CHP GUIDE #1:
Q & A ON COMBINED HEAT AND POWER FOR MULTIFAMILY HOUSING

Prepared for

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QUESTIONS TYPICALLY ASKED BY THOSE EXPOSED TO COMBINED HEAT AND POWER FOR THE FIRST TIME.

CONTENTS

NOTE:
These Questions and Answers on CHP for Apartment Buildings are adapted from the "Cogeneration Manual: *A practical guide for evaluating and selecting equipment to be used in multi-family housing*," issued by New York City in June 1989.[1] The manual was developed to assist managers, owners and boards of multi-family buildings in determining the merits of introducing CHP into their facilities. Presented here is a revised and updated version of "Questions and Answers," from "Cogeneration Manual" suitable for more general use around the U.S.

For a preliminary analysis of the potential for installing CHP in an apartment building based on the worksheets from the "Cogeneration Manual" see "CHP Guide #2 "Feasibility Screening for Combined Heat and Power in Multifamily Housing."
http://www.hud.gov/offices/cpd/energyenviron/energy/index.cfm

[1] "Cogeneration Manual" prepared for Energy Conservation Division of the New York City Office of Rent and Housing Maintenance under contract to The New York State Energy Research and Development Authority by Hirschfeld and Stone Consulting Engineers, Glen Cove, NY. The original manual had three purposes: It explained the concept of CHP in multi-family buildings. It presented guidelines to evaluate technical and economic considerations. It provided guidelines for equipment installation and operation.

Introduction

The U.S. Department of Housing and Urban Development's (HUD) *2002 Energy Action Plan*[2] includes initiative #20: to promote the use of combined heat and power (CHP) in housing. Combined Heat and Power (CHP)--also known as "cogeneration"—is the simultaneous production of two or more useful forms of energy from a single fuel consuming device. The average efficiency of the fossil-fueled power plants in the U.S. is 33% and has remained virtually unchanged for 40 years. This means that two-thirds of the energy in the fuel is lost as heat. CHP systems recycle waste heat and convert it to useful energy, and they can achieve overall efficiencies of close to 80%.

CHP can significantly reduce a multi-family building's annual energy costs. Instead of buying all the building's electricity from a utility and separately purchasing fuel for its heating (mechanical) equipment, most--or even all--of the electricity and heat can be produced for less money by a small on-site power plant operating at a higher combined efficiency. The type of CHP system commonly applied to multi-family housing uses a device that contains an engine, similar to that found in a car or truck, or a microturbine, that drives a generator to produce electricity. The heat (thermal energy) produced by this process is recovered and used to produce hot water or steam, operate a chiller or serve as a desiccant instead of being exhausted from the engine and transferred through the engine radiator (as in an automobile).

Department of Housing and Urban Development and the U.S. Department of Energy created an Interagency Agreement to help implement the HUD CHP initiative. The tasks identified in the IAA include providing CHP guides for apartment building owners, working with the eight DOE-funded Regional CHP Application Centers (RACs), preparing case studies, undertaking market analysis and promoting peer exchanges on CHP among the managers of housing developments.

For further information, see the following web sites:
DOE- http://www.eere.energy.gov/de
EPA- http://www.epa.gov/chp
USCHPA- http://uschpa.admgt.com/
HUD-- **http://www.hud.gov/offices/cpd/energyenviron/energy/index.cfm**
[The software and CHP Guides will be made available on HUD and ORNL web sites.]

The HUD contact for information on CHP—and editor of this Guide-- is Robert Groberg, Energy Management Officer, Office of Environment and Energy, US Department of Housing and Urban Development, Washington, DC 20410 robert_groberg@hud.gov
Telephone: 202 708 0614 ext 4642

For further information on the RAC program, please contact Merrill Smith, USDOE CHP Program Manager, or Patti Garland-ORNL (202-479-0292), Program Technical Assistance, or Ted Bronson-PEA (630-248-8778), Program Technical Assistance.

9-19-05

[2] See www.hud.gov/offices/cpd/energyenviron/energy for a copy of the HUD *Energy Action Plan.*

1. CHP BASICS WHAT, HOW, AND WHY

What is combined heat and power (CHP)?
CHP [also known as "cogeneration."] is the simultaneous production of two or more useful forms of energy from a single fuel consuming device.
The type of CHP system commonly applied to multi-family housing uses a device that contains an engine, similar to that found in a car or truck, or a microturbine, that drives a generator to produce electricity. The heat (thermal energy) produced by this process is recovered and used to produce hot water or steam, operate a chiller or desiccant engine instead of being exhausted from the engine and transferred through the engine radiator (as in an automobile). For more detailed explanations see web sites listed above.

