small units *can mean* big savings

In a variety of applications nationwide, small cogenerators assembled into multiple-unit systems are savings thousands of dollars each year in energy costs. Preventive maintenance is the key to system performance.

by R.L. Busby

Last year, Geneva General Hospital in upstate New York saved about $138,000 in energy costs by operating a 375-kW cogeneration system. Even after subtracting maintenance expenses, Geneva realized net savings of more than $99,000.

The savings, combined with a state grant for installing energy conservation equipment, means that the hospital will recoup its entire investment in the cogeneration system within four years or less.

This is not the only case. Other hospitals and health-care facilities, high schools and universities, retirement homes and other commercial buildings, from New York to California, are reducing their energy bills by operating small cogenerators — 60 to 75 kW each — connected into systems of two or more units.

Beside generating electricity, these units also produce usable heat (up to 440,000 to 470,000 Btuh of hot water) by recovering it from the engine's coolant and exhaust. This means cogeneration systems can be designed to follow either the heating or the electrical load, depending on the building's energy profile and local utility rates.

Small, packaged cogeneration units, as opposed to custom-built systems, were introduced by Tecogen Inc. (Waltham, MA) about eight years ago.

Today, more than 500 of these units are in operation, nearly all fueled by natural gas (a handful have propane fuel-switching capability). Although California is the biggest market for small cogeneration systems, Tecogen has installed systems throughout the U.S. and in several other countries as well.

Geneva plant

In 1991, Geneva General Hospital decided to install a cogeneration plant and other energy conservation equipment, helped along by a grant from the New York State Energy Office.

The project was designed by The Sear-Brown Group, Rochester, NY. Because the hospital has a substantial heating requirement most of the year, Sear-Brown decided on a "topping" cogeneration system, which is designed to meet the building's

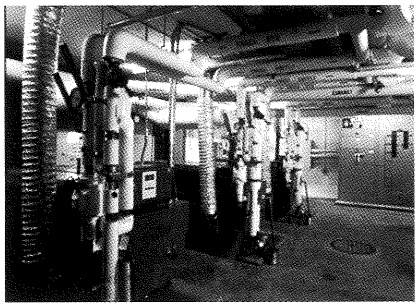
other satisfied customers

User: Mt. San Antonio Gardens (Pomona, CA), 300-unit retirement home with 62-bed hospital
System: Two 60-kW Tecogen units
Application: Thermally baseloaded cogeneration system meets all domestic hot water demand and some space heat, while generating about 75,600 kWh/month of electricity.
Savings: $75,000/yr for five years (total $575,000)
Comment: Operation has been trouble free, saving time in addition to reducing energy costs.

demand for heat rather than following the electric load.

The hospital was already equipped with steam or hot water heat exchangers that serve various types of heating equipment throughout the building, including coils, radiators, and duct heaters. A 30- by 30-ft addition was built to house five Tecogen 75-kW cogeneration modules *(Figure 1)*.

Figure 1 Geneva General Hospital cogeneration plant

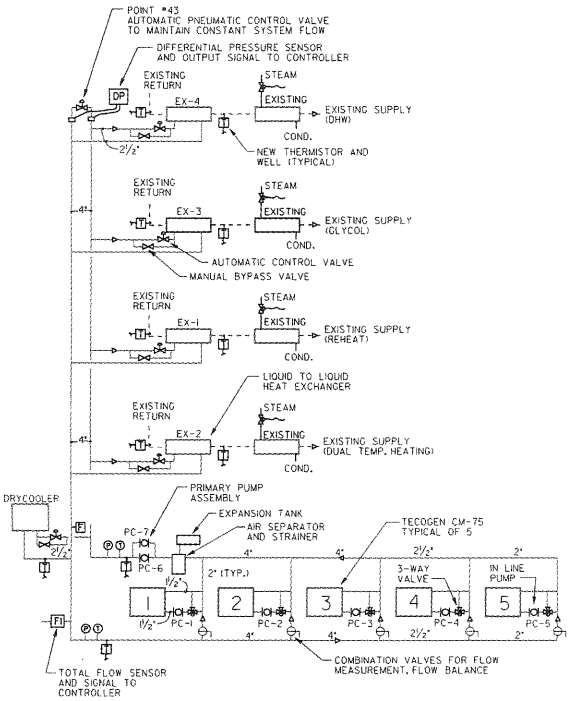


All of the return-water lines from the hospital's heating system were tied in to a second heat exchange system supplied by the cogeneration plant's recovered heat *(Figure 2)*.

