Has costs

Cogeneration for Confectioners

William Ryan, PhD
University of Illinois

With today's rising energy prices and electric supply failures, industry is looking for ways to improve energy efficiency, decrease costs and maintain or improve operating reliability. Cogeneration can deliver these benefits. In this article, cogeneration technology and benefits are explained, and what cogeneration can bring to the candy industry specifically is explored.

WHAT IS COGENERATION (OR CHP)?

Energy is a major driving force in our economy. All buildings need electric power for lighting and operating equipment and appliances. Major consumers of energy in buildings are cooling, heating and humidity control.

Two-thirds of all the fuel used to make electricity in the United States is generally wasted from power generation equipment into the air or into water streams. While there have been impressive energy efficiency gains in other sectors of the economy since the oil price shocks of the 1970s, the average efficiency of power generation within the United States has remained around 33 percent since 1960.

Integrated systems for cooling, heating and power systems significantly increase the efficiency of energy utilization by using thermal energy from power generation equipment for cooling, heating and humidity control systems. These systems are located at or near the building using power and space conditioning (Figures 1 and 2).

BCHP SYSTEM BENEFITS

Reduced Energy Costs

Building owners can reduce their energy costs by deploying cogeneration building cooling, heating and power (BCHP) systems because compared to conventional systems these systems provide the following advantages:

- Increased energy efficiency
- Reduced demand charges
- Reduced peak electric energy costs

BCHP systems offer much higher energy efficiency than conventional stand-alone equipment for a similar degree of power reliability, comfort cooling, heating and indoor air quality. Because of the higher energy efficiency of the BCHP system, it can consume up to 47 percent less fuel than conventional systems. The reduced fuel consumption significantly reduces energy cost.

The cost of electricity to buildings is generally based on power demand (measured in kW) and electric energy usage (measured in kWh). Power demand charge is generally a monthly charge ($/kW) based on the peak/maximum power used during a month. Power demand charge rates can vary with time of year.

BCHP systems reduce power demand in

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two ways: one, by generating some of the power at site, and, two, by using thermal energy from power generation equipment, instead of electricity, for operating cooling, heating and/or humidity control equipment.

The charge for electric energy usage generally varies with the time of year and the time of day. This charge is the highest during peak periods, generally from 9AM until 3PM, and the least during off-peak periods, generally from midnight till 7AM. A major portion of the cost savings for using BCHP systems may come from avoiding purchase of electric energy during peak periods.

Improved Power Reliability

Economic losses due to power outages in the United States have cost American businesses billions of dollars. Since BCHP systems generate power on-site or near-site, these systems improve power reliability by reducing the building's dependency on the electric power grid, and may provide back-up power to the building. The greater the number of buildings that use cogeneration, the lower the demand on the electric grid. In areas where the grid is at or near capacity, the reduced demand provided by BCHP will result in increased grid reliability.

Improved Economics for Enhancing Indoor Air Quality

Controlling indoor humidity improves indoor air quality in buildings. It is important to keep indoor humidity to below 60 percent to prevent growth of mold, mildew and bacteria. Desiccant systems can control indoor humidity more effectively than conventional systems. In addition, desiccant systems can be driven by low-temperature heat, such as the heat rejected by power generation equipment. This can enhance indoor air quality at very low operating costs.

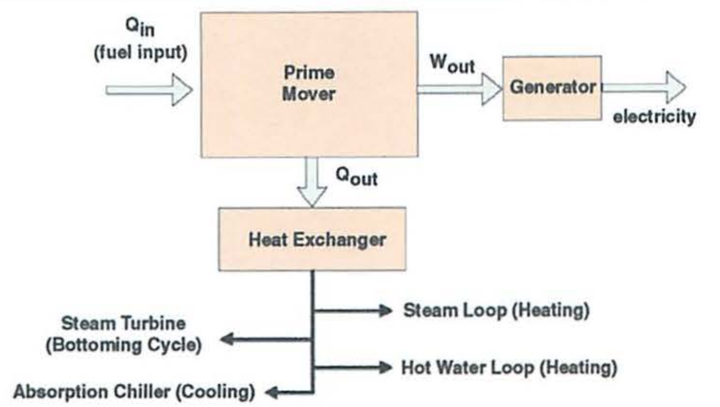
Reduced Life-Cycle Costs

The initial cost of BCHP systems is higher than purchasing electric power and using conventional chillers and boilers. However, the life-cycle cost of the BCHP system is often lower because of the energy cost savings over its useful life of more than 20 years.

