# Combined Heat and Power Playbook

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## Introduction

Combined heat and power (CHP) technologies, also known as cogeneration, generate electricity and useful thermal energy in a single integrated system. CHP projects can offer substantial economic, environmental, and energy benefits to their owners, including reduced overall energy costs, improved energy system reliability, and reduced thermal energy consumption. Local communities, public entities, and private companies are all potential CHP system owners.

CHP technologies are a good fit for a variety of applications and are particularly well suited to applications in the municipal and public sectors. This document is designed for municipal and local governments interested in developing innovative solutions to their local energy challenges. It will help them understand how CHP can benefit their communities and how to implement CHP systems. It also reviews how municipalities have used these systems historically to meet their local energy needs. Further information is included regarding the current economic and political landscape of CHP. The document concludes with a step-by-step discussion of CHP project development, from initial consideration through the design process, equipment selection, project implementation, and ongoing systems maintenance.

CHP projects promote local economic development and generally use mature technologies widely available throughout the United States. They do not depend on proximity to other power-generating equipment, and they have been successfully implemented in both rural and urban locations. CHP projects reduce greenhouse gas (GHG) emissions and give communities control over their own power supply.

CHP can also play a key role in district energy systems. Local governments that use such systems can gain greater control over their energy use by aggregating electric demand. They can manage heating and cooling loads from multiple buildings and meet the loads with locally appropriate energy generating options.

CHP and district energy systems can be complex and involve many actors throughout the design process and during day-to-day operations after installation. System designers must plan for the many regulatory and logistical hurdles they may encounter. As with any complex equipment configuration, these systems can fail to produce their claimed benefits if they are designed, constructed, or operated poorly. Therefore it is important that prospective CHP users undertake due diligence to ensure that the new system is properly designed to meet local power needs and is constructed and operated as designed.

Municipalities interested in deploying CHP and district energy can draw on a variety of resources. This document gathers these resources and delineates which are most useful at particular periods of project development and to overcome barriers and challenges. We primarily address CHP, but we also point to resources for district energy projects when they are relevant. We also include examples of CHP and district energy deployment activities undertaken by municipalities around the country. The ultimate goal of this report is to help municipalities as they move CHP projects forward in their communities and take advantage of the many opportunities for local CHP and district energy.

# Combined Heat and Power

## *WHAT IS CHP?*

CHP is not a technology, but an approach to applying various technologies. This approach generates electricity and useful thermal energy in a single integrated system. Heat that is normally wasted in conventional power generation is recovered as useful energy, avoiding the energy losses that are incurred when heat and power are generated separately.

Whereas the conventional method of producing heat and power separately has a typical combined efficiency of 45%, CHP systems often have total efficiencies of 70 to 80%. This increased efficiency reduces or eliminates the purchase of energy from offsite generating sources such as an electric utility and so saves on utility costs. Transmission losses associated with traditional grid-sourced power are also avoided.

As illustrated in figure 1, a highly efficient CHP system uses less input fuel (denoted by the yellow arrows) to produce the same amount of output energy (denoted at the center as 35 kW of electricity and 50 Btu of heat) as the conventional generation of heat and power. The conventional system has two parts: the power station that generates electricity and the boiler that generates heat. The majority of the energy in the power station fuel is lost in the conversion to electricity. Although the boiler may be able to convert up to 85% of the energy in its fuel into steam or another form of thermal energy, this efficiency cannot make up for the inefficiency of the power station generator. In contrast, the CHP approach minimizes overall conversion losses by using a single system to generate both electricity and heat.

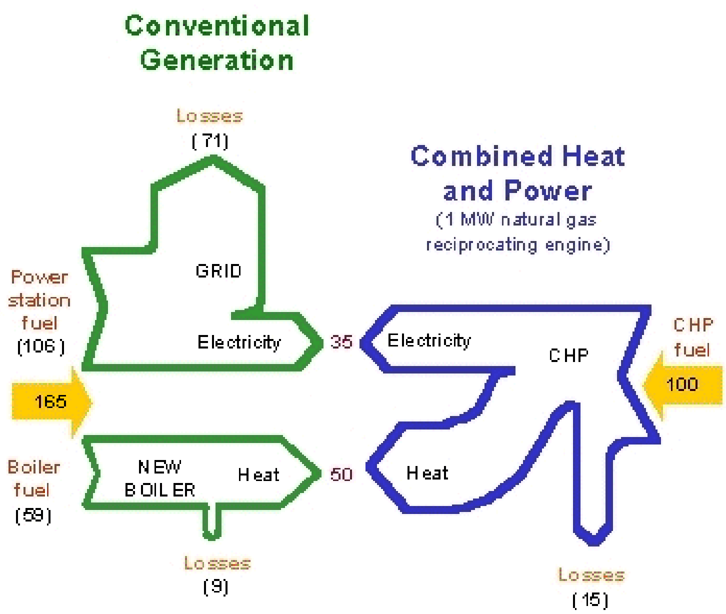


Figure 1. CHP schematic. Image courtesy of NERAC 2010.

CHP is a versatile and flexible energy resource. As a system, it can be powered by engines, turbines, fuel cells, or other prime movers. A variety of fuels can be used to feed the system, including natural gas, biomass, diesel, and waste energy streams. As a scalable power source, a CHP system can be sized to meet energy demand loads ranging from that of a single family home to that of a large industrial facility. Such systems can be deployed in either existing or new buildings in the industrial, commercial, residential, and agricultural sectors. They can be good investments and provide great benefit when appropriately designed to meet local needs.

As used in this document, "CHP" refers to new combined heat and power systems as well as those systems that take advantage of existing waste energy streams, such as one that captures waste industrial heat for additional mechanical energy. Combined heat and power systems can produce electricity, thermal energy, and mechanical power, or any combination thereof, depending on the technology and application (ORNL 2008).

### *DISTRICT ENERGY AND CHP*

CHP projects can be deployed to meet the needs of a single facility or as part of a larger facility. They can also meet the aggregated energy needs of multiple facilities. District energy systems provide an opportunity for even greater CHP deployment by aggregating the heating and cooling loads of multiple facilities into a single energy loop. CHP can be installed as part of a district energy system, used as a mini-power plant providing electricity, chilled water, hot water, steam, and other energy to the locations served by a district energy system. These systems can also incorporate other means of energy generation, including renewable energy technologies and an assortment of waste energy recovery mechanisms. District energy systems allow CHP to be scaled up to meet the needs of multiple facilities, often increasing economic and energy benefits by maximizing the overall systems efficiency. The International District Energy Association (IDEA) promotes district energy as a means of encouraging energy efficiency and environmental quality.

### *CHP EQUIPMENT AND FUEL*

CHP can comprise a number of different equipment types and use a number of different fuels. Each installed project is a combination of many different project elements. These elements are chosen based upon the unique constraints and challenges presented by each potential CHP host site, such as cost limitations, space availability, local emissions profiles, and noise concerns.

Combined heat and power systems are most often classified by the type of machine or engine that creates energy from the fuel or fuels. This piece of equipment is called the prime mover and generally falls into one of six categories.

*Reciprocating engines*, which can be sized up to about 7 MW, are the most commonly used type of prime mover. A facility may choose a reciprocating engine for the starting speed, or ability to reach the optimal level the fastest, as well as for its reliability rating.

*Steam turbines* use boiler-generated steam to generate electricity or other types of energy. Steam turbines can run on a variety of fuels and can range in size from 50 kW to 250 MW.

*Combustion turbines*, which can burn a variety of different gasses, are used in applications that require high-pressure and high-temperature steam. These turbines can be sized up to well over 100 MW and are often used by utilities interested in deploying CHP within their generating fleets.

*Microturbines* are small, often modular combustion turbines with availabilities nearing 500 kW. They are able to run on a variety of fuels and resemble small jet engines. These turbines typically offer lower emissions than other types of CHP equipment and contain few moving parts, which can be advantageous in some applications. Figure 2 shows a set of three microturbines.

Figure 2. Set of three microturbines. Image courtesy of DOE/NREL. Credit: Capstone Turbine Corporation.

*Fuel cells* create electricity using an electrochemical reaction process, concurrently producing heat byproducts such as hot water and hot air. Fuel cells have recently been used in the hospitality and residential sectors, utilizing heat for space conditioning and for general potable hot water needs in homes and hotel rooms. Fuel cells can be an expensive investment but are known for their clean operating characteristics, high efficiency, and relatively quiet operation.

Designed for residential or small commercial use, *micro-CHP* units are typically sized up to 3 kW and consist of a packaged small generator combined with a space or water heating unit. Though the technology is mature and widely available in certain countries, it is just beginning to penetrate the U.S. market.

