



Combined Heat & Power (CHP) in the Gulf Coast Region: Benefits and Challenges

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I. Introduction

This paper is a working document of the Gulf Coast CHP Applications Center. The purpose of this report is to illustrate the many benefits of combined heat and power (CHP) and to discuss the ways in which the traditional systems used to supply energy can act as challenges to the increased use of this technology. The goal of the report is to focus on specific benefits and challenges that have a significant impact on the deployment of CHP in commercial buildings and industrial facilities in the three-state (Louisiana, Oklahoma, Texas) Gulf Coast Region. Additionally, this paper discusses possible solutions for some of those challenges.

Combined heat and power (CHP) systems (also known as cogeneration systems) generate electricity (and/or mechanical energy) and thermal energy in a single, integrated system at the point of demand. CHP technologies and systems are well understood, so little technology risk is involved in their use. In fact, the nation's first commercial power plant, Thomas Edison's Pearl Street Station, which began operations in New York City in 1882, served lower Manhattan with both electricity for lighting and steam for local manufacturing.

A typical CHP system consists of a prime mover to generate electricity, a heat recovery system to capture waste heat (a by-product of electric generation), a control system, an exhaust system, and an acoustic enclosure. The most popular fuel choice in the Gulf Coast region of Texas, Louisiana, and Oklahoma is natural gas although renewable fuels such as agricultural wastes and landfill gas are becoming attractive alternatives. The most obvious benefit of a CHP system is its more efficient use of energy. The average thermal efficiency of a typical simple cycle power plant is about 33%, because the heat created through electric generation is wasted. The ability to capture waste heat makes CHP systems up to two times more efficient.

CHP offers many other important private and public benefits which can positively impact economic development, environmental protection, energy reliability, and national security. For example, energy-intensive facilities such as a food processing plant or a hospital could significantly lower their energy bills in the long-term due to increased energy efficiency and the continuous operating nature of a CHP system. CHP can also help boost the domestic economy by creating jobs since much of the equipment used in CHP systems is made in America by companies like GE, Caterpillar, Cummins, United Technologies, and Trane, among others.

Beyond economic development opportunities associated with CHP, the high efficiency levels of these systems helps to conserve our natural resources and to reduce air pollutants like nitrogen oxides, which contribute to smog formation, and carbon dioxide, the leading global warming pollutant associated with climate change. Additional environmental benefits can be achieved using renewable biofuels.

Finally, the deployment of CHP in the Gulf Coast region could provide substantial protection from extended power outages resulting from grid constraints, natural disasters, terrorist attacks, or other disruptions. At Louisiana State University-Baton Rouge, the benefits of on-site power and thermal generation were fully realized during the 2005 hurricane season. The university's cogeneration plant, which began operation in late 2004, continued to supply power to the campus during and after Hurricane Katrina. In fact, the administrative offices of both University of New

Orleans and LSU Medical School relocated to Baton Rouge during the storm and the university's conference center and hotel provided housing to many displaced LSU personnel from New Orleans.

Today, equipment producers are making CHP systems appropriate for a wide range of applications, from the neighborhood grocery store to the largest petrochemical facility. With the assistance of the U.S. Department of Energy, industry has developed advanced integrated energy systems and pushed the performance on reciprocating engines to improve both electrical efficiency and reduce emissions.¹ Despite these technological advances, the adoption of CHP technologies has been slow due to a number of challenges that impact cost or limit benefits.

Generally, the challenges facing a CHP project begin with the CHP adopter. Garnering the support of a company's top decision-makers is a difficult task because many of benefits associated with a CHP system do not have a clear or immediate impact on profit margins. Further, power production is not considered a core competency for most businesses, which can severely limit a CHP project's budget. The absence of financial incentives such as accelerated depreciation schedules for CHP equipment or credit for avoided emissions can further compound this initial challenge. Limited access to low-cost financing further complicates the process since most traditional financial institutions consider distributed generation projects as high-risk investments.

Even with project support and the availability of financing, the adopter may face difficulties with regulations and procedures imposed by the government and by electric utilities. Typical utility challenges include complex interconnection procedures and using electric rates to halt or delay the project. Finally, environmental regulations can also delay or halt a project depending on permitting regulations, particularly those related to air pollution. Typically, these challenges add cost to the development project, which in some cases can be the difference between proceeding or not.

Fortunately, progress continues to be made in the Gulf Coast Region to address these and other challenges associated with CHP deployment. Texas in particular has taken steps to streamline the interconnection process and to provide credit for emissions avoided to CHP system owners. Other challenges remain largely unsolved, particularly in regard to quantification of certain benefits and creating incentives to utilize CHP technologies.

¹ See the U.S. Department of Energy's Distributed Energy System website for more details.
[Hhttp://www.eere.energy.gov/de/H](http://www.eere.energy.gov/de/H)

II. The Benefits of CHP Deployment in the Gulf Coast Region

The stakeholder groups in the Gulf Coast region can reap tremendous benefits from deploying CHP technologies. CHP can help address critical energy-related concerns for facility owners and operators, electric utilities, society and the environment. From power reliability during utility grid outages and improved productivity to job creation and the reduction of harmful air pollutants such as NO_x, CHP technologies should be highlighted in any local, state or regional energy plan. This chapter discusses these and many other benefits of CHP categorized by stakeholder group. While this list may not be complete, it provides a solid foundation for understanding the market context of CHP in the Gulf Coast region.

Key Benefits to Facility Owners/Managers

- Improved operating margins from energy cost reductions
- Increased power reliability promotes business continuity
- Enhanced power quality promotes productivity

Key Benefits to Electric Utilities

- Enhanced reliability of transmission and distribution systems
- Additional revenue streams through the sale of steam and/or chilled water
- Customer retention
- Improve asset utilization by minimizing investments in over capacity

Key Benefits to the Environment

- Improved air quality through reductions in harmful pollutants such as nitrous oxides; the key to smog formation.
- Reduced need to utilize diesel generators for backup power
- Increased conservation of natural resources such as fresh water, natural gas and land

Key Benefits to Society

- Secure electricity supplies for emergency facilities and shelters in case of natural or man-made disasters
- Potential reduction in the cost of consumer goods through improved energy efficiency
- Boost the local economy through increased tax base and job opportunities

Facility Operations Benefits

CHP systems provide a number of important benefits that improve facility operation. These benefits help to increase host operating margins, to support the host facility during emergencies and grid outages, to improve the host facility’s power quality, and potentially to enhance the productivity of the host’s workforce.

1. Improved Operating Margins from Reduced Energy Costs

Energy is a significant operating cost for most businesses. Getting more value from energy supplies will have an immediate and direct impact on the bottom line of any business. CHP is an effective energy efficiency measure that can have dramatic positive results for many businesses. The points below explain in more detail how CHP can provide operational benefits, help reduce energy costs, and improve your operating margins.

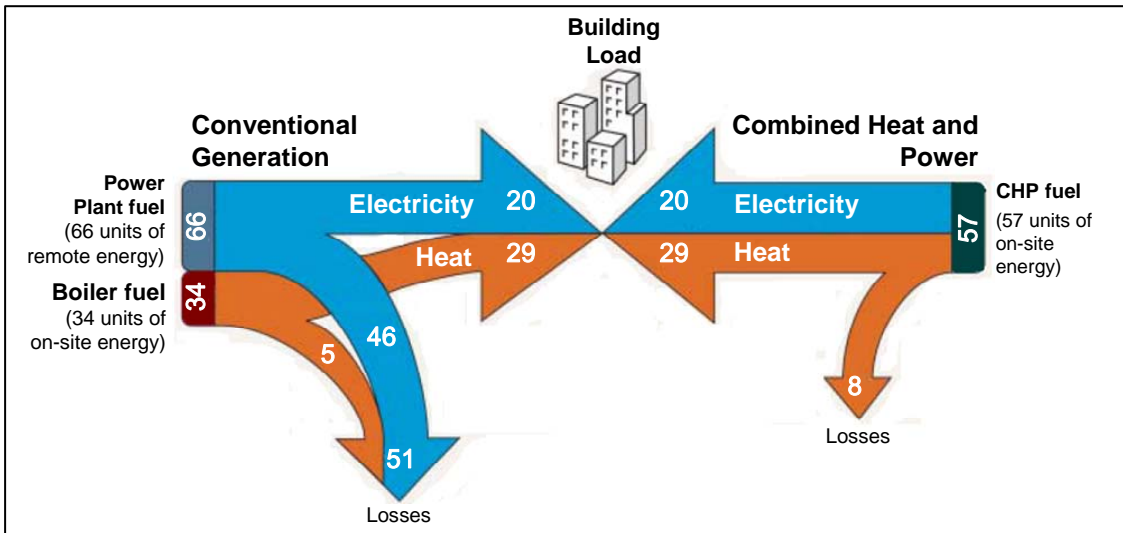
1.1. *CHP systems reduce facility energy consumption*

CHP systems often can be 2-3 times more energy efficient than purchasing heat and power separately. This means that CHP users can get more work done using the same amount of energy. The diagram below shows this concept graphically. Notice that conventional supply methods result in the consumption of 100 units of energy to supply a hypothetical facility with 20 units of electricity and 29 units of heat. That same facility could be supplied by a CHP system that consumes only 57 units of energy.

CHP “Best Adopter” Profile

Facilities that operate with the following characteristics are attractive candidates for CHP:

- Continuous operation
- Coincident electrical and thermal loads
- Low seasonal load variation
- High power reliability needs



1.2. CHP systems allow users to actively manage their energy supply routes and costs

CHP systems can be designed to provide flexibility for energy managers to reduce energy supply costs through active energy management. CHP systems allow users to respond creatively to fuel price swings, peak energy needs, demand-side energy consumption opportunities, and to consider potentially beneficial interruptible and time-of-use rates. For example, CHP systems can be optimized for cost minimization by balancing steam, chilled water, and electricity needs using the on-site generator, duct-fired boilers, absorption versus electric chillers, the electric utility, and on-site thermal energy storage.