Attractive Return on Investment

BCHP systems reduce energy costs for

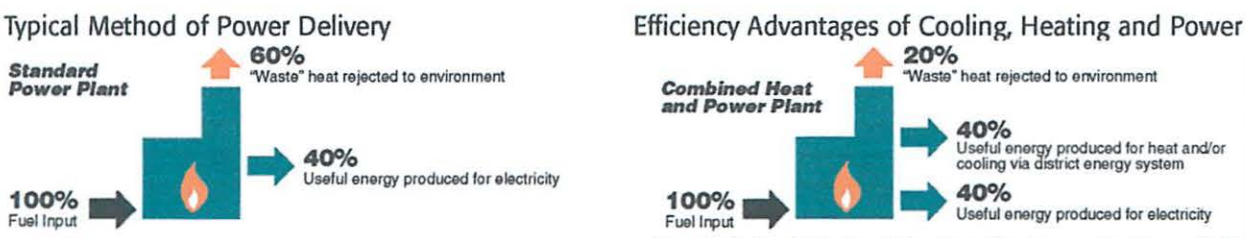
What is Cogeneration?



Cogeneration is the process of generating power at your site and using the waste heat for heating and cooling. A cogeneration system generally involves generating power or work (shaft output) from a prime mover (engine, turbine or fuel cell) and recovering the waste heat from the prime mover to deliver space heating, hot water and/or space cooling.

Figure 1 *(U.S. Department of Energy)*

Power Sources Compared



By productively using the "waste" heat from electric generation, the overall efficiency of energy delivery to the customer can significantly improve. However, transporting this heat for long distances is expensive. One solution is to move the generator nearer to the customer.

Figure 2 *(U.S. Department of Energy)*

buildings. If the incremental installed cost of BCHP systems over conventional systems is viewed as an investment, the return annual cost savings is often very attractive.

DOES COGENERATION MAKE ECONOMIC SENSE FOR YOU?

Cogeneration can be a great investment for some energy users and not for others, even in the same locations. To find out if it may make sense for you, try the following test.

Step 1 Determine your current gas price or estimate a future gas price.

Step 2 Determine your current electric price per kWh, including demand charges and taxes. The easiest way to do this is to take your current electric bill total and subtract any fixed fees like a flat monthly meter and billing charge. Do not subtract out any demand charges. Divide the remainder by the kWhs purchased to get an overall cost of electricity per kWh.

Step 3 Look at your operation. Are there heat loads, currently served by a boiler, which can productively consume the heat a cogeneration system can provide? If so, for how many hours of the year? To determine what type of loads can be served, see Figure 3.

Step 4 Perform the calculation shown in Figure 4.

COGENERATION TECHNOLOGY

Power Generation Equipment

Technologies commercially available for generating electric power or mechanical shaft power include combustion turbines, microturbines and engines.

Combustion Turbines

Combustion turbines burn natural gas or fuel oil to produce high-temperature, high-pressure gas and to expand this gas through a series of specially designed blades to provide power. Many turbines also use a heat exchanger called a recuperator, which utilizes some of the thermal energy in the turbine exhaust heat to preheat the air/fuel mixture for the combustor section of the combustion turbine system.

The efficiency of combustion turbines, operating alone, ranges from 21 to 40 percent. Combustion turbines also produce high-quality heat that can be used to generate steam and hot water for other applications, including heating and cooling (using absorption chillers).

Utilization of thermal energy in the combustion turbine exhaust significantly enhances the efficiency of energy utilization. Maintenance costs per unit of

If the incremental installed cost of BCHP systems over conventional systems is viewed as an investment, the return annual cost savings is often very attractive.

Estimate of Possible Heat Recovery Factors (Btu/kWh)

		200 kW-4 MW Engine Generator	>4 MW Gas Turbine Generator
Hot Water to 140°F	Service Water Heating	6,000	6,000
Hot Water to 180°F	Space Heating	4,500	4,500
Steam to 15 PSIG	Process & Space Heating Loads	1,500	4,500
Steam 15–125 PSIG	Hospitals and Industrial Loads	Not Recomm.	4,500

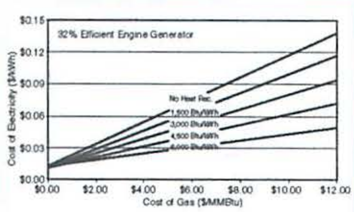
Figure 3

Calculations to Perform

1	Purchased cost of electricity	From utility bills in step 2	$0.__ /kwh
2	Cost of generated electricity	Use Fig. 4b with your gas rate	$0.__ /kwh
3	Cost savings	Subtract line 2 from line 1	$0.__ /kwh
		If line 3 is not greater than zero—stop, cogeneration will not pay in your application	
4	Peak facility electric load	From utility bills	____ kW
5	Size of generator desired	Roughly 40–60% of Line 4	____ kW
6	Hours of operation	Your estimate of hours with electric and thermal loads	____ Hrs/Yr.
7	Annual savings	(Line 7) x (Line 5) x (Line 3)	$__ /Yr.
8	Installed cost/kW	Use Fig. 4c for size on Line 5	$__ /kW.
9	Installed cost	(Line 8) x (Line 5)	$__
	Return on investment	(Line 7)/(Line 9)	__%