How is CHP used for multi-family housing?
CHP is used to produce all or part of the electricity, heat and domestic hot water required by the building. Prior to installing a CHP system, all of a building's electricity is provided by an electric utility. All the heat and hot water is provided by the building's mechanical systems (typically boilers). After installation, the CHP system provides all or part of the electricity, heat and hot water.

What are the benefits of CHP?
CHP can significantly reduce a multi-family building's annual energy costs. Instead of buying all the building's electricity from a utility and separately purchasing fuel for its heating (mechanical) equipment, all or part of the electricity and heat are produced for less money by a small on-site power plant operating at a higher combined efficiency.

In a broader sense, CHP can provide the following benefits.

Benefits For Energy End-Users:

- *Energy Savings:* When electricity is generated in large central power plants located far from consumers, about two-thirds of the energy in the fuel is lost; by using smaller onsite CHP generators, waste heat can be used to cool or dehumidify building space and/or provide domestic hot water.
- *Power Reliability and Quality:* CHP can increase the reliability and quality of a company's computing, manufacturing, processing and research functions.
- *Fuel Choice:* CHP systems can combust propane, fuel oil, hydrogen, landfill or anaerobic digester gas--providing a hedge against rising natural gas costs.
- *Improved Indoor Air Quality (IAQ):* With a desiccant dehumidifier, CHP can reduce the potential for mold and bacteria growth by providing humidity control.

Benefits for Energy and Equipment Suppliers:

- *Profit Opportunties:* Thermal sales are not subject to tariffs and could represent profit opportunities for the utility. Electric utilities can team up with third-party CHP providers who can provide design, build, financing, operations, ownership and maintenance to mitigate risk.
- *Improved Power Grid:* Onsite CHP can improve the electric grid's power quality, efficiency, and reliability.
- *Customer Retention:* A utility-sponsored CHP project could not only secure the electric revenue over a long term but also could increase overall revenue by capturing the thermal sales.

- *Fast Response to Load Growth:* By using off-the-shelf technologies, implementation of CHP is often the quickest method to respond to needs for more capacity.

Society-At-Large Benefits:

- *Fewer Blackouts:* Onsite power/thermal systems provide backup in case of emergencies and blackouts.
- *Cleaner Air:* Emissions of carbon dioxide and air pollutants like, sulphur dioxide, and volatile organic particles can be substantially reduced with CHP.
- *Enhanced Energy Security:* Because CHP is dispersed across large areas, these onsite systems are far less vulnerable to intentional and accidental disruption than centralized power plants.

Is CHP something new.?

No. CHP has been around since the turn of the last century.

Then why is it suddenly available?

CHP has grown in popularity because of escalating energy costs and the 1978 Public Utilities Regulatory Policies Act (PURPA), instituted by the federal government to promote privately-financed power production. PURPA requires a building's electric utility to permit CHP; provide the building with backup (standby) service at a reasonable cost; and, when applicable, purchase unused (excess) electricity from the cogenerator.

The Energy Policy Act of 2005 contained no tax credit for CHP, but it does have provisions affecting the interconnection of CHP with utilities, PURPA's purchase and sell requirements,. FERC rules, and the repeal of 1935 PUCHA.[3]

Because of escalating energy costs and PURPA regulations, power generation equipment manufacturers have developed efficient, small-scale CHP equipment—called "packaged systems"—capable of serving individual multi-family housing facilities. The equipment, which took years to develop, is relatively small and has been designed for easy installation. [See p.6.]

[3] EPAct 2005

- requires states to consider upgrading their standards for interconnection of small generators;
- directs a government study to quantify the benefits of distributed generation;
- changes PURPA to eliminate the "must purchase" requirement for utilities offering "qualified facilities" (QFs) competitive wholesale markets and eliminate the "must sell" requirement where a QF has access to other sellers without the requirement to serve;
- requires the Federal Energy Regulatory Commission (FERC) to redo its rules for QFs under new standards aimed at preventing abusive practices.
- repeals the Public Utility Holding Company Act of 1935 (PUCHA), will allow CHP owners to own non-QF CHP facilities in multiple states without having to register with the SEC

What federal programs support the use of CHP?

The **"*National Energy Policy*"** Report of the National Energy Policy Development Group, May, 2001, emphasizes the importance of CHP and the roles of the U.S. Department of Energy, and the Environmental Protection Agency in promoting the use of CHP. The Department of Housing and Urban Development has identified opportunities to promote the use of CHP in multifamily housing as well as in community development. For further information, see these web sites:

DOE-CHP Initiative: http://www.eren.doe.gov/der/CHP
DOE-Regional Application Centers: http://www.bchp.org/rac.html
EPA-CHP Partnership: http://www.epa.gov/CHP
HUD-CHP Profile:
http://www.hud.gov/offices/cpd/energyenviron/energy/library/hudCHPDanburyCT.pdf
FEMP: http://www.eere.energy.gov/femp/technologies/derCHP.cfm

What state programs support the use of CHP?

