A BestPractices PUBLICATION ON IMPROVING INDUSTRIAL ENERGY EFFICIENCY

ENERGY MATTERS

Fall 2001

ISSUE FOCUS:
Alternative Power Sources

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Distributed Energy/Combined Heat and Power

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OIT/Utah Showcase Industrial Energy Efficiency

On August 27-29, 2001, OIT and the State of Utah hosted the Utah 2001 Showcase at the Sheraton City Center in Salt Lake City. The event featured several advanced technologies and best practices in three of the most energy-intensive industries: aluminum, mining, and petroleum refining.

The showcase gave six manufacturing plants the opportunity to demonstrate the progress they've made toward improving efficiency, enhancing competitiveness, and reducing pollution. At the same time, the showcase demonstrated to about 400 attendees how a strategic partnership between OIT, the State of Utah, and industry has led to this progress—and how similar alliances can help industries across the nation continue to grow and prosper.

Plants Highlight Improvements

Critical factors, such as the rapid pace of technology change, rising energy costs, and competitive pressures led companies to take part in innovative partnerships that address these challenges. "The Utah Showcase brought focus to the synergy of partnerships with OIT and others," comments Jim Bollenbacher, Vice President of Environment, Health, and Safety for Alcoa's North American Extrusion unit. Alcoa, Kennecott Utah Copper, Magnesium Corporation of America (Magcorp), Chevron, Flying J, and Silver Eagle opened their doors to show what they have accomplished.

Aluminum

At the Alcoa Extrusion facility in Spanish Fork, visitors learned about energy efficiency projects, such as a compressed air system upgrade, which could yield energy savings of 1,500 million British thermal units (Btu) per year. As part of Alcoa's corporate energy conservation program, this facility is also evaluating a cooling tower control system, improved dross recovery, regeneration burners, alternative combustion methods, a vertical flotation melter, and advanced sensors.

Mining

Kennecott Utah Copper's showcase gave visitors a look at the immense Bingham mine and the Copperton Concentrator, where copper is recovered from the ore. Through a series of upgrades to its smelting operation, the company saves about 55% in energy use and has also achieved substantial emissions reductions.

Meanwhile, magnesium producer Magcorp showcased an upgraded electrolysis system that has reduced electric energy use by

(continued on page 2) ▶

Plant tours were a highlight of the Utah 2001 Showcase, where six companies demonstrated advanced technologies and best practices in the aluminum, mining, and petroleum refining industries.

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Utah Showcase

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30% and has also reduced maintenance and labor costs. Magcorp's combined heat and power (CHP) system exceeds 75% overall thermal efficiency and the company is evaluating an upgrade for even better efficiency. (See page 1 of this issue's special supplement for more on Magcorp's CHP system.)

Photo courtesy of Alcoa/PIX 10233

A vertical flotation melter demonstration was part of Alcoa's plant tour.

Petroleum Refining

Chevron provided an overview of the plant's furnace efficiency and steam system management efforts and an air system capital project. In addition, Chevron highlighted its gas combustion research project.

Flying J featured several new technologies for saving energy and improving manufacturing efficiency, among them a reverse osmosis unit that will save the company an estimated $200,000 per year. Others include advanced process controls, variable frequency drives for highly throttled pumps, a new compact cracking process, and a plant-wide energy tracking system.

At Silver Eagle, the focus was on new technology in reforming operations and an efficient waste heat boiler system. Visitors learned how Silver Eagle has implemented recommendations from DOE assessments throughout the plant.

To learn more about the participating companies' projects, see the BestPractices case studies on Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra**.

An Exchange of Ideas

Throughout the showcase, participants exchanged ideas with others who are focused on industrial efficiency. In the exhibit hall, more than 40 exhibitors demonstrated advanced technologies and practices. In addition, industry associations, the Utah Energy Office, and DOE staff offered information about partnerships, industry programs, and projects that are ready for plant floor application. During breakout sessions, presenters led discussions on research, plant technologies, business issues, and state initiatives that affect the showcase industries.

Keynote speaker Senator Orrin Hatch (R-Utah) addressed the importance of Utah's industrial sector to the state and the nation. He noted the value of OIT's partnerships with states and acknowledged that the showcase format hastens industry's understanding of new technologies.

During a congressional forum, Utah's three representatives, James Hanson, Chris Cannon, and James Matheson, heard testimony from three panels representing government, industry, and industry associations. Among the panelists was Denise Swink, OIT's Deputy Assistant Secretary, who explained that through the Industries of the Future strategy, OIT helps accelerate new technology application, increases productivity, and helps save energy.

Photo courtesy of Rolf Butters

Industry leaders address Utah congressional representatives at a forum.

Showcase cosponsors were OIT, the State of Utah, the University of Utah, Alcoa, Kennecott, Magcorp, Chevron, Flying J, and Silver Eagle.

Take Part in a Showcase

Learn more about the benefits of hosting a showcase on the BestPractices Web Site at **www.oit.doe.gov/bestpractices/pdfs/showcase.pdf**. Watch *Energy Matters* or visit the BestPractices Web site at **www.oit.doe.gov/bestpractices** for details about upcoming OIT showcases. ●

Increased Efficiency through Waste Heat Recovery from Process Heating Systems

By Richard L. Bennett, President, Janus Technology Group Inc., Rockford, IL

Many industrial heating processes generate large amounts of waste energy that simply pass out the stacks and into the atmosphere. When energy is abundant and cheap, no one seems to notice, but when supplies get pinched and prices climb, people begin to realize just how much of their fuel dollar goes sailing into the blue.

Techniques for Heat Recovery

Stack exhaust losses are part of all fuel-fired processes, and they increase with the exhaust temperature and the amount of excess air the exhaust contains. At stack gas temperatures greater than 1,000°F, the heat that is carried away is likely to be the single biggest loss in the process. Above 1,800°F, stack losses will consume at least 50% of the total fuel input to the process. Waste heat recovery offers a great opportunity to put some of this energy to work, reducing energy consumption and emissions and increasing productivity. There are several techniques for heat recovery, all

Above 1,800°F, stack losses will consume at least 50% of the total fuel input to the process. Waste heat recovery offers a great opportunity to put some of this energy to work, reducing energy consumption and emissions and increasing productivity.

based on intercepting the waste gases before they leave the process, extracting some of the heat they contain, and recycling that heat.

Direct heat recovery to the product. This is the most efficient method. It takes advantage of the fact that even in the highest temperature processes, the product or charge enters the process at ambient temperature. If exhaust gases leaving the high temperature portion of the process can be brought into contact with a relatively cool incoming load, energy will be transferred to the load, preheating it and reducing the energy that finally escapes with the exhaust.

More often, heat is transferred to a surrogate medium, like combustion air to the burner system. This reduces the amount of purchased fuel required to sustain the process. Figure 1 shows how preheating combustion air affects available heat, which is the thermal efficiency of the combustion process itself.

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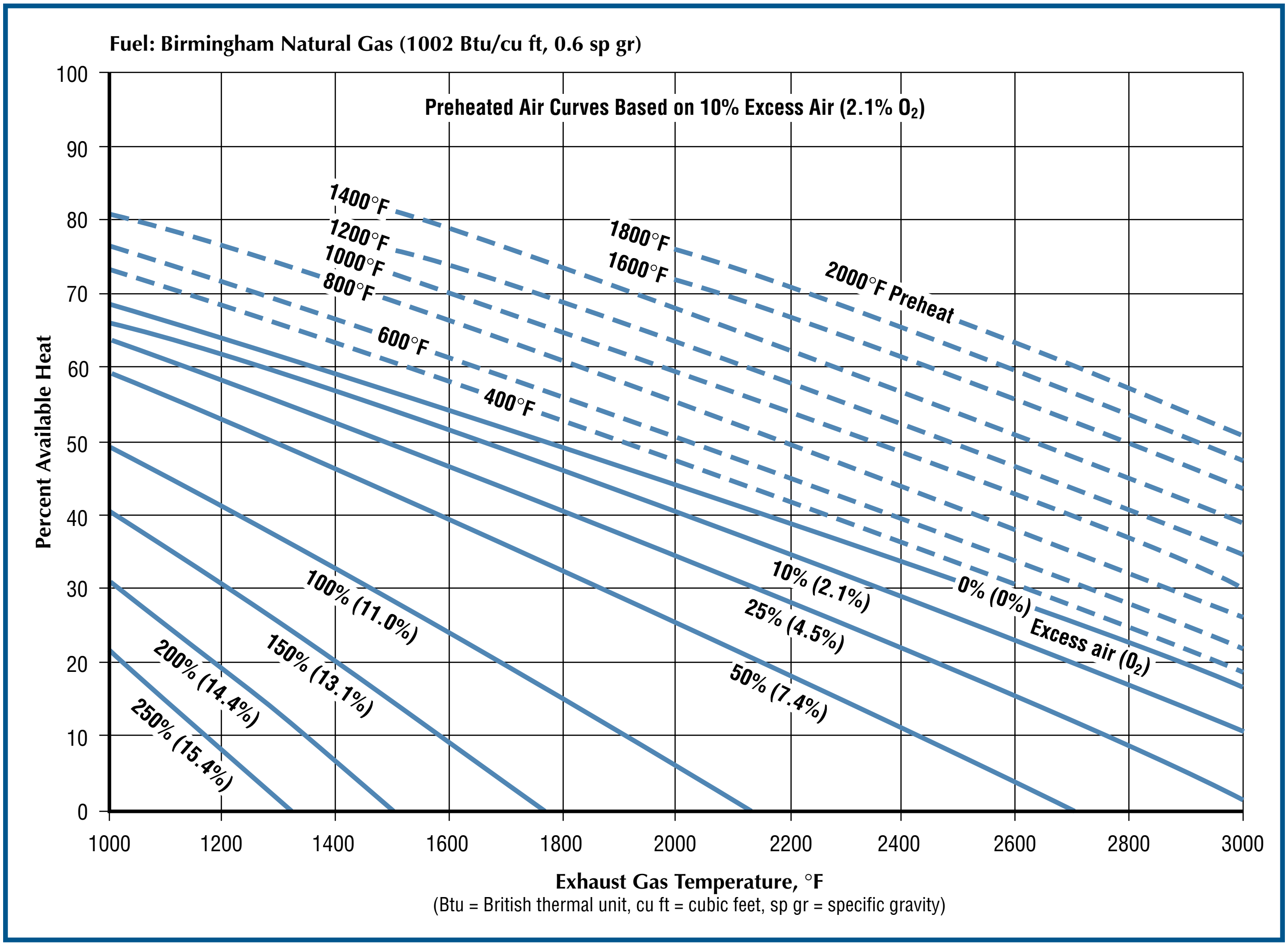

Figure 1. Effects of preheating combustion air on available heat.