Figure 4a

Cost of Electricity from On-site Generation



Use the heat recovery rate found in Step 3

Figure 4b

Installed Cost of Cogeneration

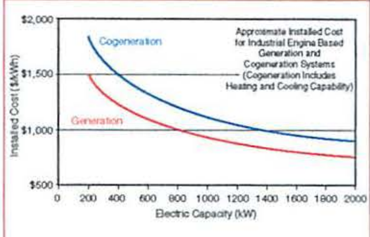


Figure 4c

Reciprocating engines are the fastest selling distributed generation technology in the world today.

power output for combustion turbines are among the lowest of all power-generating technologies.

Power output rating of all combustion turbines is based on an inlet temperature of 59°F. Output capacity of these turbines decreases with an increase in ambient air temperature. Therefore, in hot weather climates or on hot days, cooling of turbine inlet air has been found to be cost effective for many power plants for boosting power output. Three types of combustion turbines are commercially available: industrial turbines, mini-turbines and microturbines.

Industrial turbines represent one of the well-established technologies for power generation. These turbines also represent the high end of power generating capacity equipment. These can provide 1 MW to more than 100 MW of electric power. Most cooling, heating and power (CHP) systems need capacities below 20 MW, enough for large office buildings, hospitals or small campuses of offices and commercial buildings.

Mini- and microturbines are the newer generation of smaller turbines. The capacities of mini-turbines range from 100 kW to 1,000 kW and microturbines (Figure 5) range in capacities from 25 kW to 100 kW.

These turbines can use natural gas, propane and gases produced from landfills, sewage treatment facilities and animal waste processing plants as a primary fuel. The fuel source versatility of microturbines allows their application in remote areas.

Microturbines evolved from automotive and truck turbochargers, and auxiliary power units for airplanes and small jet engines used on pilotless military aircraft. Microturbines have far fewer moving parts than piston engines. Therefore, these machines have the potential to significantly reduce maintenance and operating costs.

By using recuperators, existing microturbine systems are capable of energy efficiencies in the 25 to 30 percent range. These turbines have a tremendous potential for on-site power generation for CHP systems.

Engines

Spark ignition or diesel engines produce mechanical shaft power. The shaft power can be used to operate a generator to produce electric power. It can also be used to operate other equipment, including refrigerant compressors for process or space cooling. Both of these applications of engines are very well known and widespread. Engines can use natural gas, propane or diesel fuel and are available in capacities ranging from 5 kW to 10 MW.

Reciprocating engines for power generation are low in capital cost, easy to start up, have proven reliability, good load-following characteristics and good heat recovery potential. Reciprocating engines are the fastest selling distributed generation technology in the world today. Existing engines achieve efficiencies in the range of 30 percent to over 40 percent. The incorporation of exhaust catalysts and better combustion design and control have significantly reduced pollutant emissions over the past several years.

Thermal energy in the engine exhaust gases and from the engine cooling system can be employed to provide space heating, hot water or power for absorption and desiccant equipment (Figure 6).

Engine emissions tend to be higher than for turbines or fuel cells. Depending on local air quality standards, engine emissions may limit applications for BCHP systems.

Microturbine Installation

Figure 5

Microturbine manufacturers confirm that the downward trend in installed-capacity cost continues. The current installed capacity cost for microturbines is between $1,500/kW to $2,000/kW. Manufacturers expect this number to drop to $1,000/kW over the next three years. This is in the competitive range of larger combustion turbine facilities or reciprocating engine plants.

PRODUCTIVELY USING WASTE HEAT—THERMALLY ACTIVATED EQUIPMENT

Absorption Chillers

Absorption chillers are cooling machines that use heat energy for driving an absorption refrigeration cycle. These chillers require very little electric power (0.02 kW/ton) compared to electric chillers that need 0.5 to 0.88 kW/ton. Absorption chillers have fewer and smaller moving parts and are quieter than electric chillers. These chillers are also environmentally friendly by using water as a natural refrigerant (Figure 7).

Commercially available absorption chillers can utilize one of the four sources of heat: steam, hot water, exhaust gases or direct combustion.

Absorption chillers are excellent candidates for providing some, or all, of the cooling in a BCHP system building. Modern absorption chillers feature new electronic controls that eliminate crystallization, and provide quick start-up, automatic purge and greater turndown capability than many electric chillers. Maintenance contracts and extended warranties are also available on absorption chillers at costs similar to those for electric chillers.