There are state programs, e.g. CA, NY, NJ, TX. A useful state-by-state database is available for researching the status of many of the state activities. [4]

2. PACKAGED CHP SYSTEMS

One barrier to the widespread adoption of CHP has been the lack of pre-packaged, pre-engineered energy systems that can "plug and play" into a building's existing energy system as one unit. With skid-mounted, packaged systems, end-users can greatly reduce installation time and costs. Such systems have become available. They are also the subject of further development with assistance from the U.S. Department of Energy.

What are packaged CHP systems?

The primary components are pre-packaged in the factory. Typically the packages are complete with all the heat recovery equipment, generator controls and monitoring indicators. This makes them easier and less expensive to install since the labor can be performed by plumbing and electrical contractors and easier to maintain.

Combined heat and power (CHP) technologies typically consist of prime movers such as reciprocating engines, turbines and microturbines, a generator and thermally activated technologies such as absorption chillers for space cooling, or desiccant dehumidifiers for space dehuidification. Communication and controls are necessary for seamless integration into buildings systems and monitoring.

CHP systems recover heat that normally would be wasted in electricity generation, and utilize it to produce one or more of the following: steam, hot water, heating, desiccant dehumidification or cooling. Since CHP makes greater use of fuel inputs by utilizing discarded heat, they can achieve system efficiencies from 60 to 80 percent. Communications and controls allow building

[4] State Opportunities for Action: Review of Combined Heat and Power State Activities (by Elizabeth Brown, Kalon Scott, and R. Neal Elliott) is available for free at http://www.aceee.org/pubs/ie022.pdf.

or plant energy systems to interface with the CHP systems. The basic components of a pre-packaged CHP system are:

- Engine
- Generator
- Control System
- Heat Recovery Equipment

Some of the ancillary equipment that may be required includes the following:

- Pumps
- Additional Heat Exchangers
- Storage Tanks
- Piping

What is modular co generation?

This term is used interchangeably within the industry to describe the packaged systems. We prefer the use of the term modular when units are used in multiples to fulfill a building's load requirements instead of one larger unit. An installation using multiple modules provides greater assurance that a significant part of the cogenerating facility is always available as the need to service more than one unit at any one time is less likely. The ability to have equipment running, when needed, can greatly enhance the electric demand savings of the system, particularly where there are high demand charges due to the ratchet demand charges of various utilities.
[A more detailed explanation of utility rate schedules can be found in Section 11. Electric Rate Schedules.]

3. BUILDING CONSIDERATIONS

How are these systems used in apartment buildings?

It depends on the building. In general, they can supply electricity, space heating and/or hot water. If there is a swimming pool, they can heat the water. If the building's air conditioning uses a steam absorption system, the CHP system can provide the steam to run it. There is a variety of uses, including desiccants.

Are there any limitations regarding building size?

The economics for installing CHP currently favor buildings over 100 dwelling units, but there are examples of installations in smaller buildings. Some limitations are a product of utility requirements and charges for systems connected to the grid.

Are there any exceptions?

Yes. Buildings which share a common boiler room can each be smaller in size (less than 150 units) and still benefit from a CHP system.

Are there guidelines for estimating CHP equipment size ?

Yes, they vary among engineers, and a range seems useful. One view is that if the system is sized to supply the building's domestic hot water, figure about 2-1/2 to 4 apartments per KW. In other words, a 300 unit building will typically require a CHP system supplying domestic hot water as the thermal output of between 75 KW and 120 KW. Another view considers additional loads and uses 1 1/2-2 apartments per kW.

4. RESIDENT CONSIDERATIONS

Will the residents be inconvenienced during installation?
No. No apartment access is required. Most of the work is done in uninhabited building areas such as the boiler and electrical switchgear rooms.

After installation, do the residents receive less heat, Hot water or electricity?
No. Each apartment gets just as much heat, hot water and electricity as it did before. It just costs less.

Is the unit noisy?
Most small packaged units operate at a sound level equivalent to the sound of an automobile engine revving at 55 MPH. Installations provide sound proofing to lower the noise level. In general, this is considerably quieter than the sound level associated with boilers found in most multi-family buildings.