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Recuperators. A Recuperator (Figure 2) is a gas-to-gas heat exchanger placed on the stack of the furnace. There are numerous designs, but all rely on tubes or plates to transfer heat from the outgoing exhaust gas to the incoming combustion air, while keeping the two streams from mixing. They are the most widely used heat recovery devices.

Regenerators. These are essentially rechargeable storage batteries for heat. A regenerator is an insulated container filled with metal or ceramic shapes capable of absorbing and storing relatively large amounts of thermal energy. During part of the operating cycle, process exhaust gases flow through the regenerator, heating the storage medium. After a while, the medium becomes fully charged, so the exhaust flow is shut off and cold combustion air is admitted to the unit. As it passes through, the air extracts heat from the storage medium, increasing in temperature before it enters the burners. Eventually, the heat stored in the medium is drawn down to the point where it is necessary to recharge the regenerator. At that point, the combustion airflow is shut off and the exhaust gases return to the unit. This cycle repeats as long as the process continues to operate.

Obviously, if the process is to operate without interruption, at least two regenerators (and their associated burners) are required—one to provide energy to the combustion air while the other is recharging. It is much like a using a cordless power tool—to use it continuously, you must have at least two batteries to swap out between the tool and the recharger.

The fundamental difference between recuperators and regenerators is the way they keep the exhaust gases and combustion air from cross-contaminating each other. Recuperators separate the gas streams with a physical barrier so they can operate continuously. Regenerators operate intermittently, keeping the streams separated by time.

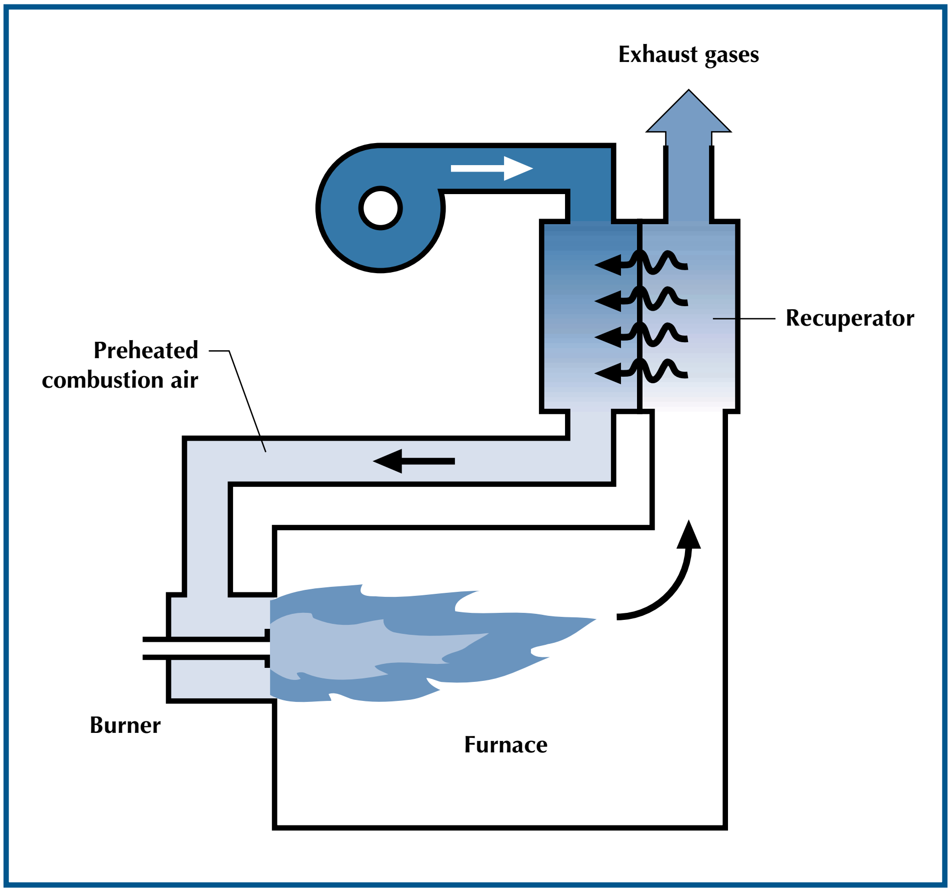


Figure 2. Recuperators transfer heat from outgoing gas to incoming combustion air without allowing streams to mix.

Waste Heat Boilers. Here is an option for plants that require a source of steam or hot water. They are similar to conventional boilers with one exception—they are heated by the exhaust gas stream from a process furnace instead of their own burners.

Making the Choice

How do you decide which recovery technique is right for your operation? In some instances, more than one might fill the bill, but here are some basic points that factor into the selection process.

- Direct heat recovery to the product has the highest potential efficiency, because it doesn't require any "carrier" to return the energy to the product. However, it does require a furnace or oven configuration that permits routing the stream of exhaust gases counterflow to incoming product or materials. This usually rules out most batch-type heating equipment.
- Recuperators are available in the widest range of sizes, configurations, and temperature ranges, and they don't require elaborate combustion control systems. However, they must be protected against overheating damage on high-temperature processes and may not be suitable for some corrosive or dirty exhaust gases.
- Regenerators can operate at temperatures beyond the range of recuperators and at higher efficiency ratings. They are highly resistant to corrosion and fouling, but because of their back-and-forth switching, they require more complex, expensive flow control systems than recuperators do.
- Waste heat boilers may be the answer for plants seeking more steam capacity, but keep in mind the boiler generates steam only when the process is running. Where this is a concern, boilers with auxiliary burners may be the answer. ●

Contact Richard Bennett by e-mail at janustech@compuserve.com, or by phone at 815-282-8044.

Industrial Manufacturers Help Develop Green Power Market

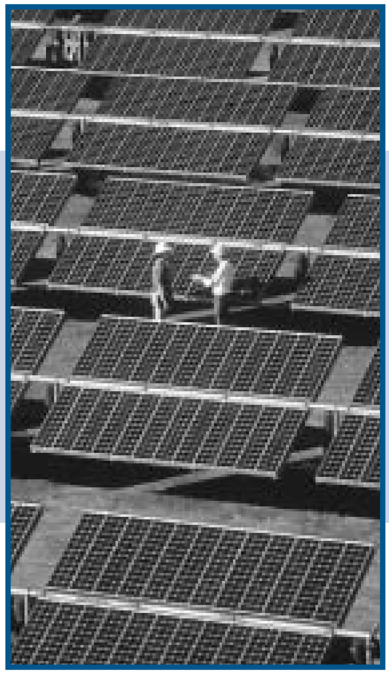
Some industrial operations not only work to improve their bottom lines and increase energy efficiency now, but also look ahead to using clean and renewable (or "green") sources of power, such as wind, solar, landfill gas, and fuel cells. Among the companies exploring these possibilities are Cargill Dow LLC, Alcoa Inc., and DuPont. Working with seven other companies within the Green Power Market Development Group (the Group), they are developing strategies to reduce green power costs, reduce market barriers, and help articulate the business case for green energy use. Other member companies of the Group are General Motors, IBM, Delphi Automotive, Interface, Johnson & Johnson, Pitney Bowes, and Kinko's.

The Group, which is organized by the World Resources Institute and Business for Social Responsibility, acknowledges that green power has substantial challenges to overcome. As corporations work to optimize shareholder value, energy purchases are often made on the basis of price alone. However, not all of green power's attributes have monetary value, and there are some good business reasons for purchasing green power, according to the Group, which says that green power purchases can:

- Protect against volatile fluctuations in fossil fuel prices by providing an alternative to traditional power sources
- Provide financial value from avoided emissions
- Help corporations build leadership and trust in the public eye, while differentiating themselves from the competition.

One of the Group's goals is to work toward a sustainable energy future. Similarly, OIT and BestPractices are facilitating a sustainable U.S. industry by helping manufacturers boost energy efficiency and improve productivity. Learn more by logging on to the OIT Web site at **www.oit.doe.gov/** and the BestPractices Web site at **www.oit.doe.gov/bestpractices/**. To learn more about the Green Power Market Development Group, log on to **www.thegreenpowergroup.org**.

Ray Bleez, NREL/PIX 03890



Sacramento Municipal Utility District/PIX 01026

Warren Gretz, NREL/PIX 00043

Landfill gas, solar photovoltaics, and wind power are examples of "green" energy sources.

Jeff Kolstad, Chief Scientist, Cargill Dow LLC, is the company's representative in the Green Power Marketing Development Group.

Jeffrey Kolstad, chief scientist with Cargill Dow, represents the company in the Green Power Market Development Group. Cargill Dow uses annually renewable resources, such as corn, to produce its polylactide polymer, developed in partnership with DOE. These resins can be used as packaging materials or fibers for textiles, carpeting, and nonwoven applications. To reduce energy-related emissions generated in the polymer production process, Cargill Dow is working with the local utility to buy energy generated from wind or landfill gas.

According to Kolstad, "Cargill Dow is committed to reducing the environmental footprint of its polylactide polymer. Using green power will enable further reductions in fossil fuel use and greenhouse gas emissions, leading to a more sustainable future."

