

Combined Heat and Power: A Resource Guide for State Energy Officials

National Association of State Energy Officials

Julia Friedman, Program Manager
Garth Otto, Project Manager

2013

This material is based upon work supported by the U.S. Environmental Protection Agency under agreement XA - 83600501 – 0.

This report was prepared by:

National Association of State Energy Officials

2107 Wilson Boulevard, Suite 850

Arlington, Virginia 22201

Acknowledgments

The National Association of State Energy Officials would like to thank those who lent their expertise during the development and review of this document: John Cuttica of the Energy Resources Center at the University of Illinois at Chicago; Jennifer Kefer of David Gardner Associates; Gary McNeil, Susan Wickwire, and Neeharika Naik-Dhungel of the U.S. Environmental Protection Agency's Combined Heat and Power Partnership; and a team of experts at ICF International.

NASEO would also like to thank the State Energy Offices for their support in the development of this document.

Cover photos courtesy of Dennis Jones, Bernard Blessinger, and the National Renewable Energy Laboratory (NREL).

Introduction

A number of important policy and market drivers have brought renewed attention to combined heat and power (CHP) including low natural gas prices, the high price of utility service disruptions, state policymakers crediting CHP in their energy efficiency and renewable portfolio standards, and President Obama's *Executive Order — Accelerating Industrial Energy Efficiency.*[i] CHP is an approach to generating electric power and useful thermal energy from a single fuel source. It is a form of distributed generation that does not refer to a single technology, but rather an integrated energy system sited at, or near, the energy-consuming facility. For the purposes of this document, CHP is used to refer both to systems that include an on-site electricity generation unit that recovers the heat normally wasted in power generation for useful heating or cooling, and also to waste-heat-to-power systems (WHP) that capture the heat released by an existing manufacturing process to generate electricity.

Both the utilization of waste heat and the proximity to load increase the overall efficiency of CHP systems relative to obtaining electricity and heat through central station generation and an on-site boiler, respectively. In a system that integrates waste energy recovery with electricity generation, heat that would normally be lost during electricity generation or from industrial processes is captured and used for any number of on-site purposes, depending on the system configuration. If designed properly, and supported by appropriate state policies and planning, CHP can provide system owners, grid operators, and others with significant economic, environmental, and reliability benefits that may align closely with a state's energy objectives.

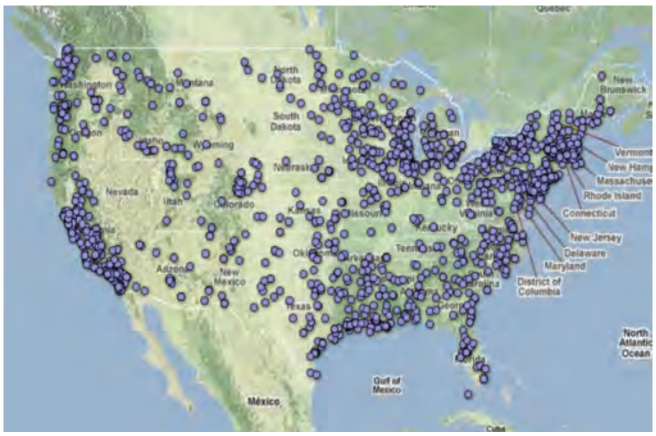
The National Association of State Energy Officials (NASEO) developed this resource guide to provide State Energy Officials with a technology and market overview of CHP and ways in which they can support CHP through state energy and energy assurance planning, energy policies and utility regulations, and funding/financing opportunities for CHP. The concepts and examples illustrate the range of initiatives that a State Energy Official or policymaker can influence or administer to affect CHP deployment. State Energy Officials may take the lead on some of the efforts described below—state energy planning or clean energy loan program administration, for example—or they may serve as advisors or conveners of parties to shape the policy and regulatory environment. Each section contains a brief summary of the topic, examples from the states, and a list of references to allow State Energy Officials to gain an in-depth understanding of the issues surrounding CHP development.

Status of the CHP Market and Technology Overview

Status of the CHP Market

As of October 2011, 82 gigawatts (GW) of CHP has been installed across nearly 4,000 industrial and commercial facilities, as seen in Figure 1.[ii] The total CHP capacity of 82 GW represents just over 8% of current U.S. generating capacity.[iii]

Figure 1: Existing CHP Installations



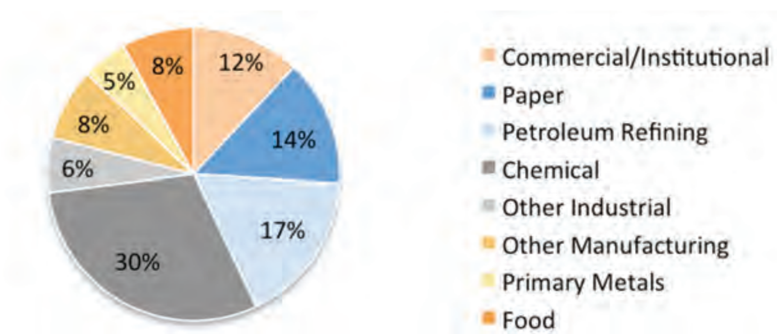
Source: Bruce Hedman, Combined Heat and Power: Markets and Challenges, ICF International. June 28, 2012. http://www.nga.org/files/live/sites/NGA/files/pdf/1206RoundtableHedman.pdf

CHP technology can be applied across a wide range of facility types and sized to meet loads of a few kilowatts to hundreds of megawatts. Potential CHP applications include:

- Commercial buildings
- Industrial manufacturers
- Institutions
- Municipal facilities
- Multi-family residential developments

By sector, as illustrated in Figure 2, installed CHP can be broken down accordingly:

Figure 2: CHP Installations by Sector (2011)



Source: Ibid.