5. INSTALLATION CONSIDERATIONS

How much space is required for a typical packaged co- generation unit?
A packaged unit, which can provide most of the hot water and a significant percentage of the annual electricity used by a typical 200 unit building will occupy a space of approximately 10 feet wide, 12 feet long and 7 feet high (including access space required for repair and maintenance).

Where are the systems usually located?
For lowest installation costs, it's best to locate the system in close proximity to the building's mechanical and electrical equipment—typically a boiler room, or an unoccupied room or space nearby. In general, the unit should be close to the building's heating and hot water equipment, the building's utility electrical service, the utility gas or fuel supply, and an area offering an exhaust outlet. The system can also be placed outside the building.

Are CHP systems expensive to install?
It varies. Costs are specific to the facility. However, packaged systems can often reduce the installation cost by reducing on-site labor. The building configuration—the location of the electrical and mechanical systems—has a major impact on the installation cost. There are also utility interconnect cost requirements which will vary from utility to utility and with the type of system installation. Estimates of cost per KW are sometimes given, but vary widely depending on building configuration**.** One estimate of installed cost for reciprocating engines ranging from 30kW to 8 MW is $300-1500 per kW. Another estimate for buildings of 100-300 units is $1,500-$3,000 per kW.

Do these systems require many approvals?
Buildings Departments usually must approve the system plans as they would for another piece of building equipment, such as a boiler or chiller. The utilities interconnect requirements for electricity and supply gas must also be satisfied.

There are regulatory and policy barriers for installing and operating CHP such as:

- *Installation and Operation*- CHP systems usually have to meet interconnection standards, local utility terms and conditions, air quality standards, and siting and permitting regulations.
- *Interconnection:* If a system owner wants a CHP unit to be connected to the local electric grid, as most are, utility, and sometimes government, interconnection requirements must be met before the CHP system can be approved.
- *Utility Practices:* Utilities have policies and practices in place that affect CHP installations, including interconnection policies, tariff and rate standards, analysis requirements, and dispute resolution processes.
- *Air Quality:* CHP systems are required to meet environmental permitting requirements that regulate the emission of pollutants such as NOx into the air.
- *Financial:* Financing may come from the manufacturer, banks, energy service companies (ESCOs), end user funds, etc. CHP systems may qualify for one of several tax treatment categories depending on the configuration and ownership of the system.
- *Siting and Permitting:* All distributed generation/CHP systems must go through a local siting and permitting process with local zoning, building, fire, mechanical, electrical and safety code inspectors.
- *Electricity Restructuring:* While there are similarities in restructuring (or "deregulation") among some States, the differences in restructuring status and interconnect details are numerous and sometimes confusing.

6. UTILITY CONSIDERATIONS

Why is it important to have the utility provide backup (standby) service?
Most small CHP systems are designed as partial load (supplementary) systems that share the building's electric load with the utility. The utility and CHP system together provide all the building's electricity. When the CHP system is down for maintenance or repair, the utility's backup (standby) service then fulfills ALL the building's electricity needs, as is required by State and Federal Regulations.

Why can it be important for the utility to buy the excess electricity*?*
Although it is generally not a factor in the design of a CHP system for multi-family applications it can sometimes make the CHP system more cost effective by allowing the CHP system to generate income during times of low building electrical use. In some areas this option is not always available.
Utilities have two different rate structures for purchasing "excess" electricity produced on site. One is "net metering" where the electric meter essentially runs backwards, "paying" the equivalent of the retail rate. They can also have "buy-back" rates where the user is paid for the electricity by kWh and sometimes even receive payment for demand charge ($kW). Buy-back rates may be very low payments to the CHP generator, frequently on the order of 2.5 to 3.0 cents per kWh --much less than the cost of the fuel to run the generator

So, deciding to cogenerate doesn't affect the relationship with the utility?
Your decision has nothing to do with the utility. If the economics are right, it's your decision. Legally, the utility must cooperate; provided the CHP equipment properly interconnects with the utility's equipment.
A building that adds a CHP system may be required by the utility to change over to a new CHP electric rate. Depending upon the building's electric demand profile, this rate may be higher or

lower than the previous rate. If it's higher, the building owner can have the utility switch the building back to its old rate. The result is that the billing rate after CHP can be lower, but cannot be higher.

Are there utility considerations that affect the economics of CHP?
The interconnect varies with each utility. Where there is a multi-family housing electrical rate structure with a higher electricity rate, a CHP system can offer greater savings by displacing more expensive electricity with low cost power. Gas rates also vary among companies.

Does this mean CHP should not be considered if the building is serviced by a particular utility?
No. Each building should be evaluated based on ALL existing factors. The utility is just one of these factors. In addition, utility rates and policy are periodically reviewed and revised. So as circumstances change, the economics of CHP can also change.