1.3. CHP systems create potential for sales of electricity, steam, and chilled water to third parties or to wholesale markets

The design of CHP systems is optimized to meet the operational goals of the facility's management. In some cases, excess thermal or electrical energy may be available during certain periods of time. As a result, the owners of CHP systems can evaluate opportunities to sell excess electricity, electric capacity, ancillary services,² steam, and chilled water to physically adjacent third parties in so-called "district energy" solutions³. These types of arrangements can be beneficial for all parties including CHP system owners, primary host, and third party purchaser. In addition, Texas allows for electrical capacity to be bid into the Texas wholesale electric market in 1 megawatt-hour increments at minimum.

1.4. In Texas, CHP systems operating on renewable fuels like biomass have the potential to generate valuable Renewable Energy Certificates (RECs)

In 1999, the Texas Legislature created a Renewable Portfolio Standard (RPS) to promote development of renewable energy in the electric sector. The initial goal of 2000 MW by 2009 was achieved four years ahead of schedule, so in 2006, the Legislature increased the mandate to 5,880 MW by 2015. To carry out the RPS mandate, a market for Renewable Energy Credits (REC) was established on July 1, 2001 to be administered by the Electric Reliability Council of Texas (ERCOT). To earn RECs, a generator must be a new facility or a small producer as defined in PUC Substantive Rule 25.173(c) and must further meet the requirements of 27.153. The

Carville Energy Center (St. Gabriel, LA)
Commercial Operation Date: June 2003
Owner: 100% Calpine Corporation
Baseload Capacity: 455 MW



Steam for industrial processing is sold to Cos-Mar Incorporated under a long-term contract expiring in 2023 that is designed to meet the customer's unique thermal energy specifications. The plant's electrical output will help supply local wholesale power markets, providing a clean and reliable energy resource to Louisiana communities.

Source: Calpine Corporation website

² Ancillary services include reactive power, voltage control, voltage regulation, load following, frequency responsive spinning reserve, supplemental reserve, backup supply, network stability, and system blackstart. See for example, Cowart, Richard, "Distributed Resources and Electric System Reliability," September 2001

³ For more information on district energy, visit http://www.epa.gov/chp/state_resources/sip.htm

market for RECs is scheduled to continue through 2019. A REC is created by generating one megawatt hour (MWh) of electricity from a qualified renewable energy system located in Texas. Eligible renewable fuels that can be used in CHP systems include biomass (combustion), bio-diesel, biogas, and landfill gas. RECs can be sold into the Texas market or banked for up to three years. REC prices in 2006 are about \$11, although they have ranged between \$2 and \$17.

A facility is not eligible for producing RECs if it is: (A) A renewable energy capacity addition associated with an emissions reductions project that is used to satisfy permit requirements in Health and Safety Code §382.0519; (B) An existing facility that is not a small producer; and/or (C) An existing fossil plant that is re-powered to use a renewable fuel.⁴

2. Maintaining more reliable electricity supplies enhances business continuity



Recent events such as the 2003 Northeast Blackout and Hurricanes Katrina and Rita highlight the limitations of the utility grid to provide highly reliable power at all times. In the aftermath of Hurricane Katrina, 2.75 million Entergy customers in Louisiana, Mississippi, Alabama and Florida were without power. Over 1 million of those customers still did not have electric service 14 days later. Electricity was finally restored to refineries within 7-10 days after the storm. For many businesses, high power reliability is vital for

computing, manufacturing, and research functions. Economic losses due to power outages in the U.S. are estimated in the billions of dollars. A recent study from the Lawrence Berkeley National Laboratory estimates the national cost of power interruptions to be about \$80 billion annually. The majority of the outage costs are borne by the commercial and industrial sectors. As a result, the total reliability costs by region tend to roughly correlate with the number of commercial and industrial customers within a region. Additionally, the study found that frequency had more impact on costs than duration. More frequent, momentary power interruptions result in a \$52 billion loss nationally.⁵

Business continuity or the ability for a company to continue to operate after a disastrous event is crucial for many of the industrial and commercial businesses located in areas prone to severe weather events like hurricanes, tornadoes and flooding. Installing a CHP system to power crucial functions reduces the impacts of a grid outage which can help a company remain competitive in the marketplace. Additionally, CHP systems installed at critical facilities such as hospitals, first responder centers, and prisons can help keep people healthy and safe.

⁴ Public Utility Commission of Texas website, URL: <http://www.puc.state.tx.us/electric/business/rec/rec.cfm>
Last visited: May 19, 2006

⁵ "Understanding the Cost of Power Interruptions to U.S. Electricity Customers," Lawrence Berkeley National Laboratory, September 2004

2.1. CHP systems can be designed to operate independently from the grid

Many businesses and facilities rely heavily on electricity for every day needs and to provide services and sanctuary during emergencies. Today, many facility operators find the reliability of the utility grid is inadequate for the needs of their businesses, and as Hurricane Katrina dramatically showed, traditional backup generators may not be available as planned to meet emergency needs. Traditional backup generators often fail to run due to lack of fuel (from damaged roads, downed trees, and limited supplies), due to inadequate maintenance, or an inability to meet long-term (1-3 week) continuous duty. CHP systems, on the other hand, offer great value in increasing power reliability because they are continuous duty systems that operate on natural gas. Since synchronous electrical generators typical in on-site CHP systems can operate independent of the grid, then depending on design, the CHP system can continue to supply power to all or part of the host facility.

The Tale of Two Hospitals

The reliability benefits of CHP are no better demonstrated than through the stories of Memorial Hermann Baptist Hospital in Beaumont, TX and Mississippi Baptist Hospital in Jackson, MS. In the days before Rita made landfall, Memorial Hermann patients were pre-evacuated to other facilities and the hospital was closed. When the storm made landfall, the hospital's backup generators started up but were unable to power the hospital's chillers and ceased operating before electric service from the utility grid could be delivered. As a result, the hospital was unable to provide services during the storm and remained closed for one week. The hospital incurred \$30 million in hurricane damages primarily related to loss of its HVAC systems. In contrast, Mississippi Baptist had installed a CHP system as backup power and was the only hospital in the Jackson area able to operate at nearly 100%. For 52 hours, the hospital ran solely off its CHP system and was able to treat a large volume of patients and provide clothing, food and shelter to storm victims during the first night.



Memorial Hermann Baptist Hospital



Mississippi Baptist Hospital

2.2. CHP systems can be designed to use multiple (redundant) prime movers

The use of multiple generators adds to overall CHP system reliability and operational flexibility. For example, the use of multiple reciprocating engines can provide a capacity buffer in case of planned or unplanned maintenance, or forced outages that might occur. Proper design can ensure that your business has sufficient power and heat during a wide range of operating events. Not only does this flexibility increase the reliability of your business operations, it can also reduce potentially expensive “standby charges” levied by the local electric utility. Multiple prime movers also allow systems to be turned on and off to meet daily load changes, with less concern about lost efficiencies at partial load operation.

University of Texas –Austin

A testament to the robust design of the university’s CHP system is the fact that the campus in the past 35 years has had only one campus-wide blackout, which was caused by a short-circuit at a critical transformer. This superior reliability is a product of the system’s design and grid connection.

2.3. CHP systems benefit from highly reliable natural gas supplies

Because natural gas is distributed in underground pipelines and compression stations using natural gas (not electricity), CHP system owners and users can count on natural gas being available nearly all the time. For example, unlike electricity, diesel, and propane, which were not available in the days and weeks after Hurricane Katrina, New Orleans maintained natural gas supplies on their high pressure distribution system. For example, Tulane University in New Orleans, which operates a natural gas fired turbine, reported having sufficient natural gas to operate their CHP system during and immediately after the hurricane. As a result, CHP systems designed to operate on natural gas bring exceptional energy availability and security to your business operations.

2.4. CHP systems can be configured for “dual fuel” operation

Many models of reciprocating engines and gas turbines are designed to operate on two fuels, typically natural gas, and fuel oil, diesel, or biogas. The use of dual fuel systems can add a further layer of reliability to ensure that your system can operate for some number of hours in the absence of natural gas. In some cases, the availability of liquid fuel storage is necessary to meet building code requirements.

Did You Know? There is significant potential in the Gulf Coast region to utilize biogas (methane) from landfills in all three states. Total bioenergy consumption in the U.S. was 839 million MWh in 2003, accounting for about 3 percent of all energy consumed. Nearly three quarters of this energy (72%) was produced from wood and wood waste. MSW and landfill gas provided another 16% of bioenergy, and corn for ethanol production accounted for 8%.

Texas – 55 candidate landfills
Oklahoma – 13 candidate landfills
Louisiana – 10 candidate landfills

Source: “Bioenergy in the USA – Success with Decentralized Bioenergy Utilization,” June 2005
URL: http://www.localenergy.org/research_bioenergy.htm. Last visited: May 19, 2006

2.5. *CHP systems can be backed up by the utility grid*

CHP systems are designed to operate continuously and utilize the grid for backup power during scheduled maintenance or the rare unexpected outage. Reducing reliance on the utility grid strengthens power reliability because the facility is better protected from anomalies on the grid yet has backup service when necessary. Connection to the grid is necessary to provide electrical service when the CHP system is down for maintenance or if it trips offline unexpectedly.

3. **Improved power quality enhances business productivity**

Manufacturers with sensitive processes, such as semiconductor manufacturing or plastic injection molding, or numerically controlled operations, can lose entire production runs if the power quality fluctuates too much. The term power “quality” is most often used to describe the relatively short term power disturbances such as sagging voltage levels, poorly controlled frequency, harmonics, and surges. Often, however, poor power quality cannot be seen by the consumer because most problems happen very quickly – in less than a second. Despite their lack of visibility, these types of power quality problems remain especially detrimental to businesses utilizing sensitive electronics and other equipment in their operations but also can more quickly degrade other electrical equipment.