Each of these systems can run on a wide variety of fuels, which is important because while there are significant cost considerations associated with the initial capital outlays for the purchase and installation of the CHP system, fuel costs can dramatically impact a CHP project's day-to-day economics. Fuel availability and long-term price forecasts often dictate which prime mover technologies are considered and ultimately chosen at a given site.

CHP systems are often operated on fuels such as natural gas purchased from a local utility or purchased as commodities from vendors. Some prime movers can also run on waste heat, waste pressure, or waste fuel streams from industrial processes. Biomass or biogas fuels can also be used when municipal waste management activities, forest management activities, or local agricultural waste streams are located in close proximity. One of the benefits of CHP solutions is that they can take advantage of multiple fuel sources to create useful outputs from what would have otherwise have become waste or pollution. These systems offer tremendous flexibility and can meet a wide variety of energy needs.

For an overview of CHP technologies and benefits, see the 2008 U.S. Department of Energy (DOE) report *Combined Heat and Power: Effective Energy Solutions for a Sustainable Future*. An additional overview of different CHP technologies is available from the U.S. Environmental Protection Agency (EPA) CHP Partnership (CHPP). A recent paper released by the DOE SEE Action Industrial Efficiency & Combined Heat & Power working group, *Guide to the Successful Implementation of State Combined Heat and Power Policies,* discusses policies important to CHP in detail and provides best practice information.

## CHP Opportunities

### *THE CHP INDUSTRY*

CHP has made significant inroads in a several countries around the world. A small number of countries have prioritized CHP and district energy, including Finland and Denmark, which have seen these systems grow to represent much higher portions of their energy capacity. Denmark, which is frequently cited as the world leader in CHP and district energy use, produces over half of its power with CHP (IEA 2009). Though the United States has seen the support of some significant CHP policies, no nationwide effort to promote the implementation of these systems currently exists, especially as compared to Denmark and other countries where governmental promotion has driven this market penetration. Figure 3 shows the CHP share of national power production for selected countries.

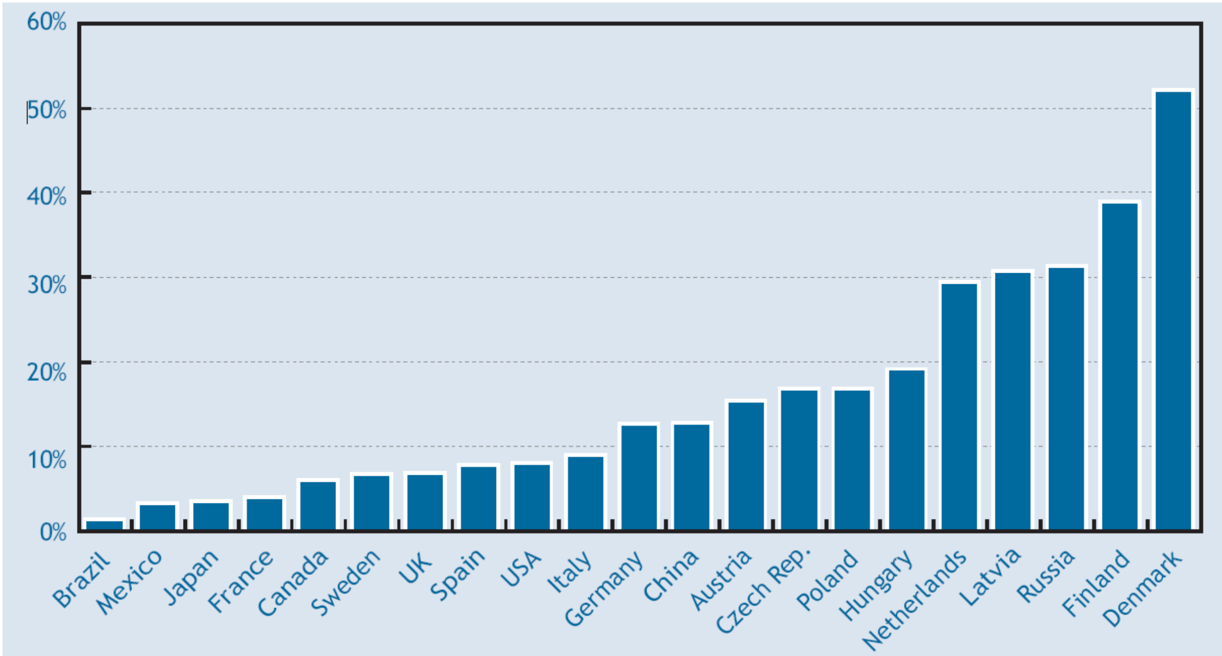


Figure 3. CHP share of total national power production. © Organization for Economic Co-Operation and Development/International Energy Agency, 2008 (IEA 2009).

In the United States, CHP represents nearly 10% of total generating capacity, although it has the potential to represent a much greater share. In its 2008 report, *Combined Heat and Power: Effective Energy Solutions for a Sustainable Future,* the Oak Ridge National Laboratory made the case for scaling up the use of CHP to 20% of U.S. generating capacity by 2030. Achieving this level of implementation would offer tremendous economic and environmental benefits, such as a reduction in $CO_2$ emissions equal to the removal from the road of more than half of all passenger cars from the road in the United States (ORNL 2008).

Even though the United States may trail some countries in this space, there are many successful examples of CHP and district energy projects found throughout the United States and in all major sectors of the economy. Typical applications include the following.

*Municipal and institutional.* Often as part of larger district energy systems, CHP powers many college campuses, health care facilities, military facilities, and other institutions where aggregated energy loads can be met by a single CHP unit or combined into a district energy system. Municipal-owned institutions and campuses such as schools, libraries, and school-district and city buildings are well suited to CHP and district energy installations. The single ownership and management of these buildings, plants, and roads in a campus or large institutional setting are ideal. Developers of these systems rarely have to cross a public right-of-way or deal with the frustrations of working with multiple asset owners. Incentives are also aligned: with these aggregated facilities, all of the energy savings belong to the institution or campus entity. The various heating and cooling loads of different buildings can also be aggregated, allowing certain technologies to be even more cost-effective, such as renewable energy resources (Thornton 2010). A particularly appropriate application has also been found in wastewater treatment plants across the country, where anaerobic digestion produces biogas, a “free” fuel that powers onsite electrical generators.

*Industrial and manufacturing.* CHP systems can power a wide variety of industrial and manufacturing processes and produce additional useful energy, such as high-pressure steam, process heat, mechanical energy, or electricity. In manufacturing and industrial settings, CHP systems can often take advantage of waste heat, waste pressure, or waste fuel streams derived from manufacturing process byproducts. Figure 4 shows an example.

Figure 4. Gas turbine CHP system at Bristol-Myers Squibb in Wallingford, CT. Image courtesy of DOE/NREL. Credit: Bernard Blessinger.

*Commercial.* A relatively newer sector to adopt CHP, commercial office buildings and other larger commercial buildings have found CHP to be an excellent way to stabilize energy costs, ensure reliability, and meet base load energy requirements. As in the residential sector, CHP systems in commercial buildings often provide space heating and cooling, in addition to electricity to power lights and other loads. Commercial facilities such as hotels will often also use the thermal energy for water heating.

*Agricultural.* Waste from agricultural production processes can be used to fuel CHP systems that provide power for onsite energy generation. This onsite power can be used to run agricultural equipment and energy-dependent building services such as lighting.

*Residential.* CHP systems have been implemented to power different sizes of residential buildings and easily meet their heating, cooling, and hot water demands in some applications. Larger CHP systems can power energy-intensive multifamily buildings, while smaller micro-CHP systems can be used to meet the energy needs of single-family homes.

In the United States, CHP is an important energy resource, though the market penetration in most areas is far below the actual economic potential. In general, CHP adoption slowed due to the recent recession as companies and municipalities have been more likely to conserve available cash and postpone large capital projects (Chittum and Kaufman 2011). CHP systems fueled by local biomass and biogas resources have been a relative bright spot in the past few years as they continue to be deployed by municipalities and other individual facilities. This is due in part to the readily available methane fuel typically collected from landfills, which in the past was flared off or released to the atmosphere. Utilizing these waste products reduces the costs incurred in disposal and regulatory compliance activities. In addition, certain states have been active in encouraging CHP development in the past few years, and have thus generally seen greater recent CHP deployment than others.

