PDHonline Course C436 (4 PDH)

Developing Combined Heat and Power Projects

Instructor: Jim Newton, P.E., DEE

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

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CHP

EPA COMBINED HEAT AND POWER PARTNERSHIP

CHP Project Development Handbook

U.S. Environmental Protection Agency

Combined Heat and Power Partnership

Foreword

The U.S. Environmental Protection Agency (EPA) Combined Heat and Power (CHP) Partnership is a voluntary program that seeks to reduce the environmental impact of power generation by promoting the use of CHP. CHP is an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source. CHP can increase operational efficiency and decrease energy costs, while reducing the emissions of greenhouse gases, which contribute to global climate change. The CHP Partnership works closely with energy users, the CHP industry, state and local governments, and other stakeholders to support the development of new projects and promote their energy, environmental, and economic benefits.

The partnership provides resources about CHP technologies, incentives, emission profiles, and other information on its website at www.epa.gov/chp.

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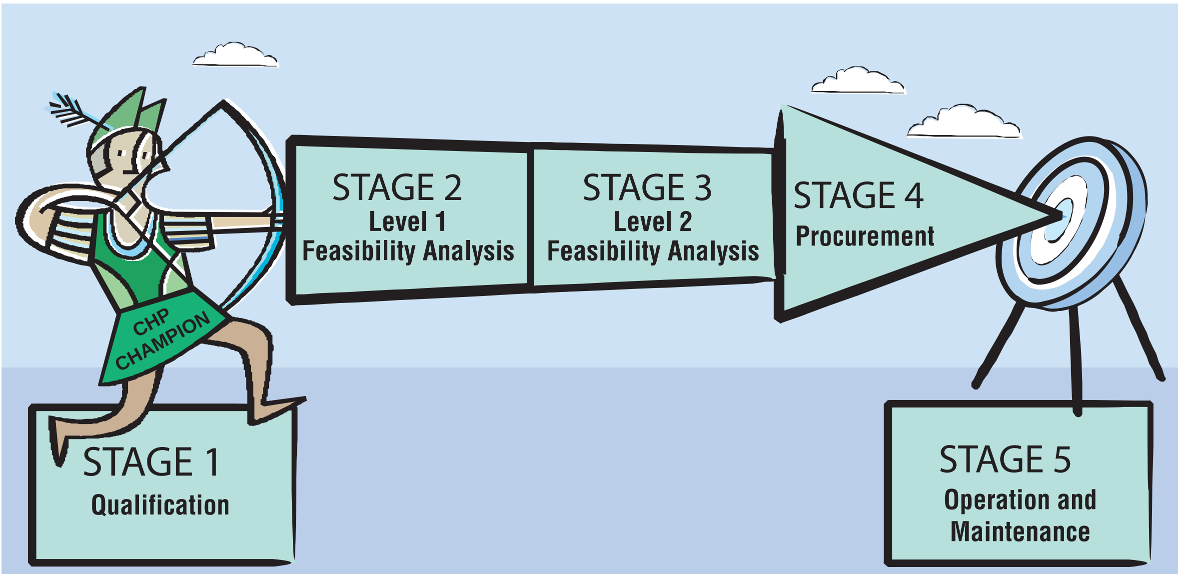


The mission of the EPA Combined Heat and Power (CHP) Partnership is to increase the use of cost-effective, environmentally beneficial CHP projects nationwide. To accomplish this mission, the Partnership has developed resources to assist energy users to design, install, and operate CHP systems at their facilities.

In order for the process to advance smoothly, a CHP Champion is necessary—someone who has the interest and the will to guide the project from conception to completion. The following pages will help you become an educated CHP Champion who can save your organization time and money, reduce business risk and environmental impacts, and improve the power reliability of your facility.

These pages provide information, tools, and hints on project development, CHP technologies, and the resources of the CHP Partnership. Resources are available throughout the process and are divided into five stages:

Stage 1: Qualification

Goal: Determine whether CHP is worth considering at a candidate facility.

Resources:
- Is My Facility A Good Candidate for CHP?
  www.epa.gov/chp/project-development/qualifier_form.html

Stage 2: Level 1 Feasibility Analysis

Goal: Identify project goals and potential barriers. Quantify technical and economic opportunities while minimizing time and effort.

Resources:
- Level 1 Feasibility Analysis Data Tool
  www.epa.gov/chp/documents/chp_phase1_data_request_form.xls
- Sample Comprehensive Level 1 Feasibility Analysis - Ethanol Facility
  www.epa.gov/chp/documents/sample_fa_ethanol.pdf

- Sample Comprehensive Level 1 Feasibility Analysis - Industrial Facility
  www.epa.gov/chp/documents/sample_fa_industrial.pdf

Stage 3: Level 2 Feasibility Analysis

Goal: Optimize CHP system design, including capacity, thermal application, and operation. Determine final CHP system pricing and return on investment.

Resources:

- Level 2 Feasibility Analysis Overview and Checklist
  www.epa.gov/chp/documents/level_2_studies_september9.pdf

Stage 4: Procurement

Goal: Build an operational CHP system according to specifications, on schedule and within budget.

Resources:

- Procurement Guide: Selecting a Contractor/Project Developer
  www.epa.gov/chp/documents/pguide_select_contractor.pdf
- Procurement Guide: CHP Financing
  www.epa.gov/chp/documents/pguide_financing_options.pdf
- Procurement Guide: CHP Siting and Permitting Requirements
  www.epa.gov/chp/documents/pguide_permit_reqs.pdf

Stage 5: Operation & Maintenance

Goal: Maintain a CHP system that provides expected energy savings and reduces emissions by running reliably and efficiently.

CHP projects have proven to be cost-effective, efficient, and reliable at many industrial, institutional, and large commercial facilities nationwide.

In order to maximize the energy and economic benefits that CHP offers, projects are designed to meet a specific site's operational needs and to integrate seamlessly into existing mechanical and electrical systems. Due to the complexity of the design process, procurement can become complicated and time-consuming. Commonly, delays occur when the project's goals (e.g., reducing energy costs, increasing reliability, expanding capacity, etc.) are not clearly outlined and accounted for throughout each stage of the planning and implementation process. As the CHP Champion, you must keep these goals in mind while facilitating each stage of the CHP system's implementation.

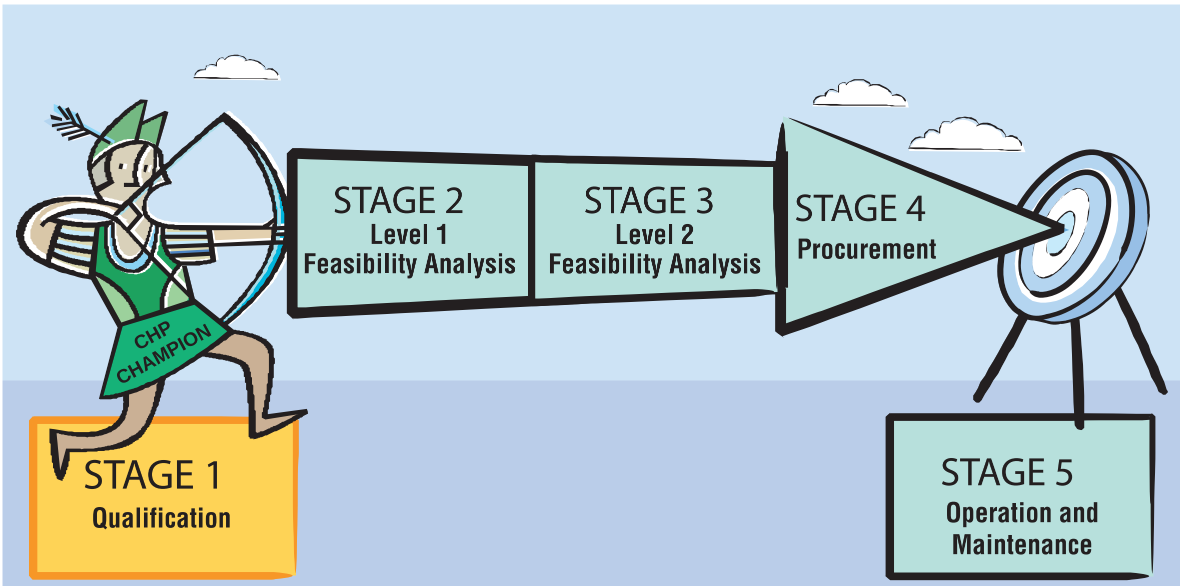
While your specific CHP project development experience will be unique, an understanding of the CHP development process will help you overcome common obstacles at your facility. The following pages outline questions, issues, and specific choices that must be addressed by all CHP projects, organized in stages 1 through 5. Reviewing these sections will help you better understand the project development process in general and smooth the way for your own project's successful implementation and operation.

The CHP Partnership has developed resources to help at each stage of project development. We also have CHP industry Partners who can assist energy users throughout their CHP project development process. Review this handbook or follow the links within the Streamlining Project Development section of the CHP Partnership website, at *www.epa.gov/chp/project-development/index.html*, for information about our services and how to access them.

Stage 1: Qualification

Stage 1: Qualification

CHP Project Development Process



Goal:
Determine whether CHP is worth considering at a candidate site.
Timeframe:
30 minutes
Typical Costs:
None
Candidate site level of effort required:
Minimal site information, average utility costs
Questions to answer:
Which of my facilities are the best candidates for CHP? Is there technical and economic potential for CHP at a particular site? Is there interest and ability to procure if the investment is compelling? What am I trying to accomplish?
Resources:
Is My Facility A Good Candidate for CHP? *www.epa.gov/chp/project-development/qualifier_form.html*

The purpose of Qualification is to eliminate sites where CHP does not make technical or economic sense. As a CHP Champion, you first need to analyze the suitability of CHP for your organization and potential site.

There are many types of CHP technologies and applications available for a range of facilities and different sectors. In order to identify the costs and benefits associated with CHP at a specific site, experienced professional engineering analysis is required. Answering some preliminary questions regarding your candidate site before beginning an engineering analysis can save your organization time and money. The Web tool "Is My Facility a Good Candidate for CHP?," available online at *www.epa.gov/chp/project-development/qualifier_form.html*, provides answers to these preliminary questions.

Diverse technical and economic factors contribute to the economic viability of a CHP project.

Technical potential for CHP is based on the coincident demand of power and thermal energy at a facility. Power can include both electricity and shaft power, which can be used for mechanical purposes. Thermal demand can include steam, hot water, chilled water, process heat, refrigeration, and dehumidification. A CHP system can be designed to convert waste heat into various forms of thermal energy to meet different facility needs, including heating hot water in the winter and chilling water in the summer.

Economic suitability for CHP at a specific site is based on: current and future fuel costs and utility rates; planned new construction or heating, ventilation, and air conditioning (HVAC) equipment replacement; and the need for power reliability at the site. CHP project economics are greatly affected by utility policies at the local, state, and federal level.

CHP can improve efficiency, save money, reduce environmental impacts, and improve power reliability for your business or organization, but only when the CHP system is an appropriate match, both technically and economically, to the specified facility or site. EPA provides project-specific technical assistance to end-user CHP Champions to help with project goal development and to increase their understanding of CHP applications and technology.

Finally, the culture of the host organization needs to be thoroughly explored. What are its goals? How are decisions made? What are the expectations for return on investment? How are projects funded? Is the organization open to new procurement approaches? Having an understanding of these basic questions about the organization's culture will streamline the time needed to navigate the project development process.

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Is My Facility a Good Candidate for CHP?

STEP 1: Please check the boxes that apply to you:	
☐	Do you pay more than $.07/kWh on average for electricity (including generation, transmission and distribution)?
☐	Are you concerned about the impact of current or future energy costs on your business?
☐	Is your facility located in a deregulated electricity market?
☐	Are you concerned about power reliability? Is there a substantial financial impact to your business if the power goes out for 1 hour? For 5 minutes?
☐	Does your facility operate for more than 5,000 hours/year?
☐	Do you have thermal loads throughout the year (including steam, hot water, chilled water, hot air, etc.)?
☐	Does your facility have an existing central plant?
☐	Do you expect to replace, upgrade, or retrofit central plant equipment within the next 3-5 years?
☐	Do you anticipate a facility expansion or new construction project within the next 3-5 years?
☐	Have you already implemented energy efficiency measures and still have high energy costs?
☐	Are you interested in reducing your facility's impact on the environment?

STEP 2: If you have answered "yes" to 3 or more of these of these questions, your facility might be good candidate for CHP.

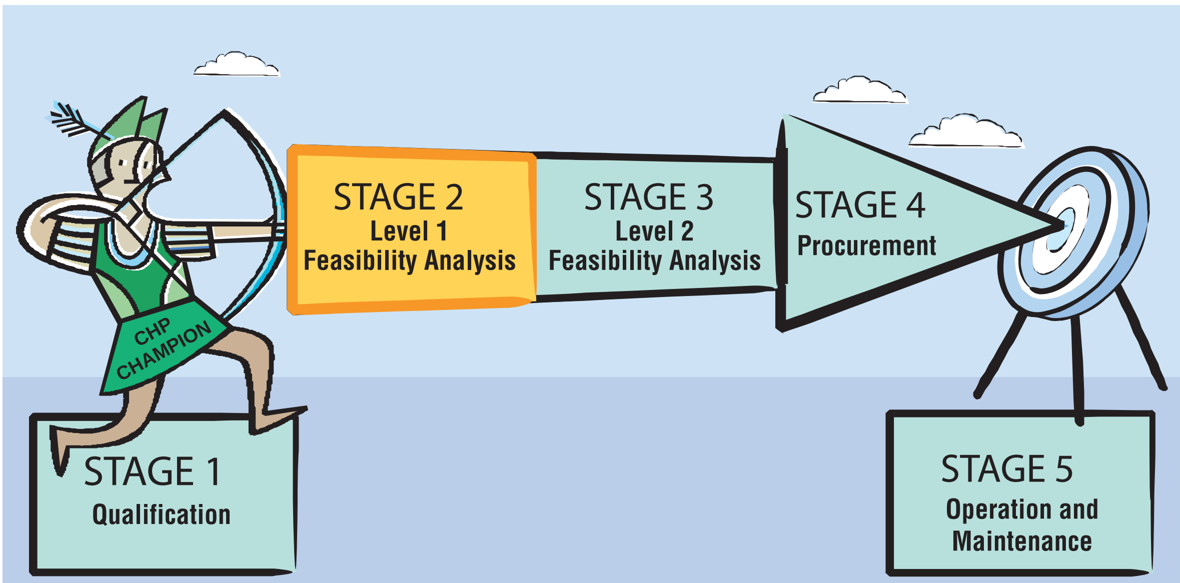
The next step in assessing the potential of an investment in CHP is to have a Level 1 Feasibility Analysis performed to estimate the preliminary return on investment. EPA's CHP Partnership offers a comprehensive Level 1 Feasibility Analysis service for qualifying projects and can provide contact information to others who perform these types of analyses.

For more information on EPA's CHP Partnership technical support services, visit *www.epa.gov/chp/project-development/qualifier_form.html* to fill out a contact form.

Stage 2:
Level 1 Feasibility Analysis

Stage 2: Level 1 Feasibility Analysis

CHP Project Development Process



Goal:
Identify project goals and potential barriers. Quantify technical and economic opportunities while minimizing time and effort.
Timeframe:
4 - 6 weeks
Typical Costs:
$0 - $10,000
Candidate site level of effort required:
4 - 8 hours, including at least two meetings with engineering provider. Provide utility data for previous 1 - 2 years; provide anecdotal knowledge of building operation, including hours of operation, HVAC, and other thermal loads; provide information about future expansion or equipment replacement plans; communicate site goals, expectations, and concerns.
Questions to answer:
Are there any regulatory or other external barriers that would prevent this project from going forward? Have your goals and concerns been identified and addressed? How compelling are the estimated economic and operational benefits? Do these benefits justify the expenditure of funds for an investment grade analysis?
Resources:
• Level 1 Feasibility Analysis Data Tool *www.epa.gov/chp/documents/chp_phase1_data_request_form.xls* • Sample Comprehensive Level 1 Feasibility Analysis - Ethanol Facility *www.epa.gov/chp/documents/sample_fa_ethanol.pdf* • Sample Comprehensive Level 1 Feasibility Analysis - Industrial Facility *www.epa.gov/chp/documents/sample_fa_industrial.pdf*

The goal for a Level 1 Feasibility Analysis is to determine if CHP is a proper technical fit for your facility and if CHP might offer economic benefits. In addition to energy savings, additional benefits of CHP might meet your organization's goals and provide added value to an investment in CHP. (See *www.epa.gov/chp/basic/index.html#benechp* for a discussion of the many benefits of CHP.) To determine the scope of the opportunity for CHP at your facility, an experienced engineer or CHP project developer should perform a Level 1 Feasibility Analysis. The purpose of a Level 1 Feasibility Analysis is to provide enough information on project economics to allow energy end users to make an informed decision about whether or not to continue exploring an investment in CHP for that particular location, while minimizing time and money spent to obtain that information. EPA's CHP Partnership offers Level 1 Feasibility Analysis services to qualified projects and can provide contact information for CHP Partners who provide these services.

Identifying Barriers

The first task at this stage is to identify if there are any uncontrollable factors that could prevent the implementation of CHP at the site. Common obstacles can include existing corporate power purchase contracts that prevent installation of onsite power generation or local utility and regulatory policies that prevent or hamper distributed generation. If one of these obstacles is present, further activity on the project should be suspended pending changes to the problem. If these factors only hamper implementation, a budgetary cost of overcoming them should be included in the Level 1 Feasibility Analysis.

Conceptual Engineering

The next task of a Level 1 Feasibility Analysis is to identify a preliminary system size, based on estimated loads and schedules for thermal and electrical demand at the site. Ideally, other types of energy conservation measures will have been considered or implemented prior to consideration of onsite generation. It is important that planned changes to site operations be discussed with the CHP engineering team. To minimize costs at this early stage of project development, it is best to have utility bills and anecdotal site information readily available to estimate the electrical and thermal loads at the site. The estimated load profiles and power-to-heat ratios will be used to investigate the applicability of various types of prime mover technologies (the devices that convert fuels to electrical or mechanical energy) for the site. (For more information about CHP prime movers, view the CHP Catalog of Technologies, available online at *www.epa.gov/chp/basic/catalog.html*.) Site visits might or might not be made to determine system placement at the site, depending on the cost and scope of the Level 1 Feasibility Analysis.

The most cost-effective CHP systems are designed to provide a portion of a site's electrical demand while providing the majority of the site's thermal needs. This type of design, known as thermal base-loading, provides the greatest efficiency and cost savings by ensuring that all of the energy produced by a CHP system is used on site. Although site needs and final system optimization might call for another approach to CHP design, a base-loaded system is often the best starting point.