Most importantly, absorption chillers can be driven by low-temperature heat, such as the heat available from power generation equipment. This both provides cooling driven by generator waste heat for high overall system efficiency and reduces the maximum power requirements of most buildings, reducing the size and cost of the on-site generator.

Desiccant Dehumidifiers

There are two separate aspects of space conditioning for comfort cooling;

- Lowering the temperature of the air (sensible cooling).
- Reducing humidity in the air (latent cooling).

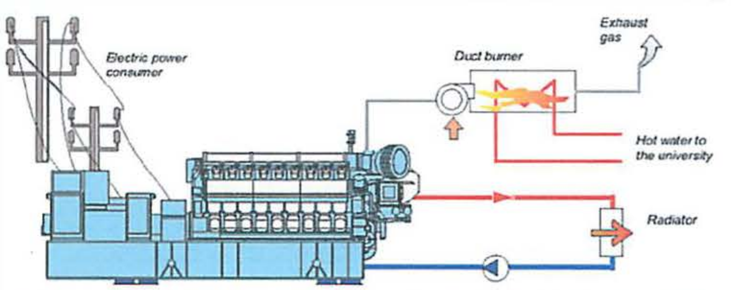
It is important to control humidity to below 60 percent to prevent growth of mold, bacteria and other harmful microorganisms in buildings and to prevent adverse health effects.

Traditionally, cooling and dehumidification have been accomplished using a single cooling coil that lowers the air temperature below the dew point temperature. Moisture in the incoming air condenses on the cooling coil. To remove enough moisture often requires cooling air below the comfortable level and reheating.

Desiccant dehumidifiers reduce humidity in the air by using a desiccant material

Absorption chillers are excellent candidates for providing some, or all, of the cooling in a BCHP system building.

Engine System with Heat Recovery



Duct burner is used for exhaust NOx_x cleanup. A heat recovery muffler is used when emissions reduction is not required.

Figure 6

Large Absorption Chiller Operating on Waste Heat

Figure 7

Cogeneration facilities in American industrial plants can produce as much power as 80 nuclear plants. A sizeable portion of the cogeneration plants are in food processing operations.

to attract and hold moisture. Desiccants can dehumidify independently of sensible cooling. Recoverable heat from the exhaust gases of turbines and engines for power generation can be used for regenerating desiccant material in these dehumidifiers.

APPLYING COGENERATION TO THE CONFECTIONERY INDUSTRY

All together, cogeneration facilities in American industrial plants can produce as much power as 80 nuclear plants. If they were all run at the same time, they would be able to handle 10 percent of the North American power load. Although not the largest users, a sizable portion of the cogeneration plants are in food processing operations (Figure 8).

To take a closer look at food processing, Figure 9 shows some of the major types of operations with cogeneration systems. The confectionery industry is well represented.

What types of cogeneration systems lend themselves specifically to the candy and confectionery industry? This depends on the individual plant's need for process heat. In smaller plants, generally those with a maximum power demand less than 4 MW, the most applicable cogeneration prime mover is an industrial gas engine. Engines are affordable at these smaller power output sizes and can produce large quantities of hot water at temperatures as high as 250°F. However, if steam is needed, engine systems can only produce a limited quantity of steam at the pressure ranges (above 15 psig) normally used for process loads. Therefore, having a sizable load for hot water below the 250°F level is important.

Applications in the candy industry include the following:

- Hot water for process equipment washing.
- Lower-temperature melting operations (chocolate).
- Generating hot air for product drying processes (hard candies).
- Building space heating.
- Driving absorption chillers for space cooling and process water cooling.
- Operating desiccant dehumidifiers to provide the deeply dehumidified air needed in some candymaking and packaging processes.

In a hot-water-producing cogeneration system (Figure 10), the engine generator is available to make electricity throughout the day and hot water is generated and stored for intermittent uses, such as machine washing or the operation of certain machines. By running the hot water systems under pressures of 15 psig or greater, which is usually lower than the pressure in the water supply system, storage temperatures to 250°F are practical, which minimizes the size of the storage tank needed. In general, each megawatt (MW) of generating capacity can produce

Cogeneration Currently Installed Nationwide

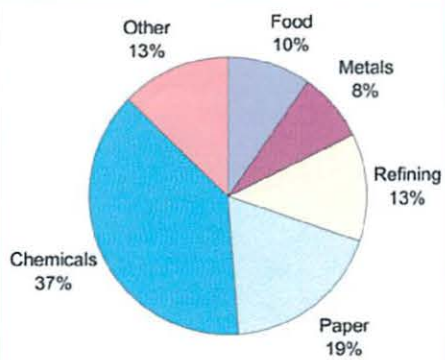


Figure 8

Cogeneration Base in Certain Sections of the Food Industry

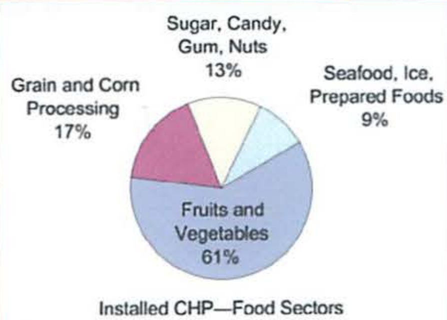


Figure 9

as much as 3,000 gallons per hour of hot water at 250°F.