While estimates vary, as of 2012 there are up to 130 GW of untapped technical CHP potential[1] at existing industrial and commercial facilities. This is equal to 40% of the total installed capacity of coal-fired power plants in the US in 2011 and nearly five times the amount of coal-fired generation capacity set to retire between 2012 and 2016.[vi,vii] The greatest technical potential for CHP is in California, Florida, Illinois, Michigan, New York, Ohio, Pennsylvania, and Texas, with each state exhibiting the potential for more than 5,000 MW

1 The technical market potential is an estimation of market size constrained only by technological limits—the ability of CHP technologies to fit existing customer energy needs. The technical market potential does not consider screening for other factors such as ability to retrofit, owner interest in applying CHP, capital availability, fuel availability, and variation of energy consumption within customer application/size classes. All of these factors affect the feasibility, cost, and ultimate acceptance of CHP at a site and are critical in the actual economic implementation of CHP.

of additional capacity. Applications with the greatest potential (by capacity additions in MWs) are chemical, paper, and food processing plants, commercial buildings, multi-family residential buildings, and institutional buildings such as hotels, hospitals, colleges/universities, and government buildings.[viii]

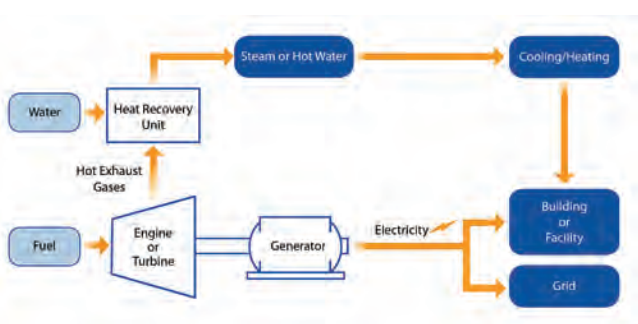
Although new CHP capacity additions have lagged in recent years due to the economic recession, changes to the Public Utilities Regulatory Policies Act, and previously volatile natural gas prices, market conditions are changing. Current and projected low natural gas prices, combined with regulatory and policy drivers at the federal and state levels, create opportunities for CHP deployment. Moreover, the ability of CHP systems to maintain critical services during Hurricane Sandy has brought significant attention to this energy resource's application in the institutional, commercial, and residential sectors.

Technology

CHP generally consists of a prime mover, a generator, a heat recovery system, and electrical interconnection equipment configured into an integrated system. CHP is a form of distributed generation, which, unlike central station generation, is located at or near the energy-consuming facility. CHP's inherent higher efficiency and the avoidance of losses in transmitting the electricity to the end-user from the central station generator result in reduced primary energy use and lower greenhouse gas (GHG) emissions. The most common CHP configuration is known as a *topping cycle*, where fuel is first used in a heat engine to generate power, and the waste heat from the power generation equipment is then recovered to provide useful thermal energy. As an example (Figure 3), a gas turbine or reciprocating engine generates electricity by burning fuel and then uses a heat recovery unit to capture useful thermal energy from the prime mover's exhaust stream and cooling systems. The heat is converted into useful thermal energy, most commonly in the form of steam or hot water. Gas turbines and reciprocating engines are ideally suited for CHP applications with large power needs relative to their thermal loads, such as industrial or commercial facilities. These systems can be fueled by natural gas, process offgases, landfill gas, or other forms of biogas.

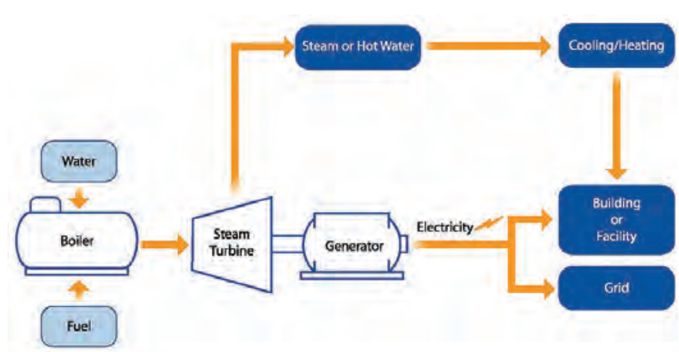
In an alternative topping cycle option (Figure 4), steam turbines generate electricity using high-pressure steam from a fired boiler before sending lower-pressure steam to an industrial process or district heating system. Steam turbine-based CHP systems are typically used in industrial processes or larger institutional applications, where solid fuels (biomass or coal) or waste products are readily available to fuel the boiler unit.

Figure 3: Gas Turbine or Engine CHP



Source: Basic Information. U.S. EPA Combined Heat and Power Partnership. December 6, 2012. http://www.epa.gov/chp/basic/index.htm

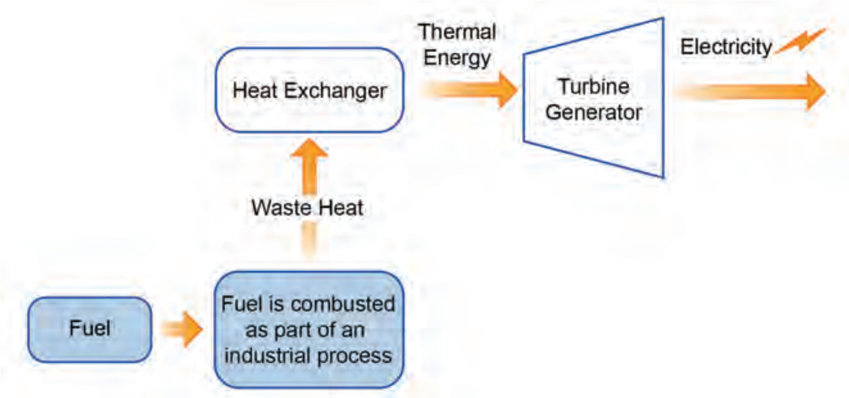
Figure 4: Boiler/Steam Turbine CHP



Source: Ibid.

Waste heat streams can be used to generate power in what is called a *bottoming cycle* CHP configuration, which is another term for WHP. In *bottoming cycle* CHP, fuel is first used to provide thermal energy in an industrial process, such as a furnace, and the waste heat from that process is then used to generate power. To be effective, a bottoming cycle must have a source of waste heat that is of sufficiently high temperature for the WHP system to be both thermodynamically and economically feasible. The key advantage of WHP systems is that they utilize heat from an existing thermal process that would otherwise be wasted to produce electricity or mechanical power, as opposed to directly consuming additional fuel for this purpose.