Preliminary Economic Analysis

An important component of a Level 1 Feasibility Analysis is the budgetary pricing and economic analysis, which will be developed for different system configurations. Many times, estimated equipment pricing is quite accurate at this initial stage, but other project development costs are often very preliminary, such as the cost of CHP system tie-in and site construction expenditures. In addition, it is important that reasonable placeholders for all other turnkey costs associated with CHP system implementation, operation, and maintenance are included in this preliminary budget.

The first level of economic analysis is usually a simple payback calculation that takes into account: (1) the amount of heat and power produced by the CHP system, the estimated amount of each to be used on the site, (2) the avoided costs of utility-purchased heat and power, (3) the amount and cost of fuel associated with running the CHP system, and (4) the budgetary cost to install and maintain the system. In addition, a sensitivity analysis might show the benefits of available grants or incentives, the additional costs and benefits associated with using the system to provide backup power in a utility outage, and the impacts of future utility rate increases or decreases.

When heat and power can be produced on site for less than the cost of power from a utility and fuel for heat (separate heat and power), then there is a positive payback for the project. The length of payback is determined by the difference between purchased and onsite energy production. If all of the previously mentioned costs and benefits are included in the preliminary economic analysis, it should provide a fairly accurate representation of the scope of the CHP project opportunity. However, given all of the assumptions and estimates used in the Level 1 Feasibility Analysis, projected return on investment is only preliminary at this stage. If the analysis demonstrates that a CHP system could meet a site's operational goals and economic expectations, then exploring CHP project procurement approaches is suggested in order to proceed. Preliminary decisions regarding approaches to procurement can influence how to proceed to the next stage in the CHP project development process—the Level 2 Feasibility Analysis.

Level 1 Feasibility Analysis Data Tool

Introduction

CHP systems can provide significant economic benefits to certain users. Whether CHP can be economically beneficial at any particular site depends on a host of site-specific characteristics such as the energy consumption profiles of the facility, the relative prices of fuel and retail electricity, and the costs of installing and maintaining the CHP equipment. A Level 1 Feasibility Analysis is often the first step in determining the economic viability of CHP at a site. The purpose of a Level 1 Feasibility Analysis is to provide enough information on project economics to allow an end user to make decisions regarding further investment, while minimizing the amount of upfront time and money spent. The EPA CHP Partnership can assist in Level 1 Feasibility Analyses as part of its project-specific technical assistance. This tool outlines the data requirements for a Level 1 Feasibility Analysis. The electronic (MS Excel) version of this tool serves as the data submittal form and is available on the CHP Partnership website at: *www.epa.gov/chp/project-development/stage2.html* under "Resources."

The primary task of a Level 1 Feasibility Analysis is to identify a preliminary system size, based on estimated loads and schedules for thermal and electrical demand at the site. In the interest of minimizing costs at this early stage of project development, load estimates are often based on utility bill analysis, readily available data, and anecdotal site information. The estimated load curves and the correlation between power and thermal demands will be used to investigate the applicability of various types of prime mover technologies for the site.

The economic analysis in a Level 1 Feasibility Analysis is usually a simple payback calculation that takes into account the amount of power and heat produced by the CHP system and the estimated amount of each to be used on-site; the offset costs of utility purchased power and heat; the amount and cost of fuel associated with running the CHP system; and the budgetary cost to install and maintain the system. In addition, a sensitivity analysis might show the benefits of available grants or incentives, the additional costs and benefits associated with using the system to provide backup power in a utility outage, and the impacts of future utility rate increases or decreases.

This tool is intended to walk an end user through the data requirements for a Level 1 Feasibility Analysis. The requirements are separated into sections, as follows:

Contact Data:	Contact information for the primary technical contact for the site
Site Data:	Basic information on facility operations (hours/day, days/year) and site-specific considerations or constraints
Electric Use Data:	Information on existing electric service to the facility, and data on consumption, peak and average demand, and monthly/seasonal use patterns
Fuel Use Data:	Information on current fuel use for boilers and heaters including fuel type, costs, and use patterns
Thermal Loads:	Information on existing thermal loads including type (steam, hot water, direct heat), conditions (temperature, pressure) and use patterns
Existing Equipment:	Information on existing heating and cooling equipment including type, capacities, efficiencies and emissions
Other Data:	Information on other site-specific issues such as expansion plans or neighborhood considerations that might impact CHP system design or operation

In the Excel version of the tool, each section is incorporated into an individual worksheet that lists the specific data requested and provides space for input from the user. User inputted cells are bordered by double lines; required data cells are highlighted in light yellow. Required data is the minimum information about the site and its energy consumption characteristics needed for a comprehensive Level 1 Feasibility Analysis.

Please note that the data requested might be more detailed than readily available to the user. In those cases, the user should input whatever relevant data is known. In certain sections, optional or additional data is requested. This information is not necessary for completing a Level 1 Feasibility Analysis, but supplying this information can enhance the results.

1. Contact Data

Site:	
Contact name:	
Title:	
Address:	
Telephone:	
Fax:	
Email:	

2. Site Data

Required Data:

Site description:
Brief Summary of application (e.g., hospital, size, general types of thermal needs, etc.)

Site location:
(If different from Contact address)

Operational information:

Operating hours per day		hours/day
Operating days per week		days/week
Operating weeks/yr		weeks/yr

Any seasonal considerations facility shutdowns, seasonal operations, etc?
If so, describe:

Any special site considerations? (e.g., space, land use restrictions, noise issues, etc.)

Additional Data (optional):

Altitude:		feet
Summer design temp:		deg F
Winter design temp:		deg F

3. Electrical Service

Servicing utility:

Service voltage:

Applicable tariff or rate schedule:

Utility contact:

Phone:

Required Data:

Annual consumption:		kWh
Annual cost:		dollars
Peak demand:		kW
Average demand:		kW

Electricity Usage Patterns: Please provide whatever information is readily available on electric demand and consumption if 12 months of electric bills are unavailable.

	Average Electric Demand (kW)	Peak Electric Demand (kW)	Electric Consumption (kWh)
Annual			
Summer			
Winter			
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Are the previous 12 months of electric utility bills available? If yes, attach to form or describe how to access.	
Does facility have Internet access to real-time consumption data from the utility? If yes and access is permitted, provide URL and password.	

Additional Data (Optional):

Transformer/service voltage: ____ kV

How many electric service drops (feeds) are there to the facility?

How many electric meters serve the facility?

Has the facility experienced power quality (e.g., low voltage, poor frequency) problems? If yes, describe.

Has the facility experienced momentary electric power outages (power fluctuations that cause computer equipment to reset)? If yes, estimate the number per year and approximate cost to facility.

Has the facility experienced sustained electric power outages? If yes, estimate the number per year, typical duration of outage and approximate cost to facility.

Does the facility have back-up generators? If yes, list capacity (kW), fuel and age.

What is the facility's power factor?

4. Fuel Use

Required Data:

Primary Fuel

Fuel type: (e.g., natural gas, #2 oil)			
Name of utility or supplier:			
Applicable tariff or rate schedule:			
Company contact: (name)			
Phone:			
Is commodity purchased under supply contract?			
Current delivered fuel price: (e.g., $/MMBtu or $/therm)		Specify units	
Annual fuel consumption: (e.g., MMBtu or therms)		Specify units	
Annual fuel cost:		dollars	
Natural gas supply pressure: (if known - include units)			
Are the previous 12 months of fuel bills available? If yes, attach to form or describe how to access.			

If fuel bills are not available, estimate monthly fuel use:

(please add a note if consumption is in units other than MMBtu)

Monthly Consumption			
January		July	
February		August	
March		September	
April		October	
May		November	
June		December	

Units:

Secondary Fuels

Please indicate fuel type and annual consumption:

CL = Coal
NG = Natural Gas
O2 = Distillate Oil
O6 = Residual Oil
OR = Other *(please describe)*

Type (e.g., NG)	Annual Use	Units

Fuel Usage:

Please indicate approximate breakdown of annual fuel consumption by use:

Process steam: ____ %

Direct process heat: ____ %

Space heating/heating hot water: ____ %

Domestic hot water: ____ %

Other: ____ %

5. Thermal Loads

Required Data:

Description of major thermal loads at site:

(e.g., hot water, process steam, sterilization, space heating)

Maximum steam demand:		lbs/hr		
Average steam demand:		lbs/hr		
Required steam conditions:		deg F		psig
Maximum hot water demand:		gal/hr, or		Btu/hr
Average hot water demand:		gal/hr, or		Btu/hr
Required hot water conditions:		deg F		
Maximum cooling demand:		tons		

Thermal load profiles:

Any information provided below on thermal load profile is helpful (change units if necessary)

Average Demand	Hot Water (gal/hr)	Steam (lbs/hr)	Chilled Water (ton-hr/day)
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Peak Demand	Hot Water (gal/hr)	Steam (lbs/hr)	Chilled Water (ton-hr/day)
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Do thermal loads generally “track” electric loads?

(i.e., do the loads rise and fall at the same time?)

6. Existing Equipment

Required Data:

Heating Equipment

What Sizes and Types of Existing Heating Equipment Are Installed?

Please mark type of heating system:

HW = Hot Water Heater
PH = Process Heater/Furnace

OHW = Hot Oil Heater
SB = Steam Boiler

O = Other
(please describe)

Type (e.g., HW)	Capacity	Capacity Units (e.g., gal/hr)	Efficiency (%)	Fuel

What percentage of steam condensate is returned to the boilers? ________ %

What is the condensate return temperature? ________ deg F

Cooling Equipment

Does the facility have a chilled water distribution system? ________

What Sizes and Types Are the Existing Chillers?

Please mark type of chillers:

AD = Absorption (Direct Fired)
ED = Engine Driven

AS = Absorption (Steam/Hot Water Fired)
E = Electric Chillers

DX = Rooftop DX units
SD = Steam Turbine Drive

Type (e.g., AD)	Individual Unit Capacity, Tons	Capacity Units (e.g., gal/hr)	Age, Years

Note: Report similar size, age and type units together. If a large number of rooftop units (>5) are being used, you may put the total capacity on a single line.

7. Other Data

Brief qualitative statements concerning:

Neighborhood considerations:
(noise abatement issues, etc.)

Known emissions considerations:
(if any)

Planned equipment replacements:
(if any)

Expansion considerations:
(if any)

Future fuel and/or electricity price projections:

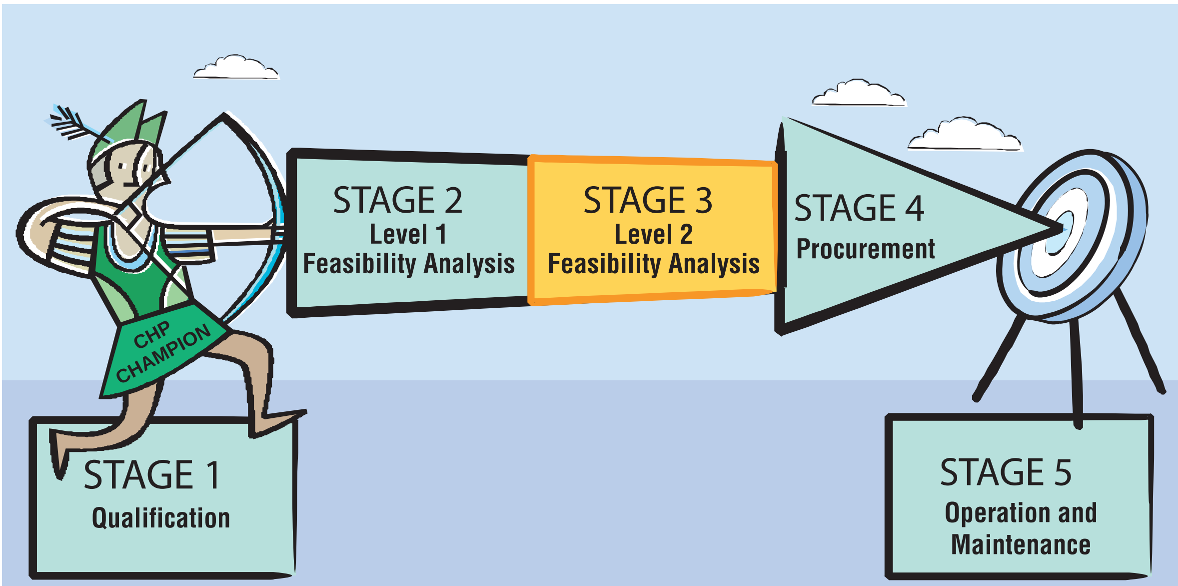
Any space constraints or limitations at the site?

Other information?

Stage 3:
Level 2 Feasibility Analysis

Stage 3: Level 2 Feasibility Analysis

CHP Project Development Process



Goal:

Optimize CHP system design, including capacity, thermal application, and operation. Determine final CHP system pricing and return on investment.

Timeframe:

1 - 4 months

Typical Costs:

$10,000 - $100,000, depending upon system size, complexity, and procurement approach

Candidate site level of effort required:

16 - 80 hours, depending upon complexity and procurement approach

Questions to answer:

Has the CHP system been designed to meet the goals of the site? Is the Level 2 Feasibility Analysis complete, comprehensive, and sound? Does the project meet the organization's requirements for investment? What is the optimal procurement approach for this project? Will you procure this CHP system?

Resources:

- Level 2 Feasibility Analysis Overview and Checklist
  www.epa.gov/chp/documents/level_2_studies_september9.pdf

Completing an Investment-Grade Feasibility Analysis

The primary purpose of a Level 2 Feasibility Analysis is to replace all of the assumptions used in a Level 1 Feasibility Analysis with verified data and to use this information to optimize the CHP system design. It is imperative that the CHP Champion and/or other parties have already identified all operational goals for the project before this stage begins; these goals should include control, monitoring, and maintenance needs, as well as the need for off-grid capabilities (if the system will be designed to run in the event of an utility outage). The results of the Level 2 Feasibility Analysis should include: construction, operation, and maintenance pricing; calculations of final project economics with a simple payback schedule; and a life-cycle cost analysis of the total investment. At the end of this stage, all information needed to make a decision about whether to proceed with the project should be available.

Final system sizing and operation are determined through the development of thermal and electrical load profiles. To the extent possible, hard data will be used to develop these profiles, pulled from electric utility interval data, existing controls systems, and the installation of measurement equipment at the site. Pending load growth due to planned site expansion or new construction will need to be considered and coordinated with any engineering organizations involved at the site. Although integrating CHP systems with new construction can present a challenge, there can be substantial cost savings to the facility by integrating CHP as part of a general construction project. Offset equipment costs and reduced construction costs dramatically improve the system's return on investment.

Multiple site visits and reviews of existing electrical, mechanical, and structural drawings will be required to complete this stage. The CHP Champion will need to work with decision-makers to ensure that important decisions are made at this stage in order to determine accurate system pricing. These might include decisions regarding CHP system specifics (e.g., size and location, prime mover type, heat applications), along with 20 to 30 percent design drawings that include flow diagrams, equipment specifications, monitoring and control specification, piping and wiring, and tie-in to existing building systems. CHP system pricing is heavily affected by the proximity and ease of electrical and thermal tie-in points, as well as the ease of the system's installation at the site. Unless budgetary pricing in the Level 1 Feasibility Analysis was very conservative, these site factors can result in substantial differences between budgetary pricing in the Level 1 and Level 2 Feasibility Analyses. Occasionally, this difference might lead to the project's ultimate cancellation. Unfortunately, there is no way to determine the impacts of the site on project costs without engaging in a fairly comprehensive review of site conditions.

Once a Level 2 Feasibility Analysis has been completed, the CHP Champion will need to ensure that it is thoroughly reviewed by the investor. The report should be comprehensive and sound, taking into consideration each of the following factors:

- Site load profiles
- System operational schedule
- Capital cost
- Heat recovery
- Mechanical system components
- System efficiency
- Sound levels
- Space considerations
- System vibration
- Emissions and permitting
- Utility interconnection
- System availability during utility outage
- Availability of incentives
- Maintenance costs
- Fuel costs
- Economic analysis including life-cycle analysis

In addition, if the Level 2 Feasibility Analysis is accompanied by a proposal for project execution, preliminary project schedule and financing options should be included.

To assist with this review, the Level 2 Feasibility Analysis Overview and Checklist is available at *www.epa.gov/chp/documents/level_2_studies_september9.pdf*.

Level 2 Feasibility Analysis Overview and Checklist

This tool provides an introduction to the elements of a Level 2 Feasibility Analysis. It also includes a checklist that energy users who are considering implementing CHP at their facilities can use to:

- Review the results of a completed Level 2 Feasibility Analysis for completeness
- Help develop the scope for the procurement of a Level 2 Feasibility Analysis

The checklist is a comprehensive listing of the items and issues that are considered in Level 2 Feasibility Analyses. Please note, however, that each item in the checklist may not apply to every project. The Level 2 Feasibility Analysis checklist is available on the CHP Partnership website at: *www.epa.gov/chp/project-development/stage3.html*.

What Is a Level 2 Feasibility Analysis?

A Level 2 Feasibility Analysis is a detailed analysis of the economic and technical viability of installing a CHP system. Usually, a Level 2 Feasibility Analysis will consider the return on investment for multiple CHP system sizes, prime movers, and heat applications. The Level 2 Feasibility Analysis normally follows a Level 1 Feasibility Analysis and is based on more detailed engineering and operational data from the site.

The *purposes* of a Level 2 Feasibility Analysis are to:

- Replace the assumptions used in the Level 1 Feasibility Analysis with verified data to identify optimal CHP system configuration and sizing, appropriate thermal applications, and economic operating strategies.
- Estimate final CHP system pricing.
- Calculate return on investment.

The *goals* of a Level 2 Feasibility Analysis are to:

- Ensure that the recommended CHP system meets the operational and economic goals of the investor.
- Provide all the information needed to make a final investment decision.

The *outcomes* of a Level 2 Feasibility Analysis are:

- Pricing estimates for construction and operation and maintenance of the CHP system.
- Existing and projected utility rate analysis.
- Final project economics, including simple payback and life-cycle cost analysis of the investment.

Who Can Conduct a Level 2 Feasibility Analysis?

Different types of companies, including engineering firms, independent consultants, project developers, and equipment suppliers, can conduct Level 2 Feasibility Analyses. Project developers and equipment suppliers may do so at lower cost if the end user agrees to contract with them on the project (if the results of the feasibility analysis meet some mutually agreed upon threshold). Alternatively, engineering firms or consultants can provide an independent third-party analysis of the CHP opportunity at an end user's site.