Many electronic devices are very susceptible to poor power quality. For example, the computer chips that operate industrial processes, telecommunications, Internet communications, and financial transactions can withstand only 8 milliseconds of power loss before losing memory.⁶ The results of power quality problems can be seen in many ways including computers that unexpectedly “lock up” or reboot, unseen and unnoticed data acquisition or storage errors, erratic control of process resulting from resetting or shutdowns of electronic equipment, process timers, and controllers, and similar types of glitches.⁷ Organizations with a heavy reliance on microprocessor controlled equipment and electronics are especially prone to power quality problems.

Dell Children’s Hospital

This CHP system is connected to the Austin Energy grid through two different substation feeders. As a result, the hospital anticipates that it will have the highest electrical reliability of any hospital in the country.



Did You Know?

During peak days primarily in the hot summers, grid supplied hospitals are often plagued with voltage sags that can wreak havoc on medical equipment. *Some hospitals report as many as 70 disruptions of power a year, causing downtime of laboratory equipment, costly delays, and medical practice disruptions.* CHP can help hospitals avoid these interruptions by providing more reliable continuous power.

Source: U.S. Environmental Protection Agency, Energy Star Program, “Inside ASHE” (Nov/Dec 2005)

⁶ USCHPA, URL: [Hhttp://uschpa.admgt.com/BenReliab.htm](http://uschpa.admgt.com/BenReliab.htm) Last Accessed: February 22, 2006

⁷ “Power Quality: Customer Financial Impact/Risk Assessment Tool” URL:

[Hwww.bchydro.com/rs_files/psbusiness/psbusiness23443.pdf](http://www.bchydro.com/rs_files/psbusiness/psbusiness23443.pdf) Last Accessed: February 22, 2006

Power quality is degraded by a number of factors including a facility's location on a distribution feeder, the amount of inductive load on the feeder, load growth in the local area, the proximity of other generating sites to the facility, and how near the utility system is to capacity. Since CHP systems are located on-site, power quality is often dramatically improved, because the facility has potential to be strengthened against disturbances on the transmission and distribution network. Although the "noise" normally passes through the on-site CHP system when operated in parallel with the grid, the "islanding" option allows the CHP system to disconnect from the grid during trouble events (such as weather events) to isolate the "noise" from the CHP system.

4. Enhanced building performance promotes worker productivity

High performance "green" buildings are known to promote worker productivity, retention, while reducing sick days and workers compensation claims. CHP is a recognized component of "green" buildings that to some degree helps to achieve these important benefits.

4.1. CHP systems can more cost-effectively enhance indoor air quality

The hot and humid climate of the Texas and Louisiana coastal areas is a central driver of energy consumption in buildings for cooling and dehumidification needs. Effective humidity control is essential to prevent the growth of mold and bacteria, which can cause poor indoor air quality and related health concerns.



Photo courtesy of U.S. CHP Association

Since low-cost heat is readily available to regenerate the desiccant, CHP facilitates the use of desiccant-based dehumidification systems, which is a more efficient method for humidity control than conventional chiller systems. Traditionally, indoor air is dehumidified by lowering the temperature of incoming air below the dew point, thereby condensing moisture. Afterward, the cold air must be reheated for comfort. The process of overcooling and reheating air is significantly more energy intensive than using desiccant dehumidification, particularly when electricity is used for the reheat.⁸

4.2. CHP systems helps achieve LEED certification

For those organizations actively pursuing LEED certification for their buildings, the use of CHP systems can earn points toward LEED certification. While LEED does not recognize individual technologies, the Energy and Atmospheric section of LEED bases minimum energy performance on ASHRAE/IESNA 90.1-1999. The available points in the energy process are performance based upon maximizing design energy cost performance against the prerequisite standard. The benefits of CHP are entirely consistent with the objectives of the USGBC and can substantially improve results compared to this minimum standard. CHP can provide clean power and

⁸ NREL, "The Energy Smart Guide to Campus Cost Savings," July 2003

improved comfort from a single reliable source of both power and heat. Systems can be designed to utilize proven absorption chiller technology to provide summertime cooling and space heating in the winter, meanwhile reducing overall electrical consumption, reducing NO_x emissions and using no ozone depleting fluorocarbons. The LEED prerequisite regarding CFC reduction in HVAC and refrigeration equipment is exceeded by CHP. The overall efficiency of CHP can easily be related to the reduction of total energy source use and can clearly be correlated to reduced operating costs for the owner.

Did You Know?

In November 2005, the U.S. Green Building Council (USGBC) issued a guidance document containing the methodology for recognizing the potential benefits of district CHP. A CHP system must meet the following criteria in order to be eligible for consideration under EA C1.

1. The minimum annual CHP system efficiency must be at least 60%.
2. The environmental performance of district CHP systems must be validated by a narrative addressing emissions and showing that the environmental impact of the system is lower than if the building heating requirements were met with a natural gas boiler and the cooling requirements with electric chillers using electricity provided by the local grid.
3. The Design Building must still meet EA Prerequisite 2 without the benefit of CHP.
4. Additionally, in order to qualify for EA Credit 1 consideration when the CHP plant owned externally and has multiple customers, a project must conform to the following criteria:
 - Long Term Commitment from the Building Owner – The project must have a long-term agreement in place (minimum ten years) to purchase CHP thermal output from the district CHP system.
 - Building Reliance on District System – The project must be reliant on the district system for 90% of its thermal energy (heating, cooling, or both depending on district service provided to the building), exclusive of any renewable energy.

Source: U.S. Green Building Council, "CHP Calculation Methodology for LEED-NC v2.2 EA Credit 1"

Facility Construction & Financing Benefits

CHP creates a number of benefits for the host during the construction and financing phase of the project.

1. CHP systems built using a third-party “design, own, and operate” model allows the host to redirect funds to more productive uses

A number of companies including engineering firms, equipment suppliers, utilities, and private financing companies are interested in actively investing in building based CHP systems. In many cases, a developer can bring financing into a CHP project, thereby allowing the host to redirect funds earmarked for the central chiller/boiler plant to revenue generating plant and equipment. Using a “design, own, and operate” model, the host can outsource the capital cost and operating risks to the developer.

Eastman Chemical Company & CSW Energy

In 1999, Eastman Chemical entered into an agreement with CSW Energy to construct, own and operate a 440-MW cogeneration plant at Eastman’s Texas Operations (TEX) in Longview, TX. The plant provides all the electricity required by TEX and sells excess electricity to the wholesale market. It also provides a large portion of the facility’s steam requirements with sufficient reliability such that TEX decommissioned its coal-fired powerhouse and reduced operations of the remaining powerhouse and steam boilers, significantly reducing NO_x emissions. The project reduced TEX costs by millions of dollars annually while allowing the facility to stay focus on its core business activities.

Source: American Chemistry Council 2002 Energy Efficiency Award Program Summary

2. CHP systems can make the purchase of a diesel backup generator unnecessary

Because CHP systems can provide primary power by operating continuously each day throughout the year, CHP systems will likely be in operation already, should a grid outage occur. As a result, in some instances, the size or number of backup generators required by a facility may be reduced or eliminated,⁹ which could result in savings of about \$350 per kW of backup generator not required.

Did You Know? State governments in Texas and Louisiana require critical infrastructure such as hospitals and police stations to use diesel backup generators for emergency power because liquid fuel is perceived to be more reliable than natural gas. After Hurricanes Katrina and Rita, some organizations were unable to obtain diesel or propane due to supply disruptions.

⁹ Note that in some cases (like hospitals) building codes may require backup generators in addition to CHP systems. CHP systems operating on dual fuels where diesel fuel is stored on site may meet code requirements.

3. CHP systems provide more reliable backup power than do traditional diesel backup generators

Traditionally, on-site diesel generators have provided protection to facilities against utility power outages. However, diesel generators often fall short of expectations – especially during extended outages, when the duty cycle could exceed the generator’s design capability or when diesel fuel supplies may not be available or deliverable. For example, during the August 2003 Northeast blackout, about half of New York City’s 58 hospitals experienced failures of their backup diesel generators. The reasons included an inability to start, mechanical breakdown at some point after the engine started, and lack of sufficient fuel to continue operations. After Hurricane Katrina, diesel fuel for backup generators could not be re-supplied for many reasons including blocked or destroyed roads, delivery trucks were unavailable, fuel supplies were contaminated, lawlessness precluded deliveries, or drivers were unavailable. The infrequent use of conventional diesel backup generators is also a problem because it increases the potential for emergency backup generators to fail when they are needed most.

Because CHP systems operate continuously (or for extended periods every day) and because they operate (typically) on natural gas, CHP systems eliminate many of these issues. For example, during and after Hurricane Katrina (and for that matter most all grid outage scenarios), natural gas lines remained pressurized. As a result, natural gas was the only fuel available for several weeks afterwards.¹⁰ Unlike diesel fuel, which suffered from disrupted supplies, natural gas availability was not a problem. A comparison of obtaining emergency backup power from a CHP system versus a conventional diesel generator is provided below.

<u>CHP System</u>	<u>Emergency Generator</u>
Sized based on electric and thermal loads	Sized to meet life safety and critical loads
If natural gas fueled (low emissions, normally cannot meet emergency startup requirements)	Diesel fueled (high emissions, meets emergency startup requirements)
Reduces/Eliminates instantaneous and/or prolonged outages	Transition from grid to generator power not smooth or instantaneous
Capable of running continuously	Not capable of running continuously
Normally in operation	Not normally in operation
Good financial payback	No financial payback
Uses electric grid as backup (emergency generators are backup to backup)	No backup

Source: “Combined Heat and Power for Hospitals (Module #1) – CHP: The Concept,” Presentation given March 18, 2003 by Midwest CHP RAC

¹⁰ Gillette, Stephen F. “CHP Case Studies – Saving Money and Increasing Security,” URL: http://www.chpcenternw.org/NwChpDocs/Microturbines_Capstone_overview_cases.pdf Last Accessed: February 23, 2006

4. CHP systems can avoid capital investments in conventional chillers, boilers, and related HVAC equipment

CHP systems are long-term capital assets that often displace the need to invest capital in conventional boilers, chillers, and related HVAC equipment. When evaluating the cost of CHP equipment, be sure to back out planned expenditures that you anticipate in the next 5-10 years for this equipment. Because of CHP implementation, many of these equipment upgrades will no longer be necessary.