CHP projects now allay concerns that had prevented utility involvement:

- *Safety:* All CHP systems include protective devices that eliminate threats to off-site equipment and linemen
- *Tariffs:* CHP users pay for the standby or backup services they use --but they do not pay rates designed to deter or punish them for seeking the efficiency and reliability of self-generation.
- *Mandatory power purchases:* Most CHP systems, designed to meet thermal energy needs, do not generate excess power to sell to the grid. However, the energy efficiency of CHP warrants sales when excess is available, with regulated avoided-cost rates to assure fairness to buyers and sellers.
- *Customer retention:* Rather than causing the loss of a customer, a utility-sponsored CHP project can reinforce a long-term relationship that combines sales of electricity and thermal energy (such as steam, hot water, chilled water, dehumidification, process heat, etc.)
- *Core business:* Electric utilities can help make customers comfortable with onsite generation--and can stretch their own offerings with thermal energy sales, feasibility studies, design, construction, finance, and system O&M.

Far from presenting problems, CHP can help utilities develop new markets and solve existing problems:

- *Rapid load growth response:* Because they use modular, off-the-shelf technologies, CHP systems are often the fastest--and most locally beneficial--way to respond to increased electricity demand.
- *Energy security:* Because CHP is dispersed and generally inside buildings, vulnerability is reduced.
- *Optimized gas use:* CHP systems can create power where natural gas is already used for thermal energy, in the process reducing the consumption of gas for central generation.
- *Emissions reductions:* doubling the useful energy output per unit of fuel, as CHP can readily do, cuts emissions in half.
- *Line losses:* An average of 10% (and perhaps 20% during peak periods) of conventional power is lost to transmission resistance. By comparison, none is lost by CHP systems.

7. SERVICE AND MAINTENANCE CONSIDERATIONS

WILL THE BUILDING STILL HAVE HEAT, HOT WATER AND ELECTRICITY IF THE ENTIRE CHP SYSTEM IS DOWN FOR REPAIR OR MAINTENANCE?

Yes. CHP systems are usually designed to supplement both the utility and the building's mechanical (heat, hot water) systems. If the CHP system stops working, -both the utility and the building's mechanical systems will automatically provide ALL the heat, hot water and electricity just as it did before the CHP equipment was installed, without any manual change-over required.

Who maintains the system?

Maintenance contracts are available from CHP equipment manufacturers and engine/generator service companies, and are highly recommended. It is important to make sure that the auxiliary equipment, which interconnects the building systems, is covered by the same contract. This includes pumps, heat exchangers, tanks, piping, valves, etc. This arrangement ensures that only one contractor must be notified, regardless of what equipment needs servicing. This places the responsibility for getting the system working properly with one contractor. As with many other building systems, a CHP system must be properly maintained to keep it running efficiently.

What about maintenance personnel? Will they need additional training?

For small scale CHP installations, e.g. 100-300 unit apartment complexes, no special on-site maintenance is necessary. Maintenance contracts provide for remote monitoring by computer, and service is provided to the site as needed. For larger systems, maintenance personnel will require some training to enable the building to get the most from the CHP system. The degree of difficulty for the training would be equivalent to that required by a new, sophisticated boiler control system. For the most part, it is important for the staff to learn, by inspection, when the system is running properly, and when to call for service. Like any other mechanical system, it does require daily supervision—a visual inspection of the unit's display indicator.

Is it necessary to have an operating engineer on site?

No. Not with the packaged CHP systems typically used in multifamily residential buildings.

How are the CHP systems monitored?

Remote monitoring systems, which pay for themselves in a very short time, should be included with the CHP system equipment. This equipment can provide automatic dialing to alert the service contractor and/or building manager of a possible problem and allow remote diagnoses. A negative operating trend can be noted and corrected well before a major problem develops. The equipment can also provide an accurate method of quantifying performance and savings. This equipment should be included in all design specifications. This option can also reduce the need for some of the additional training for maintenance personnel.

8. ELECTRIC METERING

Will the way the building is electrically metered affect the Co generation system?
The answer depends on the utility.

What are the different types of electric metering?
There are two types of electric metering - master and direct. A master meter measures the entire building's total electricity use, including common areas and the apartments. Direct metering measures each apartment's electricity use separately. With a master meter, the entire building purchases electricity from the utility at a bulk rate. Individual apartment units can be sub-metered with a master meter. In a directly metered building, the apartments are metered individually and pay a separate, higher, individual rate. If an apartment building is directly metered, the apartments must buy their electricity from the utility.