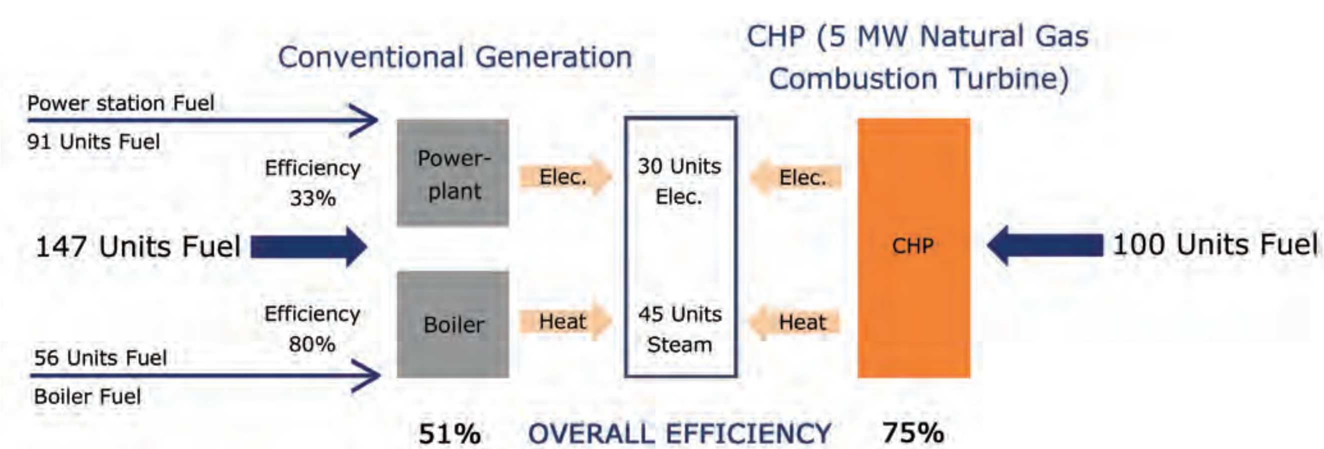
Figure 5: Bottoming Cycle or Waste Heat to Power CHP



Source: Waste Heat to Power Systems. U.S. EPA Combined Heat and Power Partnership. May 30, 2012. http://www.epa.gov/chp/documents/waste_heat_power.pdf

The high efficiency of a CHP system relative to conventional generation results in numerous economic and environmental benefits. Figures 6 and 7 illustrate the efficiency increase and subsequent emissions reductions, respectively. As shown in Figure 5, by avoiding line losses and capturing much of the heat energy normally wasted in power generation, CHP systems typically achieve total system efficiencies of 60 to 80 percent, compared to only about 50 percent for conventional separate electricity and thermal energy generation. By efficiently providing electricity and thermal energy from the same fuel source at the point of use, CHP significantly reduces the total primary fuel needed to supply energy services to a business or industrial plant.

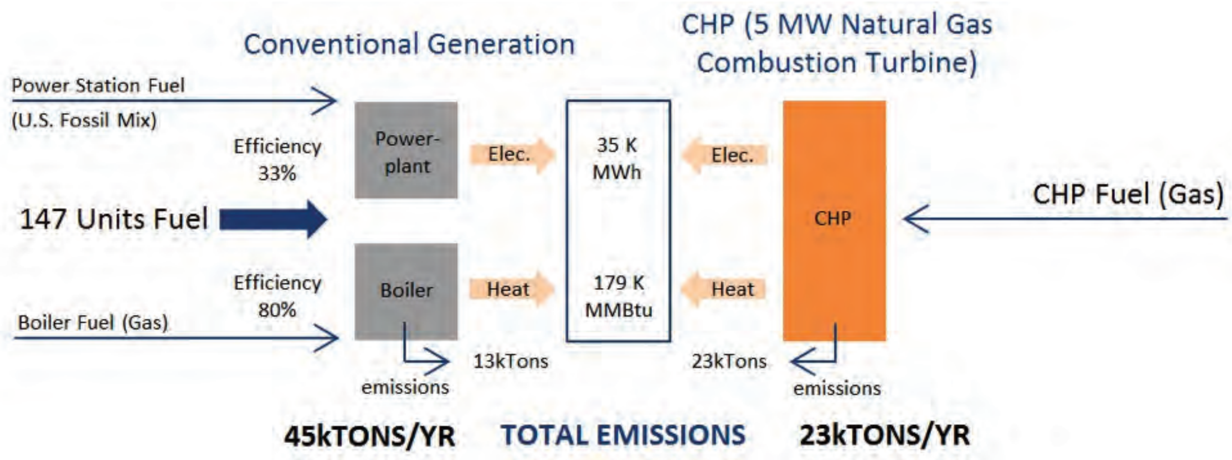
Figure 6: CHP System Efficiency



Note: Efficiency can be calculated through a number of different and legitimate ways; however, the efficiency numbers that EPA cites are referred to as "total system efficiency." Total system efficiency is the total power and useful thermal energy output of the system divided by the fuel used to produce the power and heat.

Using less fuel to provide the same amount of energy services generally translates into reduced emissions of carbon dioxide (CO_2) and other pollutants. Figure 7 shows the CO_2 emissions savings of a natural gas combustion turbine CHP system compared with conventional central station power generation and on-site natural gas boilers. In this case, the CHP system produces less than half the annual CO_2 emissions

Figure 7: CHP System Emissions Reduction



of separate heat and power while providing the same energy services. Note that individual CHP system efficiencies and resulting environmental and economic benefits will vary due to specific system design, offset fuel types, and input fuel choice.

In addition to the efficiency benefits, CHP can enhance electricity reliability and resiliency for the user and for the grid itself. CHP systems, if designed for reliability, can operate in an island mode, or independently from the grid. Unreliable electricity service represents measurable business, safety, and health risks for some industries. Typically these operations install backup or emergency diesel generators to protect against the risk of power failures. Diesel generation systems typically have high emissions, run the risk of shutting down during a prolonged outage if diesel fuel deliveries cannot be arranged, and require costly storage of large quantities of fuel that may degrade or leak over time.