Did You Know? The construction of the Baytown Energy Center (Chambers County, TX) in June 2002 allowed Bayer MaterialScience LLC to shutdown five steam boilers, which caused the site-wide NOx emissions to fall below the level needed to meet the SIP requirements for the site.

Utility Benefits

Electric and gas utilities stand to benefit from CHP if they are active participants in projects, either as developers, owners, or operators. The benefits to specific utilities depend on their location and the status of deregulation. In the deregulated portions of Texas (ERCOT), transmission and distribution utilities (TDUs) are not permitted to own electrical generating equipment, although the TDUs will see benefit from improved power factor and reduced reactive power because of distributed generation systems that are located within the distribution feeders. Municipal utilities, some cooperatives, and regulated investor owned utilities in Texas, Louisiana, and Oklahoma could also benefit. CHP provides a great opportunity for natural gas local distribution companies to increase sales to their key accounts.

1. CHP systems create the opportunity for utilities to generate revenues from thermal (cooling and heating) sales (not just from electricity)

In addition to electricity, steam and chilled water produced by CHP systems also generate revenue streams for the system owners. Utilities that take equity stakes in CHP facilities may be able to generate revenues from steam and chilled water in addition to electricity. Steam and chilled water sales are not regulated by state PUCs in Texas, Louisiana, or Oklahoma. Involvement in CHP potentially expands the product offerings available to electric utilities.

2. CHP systems can be located to enhance the reliability of transmission and distribution system

Electric utilities can market CHP systems to their customers who are located on specific distribution feeders where capacity upgrades are planned or anticipated. Many studies have examined this issue and found that the CHP systems can defer utility investment in certain distribution infrastructure for several years. A 2005 study for the California Energy Commission (CEC) found that strategically sited DG yields improvements to grid system efficiency and provides additional reserve power, deferred costs, and other grid benefits.¹¹

In the Dallas/Fort Worth (DFW) area of Texas transmission congestion continually increased in recent years due to load growth. In 2004, ERCOT reported the North Region (which includes the DFW area) had the highest local congestion costs of any region between June 1, 2003 and May 31, 2004, with approximately \$167 million, or 45% of all local congestion costs.¹² Between 1999 and 2005, ERCOT spent an estimated \$2.2 billion in capital to complete improvements to its transmission infrastructure resulting in local congestion costs decreasing from over \$360 billion in 2003-2004 to less than \$250 billion in 2004-2005.¹³ Projects identified to serve the electric system through 2011 are estimated to cost approximately \$2.8 billion over the next six years and are expected to add 3,750 circuit miles of high-voltage transmission lines and 23,600

¹¹ Evans, P.B. 2005. *Optimal Portfolio Methodology for Assessing Distributed Energy Resources Benefits for the Energynet*. CEC, PIER Energy-Related Environmental Research. CEC-500-2005-061-D. [Hhttp://www.energy.ca.gov/H2005publications/CEC-500-2005-061/CEC-500-2005-061-D.PDF](http://www.energy.ca.gov/H2005publications/CEC-500-2005-061/CEC-500-2005-061-D.PDF)

¹² ERCOT, "Electric System Constraints and Needs Within the ERCOT Region," October 1, 2004

¹³ ERCOT Press Release, October 19, 2005

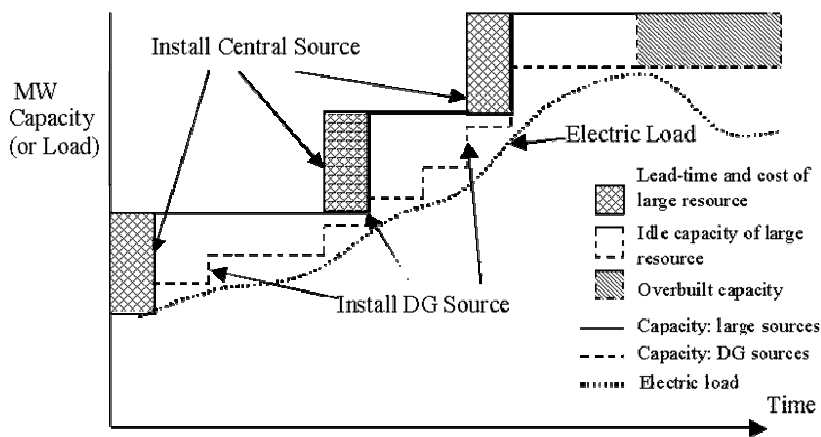
MVA of autotransformer capacity to the ERCOT system.¹⁴ Installing, connecting and potentially operating CHP systems at high-cost locations along the distribution system could be a more cost-effective and timely method for addressing local congestion in the DFW area.

3. CHP systems can be built faster than larger central station power plants

The short lead time to develop CHP systems reduces financial costs and risks, which can benefit a utility’s ratepayers. A typical 5 MW CHP project in the Gulf Coast region takes 2-3 years to develop, with 1-2 of these years required for the sales process itself. Once the initial site surveys, engineering, and design studies are completed, construction only takes another eight months to a year.¹⁵ In comparison, a 1000 MW central station coal power plant can take up to a decade to develop, design, and build. Furthermore, CHP systems do not have to wait for adequate transmission capacity to be installed, since the systems are located on or near the point of demand. The short construction period to build CHP systems allows utilities to reduce construction finance costs and risks, and to build capacity more quickly in high load growth areas.

4. CHP systems help utilities avoid investments in over capacity

The central station model for system capacity expansion often leads to a temporary build up of idle assets. As the figure below shows, large power plants brought on line in advance of electricity demand result in substantial over capacity while demand builds. By following the load curve more closely small, building-integrated CHP systems reduce slack capacity.



Source: Amory Lovins, et.al., “Small is Profitable,” Rocky Mountain Institute, Snowmass, CO, 2002, p. 122.

5. CHP systems can increase demand for natural gas utilities

Opportunities for natural gas distribution utilities can be found primarily with the installations large-scale CHP systems, although new smaller-scale technologies may provide additional source of revenues in the future. In the Gulf Coast region, natural gas historically is the primary

¹⁴ ERCOT Press Release, October 19, 2005

¹⁵ Western Governors’ Association, “Combined Heat and Power White Paper,” January 2006

fuel for CHP systems. Data for the three-state region shows that existing CHP systems primarily use the following fuels:

Fuel Type	Percentage of Total Usage
Natural Gas	92%
Waste Materials	4%
Coal	2%
Wood/Biomass	1%

Deployment of additional CHP will increase demand for local natural gas distribution companies. For example, the anticipated natural gas consumption rate for a typical 5 MW gas turbine CHP system is about 44 mcf per hour.

6. CHP systems can help retain customers

CHP systems deliver valuable benefits to adopters, so electric utilities that invest in CHP systems serve the needs of their customers. By helping key customers maintain electrical service during emergencies or periods of grid outage and improve power quality, electric utilities help retain their customers. Facilities that are well-suited for CHP, such as hospitals, universities, and manufacturers, often have multiple options to obtain electric service, especially in the deregulated areas of Texas. Locating CHP systems at key customer sites is an excellent way to provide value to these customers and create a long-term “lock-in” contract, thereby limiting the customer’s future options to seek service with other providers.

7. CHP systems have fast dispatch time to help meet daily load profiles

Small gas turbines and reciprocating engines used commonly in CHP systems are similar to the equipment routinely used by electric utilities to meet peak electrical demands. CHP systems provide rapid start capability allowing them to be dispatched as needed to meet the utility’s system load requirements.

8. Regulated utilities may be able to include CHP system costs in their rate base and earn a return on the invested capital

Like other types of power plants, utility capital invested in CHP systems can be applied to the utility’s rate base to earn the utility’s regulated rate of return. According to the Public Utility Commission of Texas¹⁶, the electrical generation asset of a CHP system can be owned by regulated utility. So the value of the electric generation components of a CHP system are included in the utility rate base while the non-electric assets (heat recovery chiller and HRSG) are considered unregulated assets that are expected to generate profitable sales of cooling and heating energy to the host site. The unregulated assets are not included in the rate base.

¹⁶ Personal communication on May 25, 2006

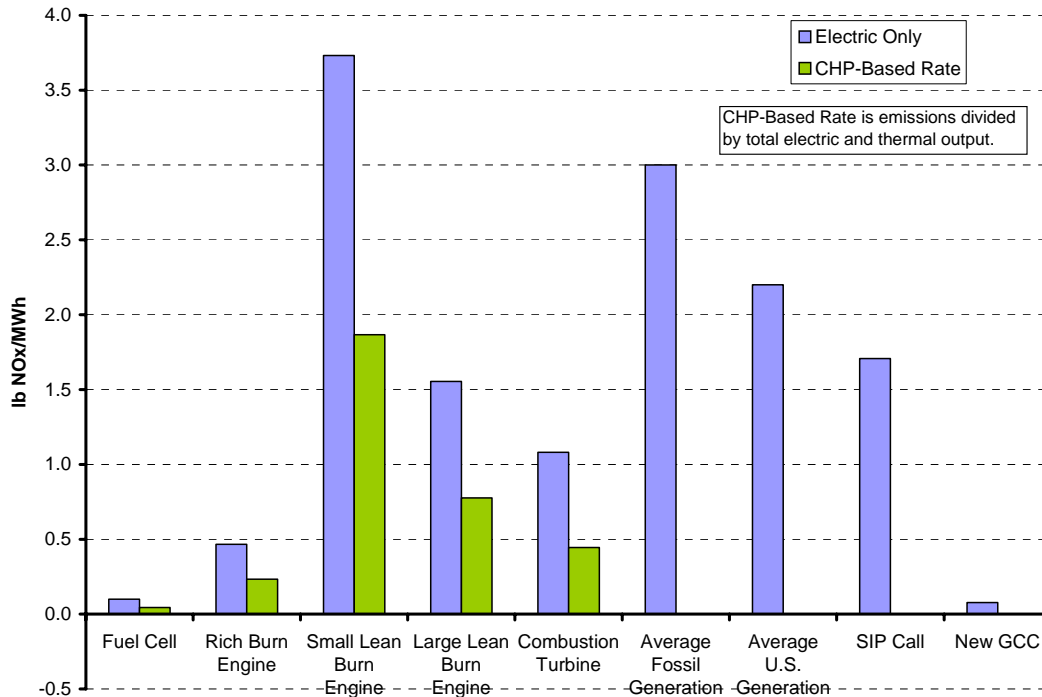
Likewise, fuel allocation should be accounted in a similar fashion. By splitting fuel costs between the generation component and the thermal component, allows both components to benefit from extraordinarily low fuel costs.