The DOE supports this database of CHP installations maintained by ICF International. Search for CHP projects around the country by location, prime mover, fuel, and size in the DOE Industrial Technologies Program CHP project database.

### *BENEFITS OF CHP FOR MUNICIPALITIES*

Implementing a CHP system today can bring many benefits to a facility or local government. It can also bring substantial energy and environmental benefits to society at large, since municipalities and local governments directly influence the way energy is used locally. The benefits of CHP and district energy to municipalities and local governments include the following.

#### Economic Benefits

CHP makes more productive use of a single fuel input, thereby reducing the energy a facility has to purchase from the grid or other source. In some cases, CHP and district energy can be fueled partly or entirely from locally available fuel at little or no additional cost. For instance, some municipalities have been capturing methane from the landfills they own or manage. Traditionally, methane from landfills has been flared off due to its noncommercial, low-grade quality. However, onsite processing of the gas can improve its quality so that the gas can be used in a nearby CHP system. The costs of initial processing systems can be recouped because of the generation of usable heat and power, with little to no fuel cost.

CHP or district energy systems also have the potential to insulate facilities from the impact of price spikes commonly felt in certain fuel markets. Even if the CHP system runs on a purchased fuel such as natural gas, electricity purchases can be reduced because electricity is generated onsite. Planning the implementation of these systems also encourages municipalities to engage in careful local energy planning. Instead of being a passive consumer, municipalities that use local energy sources take active control of their energy use, their emissions, and their energy future.

These types of systems can bring direct benefits to the facilities they serve, and can also bring larger economic development benefits to a community by creating new jobs in construction and systems maintenance and improving energy reliability.

These systems can also mitigate problems associated with traditional energy suppliers, including blackouts, brownouts, dips, surges, or weather-related outages. The impact of these events can be reduced, or potentially eliminated entirely. A reliable electric supply is more attractive to firms considering relocating or expanding, especially for mission-critical facilities, high-tech manufacturers, and financial institutions. Energy produced by CHP systems is also produced locally and can reduce or remove the need for new transmission and distribution lines to carry energy from remote generating sources. This proximity saves utilities future investment and may reduce consumer energy rate spikes.

### Use of Existing Fuel Resources

One of the greatest benefits to municipalities using CHP is the ability to use existing local fuel resources, instead of relying on fuel that is sourced from afar. These types of systems can be powered by waste energy from industrial activities, biomass from forest maintenance activities, waste gas from agricultural or sanitation facilities, and myriad other locally sourced resources. Many of these fuel resources would otherwise be wasted and would require proper disposal. By using CHP, municipalities save on transportation and disposal costs.

The immense amount of wood waste created by the destructive pine beetle is an example of local conditions that can be used to a municipality's advantage. This wood creates a fire hazard if not properly collected and disposed. However it also represents an excellent fuel source for CHP. Many states and regions with beetle-kill wood are currently exploring the development of CHP systems specifically designed to make effective use of this wood resource.

### Grid Congestion Reductions

CHP can reduce the peak and overall electric demand on the local grid. It can help constrained or overloaded grids increase their flexibility and allow adaptation to unforeseen peaks in customer demand (Thornton 2010).

In areas where new centralized generation resources are being considered to meet growing energy demand, CHP can meet these needs in a fraction of the time it takes to construct new centralized generation. CHP is quickly deployable and can also meet these needs in a cleaner and more efficient manner than many typical centralized generation sources.

### Environmental Benefits

CHP systems and district energy systems use fuel inputs more efficiently than traditional generation. When facilities implement a CHP project, overall emissions from energy use are immediately reduced. For localities searching for methods of reducing their emissions and emission-creating activities, CHP and district energy offer such reductions while simultaneously saving energy costs. When used in place of centralized energy generation, CHP can substantially reduce mercury, $NO_x$, $SO_2$, and $CO_2$ emissions. Such reductions can yield direct and immediate improvements in local air quality, improving public health and reducing smog.

In the case of waste energy recovery systems, waste energy is captured to make productive use of energy that had previously gone unused. Emissions are further reduced because of the reduction of total fuel consumed. Both waste energy recovery and new standalone CHP systems reduce greenhouse gas emissions compared to business-as-usual models.

CHP systems also reduce the burden felt by local habitats and watersheds. CHP systems use less water than centralized energy generation systems and are generally sited within existing buildings. This makes the development of new greenfield spaces often required by more traditional centralized generation unnecessary (ORNL 2008).

### *EXAMPLES OF MUNICIPAL CHP AND DISTRICT ENERGY PROJECTS*

CHP installations are found throughout the United States. Municipalities around the country have used district energy for decades to reduce emissions and municipal operating costs. One of the country's best-known district energy systems is in downtown St. Paul, Minnesota (figure 5). The system has operated for more than 20 years and was recently updated to better incorporate available biomass resources of the region. The system serves over 80% of the downtown area with electricity and thermal energy, with an overall efficiency of greater than 85%. The system has dramatically reduced heating costs for St. Paul businesses and downtown residents. These costs are lower than comparable costs in 1983, when the system began operating. This district energy system has also significantly reduced emissions by more than 50% for key contaminants including $SO_2$ and other criteria pollutants (Burns 2010 and PowerGen 2010).

Figure 5. District energy system in St. Paul. © 2008 District Energy St. Paul.

In Stamford, Connecticut, the need for greater power reliability and reduced energy costs provided the impetus to create an Energy Improvement District (EID) in 2008. The municipality found itself with an increasing demand for electricity but faced challenges to new centralized generation, such as tight local air restrictions and opposition from city residents to the construction of new power plants. The state and city developed a legal framework to allow businesses to pool their money together and build a micro-grid to foster the sharing of energy generation and the aggregation of energy loads among multiple facilities. City leaders identified the increased power reliability of such a system as a potential boon for economic development and have noted that companies concerned about power outages view the EID as an attractive place in which to locate future operations. Several major international companies have since established major operations in the Stamford area, citing the EID's increased power reliability as an important attraction (Pentland 2010).

In Austin, a district cooling system makes ice at night, when electricity is cheapest, and then uses the ice to deliver cold water to buildings connected to the district energy system. This type of technology is called a distributed thermal energy storage system. Equipment in each building connected to the district then uses the supplied cold water for air conditioning, saving energy and money along the way.

As previously mentioned, wastewater treatment plants are another good fit for CHP systems. In King County, Washington (home to the city of Seattle), a CHP system powers a wastewater treatment plant, using fuel derived from gas (methane) produced when the wastewater sludge meets anaerobic bacteria in a digester. The gas powers the wastewater treatment plant. In addition, any excess gas is sold to the local gas utility, thereby generating additional revenue (Van Holde 2009). These projects are examples of the ways CHP and district energy can be highly customized to meet the unique needs of each locality it serves.

Many CHP resources are available, such as the EPA CHP Partnership fact sheet, *CHP: Energy Efficiency Strategy for Local Governments*, which offers suggestions for localities deploying CHP. In addition, the International Council for Local Environmental Initiatives (ICLEI) maintains a list of international case studies of local initiatives, including district energy and CHP, and the American Planning Association (APA) maintains a database of community energy projects and climate change mitigation projects and plans from around the country.

## Policy, Regulatory, and Financial Environment

A number of different policies impact CHP deployment. This section will discuss the policies, incentives, financial mechanisms, and regulatory issues most critical to CHP projects. It will also discuss the impact local utilities can have on CHP projects and the ways in which utilities can encourage or discourage CHP and district energy locally. A number of web links that identify numerous best practices and offer model language for policy development are included throughout this section.

### *MARKET FOR EXCESS POWER*

CHP projects are typically sized to meet the onsite thermal load, with electricity generated by the system used as needed at the local facility. However, some CHP projects are designed to generate electricity to be sold outside of the host facility in order to garner revenue and improve project economics. For these kinds of projects, a healthy market for excess power can dramatically impact the economics of a project. Policies such as feed-in-tariffs, which provide set prices for excess power delivered to the grid, are desired by CHP project developers around the country, though such policies are relatively rare. Other beneficial policies rarely seen in the United States, but that are essential to some projects, include permitting electricity or steam from CHP to be sent across public rights-of-way, as well as using existing utility infrastructure to deliver excess electricity.

### *INCENTIVES AND FINANCIAL MECHANISMS*

Financial incentives come in many forms and have long been used by policymakers to encourage CHP deployment. While incentives typically will not suddenly make an uneconomical CHP project economical, they can help reduce costs enough to move a project forward that may have been stalled or otherwise abandoned because of financial constraints. CHP projects typically have significant up-front costs but can also provide significant savings over time. Therefore financial incentives can shorten the payback period on a project to the point where it can be incorporated into a budget. Some incentives are available only to projects that use certain fuels or technologies; therefore researching the details of each incentive is an essential early step in project development. More detailed information on these different incentives and financial mechanisms is available below.