Regardless of the type of organization selected for the Level 2 Feasibility Analysis, end users should look for the following critical qualities and capabilities when selecting the company that will conduct the analysis:

- Previous experience with CHP and with the type of application under analysis.
- Sufficient in-house resources covering a full range of expertise, including engineering, finance, operation, and environmental permitting.
- A proven track record of successfully completed Level 2 Feasibility Analyses.

A number of CHP Partners provide Level 2 Feasibility Analyses. To review a list of CHP Partners, visit: *www.epa.gov/chp/partnership/partners.html*.

Suggestions for Ensuring the Success of a Level 2 Feasibility Analysis

A number of best practices have emerged for conducting successful Level 2 Feasibility Analyses. End users can use the best practices that follow as models as they undertake their own analyses.

- Before the Level 2 Feasibility Analysis begins, it is recommended that the end user work together with the engineer, consultant, project developer, or other entity selected to perform the analysis to develop a mutual understanding of all operational goals for the project, including needs for control, monitoring and maintenance, and whether the system will be designed to run in the event of a utility outage. The potential for future load growth, due either to planned site expansion or new construction, should also be considered.
- Successful Level 2 Feasibility Analyses generally involve multiple site visits and a thorough review of existing electrical, mechanical, and structural drawings.
- Accurate system pricing generally involves making upfront determinations about system size and location, prime mover, thermal applications, and preliminary design drawings, including flow diagrams, equipment specifications, monitoring and control specification, piping and wiring, and tie-in to existing building systems.
- Level 2 Feasibility Analyses may need to include a detailed thermal and electrical load profile to determine final system sizing and operation. To the extent possible, hard data should be used to develop these profiles, pulled from electric utility interval data, existing controls systems, and/or the installation of data-loggers at the site.

Checklist For Level 2 Feasibility Analysis

1. EXECUTIVE SUMMARY
   1.1 Clear delineation of the objective of the feasibility analysis.
   1.2 Brief description of site, energy needs, and recommended CHP equipment selection.
   1.3 Overview of project concept and economics. Simple payback, net present value, and/or discounted cash flow for various financial arrangements.
   1.4 Recommendations and rationale.

2. DESCRIPTION OF EXISTING SITE PLAN AND EQUIPMENT
   2.1 Description of existing site and major energy consuming equipment; identify systems/equipment that could be replaced or impacted by the proposed CHP system.
   2.2 Plot plan of site and proposed location of CHP system.
   2.3 Description and location of existing electric feeds, transformers, and meters including critical parameters such as voltage.
   2.4 Description and location of existing gas lines, meters, fuel storage, etc., including critical parameters such as pressure and capacity.
   2.5 Identification of any site/location constraints or restrictions (site access, adjacent properties, noise/zoning limitations).
   2.6 Site expansion plans, if applicable.
   2.7 Emergency/back-up power requirements and existing generating equipment.
   2.8 Review of any possible power and thermal energy sales arrangements.

3. SITE ENERGY REQUIREMENTS
   3.1 Review of recent gas and electric bills.
   3.2 Review of current and projected gas (or other fuel) and electric rates.
   3.3 Development of average hourly use patterns for each type of energy (on a seasonal basis if appropriate) with thermal energy uses segregated by type/quality (e.g., temperature, pressure, form [steam, hot water, hot air]).
   3.4 Tables and/or graphs showing daily and annual use profiles for each form of energy (e.g., electric/steam/hot water/chilled water).
   3.5 Breakdown of energy usage, by type of energy, for equipment that is to be displaced by CHP.
   3.6 Review of CHP analysis methodology.
      3.6.1 Description of computer modeling methods used
      3.6.2 Displaced thermal loads estimates and methodology
      3.6.3 Displaced electrical requirement estimates and methodology

4. CHP EQUIPMENT SELECTION
   4.1 Rationale for equipment selection.
      4.1.1 Thermal output

4.1.2 Capacity

4.1.3 Emissions

4.1.4 Site constraints

4.1.5 Other

4.2 Discussion of alternative CHP system configurations.

4.3 A quantitative and qualitative comparison of prime movers evaluated, including model, kW capacity, fuel consumption comparison, seasonal performance, electric and thermal energy displaced, sound levels, emissions, maintenance requirements, availability/reliability, net revenue, capital cost, simple pay back, or other "profitability index" used by the client.

5. DESCRIPTION OF PREFERRED CHP SYSTEM

5.1 System description – prime mover, generator, heat recovery

5.2 Electric and total CHP efficiency, amount of site energy displaced

5.3 Schematic of system – detailed layout

5.4 Single line diagram of thermal system

5.5 Single line diagram of electrical system

5.6 System tie-ins

5.7 Controls and monitoring

5.8 Necessary site modifications

6. SYSTEM OPERATION

6.1 Operating hours per year

6.2 Recommended operating profile (e.g., thermally base loaded, electric load following, peaking)

6.3 Stand-alone (islanding) and black start capability needed

6.3.1 Is load shedding required? If so, how is it implemented? How is crossover accomplished?

7. REGULATORY AND PERMITTING REQUIREMENTS OVERVIEW

7.1 Review and description of emissions requirements for permitting, including source(s) of information.

7.2 Review and description of local siting and zoning requirements.

8. TOTAL CHP SYSTEM COSTS

8.1 Total costs – Summary of all inclusive or turnkey costs.

8.1.1 Capital costs - equipment

8.1.2 Installations costs – engineering, construction, commissioning

8.2 Capital costs - line item breakdown of major equipment/component costs.

8.2.1 Prime mover.

8.2.2 Fuel compressor (if needed).

8.2.3 Black start capability (if needed).

8.2.4 Generator.

8.2.5 Heat recovery.

8.2.6 Cooling tower or other heat dump.

8.2.7 Site electric tie-in and grid interconnection (islanding requirements included if needed).

8.2.8 Controls.

8.2.9 Site thermal tie-in.

8.2.10 Additional thermal utilization equipment (e.g., absorption chillers).

8.2.11 Other equipment/modifications.

8.2.11.1 Sound attenuation

8.2.11.2 Stack

8.2.11.3 Inlet air handling

8.2.11.4 Vibration

8.2.12 Emission controls.

8.3 Installation costs – line-item breakdown of engineering, permitting, construction, and contingency costs.

8.3.1 Site preparation

8.3.2 Buildings (if needed)

8.3.3 Materials

8.3.4 Engineering

8.3.5 Construction

8.3.6 Permitting fees

8.3.7 Contingency

9. NON-FUEL O&M COSTS

(Both fixed and variable) – Details on maintenance costs for major system components and site interfaces; information on costs of turnkey versus self-maintenance, and major maintenance/overhaul items and schedule:

9.1 Prime mover

9.2 Heat recovery equipment

9.3 Thermal utilization equipment

9.4 Emissions control

10. PROJECT SCHEDULING-DESCRIPTION OF EACH PHASE

(Should include major subcategories or elements)

10.1 Purchase of equipment

10.2 Construction

10.3 Permitting

10.4 Commissioning

11. ASSUMPTIONS FOR CASH FLOW ANALYSIS

11.1 Financing options and assumptions

11.1.1 Debt/equity ratio

11.1.2 Discount rate

11.1.3 Interest rate/Cost of debt

11.1.4 Tax rate

11.2 Total installed costs

11.2.1 CHP equipment and installation from Section 8 above

11.2.2 Any capital credit for displaced equipment purchases

11.3 Operation and maintenance

11.3.1 Self maintained

11.3.2 Supplier/vendor maintenance contract

11.4 Fuel and electric rates

11.4.1 Based on detailed tariffs/rates

11.4.1.1 Electric – customer charge, demand charge, commodity charge; peak, off-peak, shoulder.

11.4.1.2 Gas – commodity, delivery.

11.4.2 Provide fuel/electric escalation rates assumed for outyears

11.4.3 Review any changes to tariffs due to CHP

11.4.3.1 Supplemental electric tariffs

11.4.3.2 Standby rates/exit fees

11.4.3.3 Gas incentive rates

11.5 Any additional costs or credits

11.5.1 Incentives

11.5.2 Value of reliability

11.5.2.1 Cost of facility outages and value of increased power reliability

11.5.3 Other benefits that can be monetized or assigned value

11.5.3.1 Emission credits

11.5.3.2 Other

11.6 Sensitivity analysis – impact of varying:

11.6.1 Fuel costs

11.6.2 Electric rates

11.6.3 Incentives

11.6.4 CHP system availability (impact of CHP outages)

12. DISCOUNTED CASH FLOW ANALYSIS FOR PREFERRED SYSTEM

13. APPENDICES

13.1 Engineering calculations

13.2 Copies of appropriate regulations

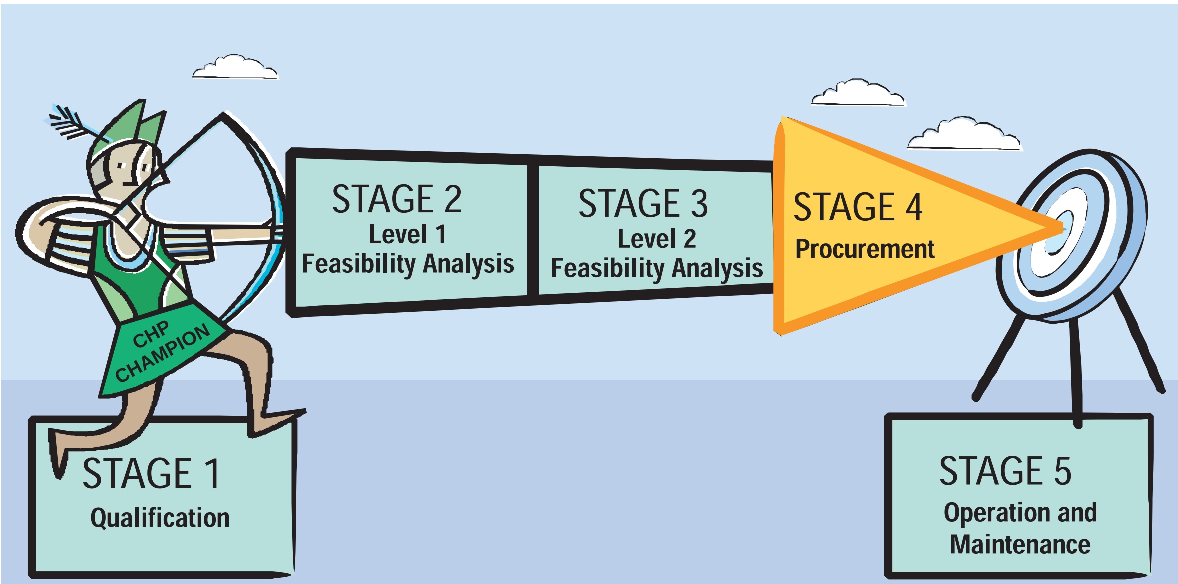
13.3 Vendor's brochures

13.4 Other pertinent information

Stage 4: Procurement

Stage 4: Procurement

CHP Project Development Process



Goal:
Build an operational CHP system according to specifications, on schedule and within budget.
Timeframe:
3 to 30 months, depending on system size and complexity
Typical Costs:
$1,000 - $4,000/kilowatt (kW) installed
Candidate site level of effort required:
Varies depending on procurement approach, similar to any construction project
Questions to answer:
Is the system fully commissioned and running as designed? Will operations and maintenance be performed by site staff or will it be outsourced? If in-house, have employees been trained to perform these functions? If outsourced, have service contracts been procured for equipment or system maintenance, equipment overhaul or replacement, system availability, or monitoring and control?
Resources:
• Procurement Guide: Selecting a Contractor/Project Developer *www.epa.gov/chp/documents/pguide_select_contractor.pdf* • Procurement Guide: CHP Financing *www.epa.gov/chp/documents/pguide_financing_options.pdf* • Procurement Guide: CHP Siting and Permitting Requirements *www.epa.gov/chp/documents/pguide_permit_reqs.pdf*

Procurement is designed to help the CHP Champion navigate the project development and implementation steps of contract negotiation, project engineering and construction, and final commissioning—a process similar to many central plant construction projects.

CHP Procurement Guide

For in-depth information to help streamline the CHP procurement process, refer to the following three sections and the CHP Procurement Guide: Selecting a Contractor/Project Developer (*www.epa.gov/chp/documents/pguide_select_contractor.pdf*), CHP Financing (*www.epa.gov/chp/documents/pguide_financing_options.pdf*), and CHP Siting and Permitting Requirements (*www.epa.gov/chp/documents/pguide_permit_reqs.pdf*).

Contractor Selection

The process of developing and installing a CHP system will require a multidisciplinary team of professionals to successfully complete the project. CHP project development requires the services of mechanical, electrical, and structural engineers and contractors; equipment suppliers; a project manager; environmental consultants; and financiers.

Information and considerations for selecting a contractor/project developer and structuring the development of a CHP project are available within the contractor selection section of the CHP Procurement Guide, located online at *www.epa.gov/chp/documents/pguide.pdf*. Specific topics include:

- Making the final decision to develop a CHP project
- Selecting contractors/consultants and the role of the project developer
- Choosing a turnkey developer
- Selecting other types of project partners
- Preparing a request for proposals
- Creating a contract/elements of an effective project development contract

A number of CHP Partners provide Level 2 Feasibility Analyses. To review a list of CHP Partners, visit: *www.epa.gov/chp/partnership/partners.html*.

Financing

The decision of whether and how to finance a CHP system is a critical step in the development of any CHP project. CHP systems require an initial investment to cover the cost of equipment, installation, and regulatory/permitting costs; these costs are then recovered through lower energy costs over the life of the equipment. The structure of financing can impact project costs, control, and flexibility, as well as affect a company's long-term return on investment.

Information and considerations for evaluating various financing methods for CHP and some advantages and disadvantages of each are available within the financing section of the CHP Procurement

Guide, located online at *www.epa.gov/chp/documents/pguide_financing_options.pdf*. Specific topics include:

- Understanding what lenders and investors are looking for in CHP projects
- Identifying CHP project risks and mitigation measures
- Weighing the advantages and disadvantages of various CHP project financing options

Permitting

Obtaining the required utility interconnection, environmental compliance, and construction permits are critical components in the CHP project development process. The number of permits and approvals will vary depending on project characteristics, such as: project size and complexity; geographic location of the selected site; extent of additional infrastructure modifications (e.g., gas pipeline, distribution); and potential environmental impacts of the construction and operational phases of the project. Permit conditions often affect project design and neither construction nor operation may begin until all permits are in the process stage or officially approved. EPA can provide a letter outlining the emission reduction benefits of a Partner's CHP project, which can help inform permitting offices about the benefits of CHP. Please contact CHP@epa.gov for more information.

More information and considerations for siting and permitting a CHP facility are available within the permitting section of the CHP Procurement Guide, located online at *www.epa.gov/chp/documents/pguide_permit_reqs.pdf*. Specific topics include:

- Understanding the overall permitting process
- Preparing for utility interconnection requirements
- Anticipating local zoning/planning requirements
- Understanding local air quality requirements
- Estimating permitting costs

Procurement Guide: Selecting a Contractor/Project Developer

1. Overview

CHP project development and implementation is similar to many central plant construction projects or comprehensive energy conservation measures. However, a critical distinguishing characteristic of CHP system procurement is the multi-disciplinary nature of the project: CHP project development requires the services of mechanical, electrical, and structural engineers and contractors; equipment suppliers; a project manager; environmental consultants; and financiers. The acquisition of these services may be carried out through a traditional design-bid-build approach, which can require the host site or owner to provide a high level of oversight and project management. An alternate approach is to contract with a turnkey CHP project developer, who will offer a single point of contact for the end user and provide all of the above through in-house capability or through subcontracting.

The selection of a contractor or project developer is a critical decision. The facility owner often relies on the contractor or developer to manage the process of transforming a feasible concept into a functioning project. Some owners have the expertise, resources, and desire to lead the development effort on their own, but even in this case, choosing the right contractor can greatly improve the likelihood of a project's success. This section provides guidance to owners who are attempting to determine (1) the role that they might take in the development process and (2) the right contractor or project developer to get the project successfully developed, financed, and built. A number of CHP Partners provide both the experience and resources required for successful project development and management. To review a list of CHP Partners, visit *www.epa.gov/chp/chp_partners.htm*.

From the owner's perspective, there are three general ways to structure the development of a CHP project:[1]

1. *Develop the project internally*—This is the traditional design-bid-build approach to project development. The facility owner or host site hires a consultant, plans and manages the design-construction effort, and maintains ownership control of the project. This approach maximizes economic returns to the owner, but also places most of the project risks on the owner (e.g., construction, equipment performance, financial performance) and requires a high level of oversight and project management.

2. *Purchase a "turnkey" project*—The facility owner selects a qualified project development company to design, develop, and build the project on a "turnkey" basis, turning over ownership and operation of the facility to the owner after commissioning. This option shifts some risk to the developer, but at a price, sometimes reducing the economic return to the facility owner or limiting the types of technologies or equipment considered.

3. *Team with a partner*—The facility owner teams with an equipment vendor, engineering/procurement /construction (EPC) firm, or investor to develop the project and to share the risks and financial returns under various partnership approaches.

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1 This section does not refer to build-own-operate (BOO) projects in which a third party builds, owns, and operates the CHP plant and sells heat and power to the user at established rates. The contractor selection process in the BOO case would be very different than the selection for an engineering and/or construction contractor as described in this section. While the selection criteria for BOO partners would include many of the experience and capability qualities outlined in this section, they would also include critical financial terms such as delivered cost of power ($/kWh) and/or thermal energy ($/MMBtu). The BOO option is more fully explained in the "Procurement" section of the CHP Project Development Process.

With these structures in mind, a facility owner can determine his or her desired role in the project development process by considering two key questions:

- Should the owner self-develop, procure through a turnkey project, or
- Find a developer or partner, and determine what kind of company best complements the owner and the project?

The facility owner can answer the first question by an examination of his or her own expertise, objectives, and resources. The second question is more complicated because it entails an assessment of the owner's specific needs and a search for the right developer or partner to complement those needs.

2. The Development Decision

Before deciding whether to develop the project internally, the facility owner must understand the role of the project developer, which is outlined in the adjacent box. Next, an assessment of the owner's objectives, expertise, and resources determines whether or not the owner should undertake project development independently or find a turnkey developer or partner.

A facility owner with the following attributes is a good candidate for developing a project independently:

- Willingness and ability to accept project risks (e.g., construction, equipment, permitting, financial performance).
- Technical expertise with energy equipment and energy projects.
- Funds and personnel available to commit to the construction process.

3. Selecting Contractors and Consultants

Once the decision to develop a project internally is made, the facility owner should review the capabilities of individual contracting firms that meet the owner's general needs. When selecting a contractor, there are several qualities and capabilities that owners should look for, including:

- Previous CHP project experience.
- A successful project track record.
- In-house resources (e.g., engineering, finance, operation), including experience with environmental permitting and siting issues.