Did You Know? In February 2003, a 500-MW cogeneration plant (RS Cogen LLC) in Lake Charles, LA began commercial operations as a joint venture between Entergy Power Group (the power development arm of Entergy Corporation) and PPG Industries, Inc. Built at a cost of \$242 million, the RS Cogen plant provides up to 425,000 pounds/hour of process steam to PPG's Lake Charles complex, and up to 600,000 pounds/hour of process steam that is being sold to Lyondell Chemical Co. for its nearby facility. RS Cogen LLC is a unique ownership model in that the equipment and the electrical generation is divided equally between the two parties. Entergy sells its half on the wholesale market while PPG uses half for producing chlorine and caustic soda at its Lake Charles complex. Although the generation assets are split 50-50, PPG is 100% responsible for operating the plant.

Sources: Entergy and PPG corporate press releases

Environmental Benefits

CHP systems provide a number of important environmental benefits impacting both air and water quality. CHP systems are estimated to produce one-tenth of the NO_x emissions of the fleet average power plant and one-third of the NO_x emissions of most cleaned-up plants.¹⁷ These estimates are particularly important to ozone non-attainment areas in Texas and Louisiana such as Baton Rouge, LA and Dallas/Fort Worth, TX. The graph below shows the benefits of NO_x emissions reductions from CHP systems compared to non-CHP systems.



Data Sources: EEA, U.S. EPA, DOE

Did You Know?

The cogeneration plant installed at BP's Texas City refining and chemical complex enables BP to reduce its NO_x emissions by 53%. Operating at nearly 78% efficiency, this system uses 33% less fuel than typical onsite thermal generation and purchased power resulting in annual CO₂ reductions of about 1.94 million tons.

1. CHP systems emit fewer pollutants into the air

CHP systems can improve air quality both regionally and globally in the following four ways:

1.1. *CHP systems use less fuel to do the same amount of work*

The average efficiency for a U.S. central station generation is estimated at about 33%. The overall efficiency of a facility using grid power and natural gas boilers is about 50%. CHP systems are typically 60% to 90% efficient overall.¹⁸ Because CHP is more

¹⁷ Elliott, R. Neal and Hedman, Bruce "The Role of CHP in Addressing Texas's Need for Pollution Reduction and Growth in Energy Demand," July 2001

¹⁸ **Need reference**

efficient, it uses less fuel and emits fewer emissions than conventional separate generation. Additionally, CHP systems burn less fuel to perform the same tasks now done by conventional power plants, chillers and boilers, CHP systems reduce emissions of greenhouse gases and emissions of criteria pollutants identified by EPA as causing local air quality problems.¹⁹

1.2. CHP systems overwhelmingly rely on clean burning natural gas and biomass fuels

CHP systems in the Gulf Coast region overwhelmingly rely on natural gas. The majority of electricity produced in the Gulf Coast region is primarily fueled by a combination of coal, natural gas and nuclear power. Natural gas-fired CHP systems are much cleaner and result in far fewer emissions of NO_x, SO_x, mercury, and CO₂ pollutants. CHP plants using biomass resources like wood chips, paper mill residues, agricultural wastes, or bio-fuels are renewable resources. This means that in Texas, they could earn valuable Renewable Energy Credits (RECs).

Village Creek Wastewater Treatment Plant (Arlington, TX)

Anxious to have an environmentally friendly, beneficial use project at its landfill, the city of Arlington turned to Renovar, a private renewable energy company. Renovar, who was already operating the city's landfill gas (LFG) collection system, determined that the best project would be to pipe LFG four miles to the Fort Worth Village Creek Waste Water Treatment Plant. The water treatment plant was already generating electricity from methane gas produced during anaerobic digestion, but needed more fuel for its two 5.2 MW gas turbine generators. The developer's ability to forge a relationship between the cities of Arlington and Ft. Worth was recognized when the project was named "Project of the Year" by EPA's Landfill Methane Outreach Program.

Source: U.S. EPA Landfill Methane Outreach Program website

1.3. CHP systems incur no transmission and distribution losses

Due to the long distances electric utilities transmit power; 7-10% of the electricity produced at the power plant is lost as heat in the transmission and distribution system. As a result, electric utilities have to over produce power, which increases their emissions of NO_x, SO_x, mercury, and CO₂. Since CHP systems are located at the site where the electricity is being used, no transmission and distribution losses occur.

1.4. CHP systems reduce the need to use diesel generators for backup power, further reducing the quantity of harmful pollutants emitted into the air.

Stationary diesel generators are commonly used for emergency power, peak shaving, and in some cases baseload power production. The estimated NO_x emission inventories for emergency, peak shaving, and baseload diesel generators in the greater Houston area (HGA)

¹⁹ NREL, "The Energy Smart Guide to Campus Cost Savings," July 2003

are approximately 33.0, 73.1, and 55.0 tons per day, respectively.²⁰ In some instances, CHP systems provide effective backup power in case of grid outage. Because the CHP system can replace all or some of these dirty diesel generators used for backup with much cleaner natural gas fueled equipment, CHP lowers NO_x emissions.

2. CHP systems reduce water consumption

Central station production of electricity requires an enormous amount of water to cool the power generating equipment. In fact, in the United States, electric utilities use about the same amount of freshwater as is used for irrigation. As indicated in the table below, on average, electric utilities use about two-thirds of a gallon of water for every kilowatt-hour of electricity produced. Since CHP systems capture and productively use the heat produced in the power generating process, very little water (if any) is required to cool the equipment.

Water Savings Comparison for CHP Plant vs. Standard Power Plant		
Assumptions		
Electric Efficiency (CHP & Power Plant)	33%	
Total CHP Efficiency	85%	
Energy Required to Evaporate Lb of Water	1,000	Btu/lb
Thermal/Electric Conversion	3,412	Btu/kWh
Pounds per Gallon of Water	8.3	lbs/gal
Calculations		
Energy Input	3.0	kW
Energy Output (Useful-Electric)	1.0	kW
Energy Output (Waste-Evaporated)	1.6	kW
<i>(Energy that would be Recovered via CHP but wasted in Power Plant)</i>		
Energy Output (Waste-Evaporated)	5,376	Btu/kWh
Amount of Water Wasted per kWh Generated	5.4	Lb/kWh
Amount of Water Wasted per kWh Generated	0.65	Gal/kWh

20 “Estimates of Emissions for Small-scale Diesel Engines,” a report prepared for the Houston Advanced Research Center (Project H-10), Michael Smylie, Lit-Mian Chan, Sandhya Rao, ENVIRON International Corporation, December 22, 2003.



Societal / Public Benefits

In addition to the environmental benefits just mentioned, CHP offers additional societal or public benefits. While cap and trade programs are beginning to offer a mechanism to monetize some environmental benefits, few other mechanisms are available today that compensate CHP projects for these generalized societal benefits. Even so, CHP projects deliver important value to society as a whole, and these benefits are part of the argument for public policies supporting CHP adoption.

Examples of societal benefits achievable with CHP include:

- Downward pressure on energy prices (by using less fuel to meet the energy needs of buildings and facilities)
- Excellent job creation potential (through the use of domestic technology and products)
- Greater homeland security (by providing secure power to emergency facilities and sanctuaries)

III. The Challenges of CHP Deployment in the Gulf Coast Region

For all their benefits, developing CHP projects is still a challenge. Even though CHP systems reduce total energy consumption, this is no guarantee that system adopters will save money compared to the traditional energy supply alternative or that the system can be developed within an organization's planning horizon, budget, and culture. Some of the challenges identified in this section are unique to CHP, while others impact the notion of distributed generation more generally. Some of the challenges have a direct and tangible impact, while others are less apparent but can have equally critical effects on a potential project.

This section highlights some of the issues that adopter and developers face, although each project may encounter its own set of unique challenges. Fortunately, only a few of the potential obstacles can actually stop a project in its tracks – most only add costs to the development process. By understanding these challenges, they can be effectively managed with minimal impact to many projects.

Key Challenges to Facility Owners/Managers

- Power production is not part of most companies' core business activities which may limit project budget
- Limited access to low-cost financing
- The project development process can appear complex and daunting
- Perceived performance risk of CHP equipment

Key Challenges from Electric Utilities

- Interconnection agreement requirements may result in additional costs and delays
- Tariff rates for standby or backup power service may become punitive
- Competitive pricing offers may undercut the financial benefits of a CHP system

Key Environmental Challenges

- The emissions permitting process can be complex and time-consuming
- No emissions credit for thermal energy production, which may increase the total emissions of a CHP system
- Unequal treatment under the New Source Review provisions of the Clean Air Act

Facility Operations Challenges

Many facility operators have experience with thermal systems. CHP systems can be challenging because they require in-house understanding and capability to deal with both thermal and electric systems. For facility managers to undertake a CHP project, they need to understand how to operate the equipment for maximum value, how to maintain it, and how to reduce fuel price risks. Fortunately, CHP technologies (and power generation equipment in specific) are mature technologies with a very robust industry capable of supporting owners and facility managers that move ahead with CHP system implementation.