"Basically, the cogenerators are providing most of the hospital's heat," says Bill Cristofaro, Sear-Brown's senior project manager-senior engineer.

The cogeneration system's computer monitors the return water temperature. When the return water is in the 170° to 175°F range, the cogeneration plant is left to run as is. When the temperature dips below 170°F, the plant begins to boost its heat output by cycling on additional units; above 175°F, the system ramps itself down.

Figure 2 Schematic of heat-rejection loop in Geneva General Hospital cogeneration system



other satisfied customers

User: Arden Wood Benevolent Association (San Francisco), 120-bed resident and nursing-patient health-care facility
System: One 60-kW Tecogen unit
Application: Electrically baseloaded cogeneration system provides enough power to cut the facility's electric bill nearly in half, while using recovered heat for space heating and domestic hot water (reducing gas bills by 12%).
Savings: $33,000/yr during first year
Comment: Since the Tecogen unit exceeded its goals, a second unit was installed a year later.

"As a general rule of thumb," Cristofaro says, "all five cogeneration units are running whenever the temperature outside is below 50°F."

But even in the summer, when the space-heating load diminishes, the cogeneration plant supplies heat for domestic hot water and for the building's reheat coil system, which warms overcooled air to a comfortable temperature. Also, whenever a cogeneration unit is running, it is producing power that directly reduces the amount purchased from the electric utility.

Preventive maintenance

Tecogen's cogeneration units rely on heavy-duty automotive engines modified for natural gas fuel. These engines have a proven track record in everyday use, but they require regular maintenance to prolong engine life and deliver maximum performance *(Figure 3)*.

Tecogen offers a fixed-price factory-maintenance contract in most parts of the U.S. Sear-Brown, in its bid for the energy conservation project, recommended that Geneva General buy a complete maintenance contract from Tecogen, which covers all costs, including engine replacement.

"We can ensure that you're going to generate power," Cristofaro told the hospital's support services people. "And we can predict how much heat you're going to recover. But the one thing we can't control is engine life."

Cristofaro compares Tecogen's

maintenance contract to an insurance policy. "If you factor in the cost of the contract," he says, "which amounts to about $1.25 per run-hour in Geneva General's case, you can analyze the economics of the cogeneration installation with much greater certainty."

Another factor in the hospital's decision was that other construction and maintenance projects were underway. No spare time was expected to be available for servicing the cogeneration units.

The maintenance contract with Tecogen has proved to be a bargain for Geneva General. Although engine life is estimated at 18,000 hours, some engines needed to be replaced sooner than that, at no cost to the hospital.

What about downtime during replacement? Tecogen's answer is to replace engines before they fail.

Whenever an engine exhibits signs of premature aging — such as high oil consumption or loss of power — the company replaces it ahead of time. "We want to avoid a situation where you get an emergency call at midnight," says Jeff Glick, Tecogen's applications engineer, Cogeneration Products.

"By planning the replacement procedure, we can reduce the amount of time required." Glick says a cogeneration unit's engine can be replaced in as little as 8 hours (with two people) up to 12 hours (with one person).

Also, with multiple cogenerators in the system, one unit can be down for maintenance without sacrificing overall system output. "That's a major selling point for these systems," Glick says.

"We avoid the risk of incurring peak demand charges, and the inconvenience of bringing other equipment on-line, by keeping the rest of the cogeneration system running while one unit is being serviced."

Economics, other benefits

Geneva General's cogeneration plant was started up in December 1991 and has logged more than two full years of operation.

During 1993, the system reduced the hospital's electric bills by more than $166,000 using less than $29,000 worth of natural gas, yielding a net energy cost savings of nearly $138,000 *(Figure 4)*. After maintenance costs of about $39,000, the hospital is saving more than $99,000/yr.

Sear-Brown reports that the energy conservation project cost a total of $777,000, including installation, an energy management system for the building's electric chillers, additional air-handling equipment, and other items.

The cogeneration system cost is estimated at $650,000, of which $250,000 was covered by the state grant, leaving Geneva General's share of the cogeneration plant at $400,000.

other satisfied customers

User: Harvard University's Blodgett Pool (Cambridge, MA); 75-meter, 750,000-gal swimming pool maintained at 80°F in 50,000-sq ft building

System: One 60-kW Tecogen unit

Application: Thermally baseloaded cogeneration system heats the pool and domestic hot water system, supplemented by gas-fired boilers. About 300,000 kWh/yr of electricity is also produced for building lighting.