For plants with electric demand exceeding 4 MW, the gas turbine option is available (Figure 11). Gas turbine generators are much more compact than engines, produce good generating efficiency and, most importantly, produce large quantities of very high-temperature exhaust. This means that an exhaust gas boiler or a heat recovery steam generator (HRSG) on a gas turbine can be used to produce steam to 250 psig or higher. This higher-pressure process steam can be used for any of the lower-temperature loads previously mentioned plus high-temperature cooking processes like sugar melting, even to hard-crack candy temperatures, and sterilization processes. In general, as much as 4,000 to 5,000 pounds of steam per hour can be made for each megawatt of installed generator.

In addition to generating affordable electricity, using the cogeneration system to provide power backup in the event of a grid failure can also be very important in candymaking. Any power failure leads to lost production time, but, in addition, some processes can be heavily damaged by an unexpected shut down due to a power failure. For example, chocolate enrobing or conch processes shut down by a lack of power will have chocolate congealing within 3 to 5 minutes, requiring the entire batch to be cleared and discarded when power returns. Loss of dehumidification equipment can cause unwrapped hard candy and chocolate to be ruined.

Manufacturers will often buy back-up engine generators to safeguard such processes. However, back-up engines are an expense. Using a cogeneration system to produce low-cost power and then to double as a back-up system during a power failure allows the owner to avoid having to purchase back-up generators, which spend most of their lives sitting and producing no income. In addition, the steam or hot water output will remain available during a power outage.

Finally, having a cogeneration system generator on your power system can repress or eliminate voltage fluctuations from utility grid switchgear, which can cause computer equipment to shut down or spend time rebooting. As production equipment becomes more computerized, this can become an attractive feature.

CONCLUSION

Although not right for all applications, cogeneration can provide significant benefits to candy and confectionery manufacturers and should be included for consideration in any energy management program. □

Presented at the AACT Annual Technical Seminar

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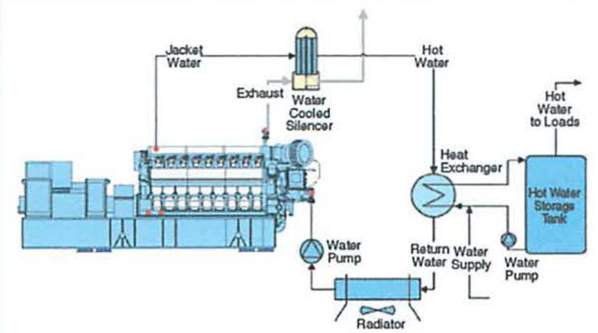
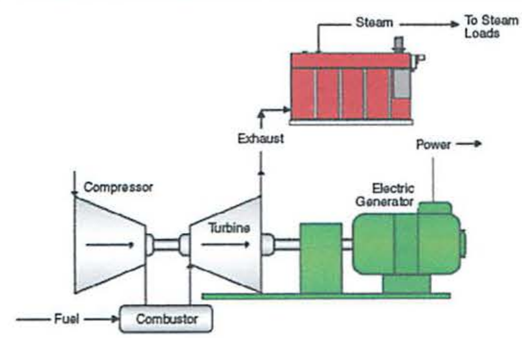
Hot-water-producing Cogeneration



For smaller plants, making electricity and hot water.

Figure 10

Industrial Gas Turbine Cogeneration



For large facilities making electricity and steam.

Figure 11

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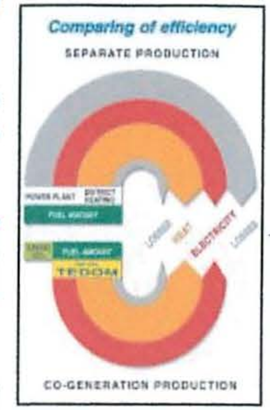
The advantages of cogeneration

Using the **cogeneration method** to produce heat and electricity involves a roughly **40% saving on fuel**. In money terms this means that the same amount of energy costs the user only 60% of the price, or *for the same amount of fuel the user gains nearly twice as much energy*, of which part can be sold, thus further reducing his own costs.