While Hurricane Sandy hit New York City particularly hard in Fall 2012, a 40-megawatt CHP system in Co-op City, a Bronx housing development, provided power to the site's 35 high-rise buildings, six schools, three shopping centers, and police precinct. The lights were kept on for more than 60,000 residents.[xiii] A number of other stories of the power staying on at institutional facilities (hospitals and universities) due to CHP systems installed prior to the storm emerged from other areas in New York and New Jersey.[xiv] Similar stories came out of the Gulf Coast states following Hurricane Katrina.[xv] Also, during the Northeast blackout of 2003, non-CHP backup power generators failed at half of New York City's 58 hospitals. During extended power outages or supply disruptions, properly configured CHP systems can provide continuous electricity and thermal energy to a facility.

A number of states are recognizing the resiliency benefits of CHP through legislation and incentive design. Texas and Louisiana have passed legislation requiring CHP to be considered in the construction or renovation of facilities that are expected to operate during an emergency. New York State Energy Research and Development Authority (NYSERDA) will soon begin requiring that all CHP projects have black-start capability to be eligible for its incentive program. Bonus incentives will be offered to CHP projects that are sited at and support critical infrastructure such as hospitals and evacuation shelters.

The societal benefits of CHP should be considered when designing energy plans, policies, and funding mechanisms supported by public dollars. For instance, the Co-op City CHP facility was supported by NYSERDA's Performance-Based CHP Incentive Program. The following sections illustrate the planning, policy and regulatory, and funding and financing mechanisms that State Energy Offices can use to create a supportive environment for CHP within their state.

Technology and Market Assessment Resources	
Industrial Distributed Energy—US DOE	This webpage provides background information on distributed energy (DE) technologies, including gas-fueled and renewable energy, as well as industrial gas turbines, micro-turbines, and thermal-activated technologies. http://www1.eere.energy.gov/manufacturing/distributedenergy/technologies.html
Clean Energy Application Centers—US DOE	DOE's Regional Clean Energy Application Centers (CEACs), formerly called the Combined Heat and Power (CHP) Regional Application Centers (RACs), promote and assist in transforming the market for CHP, waste-heat-to-power, and district energy technologies and concepts throughout the United States. http://www1.eere.energy.gov/manufacturing/distributedenergy/ceacs.html
Catalog of CHP Technologies—US EPA	This catalog provides an overview of how CHP systems work, including the key concepts of efficiency and power-to-heat ratios, in addition to cost and performance characteristics associated with CHP. http://www.epa.gov/chp/technologies.html
Efficiency Benefits— US EPA	This webpage highlights the efficiency benefits CHP systems provide, by comparing CHP to conventional generation. http://www.epa.gov/chp/basic/efficiency.html
Environmental Benefits—US EPA	This webpage highlights the environmental benefits CHP systems provide, through verification and monetization. http://www.epa.gov/chp/basic/environmental.html
Economic Benefits—US EPA	This webpage highlights the economic benefits CHP systems provide by providing operating costs and energy savings. http://www.epa.gov/chp/basic/economics.html
CHP Emissions Calculator—US EPA	The CHP Emissions Calculator compares fuel-specific emissions from a CHP system to those of a separate heat and power system. http://www.epa.gov/chp/basic/calculator.html
Waste Heat to Power Systems—US EPA	This resource provides resource owners, facility managers, developers, and other interested parties with a comprehensive overview of WHP and a characterization of the WHP market. http://www.epa.gov/chp/documents/waste_heat_power.pdf
Strategic CHP Deployment Assistance for Wastewater Treatment Facilities—ASERTTI	The Association of State Energy Research and Technology Transfer Institutions analyzed four CHP applications at wastewater treatment facilities. http://archive.asertti.org/wastewater/index.html

State Energy and Energy Assurance Planning

State Energy Offices lead the comprehensive energy planning and energy assurance planning efforts in most states. These plans bring together numerous government agencies and private-sector stakeholders to ensure a sustainable and prosperous energy future for the state. A state energy plan sets forth a long-term vision for a state's energy future and pathways for achieving that vision. Energy assurance plans establish a state's response framework in the event of an energy emergency and provide a foundation for building a secure and resilient energy infrastructure. Both plans should be data-driven efforts and continuously updated to reflect changes in the marketplace, technological innovations, and state needs as determined by demographics, industry composition, and energy resources, among other factors.

State Energy Planning: NASEO's research shows that, as of late 2011, 38 states and the District of Columbia had a state energy plan. Of the plans collected, 17 states reference CHP in one fashion or another. Some state energy plans consider CHP in the context of renewable energy resources while others group CHP with energy efficiency resources. Highlights from the plans that mention CHP include offering financial incentives; encouraging CHP to spur economic development within the manufacturing sector; suggesting that energy portfolio standards be revised to include CHP; and suggesting that streamlined permitting of CHP be implemented to encourage energy efficiency in industrial sites. For example, the 2008 Intelligent Energy Choices for Kentucky's Future encourages the adoption of an energy efficiency resource standard that includes CHP as an eligible resource. The 2006 State Energy Strategy for Georgia[xvii] recommends that the state develop a CHP roadmap so that the state may begin to realize its economic potential for CHP. The roadmap will include an examination of the state's interconnection standards, environmental regulations, financing, rate treatment, and tax treatment of CHP. The plan goes so far to designate organizations to lead the development of the CHP roadmap and set a timeline for its completion.

State Energy Assurance Planning: The goal of energy assurance planning is to achieve a robust, secure, and reliable energy infrastructure that is also resilient—able to restore services rapidly in the event of any disaster. In the past three years, nearly every state in the country has developed an energy assurance plan. Including CHP in emergency planning efforts is one step policymakers can take to improve the resiliency of public and private business operations. The NASEO Energy Assurance Guidelines encourage state energy officials to include CHP systems in their state's energy assurance plan.[xviii] As CHP facilities are installed in the state, it is important to know their location, black-state capability, and other design features so that these energy resources can be integrated into state energy assurance plans. State Energy Officials can determine where CHP systems are presently installed and operating, which of those sites meet the criteria for operating during times of emergency, which of the facilities could be utilized to meet the energy assurance plan needs during an emergency (e.g., hospitals, schools), the ease and cost of modifying existing CHP sites to meet the needs of the energy assurance plan, and whether adding CHP to a select few key facilities is desirable and affordable as part of the energy assurance plan.