How about a building that's submetered?
If an apartment building is submetered, it is always master metered. As far as CHP is concerned, what applies to a master metered building applies to a submetered building. The individual apartment submeters have nothing to do with the utility. CHP does not detract from any of the benefits of submetering with regard to utility electric rates.

What does direct or master metering have to do with CHP?
In a master-metered building, the building's electricity often passes through one meter and the building's electrical load is measured as a whole. A CHP system can contribute to that single electric load.
In a directly-metered building, there are essentially two electric loads—the apartments and the rest of the building, which includes common areas (hallways, lobby, recreation areas, etc.) and commercial areas (stores, etc.). The apartments, because they are individually metered, can only be served by the utility. They cannot be considered part of the building's electrical load as far as CHP is concerned. The building's electric load, for CHP purposes now consists of only the common and commercial areas, which may not use enough electricity to support a CHP system.
Some master metered buildings may have more than one service entrance and more than one master meter. This can affect the CHP system interconnect requirements.

Why is electric metering important in some utility territory?
In order to use a CHP system effectively in some utility territory, the building generally should be master metered. That means all the electricity is bought in bulk and generally supplied to one meter. The CHP system can contribute to that one meter.
If the building is directly metered, the apartments must buy their electricity from the utility. And where the building can't sell its excess cogenerated electricity back to the utility, all the generated electricity must be used by the site.
In many cases, the building's electric load isn't large enough to support the CHP system, unless it has a substantial common and commercial load. With a substantial common/commercial load, CHP may, however, be viable in a directly metered building.
Where you can sell the excess electricity back to the utility the type of metering is not as important.

Is it possible to switch from direct to master metering?
[In New York State, the Public Service Commission (PSC) permits a building that is a cooperative or a condominium to convert from direct to master metering.]

How is this done?
[The NY PSC mandates that 70% of the apartment owners vote affirmatively.]

Is it worth it?
If a directly metered cooperative or condominium switches to master metering, the building billing rate is reduced. The entire building's electricity is now measured through a single meter and billed at the lower bulk rate. Based on prevailing energy costs, the entire building saves approximately 20-30% on its electricity. And this is done WITHOUT REDUCING the amount of electricity it uses.

Because of the switch to master metering, the entire building (including the apartments) is now considered to be part of one electric load. The building may now be able to utilize a CHP system that can supply a larger amount of electricity. The building will REDUCE its energy costs in two (2) ways. It is master metered, so it can now buy its electricity at a bulk rate. Then it installs a CHP system, which further reduced its electricity costs.

Say the apartment building is directly metered and not a cooperative or a condominium, does that automatically mean it can't use a cogeneration system?
No. CHP may still be viable. If the load includes large commercial (stores, etc.) and common areas (hallways, recreation rooms, laundry rooms, etc.) a CHP system may still be worth considering even if a smaller system may be indicated. The apartments continue to buy from the utility. The rest of the building is supported by the CHP system. It may take more than 300 units to provide enough common area to make CHP viable.

9. LOAD CONSIDERATIONS

What is peak load?
At certain times of the day, the building requires a maximum amount of energy to satisfy its residents—the maximum amount of electricity for its appliances—the maximum amount of hot water for washing, etc. These maximum amounts are the electric and thermal peak loads. The time interval during which a peak load condition exists is generally short. Electrical peak load may or may not coincide with thermal peak load on a day to day basis. Peak loads will not necessarily be consistent on a daily, weekly or monthly basis either.

What is base load?
A building always requires a minimum amount of energy to satisfy resident needs. There is always a minimum amount of electricity needed for appliances and a minimum amount of hot water for washing dishes, etc. These are the electrical and thermal base loads.

Can one large CHP system provide all the building's energy at peak loads?
Yes, but this is not usually done in multi-family building applications.

Why not?
Two reasons:
First, a larger CHP system sized to provide all the building's electricity at peak load will obviously be oversized during the non-peak load periods which occur most of the time. This system's initial cost is much higher than a smaller system designed to meet base load. The economics of a peak load system are generally not favorable for multi-family building application.

Second, if this system supplies all the building's electricity, it will require backup either by the utility charging backup rates (which are considerably higher) or by its own backup generators. This further detracts from the economics of such an installation.

How should a CHP system be sized?
There are various sizing options that are investigated when determining the optimum CHP system size for a particular building. There are no hard and fast rules. For example, a CHP system can be sized to supply any or all of the following:

a. Base, Average, or Peak **Electrical** load.
b. Base, Average, or Peak **Thermal** load.

Despite a wide range of options, it is usually most desirable to size the CHP system to maximize its operating hours. This often can be achieved by sizing to the annual base thermal load (typically domestic hot water--DHW).

