As businesses and institutions are squeezed by rising energy and building costs, the use of central plant cooling systems is growing in popularity. Central plants provide cooling to multiple, often many, buildings. Efficient natural gas has helped unlock the advantages of central plant cooling for many situations.

**TWO APPLICATIONS**

Two different types of applications exist. One is a central cooling plant (and usually the chilled water distribution system) owned by a utility or private owner that sells chilled water to multiple building owners. These commercial district cooling operations often parallel existing district heating or central plant steam systems. Such systems are found in varying scales in many North American cities.

The other central plant cooling approach is a system that serves a number of separate buildings all owned by the same entity—for example a college campus, military base, airport complex, industrial park, or office campus. In both the commercial district cooling operation and the single-owner network, several advantages are drawing new converts every year.

**ON THE COVER**

A central-station cooling plant provides enhanced efficiency, improved reliability, and helps conserve building space in client facilities for other purposes. Such systems are widely being used at universities, medical campuses and to serve multiple users in urban centers.

**WEBSITES**

- [www.aircompressor.org](http://www.aircompressor.org)
- [www.poweronsite.org](http://www.poweronsite.org)
- [www.gasairconditioning.org](http://www.gasairconditioning.org)
- [www.cleanboiler.org](http://www.cleanboiler.org)
- [www.energysolutionscenter.org](http://www.energysolutionscenter.org)

**SIZING UNITS FOR MAXIMUM EFFICIENCY**

Use of a central chilled water plant versus individual plants at each building means units may be sized for optimum efficiency. Even on the hottest days, there is diversity in cooling load from building to building, so the total cooling tonnage is smaller. Because a central plant has multiple units, users benefit from increased reliability through unit redundancy. Individual units can be dispatched based on operating efficiency, thereby reducing energy costs.

Central plant cooling means building operators no longer have to dedicate floor space to chillers and condensing equipment, so client building utilization is improved. Chilled water is available immediately for light overnight loads or intermittent applications, avoiding the need to operate a small “pony” chiller or to run a large chiller at inefficient levels.

**COLLEGE CENTRAL PLANT SYSTEMS ARE LEADERS**

These central cooling plant operations are widespread and have a long pedigree. College campuses are among the earliest adopters and still most widespread users. Most large universities have central steam plants, and many of these also provide central chilled water service to some or all campus buildings. Among the many universities that have major steam-powered central plant cooling systems are Dartmouth, Princeton, Yale, Rochester Institute of Technology, Texas A&M, and the Universities of Idaho, Michigan, Minnesota, and Wisconsin.

Natural gas plays an important role in these central plant systems in several
ways. Many times the cooling network is part of a larger central utility operation that includes steam for heating or process purposes. This steam is commonly generated at a central plant using natural gas boilers.

**ABSORPTION, STEAM TURBINES BRING OPTIONS**

The steam supply can power absorption chillers or steam turbine-driven centrifugal chillers. If the steam plant is primarily used for building heating, the use of central cooling allows boilers to operate at more efficient levels year-round, and can sometimes take advantage of seasonal natural gas rates. Often the same tunnels used for steam distribution can be used for chilled water lines.

The University of Wisconsin at Madison has 62,000 tons of chiller capacity in three central cooling plants. Over 35,000 tons of this capacity is Carrier and York steam turbine chillers and a smaller amount of steam absorption cooling. A portion of the steam comes from dedicated natural gas boilers, part from multi-fuel boilers which can be fired by coal, fuel oil, waste products or natural gas, and a portion from waste heat recovery from a natural gas-fired cogeneration plant. Chilled water is generated at 41°F and typically returns at 52°F. Campus-chilled water distribution is through direct-buried insulated pipe.

**PLANT DIRECTOR SEES ADVANTAGES**

According to John Harrod, Director of Physical Plant at the university, the advantages of central-plant cooling include reliability from multiple units, efficiency from being able to use large, efficient units, and saving space and staffing needs at campus buildings. Harrod said, “Reliability is really critical and not just for comfort. We serve many research labs and computer centers where dependable cooling is crucial.” The three plants on the Madison campus are interconnected on a chilled water loop. This helps the university dispatch the most efficient chillers, and assures access to chilled water in the event of single or even multiple chiller outages.