Energy Planning Resources	
CHP and Energy Assurance—John Cuttica, MW CHP Application Center	This presentation offers linkages between CHP and energy assurance, as well as the value CHP provides in energy emergencies, by exploring scenarios such as the Blackout of 2003. http://www.midwestcleanenergy.org/Archive/pdfs/060614_WSEAE-Cuttica.pdf
State of Illinois, Energy Assurance Plan—IL State Energy Office	This plan includes information on CHP systems throughout Illinois. Currently, there are approximately 138 operating CHP systems, a majority of which are equipped with black-start capabilities and synchronous generators, which allow them to serve the facilities' loads in case the electricity grid de-energizes. http://www.erc.uic.edu/PDF/IL_energy_assurance_plan_August2012.pdf
Texas Clean Distributed Energy/ Texas Administrative Code—ACEEE	This webpage includes information on Texas legislation (?) requiring all state government entities to consider implementing CHP technology in government-owned buildings that are expected to serve a public health or safety function during an emergency situation. http://www.aceee.org/energy-efficiency-sector/state-policy/texas/215/all/195
Louisiana Clean Distributed Energy/Louisiana Interconnection Standard—ACEEE	This webpage includes information on Louisiana legislation (?) that prompts the state's Department of Natural Resources and Public Service Commission to deploy CHP systems to help increase and maintain stability and reliability in the state's critical facilities. http://www.aceee.org/energy-efficiency-sector/state-policy/louisiana/191/all/195
Reliability Benefits—US EPA	This webpage includes information on the reliability of CHP systems and the cost savings associated with such systems by examining both standard CHP and CHP with backup capabilities. http://www.epa.gov/chp/basic/reliability.html
Calculating Reliability Benefits—US EPA	This webpage provides various methodologies for determining the cost-effectiveness of a CHP system to provide stand-alone power. http://www.epa.gov/chp/basic/benefits.html
State Energy Assurance Guidelines, Version 3.1—NASEO	Pages 20, 21, 110, 111, 117, and 122 of the State Energy Assurance Guidelines, Version 3.1, discuss CHP as a supplemental resource and the role it plays as part of a state's energy assurance plan. http://naseo.org/eaguidelines/State_Energy_Assurance_Guidelines_Version_3.1.pdf
Statewide Comprehensive Energy Plans Database—NASEO	NASEO collected State Energy Plans from 38 states and the District of Columbia to provide as a resource to other states and territories interested in developing similar frameworks. http://www.naseo.org/stateenergyplans/

Policy, Regulatory, and Planning Considerations

As advisors to state legislators, governors, and public utility commissions, State Energy Officials play an important role in formulating energy policies and regulations that support CHP deployment. State Energy Offices take on the role of informing state energy policy and ensuring that utility regulation aligns with public policy objectives. Numerous public policy and regulatory factors impact the economic viability of CHP projects. While the set of resources below is not exhaustive, it does represent some of the most commonly cited CHP barriers and opportunities.[xix] It is important to note that the list below contains policies, plans, and regulations that often originate through state legislation and are implemented by a state energy office, public utility commission (PUC), or air quality agency. For this reason, State Energy Officials may find it advantageous to work with their counterparts across state government if they decide to pursue the objective of increasing CHP deployment.

Energy Policies

<u>Portfolio Standards:</u> Throughout the nation, 40 states and the District of Columbia and two territories have some form of an alternative portfolio standard, renewable portfolio standard, or clean energy standard that is either mandatory or voluntary. CHP is considered an eligible technology within 23 of these state generation portfolio standards.[xx] Depending upon the nature of the fuel used in the CHP system—for instance, if renewable biomass is used—the electricity and thermal output generated by the CHP facility may be eligible to meet the RPS portfolio standard in the other 17 states and the District of Columbia.

CHP is also an eligible resource to meet states' energy efficiency goals. Twenty states have an Energy Efficiency Resource Standard (EERS).[xxi] Some states also have an energy efficiency component to their RPS that effectively serves as an EERS. A total of 13 states allow CHP to count towards their EERS or the energy efficiency portion of the RPS.[xxii] Ohio is an example of a state with both an RPS and an EERS that recently passed legislation categorizing waste energy recovery as an eligible resource under the RPS and CHP as a qualifying resource under the EERS.[xxiii] Allowing CHP to qualify for EERS or RPS creates an incentive for both utility and private sector investment in CHP systems.

<u>Defining Contiguous Property:</u> The definition of contiguous property may restrict the sale of excess electricity generated by a CHP facility host to a nearby end-user. Often, the sale of electricity by on-site generation, such as CHP is restricted to end-users on the host's property or contiguous property. Expanding the definition of what is considered contiguous property to include end-users who take thermal energy from a CHP host provides the host with a potential revenue stream from the sales of electricity. New Jersey passed legislation in 2009 that enables on-site generation to include end-users "purchasing thermal energy services produced by the on-site generation facility, for use for heating, air conditioning, or both, regardless of any intervening property, public thoroughfare, or transportation or utility-owned-right-of-way."[xxiv] The legislation also allows the CHP host to use existing electricity distribution infrastructure, which is important for enabling district energy systems with CHP.

Utility Regulation

<u>Interconnection Standards:</u> Interconnection standards detail the technical and procedural process by which an electricity-generating unit is connected to the grid. These standards ensure that both the end-user and the utility's reliability and safety needs are met during the interconnection process. Typically, PUCs define

the standards for interconnection to the distribution grid, while the Federal Energy Regulatory Commission establishes standards for transmission level interconnection. Currently, more than 40 states and the District of Columbia have developed interconnection standards that define how CHP systems can be connected to the grid. In 2010, the Utah Public Service Commission adopted an interconnection policy that embraces the Institute of Electrical and Electronics Engineers' (IEEE) Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547, and provides three levels of review for customer-sited systems of up to 20 MW of system capacity.[xxv] These three elements—following the IEEE 1547 technical standard, using multiple screening processes for systems with varying degrees of size and complexity, and setting a system capacity limit of at least 10 megawatts—follow some of the best practices promoted by efficiency and distributed generation advocacy groups.[xxvi] There are several different model interconnection standards that states can adopt.[xxvii, xxviii] States may also want to consider the impacts of regional coordination of interconnection procedures to further standardize practices. Interconnection standards represent an opportunity to enable CHP systems to more easily be connected to the grid.