10. FUEL CONSIDERATIONS

Do these systems need a special type of fuel?
Not really. Natural gas or diesel fuel are typically used to run the packaged systems. Diesel fuel usually requires a storage tank. Natural gas equipment is more common and offers a greater selection of CHP equipment. Propane is another useable fuel, but is generally impractical in some cities due to restrictive local ordinances.

What is interruptible gas?
A utility will supply natural gas at a preferred rate (lower cost) if the building has the capability to burn an alternate fuel, such as oil, below a certain outside temperature (commonly about 20º F). This will generally require that the building employ a dual fuel burner. The interruptible rate is designed to be an equal fuel cost option to oil.

What is firm gas?
A utility will supply natural gas at a higher rate (higher cost) if the building requires gas at all outside temperature conditions. This will preclude the need for a dual fuel burner by the building, but firm gas typically exceeds oil in fuel costs to the building.

What do gas rates have to do with CHP?
If you use natural gas to fuel the CHP equipment—the cheaper the gas is, the less it costs you to run the equipment and the more money you save by CHP.

11. ELECTRIC RATE SCHEDULES

How do different electric rate schedules affect CHP?
The electrical rate schedules in some areas are typically comprised of a **consumption (KWH) charge** and a **demand (KW) charge**. The consumption charge is for the actual amount of electricity used during the billing month, and the demand charge is for the hourly average of the rate of electrical consumption measured during the peak consecutive 15 minute periods of the billing month.

In some utility areas, the rate schedules typically utilize a relatively low consumption charge and a high demand charge, and each month is treated independently in determining each of these

charges. In others, there is a higher consumption charge and a lower demand charge. Each month, however, is treated separately for consumption only. Demand is charged at either 85% of the summer peak (June 1-Sept 30) or the actual monthly peak, whichever is higher (this is called a **demand ratchet**). With **time of day billing**, the peak demand is measured during different periods of the day in order to determine demand charges. No monthly demand ratchet is utilized.

The rate schedule, therefore, has a very significant impact on the amount of money that can be saved with a CHP system. If a CHP system can operate at the times of peak demand each month, the building can save on the demand charge in addition to the consumption charge, thereby increasing the money saved without increasing the operating time of the CHP system. [For utilities with heavy demand charge-biased rate schedules it is important to achieve this demand savings in their area approximately 50 percent of the time for the CHP system to be economical.]

For other utilities, if the demand savings are lost in any of the four summer months the demand savings for the rest of the year can be affected. In order to reduce the likelihood of this occurring there are a number of things that can be done. The system can be designed with multiple units so at least one of the units is likely to be operating at any given time. The system can be equipped with a remote monitoring device to notify the maintenance organization automatically that there is a problem and to allow some remote diagnosis and quick response. An equipment manufacturer can be chosen that has a large and developed maintenance organization.

12. ECONOMIC S FOR CHP

What makes a building a good candidate for CHP?

CHP potential is typically assessed in terms of technical and economic feasibility factors such as:

1. Technical feasibility, including these factors:
    - Location--e.g. cooling, heating, and dehumidification loads based on climate, state incentives, access to markets, etc.
    - Energy intensity
    - Electric demand size
    - Load profile--e.g. a flat power and thermal energy load profile is more suitable for CHP.
    - Thermal/electric ratios--e.g. high thermal load will make CHP "pencil out," i.e. produce a higher return.
2. Economic feasibility
    - See "CHP Guide #2, "Feasibility Screening for CHP..."

The economic viability of CHP is based on three factors: Equipment and installation costs, operating costs and the thermal and electric savings. The interaction of these three items is what determines if a CHP system will be cost effective. The lower the installation and operating costs and the higher the savings, the more profitable the system will be. There may be regional or state incentives to consider. [See footnote 4.]

The installation costs are a function of the difficulty of the installation. A building configuration with the electric service entrance, the gas service entrance and the boiler room in close proximity will entail a lower installation cost than a 20 story building with the boiler room on the roof and the electric service entrance in the basement.

The operating costs are a function of the type of fuel the building is currently using and the related available CHP fuel rates It is important to note that these relationships can change at any time as existing gas rate schedules change.

The amount of electric savings depends upon the applicable electric rate schedule, as previously discussed, as well as the reliability of the system. To improve reliability it is important to have a quality installation consisting of an intelligent design, reliable equipment and dependable service.

The thermal savings are a function of the utilization of the thermal heat produced by the CHP system (for domestic hot water and heating or cooling). In general, a very high percentage of the thermal energy produced by the CHP system must be used by the building for a system to be economically viable. This percentage changes depending on the existing boiler and CHP fuel costs.