#### Special Natural Gas Rates

Natural gas utilities are generally supportive of natural-gas-fired CHP, as it increases their customer base and raises revenue. These systems (often termed "high-load factor" customers) tend to demand a reliably stable amount of natural gas and a relatively flat demand that does not exhibit sharp or unexpected peaks. These customers are beneficial to gas companies that prefer even demand requirements. Some natural gas utilities even offer special discounted rates for these customers to fire their CHP systems or have high load factors in general.

#### Tax Credits

Tax credits are a very popular type of financial incentive for CHP. Tax credits are offered at the state and federal level for investments in energy equipment as well as on the property on which the CHP system is placed. District energy systems can benefit from both of these kinds of tax credits. However, to enjoy tax credits, a facility or entity must have a tax liability. In some cases municipal-led projects find themselves in a position of little or no tax liability, especially if the municipal project has partnered with nonprofit (tax-exempt) organizations or businesses that already enjoy extensive tax breaks. Some municipalities and other nonprofit entities benefit by partnering with for-profit entities that can take advantage of the tax credits. For instance, a for-profit entity can sell the energy output from a CHP system to the municipality or nonprofit, passing on the savings from any tax credits.

Arizona's Energy Equipment Property Tax Exemption excludes the added value of eligible CHP systems from the valuation of property for tax purposes. North Carolina's expanded Renewable Energy Tax Credit offers a 35% tax credit for the cost of equipment, construction, and installation, up to $2.5 million.

#### Loans and Loan Guarantees

Another popular financial incentive is a loan program that offers below-market interest rates on loans for the purchase, installation, and maintenance of CHP systems. Loan guarantees are agreements between the CHP owner, a bank, and an entity willing to take on some of the risk of loan should the CHP owner default. Such loans can be offered by states, cities, local banks, and in the case of loan guarantees, the federal government. Connecticut's low-interest loans for customer-side distributed resources programs provides loans to customers for the installation of CHP. Kentucky's Energy Efficiency Loan Program offers three types of loans for state government agencies undertaking efficiency improvements

### Grants

Grants are offered to CHP systems to help offset the initial upfront cost of CHP equipment. They are typically one-time cash infusions to the project that do not have to be repaid. Massachusetts' Green Communities Grant Program provides funding for municipalities to pursue energy efficiency and renewable energy projects. New Jersey's Clean Energy Solutions Capital Investment Loan/Grant Program provides interest-free loans and grants for end-use efficiency CHP

### Rebates and Production Incentives

Rebates and production incentives are direct cash payments made to CHP owners who have satisfied established performance objectives or have installed approved equipment to certain specifications. Rebates are generally offered as a percentage of project cost, up to a certain limit, while production incentives are generally offered as a set cash rebate per kilowatt-hour (kWh) produced by a CHP system. New York's Energy $mart New Construction Program provides technical assistance and cash rebates for the installation of CHP. New York also offers a smaller scale program for existing facilities that offers production incentives for CHP systems based upon system size and output

### Bonds

Uniquely available to municipalities, bonds pay for capital expenditures with future realized energy savings. Bonds available to municipalities typically are designed to encourage energy efficiency or energy independence, and establish CHP as an eligible technology. New Mexico's Energy Efficiency and Renewable Energy Bond Act authorizes bonds up to $20 million to finance energy efficiency investments, including CHP.

### Federal Incentives

The federal government currently provides several financial incentives for CHP projects. A few of the federal incentives most relevant to CHP projects are:

- Business Energy Investment Tax Credit
- Energy Efficiency Loan Guarantees
- Renewable Energy Production Incentive
- Renewable Energy Production Tax Credit
- Rural Energy for American Program Grants
- Rural Energy for America Guaranteed Loan Program

Additional information on available financing mechanisms is available in the U.S. Department of Energy's guide, *Federal Finance Facilities Available for Energy Efficiency Upgrades and Clean Energy Deployment*.

### *PORTFOLIO STANDARDS AND GREENHOUSE GAS GOALS*

Many municipal and state governments around the country have established goals for energy reduction, greenhouse gas emission reductions, and sustainability improvements. These goals are most effective when they are legally binding, requiring that unmet goals be offset by monetary penalties. An energy efficiency resource standard (EERS) is a plan developed at the state level with a quantitative, long-term energy savings target for utilities. Utilities impacted by an EERS must procure a portion of their future electricity and natural gas needs using energy efficiency measures—typically equal to a specific percentage of their load or projected load growth. In many cases, CHP qualifies as an eligible efficiency resource, which can create an incentive for its deployment.

Another type of portfolio standard, the renewable portfolio standard (RPS), can similarly encourage CHP if it is included as an eligible technology. CHP systems fueled by renewable fuels such as biomass or waste heat are often the only types of CHP eligible for participation in an RPS. Portfolio standards in general help encourage CHP by creating an incentive for utilities to deploy CHP in their service territories.

Region-wide greenhouse gas reduction initiatives, such as the Western Climate Initiative and the Regional Greenhouse Gas Initiative, offer more formalized frameworks for encouraging clean energy and trading emissions credits. These credits are earned through efficiency improvements or renewable energy project implementation. Though these types of regional initiatives are generally non-binding, they offer a wider market in which CHP and district energy projects may find value for their emissions reductions. The EPA CHP Partnership handout, *Energy Portfolio Standards and the Promotion of Combined Heat and Power* outlines suggestions for EERSs. The Western Climate Initiative is a regional effort to reduce greenhouse gases. The Regional Greenhouse Gas Initiative (RGGI) is a market-based effort to reduce greenhouse gases in a number of northeastern and Mid-Atlantic states.

### *STANDBY RATES*

Standby rates are the rates charged by an electric utility for the backup electricity the facility may require when the facility's electric load is not fully met by its CHP system. Sometimes these systems are taken offline for routine maintenance and, less frequently, they may go offline unexpectedly. The structure of these rates can differ dramatically from utility to utility. Though they are regulated by the state utility regulatory authority, standby rates are often designed separately from other CHP policies, with little concern to the overall impact of the rates on the CHP marketplace. Favorable standby rates are those that do not overly penalize CHP-using facilities for a single spike in demand and are not based on the assumption that all CHP systems could go down unexpectedly at the same time. The EPA CHP Partnership 2009 *Standby Rates for Customer-Sited Resources: Issues, Considerations, and the Elements of Model Tariffs* outlines ideal standby rates.

### *OUTPUT-BASED EMISSION STANDARDS*

Output-based emission standards encourage and give credit for the higher levels of efficiency inherent in CHP energy generation. Historically, electricity-generating technologies have been subject to input-based emissions regulations, which measure and limit emissions per unit of fuel input. Since CHP creates more energy with its fuel input than standard generation, such traditional measures fail to account for the system's efficiency and greater energy production. Output-based standards measure and limit emissions per unit of useful energy output, allowing emissions from CHP systems to be easily compared to those of other energy-generating technologies.

Some states have output-based standards in place, recognizing that more-efficient generation creates the same amount of useful energy as traditional generation, but with fewer emissions, which benefits society. In these states, the cost of compliance with air emission regulations may be reduced for CHP systems, since the efficiency of the system will be considered when complying with local regulations. In some cases specific emissions processes for CHP and other forms of distributed generation have been developed. The EPA's CHP Partnership's 2004 publication *Output-Based Regulations: A Handbook for Regulators* [PDF] describes this issue in greater detail.

### *LOCAL UTILITIES*

Benefits of CHP accrue to both system owners and utilities. Some utilities are more supportive of CHP in their service territories than others. It is important to evaluate a local utility's attitude toward local CHP projects during the planning stages of the project and to understand how the project may benefit the utility. There are numerous ways CHP benefits the local electric system and locality. As noted earlier, these can include reduced demand and grid congestion, deferred or avoided investments in generation and distribution infrastructure, reduced system energy consumption and overall emissions, improved system reliability and diversity, and enhanced energy security.

In some areas, an existing constrained electrical grid might make a local electric utility very interested in helping move a CHP or district energy project forward. In these cases, successful installations leverage the expertise of the local electric utility by working with the utility to address technical and regulatory challenges early in project development. A number of utilities around the country have CHP programs, which provide incentives or technical assistance to CHP projects. Tapping into such programming produces substantial benefits for those implementing projects, because the utility employees and representatives often have a wealth of experience working with CHP projects of all shapes and sizes.