Standby Rates: Standby rates are often seen as a barrier to CHP deployment. Most on-site generators stay connected to the grid and contract with the utility company for electricity in the event that the on-site generator experiences an outage (scheduled or emergency). For this backup service, utilities charge customers standby rates (also called backup rates, partial requirements, and other terms). Such charges are typically comprised of two elements: energy charges that cover the actual electricity delivered the CHP facility (in $/kWh) and demand charges that reflect the cost to the utility for providing sufficient capacity to meet a facility's peak demand (in $/kW).[xxix] While many states have experienced unfavorable standby rates and a challenging working relationship with utilities, New York and the District of Columbia are two places where standby rates no longer discourage CHP as they had in the past.[xxx] This is due in part to market needs, improved regulations, and collaboration between the public and private sectors.

Integrated Resource Planning and Portfolio Management: Integrated resource planning (IRP) is the method through which utilities ensure that they have adequate supply to meet demand. Traditionally, IRP is carried out in vertically integrated states, while other portfolio management techniques are used in those states that have restructured their electricity markets. Connecticut's general statues require CHP to be included in the state's energy and capacity resource assessment as well as utilities' procurement plans. In California, utilities must prepare a distributed generation forecast as part of their long-term procurement plans. Distributed generation, of which CHP is a subset, must also be considered as an alternative to distribution system upgrades by California's investor-owned utilities. Georgia, Iowa, Indiana, Kentucky, Nebraska, Nevada, New Mexico, and Oregon also require consideration of CHP in integrated resource planning. By altering or broadening the scope of utility resource planning, state policymakers and regulators place CHP on a more equal playing field with traditional energy resources.

Environmental

Output-based Emissions Regulations: Electricity generation technologies, including CHP, have traditionally been subject to input-based emissions regulations. Input-based regulations are based on the amount of fuel burned and do not reflect a unit's efficiency. On the other hand, output-based emissions regulations define emissions limits based on the amount of pollution produced per unit of useful output, accounting for the unit's efficiency (e.g., pounds of sulfur dioxide per megawatt-hour of electricity.) Output-based standards give credit to all of the useful energy generated. CHP systems fare well under this approach because it credits both the thermal and electric energy they produce. As of September 2012, 19 states have adopted some form of output-based regulations.[xxxi] Massachusetts has adopted such an approach for a suite of air pollution regulations that includes conventional emissions limits, emissions limits on small distributed generation, allowance trading, allowance set-asides, and an emissions performance standard.[xxxii]

Policy and Regulatory Resources	
Clean Distributed Energy—ACEEE	This database provides information on best practices for the above policies and regulations, and covers areas such as standby rates and net metering. http://www.aceee.org/sector/state-policy/clean-distributed-generation
Standby Rates for Customer-Sited Resources—US EPA	This report provides further details regarding rate structures and tariff designs as they relate to distributed generation systems. http://www.epa.gov/chp/documents/standby_rates.pdf
Interconnection Standards—US EPA	This webpage includes information on the benefits of interconnection standards and also includes an assessment of interconnection rules, in addition to state examples. http://www.epa.gov/chp/policies/interconnection.html
Output-based Regulations—US EPA	This fact-sheet includes information on output-based regulations (OBR), which promote clean energy technologies that can help reduce fuel use. http://www.epa.gov/chp/documents/output_based_regs_fs.pdf
Portfolio Standards and the Promotion of CHP—US EPA	This report discusses the different ways CHP is incorporated in portfolio standards, presents basic portfolio standard design approaches, identifies key CHP-related issues for policymakers, and provides state-specific information on CHP in existing standards. http://www.epa.gov/chp/documents/ps_paper.pdf

Funding and Financing CHP

Across the country, State Energy Offices design and administer energy efficiency and demand-side management programs, or work in partnership with their utilities, to provide project funding and financing for CHP systems. The programs that State Energy Offices run bridge the financial needs of the CHP system owners and hosts with the interests of commercial lending institutions and utilities. Funding and financing opportunities for CHP have expanded from the more traditional grants and rebates programs to utilizing state bonding authority and market-based renewable energy credit systems, among other options.

Project financing is impacted by a number of factors such as the size and configuration of the CHP system and the ownership structure. Given the varied nature of the CHP market, multiple financing options may be desirable to meet the needs of CHP system owners and host facility operators including, but not limited to, commercial banks, energy service companies, third party-ownership, and utility cost recovery.

A primary consideration for the financial feasibility of a CHP system is the spark spread, or the relative difference between the price of fuel for the CHP system to produce power and heat on site and the price of electricity the customer would have purchased from the utility. Fuel sources for CHP technologies can vary—natural gas, biomass, coal, biogas, or fuel oil—and will impact the spark spread. Most CHP systems, however, are fueled by natural gas.

Despite relatively low natural gas prices, there are still upfront capital and transaction costs that a project developer must address. To assist with the upfront costs of installing a CHP system and overcome market failures, public funds may prove necessary to make CHP systems feasible under certain circumstances. The following examples illustrate the many ways in which state policy-makers can use public dollars (ratepayer funds or appropriated dollars) to improve the economic feasibility of CHP projects, often through reducing the cost of capital to project developers. While not exhaustive, it demonstrates the range of financing options for policymakers to consider from direct subsidies to market-based mechanisms.[xxxiii]

Revolving Loan Funds (RLFs): RLFs are structured so that the repayment of a loan is recycled to be loaned out again in support of another project, providing a continuous source of loan funds. The Energy Division of the Alabama Department of Economic and Community Affairs administers the AlabamaSAVES revolving loan fund program, which includes a budget of $50 million dollars. CHP is considered an eligible technology under this program, with loans ranging from $4,000–$50,000.[xxxiv]