Black Liquor Gasification Expected to Yield Energy, Environmental, and Economic Benefits

Benefits

- *Reduces NO_X, SO_2, CO, VOC, and particulate emissions*
- *Expected air emission reduction of 90%*
- *Replaces existing smelters, eliminating threat of smelt-water explosions*
- *Reduces use of nonrenewable (fossil) fuels*
- *Increases energy efficiency*
- *Decreases capital and operating costs*
- *Provides hydrogen-rich, clean-burning fuel*

Georgia-Pacific (G-P) and OIT have teamed up to study and demonstrate black liquor gasification, which is expected to reduce air emissions by 90%, reduce operating costs, and increase energy efficiency at the G-P containerboard mill in Big Island, Virginia. It will be the first full-scale black liquor gasification system used in the commercial pulp and paper industry. G-P and DOE will share the project cost of approximately $85 million.

The system will replace two 50-year-old smelters and will provide the entire chemical recovery capacity for the G-P mill. It has potential for industry-wide applications to replace Tomlinson recovery boilers, which are the energy-intensive industry standard. The process is suitable for all pulping processes—carbonate, kraft, sulfite, nonwood, and others. Although the technology initially requires a higher capital investment, it will provide capital returns from reduced energy demands and help the forest products industry meet increasingly stringent Environmental Protection Agency (EPA) regulations.

Promising New Technology

Black liquor is a spent product of the chemical pulping/digesting process and a source of energy for the papermaking industry. Black liquor gasification, the conversion of leftover black liquor into a clean-burning fuel for use in burners, boilers, and gas turbines, is a promising new technology for reducing air emissions and increasing energy efficiency in the pulping process. The G-P project will employ a reactor in which tubes, heated by pulses of fired gas, are immersed in a mixture of sodium carbonate and spent black liquor. The pulsing enhances a heat exchange between the tubes and the mixture, which promotes the chemical reactions that produce the fuel. This process will treat all of the 400,000 pounds of black liquor solids that the mill produces each day.

The process differs from other technologies because it does not require partial oxidation of the liquor inside the gasifier. Its lower temperature allows the gasifier to convert black liquor organic material to gas at temperatures well below those required for smelt formation, eliminating the danger of smelt-water explosions in the recovery boiler. This equipment will maximize the recovery of energy and chemicals while producing a medium Btu fuel gas (200 to 300 Btu/scf [standard cubic feet]).

Demonstration Phases

The project is being conducted in two phases. Phase I focuses on validating the process design and solving any technology gaps. Phase II will focus on completing the engineering and construction and functional operation of the new system.

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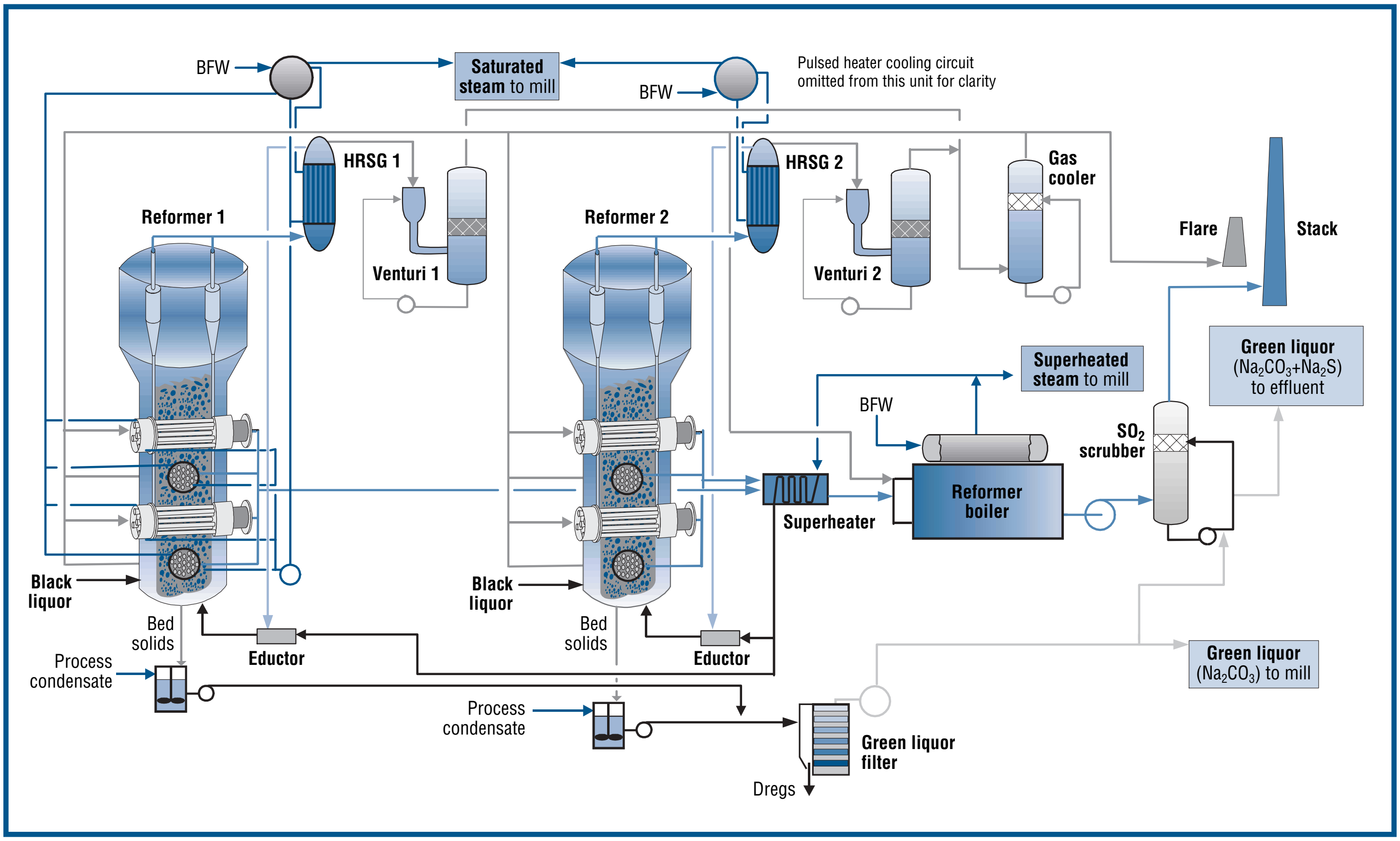

This figure depicts the black liquor gasification process to be implemented at Georgia-Pacific's Big Island, Virginia, containerboard mill.

The Power of the Wind

By Lynda Butek, representing the Electric Apparatus Service Association, Colton, CA, with guest editors Robert Thresher and Kathleen O'Dell, National Wind Technology Center, National Renewable Energy Laboratory, Golden, CO

For centuries, man has harnessed the power of the wind and put it to work. Throughout Europe, Asia, and the Americas, farmers used wind power to pump water and mill grains as far back as 300 B.C. The first turbines were developed in Denmark in the 1890s, and by 1900, small wind systems were generating direct current power for many rural homes and farms in the United States. With the advent of rural electric co-ops in the 1930s, small wind turbines were no longer used to generate electricity; however, faced with the ever-increasing cost of electric power, today we are again turning to the power of the wind to generate electricity for our homes and businesses.

Most states have enough wind to power wind turbines, and 37 states have wind resources that would support utility-scale wind power plants. The wind resource in the Great Plains, if properly developed, could supply a significant portion of this country's electricity needs. With today's wind turbine technology, the United States could supply 20% of its electricity needs from wind alone, and with cost-effective storage, wind could supply a much higher percentage.

Modern Wind Turbines

Today's wind turbines come in a variety of sizes and power ratings. Small turbines rated at 100 kilowatts (kW) and less can be used in applications such as supplementing power supplies for single-family homes and small businesses, water pumping, or communications. Large, utility-scale turbines rated as high as 2 megawatts (MW) are commonly grouped to form "wind farms" or wind power plants that are connected to the utility grid to provide power for hundreds of homes. A single 750-kW turbine can provide enough electricity to power approximately 250 average homes.

Like the windmills of old, modern wind turbines are mounted on tall towers to take advantage of the best wind resources. Utility-scale turbines are mounted on towers up to 200 feet high. Most of the turbines used today look much like a child's whirligig with two or more (commonly three) large propeller-like blades mounted on a shaft to form a rotor. The blades act much like airplane wings. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade pulling the blade toward it, causing lift. This lift force causes the rotor to spin, which turns the shaft that spins a generator to produce electricity.

In addition, wind turbines contain a speed control system or brake. Although wind is a natural part of our environment, too much of a good thing (high gusting or turbulent winds) can cause runaway generators that can overload and overheat if they are not controlled or braked. The margin of error between a full-loaded machine and one that is dangerously overloaded can be as little as 10%. Even though controls cause a loss of overall efficiency, they are necessary for safe operation of the units.

The obvious advantages of wind energy are that the fuel is free, renewable, and clean. Unlike conventional power plants, wind plants emit no pollutants or greenhouse gases. According to a study conducted by the University of California at Irvine, every 500 MW of wind generating capacity can reduce emissions of carbon dioxide, the leading greenhouse gas, by more than half a million tons annually, sulfur dioxide by 637 tons, nitrogen oxides by 1,496 tons, and particulate matter by 17 tons.

Barriers to Wind Power

Although wind energy was the fastest growing energy technology during the 1990s, before it can be developed to its full potential, researchers must find ways to overcome some barriers. One of those barriers is the cost of wind energy production. In 1980, wind energy cost as much as 30 cents per kilowatt-hour (kWh) to produce. Joint research by DOE and members of industry has helped decrease that cost by more than 80% to 4 cents per kWh. To compete with conventional fuels, the cost must be lowered further. Industry members expect to reduce the cost of production an additional 30% with continued research and the introduction of more advanced, efficient turbine designs.

Another barrier to wind energy development is that wind is a fluctuating resource. When the wind blows, it produces electricity. When the wind stops, that production stops. This creates an intermittent energy supply that may be difficult to integrate into the utility grids. In addition, good wind resources are often located in remote locations far from major population centers and transmission lines. By studying the nation's wind resources, its characterization, wind forecasting, the nature of current wind farms, and their impacts on the utility grids, researchers are identifying the best areas for development and demonstrating how wind energy can be integrated into the generation mix.