The Role of the Project Developer

- Carry out project scoping—Includes early-stage tasks such as selecting the location for equipment, determining structural and equipment needs, and estimating costs and potential energy savings.
- Conduct feasibility analysis—Includes detailed technical and economic calculations to determine the technical feasibility of the project and estimate project revenues and expenses.
- Select CHP configuration—Based on the results of the feasibility analysis, select primary equipment and configuration, and contact vendors to assess price, performance, schedules, and guarantees.
- Create a financial pro forma—Model the cash flows of the project to estimate financial performance.
- Obtain environmental and site permits—Acquire all required environmental permits, interconnection, and site permits/licenses.
- Secure financing—Secure financing for the project.
- Contract with engineering, construction, and equipment supply firms—Select firms, negotiate terms and conditions, and execute contracts.
- Provide overall project management—Provide overall project management services through design, engineering, construction, and commissioning of the project.

Information about individual firm qualifications can be gained from reports, brochures, and project descriptions, as well as from discussions with other owners and engineers. Potential warning signs include lawsuits, disputes with owners, lack of operating projects, and failed projects. Published information can be obtained by researching trade literature, through legal information services, and through computer research services.

4. Selecting a Turnkey Developer

Selecting a turnkey developer to manage the development process is a way for the owner to shed development responsibility and risks, and get the project built at a guaranteed cost. In addition, the developer typically provides strong development skills and experience. Other reasons for selecting a turnkey developer include:

- The developer's skills and experience may be invaluable in bringing a successful project online and keeping it operational.
- Many developers have access to financing.

In return for accepting project risks, most turnkey projects cost more than self-built systems. The turnkey option is a good approach if the owner does not want the risk and responsibility of construction. In a turnkey approach, the developer assumes development responsibility and construction risk, builds the facility, and then receives payment when the facility is complete and performing up to specifications. The turnkey approach enables each entity to contribute what it does best: the developer accepts development, construction, and performance risk; and the owner accepts financial performance risk.

5. Selecting Other Types of Project Partners

There are a variety of project development approaches that can lie between (or extend past) developing the project independently or opting for a complete turnkey project. And there are a number of potential project partners to choose from, so the facility owner should look for a partner that provides the best match for the specific CHP project and the owner's in-house capabilities. Three general types of project development partners, listed in order of decreasing scope of services, are:

- *Pure developer*—A firm primarily in the business of developing, owning, and/or operating energy projects. Some developers focus on onsite power projects, while others may be involved in a broad project portfolio of technologies and fuel types. Pure developers usually will own the completed CHP facility, but sometimes a developer will build a turnkey facility.
- *Equipment vendor*—A firm primarily in the business of selling power or energy equipment, although it will participate in project development and/or ownership in specific situations where its equipment is being used. The primary objective of this type of developer is to help facilitate purchases of its equipment and services.
- *EPC firm*—A firm primarily engaged in providing engineering, procurement, and construction services. Many EPC firms have project development groups that develop energy projects and/or take an ownership position.

Ideally, a developer or partner can be identified that fills specific project needs such as the ability to finance the project or supply equipment. Issuing a request for proposals (RFP) is often a good way to attract and evaluate partners. A partner reduces risks to the facility owner by bearing or sharing the responsibilities of project development, although the amount of risk reduction provided depends on the type of partner chosen. For example, a "pure developer" partner will usually take the risk/responsibility of construction, equipment performance, environmental permitting, site permitting, and financing, whereas an equipment vendor partner may only bear the risks of equipment performance.

6. Preparing a Request for Proposals

A facility owner will most likely find it beneficial to issue an RFP for a developer or partner because if the RFP is prepared correctly, respondents will generally offer creative, informative, and useful responses. The RFP process is a good way to screen proposals and focus on the best one(s) for further discussions and negotiation.

An owner who plans on issuing an RFP should carefully examine the needs at the facility and ask respondents to propose ways to meet those needs or solve problems. For example, if ability to secure financing or environmental permits is important, that should also be stated in the RFP. In this way, respondents will be encouraged to offer innovative proposals that meet the project's specific needs. In general, RFP respondents should be asked to provide the following information:

- Description of the energy project and available options
- Scope of services being offered (e.g., developer, owner, operator)
- Project development history and performance
- Turnkey facility bid (if appropriate)
- Technology description and performance data
- Environmental permitting, interconnection, and site permitting plan
- Financing plan
- Schedule
- Operation and maintenance plan

The RFP should state that the owner reserves the right to select none, one, or several respondents for further negotiation, depending on the proposal's responsiveness to the owner's criteria.

RFPs can be issued for various portions of the project development process, including:

- Investment grade feasibility analysis
- Equipment
- Construction
- Engineering (100% design)
- Permitting
- Maintenance

Elements of an Effective Project Development Contract

- Commercial operation date—Date on which the facility will achieve commercial operation.
- Milestones—Engineering completion, construction commencement, genset delivery, start-up.
- Cost, rates, and fees—Structures include fixed EPC or turnkey price, hourly labor rates, cost caps, fee amount or percentage.
- Performance guarantees—Specified output (kW, MMBtu/hr), heat rate, availability, power quality.
- Warranties—Output, performance degradation, heat rate, outage rates, component replacement costs.
- Acceptance criteria—Testing methods and conditions, calculation formulae.
- Bonus amounts and conditions—Bonus for early completion, exceeding specifications.
- Penalties and conditions—Damages for late completion, failure to meet specifications.
- Integration/impact of construction on facility operations—Schedules for power outages, limits to access, etc.

7. Preparing a Contract

Once the contractor, developer, or partner has been selected, the terms of the project structure will be formalized in a contract. The contract should accomplish several objectives, including allocating risk among project participants. Some of the key elements of a contract include project schedule and milestones, performance penalties and bonuses, and potential remedies and/or arbitration procedures (see the box above). Each contract will be different depending on the specific nature of the project and the objectives and limitations of the participants. Because of this complexity, it is often useful for the facility owner to consult in-house counsel or hire a qualified attorney to serve as a guide through the contracting process.

Procurement Guide: CHP Financing

1. Overview

The decision of whether and how to finance a CHP system is a critical step in the development of a CHP project. CHP systems require an initial investment to cover the cost of equipment, installation, and regulatory/permitting costs; these costs are then typically recovered through lower energy costs over the life of the equipment. A company might decide to invest in a CHP project if the value of the future stream of cost savings is greater than the up-front investment in equipment. The structure of financing can impact project costs, control, and flexibility, and affect the company's long-term economic health and ability to generate cash. Creative techniques can help spread risk among different participants and help overcome any capital constraints a prospective host may have.

Financial investors have a primary motive that is based on a return on their investment/capital. There are a variety of capital providers in the market, and different investors have different objectives and appetites for risk. The terms under which capital is provided vary from source to source, and will depend on such factors as the lender's appetite for risk, the project's expected return, and the time horizon for repayment.

This section discusses various financing methods for CHP, and identifies some advantages and disadvantages of each. The primary financing options available to CHP projects include:

- Company earnings or internal cash flow
- Debt financing
- Equity financing
- Lease financing
- Bonds (for public entities)
- Project or third-party financing
- BOO options including energy savings performance contracting

2. Financing: What Lenders and Investors Look For

Most lenders and investors decide whether or not to lend or invest in a CHP project based upon its expected financial performance and risks. Financial performance is usually evaluated using a projection of project cash flows over time. Known as a pro forma, this cash flow analysis estimates project revenues and cost over the life of the project including escalations in project expenses, energy prices, financing costs, and tax considerations (e.g., depreciation, income taxes). Thus, preparing an investment grade pro forma is an important step in ensuring the financial feasibility of a CHP project.

A lender or investor usually evaluates the financial strength of a potential project using the two following measures:

- *Debt coverage ratio*—The main measure of a project's financial strength is the host's/owner's ability to adequately meet debt payments. Debt coverage is the ratio of operating income to debt service requirements, usually calculated on an annual basis.

CHP Project Risks and Mitigation Measures

- Construction—Execute fixed-price contracts, include penalties for missing equipment delivery and construction schedules, establish project acceptance standards and warranties.
- Equipment performance—Select proven, compatible technologies; get performance guarantees/warranties from vendor; include equipment vendor as project partner; ensure trained and qualified operators; secure full-service O&M contracts.
- Environmental permitting—Initiate permit process (air, water) prior to financing.
- Site permitting—Obtain zoning approvals prior to financing.
- Utility agreements—Confirm interconnection requirements, schedule, and fees; have signed contract with utility.
- Financial performance—Create detailed financial pro forma, calculate cash flows, debt coverage, maintain working capital/reserve accounts, budget for major equipment overhauls, secure long-term fuel contracts when possible.

- *Owner's rate of return (ROR) on equity*—Required RORs for internal funds typically range from 15 to 20 percent for most types of CHP projects, but can be higher in certain industries (e.g., refineries, chemical manufacturers, pharmaceutical firms). Outside equity investors will typically expect a ROR of 15 to 25 percent or more, depending on the project risk profile. These RORs reflect early-stage investment situations; investments made later in the development or operational phases of a project typically receive lower returns because the risks have been substantially reduced.

The economic viability of a particular CHP project is also determined by the quality of supporting project contracts and permits, and by risk allocation among project participants. The uncertainties about whether a project will perform as expected or whether assumptions will match reality are viewed as risks. To the extent possible, the project's costs, revenues, and risk allocation are negotiated through contracts with equipment suppliers, fuel suppliers, engineering/construction firms, and operating firms. The box below summarizes the principal project risk categories (viewed from the beginning of the development process) and presents possible risk mitigation strategies, the most important of which are usually obtaining contract(s), securing project revenues if applicable, and applying for environmental and site permitting early. Potential lenders and investors will look to see how the owner or project developer has addressed each risk through contracts, permitting actions, project structure, or financial strategies.

3. Project Financing Options

3.1 Company Earnings or Internal Cash Flow

A potential CHP project owner may choose to finance the required capital investment out of cash flow generated from ongoing company activities. The potential return on investment can make this option economically attractive. In addition, loan transaction costs can be avoided with self-financed projects. Typically, however, there are many demands on internal resources, and the CHP project may be competing with other investment options for internal funds including options tied more directly to business expansion or productivity improvements.

3.2 Debt Financing

Commercial banks and other lenders can provide loans to support CHP projects. Most lenders look at the credit history and financial assets of the owner or developer, rather than the cash flow of a project. If the facility has good credit, adequate assets, and the ability to repay borrowed money, lenders will generally provide debt financing for up to 80 percent or more of a system's installed cost. Typically, the loan is paid back by fixed payments (principal plus interest) every month over the period of the loan, regardless of the actual project performance.

Debt financing usually provides the option of either a fixed-rate loan or a floating-rate loan. Floating-rate loans are usually tied to an accepted interest rate index like U.S. treasury bills.

For small businesses, the Small Business Administration (SBA) can guarantee 85 percent of bank loans up to $150,000 or 75 percent of bank loans up to $2 million for various projects, including CHP. The SBA guarantee could improve a borrower's ability to secure a loan.

Another potential source of loans is vendor financing, in which the vendor of the CHP system or a major component provides financing for the capital investment. Vendors can provide financing at attractive costs to stimulate markets, which is common for energy technologies. Vendor financing is generally suitable for small projects (below $1 million); however, some large vendors do provide financing for larger projects.

Host or facility owners should ask potential developers and equipment suppliers if debt financing is a service they can provide. The ability to provide financing may be a key consideration when selecting a developer, equipment vendors, and/or other partners.

3.3 Equity Financing

Private equity financing has been a widely used method for financing certain types of CHP projects. In order to use private equity financing, an investor must be willing to take an ownership position, often temporarily, in the CHP project. In return for a significant share of project ownership, the investor must be willing to fund part or all of the project costs using its own equity or privately placed equity or debt. Some CHP developers are potential equity investor/partners, as are some equipment vendors and fuel suppliers. Investment banks are also potential investors. The primary advantage of this method is its applicability to most projects. The primary disadvantage is its higher cost; the returns to the host/owner are reduced to cover the off-loading of risk to the investor.

Equity investors typically provide equity or subordinated debt for projects. Equity is invested capital that creates ownership in the project, like a down-payment in a home mortgage. Equity is more expensive than debt, because the equity investor accepts more risk than the debt lender. (Debt lenders usually require that they be paid before project earnings get distributed to equity investors.) Thus the cost of financing with equity is usually significantly higher than financing with debt. Subordinated debt gets repaid after any senior debt lenders are paid and before equity investors are paid. Subordinated debt is sometimes viewed as an equity-equivalent by senior lenders, especially if provided by a credit-worthy equipment vendor or industrial company partner.

The equity investor will conduct a thorough due diligence analysis to assess the likely ROR associated with the project. This analysis is similar in scope to a bank's analysis, but is often accomplished in much less time because equity investors are more entrepreneurial than institutional lenders. The equity investor's due diligence analysis will typically include a review of contracts, project participants, equity commitments, permitting status, technology, and market factors.

The key requirement for most equity investors is sufficient ROR on their investment. The due diligence analysis, combined with the cost and operating data for the project, will enable the investor to calculate the project's financial performance (e.g., cash flows, ROR) and determine its investment offer based on anticipated returns. An equity investor may be willing to finance up to 100 percent of the project's installed cost, often with the expectation that additional equity or debt investors will be identified later.

Some types of partners that might provide equity or subordinated debt may have unique requirements. Potential partners such as equipment vendors and fuel suppliers generally expect to realize some benefit other than just cash flow. The desired benefits may include equipment sales, service contracts, or tax benefits. For example, an engine vendor may provide equity or subordinated debt up to the value of the engine equipment, with the expectation of selling out its interest after the project is built. The requirements imposed by each of these potential investors are sure to include not only an analysis of the technical and financial viability, but also a consideration of the unique objectives of each investor.

To fully explore the possibilities for private equity or subordinated debt financing, host or facility owners should ask potential developers if this is a service they can provide. The second most common source of private equity financing is an investment bank that specializes in the private placement of equity and/or debt. Additionally, the equipment vendors that are involved in the project may also be willing to provide financing for the project, at least through the construction phase. The ability to provide financing can be an important consideration when selecting a developer, equipment vendors, and/or other partners.

3.4 Lease Financing

Leasing can be an attractive financing option for smaller CHP projects. The operating savings resulting from the installation of CHP—the bottom-line impacts on facility energy costs—are used to offset the monthly lease payments, creating a positive cash flow for the company. Lease financing encompasses several strategies in which a facility owner can lease all or part of a project's assets from the asset owner(s). Typically, lease arrangements provide the advantage of transferring tax benefits such as accelerated depreciation or energy tax credits to an entity that can best use them. Lease arrangements commonly provide the lessee with the option, at pre-determined intervals, to purchase the assets or extend the lease. Several large equipment vendors have subsidiaries that lease equipment, as do some financing companies.

Leasing energy equipment has become the fastest-growing equipment activity within the leasing industry. The lease payments may be bundled to include maintenance services, property taxes, and insurance. There are several variations on the lease concept, including operating, capital, and leveraged leases.

An operating lease appears as an operating expense in the financial statement. Operating leases are often referred to as "off-balance-sheet" financing and usually treated as operating expenses. To qualify as an operating lease, the agreement must NOT:

- Transfer ownership of the equipment at the end of the lease term.
- Contain a bargain purchase option.
- Have a term that exceeds 75 percent of the useful economic life of the equipment.
- Have a present value at the beginning of the lease term of the minimum lease payments greater than 90 percent of the fair value at the inception of the lease, using the incremental borrowing rate of the lessee as the discount rate.

Capital lease obligations are reflected on the balance sheet and may be subject to lender or internal capital budget constraints. The general characteristics of a capital lease are:

- It appears on the balance sheet as debt for purchase
- It requires transfer of ownership at the end of the lease

- It specifies the terms of future exchange of ownership
- The lease term is at least 75 percent of the equipment life
- The net present value of lease payments is about 90 percent of the equipment value

In a leveraged lease, the lessor provides a minimum amount of its own equity, borrows the rest of the project capital from a third party, and is entitled to the tax benefits of asset depreciation.

3.5 Project or Third-Party Financing

Project or third-party financing is an approach to obtaining commercial debt financing for the construction of a project in which the lenders look at the credit-worthiness of the project to ensure debt repayment rather than at the assets of the developer/sponsor. Third-party financing can involve the creation of a "legally independent project company financed with non-recourse debt and equity for the purpose of financing a single purpose industrial asset."[1] This entails establishing a company (e.g., a limited liability corporation) solely in order to accomplish a specific task, in this case to build and operate a DG/CHP facility. Lenders look primarily to the cash flows the asset will generate for assurances of re-payment. Moreover, they are explicitly excluded from recourse to the owners' underlying balance sheets.

In deciding whether or not to loan money, lenders examine the expected financial performance of a project and other underlying factors of project success. These factors include contracts, project participants, equity stake, permits, and technology. A good project should have most, if not all, of the following:

- Signed interconnection agreement with local electric utility company
- Fixed-price agreement for construction
- Equity commitment
- Environmental permits
- Any local permits/approval

Lenders generally expect the owners to put up some level of equity commitment using their own money and agree to a fixed-term (8- to 15-year) repayment schedule. An equity commitment demonstrates the owner's financial stake in the project's success, as well as implying that the owner will provide additional funding if problems arise. The expected debt-equity ratio is usually a function of project risk.

Lenders may also place additional requirements on the project owners. Requirements may include maintaining a certain minimum debt coverage ratio and making regular contributions to an equipment maintenance account, which will be used to fund major equipment overhauls when necessary.

The transaction costs for arranging project financing can be relatively high, driven by the lender's need to do extensive due diligence; the transaction costs for a 10 MW project may be the same as for a 100 MW project. For this reason, most of the large commercial banks and investment houses have minimum project capital requirements on the order of $10 to $20 million. Developers of smaller CHP projects may need to contact the project finance groups at smaller investment capital companies and banks, or at one of several energy investment funds that commonly finance smaller projects.

1 Esty, Benjamin. Modern Project Finance: A Case Book. 2004.

Depending on the project economics, some of the investment capital companies and energy funds may consider becoming an equity partner in the project in addition to providing debt financing.

3.6 Build-Own-Operate Options

A final third-party financing structure is the BOO option, in which the CHP facility is built, owned, and operated by an entity other than the host and the host purchases heat and power at established or indexed rates from the third party.[2] There are also build-own-transfer projects, which are similar to BOO projects except that the facility involved is transferred to the host after a predetermined timeframe. Such projects may be implemented by an energy services company (ESCO) or sometimes by equipment suppliers and project developers acting as ESCOs.

