New CHP opportunities abound—with lower capital investment, less risk and greater flexibility

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Call it a tale of two companies.

Company A and Company B compete in the same light process industry and manage three-shift operations. By coincidence, managers at both firms decide to evaluate combined heat and power (CHP), also known as cogeneration.

Company A takes the classic view: A large generating system, operating around the clock at full load, using natural-gas-fueled engine-generator sets, recovering the maximum heat from engine exhaust and jacket water circuits.

Management applies the traditional formula of equipment capital cost, depreciation, maintenance, fuel consumption, heat and electric loads, natural gas price, electricity price and energy costs avoided.

Decision: Not feasible. There isn't enough heat load to use all of the hot water and steam, all of the time. And besides, gas and electricity prices aren't fixed, as they were in the days of regulated utility monopolies. As a result, the system makes quite a bit of money in the daytime, and gives most of it back at night, on weekends and on holidays. In light of that, the economics are not favorable.


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Company B looks at things differently. Management finds that on-site power generating capacity installed and operated under a utility-sponsored load-control program can provide an extra measure of electricity price stability. During on-peak periods, the company can run its gas-fueled engine-generators whenever the real-time market price exceeds the in-house generating cost.

The project makes economic sense on that basis alone. Then management learns that a simple heat exchanger can capture low-grade heat from the engine coolant for space and water heating in winter and for absorption cooling in summer. The incremental cost is just a few thousand dollars. Now the economics look even better. Decision: Proceed. Company B now has a competitive edge.

Wave of the future

In today's markets, especially in North America, growth in CHP is most likely to follow the Company B scenario. Large-scale CHP still has its merits: It will prosper in large-heat-load applications worldwide, especially in places where governments incentivize systems that deliver high overall thermal efficiency, as they do in Europe today.

But elsewhere, limited-scale, intermittent-duty systems are likely to have the largest opportunity for growth of the CHP sector, especially for the near term. That is simply because users that have the capability to use simple CHP processes are at the core of the growing distributed generation market.

By its very nature, distributed generation encourages utilities and their customers to pursue cooperative ventures that add total grid capacity, enhance power quality, and maximize reliability—all at competitive cost. Increasingly, end users and utilities alike recognize the advantages of distributed generation.

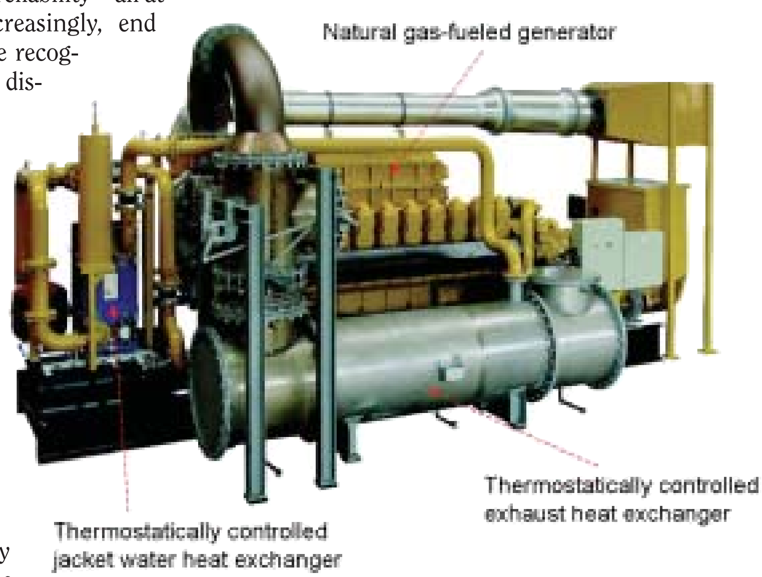
For end users, on-site power systems that carry loads during peak-demand hours provide leverage over electricity prices in sometimes volatile markets. Utilities, meanwhile, can use distributed generation to increase capacity, manage demand peaks, and improve service quality while postponing the cost and financial risks that go with large, centralized power plants and the related transmission infrastructure.

Distributed generation has the added advantage of allowing the utility to aggregate multiple small-scale, low-cost assets and sell the power on exchanges at higher market prices.

A decade ago, most distributed generation systems consisted of diesel-fueled engine-generators, hosted by a large user-owned facil-ity or by a public utility. These systems typically operated just a few hundred hours per year to augment the investor-owned utility's generating capacity at coincidental peak times each month, or on the hottest and coldest days of the year.

Today, utilities look to distributed generation to support a larger portion of the load curve. The trend is toward systems operating for 700 to 3,000 annual hours, and the fuel of choice is natural gas because it is more readily compliant with air-quality regulations.