Harrod also said that the steam chillers help the university get better utilization from its steam plant, particularly during the cooling months. “Without the steam-powered chillers, we would have to operate some of the boilers at lower, less efficient levels. So the chillers actually make the entire steam system more efficient.”

**RECOVERING ENERGY FROM GAS TURBINE EXHAUST**

A natural gas-fired combustion turbine used for central plant electric generation may exhaust to a waste heat boiler, which may provide the steam input for both heating plant steam and for chillers. Such a system is used at Princeton University, where a central campus energy plant uses a 15 MW aeroderivative gas turbine for campus energy supply. According to Ted Borer, energy plant manager, this system, completed in 1997, offers real efficiency advantages to the university. He says, “We benefit with improved reliability, higher efficiency, saved building space, reduced maintenance expense and reduced demand charges.”

He indicates that Princeton is proud of having received the EPA Energy Star award for energy efficiency and pollution reduction. Borer said that through the use of cogeneration and central plant cooling, Princeton has been able to reduce the campus peak electric demand from the grid from about 25 MW to 2 MW. For cooling, the school uses a combination of five electric centrifugal chillers and three steam turbine-drive machines.

The steam normally comes from the turbine exhaust fired into a Nebraska heat recovery steam generator. By using the turbine exhaust alone the system produces about 50,000 lbs of steam per
hour. By firing a duct burner aft of the turbine, the system makes as much as 180,000 lbs per hour.

**AUXILIARY BOILERS FOR STEAM SUPPLY REDUNDANCY**

Princeton has two auxiliary boilers that can be fired on natural gas or diesel fuel and can each produce up to 150,000 lbs of steam per hour. Steam is generated at 210 psig. The provider of natural gas service to the Princeton campus is PSE&G of New Jersey. The school uses a natural gas supply contract with UGI.

Similar to the use of turbine exhaust as a thermal source, reciprocating engine electric generation can supply hot water to meet some, or all of the heat input requirements of single-stage absorption chillers at a central plant. These cogeneration approaches to central cooling improve the economics of both the electric generation and the cooling systems by using byproduct heat rather than simply exhausting it to the atmosphere.

**URBAN DISTRICTS SELL CHILLED WATER SERVICES**

In addition to the central plant which serves multiple buildings with one owner, another type of central plant cooling system is the urban commercial district cooling system. These provide chilled water to various commercial clients. As with university systems, this approach offers high reliability and can dramatically reduce the individual building’s electric demand charges. Often it is a lower cost solution, and eliminates the client facility's need for cooling towers, condensers and chiller plant, improving building aesthetics and increasing the amount of usable or rentable space. District cooling is frequently combined with district heating and central steam systems. The same boilers used for winter heat provide central cooling.

**MINNEAPOLIS DISTRICT SERVES 40 BUILDINGS**

There are dozens of these systems in the United States and Canada. One example of a highly successful system is the NRG Energy Center Minneapolis, which encompasses a 140 square block area in downtown Minneapolis and serves 40 cooling customers including the Hubert H. Humphrey Metrodome, the Federal Reserve Bank, the U.S. Courthouse, the IDS Center, and many others. The system serves 22 million sq. ft. of customer space and operates approximately 40,000 tons of steam-powered cooling capacity. The natural gas supplier is CenterPoint Energy.

**CONSIDER SWITCHING TO CENTRAL PLANT COOLING**

For operators of multiple buildings in geographic proximity, and for operators of central heating or steam districts, it could be that offering central plant cooling can be a real success. As energy costs rise and the expectation of a reliable cooling system increases, now is a good time to consider establishing or enlarging a natural gas-powered steam cooling plant.

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**District Cooling Customer Electric Demand Profile**

This graph shows the changed electric energy use pattern of a 350,000 sq. ft. office building in Cleveland, OH. Two electric chillers were replaced by central cooling. Actual peak kW meter readings varied just 2% between January and July.