In other places, the local electric utility can make deploying CHP projects very difficult, or nearly impossible. In these instances, incentives to encourage CHP may be not be available, as the electric utilities may view these projects as potentially revenue-reducing ventures by switching load from electricity to natural gas. In these situations, the development of a clear understanding of benefits, local policies, and regulations is critical. Here, certain steps within the project development, such as interconnection (as discussed below), may take longer than anticipated and may add delays to the overall project cost.

### *INTERCONNECTION AND NET METERING PRACTICES*

To remain economically viable, CHP systems typically rely on their ability to purchase backup power from the electric grid, and in some cases to sell excess electricity they generate back to it. In order for this to occur, a system must be interconnected with the local electric grid. In some states, the lack of consistent standards that establish parameters and procedures for connecting to the grid drive up monetary and transaction costs for technology manufacturers and owners. An interconnection standard, typically adopted at the state level, requires that utilities follow a standard procedure for considering interconnection requests. These regulations typically include a set of clear and transparent timelines and fees.

Electric utilities have a major role to play in the interconnection process, especially since they are the true source on the interworking of their proprietary grid. The local utility will typically require a study to determine any potential interconnection issues and what safety controls a CHP developer must incorporate into a project. However, in some instances the regulatory requirements over the interconnection process can outweigh other aspects of the project and can lead to large delays or the permanent postponement of a project. Recent research suggests that, despite the presence of an interconnection standard in some states, some jurisdictions still require lengthy and expensive studies or tests prior to interconnection (Chittum and Kaufman 2011).

Smaller CHP systems may benefit from the presence of net metering rules, which allow distributed generation systems to receive credit for excess electricity produced onsite. This can make smaller CHP affordable. Electrical utilities may also benefit from net metering, because when additional electricity from a non-grid source is produced during peak periods, the overall load factor of the grid is improved. Net metering standards are often developed in conjunction with interconnection standards; they are currently available in 35 states. In some states, a system must plan to meet net metering requirements in order to be interconnected with the grid. Without net metering, a second meter is usually installed to measure the electricity that flows back to the local utility, with the power sold at a rate much lower than the retail rate.

The Interstate Renewable Energy Council (IREC)'s 2009 edition of *Connecting to the Grid, 6th Edition* [PDF] discusses issues surrounding interconnection and net metering. IREC's *Model Interconnection Procedures* [PDF] provides suggested models. IREC's *Net Metering Model Rules* [PDF] also provides suggested models. The Network for New Energy Choice's 2009 version of "Freeing the Grid" [PDF] offers a state-by-state scorecard of interconnection and net metering standards. The EPA's CHP Partnership's guide to best practices in interconnection standards offers suggestions for model interconnection standards

## Your Local CHP Landscape

As you review the economic realities of the locality in which CHP or district energy is being considered, a thorough understanding of the local policy landscape is important. In some cases, the economics of other energy resources are such that these projects make economic sense. In others cases, fuels and electricity are priced such that these systems often appear to be less attractive than many other energy options. Similarly, some states and cities have developed policies and regulations designed explicitly to encourage CHP deployment, while others offer few of these policies, or in some cases discourage it outright. Multiple resources exist to assist project developers or potential owners in learning about the political, regulatory, and economic realities of their future CHP project. Resources are also available to direct project managers toward local combined heat and power support services.

### *LEARN HOW YOUR REGION COMPARES*

Each year ACEEE ranks states on a variety of energy efficiency policies, including specific policies in place that help and hinder the local CHP market. In its *2013 State Energy Efficiency Scorecard,* ACEEE ranked all states on six policies that directly impact their local CHP markets, including interconnection standards, standby rates, financial incentives, output-based emission standards, relation to EERS/RPS, and net metering standards. Similarly, the Database of State Incentives for Renewables & Efficiency (DSIRE) maintains a robust list of local, state, and federal incentives and policies applicable to CHP projects. In addition, the EPA's CHP Partnership maintains a list of available policies and incentives for CHP. The ACEEE Scorecard report can be downloaded for free. An online database featuring the current energy efficiency policies governing each state, including relevant CHP policies, is maintained by ACEEE. A report published by ACEEE, *Challenges Facing Combined Heat and Power Today: A State-by-State Assessment* (Chittum and Kaufman 2011), profiles the environment for CHP in all 50 states

### *USE LOCAL AND REGIONAL RESOURCES*

Advocates of CHP resources understand that the deployment of CHP must respond to local opportunities and challenges in order to be successful. A good starting place to understand the local climate is the local CHP Technical Assistance Partnerships (CHP TAPs). These centers are sponsored by the U.S. Department of Energy (DOE) and are a great resource of the particular regulatory and economic realities of CHP project development in each of their regions. Eight CHP TAPs serve different regions of the country, each with its own website featuring case studies and policy issues pertinent to their respective region. Figure 6 displays the different CHP TAPs regions operating today.

Some utilities and state energy offices have CHP programs with dedicated staff and specific CHP deployment goals. In many cases, CHP support is found within their industrial energy efficiency programs or commercial building efficiency programs.

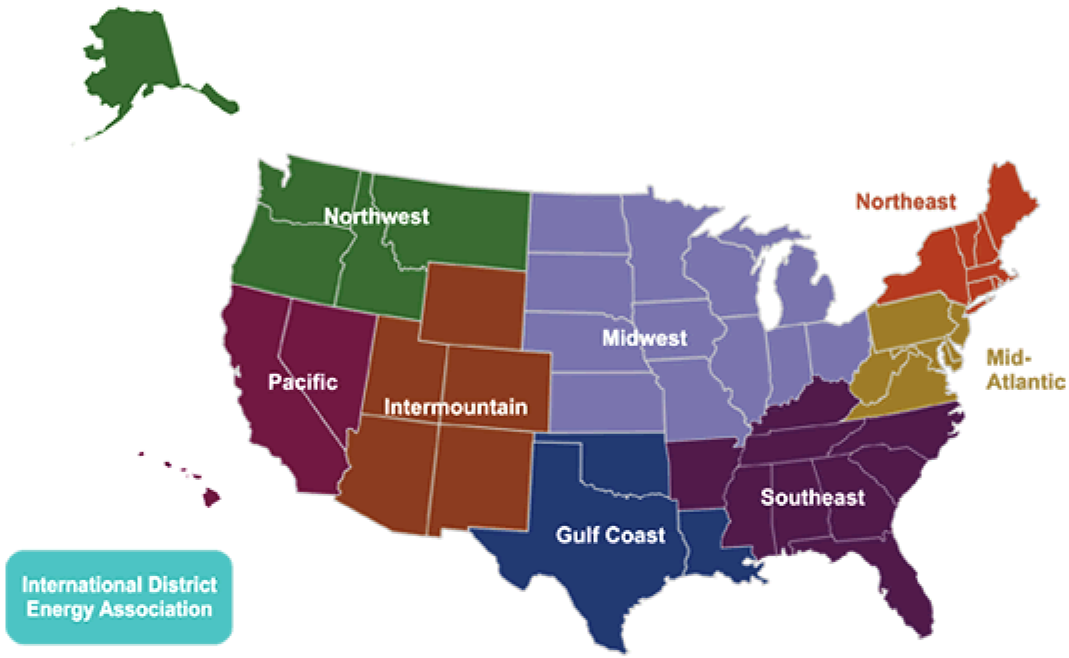


Figure 6. DOE CHP Technical Assistance Partnership Centers

The DOE maintains a list of all active CHP TAPs with individual contacts for each region. This database of CHP case studies from the CHP TAPs is searchable by state, prime mover, fuel type, thermal energy use, market sector, and more

## Considering CHP for a Project in Your Municipality

Although CHP and district energy are great fits for many different applications, they may not always be a cost-effective or adequate solution to specific energy problems and needs within a municipality. Since these projects are generally capital-intensive investments and require substantial planning, engineering, and operations expertise, the primary criteria of a CHP or district energy system must be thoroughly evaluated at the outset of the project. Thorough effort spent at the onset of a project will mitigate wasted time and money used to develop feasibility assessments or researching specific technologies that may not be relevant to a project. This upfront planning may conclude that a project is not viable from the beginning.

The EPA CHP Partnership offers a robust free handbook for those considering CHP at their facility. The handbook is available online and for full download as a PDF document. Although the next few sections will borrow liberally from the Partnership's available resources, they should be augmented with additional external tools. Though not specifically written for district energy issues, many of the tools and resources suggested can provide initial assistance when considering these systems.