The prospect of adding CHP capability to such a system, at a relatively low cost and with minimal financial and technical risk, can make distributed generation even more attractive to power users. The key to growth in this sector lies in power users and utilities working together to design generating systems and structure contracts in ways that meet each party's business objectives.



Reprinted with revisions to format, from the August 2003 edition of **ELECTRIC LIGHT & POWER**

Getting beyond stereotypes

CHP has obvious environmental and economic benefits, delivering higher resource efficiency and fewer air pollutants per unit of fuel than separate power generation and heating systems. Total system thermal efficiency of 95 percent or more is technically possible; system efficiencies from 75 to 85 percent are more common and can be achieved at reasonable cost.

European countries have used CHP for many years in industrial process applications and for district heating—electric power production with recovered heat collected and circulated locally to heat homes and businesses. Hundreds of multiple-engine CHP systems, delivering more than the 86 percent thermal efficiency required to qualify for government incentives, operate in Europe today.

However, despite its clear advantages, CHP has not yet gained universal acceptance as a mainstream energy strategy worldwide. The concept became popular in North America in the 1960s and early 1970s as federal tax incentives encouraged what then was commonly called total energy. However, interest waned when the tax incentives disappeared.

Since then, CHP has been largely misunderstood and far too narrowly defined. The stereotype holds that CHP projects work financially only:

- In facilities with large, continuous process heat loads and with generating equipment that operates at full load, around the clock.
- In limited geographic areas where electric rates are high and gas prices low.
- With large generating equipment using complex heat-recovery systems that consistently extract the maximum heat from engine jacket water and exhaust.

Those issues aside, a given CHP cogeneration project can face several technical and market barriers. Strict air-quality standards can be a deterrent. Some prospects hold back because uncertainties in restructuring of the electric power industry make economic returns difficult to predict.

In other cases, power users face restrictive requirements and high costs for interconnecting with the electric utility grid. Finally, power projects can face difficulties in meeting local zoning, building and fire protection codes or noise and aesthetics ordinances.

Gaining support

Recently, as governments address concerns over air quality and the prospect of global climate change, the political tide has turned in favor of CHP.

In the United States, the U.S. Combined Heat and Power Association (USCHPA) worked with the federal Department of Energy (DOE) and the Environmental Protection Agency (EPA) to produced a National CHP Roadmap. It outlines an ambitious plan to double the nation's CHP output by adding 46 GW of new electric power generating capacity with CHP before the end of the current decade.

Similar initiatives are underway elsewhere. In the European Union, where some countries use primarily reciprocating engine-driven CHP systems to produce more than 25 percent of their electricity, the European Commission last year proposed a CHP Directive, defining specific policies to promote CHP growth.

In India, the Ministry of Power has estimated total potential for 15 GW of CHP capacity by 2012, versus just 2 GW installed in the country to date. In Japan, the General Energy Research Council has produced targets for future energy production that include 4.65 GW of natural-gas-fueled CHP by 2010.

Meanwhile, work continues on new, more efficient reciprocating engine generating technologies that can help make distributed generation and CHP more economically attractive. The DOE's Advanced Reciprocating Engine Systems (ARES) program, implemented by a consortium of generator set manufacturers, universities and research laboratories, aims to develop cleaner, more efficient gas-fueled engines, largely for the distributed generation and CHP markets. The goal is to produce engines with significantly lower installed cost, higher thermal efficiency, lower engine emissions and lower maintenance costs than any engines available today.

The first ARES engine-generator sets, now commercially available, can achieve simple-cycle mechanical efficiencies up to 43.5 percent without heat recovery, vs. 32 to 37 percent just a few years ago. The addition of heat recovery can dramatically improve total system efficiency and enhance return on investment.

A new approach

In the midst of all this change, utilities and power users are rethinking the definition of cogeneration. Defined broadly, cogeneration is simply the simultaneous and sequential use of power and heat from the same fuel source. Nowhere is it written that a cogeneration system must operate continuously at full load and extract all available heat from the generating source in order to be cost-effective. The only absolute requirement is that the value of heat recovered outweigh the incremental cost of the heat-recovery mechanism.

From that perspective, power planners are finding that limited-scale CHP lends itself exceedingly well to today's limited-duty, engine-driven distributed generation systems.

Traditional CHP favors industries with large process heat loads: chemical processing, pulp and paper, electronics manufacturing, textiles, food processing, electroplating, pharmaceuticals, and agricultural and forest products. But limited-duty CHP with less intensive heat recovery can benefit a wide range of other industries, as well as commercial office buildings and institutions such as hospitals and colleges.