Illustration courtesy of the International District Energy Association

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For More Information

- Carrier
  www.carrier.com
- International District Energy Association
  www.districtenergy.org
- Thermax
  www.thermax-usa.com
- Trane
  www.trane.com
- York International
  www.york.com
The search for energy efficiency
In commercial laundries—Finding ways to improve

The commercial laundry industry is an energy-intensive business that looks for opportunities to reduce operating overheads by using energy more efficiently. Most people do a large part of their personal laundry at home, yet there are flourishing commercial laundries that do healthcare linens, restaurant linens, towels, and custom personal laundry of all types. Clothes that cannot be machine-washed go to a dry cleaner that is often part of the same business. In addition, there are thousands of institutional laundries for universities, hospitals, and correctional facilities.

The areas with the greatest energy savings are the steam cycle—the feedwater, boiler, distribution, and condensate return systems. Major opportunities also exist in water heating, heat recovery and water recycling.

Craig Simons from Marine Specialty Co. said the areas with the greatest energy savings are the steam cycle—the feedwater, boiler, distribution, and condensate return systems. Major opportunities also exist in water heating, heat recovery and water recycling.

Simons said many steps are taken to make the typical laundry steam system more efficient without major capital expenditure. “This can be as basic as finding and correcting steam leaks, and adjusting boilers and pumps to operate...”

A 10 hp ThermoSteam boiler — the type widely installed today by laundry and dry-cleaning businesses.

AT A GLANCE
❯ Finding steam leaks and improving insulation
❯ Avoiding pipe scale losses
❯ Water treatment crucial for boiler life, efficiency
❯ Boiler replacement pays for itself
❯ Consider direct-contact for water heating

ENERGY-INTENSIVE BUSINESS
Commercial laundries use energy in a variety of ways, including water heating, steam for pressing and other laundry processes, heated air for clothes drying and drycleaning, and motor power for the large machinery involved in so many parts of the process.
at optimal levels.” For example, he said, a 1/32 in. leak in a 100 psi steam line costs the operator 4.5 lbs of steam per hour, or about $135 per year. A leak twice this size costs four times as much.

Another area that Simons highlighted is pipe insulation. “Many laundries were built years ago, when energy costs were not as critical. We often see long runs of uninsulated or only thinly insulated steam pipe or condensate return. Just 1 in. of insulation cuts the energy loss by 75 to 80%—even more in outdoor installations.”

STARTING WITH THE BASICS
This opinion is echoed by Steve Katz of ThermoSteam Systems, South Bend, Ind. His firm is a manufacturer of boilers that are used in the laundry and dry cleaning industries. “If you’re serious about reducing energy consumption in your laundry facility, you can start with the basics. Review the piping system to make sure it is appropriate for current operations. Insulate all steam and condensate return piping, and systematically find and correct all the steam leaks in the system,” Katz said.

A second area is the system steam traps. Steam traps serve the dual purposes of removing non-condensable gases from the system, and allowing the quick and efficient return of condensate. Simons said that many systems are built with the least expensive steam traps, which are often not the most efficient or reliable.

Simons recommended having a steam system expert perform a complete inspection of all the steam traps, making adjustment or replacement where appropriate. The traps should be inspected annually to ensure that they are operating correctly.

REGULAR INSPECTIONS FOR BOILERS
Boilers are at the heart of the mechanical plant at most commercial laundries. Katz indicated that it should regularly be inspected and when necessary, cleaned and adjusted. He said that to maintain operating efficiency, the typical laundry boiler should be descaled every one to two years. “Also you need to perform a boiler blowdown at least every day. This is probably the single most important step in avoiding pipe scale.”

Katz emphasized the efficiency penalty of scale in boiler tubes. “You have a 15% reduction in efficiency with just a 1/16 in. of boiler tube scale, and a 39% reduction with a 0.25 in. You have to work hard to prevent that from happening.” He noted that in addition to the daily blowdown, feedwater treatment is critically important.

CRUCIAL FEEDWATER TREATMENT
Because of its dominant influence on boiler tube and steam line scaling, owners need to pay special attention to feedwater. Even without system leaks, system water is continually lost through steam use in such operations as clothespressing, and through boiler blowdown.