In a BOO project, the ESCO finances the entire project, owns the system, and incurs all costs associated with its design, installation, and maintenance. The ESCO sells heat and power to the host at a specified rate that offers some savings over current energy expenditures, or can enter into an energy savings performance contract (ESPC) with the host. In an ESPC, the ESCO and the host agree to share the cost savings generated by the project; in return, the ESCO guarantees the performance of the CHP system. An ESPC mitigates the risks associated with new technologies for facility owners, and allows operation and maintenance of the new system by ESCO specialists.

ESPCs are frequently used for public-sector projects. There are no upfront costs other than technical and contracting support. Traditional ESPCs have three components:

- A project development agreement
- An energy services agreement
- A financing agreement

As such, an ESPC is not a financing agreement by itself, but it may contain the financing component. Most lending institutions prefer to see the financing section as a stand-alone agreement that can be sold into the secondary market. This helps create demand for this financial instrument, usually resulting in better pricing.

The host must usually commit to take a specified quantity of energy or to pay a minimum service charge. This "take or pay" structure is necessary to secure the ESPC. The project host gives up some of the project's economic benefits with a BOO or ESPC in exchange for the ESCO becoming responsible for raising funds, project implementation, system operation, system ownership or a combination of these activities. Some of the disadvantages of this approach to financing include accounting and liability complexities, as well as the possible loss of tax benefits by the facility owner.

3.7 Financing Options for Public Entities

Public sector facilities have additional financing options to consider.

Bonds. A government entity (e.g., municipality, public utility district, county government) can issue either tax-exempt governmental bonds or private activity bonds, which can be either taxable or tax-exempt, to raise money for CHP projects. Bonds can either be secured by general government revenues (revenue bonds), or by specific revenues from a project (project bonds). The terms for bond financing usually do not exceed the useful life of the facility, but terms extending up to 30 years are not uncommon.

2 This approach is often called "chauffage."

The primary benefit of governmental bonds is that the resulting debt has an interest rate that is usually lower (1 to 2 percent) than commercial debt. However, in addition to initial qualification requirements, many bond issuers find that strict debt coverage and cash reserve requirements may be imposed on an energy project to ensure the financial stability of the issuer is preserved. These requirements may even be more rigorous than those imposed by commercial banks under a project finance approach.

To qualify for a tax-exempt governmental bond issue, a project must meet at least two criteria:

- *Private business use test*—No more than 10 percent of the bond proceeds are to be used in the business of an entity other than a state or local government.
- *Private security of payment test*—No more than 10 percent of the payment of principal or interest on the bonds can be directly or indirectly secured by property used for private business use.

Federal government facilities. The Federal Energy Management Program (FEMP) of the Department of Energy has signed indefinite quantity contracts with ESCOs on a regional basis for streamlining energy efficiency improvements, including CHP, at federal facilities. Realizing that awarding a stand-alone ESPC can be very complex and time-consuming, FEMP created streamlined Super ESPCs. The Energy Independence and Security Act of 2007 (EISA), Section 514, extended the authority for all federal agencies to use ESPCs permanently. These "umbrella" contracts allow agencies to undertake multiple energy projects under the same contract. An agency that uses a Super ESPC can bypass cumbersome procurement procedures and partner directly with a pre-qualified ESCO to develop an energy project. Section 512 of the EISA increases financial flexibility for agencies by allowing them to use both private and appropriated funds for an ESPC project. With Super ESPCs, FEMP has already completed the Federal Acquisition Regulations (FAR) procurement process, in compliance with all necessary requirements, and awarded contracts to selected ESCOs. Federal facilities can place and implement a Super ESPC in much less time than it takes to develop a stand-alone ESPC. As a result, Super ESPCs are being used more frequently by federal agencies.

Another way for federal agencies to implement efficiency and CHP projects is through partnerships with their franchised or serving utilities. Federal agencies can enter into sole-source utility energy service contracts (UESCs) to implement energy improvements at their facilities. With a UESC, the utility typically arranges financing to cover the capital costs of the project. Then the utility is repaid over the contract term from the cost savings generated by the energy efficiency measures. With this arrangement, agencies can implement energy improvements with no initial capital investment. The Energy Policy Act of 1992 authorizes and encourages federal agencies to participate in utility energy efficiency programs offered by electric and gas utilities and by other program administrators (e.g., state agencies). These programs range from equipment rebates (i.e., utility incentives) to delivery of a complete turnkey project. Federal legislation and numerous legal opinions demonstrate that agencies have full authority to enter into utility energy service contracts as well as take advantage of utility incentive programs.

3.8 Capital Cost Effects of Financing Alternatives

Each financing method produces a different weighted cost of capital, which affects the amount of resources required to cover CHP system installation costs. Generally speaking, the financing methods are ranked from lowest cost to highest cost as follows:

- Internal cash flow financing
- Governmental bond financing
- Commercial debt financing
- Project financing
- Private equity financing

Governmental bond financing achieves its advantage through access to low-interest debt. Project finance generally produces a higher financing price because funds are required to pay interest charges as well as ROR on equity. Private equity can be the most expensive option because it usually demands a higher return on equity than project finance, and equity often makes up a larger share of the capital requirement. BOO and ESPC options remove capital financing from the users' responsibilities.

Procurement Guide: CHP Siting and Permitting Requirements

1. Overview

Obtaining the required utility interconnection, environmental compliance, and construction permits is an essential step in the CHP project development process. Permit conditions often affect project design, and neither construction nor operation may begin until all permits are in process or in place. The process of permitting a CHP system will typically take from 3 to 12 months to complete, depending on the location, technology, and site characteristics.

One critical set of requirements are the approvals necessary for connection with the servicing utilities, both natural gas and electric. There are also a number of pre-construction, construction, and operating approvals that must be obtained from a variety of local government jurisdictions for any CHP project. The more involved government approval procedures are those required by the local planning and building departments, fire department, and air quality district. Local agencies must ensure that a CHP project complies with:

- Local ordinances (e.g., noise, set-backs, general planning and zoning, land use, and aesthetics)
- Standards and codes (e.g., fire safety, piping, electrical, and structural)
- Air emissions requirements (e.g., NO_x, CO, and particulate standards)

Approvals may be in the form of a permit or license issued after an agency has verified conformance with requirements, or may be in the form of a program (e.g., landscaping, noise monitoring) that must be developed to ensure that the environmental impacts are mitigated.

The number of permits and approvals will vary depending on project characteristics such as the size and complexity of a project, the geographic location, the extent of other infrastructure modifications (e.g., gas pipeline, distribution), and the potential environmental impacts of construction and operations. Key government agencies and other entities involved would be the city or county planning agency, the fire marshal at the respective fire department/authority, the city or county building department, the environmental health department, the air district, and the local distribution utility.

2. Required Approvals

CHP installations typically require the following types of permits or approvals:

- Local utility company approvals

    —Electric utility interconnection study and approval
    —Natural gas connection/supply

- Local jurisdiction pre-construction and construction approvals

    —Planning department land use and environmental assessment/review.
    —Building department review and approval of project design and engineering (based on construction drawings).
    —Air quality agency approval for construction.

- Local jurisdiction post-construction and operating approvals

    —Planning department and building department confirmation and inspection of installed CHP source.
    —Air quality agency confirmation that CHP emissions meet emissions requirements.

In general, facilities that need a construction permit also require an operating permit.

3. Overall Permitting Process

A typical basic pre-construction/construction-phase permitting process for a CHP project within any given entity (utility company or government agency) involves three major steps:

1. The owner or developer completes and submits application forms, accompanied by fee payment(s), to the relevant entity.
2. The entity reviews the application for completeness. In this step, the entity and the developer may complete a number of rounds of information exchange before the application is considered complete and accurate.
3. The entity completes its review and issues the relevant approval/permit.

The approval process may also feature one or more meetings between agency or utility staff and the project developer or development team. More importantly, in some states and government agencies, public comment periods are added to Step 2 to allow interested parties to review and comment on the completed application. The comment periods are usually a minimum of 30 days in length. The agency then addresses the comments received, usually explaining why they did or did not incorporate or act on specific suggestions. Public review processes can add months to the approval process.

The post-construction/operating phase adds a fourth step for many state and local government approvals and for utility interconnection approval:

The agency/organization confirms that the installation does not deviate from the approved application and/or that it conforms to the applicable requirements, and issues the related approval or permit. This step often involves a site inspection by an agency official. If the agency determines that the project falls short of compliance, the developer takes the steps necessary to bring it into compliance. As in Step 2 above, this may be an iterative process, with a number of rounds of developer corrections and agency re-inspections.

The success of the permitting process relies upon a coordinated effort between the developer of the project and the various entities that must review project plans and analyze their impacts. Project developers might have to deal with separate government agencies with overlapping jurisdictions, underscoring the importance of coordinating efforts to minimize difficulties and delays. There are a number of steps that the developer can take to facilitate the permitting process:

- *Hold preliminary meetings with key regulatory agencies.* Meet with regulators to identify permits that may be required and any other issues that need to be addressed. These meetings also give the developer the opportunity to educate regulators about the project, since CHP technologies may be unfamiliar to regulators.
- *Develop permitting and design plans early.* Determine the requirements and assess agency concerns early on, so permit applications can be designed to address those concerns and delays will be minimized.
- *Submit timely permit applications to regulators.* Submit complete applications as early as possible to minimize delays.
- *Negotiate design changes with regulators in order to meet requirements.* Permitting processes sometimes provide opportunities to negotiate with regulators. If negotiation is allowed, it may take into account technical as well as economic considerations.

4. Utility Interconnection Requirements

These include the technical and contractual requirements for interconnection to the local electricity grid for those systems that will operate in parallel with the utility. "Parallel with the utility" means the CHP system is electrically interconnected with the utility distribution system at a point of common coupling at the site (common busbar), and facility loads are met with a combination of grid and self-generated power. Interconnection requires various levels of equipment safeguards and utility approvals to ensure that power does not feed into the grid during grid outages.

Historically, negotiating the technical and contractual requirements for parallel grid interconnection has often been problematic for CHP installations. Each utility has had its own specific requirements that have sometimes appeared to be arbitrary, overly complicated and prohibitively expensive. The situation is improving, however: regulatory intervention, agreement standardization and equipment certification initiatives at the federal and state levels are helping to provide better definition and certainty to both the technical and contractual requirements for interconnection approval.[1] Streamlining and standardization of interconnection is being promoted with the intent that small, low-impact CHP projects can be reviewed quickly and cost-effectively, and the technical and equipment requirements will be only as complex and expensive as required for safe operation.

While standardization of the technical and contractual requirements for parallel grid interconnection is not yet nationwide, the approval process typically includes the following steps:

1. *Application*—A formal application is filed with the servicing electric utility. This application usually asks for information on the location, technical and design parameters, and operational and maintenance procedures for the planned CHP system. The level of detail required and application fees can vary considerably from one utility to another.

2. *Interconnection studies*—There are a number of technical interconnection studies that might or might not be required, depending on the size and configuration of the CHP system and the specific requirements of the servicing utility:

   —*Minimum engineering review*—Designed to identify any adverse system impacts that would result from interconnection of the CHP system. Examples of potential negative impacts to the grid include exceeding the short circuit capability of any breakers, violations of thermal overload or voltage limits, and inadequate grounding requirements and electric system protection.

   —*System impact study*—Required if any adverse impacts are identified in the minimum engineering review. Designed to identify and detail the impacts to the electric system operation and reliability of the proposed CHP system, focusing on the potential adverse system impacts identified in the engineering review.

   —*Facility study*—Might be required if the system impact study indicates that grid system reliability would be adversely affected by interconnection of the CHP system. This study would identify and design any required facility or system upgrades that might be necessary to maintain grid integrity.

1 A number of states have developed streamlined procedures and established timelines for interconnection approval for systems below certain capacity levels (New York, Texas, and Delaware among others). Both the Federal Energy Regulatory Commission (FERC) and the National Association of Regulatory Utility Commissioners (NARUC) have issued rules and model guidelines that promote standardized interconnection procedures and business terms for small distributed generation resources connected to the grid. IEEE 1547 has been issued, providing a "Standard for Interconnecting Distributed Resources with Electric Power Systems" that addresses the performance, operating, testing, and safety requirements of interconnection hardware and software.

The costs of the studies are typically paid by the applicant, but can be negotiated with the utility. It is important to execute specific agreements with the utility if specific studies are required. These agreements should outline the scope of the study and requirements and include a good faith estimate of the cost to perform the study.

3. *Interconnection agreement*—There are also contractual issues that must be addressed in parallel to the technical requirements for interconnection. The interconnection agreement will cover such issues as back-up services, metering requirements, inspection rights, insurance requirements, and the responsibilities of each individual party.

4. *Power purchase agreement*—If sales of excess power to the grid are contemplated, the terms and conditions of power purchases would be contained in a separate power purchase agreement (PPA) between the utility and the site. Primary considerations for a PPA include:

   —*Term:* The contract term should be sufficient to support financing and/or the life of the project. A typical term can be 10 years or more.

   —*Termination grounds:* The grounds for contract termination should be limited in order to protect the long-term interests of all parties.

   —*Assignment:* The contract should consider assignment for purposes such as financing or changes in ownership.

   —*Force majeure:* Situations that constitute force majeure (e.g., storms, acts of war) should be identified and agreed upon; otherwise this clause could be used to interrupt operations or payment.

   —*Schedule:* There should be some flexibility allowed for meeting milestone dates and extensions (e.g., in penalty provisions such as non-performance). This provision is necessary in case unforeseen circumstances cause project construction delays.

   —*Price:* The value of sales of power to the grid will typically be based on the utility's avoided cost or some negotiated rate, either of which will be close to the wholesale commodity costs for power (i.e., not the higher retail rate displaced by power used on-site). Many utilities have a standard offer contract for FERC qualifying facilities.[2]

The utility should establish a definitive period of time in which to process the application and studies, and provide one of the following notifications to the applicant:

- Approval to interconnect.
- Approval to interconnect with a list of prescribed changes to the CHP system.
- Justification and cost estimate for prescribed changes to distribution systems that are required to accommodate the CHP system.
- Application rejection with justification.

2 In 1978, the Public Utilities Regulatory Policy Act (PURPA) required an electric utility to buy electricity from power projects that are granted Qualifying Facility (QF) status by FERC. Under this provision, the electricity would be bought at the utilities' current avoided cost rate. However, the federal Energy Policy Act of 2005 amended PURPA; for new contracts, utilities are no longer required to buy or sell excess power from QFs if the cogeneration facilities have access to transmission services and wholesale markets. In 2006, FERC issued a proposed rule to repeal the mandatory purchase obligation in Day 2 Regional Transmission Organization (RTO) territories: Midwest ISO, PJM, ISO New England, and NYISO. At the time of this writing, FERC has not issued a final rule. For Day 1 RTOs or markets of comparable competitive quality, the mandatory purchase obligation will be evaluated on a case-by-case basis. A power project is granted QF status as either a "small power producer" or a "qualifying cogenerator" after meeting certain fuel or efficiency requirements, as amended by FERC in 2006 (see FERC Docket No. RM05-36-001; Order No. 671).

The time period for the review and approval process can vary depending on the number and level of studies required and the organization of the utility itself. Some utilities have assembled a handbook of procedures, options, and draft contracts. In these cases, the procedures will be relatively orderly and straightforward, and the process will be expedited. Other utilities have dispersed the responsibilities. In such cases it will take time to determine the right contacts and all the specific interconnection requirements. States that are streamlining the interconnection process have targeted a time period of 4 to 6 weeks for review and completion of a simple interconnection application. In general, the larger the project, the more complex the interconnection scheme; if there are specific issues with the section of the grid being accessed (e.g., rural lines or weak distribution areas), the higher the costs both for studying the interconnection configuration and for the necessary electrical equipment to interconnect.

It is recommended that the local utility be contacted early in the project development process in order to identify interconnection requirements and potential issues. A useful starting place for a potential applicant is to identify existing onsite generation systems that have already been connected with the utility and gather information on their requirements and application process. The EPA CHP Partnership can often help identify such sites.

5. Local Zoning/Planning Requirements

Project siting and operation are governed by a number of local jurisdictions. It is important to work with the appropriate regulatory bodies throughout all stages of project development in order to minimize permitting delays that cost both time and money. Applicable local agencies include:

- County and city *planning bureaus* govern land use and zoning issues. They may conduct environmental impact assessments, including noise studies, and are responsible for compliance with local ordinances. For example, most local zoning ordinances stipulate the allowable decibel levels for noise sources and these levels vary, depending on the zoning classification at the site. The local zoning board or planning bureau determines whether or not land use criteria are met by a particular project, and can usually grant variances if conditions warrant.
- State and local *building and fire code departments* address CHP-related safety issues such as exhaust temperatures, venting, natural gas pressure, fuel storage, space limitations, vibration, gas and steam piping, and building structural issues. Building departments are often part of a city's planning division. Most CHP projects require a building permit.
- The *environmental/public health department* looks out for public health and safety, focusing on hazardous materials and waste management requirements.
- *Water/sewer and public works authorities* rule on water supply and discharge matters. Typically, they ensure that a project is compliant with the federal Clean Water Act; decide whether local water and wastewater quality standards will be or are being met; and evaluate waste streams that empty into lakes, rivers and other bodies of water.

6. Local Air Quality Requirements

Air quality agencies/districts at the state and local levels are responsible for administering air quality regulations, with a primary focus on air pollution control. The primary criteria pollutants of concern include NO_x, CO, SO_2, particulates, and certain hazardous air toxics. Local air agencies ensure that a project complies with federal and state Clean Air Act mandates. These authorities issue construction permits based on their review of project design and performance objectives. After construction and installation is complete, projects receive operating permits based on emissions performance relative to applicable emissions thresholds. Issues that air agencies consider include exemption thresholds[3] (e.g., capacity, emission levels), controlled emission levels, type of fuel(s) fired, proximity to sensitive receptors (e.g., schools, day cares, hospitals), siting at a new location or an existing site (e.g., commercial building, industrial facility), and a demonstration that projected emission levels are met via source testing.

Major characteristics that typically differentiate projects for air permitting purposes include:

- Does the CHP system trigger permit requirements? If it is not exempt, what relevant emissions threshold is it below or above?
- Is the site in an attainment area?[4] Non-attainment areas feature more rigorous guidelines.
- Is the site an existing or new facility? Is the site currently considered a major emissions source or a minor emissions source? Adding a new source of emissions to an existing major source can trigger additional permitting requirements; adding a new source to an existing minor source may move the facility into the major source category.
- Do emissions of criteria pollutants and air toxics affect surrounding communities? If it appears that the source's emissions may affect public health, air quality modeling or an evaluation study may be necessary.