### *IDENTIFYING A CHP CHAMPION*

It is widely acknowledged among project developers that CHP projects are most successful when an internal individual at the host facility or municipality becomes the CHP champion.

Assuming this person or group of people is in a position to influence the municipal decision makers, the champion is essential in moving the development process through the major project steps. This person can also ensure that the project remains a priority and that it is reviewed and approved by all the relevant stakeholders and decision makers. As noted by the CHPP, the champion tracks the project from beginning to end and helps navigate the unique challenges all CHP developments face. Selecting a single point person to interact with vendors and internal management staff will help the project run more smoothly.

### *PROJECT QUALIFICATION*

As noted above, the substantial engineering analysis required to execute a CHP project is expensive, and therefore it is important to first evaluate projects with respect to fundamental economic and technical criteria. After completing the EPA CHP screening questions noted in the references below, the next step is to contact your local CHP TAP or the EPA CHP Partnership. The CCHP has a free first-level technical and economic screening available.

In addition to the EPA documents, several screening tools that offer varying degrees of detail exist for organizations and municipalities interested in considering CHP. Initial project screening will help identify which projects should receive additional analysis and are best targeted for effective CHP projects.

Some utilities have established CHP programs that offer direct technical assistance to CHP projects. Colleges and universities that specialize in energy efficiency technologies may also have programs available. Contact your local utility or state energy office to find available program offerings. Another method is to hire an engineering firm that specializes in CHP. These firms should have an understanding of the challenges presented with implementing these large systems and can offer a one-stop shop for any community interested in developing a CHP system. Whatever path is followed to implement a project, obtaining an expert or pool of experts to guide one through each step of the process is an invaluable asset and is highly recommended.

The EPA's CHP Partnership has a list of 11 simple questions to help facilities decide whether CHP is a good fit for their needs. The U.S. Department of Housing and Urban Development (HUD) offers a screening tool to determine whether CHP is a good fit for various multifamily buildings. HUD also offers a guide [PDF] for those considering CHP for the first time, specifically targeting CHP in the multifamily housing sector.
The EPA's CHP Partnership offers direct technical assistance for facilities and entities considering CHP. The Renewable-energy and Energy-efficient Technologies screening tool (RETScreen) is a free comprehensive software package that can help evaluate CHP costs and savings. Your local CHP TAP can provide varying levels of technical assistance and continued guidance as a project progresses through all stages of project development.
Oak Ridge National Laboratory also offers technical assistance for some CHP projects.

## Planning Your CHP Project

### *INITIAL FEASIBILITY ASSESSMENT: THE 30,000-FOOT PERSPECTIVE*

Feasibility assessments are used to identify the specific technologies that will be used in the CHP project. These assessments can also paint a picture of the economics of the potential CHP project so that all parties are clear about the project's payback, up-front capital requirements, and ongoing financial obligations. The EPA CHP Partnership recommends two levels of feasibility analysis. The initial level will "determine if CHP is a proper technical fit for your facility." A second, deeper analysis will optimize project design and produce an investment-grade feasibility analysis for use in future financing activities (CHPP 2011).

The initial feasibility assessment should determine the viability of implementing CHP in the new or existing facility. At this early stage in project development, familiarity with the political and regulatory landscape is critical. The degree to which political or regulatory barriers impact a CHP project varies by state and service territory. If all barriers appear to be surmountable, a project should continue apace, and the cost of overcoming those barriers should be built into any feasibility analysis. Interacting with local technical assistance providers will help clarify how the local utilities tend to view CHP projects and identify obstacles. In areas with supportive climates, technical assistance providers can highlight resources from utilities and ensure projects are started on the best possible footing.

Several terms are used in CHP project development to describe the economic viability of a project. *Spark spread* is often used to describe the difference between the cost of buying heat and power from the grid and the cost of generating it onsite with a CHP system. Spark spread is heavily affected by the local cost of grid-supplied electricity. Therefore, areas of the country with high electric rates often have a wide spark spread, making CHP more economically attractive. Conversely, areas of the country that enjoy cheaper electric rates often see very small or negative spark spread, making CHP projects hard to justify on a strictly economic basis.

*Payback period* is another term used to describe the length of time it takes for a CHP system to pay back its owner in saved energy costs. Since CHP systems are expensive, it can take several years to produce enough energy savings to make up for the initial up-front capital costs. Some communities and organizations have internal rules restricting capital project investments to those with a defined payback period. A number of factors influence an organization's go/no-go metric, but a typical simple payback period for a CHP project is five years. An initial feasibility assessment should include a simple payback analysis or other comparative metric so that the proposed project can be compared against other options and capital investments.

The initial economic analysis will take into account the cost of available grid-supplied electricity, the cost of different fuels for the CHP systems being considered, and the cost of the CHP equipment and installation themselves. By determining what a facility would pay for heat and power in a business-as-usual scenario—that is, without any CHP deployed—the initial feasibility assessment can determine whether it makes economic sense to move forward with the CHP project. The assessment should also include any understanding of area policies and regulations and a discussion of how they could affect the success of the project. All these procedures were followed in developing the CHP-powered U.S. Navy facility shown in figure 7.

Figure 7. CHP-powered U.S. Navy facility in Japan. Image courtesy of DOE/NREL. Credit: DOE Federal Energy Management Program.

The EPA CHP Partnership suggests a framework for the initial feasibility assessment. The Partnership prepared two sample initial feasibility assessments for a hypothetical ethanol plant and industrial plant considering CHP. The HUD has published a guide to its aforementioned screening tool, suggesting steps for an initial feasibility analysis for multifamily housing in particular. The Partnership recommends points of inquiry for an initial feasibility assessment and also provides some Level 1 feasibility analysis support. Fill out this web form to begin the dialogue with the Partnership. The Partnership's *Project Development Handbook* provides step-by-step instructions for CHP project development and is also an excellent resource manual.

### *SECONDARY FEASIBILITY ASSESSMENT: THE DEEPER DIVE*

The secondary feasibility assessment is a more detailed technical document that identifies specific equipment, possible vendors, timelines, and financing options. It will form the basis of future requests for quotes from equipment and construction vendors, structure discussions with internal finance departments and external lenders, and supply some of the information needed for land, water, and air permits.

The secondary feasibility assessment is typically conducted by an experienced CHP project developer or engineering firm, equipment vendor, or similar entity intimately familiar with CHP applications in the area or sector being considered. As noted by the CHPP in its guide to the "Level 2" feasibility study, the assessment may be conducted by a firm with a vested interest in the outcome of the assessment, such as an equipment vendor whose product is being considered, or by a neutral third party contracted to provide an independent assessment of the project's opportunities and challenges. Whoever conducts the study should answer some basic but critical questions, including:

- What will our return on investment be if the project is implemented?
- How much will this project cost, up front and over the long term?
- How do these expenses compare to buying heat and power from the grid?
- Which prime mover technology should be most seriously considered?

The secondary assessment should also collect information pertaining to the current energy load profiles of the facility or facilities under consideration. It will suggest appropriate places to tie into the local grid and fuel lines and should develop some basic predictions of how the CHP system will affect the facility's future energy usage. Most importantly, the assessment should contain reliable pricing estimates for all of the major system components and installation and commissioning expenses. The EPA's CHP Partnership's guide to the "Level 2 Assessment" [PDF] outlines a suggested framework for the secondary feasibility assessment. HUD has developed a robust screening tool, currently in beta version, designed to help conduct a secondary feasibility assessment for multifamily housing facilities.

## Implementing Your CHP Project

The municipality or facility owner must determine how the CHP project will be developed, the types of internal and external resources available, and who the essential partners in the project are. The implementation stage should include the selection of all relevant contractors and partners, the selection of an appropriate financing mechanisms, and the acquisition of all necessary permits. These three steps are fundamental to the CHP project and must be completed before the project can truly move forward.

### *CHOOSING A CONTRACTOR*

When choosing a contractor, it is important to understand that a CHP project will typically require more than one company to implement the project. As the CHPP notes, a multidisciplinary team will generally be required to provide engineering, financial, project management, environmental compliance, and equipment expertise (CHPP 2011). While some firms possess multiple layers of expertise, it is most common to develop agreements and contracts with multiple firms to ensure all aspects of the project are covered by those most familiar with each particular aspect.