David Picou, a water care specialist from Ecolab, indicated that without careful attention to boiler feedwater quality, boiler operators run risks from both scaling and corrosion. Corrosion risk increases as the feedwater pH goes below 10.0. “We suggest holding a pH between 8.3 and 10.5. “The water in the boiler itself should be controlled within a pH range of 10.5 and 12; this prevents corrosion inside the boiler.”

![Effect of Pipe Scale on Energy Needed for Steam Generation](chart.png)

- 15% more fuel required with 1/16" scale
- 20% more fuel required with 1/8" scale
- 39% more fuel required with 1/4" scale
- 55% more fuel required with 3/8" scale
- 70% more fuel required with 1/2" scale
REMOVE CALCIUM IONS TO PREVENT SCALE
Additionally it is important to treat the water to remove calcium ions, which promote scaling. This is accomplished with ion-exchange systems that soften the water by replacing calcium ions with sodium, which normally stay in solution rather than contributing to the formation of scale.

Picou said, “The most common problem in feedwater is lack of complete oxygen scavenging and subsequent boiler tube failure from oxygen pitting.” He pointed out that putting in an aggressive boiler water treatment program can pay for itself quickly. The savings come both from extended equipment life and the prevention of energy-robbing scale on boiler tubes.

Picou noted, “The savings in natural gas consumption (from having no scale on the heat transfer surfaces), make-up water and sewer discharge costs (reduced water usage from proper boiler water chemistry and control) would pay for the pre-treatment and chemical programs and still have excess savings.” He suggests that adding a comprehensive water treatment program for a 50 hp boiler will produce annual savings of up to $35,000 per year.

According to Simons, perhaps the single area that represents the greatest opportunity for efficiency improvement is the condensate return system. “It’s already hot, it’s already treated with chemicals, so you want to get it back to the boiler as quickly and as hot as possible.” This is why insulating condensate lines is important, and why assuring the correct operation of steam traps is critical. He emphasized, “Hot condensate is like gold.”

CHECKING BOILER EFFICIENCY
The experts also stressed the importance of checking the operating efficiency of the boiler. Katz said, “You can do a flue test, and you should. But that only measures the combustion efficiency of the boiler, not its efficiency at producing steam. You also need to measure steam production in relation to gas use, or in-service efficiency.” To do that you need to be able to measure gas flow and steam flow. Katz indicated that most laundry operators would have to have an energy expert perform that test. He suggests also performing a stack test to look for energy lost in the stack.

PAYBACK FOR BOILER REPLACEMENT SHORT
According to both Simons and Katz, in many cases it is most cost-effective to replace an older boiler with new equipment. Simons pointed out that new boilers are generally more efficient. Part of that comes from advanced control systems. “New controls allow you to continuously check operating efficiency, and often include diagnostics that will alert you when service or adjustment is required.”

Simons noted that the useful operating life of a boiler in a laundry/dry cleaning business ranges from 15 to 30 years, depending on initial quality and the maintenance history. “For many operators, this is a major capital expense, but often at today’s energy costs, the payback for a replacement is short.” He adds that newer boilers are generally more compact and sometimes have additional features such as two-level firing modes that improve operating efficiency.

BOILERS DESIGNED FOR LAUNDRY APPLICATIONS
Manufacturers such as ThermoSteam and others offer boilers ideal for the modern laundry/dry-cleaning business. ThermoSteam has models ranging in size from 9.5 to 90 hp, in vertical configurations to minimize floor space, and with advanced burner controls and integrated internal return tanks. These boilers are pre-piped and wired at the factory for rapid installation.

Unrelated to the boiler system, but another important area for improved thermal efficiency in commercial laundries is heat recovery from wash water. Simons said a growing number of commercial laundries are installing washwater heat recovery. Used wash water is sent through a heat recovery unit—typically a plate-and-frame unit—before being discharged or sent to a water recycling unit. In the heat recovery unit, the thermal energy typically is used to preheat wash water. Simons indicated that these installations typically have a payback period of less than a year and are rapidly growing in popularity, even for small commercial laundries.