13. GENERAL CONSIDERATIONS

Why is CHP an attractive energy conservation measure?
CHP makes use of heat normally wasted in generating electricity . It provides the same amount of energy and building services as before, only the total cost for this energy will now be less. Nothing is installed in the apartments, therefore, the residents are not inconvenienced. There is no equipment in the apartment that can be tampered with. [Approval from the State Public Service Commission is generally not required.]

Can CHP be combined with other building improvements?
Yes. CHP system(s) can readily be added or provisions for future installation of this equipment can be made as part of a building boiler retrofit program. When a boiler room becomes cluttered with obsolete, unused or inefficient equipment, it can be redesigned - to provide updated, more efficient boiler(s) and auxiliary equipment. Adding CHP at this time can reduce both engineering fees and equipment installation costs.

How does CHP affect the state or the country?
By generating both electricity and thermal energy at a higher overall efficiency than the combination of the utlility's power plant and building's boiler, the CHP system can produce the same energy output with 40 percent less energy input. This has the dual effect of reducing the operating costs of the building and reducing the overall energy consumption, with its associated negative environmental impact (acid rain, smog, poor air quality) and political consequences (reliance on foreign oil) of both the state and country.

14. NEXT STEPS

Where can I get advice on CHP?
The U.S. Department of Energy supports eight Regional Application Centers that provide information, advice and technical assistance for combined heat and power systems. See: www.bchp.org/rac.html or contact the staff and consultant identified on page 3.
The Environmental Protection Agency provides similar services. See:
EPA CHP Partnership: www.epa.gov/chp

Will a building require a consulting engineer?
Yes. Unless the building is working with a performance contractor capable of providing all required engineering services, it is a good idea to hire an expert. A Consulting Engineer is needed to perform a detailed on-site inspection/fuel use evaluation. A Consulting Engineer will determine the feasibility for cogeneration, help select the right system for your building, prepare the necessary plans and specifications, and expedite the utility and building department approval process
A consulting engineer experienced in the CHP field, can also assist the building obtain the best system for the least cost by participating in negotiations with equipment suppliers and contractors.

How can a CHP system be financed?
These systems can be financed similarly to any other building improvement. In addition, there are occasional state sponsored programs which may provide partial funding or partially subsidized loan programs. .

There is a variety of performance contracts offered by manufacturers and other third party investors. Gas utilities may provide a loan. Some states provide tax incentives. Others may subsidize the installation.

Leasing is also an option. A common approach involves a third party who installs the CHP system, maintains it and provides the building with energy at a reduced rate. However, since the third party assumes all the financial risks, it usually derives the lion's share of the profit. The building, however, assumes none of the financial risk and still reduces its energy costs.

What is necessary to achieve a successful CHP project?
In addition to the points previously discussed there are some important ingredients that are necessary for a successful CHP project. These are:

a. Commitment of management to support the project during project planning, installation and operation.

b. The implementation of a comprehensive (total) maintenance program for both the CHP unit and all ancillary CHP equipment.

c. The utilization of a responsive and reliable maintenance organization.

d. The incorporation of a monitoring system into the CHP control system to provide remote diagnosis and allow for predictive maintenance.

If I am interested in CHP, what should I do now?
a. Review this Guide to obtain a better understanding of what CHP is and what it can do for you.

b. See Guide #2, Feasibility Screening for Combined Heat and Power in Multifamily Housing." Using the software provided, complete the economic evaluation worksheet to help determine if CHP can be an economically viable project for your building. **[Where to get it? It will be on the HUD and ORNL web sites.]**

c. Hire an engineer to conduct a preliminary feasibility study, including approximate equipment sizing, costs (equipment, operating and maintenance), savings and paybacks and system configuration.

d. Based on the preliminary feasibility study, decide on whether or not it is feasible to continue with this project and with what type of equipment. If you are still interested in CHP but do not wish to fund the project yourself, the Engineer can suggest other financing possibilities (e.g. Performance Contracting.).

e. The engineer will then finalize the design and prepare bid specifications.

f. The building owner and/or the managing agent should consult with their financial advisor to determine what finance options are best for the building.

g. The engineer will assist your bulding to obtain bids for the CHP installation, evaluate the bids, negotiate with the contractors and provide recommendations to the owners. The owner will then select the contractor and award the contract

h. The engineer will then coordinate with the local electrical utility to obtain the required interconnection approval, and submit plans to the building department to obtain the required approval.

i. Installation will then commence with the engineer providing supervision and final equipment and system check-out.

j. Secure a maintenance contract.

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