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GENERATING YOUR OWN POWER

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Brooklyn, New York company offers an example of how to save over $200,000 a year by lowering power and heat costs with on-site systems that are developing into new industry.

Diane Greer

FACED with rising utility costs taking a big bite out of his bottom line, Wayne Celauro - owner of 4C Foods in Brooklyn, New York - decided to act. His solution resides in a 40-foot shipping container in his parking lot. The container emits a gentle hum that turns to a roar when the doors are opened, revealing a mini power plant.

This on-site power plant generates over 80 percent of the food processor's electricity. Waste heat from the system is captured and used for space heating and cooling along with process heat. But what Celauro likes best about the combined heat and power (CHP) system is the savings. On-site power generation and heat recovery lowers energy costs 38 percent, saving over $200,000 a year.

4C Foods is one of a growing number of manufacturing and commercial operations significantly increasing energy efficiency and reducing energy costs with CHP systems. Today, over 2,900 on-site CHP plants generate about 8 percent of the country's power, saving users $5 billion a year while reducing greenhouse gas emissions by 35 million metric tons.

Traditionally, separate heat and power systems provide the energy required to run manufacturing and commercial operations. Centralized utilities generate electric power while on-site equipment supplies heating and cooling.

Centralized utility plants that produce approximately 92 percent of the world's electricity employ relatively inefficient processes. "The efficiency with which we convert fuel to electricity is on average 33 percent across the country," explains Mark Hall, Senior Vice President for External and Environmental Affairs at Primary Energy.

In other words, central utility generation consumes three units of fuel to produce one unit as electricity. The remainder is waste heat. Plants are often sited in remote areas, far from potential users of waste heat. Since it is not economical to transport waste heat over long distances, the energy is discarded into the atmosphere or adjacent waterways. Another 5 percent-20 percent of electricity is lost transmitting it over power lines.

In contrast, CHP systems recycle the waste heat produced by on-site electric generation, providing energy for space heating and cooling and process heat applications. By recycling waste heat, the efficiency of CHP systems ranges from 70 percent to 90 percent according to Richard Sweetzer, President of Exergy Partners Corporation.

An often-cited example of the efficiency advantage of CHP shows separate heat and power systems consume 189 units of fuel to produce the energy generated by a CHP system using 100 units of fuel.

Reducing air pollution and greenhouse gas emissions is another significant benefit of CHP systems. "Since you are more efficient and burning less fossil fuel, you are producing less pollution," said Hall. The U.S. Combined Heat and Power Association (USCHPA) estimates current CHP systems reduce annual nitrogen oxide (NOx) emissions by 0.4 million tons, sulfur dioxide (SO2) emissions by 0.9 million tons and release of greenhouse gases by 35 million metric tons.

At 4C Foods in Brooklyn, the CHP plant utilizes three gas-fired cogeneration units to produce 380kW of electricity. Waste heat from the cogeneration plant runs an absorption chiller providing air conditioning in the summer and a boiler that heats the facility in the winter. The heat also dries grated cheese. "They use about 90 percent of their waste heat," said William Cristofaro, President of Energy Concepts Engineering, designers of the CHP system. As a result of the CHP system, 4C Foods' greenhouse gas emissions have fallen by 717 tons per year.

CHP DRIVERS

Several key drivers determine if a business or institution is a good candidate for a CHP

system. The first is the local spark spread, quite simply the difference between the prices of electricity and natural gas. Natural gas enters into the equation as the predominant fuel used to power most industrial and commercial CHP applications.

"If you are paying less than six cents/kWh for electricity, there is no way you can produce power and heat on-site for less," adds Kim Crossman, Program Manager for the EPA CHP Partnership. On the other hand, markets with high and/or rising electricity prices present good opportunities.

"Another factor is being located in a deregulated electricity market or a less regulated electricity market," adds Crossman. "Deregulated markets tend to be better for CHP, often because the electricity prices are higher."

The next key determinant of the applicability of CHP is the coincident demand for both thermal energy and electrical power. An analysis of a facility's thermal and electrical load profiles can determine if electric use and heat demand occur at the same time. "We look at the heat balance of the building versus power produced and the waste heat from the cogeneration plant," says Cristofaro. "We really design the CHP plant to be heat loaded."

Long operating hours and high thermal loads are other good indicators of good CHP candidates. "Running long hours is a good indicator of payback period," points out Crossman. "Every hour you are running, you are making your money back."