The following list presents some of the major challenges that many organizations face when attempting to develop and implement CHP systems:

1. **Power production is not central to business objectives**

While having a reliable and secure source of energy is vital to most businesses, the production of energy and electricity in particular, is not seen as a core activity. Today, nearly all commercial and institutional facilities outsource electricity supply to the electric utility. Many businesses are reluctant to engage in CHP because they currently don't have the skill set to operate and maintain the equipment themselves and many are reluctant to hire additional staff with the needed skills. A few factors that CHP owners and facility managers may need to address include:

- Limited experience operating and maintaining prime movers, generators, and some thermal equipment like absorption chillers
- Limited knowledge of fuel contracts and fuel cost management
- Concern over noise, vibration, emissions, and community relations
- Insufficient space for the equipment and cooling towers
- Limited availability or high cost of water
- Organizational inertia regarding energy supply methods

2. **Electric rates offered by the local utility may be cheaper than using on-site combined heat and power**

The availability of inexpensive grid power can be a significant hindrance to the adoption of CHP. Many facility operating characteristics affect the economic performance of CHP systems, including the facility's electricity and thermal energy needs, fluctuations in energy demand throughout the day or season-to-season, local electricity rates, and other factors. The lure of "competitive" pricing offered by some electric utilities may be enough to delay or cancel a potential CHP project. In many cases, an economic feasibility analysis will show that the traditional utility supply methods are still a good value for many facilities.

A few reasons why facilities may opt for utility power rather than installing a CHP system include:

2.1 The facility operating characteristics are not well-suited for CHP

The following characteristics are conducive for CHP adoption. To the extent that a facility has more of these characteristics to a greater degree, CHP systems will be favored:

- Coincident electrical and thermal loads
- 24 hour/day, 7 day/week, 365 day/year operation
- Low seasonal variation in loads
- High power reliability needs

While these guidelines are useful, facilities that meet all of them are not guaranteed to be good candidates for CHP, and conversely, not meeting all of these characteristics may not preclude the economic adoption of a CHP system. Other factors can compensate for less optimal facility operating characteristics include a high tariff rate for electricity, the sale of environmental benefits (e.g., tradable emissions or renewable energy certificates), or special payment for emergency power.

2.2 Utilities have economies of scale, commodity purchasing power, fuel switching capabilities, capital resources, and other advantages that most facilities can't match

Electric and gas utilities serve large numbers of customers. Their large size creates opportunities not available to individual facilities. For example, while CHP adopters pay retail prices for natural gas, electric utilities employ sophisticated energy purchasing strategies to obtain better fuel pricing. Furthermore, utilities have greater flexibility to switch between coal, natural gas, nuclear, and renewable energy technologies to manage costs. Utilities have other advantages such as access to fully depreciated infrastructure, access to low-cost capital, and in the case of regulated utilities; a guaranteed return on investments.

2.3 High natural gas costs

Because most CHP operate on natural gas, high natural gas costs impede CHP system adoption, especially when combined with low electricity prices. The “spark spread,” which is the ratio between the selling price of electricity and the cost of natural gas, is a key metric often used to evaluate CHP opportunities.²¹ High spark spreads generally support CHP development, while low spark spreads generally hinder CHP adoption. Typically, there is a 1-2 year delay before electric retail rates catch up to natural gas prices due to the nature of the electric power industry.

“Spark spreads” vary over time and from region to region depending on natural gas demands by local industry, natural gas availability, and the type of electrical generating technologies used by electric utilities. Because electric rates are regulated in many areas while natural gas commodity prices fluctuate rapidly, spark spread can be volatile. In some cases, spark spreads can be less than unity, implying that

²¹ RealEnergy Inc, “Challenges to CHP Deployment: Market Trends, Field Operations, and Integration,”

electricity prices are cheaper than natural gas. As natural gas is an important utility fuel for power generation, this phenomenon is usually temporary.

Key Factors for CHP Financial Attractiveness

- Coincidence of Need for Electric Power and Thermal Energy - The more overlap between a facility's electricity and thermal needs, the more attractive are the savings and the shorter payback period associated with the CHP system. **Rule of Thumb:** CHP makes the most sense when more than 50% of the available thermal energy from the prime mover can be used effectively.
- "Spark Spread" - The higher the differential between the cost of buying electric power from the grid and the cost of natural gas, the greater the savings achieved with CHP and the shorter the payback period. **Rule of Thumb:** CHP is most favorable when the "spark spread" is greater than \$12/MMBtu.
- Installed Cost Differential - The lower the differential between the installed costs of a CHP system and that of a conventional system, the more attractive the savings and payback associated with CHP become.
- Long Operating Hours - The longer the operating hours of a facility (generally >3,000 hours annually), the more attractive the savings and payback associated with CHP become. Less than 3,000 hours annually will normally not generate enough energy cost savings unless other factors are taken into consideration.
- Building Size – Larger CHP systems are generally more attractive than smaller systems. Larger buildings and facilities often provide more attractive savings and shorter payback periods. *Note: Most CHP technologies decrease on a "cost per kW" basis, as they get larger.*

Source: Midwest Regional Application Center, "Guide to Combined Heat and Power"

3. The CHP project development process is complex

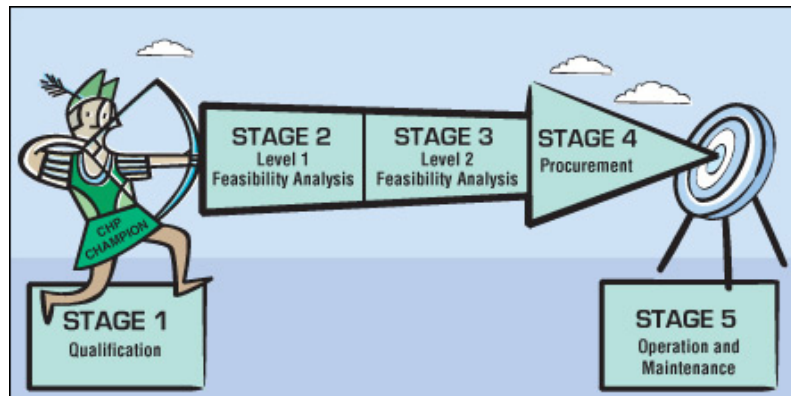
Deployment of CHP systems involves a complex and challenging development process. In most cases, CHP projects are multi-million dollar deals that involve detailed arrangements to finance, permit, engineer, construct, and operate the facility. The personnel costs and those of consultants and contractors can be substantial sunk costs that are not recoverable until the project is operational. One way to help ensure the successful completion of a CHP project is to identify the project's "champion" within the senior-level decision-makers. The "champion" is an individual willing to spend the time and effort to ensure the project continues to progress in a timely manner.

Some of the challenges encountered in the development process include:

3.1 Facility screening and feasibility analysis

Initiation of the development process often involves an iterative process of screening and analyzing a facility for CHP compatibility. While the process is intended to limit upfront expenditures and reduce financial exposure, the process can be time

consuming and complex. Some amount of cost will be sunk into the process of determining whether CHP is feasible for a facility and what type of CHP configuration is most suitable. To help potential adopters work through this process expeditiously, the Department of Energy's eight Regional Application Centers²² provide a low-cost or free feasibility analysis and project support.



Graphic courtesy of the U.S. Environmental Protection Agency – CHP Partnership website

3.2 Permitting

In many jurisdictions, CHP facilities could require local, state, or federal permits to comply with utility regulations, environmental regulations, fire, zoning, and building codes. Unfamiliarity with CHP technologies could hamper the permitting process.²³ These permitting issues can be particularly costly in both time and money for smaller-scale projects because many existing regulations were developed based with large, central power plants in mind. Permit issues could involve multiple jurisdictions and they may differ state-to-state or within specific areas of a state. Locating CHP systems within EPA designated “non-attainment zones” for the Clean Air Act could present additional requirements. The permitting challenge can often be resolved quickly by working with experienced environmental consultants.

Did You Know? The Texas Commission on Environmental Quality (TCEQ) draft guidance document for emission banking and trading includes a provision for the transfer of offsets from one nonattainment area to another providing three conditions are met. First, the reductions must be generated in an area with a nonattainment classification equal to or higher than the area in which they are used. Second, a demonstration of transport must be made to show that emissions from the area in which the reductions are generated contribute to nonattainment in the area of use. Third, the Executive Director of TNRCC must give approval prior to the trade. For potential CHP adopters looking to install a CHP system within a nonattainment area, the ability to transfer offsets from one nonattainment area to another could address issues relating to increases in emissions from the site.

Source: “Emission Reduction Credits Draft Guidance,” Texas Commission on Environmental Quality, 2001

²² A map showing the DOE's eight Regional Application Centers with links to their websites is available at [Hhttp://www.gulfcoastchp.org/State/H](http://www.gulfcoastchp.org/State/H)

²³ Reid, Edward A. and Treadway, Nat, “The Role of the Federal Government in Distributed Energy,” January 2002

3.3 Fuel supply issues

Gaining access to reasonably priced fuel is a central concern in any CHP development. Many commercial and institutional users do not have expertise in fuel supply contracts and hedging strategies. While this expertise is available in Gulf Coast region, volatile fuel prices are a real concern. Sustained high natural gas prices, especially in the face of slowly rising electric rates, could have a substantial negative economic impact on CHP facilities. Facilities that have a ready supply of an “opportunity” fuel (e.g. biogas, wood waste, agricultural byproducts) could have a great way past this challenge.

3.4 Property taxes

CHP system adopters may find their property is more valuable with a CHP system, and that can mean an increase in property taxes. Projecting payments for potentially fluctuating property tax rates can increase the perceived risks in a proposed CHP development. While tax abatements for CHP systems are not typical, in Texas, some property tax relief is possible for pollution control property, which can include all or portions of a CHP system,²⁴ as well as property tax exemption for renewable energy systems which include anaerobic digesters and biomass technologies. The intent of the Texas program is to ensure that capital investments undertaken to comply with environmental regulations do not result in an increase in property taxes. Additionally, in Louisiana, cogeneration equipment receives exemption from the state sales tax.²⁵ Data collected for environmental permits will potentially support claims for property tax exemptions.