Up-to-date information on state emissions requirements for CHP and other onsite generation systems can be found at: *www.eea-inc.com/rrdb/DGRegProject/index.html.*

7. Permitting Costs

Siting and permitting can require significant investments of time and money in researching, planning, filing applications, meeting with officials, and paying fees. Interconnection, environmental regulatory, and local government agency approval costs may approach 3 to 5 percent of project costs for smaller systems and need to be included in any CHP project economic evaluation. Equipment needed to ensure compliance, such as air pollution control equipment or noise abatement equipment, would be in addition to these fees.

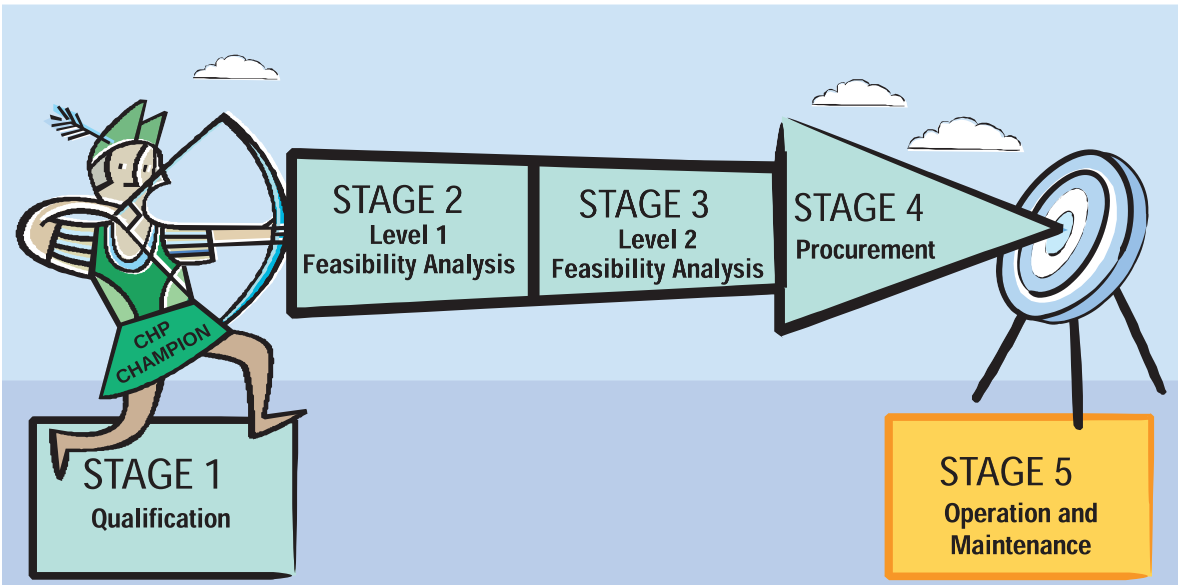
3 Agencies typically have a rule for which equipment and processes are exempt from permitting, a rule that is often based on whether the equipment falls below a given emissions threshold. Exemptions may also exist based on the type or function of the equipment, e.g., if it is emergency standby generation or a fuel cell installation, or if it has been precertified.

4 When an area does not meet the air quality standard for one of the criteria pollutants (ozone, nitrogen dioxide, carbon monoxide, sulfur oxides, particulate matter, and lead), it may be subject to a formal rule-making process that designates it as in "nonattainment." The Clean Air Act further classifies ozone, carbon monoxide, and some particulate matter nonattainment areas based on the magnitude of their problems. Nonattainment classifications may be used to specify what air pollution reduction measures an area must adopt, and when the area must reach attainment. The technical details underlying these classifications are discussed in the Code of Federal Regulations, Part 81 (40 CFR 81) and on the U.S. EPA website—*www.epa.gov*.

Stage 5:
Operations & Maintenance

Stage 5: Operations & Maintenance

CHP Project Development Process



Goal:
Maintain a CHP system that provides expected energy savings and reduces emissions by running reliably and efficiently.
Timeframe:
Ongoing
Typical Costs:
$0.005/kilowatt-hour (kWh) - $0.015/kWh for maintenance, depending on type of equipment and operations and maintenance (O&M) procurement approach; possible cost for energy consultant to negotiate fuel purchase, depending on system size and in-house capabilities.
End-user level of effort required:
Varies depending on O&M procurement approach

Congratulations! You are now the proud owner of a CHP system, which is saving your organization energy and money while reducing your facility's impact on the environment every hour it runs!

Now that your project is operational, take advantage of the CHP Partnership's public recognition opportunities for organizations and businesses that implement highly efficient CHP systems.

- Estimate the carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) emission benefits from your CHP system, compared to separate heat and power, with the CHP Emissions Calculator, which can be found online at *www.epa.gov/chp/basic/calculator.html*.
- Apply for an ENERGY STAR CHP Award by completing the application available online at *www.epa.gov/chp/public-recognition/awards.html#howtoapply*. Highly efficient, thermally base-loaded CHP systems that have one year of operating data may apply for an award.

The CHP Partnership also provides opportunities for Partners to share their knowledge, showcase their CHP projects, and educate others about the benefits of CHP technology. These opportunities might include:

- Presenting at conferences and workshops with EPA's CHP Partnership
- Submitting a short article to the CHP Partnership for inclusion in the CHP Partnership monthly e-mail
- Submitting a short article to the CHP Partnership for inclusion on the website

For more information visit: *www.epa.gov/chp/public-recognition/index.html*.

CHP Partnership Resources

EPA's Combined Heat and Power Partnership

Combined heat and power (CHP), or cogeneration, is an efficient and clean approach to generating power and useful thermal energy from a single fuel source. CHP is used to replace or supplement conventional separate heat and power (SHP) (i.e., central station electricity available via the grid and an onsite boiler or heater). Every CHP application involves the recovery of otherwise wasted thermal energy to produce additional power or useful thermal energy; as such, CHP provides greater energy efficiency and environmental benefits than SHP.

The U.S. Environmental Protection Agency (EPA) established the EPA CHP Partnership as a voluntary program that promotes high-efficiency CHP technologies across the United States. The Partnership works closely with energy users, the CHP industry, state and local governments, and other clean energy stakeholders to facilitate the development of new projects and to promote their environmental and economic benefits.

Benefits of CHP

CHP systems achieve fuel use efficiencies of 60 to 80 percent, compared to average fossil-fueled power plant efficiencies of 33 percent in the United States. This improvement in efficiency translates to:

- Reduced total fossil fuel use.
- Lower operating costs.
- Reduced emissions of regulated air pollutants.
- Reduced emissions of greenhouse gases.
- Increased reliability and power quality.
- Reduced grid congestion and avoided distribution losses.

For these reasons, businesses and others have installed more than 80,000 megawatts (MW) of CHP capacity in the United States, making CHP a proven pollution reduction technology option.

Benefits of Joining the EPA CHP Partnership

The Partnership offers a variety of resources designed to facilitate and promote Partners' development of CHP projects. In addition to the offerings listed, check out the complete list of tools, services, and benefits on our website: *www.epa.gov/chp*.

Education & Outreach

- Information for regulators, policymakers, and utilities to encourage energy efficiency and CHP.
- Peer-to-peer marketing and networking at workshops and conferences.
- Examples of model state policies for promoting CHP, such as output-based emissions regulations, CHP-friendly utility rates, and renewable portfolio standards that include CHP.
- The CHP Partnership newsletter, which provides information about Partner activities and accomplishments, funding opportunities, and upcoming events.
- The biannual Partnership Update, which showcases the efforts and accomplishments of our Partners and highlights opportunities for increased use of CHP.

Public Recognition

- ENERGY STAR® CHP Awards and publicity.
- A profile on the Partnership website with information about each Partner.

What You Can Do to Encourage CHP

Energy Users. Evaluate your needs for clean, reliable power, as well as heating and/or cooling, and consider CHP. Potential CHP users include industrial plants, data centers, universities, commercial or institutional buildings, district energy systems, hotels/casinos, ethanol production facilities, wastewater treatment facilities, and light industrial power parks. Energy users can achieve emissions reductions, cost savings, and increased reliability with CHP.

CHP Project Developers and Equipment Suppliers. Take advantage of the CHP Partnership's market development activities, tools, permitting guidance, networking, and project recognition to increase your profile, effectively target energy users, and expand your business.

Utilities. Establish policies and rates that facilitate CHP development in your service territory. In areas of electric grid congestion or high demand, CHP can reduce load pockets and offer grid support at times of peak demand. Through teaming with customers that have large thermal demands, CHP can allow a generation utility to generate electricity with less fuel while receiving a steady revenue stream from a thermal host.

State and Local Governments. Review energy policies in your state to ensure that they are not creating unintended barriers to CHP deployment by energy users. Using CHP to improve the efficiency of the energy sector helps state and local governments meet energy and air quality goals.

- An Annual Greenhouse Gas Reduction Report—a certificate that shows the carbon reductions associated with the Partner's projects, as well as equivalent benefits in terms of acres of trees planted and car emissions prevented.

Direct Project Assistance

- CHP project qualification to determine whether CHP is worth considering at a particular facility.
- Technical assistance for candidate sites, including spark spread analyses, level 1 feasibility studies, and third-party review of feasibility/design studies.
- Up-to-date lists of state and federal incentives for CHP, biomass- and biogas-fueled applications, and information on state policies and utility rates favorable to clean distributed generation projects.
- The CHP Emissions Calculator, which compares the anticipated CO_2, SO_2, and NO_X emissions from a CHP system to the emissions from a system that uses separate heat and power.

Resources

- Current information on funding resources, including lists of state and federal incentives for CHP and biomass/biogas projects, as well as favorable regulatory/rates opportunities.
- Analyses of CHP potential in targeted strategic markets, such as ethanol, hotels/casinos, wastewater treatment, and data centers.
- Technical white papers and clean energy policy resource documents.

Your Role as a Partner

Partners work with EPA to promote CHP benefits and support the development of new CHP capacity. EPA provides tools and services to support Partners as they investigate and develop new CHP capacity.

Industry and Energy User Partners agree to work with EPA to:

- Assess the potential for additional CHP development at their facilities.
- Publicize the energy, environmental, and economic benefits of their projects.
- Provide EPA with minimal operational data, allowing EPA to evaluate the partnership's success at reducing emissions through CHP.

Government Partners agree to:

- Support the development of new projects within their state and promote the benefits of CHP within their agency and their state.

For more information about the EPA's CHP Partnership, including how to join, contact:

Neeharika Naik-Dhungel, Program Manager
Tel.: 202-343-9553
e-mail: naik-dhungel.neeharika@epa.gov

Claudia Tighe, Program Manager
Tel.: 202-343-9920
e-mail: tighe.claudia@epa.gov

Fax: 202-343-2208
website: www.epa.gov/chp

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Technical Assistance for Candidate Sites

EPA's Combined Heat and Power Partnership (CHPP) provides information, tools and technical assistance to energy users who are considering implementing combined heat and power (CHP) projects. Two key resources are:

- CHP Catalog of Technologies. A comprehensive guide to CHP technology with descriptions of how prime mover and heat recovery technologies function, plus cost and performance characteristics. (*www.epa.gov/chp/basic/catalog.html*)
- Biomass CHP Catalog of Technologies. A detailed technology characterization of biomass CHP systems. Includes technical and economic information about biomass resources, biomass preparation, energy conversion technologies, power production systems, and complete integrated systems. (*www.epa.gov/chp/basic/catalog.html#biomasscat*)

For additional assistance, during a preliminary phone call, the Partnership can help:

- Identify opportunities for cost-effective CHP
- Assess goals, drivers, and potential barriers for a project
- Direct energy users to existing tools and resources
- Determine next steps for project technical assistance

If there is a compelling technical and business case for CHP at the site, a goal of the call will be to identify the information necessary to advance to the next stage of project development. This may include quantifying the technical and economic potential at a site, estimating the environmental impacts and providing letters of support for beneficial projects, or providing information on a variety of technical or policy issues that will be important when considering, planning, or building your CHP system. The CHPP may supply no-cost technical assistance for qualified single or multiple sites in some of the following ways (See: *www.epa.gov/chp/partnership/tech_assistance.html*):

Spark Spread Screening for CHP Candidate Sites

Based on minimal site information, the CHPP team can provide your organization with a preliminary spark spread screening of CHP economic viability for a single or multiple end-use sites. The screening includes assumptions about typical CHP system performance characteristics, fuel prices, and credit for displaced thermal energy to estimate the operating cost of onsite power generation at each site. The difference between the cost of purchased power and the cost to produce power on site indicates whether CHP will provide energy savings. For multiple-site screenings, an overlay of the utility policy environment in each state will be added to the spark spread analysis in order to rank the best candidates for CHP.

Level 1 Feasibility Analysis

If a site is determined to have a good economic and technical potential for CHP, the CHPP team may conduct a Level 1 Feasibility Analysis to help Partners determine how compelling the opportunity is.

The CHPP team evaluates several CHP technologies or system options and develops budgetary pricing and economic analysis for each option to determine a simple payback timeframe. In addition, we can conduct sensitivity analyses to help quantify the benefits of available grants or incentives, the additional costs and benefits associated with using the CHP system to provide backup power in utility outages, or the impacts of future utility rate increases or decreases.

Third-Party Review of Feasibility/Design Analyses

The CHPP team can provide third-party reviews of CHP system feasibility and/or design studies. A review will include an evaluation of critical assumptions, approaches to CHP equipment selection and sizing, as well as project economics.

Incentive/Policy Analysis

The Partnership team can provide a review of specific national and state incentives and policies that could impact a prospective CHP installation at a given location. The policy analysis will identify national and state incentives that might apply to the installation. The review also outlines critical policies or regulations that could impact the economic viability of the project.

Energy and Emissions Savings Calculations

The CHP Partnership team has developed an easy-to-use online tool, located at *www.epa.gov/chp/basic/calculator.html*, that your business can use to quantify the energy and emissions (carbon dioxide, sulfur dioxide, and nitrogen oxides) savings from using CHP technology. The tool compares the energy use and emissions reductions of a CHP system with the energy and emissions from separate heat and power generation. The Partnership team is available to help a candidate or operating site run the tool and will send a letter to the site owner outlining the results, upon request.

If you are interested in accessing the technical assistance services of the Partnership, please complete and submit the qualifier tool, *Is My Facility a Good Candidate for CHP?*, available at: *www.epa.gov/chp/project-development/qualifier_form.html*.

Funding Database

CHP and biomass/biogas funding opportunities are offered by various entities throughout the country, many at the state and federal level. These opportunities take a variety of forms, including:

- Financial incentives, such as grants, tax incentives, low-interest loans, favorable partial load rates (e.g., standby rates), and tradable allowances.
- Regulatory treatment that removes unintended barriers to CHP and biomass project development, such as standard interconnection requirements, net metering, and output-based regulations.

The Funding Database, available online at *www.epa.gov/chp/funding/funding.html*, lists these and other incentives that might be applicable to your CHP project and organizes funding opportunities in two general categories: type of project and type of incentive.

Type of Project:

- State and federal incentives applicable to CHP systems, such as direct financial incentives or favorable regulatory treatment. (*www.epa.gov/chp/funding/funding.html*)
- State and federal incentives applicable to biomass/biogas-fueled CHP and distributed generation projects, including financial incentives and favorable regulatory treatment. (*www.epa.gov/chp/funding/bio.html*)

Type of Incentive:

- The financial incentives page includes grants, tax incentives, low-interest loans, favorable utility rates, tradable allowances, and renewable portfolio standards—all of which could help CHP project developers or end users locate additional funding for their CHP or biomass project. (*www.epa.gov/chp/funding/financial.html*)
- The regulatory treatment page lists regulations that remove unintended barriers to CHP or biomass project development and can include: standardized interconnection rules, net metering rules, or output-based regulations. (*www.epa.gov/chp/funding/regulatory.html*)

The CHP Partnership updates this information every two to four weeks.

CHP Emissions Calculator

The CHP Emissions Calculator, located online at *www.epa.gov/chp/basic/calculator.html*, compares the anticipated carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) emissions from a CHP system to those of a separate heat and power system. The calculator also presents estimated emissions reductions as metric tons of carbon equivalent, acres of trees planted, and emissions from cars, as shown below.

The calculator is designed for users with at least a moderate understanding of CHP technology and its terminology. To learn more about CHP technologies, please review the *Catalog of CHP Technologies,* online at *www.epa.gov/chp/basic/catalog.html*.

The estimate of environmental benefits of CHP generated by the calculator are appropriate for educational and outreach purposes only.

CHP Emissions Calculator

CHP Results

The results generated by the CHP Emissions Calculator are intended for eductional and outreach purposes only,
It is not designed for use in developing emission inventories or preparing air permit applications.

Annual Emissions Analysis	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions Reduction	Percent Reduction
NOx (tons/year)	48.89	230.06	120.56	301.73	86%
SO2 (tons/year)	0.33	744.79	593.49	1,337.95	100%
CO2 (tons/year)	65,008	82,736	61,788	79,515	55%
Carbon (metric tons/year)	17,729	22,564	16,851	21,686	55%
Fuel Consumption (MMBtu/year)	1,111,249	807,202	602,806	298,760	21%
Acres of Forest				21,686	
Number of Cars				13,554	

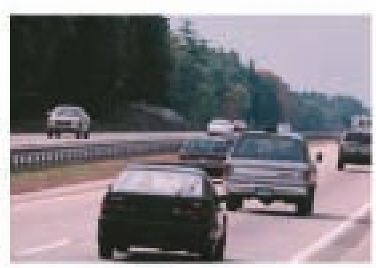
This CHP project will reduce emissions of Carbon Dioxide (CO2) by 79,515 tons per year

This is equal to 21,686 metric tons of carbon equivalent (MTCE) per year

This reduction is equal to removing the carbon that would be absorbed by 21,686 acres of forest

OR

This reduction is equal to removing the carbon emissions of 13,554 cars



Basic Directions

Download the Excel calculator tool from *www.epa.gov/chp/documents/chp_emissions_calc.xls*. The calculator provides concise instructions and default values for each of the inputs within the tool. To view input notes, move the mouse cursor over any cell with a red triangle in its upper right-hand corner.

The tool will work with a minimum of three pieces of information about the CHP system being evaluated:

1. Technology type (also known as the CHP prime mover)

2. Size/capacity

3. Fuel type

For users who are interested in more accurate emissions estimates, the calculator allows users to specify up to 26 additional CHP system characteristics.

For detailed information and instructions, please refer to the user instructions tab included in the calculator. If you need help when using the tool, please contact EPA Technical Support Contractor Bob Sidner (bob.sidner@erg.com), 703-633-1701.