Operations with large thermal load throughout the year requiring steam, hot water and/or processed heat coincident with electricity demand can efficiently use the waste heat from a CHP system. Brooklyn-based Arrow Linen Supply Company provides a good example. Arrow installed a 300kW cogeneration plant supplying 75 percent of the electricity required to run their facility. The plant operates during peak hours from 4 am to 8 pm. Waste heat from the generators and the engine exhaust produce over 130,000 gallons of hot water each day, enough to run the laundry machines plus heat the facility, according to Frank Park, Maintenance Engineer at Arrow. The on-site generation plant reduces the company's energy costs 36 percent. Park estimates the payback for the system as a little over 3 years.

CHP may make sense for companies replacing mission critical central plant equipment or expanding facilities, explains Cristofaro. Installing a system when a facility is replacing or overhauling a boiler or chiller is the most cost effective. At new facilities, CHP often allows boiler plants to be smaller and absorption chillers to replace electric chillers.

RELIABILITY AND CONTINUITY

Reliability and business continuity are other factors driving the installation of CHP systems. At a company with large volumes of financial transactions, a grocery store with cases of refrigerated and frozen food or a hospital, power outages can prove costly and even life threatening. The Electric Power Research Institute estimates annual losses due to power outages cost $120 billion annually. "People are increasingly aware that the grid is vulnerable to external forces that no one can control and are realizing it might make sense to provide for themselves if they need power quality and reliability," said John Jimison, Executive Director of the USCHPA.

CHP's contribution to power reliability was exhibited on the morning Hurricane Katrina hit Louisiana, Mississippi and Alabama, resulting in $125 billion in damages and massive power outages. The only medical facility in the Jackson, Mississippi area to remain operational was the Mississippi Baptist Medical Center. The 624-bed hospital's CHP system allowed the facility to operate in standalone mode for 50 hours, until electricity was restored. "All but the MRI," said Sweetzer. "The hospital did a little load shedding but was fully functional during the whole course of the Hurricane, whereas the rest of the facilities in the metro area were shut down."

Besides hospitals, CHP plants are providing economic and environmental benefits at refineries, chemical plants, pharmaceutical companies, ethanol plants, food processors, laundries, colleges, hotels, casinos, grocery stores and commercial office buildings, just to name a few.

While natural gas is the primary fuel used to power CHP plants, a growing number of operations are starting to utilize so called "opportunity fuels". Pulp and paper mills offer a good example of an industry powering CHP using wood wastes. Anaerobic digesters, either at wastewater treatment facilities or on farms, produce biogas to fuel CHP.

Real Energy of Yountville, California is investing in a CHP operation on one of the largest dairy farms in Oregon. The company's Real Energy Clean Tech Fleet Opportunity Fund will provide financing for the digester and CHP equipment for the facility. Real Energy will own and manage the CHP operation, selling the power generated to the grid under a 15-year contract and the compost by-product of anaerobic digestion in the local Salem-Eugene area, according to company CEO Kevin Best. "There are 12 or 13 similar operations right behind it," said Best. "We hope to install systems at 300-400 dairies over the next few years."

Most companies interested in installing CHP system work with engineering firms specializing in the design and implementation of CHP. Feasibility studies, sizing analyses, integration with electrical services and existing plant equipment, installation management, interconnection with the grid and sourcing of financing and outside funding are services offered by experienced CHP engineering firms.

A typical CHP installation consists of an electric generator, such as a gas turbine, steam turbine or combustion engine, and a waste heat exchanger to recover heat from the generator exhaust. The recovered heat is used to generate process steam, space heating, hot water and refrigeration through absorption chillers. "Successful CHP installations need a certain amount of customization at the site to tie into the facility," said Cristofaro.

At Arrow Linen, "the CHP system was designed around the existing system," explains Park. Due to space limitations within the facility, the CHP generator was placed on the roof and the heat exchangers were hung on the wall. "We only sacrificed a couple hundred square feet of the facility." In order to comply with EPA noise regulations, Arrow installed an acoustic wall around the generators and put a noise level monitoring system at the property line.

REGULATORY HURDLES

Given the benefits of CHP, it seems puzzling that the technology is not generating a larger proportion of the country's electricity. Denmark produces 52 percent of its electricity with CHP. The Netherlands, Finland and Russia use CHP to produce over 30 percent. So why is the US lagging behind at only at 8 percent?

"There is basically one hurdle, a 100 year old hurdle," says Sean Caston, CEO of Turbosteam Corporation. "The hurdle is we regulate our utilities with guaranteed profits based on their costs."

The electric utility industry is the only industry in the world that is less efficient today than it was 100 years ago. Thomas Edison's first electric plant in 1882 was a CHP facility in lower Manhattan. "For every 100 units of fuel Edison bought, he made 50 units of a saleable commodity. Most of it was heat but some of it was power," continues Caston.