A range of gas companies also provide various forms of *discount on the consumption of gas for cogeneration*. **Heat and electricity** are also generated at the point of consumption, by which costs for the distribution of energy and loss from distant distribution are cut. Heat originating in cogeneration units is used to heat buildings, to prepare hot water or to prepare technological heat.

Cogeneration units therefore can be **part of emergency sources of electrical energy** at the point of its continuous consumption. With the help of absorption exchangers it is possible to use the generated heat to **produce coolants** for technological purposes or **air-conditioning**. In such cases we speak of so-called tri-generation - the combined production of electricity, heat and cold. Therefore the **economic return of TEDOM cogeneration units** usually runs at around **3 - 5 years** depending on output and method of use.

Because using the cogeneration method of production for heat and electricity saves about 40% of fuel costs, from the **ecological point of view** cogeneration units r**educe the damage to the environment** by a similar level. Therefore cogeneration units are currently among the most acceptable ways of producing *heat and electricity* in both the ecological and economic senses.

Micro-cogeneration unit at the "Schiestlhaus"

The "Schiestlhaus" is the first alpine refugee hut of the Austrian tourist club with 100% regenerative energy supply and passive house quality above 2000m altitude

Description of the application

The "Schiestlhaus", which opened in 2005, is located on the "Hochschwab" mountain in the Austrian alps at 2154m altitude. This mountain area is one of the main water sources for the supply of the 2 cities of Vienna and Graz. Therefore it must be well protected against all kinds of pollution. The total electrical energy demand of the building (6570 kWh_{el}/a) is covered by 60% through a photovoltaic system and by 40% through the cogeneration plant. The arising heat during electricity production can be stored in 3 storage tanks with a total volume of 2400 litre and can be used at a later time for heating or hot water production. Both the calculated electrical and thermal peak load of the "Schiestlhaus" is covered with the micro-cogeneration plant.

Technical specification

Plant	Diesel
Type	Micro CHP plant
Fuel	Rapeseed oil
Output heat	27 kW
Power	14 kW
Investment costs	Not specified
Share of subsidies	Not specified
Annual operating hours	Not specified

Contact information

- Location: mountain area
- Address: Hochschwab, 8636 Seewiesen
- Visit opportunity:end of May – end of October
- Contact: Austrian tourist club, tel: +43 1/5123844, email: zentrale@touristenklub.at

Picture

"Schiestlhaus" at 2154m on the "Hochschwab" - mountain

The COGEN Challenge project

The COGEN Challenge project aims at developing a broad range of support tools and structures to facilitate small-scale cogeneration projects. These small-scale units rated below 1 MWe generate electricity together with heat at very high efficiencies.

COGEN Challenge contacts

- Graz Energy Agency Ltd. – Austrian CHP-Info-Point, www.grazer-ea.at
- COGEN Europe - The European Association for the Promotion of Cogeneration, www.cogeneurope.eu
- COGEN Challenge Project, www.cogen-challenge.org

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PATH Attributes:

Ease of Implementation: EASY DIFFICULT

Initial Cost:
Operational Cost:
Field Evaluations: N/A
Code Acceptance

Summary

Once available only to large commercial buildings, Combined Heat and Power generation (CHP) systems are now being produced on a scale that is safe, practical, and affordable to homeowners. CHP technologies, sometimes referred to as cogeneration, have provided heat and electrical energy efficiently at commercial and industrial sites for many years. However, after hundreds of successful residential installations in Japan and Europe, several manufacturers are now offering models in the U.S.

A CHP system uses fuel such as natural gas to produce heat and electricity simultaneously. The electricity can be used for any household device such as lights and appliances. Simultaneously, the heat produced can be used for water heating and/or space heating. About 10% of the fuel used is lost as exhaust, much like a high efficiency furnace.

The engines used in the CHP units for producing electricity can be internal combustion or Stirling (also called external combustion) engines. Other types of generation technologies, such as fuel cells, have not reached the commercialization stage. Micro-CHP, as residential-sized CHP systems are usually called, run on propane, natural gas, or even (in the case of Stirling engines) concentrated solar energy or biomass. The byproduct of electricity generation is waste heat—and plenty of it. One 6-kW unit provides 10 gpm of hot water at 140 to 150°F. This waste heat can be used to heat an entire home, water for domestic use, for swimming pools and spas, or even as an energy source for heat-driven (absorption) cooling systems.

CHP systems are extremely efficient, offering combined heat and power generating efficiency of about 90%, compared to about 30 to 40% for electricity from a central power station.

Micro-CHP units range in capacity from about 1 kW to 6 kW and are about the size of a major appliance. Installation may be performed initially by specialists and, after the technology matures, by an experienced plumber, electrician, or HVAC technician. Units come as grid-tied systems which connect to utility power as backup or as stand-alone systems for remote residences.