Calculating Reliability Benefits

Overview

Power reliability is a critical issue for many customers, representing a quantifiable business, safety, and health risk to their operations. These risks often compel customers to install back-up or emergency diesel generator sets, tying up significant capital in rarely used assets that require periodic maintenance and frequent testing. However, even these measures are not foolproof, as shown during the Northeast blackout of 2003, when half of New York City's 58 hospitals suffered failures in their back-up power generators.[1]

CHP can be a reliable and cost-effective alternative to installing back-up generators to provide protection against extended outages. A CHP system is typically selected for a facility due to its ability to reduce operating costs and overall emissions. However, power outage protection can also be designed into a CHP system that efficiently provides electricity and thermal energy to the site on a continuous basis. CHP systems can be configured in a number of ways to meet the specific reliability needs and risk profiles of various customers, and to offset the capital cost investment for traditional back-up power measures.

A key step for a customer considering a potential investment in CHP as a solution to reliability concerns is to identify and quantify the value of reliable power to their operations and compare these costs to those associated with configuring CHP to include outage protection.

Reliability Issues and Frequency

Reliability is often defined as how often and how long electric power service is interrupted. Service interruptions and variations in power quality can happen at any time. Although most grid outages are momentary occurrences that are generally brief and do not adversely impact anyone other than the most sensitive operations, an average facility can expect to experience an extended outage (lasting more than five minutes) every other year.[2]

In disaster situations, power outages can have dramatic effects. During the blackout of 2003, portions of the Midwest, Northeast, and Ontario, Canada were without power for up to four days in some locations. Total losses related to the power outage topped $10 billion, and affected more than 50 million people.

The cost of a service interruption varies by customer and is a function of the impact of the interruption on the customer's operations, revenues, and/or direct health and safety. As an example, Pacific Gas & Electric Company (PG&E) researched the estimated direct costs of outages to their customers (based on a combination of direct cost measures and willingness-to-pay indicators) and showed that the value of service can vary widely by customer class (Table 1).[3] A 2004 study estimated total annual cost of power outages to United States customers at $79 billion per year.[4]

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1 New York Times, August 16, 2003.

2 Electric Power Research Institute (EPRI), An Assessment of Distribution System Power/Quality: Volumes 1-3, TR-106294 (V1, V2, V3), EPRI, Palo Alto, CA, 1995.

3 California Energy Commission (CEC), The Cost of Wildlife-Caused Power Outages to California's Economy, Energy and Environmental Economics, CEC Report CEC-500-2005-030, February 2005.

4 Kristina H. LaCommare and Joseph H. Eto, Understanding the Cost of Power Interruptions to U.S. Electricity Consumers, Lawrence Berkeley National Laboratory, September 2004.

Power Sensitive Loads

For certain types of customers, reliability is a true business and operations issue, rather than merely an inconvenience. These customers cannot afford to be without power for more than a brief period without significant loss of revenue, critical data/information, operations, or even life.

Some particularly power sensitive customers include:

- Mission-critical computer systems.
- Industrial processing companies.
- High-tech manufacturing facilities and clean rooms.
- Financial institutions.
- Digital communication facilities (phone, television, satellite).
- Military operations.
- Wastewater treatment facilities.
- Hospitals and other health care facilities.

Table 1. Estimated Direct Costs of Outages for PG&E Customers

Customer Class	$/kWh unserved
Industrial	$12.70 – $424.80
Commercial	$40.60 – $68.20
Agricultural	$11.50 – $11.70
Residential	$5.10 – $8.50

Problems with Traditional Emergency Generators

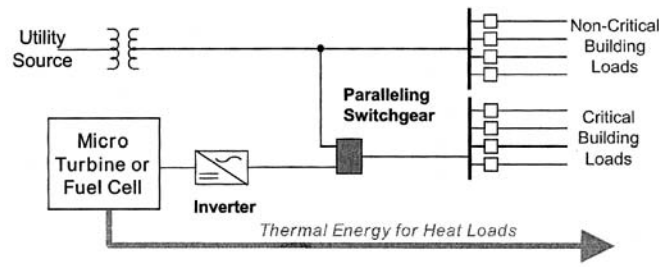
There are at least five notable drawbacks to using diesel gen-sets, which are typically employed as back-up generators:

1. Back-up diesel generators are rarely called to operate and might not start and run when needed. Unless a facility keeps up with maintenance and frequent testing, emergency generators can fail to start on the rare occasions they are needed.
2. Diesel fuel deliveries can be difficult or impossible to arrange during a widespread disaster. During a major hurricane or regional blackout when a prolonged outage occurs, a diesel back-up system might have to shut down due to lack of fuel.
3. Storing large quantities of fuel imposes high costs and risks of fuel leakage or fuel degradation. Diesel fuel begins to chemically break down within 30 to 60 days of delivery and tends to absorb moisture from the air. These fuel quality issues can lead to unreliable engine operations and higher maintenance costs if fuel storage is used to hedge against potential shortages.
4. Diesel engines used for back-up service typically have high emissions and are permitted for limited use. Having limited permitted hours for operation makes it difficult to keep the engines in the proper state of readiness and prevents generator use for meeting general facility energy needs or reducing operating costs.

CHP as a Reliability Solution

Rather than install a diesel back-up generator to provide outage protection, a facility can design capability into a CHP system that provides electric and thermal energy to the site on a continuous basis, resulting in daily operating cost savings (Figure 1). In this type of configuration, the CHP system would be sized, as normal, to meet the base load thermal and electricity needs of the facility. Supplemental power from the grid would serve the facility's peak power needs on a normal basis and would provide the entire facility's power when the CHP system is down for planned or unplanned maintenance. However, the CHP system would also be configured to maintain critical facility loads in the event of an extended grid outage. In order to operate during a utility system outage, the CHP system must have the following features:

Figure 1. CHP System with Back-Up Responsibility for Critical Loads



1. Black start capability. The CHP system must have a battery-powered starting system.
2. Generator capable of operating independently of the utility grid. The CHP electric generator must be a synchronous generator, not an induction generator that requires the grid power signal for operation. High frequency generators (microturbines) or direct current (DC) generators (e.g., fuel cells) need to have inverter technology that can operate independently from the grid.
3. System integration with load shedding. The facility must match the size of the critical loads to the capacity of the CHP generator. These loads must be isolated from the rest of the facility's noncritical loads, which must be shut down during a grid system outage using appropriate switchgear and control logic. The critical load isolation approach can be manual or automatic and can be configured to incorporate dynamic prioritization of load matching to the CHP system capacity.

The additional costs for switchgear and controls for a CHP system depend on the level of control and the speed with which the facility needs to have the CHP system pick up the critical loads in the case of a utility power outage. Table 2 describes three levels of protection—manual, automatic, and seamless—and site-specific costs for reconfiguring the site wiring and control panels to isolate and serve the critical load. The level of back-up capability and control chosen for a CHP system will be directly tied to the value of reliability and risk of outages for the customer.

Manual control requires an operator to isolate the generator to the emergency circuits using manual transfer switches. An *automatic* transfer switch eliminates the need for operator intervention. The generator is switched to the emergency circuit automatically, a process in which the circuit is open for only a fraction of a second (5-10 cycles). *Seamless* transfer—most often integrated with a full uninterruptible power supply (UPS)—utilizes a more costly, closed transition, automatic transfer switch with bypass isolation. This switch is a "make-before-break" design that momentarily parallels the two circuits before switching. An isolation bypass switch allows removal of the automatic switching mechanism in the case of failure, with the ability to then manually switch the load.

Table 2. Control Costs for Generator Back-Up Capability[5]

Control Level	Time to Pick Up Load	Equipment Required	Capital Cost
Manual	Up to an hour	• Engine start • Manual transfer switch • Distribution switchgear	\$20 – \$60 per kW
Automatic	5 to 10 cycles when running	• Engine start • Open transition automatic transfer switch • Distribution switchgear	\$25 – \$105 per kW
Seamless	¼ to ½ cycle when running	• Engine start • Closed transition automatic transfer switch with bypass isolation • Distribution switchgear	\$45 – \$170 per kW
Reconfiguring for Load Shedding	Not applicable	As needed by the site: • Design • Engineering • Rewiring • Added electrical panels, breakers, controls	\$100 – \$500 per kW

Note: Cost range figures represent estimates for a 500 kW CHP system at the high end and a 3,000 kW CHP system at the low end. Cost estimates do not include recircuiting costs, which depend on site needs.

Estimating Costs of Outages

Traditionally, facilities have perceived that it is difficult to quantify the value of reliability to their operations; however, to justify the added costs of configuring a CHP system to provide stand-alone power, the value of reliability must be determined as a factor in the feasibility analysis. At least two different approaches can be used to estimate the value of reliability:

1. Estimate the direct costs of service interruptions based on experience. Customers pay for electricity based on the utility cost of service. While the cost of service determines the electric rates, the value of that service is different for each customer. When power delivery is disrupted, customers generally experience losses to their operations that are much greater than the cost of the electricity not delivered. The value of these losses can be referred to as the customer's value of service (VOS). VOS can be measured in terms of the direct costs of an outage. Power outages or service interruptions can impose direct costs on customers in a number of ways:

   - Damaged plant equipment
   - Spoiled or off-spec product
   - Extra maintenance costs
   - Cost for replacement or repair of failed components
   - Loss of revenue due to downtime that cannot be made up
   - Costs for idle labor
   - Liability for safety/health

5 Adapted from: K. Darrow and M. Koplow, *Dual Fuel Retrofit Market Assessment*, Onsite Energy Corporation for Gas Research Institute, 1998. (Costs escalated at 3 percent per year for equipment and 6 percent per year for labor.)

Some customers can determine their VOS—the direct costs of outages—by reviewing recent outage history and estimating an annualized cost of outages to their operations. One approach is to quantify the direct cost impacts of momentary outages (less than 10 seconds) on either a dollars per incident or dollars per minute basis if the momentary outage results in an extended disruption at the facility, and to similarly quantify the direct cost impacts of extended outages (greater than 10 seconds) on a dollars per minute or dollars per hour basis. Estimates of typical annual values for the number of momentary outages and total time of extended outages can be determined by reviewing utility bills and/or facility records. The resulting cost value represents an annual direct operating cost that could be avoided with a properly configured CHP system and would be treated as operating savings in a CHP feasibility analysis. Dividing this total cost value by the number of unserved kWh (average power demand in kW times total annual outage time in hours) produces a value of service estimate similar to those included in Table 1.

Table 3 presents an example of how to quantify the cost of facility disruptions due to both momentary and long-term outages. The number of occurrences in this example is based on electric industry survey data[5]. The disruption caused by a particular type of outage is customer specific. In this example, even momentary outages cause extended disruption to plant operations (30 minutes), as would be the case where production is controlled by programmable logic controllers that need to be manually reset after an outage. The cost of an outage for this customer is estimated at $45,000 per hour of disruption based on operating history. Assuming an average plant power demand of 1,500 kW, the value of service is estimated to be $30/unserved kWh; this is towards the lower range of outage costs for industrial customers as shown in Table 1.

Table 3. Value of Service Direct Cost Estimation and CHP Value

Facility Outage Impacts			Annual Outages		Annual Cost	
Power Quality Disruptions	Outage Duration per Occurrence	Facility Disruption per Occurrence	Occurences per Year	Total Annual Facility Disruption	Outage Cost per Hour*	Total Annual Costs
Momentary Interruptions Long-Duration Interruptions	5.3 Seconds 60 Minutes	0.5 Hours 5.0 Hours	2.5 0.5	1.3 Hours 2.5 Hours	$45,000 $45,000	$56,250 $112,500
Total			3.0	3.8 Hours		$168,750
Unserved kWh per hour (based on 1,500 kW average demand)			1,500 kWh			
Customer's Estimated Value of Service (VOS), $/unserved kWh			$30/unserved KWh			
Normalized Annual Outage Costs, $/kW-year			$113 $/kW-year			

*Outage costs per hour estimated based on facility data and include production losses, increased labor, product spoilage, etc.

2. Estimate the willingness-to-pay to avoid loss of service. Because outages occur infrequently at different times and last for different durations, it is sometimes difficult to determine the annualized cost of outages. In this situation, customers can use an alternative measure to estimate the value of reliability—their *willingness-to-pay* to avoid loss of service. If customers invest in back-up power generators, a second utility feed, power conditioning equipment, or UPS, these costs represent their willingness-to-pay to avoid an outage and therefore, represent an approximation of how much they value reliable electric service. The costs of these measures (e.g., the capital and maintenance costs of back-up generators) can be quantified and are important to consider as cost offsets in a CHP feasibility analysis.

5 An Assessment of Distribution System Power Quality, Volumes 1-3, TR-106294-V1, V2, V3, EPRI, Palo Alto, CA, 1995.

As an example of how these cost offsets can impact CHP economics, Table 4 provides an economic comparison of a hypothetical 1500 kW natural gas-fueled CHP system with and without the capability to provide back-up power to a site during grid power outages. The impact of enhanced reliability is calculated two different ways. The first method is based on a customer's specific calculations for the value of service and expected number of hours per year of facility disruption that could be avoided (Table 3) with a CHP system that includes back-up capability. For a customer with a VOS of $30/unserved kWh and an expected decrease in downtime of 3.75 hours/year, the internal rate of return for the CHP project example increases from 12.2 percent for the standard CHP system to 17.5 percent for the system with back-up capabilities, and the net present value increases by a factor of four. The second approach, based on willingness to pay, is simply to take a capital cost credit for avoiding the cost of a diesel back up generator. A capital credit is taken for the back-up gen-set, controls, and switchgear that would not need to be installed at the site because back-up capability is integrated into the CHP system (note that the CHP system includes an additional capital cost for this capability, but the incremental capital cost is more than offset by credit from the displaced back-up gen-set). With the second method, the simple payback for the CHP system is reduced from 6.8 to 5.3 years and the internal rate of return is increased to 16.9 percent.

Table 4. CHP Value Comparison With and Without Back-Up Power Capability

CHP System Components	Standard CHP (no off-grid reliability benefit)	CHP With Back-Up Capabilities – Direct Cost Measure	CHP With Back-Up Capabilities – Avoided Diesel Generator Measure
Generator Capacity (kW)	1500	1500	1500
CHP System Installed Cost, ($/kW)	$1,800	$1,800	$1,800
Added Controls and Switchgear Cost, ($/kW)	N/A	$175	$175
Typical Back-Up Gen-Set, Controls, and Switchgear, ($/kW)	N/A	Not valued directly	($550)
Total CHP System Capital Cost, ($/kW)	$1,800	$1,975	$1,425
Total CHP System Capital Cost, ($)	$2,700,000	$2,962,500	$2,137,500
Net Annual Energy Savings, ($)	$400,000	$400,000	$400,000
Decrease in Annual Outrage Time (hours/year)	0	3.8 hours	Not valued directly
Customer Value of Service ($/kW-year)	N/A	$113/kW-year	Not valued directly
Annual Decrease in Outage Costs	N/A	$168,750	Not valued directly
Total Annual Savings	$400,000	$568,750	$400,000
Payback	6.8 Years	5.2 Years	5.3 Years
Internal Rate of Return	12.2%	17.5%	16.9%
Net Present Value (at 10% discount)	$311,302	$1,239,507	$822,665

It should also be noted that a properly configured CHP system can provide better protection than a back-up generator because the CHP system reduces the time to pick up load (when it is running), and it provides a measure of voltage support that helps to protect the facility from momentary, as well as extended outages.

7 Adapted from The Role of Distributed Generation in Power Quality and Reliability, Energy and Environmental Analysis, Inc. for New York State Energy Research & Development Administration. June 2004.

Methods for Calculating Efficiency

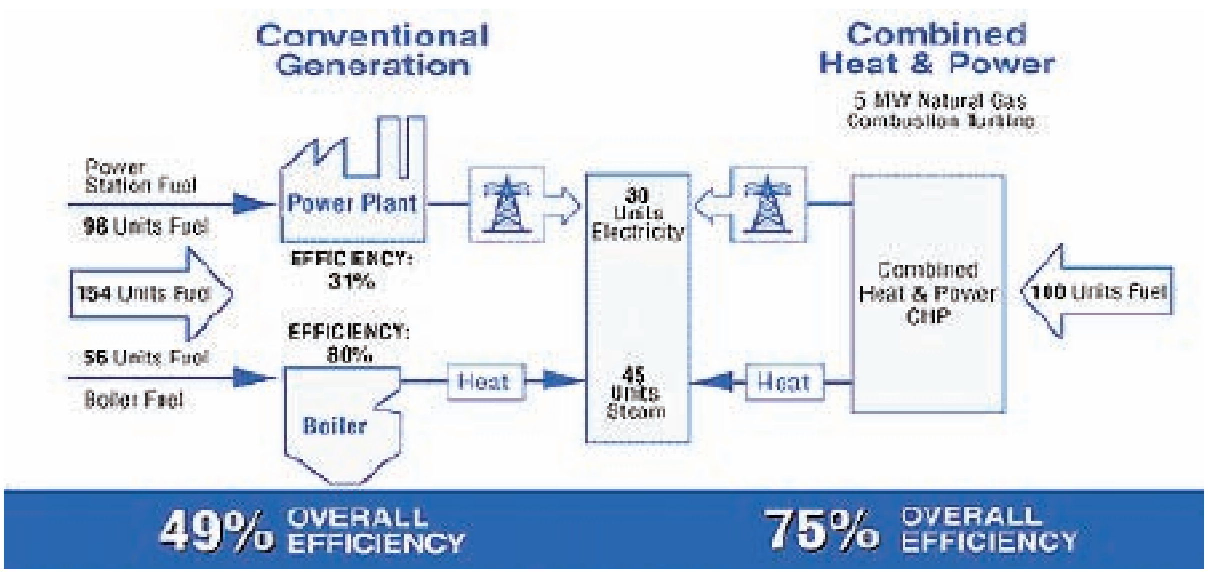
The CHP is an efficient and clean approach to generating power and thermal energy from a single fuel source. CHP is used either to replace or supplement conventional separate heat and power (SHP) (i.e., central station electricity available via the grid and an onsite boiler or heater).

CHP System Efficiency Defined

Every CHP application involves the recovery of otherwise wasted thermal energy to produce additional power or useful thermal energy. Because CHP is highly efficient, it reduces emissions of traditional air pollutants and carbon dioxide, the leading greenhouse gas associated with global climate change.

Efficiency is a prominent metric used to evaluate CHP performance and compare it to SHP. This Web page (*www.epa.gov/chp/basic/methods.html*) identifies and describes the two methodologies most commonly used to determine the efficiency of a CHP system: *total system efficiency and effective electric efficiency*.

Conventional Generation vs. CHP: Overall Efficiency



The illustration above illustrates the potential efficiency gains of CHP when compared to SHP. In this example of a typical CHP system, to produce 75 units of useful energy, the conventional generation or separate heat and power systems use 154 units of energy—98 for electricity production and 56 to produce heat—resulting in an overall efficiency of 49 percent. However, the CHP system needs only 100 units of energy to produce the 75 units of useful energy from a single fuel source, resulting in a total system efficiency of 75 percent.