In these applications, there is no need to invest in exhaust heat recovery systems that have higher engineering, equipment and operating costs. A low-cost, single-pass shell-and-tube heat exchanger connected to the engine cooling system can produce hot water at 180° to 225° F. That hot water is completely suitable for applications such as:

- Space or domestic hot water heating;
- Seasonal cooling (by way of absorption chillers);
- Desiccant dehumidification;
- Heat for light production processes;
- Process cooling; and
- Condensate or make-up water preheating for boilers.

The financial picture

The key to CHP in distributed generation projects is that heat recovery is added to a project that already makes economic sense purely from cost savings on electric energy and demand. Starting from that point, it is easy.

It is relatively simple to calculate the incremental benefits of CHP. Suppose the owner of a major office building enters a distributed generation contract with a utility that calls for operation of gas-fueled generator sets five days per week during business hours.

If the owner can self-generate at five cents per kWh, vs. purchasing energy at seven or eight cents per kWh, then the generating equipment in itself provides an attractive return. If heat recovery from an inexpensive jacket-water heat exchanger can then offset part of the cost of fuel for space heating, water heating or dehumidification, then return on investment improves.

Now consider a small or mid-sized manufacturer with an on-site generator set and a hot-water load amounting to roughly one-third of the heat recoverable from the engine cooling circuit. A heat exchanger installed in the engine's cooling system loop, with a thermostatically controlled diverter valve to regulate the flow to the in-plant load, could cost-effectively satisfy the hot-water requirement.

An automotive parts plant on the East Coast of the United States used such a system with a 1,600 kW generator set operating about 500 hours per year under an already profitable distributed generation contract with a utility. The CHP system yielded an average of $1,800 per year in added fuel savings for a one-time, $7,000 incremental investment in heat recovery equipment. Simple payback was less than four years.

Making it work

Clearly, distributed generation with CHP can be financially attractive for power users. However, many users resist even the basic concept of distributed generation on the grounds that they would rather focus on their core business than become players in the power exchanges. The user does not want to invest limited resources in trying to dispatch and maintain distributed generation resources. In such cases, cooperation between end users and utilities can lead to progress.

Jason Norlen, generation manager with Heber Light & Power based in Heber City, Utah, manages nearly 12 MW of gas- and diesel-fueled distributed generation assets. He counsels new industrial and commercial power users to consider installing on-site generation as a hedge against energy price volatility.

"Volatility is precisely the reason power users need to be doing things like distributed generation," says Norlen. "The only way they can exert control over the market is to have the ability to push a green button. When market prices escalate, they need to be able to dispatch a generator set and shed some utility load."

Norlen observes that monitoring market prices and dispatching generation is far simpler than many end users realize. For example, he and his staff manage power purchases and on-site resource dispatching on an hour-by-hour basis for top 25 percent of daily load using a simple Microsoft Excel workbook created in-house.

Even simpler for the end user would be a distributed generation system remotely dispatched by the utility. Norlen believes end users will be most receptive where utility and equipment manufacturer representatives approach them together with a complete equipment and service package.

"It's a matter of bringing all the parties to the table," Norlen says. "The utility can say to the end user, 'You are bringing a substantial load to us—here is what we would like to see done. You build a distributed generation facility, and add CHP if it makes sense. In return for paying the capital cost, you will get electricity, heat and air conditioning, all from this plant. Now, here are the price breaks you will receive on your electricity if you let our dispatchers control that facility and run it when we need it to run.'"

Whatever its size and scope, a CHP system must deliver a return on investment that suits the user's criteria. To evaluate the economics realistically, owners should first conduct a cost-benefit analysis to decide what forms of heat recovery and what distributed generation operating scheme will deliver the most attractive return.

That issue aside, a CHP project typically must compete for capital with the owner's other business priorities. Many organizations measure economic return in terms of simple payback. However, today's financing vehicles provide alternatives to that approach.

For example, traditional debt financing or leases can be structured with fixed monthly or annual payments costing less than the owner's net savings on energy. In this scenario, the owner sees immediate positive cash flow—a net reduction in operating expenses from the first month the system is in service. Leased equipment has the added advantage of being classified as an operating rather than capital expense. That can help expedite management approvals and take the projects out of competition for capital.

Growth in distributed generation adds an entire new spectrum of opportunities for CHP projects. Limited-duty CHP systems using simple heat-recovery technology greatly simplify the process of cost justification. That, in turn, can help power users take advantage of cost-saving benefits and help achieve society's broader goals of greater energy efficiency and improved air quality. **ELP**

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Devine is the gas product/marketing manager for Caterpillar Inc.'s electric power group. Involved in the field of power generation since 1979, he has spent the majority of this time working to develop power generation products to serve the load management, distributed power and quality power markets.

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