DIRECT-CONTACT WATER HEATING
Increasingly, laundries are turning to direct-contact water heaters for their rapid response capabilities and higher energy efficiencies. Gas-fired direct-contact systems have efficiencies up to 99%. Such systems help reduce the load on the plant boiler and operate efficiently over the full range of water usage.

For both institutional and commercial laundry operations, rising energy costs have stimulated interest in improving process efficiency. Typically, energy represents 15% to 20% of the total cost of operation, so this emphasis is correctly placed. The boiler and steam system and wash water heat recovery are usually the single best targets for energy efficiency improvement. Now is a good time to look for help making these improvements.
A recent report by the U.S. Department of Energy (DOE) indicates that approximately two-thirds of the thermal energy used to generate electricity is discarded in the form of waste heat. The report points out that combined heat and power (CHP) systems—also called cogeneration—recover a large portion of the heat used for electric generation, thereby reducing energy usage. About 7% of the electricity generated in North America is from CHP systems.

ORGANIZATIONS PROMOTING CONCEPT
Many government and industry organization are pressing for an expansion of CHP applications. In the United States, the U.S. Clean Heat and Power Assn. plays an active role in educating and promoting appropriate CHP installations. In Canada, COGENCanada is a similarly chartered organization committed to promoting CHP installation through promotion, training, and interaction between private and government organizations. The Energy Solutions Center has been active in promoting the advantages of CHP in both countries.

DOE stated the industrial sector offers the greatest potential for near-term CHP growth. Large industrial CHP systems are used widely in the petroleum refining, petrochemical, and pulp and paper industries. A DOE report noted, “Thousands of boilers provide process steam to a broad range of U.S. manufacturing plants. This offers a large potential for adding new electricity generation between 50 kW and 25 MW by either modifying boiler systems to add electricity generation, or replacing the existing boiler with a new CHP system. Small manufacturers represent an important growth segment over the coming decade.”

INDUSTRY LOOKING FOR LOAD FACTOR IMPROVEMENT
The concept is not new, having been used in the heavy industrial sector for many years. However, Foley said that over the last decade, owners have become more aggressive about exploiting the thermal component. “Industrial users have traditionally used CHP systems but until now have been somewhat complacent on thermal load factor—the percentage of thermal power used versus the amount of energy available for recovery.” He said...
that with higher fuel costs, industrial CHP owners need to make sure that they are utilizing the thermal energy as well as the electrical energy output from the CHP system in order to meet return on investment expectations.

Foley said that as a result of rising energy costs, fewer of the marginal CHP projects have gone ahead. “The lower load factor projects have become untenable, but this change also makes for better projects with higher utilization rates,” he said.

NEWER GENERATION EQUIPMENT MORE SUITED TO CHP

Foley also said that newer generation equipment is better suited to CHP, especially in medium and small applications. He said “Reciprocating engine generators have come a long way in the past ten years, combining higher power densities with better fuel/air control, higher efficiency air intake systems and microprocessor controls among other improvements. Newer stationary engine generators from multiple sources are providing up to 40% electrical efficiency (LHV) while also greatly reducing NOx, CO and VOC emissions.” Foley explained that with catalytic after-treatment, these reciprocating engines can also meet emission restrictions in very low emission zones, matching the performance with turbines.

CHP technology using turbines has similarly advanced over the last 10 years. Foley noted that microturbines have begun to penetrate the market for smaller applications where thermal loads are high and emission requirements are very strict. “These units are now available from multiple vendors in sizes ranging from 60 kW to 250 kW,” Foley said. He further points out that on the larger equipment side, Solar Turbines has developed the Mercury recuperated combustion turbine, which offers both high electric and thermal efficiency in a single, low-emission package.

BETTER EQUIPMENT TO EXPLOIT THERMAL RESOURCES

Not only has the performance of electric generation equipment improved, but more technologies have become available for the efficient usage of the thermal resource. Most notably, cooling equipment is now available so that the thermal output of engines can be more fully utilized. This allows the byproduct heat output to be used in the summer as well as in the winter. Technology developments in this area include low temperature single-stage absorption chillers, ammonia absorbers, adsorbers, liquid desiccant systems, and improved steam turbine chillers with higher efficiency.