One unit with a new, small capacity engine simultaneously produces 1.2 kilowatts of electric power and 11,000 Btus of heat in the form of hot water. The system is combined with a high efficiency natural gas-fueled warm air furnace or boiler for supplemental space heating

The small engines tend to burn very cleanly - exceeding all emissions requirements for CO_2 and NO_x. One unit claims to produce less CO and nitrous oxides than a single burner on a kitchen gas range.

The primary challenge for getting the highest efficiency and best economic return on CHP is to fully utilize all of the thermal energy produced when generating electricity. As the technology develops, various operating regimes will be tested to optimize the energy available based on variables such as the loads in the home, the climate and the season.

BACK TO TOP ^

PATH Attributes

- Combined heat power systems are offer generating efficiency of about 90%, compared to about 30 to 40% for electricity from a central power station.
- Systems are expected to reduce CO_2 emissions, when compared to conventional heating and electrical generation, by 30%.
- CHP units could provide electric energy in a wide-spread power outage.

BACK TO TOP ^

Ease of Implementation

The type of CHP system, and its level of interactivity with the electric utility grid will dictate the complexity of the installation. For CHP systems that are designed to feedback electricity to the utility and obtain credit at the same rate for which the electricity is purchased (a net-metering arrangement), the installation will be the most straightforward. If the utility does not accept power fed back to their grid or if it is not credited at the retail rate, the sizing and application of the system will be extremely important. Interconnection with the utility grid means that the CHP unit will need to satisfy utility requirements for power quality and utility protection. In addition, connection to the utility will require special agreements with the utility to allow credit for any power fed back to the utility system. Sizing of the CHP system is important to maximize the benefits of the CHP system to provide both electricity and thermal energy – loads that are often not coincident in homes. CHP systems can be designed to satisfy a thermal load, with electricity as a by-product, or they can be designed to produce electricity with the thermal production as a by-product.

Since residential CHP units are very uncommon, the approval process will need to be evaluated on an individual basis and comply with local building codes. Once the CHP systems gain momentum with practical field experience, and obtain the necessary listings and certifications, the installation of CHP units should occur much like that of other energy producing systems such as PV or wind systems.

Since the CHP systems on the market today utilize piston engines to drive the electrical generator, annual to bi-annual servicing may be necessary but also should be straightforward for anyone familiar with engine maintenance.

High initial cost, combined with historical low electricity rates throughout much of the country, will likely be the biggest impediment to adoption of the technology. Changing electricity and natural gas rates can change the economics of CHP systems in a short period of time.

BACK TO TOP ^

Initial Cost

Cost for a system having 1.2 kW of electrical generating capacity and 11,000 Btuh heating capacity is anticipated to be twice the cost of conventional heating equipment. Unit cost for 2 to 6 kW systems is on the order of $10,000 to $20,000. The cost for installation should be moderately more than a conventional heating system for the additional natural gas line and the additional venting and electrical requirements. One manufacturer estimates installation cost for a system that modulates between 2 and 4.7 kW to be about $4,000 for new homes.

BACK TO TOP ^

Operational Cost

Operating cost and energy savings will vary by type and cost of fuel, efficiency of the system, amount of electricity produced, and whether net metering is available at the site. For the average homeowner in the Northeast, a 1.2 kW system will provide approximately half of the annual household electricity needs. The cost of operating the CHP unit to its full capacity (fully using the thermal output of the CHP) will be less than buying an equivalent amount of fuel gas and electricity as long as electricity costs remain above 8.5 cents per kWh, which is the case in most of the country. Annual maintenance costs are on the order of a few hundred dollars.

In areas with net metering (where power sent into the utility grid is credited at the retail rate), electric costs will be cut by about half.

BACK TO TOP ^

U.S.Code Acceptance

Systems will need to meet all the relevant IEEE standards and UL requirements referenced in the International Residential Code parts 6, 7, and 8 (Fuel Gas, Plumbing, and Electrical).

The manufacturers will play an important role in securing acceptance by the local building departments.

BACK TO TOP ^

Field Evaluations

Hundreds of micro CHP systems have been operating in Japan and Europe for years. Several manufacturers and organizations are conducting ongoing field trials in the United States.

BACK TO TOP ^

Installation

Installation uses the same methods as standard heating equipment. An additional natural gas connection and a vent pipe to the engine generator are required. Systems are appropriate for new and existing homes. In an existing home, the existing furnace or boiler would be replaced but existing ducts or heating pipes would remain unchanged. An indirect water heater provides hot water for domestic use.

BACK TO TOP ^

Warranty

Warranties are expected to be similar to conventional heating and power generating equipment.