Grant or Rebate Programs: Grant (non-repayable funds) and rebate (refunds) programs may be designed in a prescriptive manner or so that the receipt of funding is contingent on the performance of a project. The Massachusetts Department of Energy Resources' Green Communities Designation and Grant Program has invested more than $17 million dollars to over 85 communities for energy efficiency upgrades, renewable energy technologies, and energy management services, including CHP systems.[xxxv]

State Tax Incentives: Tax incentives encourage economic activity among the for-profit private sector, offsetting the cost of projects through tax exemptions (deductions or credits). In 2012, the Florida Department of Agriculture and Consumer Services released an independent economic analysis of Florida's Energy Bill, HB 7117, an update to the 2006 renewable energy production tax credit. Under this bill, which includes CHP systems, credits may be claimed for electricity produced and sold on or after January 1, 2013, through June 30, 2016.[xxxvi]

Loan Guarantees or other Credit Enhancement Mechanisms: A loan guarantee promises that the state government will take on any debt obligations of a borrower should the borrower default. Such guarantees, or other credit enhancement mechanisms such as loan loss reserves, reduce the risk of investment by private financiers. In September 2012, the California legislature passed SB 1128, which requires the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) to provide financial assistance, including loan guarantees and credit enhancements, to participating parties for such "alternative sources" or other technologies, which include CHP systems.

State Bonding Authority: Through state bonding authorities, a bond (financial security) may be issued by the government as a way for other agencies to borrow money to invest in operational endeavors and projects. Policymakers in Minnesota recently approved $64.1 million in bonding that will allow the University of Minnesota to make improvements to its campus infrastructure. Of that $64.1 million, $10 million is being dedicated to a CHP project, designed to replace current coal furnaces.[xxxvii]

Renewable/Thermal Energy Credit Markets (RECs): RECs monetize the value of the environmental attributes of energy (electricity or useful thermal) generated from eligible renewable resources and are separate from the commodity electricity. Generally, one megawatt of renewable energy generation produces one REC. RECs are also a means of tracking a utility's compliance with a state's RPS. Utilities will purchase RECs from renewable energy generators for a price that is determined by the marketplace as long as the price is below the alternative compliance payment set by the PUC (the price of non-compliance). To earn RECs, a CHP facility must often meet certain efficiency or emissions requirements. For instance, under the Massachusetts Alternative Energy Portfolio Standard, CHP units that can earn alternative energy credits must have a net carbon dioxide emissions rate of 890 lbs/megawatt hour.[xxxviii]

Property Assessed Clean Energy (PACE) Financing: In areas where PACE legislation exists, municipal governments lend consumers money to make energy improvements to their properties; these loans are repaid through an assessment on their property taxes. Missouri enacted PACE legislation, HB 1692, in 2010 and in January 2011, Jefferson City became the first city to adopt the ordinance, which provides 100 percent of upfront costs for energy efficiency and renewable energy projects, including CHP, for residential and business properties.[xxxix]

Financing Resources	
CHP Financial, Tax, and Operating Incentives—US DOE, NE Clean Energy Application Center	This webpage includes information on financing mechanisms, such as systems benefit charges, tax credits, and tax and tariff exemptions. In addition, it provides examples of policies implemented at the state level. Lastly, it provides a link to an incentives report compiled by ACEEE. http://www.northeastcleanenergy.org/policymakers/incentives.php
Financing Options—US DOE, Gulf Coast Clean Energy Application Center	This webpage includes definitions on a variety of financing options such as bonds, end-use purchases, enhanced leasing, and joint ventures, among others, all designed to help promote CHP projects. http://www.gulfcoastcleanenergy.org/PROJECTSUPPORT/Financing/tabid/1672/Default.aspx
CHP Fact Sheet—WA State University Energy Program	This fact sheet provides details on regulatory risk and power/thermal sales contracts, as well as lenders' criteria for financing. http://www.northwestcleanenergy.org/NwChpDocs/CHP_Understanding_lenders_criteria.pdf
CHP Financial Tools—PUC of Ohio	This webpage includes financing presentations from a CHP workshop held in the summer of 2012 by the Ohio Public Utilities Commission. http://www.puco.ohio.gov/puco/index.cfm/industry-information/industry-topics/combined-heat-and-power-in-ohio/chp-financial-tools-august-2-2012/
CHP Case Studies from Hurricanes Sandy and Katrina, Alliance for Industrial Efficiency	This document includes a number of case studies on how CHP systems performed during and in the aftermath of Hurricanes Sandy and Katrina. It also examines lessons learned, as well as CHP reliability in the event of such natural disasters. http://www.dgardiner.com/doc/Combined%20Heat%20and%20Power%20and%20Electric%20Reliability%20rev.12-5-12.pdf
Financial Incentives for Facilities Affected by US EPA Emission Standards—ICF	This report includes information on boiler MACT regulations and federal incentives (tax deductions and tax credits), as well as state-specific summaries on incentive programs for CHP systems and large scale boilers. http://www1.eere.energy.gov/manufacturing/states/pdfs/incentives_boiler_mact.pdf
Database of CHP Policies and Incentives—US EPA	This database provides an extensive list and additional information on CHP policies and incentives at the state and federal levels. http://www.epa.gov/chp/policies/database.html

Conclusion

State energy officials can support the deployment of CHP in numerous ways—as energy and resiliency planners, advisors to legislatures and governors, and financiers. They can ensure that CHP is considered a resource for meeting state environmental, economic development, and reliability goals by including CHP as a resource in state energy plans and energy assurance plans and creating opportunities for CHP through state energy policies and utility regulations. Beyond creating a more supportive policy and regulatory environment, state energy officials can leverage public dollars to support private sector investment in CHP, aiding CHP system operators and energy consumers in capturing the efficiency and reliability benefits of combined heat and power.

i. The White House, Office of the Press Secretary. August 30, 2012. http://www.whitehouse.gov/the-press-office/2012/08/30/executive-order-accelerating-investment-industrial-energy-efficiency

ii. Todd Currier and Greg White, Industrial Energy Efficiency/CHP Working Group Executive Summary, ICF International. March 25, 2011. http://www1.eere.energy.gov/seeaction/pdfs/seeaction_ie_chp_executive_summary.pdf

iii. Combined Heat and Power: Frequently Asked Questions, U.S. Environmental Protection Agency. January 6, 2012. http://www.epa.gov/chp/documents/faq.pdf

iv. Bruce Hedman, Combined Heat and Power: Markets and Challenges, ICF International. June 28, 2012. http://www.nga.org/files/live/sites/NGA/files/pdf/1206RoundtableHedman.pdf

v. Ibid.