There are many methods to assess contractors and their ability to implement a future CHP project. The CHPP maintains a partners program that invites companies in the CHP industry to work together to share best practices and support local and nationwide policies. Its partners are listed in a database organized by state and type of service offered. Most of the local CHP TAPs have lists of local contractors working in the CHP industry as well as case studies of successfully completed CHP projects. Reviewing these case studies may point to specific companies well versed in local CHP challenges and opportunities. Those considering CHP may find that an ideal contractor is already a partner with one of these organizations. Municipalities or organizations considering CHP in the future may find these resources an ideal start for identifying future contractors. The EPA's CHP Partnership guide outlines the reasons a facility owner may choose each of the different available types of project contractors. The Energy Trust of Oregon offers some specific suggestions for issuing RFPs for energy efficiency services within the wastewater treatment industry.

### *SECURING PROJECT FINANCING*

As an organization begins a CHP project, securing project financing is critical to the project's success. As with any capital project, there are many methods of financing a CHP project. Some organizations may be able to finance the project entirely out of internal funds, while others may need to borrow money or may need help from a financial assistance program in order to move forward.

Most CHP projects require some level of external financing. But because CHP remains confusing to many conventional financing and lending institutions, many organizations interested in promoting greater use of CHP have developed programs to offset this market barrier.

Several cities and states finance CHP and district energy systems with economic development tools such as development of special taxing districts with exemption from property taxes, and issuance of municipal bonds that enable borrowing at lower interest rates. District energy systems, in particular, can benefit from special taxing districts and rules. Facilities are encouraged to connect to a district energy system through tax incentives, reduced upfront connection costs, or discounted energy pricing.

While there is evidence that the recent economic recession has made it difficult to finance CHP projects (like other capital-intensive projects), most see this as a temporary condition. Some projects may have been stalled because of the longer payback periods estimated during initial feasibility studies (Chittum and Kaufman 2011). Fortunately, ARRA funding helped move certain municipal projects forward that would not have otherwise been developed in the recession. The EPA's CHP Partnership has outlined different types of financing available to CHP projects, as well as the types of firms offering such financing.

### *SITING AND PERMITTING THE PROJECT*

Once the project is designed and its basic components are confirmed, the next step is to acquire all necessary permits to site and operate the project legally. Air emission permits are often of the highest concern because the limits are frequently influenced by neighboring facilities and communities and they often require expensive control technologies. Locally developed ordinances such as noise permits or zoning requirements may also impact project siting. CHP projects contain large pieces of heavy-duty equipment and as such are generally required to meet safety codes that impact electrical, water, and fuel lines or other critical pieces of infrastructure. A CHP system is most often interconnected with the electric grid, so specific requirements must be met before that interconnection can be made.

A typical CHP project of several megawatts will require a building permit, a water permit, and an air permit. The facility will be subject to inspections related to fire hazards, boilers, and health and safety regulations. Transaction costs of complying with these permits, standards, and ordinances can be quite high. Lawyers and experts in these particular permitting areas are often sought to expedite these permits, which can lead to higher overall project costs. Although these expenses may vary, compliance often ranges from 2% to 5% of the typical project cost. The CHP Partnership has outlined the major types of permitting that must be dealt with in typical CHP installations.

## Evaluating and Maintaining Your Project

### *MEASUREMENT AND VERIFICATION*

In the development phase of a CHP project, estimates of future performance and potential savings are made based on the equipment selected. The actual performance of the CHP system depends on the quality of the engineering and the installation of the selected equipment. To determine the actual performance of the system, an energy balance analysis is conducted. This analysis measures the inputs (volume and qualities of fuels, temperature of air and water) and the outputs (electricity in kWh), and the volume and temperature of steam, hot water, and air emissions) and determines an overall conversion rate.

Once a system has been installed and interconnected with the grid, it should be routinely evaluated to ensure that it is operating as effectively and efficiently as possible. During this testing, the system's equipment and operations are fine-tuned, allowing adjustment to the efficiency of the entire operation. Accessing these measurements at regular intervals, often termed *continuous commissioning*™, will also assist in maintaining the highest efficiencies possible by the systems design.

Once these system component performances are quantified, additional calculations should help gauge the full measure of the system's operations. Comparing the actual performance of the whole system to the estimated performance described in the earlier stages of the project will confirm the benefits projected earlier in the project timeline. Financial models developed during the earlier assessment periods can be revised to confirm the actual length of the payback period.

There is no standard protocol for evaluating and assessing the energy efficiency benefits a CHP system will have on the grid or for determining any net environmental benefits. Several state energy efficiency programs that encourage CHP projects through inclusion in EERS or RPS mandates have established equations for crediting these benefits, but each is specific to the covered service territory.

Most state incentive programs, such as the State of New York's CHP programs, require a certain degree of monitoring of system performance, often by a neutral third party, after the first year of operation. This measurement and verification (M&V) of energy savings or emission reductions is performed to determine the effectiveness of the incentive program and ensure effective use of ratepayer or taxpayer funds.

### *OPERATION AND MAINTENANCE*

In addition to performing M&V activities to ensure that the claimed energy savings are in fact happening at the system level, regular maintenance and upgrading of system components will be required. Maintaining a CHP system will ensure that the system continues to operate as efficiently and trouble-free as possible, producing the benefits identified in initial feasibility studies.

Individual CHP developers frequently offer continuous maintenance, verification, and evaluation services to their customers to help ensure the optimal efficiencies of the system are achieved. These services are often combined with operational effectiveness assistance in a single integrated service product. Some municipalities and counties that use CHP in their facilities find that hiring an individual or team to monitor daily CHP operations is the best way to ensure the successful operation of the CHP system. Others contract directly with the CHP developer to provide these services on a scheduled and as-needed basis.

In general, some external assistance will be required for scheduled system maintenance, and system component upgrades are required. CHP systems are, as noted throughout this document, quite complex. Though day-to-day operation, maintenance, and monitoring activities can be completed by onsite engineers, there will likely be some critical assessment periods that will require advice from external experts. In addition to CHP developer firms and other third-party engineering firms, basic evaluation, operation, and maintenance activities can be supported by local CHP TAPs. The New York State Energy Research and Development Authority describes its M&V requirements for its CHP funding programs in its CHP systems manual. The United Kingdom's Department of Energy and Climate Change offers online resources to learn more about operation and maintenance of CHP Sharing Lessons.

### *LESSONS LEARNED AND EARNING RECOGNITION*

After the CHP system has been developed and evaluated, it is important to share lessons learned and to celebrate the successful development of your CHP system. Follow-up may include the following:

- Share lessons learned with the local CHP TAP so that future CHP projects in your area can benefit from your experiences.
- Join the U.S. EPA's CHP Partnership, share your system's development story, and participate in the Partnership's regular webinars and in-person gatherings to learn more about today's best practices in CHP project and policy development.
- Apply for recognition from the federal ENERGY STAR™ program, which offers a specific CHP award to systems that "demonstrate considerable fuel and emissions savings" when compared to new generation of separate heat and power.
- Make sure the ribbon-cutting is covered in your local media, and that the prospective efficiency, economic, and environmental benefits are emphasized. In addition, offer a way for other prospective CHP users, groups of students, or groups of policymakers to tour the system.

By earning public recognition, an organization can draw attention to the positive attributes and benefits of CHP projects. Providing information about the economic benefits of CHP is typically a message that resonates with a wide group of community stakeholders. In addition, demonstrating a commitment to reducing emissions can have a positive effect on an organization's public image.

With careful planning, combined heat and power, waste-heat-to-power, and district energy projects can be outstanding methods for reducing overall energy costs, improving energy reliability, reducing the need for central generation, and providing substantial environmental benefits.

## Additional Resources

ACEEE provides a wealth of information on its CHP web page and in its technical assistance resource document [PDF].

The DOE SEE Action Industrial Energy Efficiency and Combined Heat and Power working group publishes a number of resources on CHP policy, implementation, and best practices.

The EPA CHP Partnership hosts regular webinars focusing on specific issues of CHP project development and CHP policy challenges. A full list of past webinars can be found here: CHP Partnership Past Webinars.

The EPA also offers relevant tips and advice through its Local Climate and Energy Program. The United States Clean Heat and Power Association supports and advocates for policies that encourage clean heat and power technologies at the state and federal level

RETScreen is a free, downloadable program that evaluates multiple elements of a proposed energy-efficient or renewable energy project.

The EPA CHP Partnership offers, with some basic input information, an estimate of your CHP project's emissions impact versus standard centralized energy generation.