BACK TO TOP ^

Benefits/Costs

Payback on investment varies with fuel cost, electricity cost, the availability of net metering (where the utility credits the customer for excess electricity placed onto the utility grid at the retail rate), and the need for the waste heat (e.g., a system heating a pool will provide useful heat and electricity in the summer and winter). Some units operate only when there is a need for heat and are therefore more cost-effective in cold climates. The best economics will be found in cold climates having high electric rates and low natural gas rates.

Combined heat and power systems produce electricity at a very high efficiency when there is a demand for heating. If net metering is available (where the utility credits the customer full retail rate for electricity sent into the grid), the systems can reduce annual energy costs, however, with current technologies and utility rates the payback period can be long. When there is no heating demand, no electrical generation ensues. Payback time decreases as electric rates and heating demand increase.

The extent of maintenance depends on the type of engine and the type of fuel. For a natural gas internal combustion engine, routine maintenance is required every 4,000 to 10,000 hours (about 1 to 3 years). At this interval, an oil and filter change, spark plug replacement, and minor adjustments are necessary. The servicing takes about one hour and costs about $200. It is imperative that internal combustion CHP systems have routine scheduled maintenance. Therefore, most manufacturers are offering systems through authorized installers who will also offer service contracts.

One manufacturer of a Stirling free-piston engine, expected on the market in 2008, touts its product as zero-maintenance because there is no contact between moving parts in the engine.

Another manufacturer will distribute, install, and service through authorized and certified contractors, only. While this will help ensure quality installations, it may be difficult to find qualified contractors in the early stages of the products' development except in specific markets.

BACK TO TOP ^

PATH

A Public-Private Partnership for Advancing Housing Technology

R&D TECHNOLOGY SCANS

Emerging Scanning Technologies: MicroTurbines

PATH Roadmap Applicability:

- ☐ Advanced Panelized Construction
- ☑ Energy Efficiency in Existing Homes
- ☐ Information Technology
- ☑ Whole House & Building Process Redesign

Summary

As you look out the window during a recent storm, the neighborhood looks particularly dark. The power grid has gone down again. Fortunately, on this exceptionally cold night, your heating syster continues to operate from the electricity generated by a recently-installed microturbine. In fact, al the townhomes on your block are powered and heated using this form of decentralized energy generation for much less than the cost of energy purchased from the electric company.

Decentralized energy distribution is increasing as an alternative method of power generation. Microturbines generate electricity by burning natural gas or another fuel to produce pressure that turns a shaft. The shaft is connected to a turbine wheel on one end and a magnetic generator on t other. The electricity that is produced is typically passed through an inverter to provide AC power.

Several companies have introduced commercially-available microturbines, sometimes called mini-turbines. Currently, the smallest systems are about 30 kW in size, about three to six times as much capacity as is needed for a typical home. But the time may arrive when separate units will be available for an individual home.

Benefits of microturbines include societal benefits such as potentially reducing or eliminating the need for new powe plants. Microturbines can also produce each kilowatt of electricity with fewer smog-producing emissions than all but the very latest natural gas-fired utility plants. Much higher efficiencies are also possible with distributed energy production.

Benefits at the site or the home level include minimized need for connection to the grid, or elimination of this infrastructure altogether, typically a large cost in rural or isolated regions. The cost to produce electricity with a microurbine can be half that of electricity purchased from the grid in many areas of the United States.

Application to PATH Roadmaps

The use of microturbines is applicable toward meeting the goals of the energy efficiency and affordable goals of PAT The Year One progress report of the PATH Energy Efficiency in Existing Homes Roadmap identifies the need for distributed or decentralized energy production as one of the primary strategies of the roadmap. Microturbines also c be used for new homes, and thus have implications on the Whole House and Building Process Redesign Roadmap. Microturbines bring us closer to the realization of a net-zero energy home--a home that produces as much or more energy than it uses.

Current Status of Technology

About 3,000 microturbines have been shipped world-wide since their introduction in 1998. The smallest units are in range of 28 to 30 kW. Although this size is more applicable to multi-family homes, townhomes or possibly a group c detached homes, than to the typical individual home, smaller turbines will likely be part of the future.

The current initial cost of microturbines is a factor, especially compared to other alternatives such as connecting to t grid or other distributed technologies. Cooperative research efforts with the major manufacturers of microturbines a the U.S. Department of Energy have set a goal to improve the efficiency and reduce the cost of microturbines. Their target is to reduce today's cost of $800 to $1,000 per kW to about $500 per kW, which is comparable to today's engine-driven generators.

There are many advancements taking place to improve the efficiency of microturbines. One approach is focused on recuperators. A recuperator is similar to a heat exchanger that is designed to capture exhaust heat and return it to reduce the amount of incoming heat required to turn the turbine shaft. Information on existing microturbines and related research efforts is available from the contacts listed below.

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