UCONN COGENERATION PLANT

An example of a modern combined heat and power plant is a new facility at the main campus of the University of Connecticut in Storrs (UCO). Faced with rising energy costs and a rapidly growing campus, the University began construction of a 25 MW cogeneration plant in 2003. The plant went online in 2006 at a cost of about $80 million.

For electric generation the plant uses three 7.5 MW Solar Taurus 70 gas turbines, which normally run on natural gas but can use fuel oil as a backup. According to energy plant manager Ronald Gaudet, the exhaust from the turbines, which runs as high as 900°F, goes to heat recovery steam generators (HRSGs) to produce both high pressure and low pressure steam. Gaudet noted that UConn could have had the benefit of somewhat higher operating efficiency by using a single large gas turbine. But, he says, that would have come at the price of somewhat lower system reliability. “We wanted the redundancy from having three generating units.”

STEAM PROVIDES HEATING AND COOLING

The high-pressure steam coming from the HRSGs at 600 psi is used to power a single-stage Dresser Rand steam turbine that powers a generator rated at 5 MW. The low-pressure steam as well as exhaust steam from the turbine supplies campus heating. During the warmer months when heating loads are greatly reduced, the steam powers three 2,100-ton York steam turbine chillers.

These chillers provide chilled water for campus building cooling. Gaudet notes that in addition to comfort cooling, a small portion of the chilled water serves heat exchangers that reduce gas turbine inlet air temperature during hot weather. This allows the turbines to continue to operate near peak capacity when they would otherwise be derated by warm inlet air.

PROFESSOR LED MOVE TO CHP

Gaudet credits UConn mechanical engineering professor emeritus Lee Langston with helping to guide plans during the study of this cogeneration option, and for encouraging the University to take the step. “He really helped us understand the possibilities of cogeneration.” Langston wrote a feature article on the project in the December 2006 issue of Mechanical Engineering magazine.

In the article Langston describes the long process of moving toward cogeneration, as well as the specific features and benefits of the project as finally built. He noted, “A financial study done by consultants during the plant’s planning phase shows definite savings over the long run.”

Industrial energy users can benefit from the same economies resulting from using the otherwise-wasted thermal component of electric generation. Foley and others recommended that the CHP facility be sized to match the site thermal load. CHP is not the right solution for all energy users, and careful study should go into the decision. Gaudet said that potential users should visit operating CHP facilities and learn from their operators. “These are complex facilities, and not every organization has the staff or commitment to take this step. But for the right site, CHP is a beautiful solution.”

For More Information

COGENCanada
www.cogencanada.org
DOE Distributed energy information
www.eere.energy.gov/de/chp/chp_applications/information_resources.html
Integrated CHP Systems Corp.
www.icbps.com
Mechanical Engineering magazine article
www.memagazine.org/doc/06/features/campusphp/campusphp.html
U.S. Clean Heat and Power Assn
uscpaadmgt.com
In an ideal application for backpressure turbogenerators, Morning Star Company in Williams, Calif. uses three units to reduce the pressure on system process steam and thereby also generates 3 MWe to meet most of their plant needs. This application shows the bright energy-saving possibilities for this technology.

**BOILER PRESSURE OFTEN HIGHER THAN NEEDED**

In many industrial facilities, it is usual to have boilers that produce steam at higher pressures than are needed for some or all of the process applications. Generating steam at a higher pressure than needed for plant applications in some cases reduces steam distribution costs. The common practice is to use pressure-reducing valves (PRVs) near the point of use to reduce the pressure to the level needed for those applications.

But generating higher pressures than needed then using PRVs comes at the expense of higher fuel costs. PRVs effectively reduce pressure, but increase the amount of energy needed in the boiler. An alternate approach that is increasingly being employed is to use backpressure turbogenerators. These reduce steam pressures downstream of the boiler while supplying useful electric energy for plant use, thus reducing energy costs.