Several environmental groups have voiced concerns about the impacts wind turbines may have on avian populations, especially the raptor populations. In response to their concerns, DOE has worked with industry members to conduct studies on how birds interact with wind turbines. Their studies show that with proper wind farm siting, impacts on avian populations can be greatly reduced.

Despite the barriers facing the wind energy industry today, wind energy's potential to meet this nation's growing electricity needs remains immense. With continued research and development, barriers to wind energy development will be removed, allowing the technology to become a major player in the energy industry so that it can help stabilize energy supplies and pave the way to a cleaner energy future.

To learn more about wind technology research, its potential, and current applications, please visit the National Wind Technology Center Web site at **www.nrel.gov/wind**, or DOE's Wind Energy Program Web site at **www.eren.doe.gov/wind**. ●

Performance Optimization Tips

Measuring the Heart Rate of Motor Systems: Electric Current

By Don Casada, Diagnostic Solutions LLC, Knoxville, TN

Don continues his series on field measurements. To read previous columns, go to Energy Matters Extra at ***www.oit.doe.gov/bestpractices/energymatters/emextra*** *and select "Casada's Corner."*

The measurement of electric motor current is used in a variety of ways in industrial settings. Protective devices, such as fuses and thermal overload relays, work because of the heating effect of current, but current measurements usually rely on the magnetic field generated by the current passing through a conductor. Current transformers (CT)[1] are used to estimate this current. However, other devices, such as Hall-effect probes are also used.

Operations and maintenance personnel use current as an indicator of properly operating equipment, and use procedures or log sheets to specify "normal" current ranges. A newer use of current is to diagnose equipment health. Commercially available systems alert users to abnormal conditions, such as very lightly loaded motors (which might mean, for example, that a pump is running dry). More sophisticated techniques use information available in the motor current frequency spectrum to help evaluate the health of the motor and the device it drives.

For those of us doing energy work, current measurements often help estimate the motor load. While we're fundamentally interested in measuring input power, which requires current measurement, current alone can provide us with a means of *estimating* power, even when we don't have or can't use a portable power meter. For example, OIT's Pumping System Analysis Tool (PSAT)[2] uses average motor performance characteristics from the MotorMaster+ motor manufacturers database to estimate electric input power from current measurements[3].

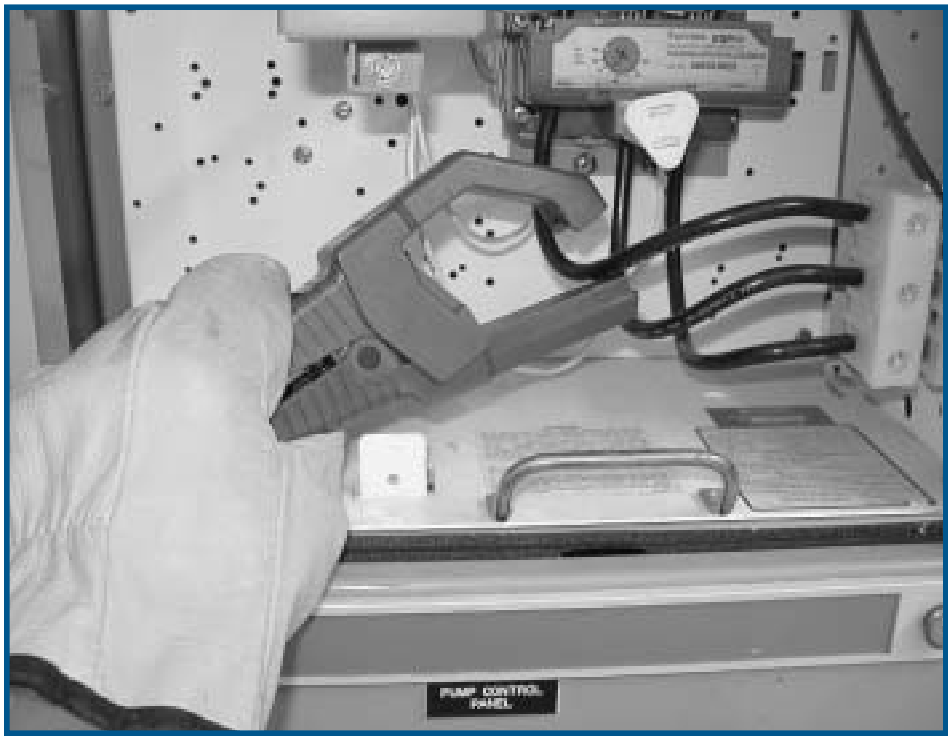

Figure 1: Installing a clamp-on current transducer.

Protective and operations support functions depend on permanently installed CTs. For energy measurements, we often resort to using temporary, clamp-on CTs, such as those shown in Figure 1. If a motor has permanently installed CTs (and you trust the indicator), those can be used.

Practical Considerations for Clamp-on CTs

It should go without saying that use of accurate test equipment is of fundamental importance. But, there are several important considerations that are specific to the field use of temporary, clamp-on CTs.

1. Make sure the jaws close properly. This is essential to completing the magnetic circuit of the CT. If there are tight clearances where the CT is used, the jaws can bind partially open, even when hand tension is released. The indicated current may be considerably in error. Figure 2 illustrates the effect when a fixed load current of approximately 100 amps was monitored with a) the jaws of the CT fully closed and b) a gap of 0.04 inches (less than the thickness of a dime) separating the jaw faces.

To ensure the jaws are fully closed, wigggle the probe a bit, making sure it moves freely and is not bound by adjacent wires or other obstructions. At higher current levels, a magnetic "buzz" created by a slight jaw separation can be heard and felt (through gloves, of course).

2. When possible, measure and average all three phases. This precaution applies to both permanent and temporary CTs. A small unbalance in the supply voltage can result in a large current unbalance among

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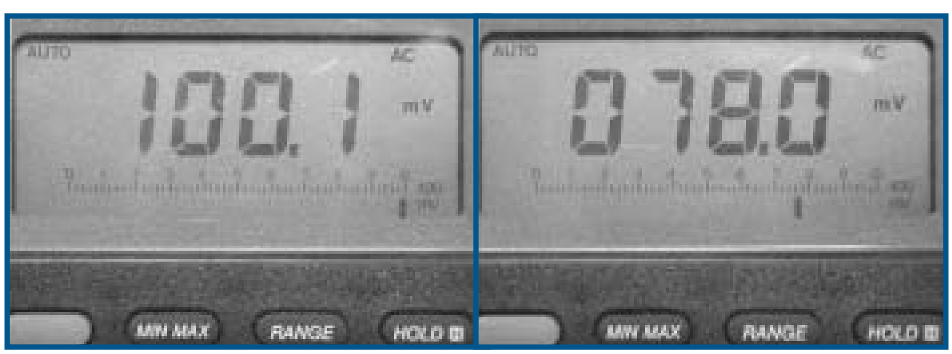

Figure 2: Current indicated by current transducer with fully closed jaws (left) and 40-millimeter gap (right) with constant load (1 millivolt/amp scaling).

Performance Optimization Tips
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the three phases. As a rule, a 1% unbalance in voltage will result in roughly a 7% unbalance in current. Even in the presence of a balanced power supply, there may be current unbalance on the order of 5%.

3. Use properly sized CTs. Like most other measurement devices, CTs lose accuracy when operated at a fraction of their rated range. For example, using a 2,000-amp CT with 0.5% of full span accuracy (which is excellent) to measure a 20-amp current may result in a 50% measurement error.

4. Average current on fluctuating loads. Many motor loads are fluctuating in nature. The current for belt-driven equipment, for example, tends to fluctuate at belt- and sheave-pass frequencies. Some current monitoring devices grab a very short sample (a few cycles, or milliseconds) of data and display a fixed result. Other devices continuously update the data, but the fluctuations make it difficult to pin down.

A more representative measurement can be obtained on a multimeter with a min/max averaging feature. The multimeter shown in Figure 2 has this feature (note the MIN MAX button near the bottom of the picture). This feature is also helpful in averaging other system parameters that tend to fluctuate, such as pressure. If no such function is available, several samples can be statistically averaged. A computer-based data acquisition system or data logger simplifies the collection and analysis of many (and/or longer duration) samples.

5. Make sure the current measured is really the *motor* current. Power factor-correcting capacitor banks are often used with induction motors. When capacitors are used, particular care must be exercised in selecting the measurement location. The current from the line to the combination of the motor and the capacitor bank will be less than the motor current. This seemingly contradictory behavior is real, and it occurs because the current to the capacitor bank will lead the voltage by 90°, while the current to the motor will lag voltage by a variable amount, depending on load.

If the current will be used to estimate motor load, such as when it is an input to PSAT, the current going to the motor should be measured, not the incoming current from the line. Figure 3 illustrates the error that can occur when this is not done. The current to the motor is 22% greater than the incoming line's current to the motor and paralleled capacitor bank.