Savings: About $28,000/yr for more than eight years (total of approximately $245,000)

Comment: The cogeneration system provides the same comfort levels, while reducing heating costs and electric utility charges.

Figure 3 Scheduled service intervals for Tecogen units at Geneva General Hospital

Month	Run-hr	Electricity generated (kWh)	Estimated demand saved (kW)	Electric utility savings ($)	New gas use increase (therms)	Net gas cost increase ($)	Net energy cost savings ($)	Maintenance contract cost ($)	Net savings ($)
Jan.	est.	230,000	200	17,400	2,600	1,050	16,350	3,900	12,450
Feb.	3,163	228,137	199	17,453	2,694	1,077	16,376	3,900	12,476
March	3,009	220,749	124	16,196	6,256	2,502	13,694	3,762	9,932
April	2,573	175,135	78	12,641	5,017	2,007	10,634	3,217	7,417
May	2,056	134,518	0	9,456	4,937	1,975	7,481	2,570	4,911
June	2,268	153,015	71	11,152	5,089	2,035	9,117	2,835	6,282
July	1,935	115,463	150	9,241	7,785	3,114	6,127	2,419	3,708
Aug.	2,009	116,870	195	9,775	7,456	2,982	6,793	2,511	4,282
Sept.	2,070	132,129	137	10,740	7,303	2,921	7,819	2,588	5,231
Oct.	2,459	172,405	216	14,297	7,322	2,929	11,368	3,074	8,294
Nov.	3,125	225,225	296	18,822	7,618	3,047	15,775	3,907	11,867
Dec.	3,195	241,013	244	19,447	8,018	3,207	16,239	3,994	12,245
Total	27,862	2,144,659	1,910	166,620	72,095	28,846	137,773	38,677	99,095

other satisfied customers

User: Waverly (New York) Junior-Senior High School, 1,000 students and staff, 200,000 sq ft
System: Five 75-kW Tecogen units
Application: Retrofit of all-electric building. Electrically baseloaded cogeneration system provides power for lights, computers, motors, and other equipment. Byproduct heat is used for water heating, hydronic space heating, and absorption chiller air conditioning.
Savings: $100,000/yr for three years (total $309,000)
Comment: The Waverly School District's education funds are not going "up the chimney."

Besides paying for its entire cost within four years or less, the cogeneration project has generated favorable publicity — and valuable community support — for the hospital's energy conservation efforts.

"Groups are coming here all the time to see the system," says Sayle Temple, Geneva General's director of facilities management. "I've shown the plant to hospital administrators, city planners, engineers — anybody who can benefit from saving energy." As a result, a hospital in nearby Clifton Springs recently decided to install a similar cogeneration system.

Upstate New York hospitals typically have old physical plants, and utility bills are a prime cost-cutting target. But this market is just one of many types of commercial buildings that are reducing overall energy expenses by operating small cogeneration systems. Other customers in different parts of the country are saving money with cogeneration units.

What next?

In Geneva General's case, the cogeneration system's economics could be improved even further by using more heat during the summer.

An ideal use for this heat would be in absorption chillers — heat-driven machines that cool via heat exchange between a refrigerant and an absorbent. Although this cooling technology has been known for decades, many industry observers anticipate an increase in absorption chiller sales in the U.S., driven largely by new regulation of CFC refrigerants.

"We are now analyzing the addition of absorption chillers to Geneva General Hospital's system," says Cristofaro. "By using additional heat, we could run the cogeneration plant flat-out all year."

Cristofaro notes that a similar state energy conservation grant might be available to upgrade the hospital's chilled-water plant with an absorption machine and, at the same time, tie it into the cogeneration system. **ES**

Busby has 20 years of experience in energy research and the gas industry, and has written technical material for many hvac manufacturers.

Figure 4 Total energy balance (heat and electricity) during 1993 for five-unit Geneva General Hospital Cogeneration System

Interval, run-hr	Item	Action
750	Lubricating oil	Replace
	Oil filter	Replace
	Air filter*	Replace
	PCV valve	Check
	Battery	Inspect
	Coolant system	Check level, belt
	Condensate trap	Clean
	Air inlet louver	Inspect and clean
	Timing	Check
	Carburetor	Adjust
	Electrical interface submodule	Tighten connections
	Ignition overspeed circuit board	Check and adjust
2,250	Coolant system	Replace pump belt
	Spark plugs	Replace
	Ignition wires	Replace
	PCV valve	Replace
	Ignition system	Check
	Generator	Check connections
4,500 or biannually	Coolant	Replace and flush
	Generator	Grease bearings
	Vibration mounts	Check

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