**SAME PRINCIPAL AS UTILITY MACHINES**

The turbogenerator operates on the same principle as the large machines used by electric utilities at steam power plants. Shaft power is produced through a nozzle directing steam onto the blades of the turbine’s rotors. The rotating shaft turns an electric generator. The energy used causes a reduction in steam pressure as it expands through the turbine. Unlike electric utility turbines, with a BPTG the pressure of the steam is not fully taken down to condensing levels, but is reduced only partially to a pressure suitable for local use. The electric energy produced can be directed to a specific process or comfort system, or can be connected to the general plant power grid.

Dresser-Rand is one of the major manufacturers of backpressure turbogenerators. According to company spokesman Mike McGuinness, the technology has been available for many years, and is common in many industries. Owners of industrial facilities continue to install these systems today. With rising energy costs, some foresee an increase in the application of this technology.

**CERTAIN INDUSTRIES HAVE GOOD OPPORTUNITIES**

According to McGuinness, backpressure units commonly are used in lumber and paper industries, and in institutions like universities and hospitals. He added, “But any industry that has a boiler and a PRV system could benefit from a backpressure turbogenerator set.”

McGuinness noted that most installations are done in parallel with a PRV, so the turbogenerator can be taken out of service for maintenance or any other reason without affecting the steam application. He indicates that experience has shown the turbines and generators to be quite reliable, with minimum maintenance needed.

McGuinness suggested that it is common for these units to run for three years without shutting down. “As long as the unit is supplied with good quality steam and the oil quality is good, it requires little maintenance.” The unit normally does not require an attendant.

This is echoed by Darren Schaperjohn at Hexion Specialty Chemicals in South Glens Falls, N.Y. “We have a 450 kW machine using 110 psi steam that operates 24 hours a day, five days a week. It requires very little maintenance. We change the oil every three months, and periodically check the bearings. That’s about it.”
INVESTMENT PAYBACK LESS THAN TWO YEARS
According to both McGuinness and Kempland, the investment payback for an appropriately sized unit can be less than two years, and payback periods of 2-3 years are common. Dresser-Rand’s McGuinness said, “It depends on the cost of electricity. If the infrastructure (boiler and PRV) is already there, and if there is a fairly consistent flow of steam going through the PRV, energy is being wasted.” He indicated that the more hours per year the turbogenerator set is on line and generating power, the better the economics.

According to Kempland, increases in electric rates and projections for long term rate increases are making projects economically feasible that may not have been previously. Kempland added, “Furthering that trend are the states—including New York, New Jersey, Pennsylvania, Texas, Oregon, and California—that also provide incentives. Many state programs will pay up to 30% of the installed cost of a steam turbine generator set.”

MULTIPLE SIZES, DESIGNS AVAILABLE
Backpressure turbogenerators are available in a wide range of sizes. Turbosteam has done projects as small as 50 kW and as large as 15,000 kW. Depending on the application, the systems can be single-stage or multi-stage turbines, with either induction or synchronous generators. All packaged systems by Turbosteam are custom engineered, including the programmable logic controls.

MIDDLEBURY COLLEGE SEES OPPORTUNITY
In addition to industrial applications, another common installation of back-pressure turbogenerators is at colleges and universities. For example, Middlebury College in Vermont equipped each of their boilers with backpressure steam turbine generator systems designed by Turbosteam. These units today provide electric energy for campus use.

According to Michael Moser, Middlebury’s central heating plant manager, “The college recognized the opportunity to extract useful energy from the steam in the process of reducing it to our application levels of 22 psig or lower (from 125 psig or 222 psig depending on the boiler).”

INDUSTRIAL USE IN FOOD PACKING INDUSTRY
In the example cited at the beginning of this article, Morning Star Company, a California food processor, has discovered the opportunities presented by BPTGs. According to Morning Star spokesman Bob Smith, the three 1 MWe units at the plant use saturated steam at 450 psig from four Nebraska A-type water tube boilers. Two of the units reduce the steam to 120 psig, and the third to 30 psig.

“Being in California, we have high electrical costs and reasonable natural gas costs in the summer. As an evaporation plant we have high thermal needs, which fit well with a backpressure turbine. The trick is in the design stage and knowing the loads,” Smith said. He also said that the added pressure for the boilers was a minor adder in cost at the time of construction. “We didn’t install superheat at the time of construction because steam reliability could be an issue with seasonal operations and the added complexity of use under changing loads. Two of the turbines have been in operation since plant construction in 1995, and the third was installed in 1999.”