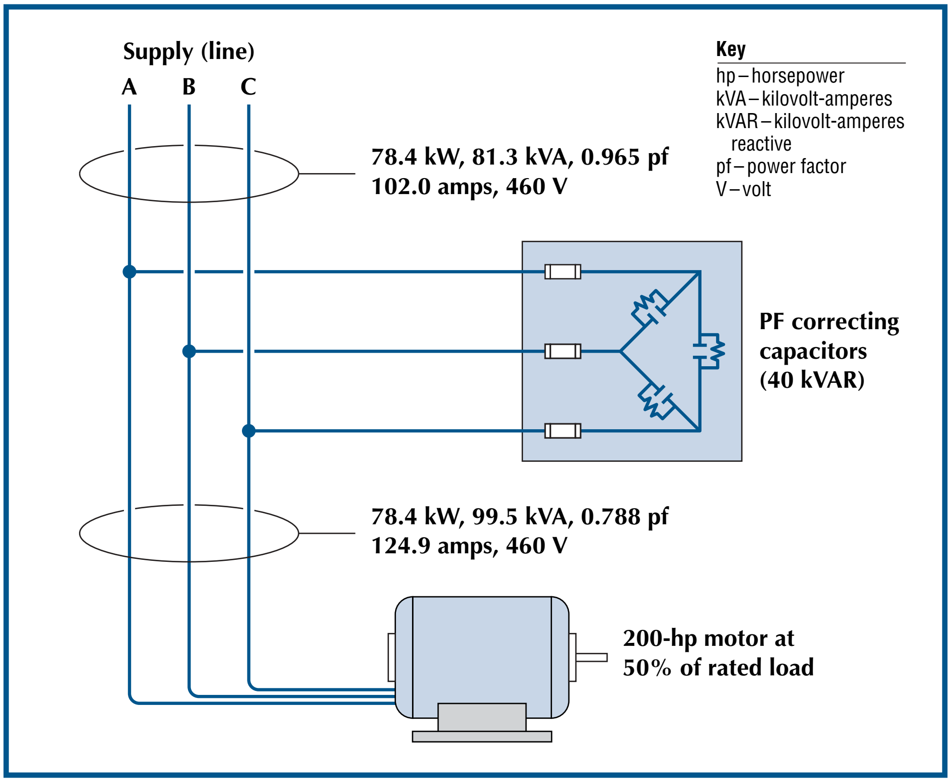

Figure 3. Motor measurements upstream and downstream of a paralleled capacitor bank.

6. Take safety precautions. This is absolutely the most important consideration[4]. A 50% error in the current measurement because of failure to follow previously mentioned precautions or other mistakes could result in a poor diagnosis of equipment health or a loss in company profits. But, failure to exercise proper safety precautions during testing (such as wearing insulated gloves) could result in a poor diagnosis for *your* health or the company's loss being *you*. Be careful out there! ●

E-mail Don Casada at doncasada@icx.net.

[1] CT usually refers to current transformer. However, this discussion equally pertains to Hall-effect probes; for purposes of this article, CT stands for the broader term, current transducer.

[2] PSAT and MotorMaster+ are available free from the BestPractices Web site at **www.oit.doe.gov/bestpractices/software_tools.shtml**.

[3] Author's note: In my experience, the PSAT estimate of electric power (made from measured current and voltage) usually agrees with the measured power within a few percent.

[4] From strictly a safety perspective, I definitely prefer an instrument whose indication is NOT built into the CT. That way, I don't have to stick my nose into the electrical cabinet to get my reading.

*Here are some previous articles by Don Casada on field measurements. Log on to Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra** to review these and other columns in "Casada's Corner."*

2000

Field Measurements in Pumping Systems, May/June—*Two methods of estimating flow rate in systems with no installed flow meters.*

Field Measurements in Pumping Systems, March/April—*Understand pumping system operations by maintaining a system perspective.*

1999

Field Measurements in Pumping Systems, September/October—*Velocity is the third element of pump head.*

Field Measurements in Pumping Systems, July/August—*Elevation is the second element of pump head.*

Field Measurements-Practicalities and Pitfalls in a Parabolic Context, May/June—*Continues the discussion on the changing picture of system operations.*

Understanding the Changing Needs of Your Systems, March/April—*Understanding the changing picture of system operations.*

1998

How to Cope with Potential Field Measurement Pitfalls, November/December—*Useful assessments of motor system efficiency and reliability depend on getting the right measurements in the right way.*

OIT Developing Portfolio of Plant-Wide Assessments

DOE is aiming to increase the use of efficient energy systems across U.S. industry. To that end, DOE is developing a portfolio of assessment methods that industry can use to identify energy- and cost-saving opportunities. One of OIT's roles in this effort is working in partnership with Industries of the Future (IOF) to perform plant-wide assessments. These assessments indicate areas in which plants can significantly reduce energy use, increase productivity and global competitiveness, and reduce waste by implementing appropriate technology. Through solicitations over the past 3 years, OIT has provided cost-shared funding and offered technical assistance to facilities to conduct such plant-wide assessments.

Specifically, these solicitations seek proposals in which teams consider adopting best available and emerging technologies using a variety of tools, information, process engineering techniques, and BestPractices plant support and process systems. In addition, projects that can be replicated by other plants are highly desirable. Only industrial sites that fall within the IOF strategy areas are considered for awards. These include agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum refining, and steel. The purpose is to demonstrate projects or technologies that can be replicated by other industries, particularly in the IOF sector.

OIT launched the plant-wide assessment effort in 1999 to encourage industrial facilities to identify potential energy savings, process improvements, and opportunities for new technologies throughout the plant. With cost-shared funding and technical assistance from OIT, such assessments could facilitate improvements for industrial plants. So far, OIT has made awards to at least 23 plant-wide assessment projects.

You, too, are part of the vast potential for replicating energy savings, cost reductions, and productivity improvements. Get involved and help your company reap the benefits. Find out how you can take part in a plant-wide assessment at the BestPractices Web site, **www.oit.doe.gov/bestpractices/**. For case studies on how plant-wide assessments have helped U.S. companies improve efficiency and productivity and reach environmental goals, visit **www.oit.doe.gov/bestpractices/case_studies.shtml#assessment**, or view the *Plant Profiles: Industrial Energy Management in Action* brochure at **www.oit.doe.gov/bestpractices/pdfs/plantprofiles.pdf**.

AMCAST Industrial Corporation in Wapakoneta, Ohio, performed a plant-wide assessment that resulted in recommendations for 12 separate projects, including improvements to the process heating and compressed air systems. By investing an initial capital requirement of $1 million, AMCAST is expected to realize annual energy savings of at least $3.7 million. In addition, implementing these projects has the potential to reduce the plant's carbon dioxide emissions by more than 11 million pounds per year. The assessment approach could be applied at other aluminum casting facilities, and many areas of study could be included in the analysis of almost any industrial process facility.

Assessment of Compressed Air Market Now Available

Fully 70% of all manufacturing facilities in the United States use compressed air in their production processes. In fact, compressed air systems account for 10% of all electricity use and roughly 16% of the U.S. manufacturing industry's motor system use. However, more than 50% of industrial plant air systems could be optimized for large energy savings—with relatively small project costs.

OIT has recently released the *Assessment of the Market for Compressed Air Efficiency Services,* a comprehensive report of the compressed air market for services that lead to compressed air system energy efficiency. The assessment discusses key findings about supply and demand side views of compressed air system efficiency. This report is now available online in a PDF format at **www.oit.doe.gov/bestpractices/technical_publications.shtml#market.** Order the report in print from the OIT Clearinghouse by logging on to **www.oit.doe.gov/clearinghouse**, or by calling 800-862-2086.

Black Liquor Gasification
continued from page 6

During Phase I, G-P and OIT conducted an engineering study to define the scope of a full-scale demonstration of the technology. Process study areas include the reformer pressure vessel design and refractory system, the product gas clean-up, the pulse heater pressure design, the system start-up methodology, the liquor storage capacity, and the flare system. In addition, the Big Island mill signed an agreement with EPA to install and demonstrate the system under flexible regulatory terms. Phase I is nearing completion, and Phase II, which emcompasses gasifier construction and demonstration, will begin shortly. Site preparation work and demolition of existing structures is already underway.

For more information on the G-P black liquor gasification project, visit the OIT Forest Products Web site at **www.oit.doe.gov/forest/pdfs/factsheets/bigisland_va.pdf**, or contact Bob Gemmer, DOE program manager, at bob.gemmer@ee.doe.gov or Dan Cicero, DOE project manager, National Energy Technology Laboratory, at dcicer@ netl.doe.gov. Also contact Robert DeCarrera, Georgia-Pacific Corporation, at rdecarre@gapac.com.

Energy Solutions for California

In partnership with the California Energy Commission, OIT's Best Practices is hosting a series of one-day events to assist California industries in improving system efficiency and reducing electrical demand. The first of these events took place on August 14 in Sacramento, California. Keynote speaker for the event was California State Senator Michael Machado (D-Linden). Co-sponsoring organizations included the Association of California Water Agencies, California Farm Bureau Federation, California League of Food Processors, and the California Manufacturers and Technology Association.

More than 200 people participated in the event that included exhibitors from the BestPractices Allied Partner program and speakers offering practical advice and solutions for managing electrical demand and improving system efficiency. Case studies of California industries were also used to illustrate how electricity use can be reduced by using a systems approach. Participants commented that the event was "well worth the time" and that they were "looking forward to more."

The next event will be held on January, 16, 2002, at the San Jose McEnery Convention Center in San Jose, California. For information about the January event and a complete list of participants and case studies from the August event, go to the BestPractices Web site at **www.oit.gov/bestpractices**, or call 703-748-8608. ●

Participants in the Energy Solutions for California event met with exhibitors and attended presentations to learn practical ways to save energy and improve system efficiency in their plants.

Energy Matters EXTRA

Check out Energy Matters Extra for additional information on alternative power sources for industry. You'll also find more about OIT and BestPractices assistance.

Get more facts about on-site power generation by linking to the report *Assessment of On-Site Power Opportunities in the Industrial Sector*. Visit the Distributed Energy Resources Web site and find out why distributed generation may be part of your company's future. Learn more about the Green Power Marketing Development Group by linking to its Web site.

See how wind turbine manufacturing is becoming an emerging market for IOFs. In addition, access new BestPractices fact sheets that document recent energy-efficiency projects implemented by participants in the Utah Showcase.

Log on to Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra/**. ●

Letters to the Editor

Energy Matters welcomes your typewritten letters and e-mails. Please include your full name, address, organization, and phone number, and limit comments to 200 words. Address correspondence to:

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1617 Cole Blvd.
Golden, CO 80401
E-mail: michelle_sosa-mallory@nrel.gov

We publish letters of interest to readers on related topics, comments, or criticisms/corrections of a technical nature. Preference is given to articles that appeared in the previous two issues. Letters may be edited for length, clarity, and style. ●

Editor's Notes

Megawatt Mix-up

We heard from a few readers about our use of the term "MW per hour" in the article "California Cement Plant Battles Electricity Interruptions with Its Own Cogeneration Plant," which appeared in the May/June 2001 issue of *Energy Matters*. We should have used "MW" throughout the article when referring to electrical load. Our sincere apologies to California Portland Cement Company for the error. Please take a look at a revised version of the article on Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra**.