The industry continued to make efficiency gains until it became regulated. "Once we regulated the industry it stopped recovering the heat and by 1957, it was only 33 percent efficient and has not improved since. If all you did was bring the U.S. electricity industry up to the efficiency it was at in 1920, you would save on the order of $100 billion dollars a year and reduce CO2 emissions by one billion tons per year."

Regulation gave utilities exclusive monopolies to sell electricity in exchange for insuring reliable electrical service to everyone in their coverage areas. As a result, electric utilities had no incentive to capture waste heat because their monopoly power only extended to electricity and they were not incentives to conserve costs, explained Caston.

From 1978, when PURPA (Public Utility Regulatory Policies Act) was signed into law, until 1992, slow but steady progress was made introducing market forces to the electric industry. Despite the progress deregulating the industry and reducing its monopoly power, electric utilities still exercise tremendous control over issues like grid interconnects and the structure of standby tariffs.

Most companies installing CHP systems wish to remain connected to the grid. The grid provides back-up power if the CHP system fails or is taken offline for maintenance. It also provides supplemental electricity if for economic reasons the CHP system was sized to meet only base load power needs or heat demand.

Interconnection rules define how facilities with CHP systems can connect to the grid. In some jurisdictions, complex rules slow approvals and raise costs. Utilities can also require costly studies and demand installation of unnecessary equipment.

Utilities impose standby tariffs and "exit fees" on customers choosing to remain connected to the grid for back-up purposes. Many utilities assume that all CHP systems on the grid will fail simultaneously, requiring the utility to maintain generating capacity as if the CHP systems did not exist. As a result, the standby rates can be onerous, negating much of the savings realized by the installation of a CHP system.

One of Cristofaro's clients, Fonda Fultonville Central School District, chose an off-grid CHP system because of Niagara Mohawk's standby tariffs. Originally the school intended to install a grid-connected system. "But the tariff in place at the time made it uneconomical," said Cristofaro. Today the off-grid CHP system produces all the electricity for the school along with heat and chilled water for cooling via an absorption chiller. The school purchased a standby diesel generator to be used should the CHP system go down.

Byzantine laws exist in some states prohibiting third parties from selling electricity to retail customers. "The only people allowed to sell electricity in North Carolina to a retail customer is a regulated utility," said Hall. Third parties are allowed to sell electricity back to the regulated utilities, but PURPA set rates at the utility's avoided cost of electricity. These rates are often below local market levels since the utility can base them in a remote generation plant far from the location of the CHP plant.

"If you are in New England, you are probably paying 13 to 14 cents per kwh," said Caston. "But if I was to generate a kwh they only need to pay me five or six cents per kwh based on [the avoided cost of] a coal plant in Salem Harbor, Massachusetts."

Laws also prohibit so-called private wires. Only utilities can string electrical wires. "If I run a wire across the street to sell that extra power to my neighbor, I go to jail," said Caston.

Private wires would allow the owner of a CHP plant to sell excess electricity directly to a nearby facility. Hall believes few people would run private wires if the rules were changed, but they would have the same effect on the market as the law allowing third party access to interstate gas pipelines. The ability to bypass local gas distribution companies introduced "rationality into the way gas was being priced," explained Hall. Likewise, Hall believes allowing private wires would permit for more rational pricing of third party electricity generation.

REMOVING THE BARRIERS

Regulatory hurdles are gradually being overcome. "The interesting thing that has happened since 2000 has been the removal of barriers, but it is happening at the states not the federal level," said Caston. New York, California and Texas are leading the change. Recently most of New England and some Midwestern states are jumping on the

bandwagon. New rules are being adopted for fairer interconnection standards and reasonable backup, standby and exit fees. But a lot more needs to be done.
Localities are also starting to realize CHP can relieve congested transmission lines, alleviate the pressure to build new generation capacity and improve air quality. Recent legislation is starting to level the playing field, forcing utilities to facilitate the implementation of CHP and other alternatives.
For example, in Vermont recently passed legislation requires utility rates be restructured to remove their throughput bias. "This means, among other things that they eliminate their ability to earn more money by selling more kilowatt hours," said Caston. Utilities regulators are also required to insure that utility investment conforms to least cost plans. So a utility seeking regulatory approval to build new transmission or distribution capacity must now show why options like conservation and distributed generation technologies like CHP are not better alternatives. "There is no other state taking such a holistic approach," said Caston.
Federal, state and local municipalities are also providing incentives for CHP. Incentives include grants for technical studies and system installation, reduced natural gas pricing, emission credits and inclusion of waste heat recovery in renewable portfolio standards. Websites listing state incentive programs can be found in the resources sidebar accompanying this article.