heat and Power: A Clean Energy Solution*. DOE/EE-0779. August 2012.

[4] U.S. DOE and EPA. August 2012.

[5] Oak Ridge National Laboratory (ORNL). *Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities*. ORNL/TM-2013/100. Prepared by A. Hampson, ICF International; T. Bourgeois, Northeast Clean Energy Application Center; G. Dillingham, Gulf Coast Clean Energy Application Center; I. Panzarella, Southeast Clean Energy Application Center. March 2013.

[6] New York State Energy Research and Development Authority. *The Contribution of CHP to Infrastructure Resiliency in New York State*. NYSERDA Report 10-20. Prepared by Energetics Incorporated; Pace University Energy and Climate Center; and Energy and Analysis, Inc., an ICF International Company. April 2009.

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

[8] For a review of several case studies from Hurricane Sandy, see ORNL. *Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities*. ORNL/TM-2013/100. Prepared by A. Hampson, ICF International; T. Bourgeois, Northeast Clean Energy Application Center; G. Dillingham, Gulf Coast Clean Energy Application Center; I. Panzarella, Southeast Clean Energy Application Center. March 2013.

[9] D. Bullock, Gulf Coast CHP Applications Center. PowerPoint Presentation: *Resilient Energy Systems: The CHP Solution*. September 25, 2006. http://files.harc.edu/sites/gulfcoastchp/Presentations/KatrinaForum_NOLA-060925.pdf

[10] ORNL. *Combined Heat and Power, Effective Energy Solutions for a Sustainable Future*. 2008.

[11] U.S. DOE and EPA. August 2012.

[12] A. Chittum and T. Sullivan, ACEEE. *Coal Retirements and the CHP Investment Opportunity*. September 2012. http://www.aceee.org/research-report/ie123

[13] A. Chittum and T. Sullivan, ACEEE. September 2012.

[14] S. Vaidyanathan, S. Nadel, J. Amann, C. J. Bell, A. Chittum, K. Farley, S. Hayes, M. Vigen, and R. Young, ACEEE. *Overcoming Market Barriers and Using Market Forces to Advance Energy Efficiency.* March 2013. http://rste040vlmp01.blackmesh.com/research-report/e136

[15] The White House. *Accelerating Investment in Industrial Energy Efficiency.* Executive Order. August 30, 2012. http://www.whitehouse.gov/the-press-office/2012/08/30/executive-order-accelerating-investment-industrial-energy-efficiency

[16] U.S. EPA, Combined Heat and Power Partnership. *Portfolio Standards and the Promotion of Combined Heat and Power*. January 4, 2013. http://www.epa.gov/chp/documents/ps_paper.pdf

[17] U.S. Energy Information Administration. *Combined Heat and Power Technology Fills an Important Energy Niche*. October 4, 2012. http://www.eia.gov/todayinenergy/detail.cfm?id=8250

[18] G. Morris. *Bioenergy and Greenhouse Gases*. Berkley, CA: Pacific Institute. 2008. http://www.pacinst.org/reports/Bioenergy_and_Greenhouse_Gases/index.htm. See also P. Spath and M.K. Mann. *Biomass Power and Conventional Fossil Systems with and without CO2 Sequestration – Comparing the Energy Balance, Greenhouse Gas Emissions and Economics.* NREL/TP-510-32575. Golden, CO: NREL. 2004. See also U.S. Department of Agriculture, Forest Service, Southwest Research Station. *Biomass to Energy: Forest Management for Wildfire Reduction, Energy Production, and Other Benefits*. California Energy Commission, Public Interest Energy Research Program. CEC-500-2009-080. 2009.

[19] B. Hedman, ICF International. *Biomass CHP: An Overview.* PowerPoint Presentation. EPA Combined Heat and Power Partnership Webinar. June 25, 2009. http://www.epa.gov/chp/documents/wbnr062509_hedman.pdf.

[20] P. Hutton. "Biomass in Microturbines," *Renewable Energy World*. August 20, 2010. http://www.renewableenergyworld.com/rea/news/article/2010/08/biomass-in-microturbines

[21] A. Kumar, D.D. Jones, and M.A. Hanna. "Thermochemical Biomass Gasification: A Review of the Current Status of the Technology," *Energies*, 2, 556-581. 2009. And D. Peterson, S. Haase. *Market Assessment of Biomass Gasification and Combustion Technology for Small- and Medium-Scale Applications*. Technical Report. Golden, CO: NREL. 2009. http://www.cleanenergystates.org/Publications/NREL_Biomass_Gasification_Mkt_Assessment_46190.pdf.

[22] International Energy Agency (IEA). *Biomass for Power Generation and CHP. http://*www.iea.org/techno/essentials3.pdf*. 2007.*

[23] ORNL. *Biomass Energy Data Book*: Edition 2. ORNL/Tn-2009/098. December 2009. http://cta.ornl.gov/bedb/pdf/BEDB2_Full_Doc.pdf.

[24] E. Brown, M. Mann. *Initial Market Assessment for Small-Scale Biomass-Based CHP*. White Paper NREL/TP-640-42046. 2008. http://www.nrel.gov/docs/fy08osti/42046.pdf. Also see M. Laser, E. Larson, B. Dale, M. Wang, N. Greene, and L.R. Lynd, "Comparative Analysis of Efficiency, Environmental Impact, and Process Economics for Mature Biomass Refining Scenarios," *Biofuels, Bioproducts, and Biorefining*, 3, 247-270. 2009. Also see U.S. EPA, CHPP. Impact *of Combined Heat and Power on Energy Use and Carbon Emissions in the Dry Mill Ethanol Process*. 2007. http://www.epa.gov/chp/markets/ethanol.html.