Thanks to the readers who let us know about the misprint.

A New Schedule for *Energy Matters*

Beginning with this issue, *Energy Matters* will be a quarterly instead of a bimonthly publication. However, each issue will be expanded to 12 pages instead of 8 pages. This new format gives us an opportunity to offer more in-depth coverage of technical topics while "living within our means." We hope you will continue to find the coverage in *Energy Matters* useful and informative, and, as always, we welcome your feedback. ●

Coming Events

Capturing the Value of Steam Efficiency Workshop

- November 27, 2001, Orlando, FL

For more information, contact Rachel Madan at the Alliance to Save Energy 202-530-4349.

Business Energy Solutions Conference & Expo

- November 28-29, 2001, Orlando FL

For more information, contact Ruth Whitlock at the Association for Energy Engineers at 770-447-5083.

Energy Solutions for California

- January 16, 2002, San Jose, CA

For more for information about this event, log on to **www.oit.doe.gov/bestpractices**, or call 703-748-8608. Also see page 11 of this issue for more about this series of workshops.

OIT Customer Appreciation Day 2002

- May 8-9, 2002, Washington, DC

For more information, log on to **www.oit.doe.gov** or call the OIT Clearinghouse at 800-862-2086. Watch for more details in future issue of *Energy Matters.*

Coming Next Issue:
The next issue of Energy Matters *will focus on smart systems with a look at the latest technologies for improving industrial energy efficiency.*

*To keep up-to-date on OIT training and other events, check the calendar regularly on Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra.***

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BestPractices

The Office of Industrial Technologies (OIT) BestPractices initiative and its *Energy Matters* newsletter introduces industrial end users to emerging technologies and well-proven, cost-saving opportunities in motor, steam, compressed air, and other plant-wide systems. For overview information and to keep current on what is happening office wide, check out the newsletter—The OIT Times—at **www.oit.doe.gov/news/oittimes.shtml**.

Information Clearinghouse

Do you have questions about using energy-efficient process and utility systems in your industrial facility? Call the OIT Information Clearinghouse for answers, Monday through Friday 9:00 a.m. to 8:00 p.m. (EST).

HOTLINE: 800-862-2086

Fax: 360-586-8303, or access our homepage at www.oit.doe.gov/clearinghouse.

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DISTRIBUTED GENERATION/ COMBINED HEAT AND POWER

A Special Supplement to *Energy Matters*

Magnesium Producer Relies on Distributed Generation with Combined Heat and Power

By Roger Swenson, E-Quant Consulting, Salt Lake City, UT, and Dr. R. Neelameggham, Magcorp, Salt Lake City, UT

More than 20 years ago, Magnesium Corporation of America (Magcorp) put in place a combined heat and power (CHP) system to help minimize energy costs. Today, the system still operates effectively, and Magcorp has integrated the system into its magnesium production process. By using a substantial portion of the total energy available from the input energy in the process, the CHP system helps the company save energy and money.

Magcorp, located on the shores of the Great Salt Lake 65 miles west of Salt Lake City, Utah, is the only large magnesium production facility remaining in the United States. It is the third largest producer of magnesium in the world. At full production, the facility exceeds 80 million pounds of magnesium per year. The Great Salt Lake provides the mineral source for the magnesium that is produced. The lake has a 0.4% concentration of magnesium—which is three to four times the concentration of the world's oceans.

Photo courtesy of Magcorp

Magcorp pumps brine from Utah's Great Salt Lake to produce magnesium.

To produce the magnesium, Magcorp pumps brine from the lake into shallow, manmade evaporation ponds that stretch over 120,000 acres of desert. Solar energy evaporates the pond water and concentrates the brine to more that 20 times its original level. Next, the concentrated brine is purified and directed to preheaters and into high-volume spray dryers. The spray dryers flash dry the solution into magnesium chloride powder, which is transferred to melt cells for melting and purification. Purified molten magnesium is then transferred to electrolytic cells, where direct current electricity separates the magnesium chloride into molten magnesium metal and chlorine gas. Finally, the molten metal is collected and taken to the cast house, where it is cast into ingots for shipment.

The process is very energy intensive. In fact, energy can account for 40% of production costs. Because of these energy requirements, Magcorp continues to seek ways to improve the production process to remain competitive and reduce chlorine emissions. For example, new electrolytic cell technologies have been deployed that will reduce electric energy consumption by 30%. Additionally, the initial plant configuration included a CHP system that provides substantial energy savings to the operation.

Photo courtesy of Magcorp

A CHP system improves Magcorp's process for producing magnesium.

The CHP System in Operation

Magcorp's CHP system generates power with three 12.4-megawatt (MW) natural gas-fired turbines. The exhaust gas from the turbine system is split between a waste heat boiler, which produces steam, and a spray drying system. Most of the exhaust gas is directed to the spray drying system; in turn, the exhaust moves to the brine preheater. The exhaust gas from the brine preheater vents through a scrubber to the atmosphere at 170°F. The equivalent energy remaining in the exhaust stream from the waste heat boiler and the brine preheater is only 13.5% of the initial input energy. Figure 1 (on page 2) shows the process.

Energy and Cost Savings

The energy savings Magcorp realizes from the CHP system make it a worthwhile investment. Table 1 (on page 2) shows the CHP system energy use and savings compared to a nonintegrated system. The CHP system requires purchased energy input of

(continued on page 2) ►

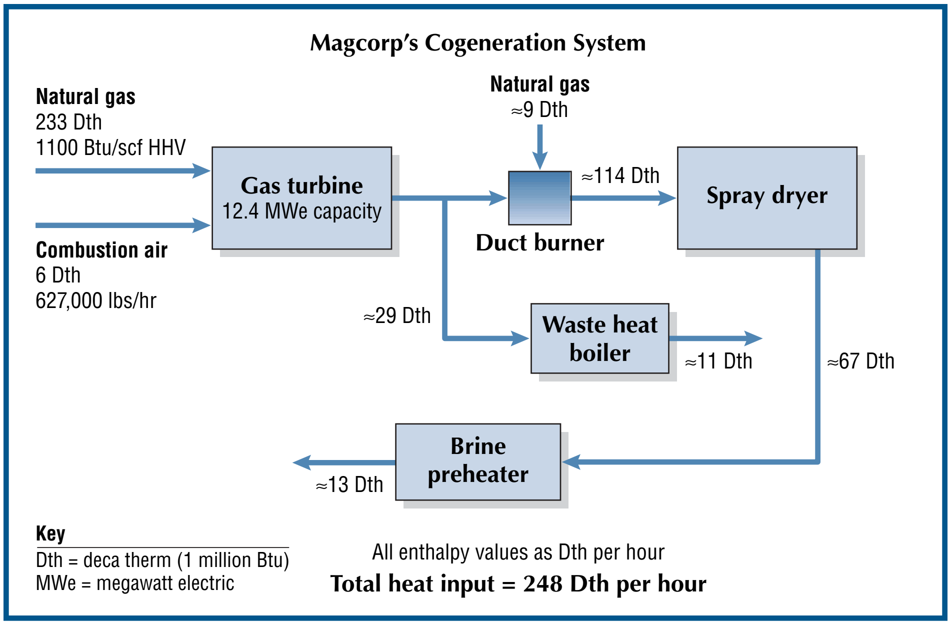

Figure 1. Magcorp's CHP system begins with three 12.4-MW gas turbines that produce enough exhaust gas to fuel a waste heat boiler, a spray dryer, and eventually, a brine preheater.

Magcorp

continued from page 1

natural gas to run the turbine system and a duct burner to boost the turbine exhaust to the temperature required for spray drying. In contrast, the non-CHP system would require the purchase of an equivalent amount of power produced by the CHP system, plus extra power to run a fan that pressurizes the spray drying system. In addition, a nonintegrated system would require natural gas for the spray drying system and a boiler to produce an amount of steam comparable to what the waste heat boiler generates.

Besides energy savings, Magcorp realizes substantial cost savings by using CHP. However, the economic benefits of the CHP system depend on the value of the electricity produced, the cost of natural gas, and the value of the thermal energy used by the system. Table 2 reveals the projected annual savings created by the CHP system under various power and natural gas pricing scenarios.

New and Improved CHP System

Table 2 also shows the potential savings if the system were upgraded—an option Magcorp has considered. Although still operating effectively, the existing system uses turbine technologies that are more than 20 years old. Newer turbine technologies have been developed that produce more electricity with a given amount of natural gas. So Magcorp has investigated replacing its turbine system with one of the newer, more efficient turbines in the current CHP configuration. The upgraded system would create additional savings because of the increased production of the high-value electric output. Based on an estimated $500 per kilowatt (kW), the upgraded system could have a payback of 3 years or less.

Magcorp's example demonstrates that the economic returns from a CHP system are attractive under conditions of high load factor and full thermal utilization. Lower load factor or unmatched thermal/electric utilization systems require conditions, such as higher power values and low natural gas costs to achieve desired returns on investment. Reduced need for transmission system upgrades, reduced real system losses, backup generation, and system voltage support may provide additional value if utilities pass along savings that result from a site's installation of distributed generation systems.

Careful analysis of costs and energy use assures Magcorp that the CHP system provides value to its operation; other sites can do the same to determine if CHP has potential for their operations. ●

For more information on CHP or the Magcorp process, contact Roger Swenson at roger.swenson@prodigy.net or Dr. R. Neelameggham at rneelameggham@magnesiumcorp.com.