vi. Combined Heat and Power, A Clean Energy Solution, U.S. Department of Energy and U.S. Environmental Protection Agency. August 2012. http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

vii. Today in Energy, U.S. Energy Information Administration. July 27, 2012. http://www.eia.gov/todayinenergy/detail.cfm?id=7290

viii. Bruce Hedman, Combined Heat and Power: Markets and Challenges, ICF International. June 28, 2012. http://www.nga.org/files/live/sites/NGA/files/pdf/1206RoundtableHedman.pdf

ix. Basic Information. U.S. EPA Combined Heat and Power Partnership. December 6, 2012. http://www.epa.gov/chp/basic/index.html

x. Ibid.

xi. Waste Heat to Power Systems. U.S. EPA Combined Heat and Power Partnership. May 30, 2012. http://www.epa.gov/chp/documents/waste_heat_power.pdf

xii. Efficiency can be calculated through a number of different and legitimate ways; however, the efficiency numbers that EPA cites are referred to as "total system efficiency." Total system efficiency is the total power and useful thermal energy output of the system divided by the fuel used to produce the power and heat.

xiii. Pentland, William. Lessons From Where The Lights Stayed On During Sandy. Forbes. October 31, 2012. http://www.forbes.com/sites/williampentland/2012/10/31/where-the-lights-stayed-on-during-hurricane-sandy/

xiv. Combined Heat and Power and Electric Reliability, Case Studies from Sandy and Katrina, Alliance for Industrial Efficiency. December 2012. http://www.dgardiner.com/doc/Combined%20Heat%20and%20Power%20and%20Electric%20Reliability%20rev.12-5-12.pdf

xv. Louay Camra and Keith Hodge, CHP at the Mississippi Baptist Medical Center, Mississippi State University. November 2007. http://www.southeastcleanenergy.org/resources/reports/CHP-MBMC.pdf

xvi. Many states' energy plans discuss distributed generation, which may include CHP.

xvii. This plan is still operational although it was updated in 2009. State Comprehensive Energy Plans, National Association of

State Energy Officials. Date accessed, January 9, 2012. http://www.naseo.org/stateenergyplans/

xviii. State Energy Assurance Guidelines, National Association of State Energy Officials. December 2009. http://naseo.org/eaguidelines/State_Energy_Assurance_Guidelines_Version_3.1.pdf

xix. The information contained in this list is compiled from: the Database of State Incentives for Renewable Energy and Energy Efficiency, the American Council for an Energy Efficient Economy, the Intermountain Clean Application Energy Center, and the Pacific Clean Energy Application Center.

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

xxi. Energy Efficiency Resource Standards, Database of State Incentives for Renewables and Efficiency. October 2, 2012. http://dsireusa.org/documents/summarymaps/EERS_map.pdf

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

xxiii. SB 315: Ohio's Energy Policy, Ohio Development Services Agency. June 11, 2012. http://development.ohio.gov/files/bs/SB%20315_Energy%20FINAL.pdf

xxiv. State of New Jersey. 213th Legislature. Adopted December 3, 2009 http://www.njleg.state.nj.us/2008/Bills/PL09/240_.HTM

xxv. State Energy Efficiency Policy Database, American Council for an Energy-Efficient Economy. Date accessed, November 7, 2012. http://aceee.org/energy-efficiency-sector/state-policy/utah/216/all/195

xxvi. Interconnection Standards, American Council for an Energy-Efficient Economy. Date accessed, January 9, 2013. http://aceee.org/sector/state-policy/toolkit/chp/interconnection

xxvii. Model Interconnection Procedures, 2009 Edition, Interstate Renewable Energy Council. January 2010. http://irecusa.org/wp-content/uploads/2010/01/IREC-Interconnection-Procedures-2010final.pdf

xxviii. Madri Model Small Generator Interconnection Procedures, November 2005. http://sites.energetics.com/MADRI/pdfs/inter_modelsmallgen.pdf

xxix. Standby Rates, American Council for an Energy-Efficient Economy. Date accessed, January 9, 2013. http://aceee.org/topics/standby-rates

xxx. Anna Chittum and Nate Kaufman, Challenges Facing Combined Heat and Power Today: A State-by-State Assessment, American Council for an Energy-Efficient Economy. September 27, 2011. http://www.uschpa.org/files/public/ie111.pdf

xxxi. Combined Heat and Power Partnership, Output-Based Environmental Regulations Fact Sheet, U.S. Environmental Protection Agency. Date accessed, December 26, 2012. http://www.epa.gov/chp/policies/output_fs.html

xxxii. Ibid.

xxxiii. State Energy Offices may also work with their public utility commissions and utilities to design utility-administered energy efficiency and demand-side management programs that include CHP as an eligible resource.

xxxiv. AlabamaSAVES, Alabama Department of Economic and Community Affairs. Date accessed, November 7, 2012. http://www.alabamasaves.com/Default.aspx

xxxv. Energy and Environmental Affairs, Massachusetts Executive Office of Energy and Environmental Affairs. Date accessed, November 7, 2012. http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/gc-grant-program/

xxxvi. Independent Economic Analysis of Florida's Energy Bill Proves Legislation Will Create Jobs and Result in a Net Gain in Tax Revenue, Florida Department of Agriculture and Consumer Services. Date accessed, November 7, 2012. http://www.freshfromflorida.com/newsroom/press/2012/04132012.html

xxxvii. Session Successes Position University of Minnesota to Advance Research and Education Missions While Restoring Infrastructure, University of Minnesota. Date accessed, November 7, 2012. http://www1.umn.edu/news/news-releases/2012/UR_CONTENT_388644.html

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

xxxix. Property Assessed Clean Energy (PACE), Missouri Department of Natural Resources. Date accessed, November 7, 2012. http://dnr.mo.gov/energy/financial/PropertyAssessedCleanEnergyPACE.htm