3.5 Insurance and indemnification

Interconnection of CHP systems to the utility’s electric grid may require the host to obtain liability insurance or to indemnify the utility. Liability insurance protects the utility and their employees in the event of an accident attributable to the operation of the customer’s CHP installation. The electric utility may also require indemnity to secure the utility against claims by the host for compensation for damages, losses, or injuries related to the CHP system and grid interconnection.²⁶ Liability insurance and indemnification requirements potentially add costs for some organizations wishing to pursue CHP developments. In Texas, the interconnection rule promulgated by the

²⁴ The TCEQ is responsible for determining whether a facility or political subdivision uses certain property, in whole or in part, for pollution control purposes (referred to as a “use determination”) and whether it may apply for a property-tax exemption with its local appraisal district. The rules governing the program are found in [H30 Texas Administrative Code 17H](#). Some or all of a CHP plant may qualify. More information is available at <http://www.tceq.state.tx.us/assistance/Prop2/prop2.html#ineligibleH>.

²⁵ Gulf Coast CHP Center website, URL:

<http://files.harc.edu/Sites/GulfcoastCHP/Regulations/TaxExemptionsCogenerationEquipment.pdf>

²⁶ Larsen, Chris and Cook, Chris “Connecting to the Grid: A Guide to Distributed Generation Interconnection Issues,” (Fourth Edition), 2004

Texas Public Utilities Commission stipulates that utilities may not require CHP adopters to obtain additional insurance and liability is limited.

3.6 Equipment depreciation

Current federal tax codes require a depreciation schedule for CHP power generating equipment of 15, 20, 27 or 39 years depending upon ownership.²⁷ In some cases, the depreciation schedule is longer than the anticipated life of the equipment. For CHP system adopters that pay federal income taxes, longer depreciation schedules extend a project's payback period.

3.7 Third-party ownership concerns

Entering into a long-term contract with a third-party may not be appropriate for some facilities. Working with a third-party owner-operator potentially provides numerous advantages to the host facility including access to capital and reduced operating risks. On the downside, third-party involvement raises issues related to how the owner-operator will operate the CHP system, whether the third party's motivations are aligned with the host's operational needs and goals, and the third-party's organizational and financial stability. Alleviating these concerns adds transactional, financial, and operational complexity.

4. Performance Risks of Equipment

With a few exceptions, the equipment used in CHP systems to generate power and capture and use thermal energy is well established. Equipment like reciprocating engines, natural gas turbines, heat recovery steam generators, heat exchangers, and related equipment do not have undue technical or operating risks. The equipment is supplied by a number of large, well-known manufacturing companies with well established warranty and service capabilities. The table below provides typical cost and performance data for CHP prime movers (power generators).

More recent innovations in absorption chilling, micro-turbines, integrated energy systems, and air handlers with integrated desiccant wheels are relatively new, so potential operating risks are perceived to be slightly greater, either a result of equipment performance itself or due to the operating conditions under which the equipment is used. Many of the innovative products involve systems that have been downsized to meet emerging applications in buildings and small facilities. While the technology risk is low, potential CHP system adopters interested in small, integrated systems should look at maintenance requirements and equipment warranties closely.

In addition, certain operating conditions such as high temperature operation or partial load operation can negatively impact design and published performance specifications. The result could be system efficiency lower than anticipated or added maintenance. Much of these effects are well-known and information is readily available from CHP system

²⁷ United States CHP Association, "Provide a 7-Year Depreciable Life for Combined Heat & Power Energy Systems," URL: <http://uschpa.admgt.com/TaxDeprCHP.htm> (Last accessed: February 20, 2006)

developers and equipment vendors. Because the technology and operational risks are low, CHP adopters that are aware of system limitations should not find these risks to be substantial barriers to selecting CHP.

Technology	Steam turbine	Diesel engine	Natural Gas engine	Gas turbine	Micro-turbine	Fuel Cell
Power efficiency (HHV)	15-38%	27-45%	22-40%	22-36%	18-27%	30-63%
Overall CHP efficiency (HHV)	80%	70-80%	70-80%	70-75%	65-75%	65-80%
Fuel Utilization Efficiency	75%	70-80%	70-80%	50-70%	50-70%	60-80%
Availability	Near 100%	90-95%	92-97%	90-98%	90-98%	>95%
Start-up time	1 hr – 1 day	10 sec	10 sec	10 min – 1 hr	60 sec	3hrs – 2 days

Source: Introduction to CHP Catalog of Technologies, EPA

Facility Construction & Financing Challenges

Traditional financial analysis methods and accounting principles used to evaluate investments have a big impact on the viability of CHP systems. Whether developed in existing buildings or in new construction, current preferences for how investment alternatives are evaluated underestimates the full benefits of CHP systems. As a less traditional method of securing energy supplies, CHP systems may not fit perfectly within these well-established methods. Some modifications in approach are justified in order to take advantage of CHP system benefits, so flexibility within the planning, financing, and procuring process helps overcome these challenges.

1. Economic decision making based upon first costs

Competitive bidding requirements often evaluate bids by comparing construction costs on a price per square foot or first cost basis. In many cases, long-term operational costs are not considered in the decision-making process regarding vendor selection. “Life-cycle assessment,” a process that evaluates all costs to build and operate a facility, is not the standard method for evaluating proposals. In many cases this makes perfect sense, because building and facility developers do not intend to be the long-term owner-occupiers of a facility, hence they are not motivated to care about ongoing operating costs or facility power reliability. As a result, CHP systems can increase the apparent first cost of a bid. Although not an apples-to-apples comparison, the higher first cost can leave the CHP bidder at a disadvantage relative to any competition.

2. Limited access to low-cost financing

CHP systems involve significant capital expense. As shown in the table below, installed costs could be as high as \$1300/kW of capacity. Thus, a 5-MW system typical for a mid-sized hospital could require upwards of \$6.5 million. Additional functionality including extensive absorption chilling, chilled water storage, complex critical load circuits could drive the costs higher.

Some facility owners and managers are reluctant to seek capital for CHP systems, because the long-term benefits provided by CHP are both difficult to quantify and often don't have immediate and impressive impact on quarterly reports. As a result, a perception exists that capital for CHP systems will be difficult to obtain or expensive.²⁸ For many organizations, priority in the capital budget is given to procurement of equipment that generates revenue in the firm's core business. While CHP systems may have higher capital costs, the initial investment takes into account the additional perks of these systems including higher power reliability, enhanced operational control, and other benefits.

²⁸ Several alternatives to self-financing are available including financing from the developer or equipment supplier, third-party financing, lease purchasing, and shared savings (performance) contracts.

Installed CHP System Costs (including power generator and heat recovery equipment)		
Prime Mover Technology		Cost (\$/kW)
Reciprocating Engines	Diesel	700-1,000
	Dual Fuel	800-1,200
	Natural Gas Spark Ignition	800-1,200
Gas Turbines	Combustion turbines	700-1,000
	Micro-turbines	700-1,300

Source: California Energy Commission, Distributed Energy Resources Guide: Combined Heat and Power,
URL: <http://www.energy.ca.gov/distgen/equipment/chp/cost.html>

Utility Challenges

Electric utilities are extremely important to the CHP development process. Many utilities oppose CHP development in their service territories because:

- Regulated utilities view CHP owners as competition in their monopoly service territories
- The “rate-of-return on invested capital” model enjoyed by regulated utilities favors their investment in larger, more expensive, central station power plants
- Utilities may not be able to own and rate base CHP systems, especially thermal equipment that doesn’t generate electricity and that serves a single customer
- Utilities are inexperienced with managing grid operations and determining optimal generator dispatch methods with a more complex portfolio of small and large resources

Utility opposition to CHP systems can be a substantial obstacle in the development process. Electric utilities have a number of technical, procedural, and legal avenues by which they can negatively impact CHP developments. Consequently, understanding the utility’s perspective and the strategies it could use to delay or cancel a project is important. CHP projects that have the backing and support of the local electric utility can be developed far more easily and inexpensively, so getting the utility involved in the project early and productively is very important.

1. Interconnection to the utility grid

CHP systems need to be connected to the grid regardless of whether the export of electricity is contemplated. The rules for interconnecting to the utility grid differ from state-to-state and the Federal Energy Regulatory Commission (FERC) also has some say for utilities under their jurisdiction. In all cases, an “Interconnection Agreement” must be executed between the system developer and the electric utility, which can give the utility substantial leverage to drive up costs and delay the project.

In Texas, the interconnection rule is favorable for CHP system developments under 10 MW. The rule lists specific timelines, fees, and technical review required of CHP projects. The interconnection rule is promulgated by the Public Utility Commission of Texas in:

- *Substantive Rule §25.211: Texas Interconnection of On-Site Distributed Generation*
- *Substantive Rule §25.212: Technical Requirements for Interconnection and Parallel Operation of On-Site Distributed Generation Distributed Generation Manual for Texas*

Because CHP systems are often not under the direct operational control of the local utility, utilities are concerned about the impact of CHP systems on grid stability and safety. Both the quality of the equipment and the skill of the operators who must maintain

synchronous operation with the grid are primary concerns. Protection against “islanding,” which is a condition where a generating facility continues to supply power to a portion of the grid when the balance of the grid has been de-energized, is a particular safety concern voiced by the utilities. As a result of these concerns, equipment manufacturers ensure their products are certified and that sound engineering is used to interconnect to the grid. While safety issues are important, technical solutions are readily understood and available. Nevertheless, utilities can use these issues to delay the Interconnection Agreement or to add additional costs to the project for redundant safety equipment.