Magcorp recently took part in the Utah Industry Showcase in partnership with OIT and the State of Utah. The company featured its CHP installation, along with a new, efficient electrolysis system. Read more about Magcorp's involvement in the Showcase on page 1 of the Fall 2001 issue. You can also learn more about the electrolysis system upgrade by viewing the case study on Energy Matters Extra at ***www.oit.doe.gov/bestpractices/energymatters/emextra****.*

Table 1. Magcorp's CHP Energy Use and Savings Compared to a Nonintegrated System

	Combined Heat & Power		Nonintegrated System	
	Dth	MWh	Dth	MWh
Turbine generator	466.00		0	
Electric purchase		0		26.80
Spray dryer	17.34		228.00	
Boiler (80% eff)			71.50	
Brine preheat			0	
Total per hour	483.34		299.50	26.80
Total per year*	4,234,058		2,623,620	234,768

*Assuming 2 units (12.4 MW each) required at 100% load factor

Table 2. Magcorp's Potential Annual Savings from CHP under Various Power and Gas Pricing Scenarios

	$3/Dth Gas, $.04/kWh	$4/Dth Gas, $.06/kWh	$5/Dth Gas, $.08/kWh
Existing system	$4,089,869	$ 7,174,790	$10,259,712
Proposed new system	$6,381,362	$10,724,763	$15,068,163

Distributed Generation: A New View on Energy Sources

Though central power systems remain critical to the nation's energy supply, their flexibility to adjust to changing energy needs can be limited. In light of current higher energy costs and regional outages, some industries may want to consider alternatives. Distributed generation (DG), or distributed power, is modular electric generation or storage located near the point of use. Distributed systems include biomass-based generators, combustion turbines, concentrating solar power and photovoltaic systems, fuel cells, wind turbines, microturbines, engines/generator sets, and storage and control technologies. Distributed resources can either be grid connected or operate independently of the grid. Those systems that are linked to the grid are typically connected to it on site. In contrast to large, central-station power plants, distributed power systems typically range from less than a kilowatt to tens of megawatts in size.

Warren Gretz, NREL/PIX 00072

Distributed generation systems, such as biomass generators, can be grid connected or operate independently of the grid.

Benefits of Distributed Generation

Because central power is composed of large, capital-intensive plants and a transmission and distribution grid to distribute electricity, significant investments of time and money are required to increase capacity. DG, on the other hand, complements central power by:

- Providing a relatively low capital cost response to incremental increases in power demand
- Avoiding transmission and distribution capacity upgrades by locating power where it is most needed
- Providing the flexibility to put surplus power back into the grid at user sites.

Capstone Turbine Corporation/PIX 08130

Micro turbines, one example of distributed generation, can be powered by natural gas or biofuels.

Applications for Industry

There are many useful industrial applications for DG. For example:

Standby Generation. Standby generators provide power during system outages until service can be restored. Large manufacturing facilities that depend on sensitive electronic controls may require reliable power in order to avoid high outage costs. Distributed resources can be used to provide on-site standby power for customers that require uninterrupted electric service 24 hours a day, 7 days a week. Industrial customers that maintain distributed power systems for back-up power may also be able to lower the cost of their power purchases by participating in peak load reduction programs offered by utilities.

Peak Shaving. Power costs vary hourly depending upon system demand and the availability of generation assets. Larger customers often pay time-of-use (TOU) rates that convert these cost variations into daily and seasonal rate categories—such as on-peak, off-peak, mid-peak, and shoulder rates. TOU customers and those competitively acquiring power could select distributed generation during high-cost peak periods, and reduce their overall cost of power. The electric supplier in turn may be able to reduce the amount of high-cost power purchased during system peaks.

Remote or Stand-Alone Generation. In isolated or remote applications, obtaining stand-alone DG may be more economic than integrating with the power grid. For instance, some combined heat and power (CHP) system owners might separate from the grid if they are unable to negotiate economic back-up power from their retail electric supplier.

Combined Heat and Power (Cogeneration). In the process of converting fuel into electricity, a large amount of heat is created (on average two-thirds of energy content of the fuel). Industrial plants can use this heat if a power generation system is located on-site or near the facility. By using CHP, plant operators can increase efficiency, lower greenhouse gas emissions, and lower power costs. CHP is best suited for mid- to high-thermal use customers, such as process industries. (For example, see the article about Magcorp on page 1.)

Barriers

There are some barriers that hinder implementation of distributed power technologies. Based on recommendations from industry and other stakeholders, DOE's Distributed Power Program is addressing a number of these barriers, including:

- Interconnection with the grid
- Utility pricing practices and tariff structures
- Siting, permitting, and environmental regulation
- Current business models and practices.

With time, these challenges can be overcome and DG applications can be a valuable tool in industry's quest to increase energy efficiency, reduce operating costs, and improve environmental performance.

For more information on DG, see the Distributed Energy Resources Web site at **www.eren.doe.gov/der**. See also DOE's Fossil Energy Distributed Power Systems Web site at **www.fe.doe.gov/coal_power/distributed_power.html**. ●

Opportunities for Combined Heat and Power

By Rod Hite P.E., Senior Consultant Energy Nexus Group, Carlsbad, CA

This article summarizes the author's paper on combined heat and power, which will be presented at the World Energy Engineering Congress in October 2001

Combined heat and power (CHP), or cogeneration, came into use at the beginning of the 20th century, and power was often generated on site at large industrial facilities, such as paper mills. With the expansion of the electric grid and inexpensive raw energy, its use declined. A major expansion of the technology occurred in the 1980s as a result of the Public Utilities Regulatory Policy Act of 1978, but interest in CHP declined near the end of the 1980s because of lack of support by utilities and economic barriers. However, today's high energy prices and constrained generating capacity have led to a renewed interest in the technology. In California, for example, where power shortages and high electric rates prevail, the economics for CHP have never been more robust. Simple paybacks for industrial process and building applications can be as little as 2 or 3 years.

CHP has applications in many of the most energy-intensive industries. The presence of a large and consistent steam load, around-the-clock operation, and fairly stable electric consumption all indicate the possibility of a rewarding project. In addition to pulp and paper mills, oil refineries, food processing plants, chemical plants, and textile mills are reaping the benefits of CHP. While the power dilemma in California provides immediacy and forces industries there to focus on power alternatives such as CHP, industries throughout the country can also take advantage of the economic and energy benefits CHP might offer.

Understanding CHP Technology

To understand its potential, industrial plants must get a feel for CHP technology. So how does CHP work and what are the technology options?

CHP is the sequential use of one fuel source to produce power and thermal energy. The energy cascade it provides helps plants avoid losses that occur when power is traditionally generated at a central station power plant and thermal energy is provided on site with a boiler. CHP can be used either in a topping cycle or a bottoming cycle, although topping cycles are the most common.

The figure below illustrates the concept. In the traditional case, steam is raised with a boiler on site and power is purchased from the local utility. The boiler requires 59 units of energy input to raise 50 units of useful steam. The utility requires 121 units of energy to generate 35 units of useful electrical energy[1]. Much of the energy loss is unavoidable because of the 2nd Law of Thermodynamics. On the other hand, CHP uses energy, which would ordinarily be 2nd law losses, for another useful purpose. In this example, CHP losses can be held to only 15 units of energy.

Prime Movers

Reciprocating engines and combustion and micro turbines are the prime movers that provide shaft power to generators. Fuel cells could one day become significant, but the technology is not yet fully developed.

Reciprocating Engines. Most CHP facilities have reciprocating engines, using natural gas as the fuel. Heat from a reciprocating engine can be either in the form of hot water or low-pressure steam (15 pounds per square inch gauge [psig] or less). The phase change from liquid to steam can either take place within the engine or in a drum separate from the engine. The hot water or steam can be used for process needs, building heat, to heat potable hot water, or to generate chilled water in an absorption chiller. Reciprocating engines are typically more efficient than combustion turbines in smaller applications less than 3 MW. Industrial uses of reciprocating engines include metal plating and food processing.

Combustion Turbines. Combustion turbines can provide higher quality heat than reciprocating engines with available steam pressures exceeding 650 psig. The steam produced can be used for process needs, building heating or in double-effect[2] absorption chillers to produce chilled water. As a class, at least in the smaller size ranges, their heat rates are higher than for reciprocating engines. Some manufacturers are developing combustion turbines with recuperation and efficiencies that approach 40%.

Micro Turbines. A micro turbine is a small combustion turbine (not larger than 100 kW). Turbine speeds exceed 50,000 revolutions per minute (rpm) and sometimes exceed 100,000 rpm. This keeps their size small. However, because they are intrinsically inefficient, micro turbines are equipped with recuperators.

In CHP analyses, the micro turbine performs like the reciprocating engine, but with a slightly higher heat rate. Micro turbines have fewer parts, which, in theory, should make them cheaper to build and maintain. However, manufacturers are anxious to recover micro turbine development costs so purchase costs remain stubbornly high. Maintenance cost will eventually decrease as manufacturers understand what those costs will be.

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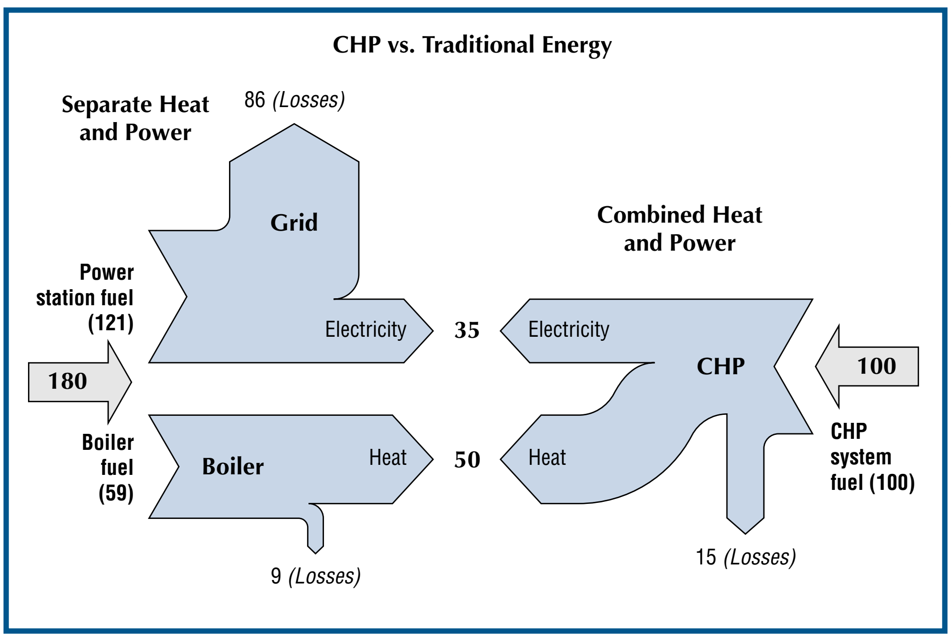

U.S. CHPA—Source: Kaarsberg 1998

CHP losses compared to traditional energy losses.