Mid-Atlantic Distributed Resources Initiative (MADRI)

Policy and regulatory environment:

- New Jersey's thermal rule link
- Feed-in-tariff (California) rule link

State-specific resources can be found here:

- New Jersey SmartStart Buildings
- New York State Energy Research and Development Authority (NYSERDA)
- Wisconsin's Hospital Market Sector study on CHP [PDF]
- Pacific Gas & Electric's Distributed Generation page
- Montana's biomass report [PDF]
- NYSERDA's CHP pages, technical assistance page

District energy programs in Calgary [PDF] and St. Paul [PDF]

Some free print publications offering case studies, policy developments, market sector-specific information, and more can be found here:

- *Cogeneration and Onsite Power Production* magazine
- *Distributed Energy* magazine

The EPA has published a strategy guide on CHP that reviews some of the stakeholders' considerations when considering CHP development.

## Glossary

***American Recovery and Reinvestment Act of 2009 (ARRA).*** Commonly referred to as the Stimulus Act, this piece of federal legislation dedicated substantial funds to the research and deployment of energy efficiency and renewable energy technologies. Over $156 million in funds were earmarked for CHP and other waste energy projects, enhancing several federal tax incentives relevant to CHP.

***Combined heat and power (CHP).*** Also known as cogeneration, CHP is a method of simultaneously generating thermal energy (heat) and electricity (or mechanical energy) in a single, integrated system. The heat, generated during the creation of electricity, is collected for use in another process.

***Combined Heat and Power Partnership (CHPP).*** A voluntary program supported by the EPA that seeks to reduce the environmental impact of power generation by promoting the use of CHP.

***CHP Technical Assistance Partnerships.*** Centers supported by the DOE that promote CHP, waste heat recovery, and other clean energy technologies and practices and offer regional assistance for specific projects throughout the United States. Originally named Regional Application Centers (RACs), the RACs were renamed Clean Energy Application Centers (CEACs) in the mid-2000s and renamed CHP Technical Assistance Partnerships in 2013.

***Continuous commissioning™.*** An ongoing quality-assurance-based process used to resolve operating problems, optimize energy use, and identify retrofit processes in facilities. It includes the delivery of preventive and predictive maintenance plans, operating manuals, and training procedures for users to follow during the equipment life. This process is most often associated with the post-installation review and functional testing of equipment.

***Distributed generation (DG).*** Electric power generation located at or near the point of use.

***District energy systems.*** An integrated system of pipes and wires that brings shared hot water, chilled water, steam, or other forms of energy to multiple buildings connected by the network of wires and pipes. These systems can be powered by a variety of energy generators, including CHP, and can replace individual HVAC equipment in each building connected to the district energy system.

***Energy efficiency resource standard (EERS).*** A market-based mechanism designed to encourage more efficient generation, transmission, and use of electricity and natural gas. An EERS consists of electric or gas energy savings targets for utilities, often with the flexibility to achieve the target through a market-based trading system. All EERSs include end-user energy saving improvements that are aided and documented by utilities or other program operators. This term is often used in conjunction with a renewable portfolio standard (RPS).

***Heat rate.*** The rate at which an energy generator converts heat (Btus) to energy (kWh). The heat rate of a system is a measure of its inherent efficiency: lower heat rate values are more efficient than higher heat rate values.

***Interconnection and interconnection standards.*** For all distributed generation—solar, wind, CHP, fuel cells, etc.—interconnection with the local electric grid provides backup power and an opportunity to sell or receive credit for excess power when such opportunities are available. In many cases, distributed generation systems are interconnected with the grid. However, adding small generators at locations within the electric grid can produce a number of safety concerns and other difficulties. Therefore, utilities generally work with their state-level regulatory bodies to develop interconnection standards that clearly delineate the manner in which distributed generation systems may be interconnected.

***Kilowatt-hour (kWh).*** A basic unit of electrical energy. 1 kWh = the amount of energy consumed by 1 watt for 1 hour = 3,412 Btu.

***Microgrid.*** A locally based approach for creating, storing, and distributing electricity, often combined with thermal generation and distribution. The microgrid is often used in tandem with the traditional electric grid while including multiple and dispersed generation sources. The microgrid can also be isolated from a larger electrical network to provide highly reliable electric power. Byproduct heat from generation sources within the microgrid, such as microturbines, can be used for local process heating or space heating, allowing flexibility between the needs for heat and electric power.

***Net metering.*** Net metering allows distributed generation owners to receive credit for the unused energy generated by their distributed resources. A meter monitors the total outflows of energy (from the DG system) and the inflows of energy (from the grid) and thus calculates the net energy use/energy production from a system. In many states, DG owners can receive credit, in the form of payment equivalent to the retail price of electricity for kW generation when the net exchange of power is positive.

***Nonattainment areas.*** Areas of the country where air pollution levels persistently exceed the National Ambient Air Quality Standards set by the EPA. A designation required by the Clean Air Act and made by the EPA.

***Output-based emission regulations.*** Air quality regulations that set pollutant limits based on the useful output of a generator (in pounds of pollutant per kWh, for instance) are output-based emission regulations. More traditional regulations set pollutant limits based upon the input fuel burned in a generator to produce energy. CHP and other highly efficient equipment can produce more useful output from the same amount of fuel when compared to less efficient generators.

***Regional Greenhouse Gas Initiative (RGGI).*** A cooperative effort by northeastern and mid-Atlantic states to reduce carbon dioxide emissions. To address this important environmental issue, the states participating in RGGI will be developing a regional strategy for controlling emissions. Central to this initiative is the implementation of a multistate cap-and-trade program with a market-based emissions trading system. Similar initiatives are set up in the Midwest through the Midwestern Greenhouse Gas Accord and in the West through the Western Climate Initiative.

***Renewable portfolio standard (RPS).*** A legally binding goal that requires electricity suppliers within an indicated area to use renewable energy resources to supply a certain portion of their electricity. RPSs are usually enacted on the state level and can sometimes include CHP or waste energy recovery as eligible renewable energy resources.

***Spark spread.*** In the context of CHP, describes the difference between the cost of fuel needed to create heat and power on-site and the cost of purchased power from the grid to offset that same load if a CHP system were not in place.

***U.S. Department of Energy (DOE).*** A federal department that lends technical assistance to CHP installations and promotes research of these systems as well as the continued development for CHP. The DOE also administers the Energy Star program in conjunction with the EPA.

***U.S. Environmental Protection Agency (EPA).*** A federal agency that administers voluntary programs for the reduction of environmental impacts. It promotes the use of combined heat and power systems through the CHP Partnership (CHPP). In addition, the EPA administers the ENERGY STAR® program in conjunction with the DOE.

## References


Burns, M. 2010. *Ever-Green Energy: District Energy St. Paul.* Webinar presentation made to the U.S. EPA CHP Partnership. May 20. http://www.epa.gov/chp/documents/wbnr052010_burns.pdf.

Chittum, A., and N. Kaufman. 2011. *Challenges Facing Combined Heat and Power Today: A State-by-State Assessment*. Washington, DC: American Council for an Energy-Efficient Economy.

CHPP (United States Environmental Protection Agency Combined Heat and Power Partnership). *CHP Project Development Handbook*. Accessed January 2011. http://www.epa.gov/chp/documents/chp_handbook.pdf.

IEA (International Energy Agency). 2009. *Cogeneration and District Energy: Sustainable Energy Technologies For Today…and Tomorrow.* http://www.iea.org/files/CHPbrochure09.pdf.

NERAC (Northeast Clean Energy Regional Application Center). 2010. *What Is CHP?* Accessed December 30, 2010. http://nechpi.org/resource-library/what-is-chp/

ORNL (Oak Ridge National Laboratory). 2008. *Combined Heat and Power: Effective Energy Solutions for a Sustainable Future*. http://www.chpcenterse.org/pdfs/ORNL_CHP_Report_Dec_2008.pdf

Pentland, W. 2010. "Clean Energy Tops Agenda in Connecticut," *Forbes*. November 9. http://blogs.forbes.com/williampentland/2010/11/09/microgrids/

PowerGen Worldwide. 2010. "District Energy St. Paul Wins IDEA Top Prize for Second Time." Press release. July 1. http://www.powergenworldwide.com/index/display/articledisplay/3634037457/articles/powergenworldwide/distributed-generation/district-energy/2010/07/district-energy_st.html

Thornton, R. 2010. *District Energy and Combined Heat & Power: Local Solutions, Global Benefits*. International District Energy Association. Webinar presentation made to the U.S. EPA CHP Partnership. May 20. http://www.epa.gov/chp/documents/wbnr052010_thornton.pdf

Van Holde, D. 2009. *Building a Sustainable County: King County Washington's 20-Year Commitment to Renewable Energy*. King County Department of Natural Resources & Park. Webinar presentation made to the US EPA CHP Partnership. November 19. http://www.epa.gov/chp/documents/wbnr111909_dvh_presentation.pdf