2. Standby and back up power charges

Facility managers will continue to need the electric utility to provide power during times when facility power demands exceed the capacity of the CHP system, or during times when the CHP system is off-line for maintenance. As a result, the electric utility must maintain capacity within their fleet of generators and on their distribution wires to provide this service. Utilities often charge “standby rates” to CHP system owners, which may take the form of a monthly demand charge per kW of standby service needed, to recover the costs associated with providing this service.²⁹ Few rules exist on how standby charges are calculated giving utilities substantial flexibility to make the standby rate punitive.

3. Lack of electricity rates with demand charges, time-of-use provisions, or interruptible clauses

With the deregulation of the Texas retail market in 1999, many commercial and institution power customers engaged in bilateral contracts for electricity supply with Retail Electric Providers (REPS). Many of these contracts do not require payment for electricity demand, which provides customers no financial benefit to shift energy consumption to low-cost, off-peak periods. As a result, the economic value of CHP to these customers is diminished. Conversely, development of CHP increases the desirability of negotiating electricity rates with demand charges or with time-of-use and interruptible provisions. Either scenario can potentially derail a CHP project.

4. “Competitive” pricing offers

State public utility commissions have made a number of rate options available to electric utilities to help attract new business to the service territory or to retain existing businesses thinking of moving operations elsewhere. So-called “economic development” rates were created to protect jobs and foster economic growth. In some cases, the utilities have broad discretion regarding how they structure and negotiate economic development rates with customers. Electric utilities could use the economic development rate as a way to undercut the prices offered to facility owners by CHP developers. As a result of this capability, some commercial and institutional customers use the potential for CHP development as leverage to engage the utility in price concessions.

²⁹ EEA, Inc, URL: [Hhttp://www.eea-inc.com/rrdb/DGRegProject/StandbyRates.html](http://www.eea-inc.com/rrdb/DGRegProject/StandbyRates.html) (Last accessed: February 21, 2006)

5. Influence with regulators and politicians

Electric utilities are well organized and have deep relationships with regulators and state politicians. The cost of the utility's legal staff is allowed by state regulators to be rate based, thus they earn a return on investment on legal and lobbying expenses. Utilities have little motivation to scale back legal and lobbying activities. Compared to an unorganized stand-alone facility, utilities can use the political process to create opposition to specific CHP projects. The organization of a CHP initiative in this region can help increase awareness of elected officials about CHP and its benefits and make progress in making the necessary policy changes possible.

Environmental Challenges

The Federal Clean Air Act requires pre-construction environmental permitting of new stationary facilities in order to meet the goals of the NAAQS program. The regulated “criteria pollutants” of greatest relevance to DG are NO_x, CO, SO₂ and PM. NO_x is the primary (and often only) criteria pollutant that significantly affects most DG projects. The most significant impact on DG generally comes from state minor source review in nonattainment areas.

Although CHP systems reduce total energy consumption and produce far less emissions than an equal amount of utility supplied electricity, CHP systems must still meet strict emissions limits. A complicating factor is that CHP could actually increase local emissions in those areas close by the CHP facility. Because CHP systems must be located close to thermal loads, they are often located in urban or suburban settings, rather than the rural location of many central station generating plants. Thus, the rules pertaining to electric generators and the allowable emissions levels in urban areas, especially non-attainment areas, are very important.

1. Emissions Permitting Process

The emissions permitting process can be difficult to navigate for many CHP project developers. Locating a project with an EPA designated non-attainment zone could further complicate the process or tighten the permitted emissions limits. In Texas and Louisiana, the cities of Austin, Baton Rouge, Beaumont-Port Arthur, Dallas-Fort Worth, El Paso, and Houston-Galveston are all designed as being in non-attainment for ozone.

Did You Know? The Houston-Galveston area (HGA), which consists of eight counties in the Houston metropolitan area, is designated “nonattainment-severe” for ozone and has until November 2007 to be in attainment. Texas Commission on Environmental Quality (TCEQ) regulations specify that industrial facilities in the Houston-Galveston area must reduce NO_x emissions 80% by 2007 to be in compliance with federal regulations. The Dow Chemical Company (Dow) operates seven chemical and materials manufacturing sites in this area. These seven sites represent over 150 separate NO_x point sources. Gas turbine exhausts, primarily generated at its Freeport facility are responsible for the majority of NO_x emitted from these sites. The 30 TAC Chapter 101 regulations allow Dow the flexibility to establish a combined cap from all of the company’s facilities within the HGA, effectively enabling the trading of NO_x reduction credits between individual point sources and between plants. Therefore, where actual emissions from a point source (after NO_x abatement) are lower than the mandated emissions level, the difference between the two can be credited toward another point source or facility. Using this approach, Dow established one control plan for all seven sites in the HGA, moving NO_x credits between sites as regulations allow. Most NO_x control technologies can be very expensive,. Preparing one control plan for all seven sites and identifying individual allowances and abatement options helped Dow prioritize NO_x compliance efforts to achieve more cost-effective results.

2. Lack of emissions credit for thermal energy production (Output-based Emissions Regulations)

In Oklahoma and Louisiana, electricity generators are required to meet permitted emissions levels. Permits requirements are expressed in terms of a rate per unit of

electricity produced. This type of permit level does not allocate any value to the thermal energy created by the CHP system. Output-based emissions regulations are a way for regulators to consider emissions generated against the total amount of useful energy produced by the system. In 2001, Texas regulators promulgated a standard permit utilizing output-based emission limits. This rule allows CHP system owners to gain credit for thermal energy capture and use. Texas rules allow heat to be converted to an electrical equivalent at the rate of 1 kWh per 3,412 Btus of heat utilized.

3. Lack of credit for avoiding emissions caused by electric utilities

Because CHP facilities mostly use clean-burning natural gas, they often times produce far fewer emissions of NO_x, SO_x, CO₂, and mercury than standard utility power, which relies on mix of fuels including coal and fuel oil. Like energy efficiency, the operation of a CHP system offsets the emissions that the utility would have produced to supply the power.³⁰ Unfortunately, current regulations do not provide a mechanism for CHP system owners to obtain permit credit or tradable certificates for these emissions reductions.³¹

4. Clean Air Act

While the goal of the Clean Air Act (CAA) is to lower air pollution levels by regulating emissions sources, power plants built before 1977 are exempt from the Act's emissions standards. This exemption puts lower emitting technologies such as CHP at a disadvantage. While CAA standards apply to new generators, "grandfathered" units are allowed to operate at full capacity and emit pollutants at orders-of-magnitude higher rates.³² Moreover, small upgrades to grandfathered power plants are permitted without triggering expensive and time-consuming New Source Reviews.

Proposed Amendments to Air Quality Standard Permit for Electric Generating Units

(Texas Commission on Environmental Quality, April 2006)

The commission proposes to amend the NO_x limits that apply to small electric generating units (EGUs) in East Texas. Small EGUs with a capacity of 100 kW or less will be allowed to comply with a limit of 0.47 lb/MWh instead of the current standard of 0.14 lb/MWh. The commission is proposing this change because the technology needed for very small EGUs to comply with a standard of 0.14 lb/MWh has not developed as rapidly as the commission anticipated. Most small engines, turbines, and microturbines are not currently able to meet the 0.14 lb/MWh standard without additional emission control.

³⁰ Department of Energy Office of Energy Efficiency and Renewable Energy, "Combined Heat and Power: A Special Supplement to *Energy Matters*," March/April 2000

³¹ CHP systems can claim benefits for emissions reduced by the thermal side of the project, namely emissions eliminated by the CHP system replacing dirty boilers.

³² Northeast-Midwest Institute, "Overcoming Barriers to the Deployment of Combined Heat and Power,"

Other Challenges

As a less traditional method of securing energy supplies, CHP systems do not always fit within the established institutional systems, regulatory regimes, building codes, and organization cultures. While friction points can be difficult to identify and ascertaining their impact on CHP deployment is nearly impossible, these challenges are real and have a tangible impact on CHP adoption rates. A comprehensive analysis of institutional methods could identify a large number of CHP challenges. This paper examines only one – the code for medical facility back up power – to show an example of how this code impacts CHP system deployment in hospitals.

1. Secure back up power requires the use of liquid fuels with on-site storage

State building codes require medical facilities to provide on-site back-up power generators to ensure life-support systems remain powered during a grid outage. Current code is quite specific in requiring on-site back-up generators to be powered by a liquid fuel stored on-site. As a result, back-up generators using diesel or propane fuel are routinely found at hospitals.

As seen this past summer after Hurricanes Katrina and Rita, re-supply of liquid fuels after a major storm is sometimes not possible because roads are blocked or washed out, supplies are limited, and delivery trucks are damaged. While natural gas supplies were not compromised by the storm and a CHP system would have been able to continue to run during and after the storms, natural gas does not meet code requirements for medical backup. Thus, a hospital that uses a CHP system will still have to purchase additional backup generators operating on liquid fuels or ensure that the CHP system is capable of dual fuel operation. The added cost of multiple and redundant systems required by the code can impact CHP development in a number of ways. For example, the added cost of purchasing and installing two sets of generators may reduce the project's financial performance or the added space required to locate the extra generators may simply be unavailable.

IV. Conclusion

The Gulf Coast region has a long and successful history with CHP and today continues to be a location of active CHP development. While most existing CHP in the region serves industrial facilities, interest in CHP among commercial and institutional facility operators is growing due to the desire to ensure business continuity in the face of grid outages. This is especially true in Texas, where the regulatory environment is more favorable distributed generation.

The development of CHP offers numerous benefits including operational benefits, construction and financing benefits, environmental benefits, and utility system benefits. While many of advantages of CHP benefit the adopter and other project participants, a number of important benefits impact organizations not involved in the project, including for example the local electric utility, the public and others. Today, few mechanisms exist to monetize these benefits for the projects. The rise of cap-and-trade and similar programs, and by seeking project participation of all parties with the potential to benefit from CHP, the ability of CHP developers to capture maximum economic value from a project is increasing. Still, the disaggregated nature of the benefits of CHP remains a central challenge to successful competition against traditional separate heat and power solutions. In addition, a number of other issues must be addressed and overcome for a CHP solution to offer compelling technical and economic benefits.