Key Terms Used in Calculating CHP Efficiency

Calculating a CHP system's efficiency requires an understanding of several key terms, described below.

- CHP system. The CHP system includes the unit in which fuel is consumed (e.g. turbine, boiler, engine), the electric generator, and the heat recovery unit that transforms otherwise wasted heat to useable thermal energy.
- Total fuel energy input (Q_{FUEL}). The thermal energy associated with the total fuel input. Total fuel input is the sum of all the fuel used by the CHP system. The total fuel energy input is often determined by multiplying the quantity of fuel consumed by the heating value of the fuel.

  Commonly accepted heating values for natural gas, coal, and diesel fuel are:

  —1020 Btu per cubic foot of natural gas

  —10,157 Btu per pound of coal

  —138,000 Btu per gallon of diesel fuel
- Net useful power output (W_E). Net useful power output is the gross power produced by the electric generator minus any parasitic electric losses in other words, the electrical power used to support the CHP system. (An example of a parasitic electric loss is the electricity that may be used to compress the natural gas before the gas can be fired in a turbine.)
- Net useful thermal output (Q_{TH}). Net useful thermal output is equal to the gross useful thermal output of the CHP system minus the thermal input. An example of thermal input is the energy of the condensate return and makeup water fed to a heat recovery steam generator (HRSG). Net useful thermal output represents the otherwise wasted thermal energy that was recovered by the CHP system.

  Gross useful thermal output is the thermal output of a CHP system *utilized* by the host facility. The term utilized is important here. Any thermal output that is not used should not be considered. Consider, for example, a CHP system that produces 10,000 pounds of steam per hour, with 90 percent of the steam used for space heating and the remaining 10 percent exhausted in a cooling tower. The energy content of 9,000 pounds of steam per hour is the gross useful thermal output.

Calculating Total System Efficiency

The most commonly used approach to determining a CHP system's efficiency is to calculate *total system efficiency*. Also known as *thermal efficiency*, the total system efficiency (o) of a CHP system is the sum of the net useful power output (W_E) and net useful thermal outputs (Q_{TH}) divided by the total fuel input (Q_{FUEL}), as shown below:

$$o = \frac{W_E + Q_{TH}}{Q_{FUEL}}$$

The calculation of total system efficiency is a simple and useful method that evaluates what is produced (i.e., power and thermal output) compared to what is consumed (i.e., fuel). CHP systems with a relatively high net useful thermal output typically correspond to total system efficiencies in the range of 60 to 85 percent.

Note that this metric does not differentiate between the value of the power output and the thermal output; instead, it treats power output and thermal output as additive properties with the same relative value. In reality and in practice, thermal output and power output are not interchangeable because they cannot be converted easily from one to another. However, typical CHP applications have coincident power and thermal demands that must be met. It is reasonable, therefore, to consider the values of power and thermal output from a CHP system to be equal in many situations.

Calculating Effective Electric Efficiency

Effective electric efficiency calculations allow for a direct comparison of CHP to conventional power generation system performance (e.g., electricity produced from central stations, which is how the majority of electricity is produced in the United States). Effective electric efficiency (EE) can be calculated using the equation below, where (W_E) is the net useful power output, (Q_{TH}) is the sum of the net useful thermal outputs, (Q_{FUEL}) is the total fuel input, and equals the efficiency of the conventional technology that otherwise would be used to produce the useful thermal energy output if the CHP system did not exist:

$$EE = \frac{W_E}{Q_{FUEL} - (Q_{TH} / \ )}$$

For example, if a CHP system is natural gas fired and produces steam, then a represents the efficiency of a conventional natural gas-fired boiler. Typical a values for boilers are: 0.8 for natural gas-fired boiler, 0.75 for a biomass-fired boiler, and 0.83 for a coal-fired boiler.

The calculation of effective electric efficiency is essentially the CHP net electric output divided by the additional fuel the CHP system consumes over and above what would have been used by conventional systems to produce the thermal output for the site. In other words, this metric measures how effectively the CHP system generates power once the thermal demand of a site has been met.

Typical effective electrical efficiencies for combustion turbine-based CHP systems are in the range of 51 to 69 percent. Typical effective electrical efficiencies for reciprocating engine-based CHP systems are in the range of 69 to 84 percent.

Which CHP Efficiency Metric Should You Select?

The selection of an efficiency metric depends on the purpose of calculating CHP efficiency.

- If the objective is to compare CHP system energy efficiency to the efficiency of a site's SHP options, then the total system efficiency metric may be the right choice. Calculation of SHP efficiency is a weighted average (based on a CHP system's net useful power output and net useful thermal output) of the efficiencies of the SHP production components. The separate power production component is typically 33 percent efficient grid power. The separate heat production component is typically a 75- to 85-percent efficient boiler.
- If CHP electrical efficiency is needed for a comparison of CHP to conventional electricity production (i.e., the grid), then the effective electric efficiency metric may be the right choice. Effective electric efficiency accounts for the multiple outputs of CHP and allows for a direct comparison of CHP and conventional electricity production by crediting that portion of the CHP system's fuel input allocated to thermal output.

Both the total system and effective electric efficiencies are valid metrics for evaluating CHP system efficiency. They both consider all the outputs of CHP systems and, when used properly, reflect the inherent advantages of CHP. However, since each metric measures a different performance characteristic, use of the two different metrics for a given CHP system produces different values.

For example, consider a gas turbine CHP system that produces steam for space heating with the following characteristics:

Fuel Input (MMBtu/hr)	41
Electric Output (MW)	3.0
Thermal Output (MMBtu/hr)	17.7

Using the total system efficiency metric, the CHP system efficiency is 68 percent (3.0*3.413+17.7)/41).

Using the effective electric efficiency metric, the CHP system efficiency is 54 percent (3.0*3.413)/(41-(17.7/0.8).

This is not a unique example; a CHP system's total system efficiency and effective electric efficiency often differ by 5 to 15 percent.

NOTE: Many CHP systems are designed to meet a host site's unique power and thermal demand characteristics. As a result, a truly accurate measure of a CHP system's efficiency may require additional information and broader examination beyond what is described in this document.

For More Information

Additional information about CHP applications and technologies can be found on the Basic Information page of the CHP website at *www.epa.gov/chp/basic/index.html*.

EPA Clean Distributed Generation Policy Documents & Resources

EPA regularly provides direct assistance to state utility commissions in the form of electric sector policy assistance and resources. These resources include policy-related fact sheets, guidance documents, and forums for peer-to-peer exchanges as summarized below.

Various EPA programs and initiatives—including the CHP Partnership, the Clean Energy-Environment State Partnership, and clean energy policy initiatives within the Climate Protection Partnerships Division—work directly with project developers, utility commissions, regulators, and policy-makers at states across the country. These interactions have resulted in best practices and lessons learned for states interested in advancing clean distributed generation (DG), as contained in the documents described here.

Benefits of clean DG, such as renewables and CHP, include:

- Enhanced economic development in the state
- Reduced peak electrical demand
- Reduced electric grid constraints
- Reduced environmental impact of power generation

EPA hopes that the variety of resources it offers will help state policy makers and regulators capture these benefits for their states.

Please contact Neeharika Naik-Dhungel *(naik-dhungel.neeharika@epa.gov)* or Gary McNeil *(mcneil.gary@epa.gov)* for more information or to inquire about receiving assistance.

EPA Utility Policy Resources

Standardized Interconnection Rules

- The Interconnection Fact Sheet outlines how and why states could implement standard interconnection rules to encourage DG technologies. *(www.epa.gov/chp/state-policy/interconnection_fs.html)*
- Chapter 5.4 - Interconnection Standards, Clean Energy-Environment Guide to Action discusses standard interconnection rules for DG systems through defined application processes and technical requirements, in addition to offering approaches to net metering and resources for additional information. *(www.epa.gov/cleanenergy/documents/gta/guide_action_chap5_s4.pdf)*
- The Survey of Interconnection Rules was prepared by the Regulatory Assistance Project, with funding provided by EPA, for the June 2006 Oregon Public Service Commission Workshop on Interconnection of Distributed Generation and was updated in 2007 to include information about Maryland and Oregon. This paper addresses the regulatory context for interconnection of smaller scale DG. The paper is intended to highlight critical issues in interconnection and to provide a condensed summary of the interconnection provisions contained in existing interconnection rules and in selected draft and model interconnection rules. *(www.epa.gov/chp/documents/survey_interconnection_rules.pdf)*
- The State Clean Energy-Environment Technical Forum provides a venue for exploring analytical questions and resolving key issues surrounding state clean energy efforts. On February 9, 2006,

EPA's Clean Energy-Environment State Partnership facilitated a discussion about DG and CHP interconnection standards. Presentations and supporting documents from the forum are available at: *www.keystone.org/html/documents.html#dg.*

Utility Rates

- The Utility Rates Fact Sheet outlines appropriate rate design to allow both utility cost recovery and the expansion of clean DG. *(www.epa.gov/chp/documents/utility_rates_fs.pdf)*
- Chapter 6.3 - Interconnection Standards, Clean Energy-Environment Guide to Action discusses approaches to remove unintended utility rate barriers to DG systems through innovative standby rates, exit fees, natural gas rates for CHP, and it offers resources for additional information. *(www.epa.gov/cleanenergy/documents/gta/guide_action_chap6_s3.pdf)*

EPA State Policy Resources

Renewable Portfolio Standards

- The Renewable Portfolio Standards (RPS) Fact Sheet describes the benefits of RPS for states, how RPS encourages CHP projects, and examples of state RPS requirements. *(www.epa.gov/chp/documents/rps_fs.pdf)*
- Chapter 5.1 - Renewable Portfolio Standards, Clean Energy-Environment Guide to Action discusses state approaches to designing and implementing a RPS, in addition to offering resources for additional information. *(www.epa.gov/cleanenergy/documents/gta/guide_action_chap5_s1.pdf)*
- Energy Portfolio Standards (EPS) and the Promotion of Combined Heat and Power outlines the elements of successful EPS and RPS policies and how these policies can promote distributed generation, energy efficiency, and CHP. The white paper provides examples of state EPS programs that include CHP and offers an overview of the benefits and characteristics of CHP. *(www.epa.gov/chp/documents/eps_and_promotion.pdf)*

State Clean Energy Funds

- The State Clean Energy Funds Fact Sheet describes why states would implement public benefit funds, different fund options that exist, and which states currently have clean energy funds. *(www.epa.gov/chp/documents/clean_energy_funds.pdf)*
- Chapter 5.2 - Public Benefit Funds for State Clean Energy Supply Programs, Clean Energy-Environment Guide to Action discusses state approaches to designing and implementing a state clean energy fund, and considerations and best practices for CHP, renewable energy and energy efficiency programs, in addition to offering resources for additional information. *(www.epa.gov/cleanenergy/documents/gta/guide_action_chap5_s2.pdf)*

Output-Based Environmental Regulations

- The Output-Based Environmental Regulations Fact Sheet describes how output-based regulations encourage CHP projects and which states have already implemented them. *(www.epa.gov/chp/documents/output_based_regs_fs.pdf)*
- Output-Based Regulations: A Handbook for Air Regulators was developed to document the benefits of output-based emission limits and the experience of several states in implementing them. This handbook is intended as a resource for air regulators in evaluating opportunities to adopt output-based regulations. *(www.epa.gov/chp/documents/obr_final_9105.pdf)*

- Chapter 5.3 - Output-Based Environmental Regulations to Support Clean Energy, Clean Energy-Environment Guide to Action discusses state approaches to designing and implementing output-based approaches, including in allocations in a cap and trade program, allocation set-asides for energy efficiency and renewable energy, and in multi-pollutant emission regulations using an output-based format, in addition to offering resources for additional information. *(www.epa.gov/cleanenergy/documents/gta/guide_action_chap5_s3.pdf)*
- EPA's CHP Partnership held a Web-based workshop for Midwestern state regulators on May 10, 2006 entitled *Opportunities to Encourage CHP through Output-Based Emission Limits & Allocations.* EPA presented a similar workshop in Boston, Massachusetts on June 22–23, 2006 through the Clean Air Association of the Northeast States (NESCAUM).

Electric Sector Policy Assistance

EPA's utility commission policy assistance focuses on state rules and policies that significantly affect the deployment of customer-sited clean distributed generation, in particular: interconnection standards, standby rates (also called partial load rates), and eligibility requirements for energy portfolio standards. EPA's goal is to assist states in identifying and evaluating policies and programs that promote/support the deployment of clean DG.

In addition to direct assistance, EPA submits formal written comments to state utility commissions regarding interconnection standards, standby rates, and other important policies and programs that impact DG. Examples of states that have received written comments include Ohio, Washington, Georgia, Pennsylvania, and New York.

EPA's policy assistance is provided primarily through workshop participation and preparation, conference calls, and email correspondence. EPA works directly with state regulators and policy-makers to help them consider and develop interconnection rules, standby rate design, and portfolio standard policies in support of CHP. EPA activities can include:

- Interconnection Rules. Reviewing existing and proposed public utility commission rules, including models, and providing recommendations on whether and how to modify them to promote clean DG.
- Standby Rates. Reviewing standby rates and evaluating their effects on clean DG. Describing the fundamental economic and regulatory principles and methods that underpin ratemaking and rate design, and discussing how these are, or could be, applied to the setting of rates for standby and other services (e.g., maintenance, supplemental) for clean DG. Providing examples of innovative rate designs.
- CHP as a Portfolio-Eligible Resource. Describing the policy and technical considerations related to CHP's eligibility to participate in a state's renewable portfolio standard program and/or energy efficiency portfolio standard program. Describing how states have addressed this question, how they have accounted for CHP and waste heat recovery, and offering lessons learned.

Case Studies

Oregon: EPA is assisting the Oregon Public Utility Commission (PUC) with the development of uniform interconnection technical standards, procedures, and agreements. On June 20, 2006, the Oregon PUC held their first workshop related to developing uniform interconnection technical standards for Oregon's investor-owned electric utilities to remove barriers to DG. This workshop was the first of four devoted to discussing and evaluating potential interconnection rule recommendations for the PUC Public Staff to propose to the Commission in 2007.

EPA provided in-depth assistance to the PUC during this process. Specifically, the consultant spoke at all four Oregon workshops on interconnection procedures and agreements, components of interconnection procedures and agreements, and a discussion and comparison of Mid-Atlantic Distributed Resources Initiative (MADRI) and Federal Energy Regulatory Commission (FERC) model procedures. EPA assisted participants' understanding of the MADRI model rule, evaluated stakeholder comments on the Oregon proposed rule, and provided assistance to the Public Staff in drafting the final proposed rule.

Oregon's municipal utilities, electric cooperatives, and public utility districts have participated in the workshops and have been involved in the development of the interconnection standards. They have also expressed interest in adopting the standard the PUC finalizes, pending their boards of directors' approval. The Oregon Standard Small Generator Interconnection Rule is available online at: *www.puc.state.or.us/PUC/admin_rules/workshops/interconnection/12_6_revdft.pdf.* Per the Energy Policy Act of 2005, the Commission must make a determination on whether to adopt these standards by August 2007.

Florida: In December 2006, the Florida Public Service Commission (PSC) endorsed the recommendations of the National Action Plan for Energy Efficiency, which presents policy recommendations for creating a sustainable, aggressive national commitment to energy efficiency through gas and electric utilities, utility regulators, and partner organizations.

The PSC staff invited EPA to participate in a renewable energy workshop in January 2007. EPA engaged the PSC in a larger discussion about how clean DG could be beneficial to Florida, several barriers that are preventing its further growth, and how utility policy barriers could be included in the January workshop. In December 2006, EPA provided PSC staff with a white paper on the barriers to increased clean DG deployment in Florida. EPA participated in the renewable energy workshop as a speaker on this topic, which occurred January 19, 2007, through EPA technical contractor Ted Bronson of Power Equipment Associates. A key workshop outcome was staff interest in addressing standby rates and interconnection standards. EPA has committed to assisting the PSC in exploring both topics.

Hawaii: In February 2005, EPA and the National Association of Regulatory Utility Commissioners (NARUC) announced the formation of EPA-State Energy Efficiency and Renewable Energy (EERE) Projects between EPA and utility regulators from six states. The six states involved in the initiative are Arkansas, Connecticut, the District of Columbia, Hawaii, Minnesota, and New Mexico. The projects involve state utility regulators working with EPA to explore approaches for reducing the cost of consumer electric and gas bills through cost-effective energy efficiency, renewable energy, and clean distributed generation. Through the EERE Projects, EPA is assisting the Hawaii Public Utilities Commission with the review of its electric utilities' proposed tariffs.

ENERGY STAR® CHP Awards

CHP systems can qualify for our award of merit, the ENERGY STAR CHP Award, if they demonstrate considerable fuel and emissions savings over comparable, state-of-the-art separate heat and power generation.

When a system qualifies for an award, EPA:

- Sends a letter to the recipients acknowledging their achievement.
- Develops an announcement describing the system and highlighting the system's energy and environmental excellence. The announcement is posted on the CHP Partnership website.
- Presents the framed award to the recipient at an event attended by their peers.

The ENERGY STAR CHP Award recognizes highly efficient CHP systems that reduce emissions and use at least 5 percent less fuel than comparable, state-of-the-art, separate heat and power generation.

EPA was pleased to present five ENERGY STAR CHP Awards in 2007. These systems range from a 5 MW system at an ethanol facility to a 15 MW facility that supports a large university. Learn more about the projects that have received awards by visiting: *www.epa.gov/chp/public-recognition/current_winners.html*.

How To Apply

To apply for an ENERGY STAR CHP Award, download the application spreadsheet from *www.epa.gov/chp/public-recognition/awards.html*. The information required by the application includes identifying system characteristics and operational information. The CHP Partnership will help facilitate the process as needed.

Contact CHP@epa.gov, or EPA contractor Bob Sidner, 703-633-1701, for assistance with your application.


ENERGY STAR

2007 ENERGY STAR® AWARD
COMBINED HEAT AND POWER

Presented to

Your Company Here

By the United States Environmental Protection Agency and the United States Department of Energy in recognition of the significant pollution reduction and energy efficiency qualities of Your Company Here.

Awarded on February 28, 2007

Kathleen Hogan
Director, Climate Protection Partnerships Division
U.S. Environmental Protection Agency

To apply for an ENERGY STAR CHP Award, a combined heat and power (CHP) system must:

- Be in commercial operation.
- Have a minimum of 12 months and 5,000 hours of measured operating data. Because awards recognize contemporary performance, the operating period covered by the submitted data must begin within 14 months prior to the date of application.
- Be operating within the emission limits stipulated in its permits.