Distributed Generation Challenges: Air Quality, Siting, Permitting

By Shirley F. Rivera, Principal, Resource Catalysts, San Diego, CA

The following is condensed from the author's paper, which appeared in the Association for Energy Engineer's Strategic Planning for Energy and the Environment, *Winter 2000-2001 issue. It appears here with the publisher's permission.*

Several environmental, engineering, and social issues affect successful siting of distributed generation (DG). Addressing issues prior to equipment operations can include obtaining siting, construction, and operating approvals from multiple regulatory and governmental agencies, and possibly undergoing public review and scrutiny. The level of agency involvement typically depends on the extent of a source's environmental impact. Specific siting issues can arise that may result in project start-up delays, costly permitting, and project cancellation.

Siting Issues

With the ongoing electric utility restructuring, DG is being positioned in the marketplace as an option for the traditional central power plant energy suppliers, as well as a source of reliable and cost-effective energy supply. Since January 1998, there have been numerous regulatory initiatives and the emergence of several organizations focused on the market placement of DG.

The issue of air quality impacts is particularly critical within the context of fossil fuel-fired technologies, as well as those DG technologies that may directly replace or displace fossil fuel-fired technologies. Air quality requirements and procedures vary from state to state. Because permit requirements are dependent on emissions impacts, the type of DG technology and application will determine the complexity of permitting and regulatory scrutiny.

Project Planning

The issues affecting DG siting and permitting include environmental, energy, and social issues. *Environmental issues* include regulated media, plan or permit approvals, and compliance mandates; *energy issues* include engineering considerations; *social issues* include community concerns and economic considerations.

Projects become complex because approvals must be obtained by various local agencies, and because of the need to work with the local distribution company to ensure proper and safe interconnection. Additionally, nearby residents and other businesses may be involved in public review and comment of a DG installation.

Prepare, Execute, Communicate

Because requirements vary from agency to agency, understanding what requirements must be met involves planning to reduce the potential for project delays. To minimize the uncertainty associated with DG source installation approvals, a three-part approach is to prepare, execute, and communicate.

Prepare: Understand the Issues, Agencies, and Regulations. Prior to formally proposing a DG installation to local agencies, identify potential siting and environmental issues, direct (and oversight) approval agencies, and the applicable regulatory requirements. At this stage, potential environmental impacts/consequences should also be identified in case they must be mitigated or controlled.

One of the most overlooked factors in project preparation is consideration of the affected local community and their acceptance or rejection of a DG installation. Preparation of the rollout of a DG project should involve identifying community members who might be affected.

Execute: Scope, Compile Information, and Do Your Homework. As part of the project execution, scope out the issues and barriers and develop contingencies. This involves a more thorough evaluation of the information gathered in the preparation stage. Given the multiagency involvement, different approval criteria, and review time frames, the appropriate information for approval processes, forms, fees, and necessary equipment/operations should be identified and completed. One approach is to work closely with the approval agency prior to submitting any application.

Finally, given that many agencies' actions are through public entities, take advantage of lessons learned by other DG project efforts. At a minimum, agencies' records can be petitioned for review and copy. The first-hand experience of others may provide insight to the siting hurdles that were overcome.

Communicate: Identify the Target Audience, Speak a Common Language, and Compromise. Throughout project planning and execution, understand the target audience. Although it is not necessary to undertake an extensive public affairs effort for certain types of DG installations, it is necessary to understand what information should be readily available to properly characterize and present a project.

Too often the characterization of a project is in technical terms, which may confuse rather than properly inform agencies and the public. Preparing information that speaks to the affected parties can greatly minimize confusion, resulting in a more streamlined review and understanding of project benefits.

As part of project impacts communication, negotiation strategies should be developed to address potential regulatory (and public acceptance) barriers.

Air Quality Permitting and Regulatory Issues

There are several considerations with respect to air quality regulatory compliance issues.

- **Exemption/permit thresholds—whether a DG source triggers permit requirements.** Permit exemption levels may exist for relatively small, low-emitting operations. For example, gas turbines less than 0.3 MW are exempt from permitting in several California air districts. In other areas of the nation, sources with emissions of less than 5 tons per year may be exempt.
- **Regional air quality—whether the site is in an attainment or nonattainment area.** Sites in nonattainment areas (e.g., areas where a pollutant concentration exceeds an ambient air quality standard) have more rigorous permitting requirements.
- **Facility/site characteristics—whether the site is an existing or new facility that is considered a minor or major source.** The addition of a source to an existing major source (e.g., "major" as defined by an air agency is based on a site's total tons of emissions per year) can result in more rigorous permitting requirements.

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Report Assesses On-Site Power Potential for Industry

The potential for on-site power generation in the nine most energy-intensive U.S. industries, OIT's Industries of the Future (IOF), is the subject of a recent report prepared for OIT. On-site generation can reduce energy costs, help a facility comply with environmental regulations, and ensure a reliable power supply. Electric market restructuring and its effect on pricing and reliability are creating strong interest in this subject.

The report covers existing and potential on-site generation; combined heat and power (CHP) and its potential, its economics, and its environmental benefits; barriers to on-site generation; and policy and technology recommendations.

Here are a few highlights from the report.

- Existing on-site generation capacity in the industrial sector (not including emergency generation) is more than 45,000 MW, the vast majority of which is in CHP plants.
- The remaining potential for on-site generation in the industrial sector is estimated at 140,000 MW. The IOFs represent 79% of this potential.
- The remaining CHP potential is estimated at 88,000 MW, with 69% of that in the IOF realm.
- If the full potential for CHP were realized, it would result in a 70 million metric ton reduction in carbon equivalent emissions—equivalent to approximately 285 million tons of carbon dioxide.

To learn more, see the full report, which can be ordered from the Energy Nexus Group. Please contact Kathy Gallagher at kgallagher@energynexusgroup.com, or by phone at 760-710-1671. ●

Distributed Generation Challenges

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- **Project/equipment composition—whether there is one unit or multiple units at a site.** Cumulative emissions impact of multiple units may need to be considered in the permit evaluation versus the impact of each individual DG unit.
- **Emissions impact—whether criteria and air toxic pollutants have an impact on nearby communities.** Air quality modeling or the evaluation of public health impacts may be required, particularly for diesel fuel-fired operations.

Conclusion

DG sources can be sited, installed, and operated. By proper planning, evaluation of economic impacts and facility operations, and compliance with the local agency requirements, approvals can be obtained. Consideration must be given to the numerous siting issues and the roles of multiple regulatory and governmental agencies and the public when planning any DG project installation.

To view the full text of this excerpt, please log on to Energy Matters Extra ***www.oit.doe.gov/bestpractices/energymatters/emextra.***

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Opportunities for CHP

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Fuel Cells. Although they offer excellent potential for efficiency and emission reductions, fuel cells face many technological hurdles. Mass producing small reformers needed to create pure hydrogen to fuel proton exchange membranes (PEM) has been a challenge for the industry. Meanwhile, solid oxide fuel cells do not require fuel conditioning, but the fuel cells are difficult to manufacture. The good news is that they are very efficient (around 50%) and are being tested with micro turbines to develop a high-efficiency hybrid cycle (65% to 75%). For the near term, there is some good news emerging from the effort to develop molten carbonate fuel cells. Developing the technology, though, is still very challenging.

The Case for CHP

Although capital-intensive, CHP can be an effective way to manage energy. The following example gives estimates of costs and potential savings that an industrial plant could realize by installing a 4,900-kW combustion turbine to produce steam. Such a CHP plant might be found in a paper mill. The value of the power generated is in the savings obtained when the power is not purchased from the electric utility. The value of the steam is in the boiler fuel not purchased from the local gas utility. The primary operating cost is the turbine fuel. The power avoided is worth approximately 10.8 cents per kilowatt-hour (kWh) and the customer's net cost of generation (considering the savings from CHP) is around 4.7 cents per kWh.

Estimated Costs and Savings for CHP Installation

Combustion turbine capacity	4,900 kW
Annual value of power generated[3] (less standby charges)	$4,635,000
Annual value of steam raised	$1,544,000
Annual fuel cost	($3,324,000)
Annual maintenance cost	($258,000)
Energy cost savings	$2,597,000
Estimated first cost	$5,700,000
Simple payback	2.2 Years

CHP is serious energy management. Proven technology exists today that can reward the investor with returns not found elsewhere in the plant. Technology is evolving that promises even better efficiencies and more cost-effective CHP for smaller applications. Additionally, application of CHP could help industrial plants achieve societal goals for improved environmental performance. However, like other capital-intensive energy management, CHP requires regulatory stability to attract investment and mitigate barriers.

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[1] An adjustment is also made for the line loss that occurs when getting power from the utility's generating station to the customer's site.

[2] The two types of absorption machines are single-effect and double-effect. Single-effect uses twice the heat to produce the same amount of chilling as the double-effect. However, the single-effect machine can use low-quality heat, but the double-effect machine requires high-pressure steam (>100 psig). Double-effect absorbers cannot be used with reciprocating engines.

[3] Analysis is based on Southern California Edison's TOU-8 (Secondary) electric tariff.