MEETS MOST PLANT ELECTRIC LOADS
The electrical output from the generators goes to the main distribution panel, and it supplies most of the plant electrical load. Smith pointed out, “For operational reasons we maintain 200 kW to 300 kW import from the utility, but that has been a source of grief when the utility has unusual outages. We have run totally islanded (separated) from the utility for extended periods—up to a week or more.

The Morning Star experience is an example of how energy-intensive industries can use BPTG technology to avoid the energy losses from PRVs and can meet part or all of their electric load from internally generated steam. It’s an idea worth considering.
From the time the U.S. Dept. of Energy’s (DOE) Save Energy Now program began in 2005, teams have completed energy assessments at 344 industrial plants throughout the United States. The assessments focus on energy-intensive systems such as compressed air, fans, pumping, process heating, and steam.

According to DOE spokesman Luke Nickerman, if the assessed plants fully implement the recommendations, the plants will reduce their energy bill by more than 7% on average, averaging $2.5 million per year. From an emissions perspective, this translates into a potential CO$_2$ reduction of nearly 4 million tons per year.

Each assessment is a detailed on-site review by a team that includes a trained energy expert and a representative of the reviewed plant.

**PROCESS EXPANDED BEYOND STEAM SYSTEMS**

Initially, the assessments focused on steam systems and process heat applications. Based on the experiences of the reviewers, the process was expanded in 2006 to include compressed air systems, pumps, and fan applications.

He said that the program is on track to reach its goal of doing 250 assessments in 2007, and plans to do an additional 250 in 2008.”

**CLIENTS PLEASED WITH ASSESSMENT RESULTS**

Nickerman indicated that the recommendations have been enthusiastically received by private industry clients. “They frequently comment on how amazed they are at how efficiently the program operates.” He said that some participating companies have done similar experiments in other plants. “This is something we love to see. The program is predicated on the idea that we are helping industry get started, not holding their hand through the entire process.”

From the beginning, DOE has emphasized that Save Energy Now needs to be a program that offers concrete recommendations that can and will be adopted quickly. Of the $586 million in potential energy savings identified to date, $75 million have been implemented, $66 million are underway, and $189 million are scheduled.

**FINDING WAYS TO WORK WITH STATES**

As the Save Energy Now program has developed, DOE has begun looking for partnership arrangements to create synergies with states. An example is a new program that the DOE is developing with Wisconsin. Under a partnership agreement, DOE will use its protocols, experts, and tools and the state will cost-share and help in the implementation of the results.

**OKLAHOMA PLANT TAKES THE STEP**

An example of the program method and actual achievable results is an assessment done by the Terra Nitrogen Co. In early 2006, the company received a Save Energy Now Assessment at its ammonia and fertilizer plant in Verdigris, Okla. The plant is served by Oklahoma Natural Gas Company, a division of ONEOK.

The assessment was done by DOE energy expert Veerasamy Venkatesan of VGAEC Inc. A team was formed to also include two plant employees. As part of the assessment process, the team used DOE’s steam system assessment tool (SSAT) software.

The team identified some important opportunities to improve the steam system’s efficiency. The recommendations ranged from near-term relatively simple changes in operations to longer-term opportunities for plant modifications. The team examined the boiler in an ammonia plant and found that all of the boiler’s coils were dirty and one was leaking. The team estimated that cleaning and repairing the coils could improve process efficiency by 0.3 MMBtu/ton. The team also evaluated the condensing turbines in the plant and decided to overhaul the turbines by changing the rotors, cleaning the cooling units, and replacing the low-pressure steam ejector nozzles during a 2007 plant shutdown for maintenance. These modifications have been completed.

The aggregate annual energy and cost savings resulting from these and other measures is approximately 497,000 MMBtu and more than $3.5 million. With project costs of around $3.1 million, the plant achieved a simple payback in less than 11 months.

This project exemplifies the opportunities that are being found with Save Energy Now. This is one government program that is paying dividends in dollars and energy saved. For more information, go to www1.eere.gov/industry/saveenergynow.