Putney Paper Company Becomes More Energy Efficient with Help from Green Mountain Power

A major rebuild of your processing plant may seem like a daunting endeavor, but Putney Paper Company did just that and is now saving energy and money. The Vermont-based paper-recycling mill upgraded many of its older motors and installed variable frequency drives (VFDs) on its pump and agitator system. The upgrade also entailed rerouting water flow, which eliminated the use of one pumping system.

The project is saving the company 400,000 kWh of electricity, or $30,000 annually.

To offset costs and increase efficiency, Putney took advantage of technical assistance and rebates from its electric utility, Green Mountain Power Corporation (GMP), an OIT Allied Partner.

Using original equipment installed in the 1930s was costing Putney Paper Company a heavy price in high energy bills. In an effort to lower costs, in the early 90s, Putney learned of energy efficiency incentives offered by GMP and replaced 27 motors with high efficiency ones that meet or exceed EPAct requirements. The positive results led to further upgrades and opportunities to work with GMP on the recent major plant rebuild.

By 1997, Putney planned to rewind about 13 of the plant’s motors driving the mill’s pumping process. GMP’s review of the plans led to the mill changing the project plan. Instead of rewinding, Putney decided to replace the motors and include upgrades to the agitator systems. “Putney was already committed to upgrading their older equipment to improve productivity. What we were able to bring were recommendations for getting the maximum possible energy savings out of the upgrades,” said Dan Gaherty, Green Mountain Power Corporation. GMP provided MotorMaster+ software to help Putney analyze motor replacement options. As a result, Putney installed 15 premium efficient motors and 2 VFDs to operate its pump system. Putney also changed the routing of tray water from the paper machine. The rerouting enabled the company to shut down one pump and use gravity flow in its place, which offered more reliability and cost reductions.

Benefits
In addition to cost savings and energy efficiency, the upgrade has other benefits. For instance, the VFDs have given the operators more control of the process. “We’re saving energy by using inverters [VFDs] to achieve the pumping capacity we need. We’ve eliminated valves and the waste associated with throttling back,” said Don Sellarole, plant engineer at Putney. Without throttling back, the operating life of the pump is extended. Also, pressure adjustments have been converted to a digital mode, which allows greater precision and saves time on maintenance. The only drawback is the more complicated drive system that requires greater technical knowledge and expertise to run effectively. To address this, Putney has provided staff training in maintenance and troubleshooting.

Incentives from GMP for the two VFDs reduced payback time from 1.2 years to less than a year.

Working together, Putney Paper and GMP prove that energy efficiency, lower costs, and technological advancement can be affordable realities.

Regenerative drive system on #4 rewinder.
Learning to Use Bifocals

By Don Casada and John Kueck, Oak Ridge National Laboratory (ORNL)

Both of the authors of this article are learning to use bifocal glasses. The general idea with bifocals is that they provide two general zones of focus—the lower portion for close up (e.g., reading) and the upper for distance. Leaning your head back while driving or looking out the bottom part of your glasses while descending stairs are recipes for disaster.

There are many demerits associated with our condition (not the least of which are egotistical factors), but like most of life’s difficulties, the lessons we learn here have analogs in other arenas.

Take the case of adjustable speed drives, for example. We’d like to discuss two common aspects of drives from a couple of different focal lengths.

Efficiency or Power?

A common way of comparing device A with device B in the energy domain is to compare efficiencies. After all, efficiency is a sort of universal standard that is used in everything from hog farming to haute cuisine, defining the value of the product in proportion to the cost of the input.

Figure 1 shows typical combined drive and motor efficiencies for a new, pulse-width-modulated (PWM) drive and an older eddy-current (EC) drive when connected to a centrifugal load, such as a pump or fan.

Consider a situation where we have a fan load that operates at full speed 75% of the time and at half speed 25% of the time. Table 1 shows the combined motor and drive efficiencies at those speeds and calculates an average efficiency.

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>Full-speed efficiency</th>
<th>Half-speed efficiency</th>
<th>Average efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM</td>
<td>86%</td>
<td>77%</td>
<td>84%</td>
</tr>
<tr>
<td>EC</td>
<td>86%</td>
<td>38%</td>
<td>74%</td>
</tr>
</tbody>
</table>

The average electromechanical efficiency with the EC drive is only 88% of that with the PWM drive, certainly a noteworthy difference.

Now let’s extend our point of focus to include the electric meter. Does our electric bill include an average efficiency term? Of course not—we pay for energy. Let’s assume that the fan requires 50-hp shaft output power at full speed and behaves according to the centrifugal load affinity laws (flow rate is proportional to speed, and power is proportional to the speed cubed). For this assumed load, the electric input power vs. speed shown in Figure 2 applies.
Operating energy costs continue to be a major concern for plant managers. Recent studies of electric motor applications show that pumps require 31% of the energy used, 18% for compressors, 18% for blowers and fans, and about 14% for conveyors. Variable torque applications are the best candidates for adding an adjustable speed drive (ASD) to save energy. Centrifugal pumps and fans are variable torque loads where the amount of power required drops off by the cube of the speed decrease. Thus, the actual savings come from reducing the motor speed, resulting in lowering the motor's power requirements.

Variable torque applications are the best candidates for adding an adjustable speed drive (ASD) to save energy. Centrifugal pumps and fans are variable torque loads where the amount of power required drops off by the cube of the speed decrease. Thus, the actual savings come from reducing the motor speed, resulting in lowering the motor's power requirements. Constant torque applications such as conveyors often use ASDs, but generally this is not for reasons of energy savings, rather it is for production flow improvements.

Let's look at a pump application with varying flow requirements. Typically, control valves are used to regulate flow from a pump with the motor and pump operating at fixed speed with the motor driven directly from the power line. As the valve is closed, the amount of energy that is wasted is increased. If instead of throttling, an AC inverter (a type of ASD) is employed, considerable savings can be achieved. To illustrate, assume we have a centrifugal pump that requires 100 hp at design flow. Let's further assume an electrical cost rate of $0.07/kWh, an equipment and installation cost of $8,800, and required flow rate that varies from 40% to 90% of design capacity, per Table 1.

Table 1. Load Profile

<table>
<thead>
<tr>
<th>% of flow rate</th>
<th>% of year</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>70</td>
<td>15</td>
</tr>
<tr>
<td>80</td>
<td>10</td>
</tr>
<tr>
<td>90</td>
<td>5</td>
</tr>
</tbody>
</table>

As shown in Figure 1, the purchase and installation costs would be recovered from energy savings in less than 5 months, with annual savings of about $22,000.

Caution needs to be taken in this inverter retrofit. Inverters not only reduce the speed by adjusting the voltage and frequency, the motor can also be made to operate above its base speed. Since horsepower requirements on a centrifugal pump increase by the cube of the speed change, it doesn't take much more speed to overload the motor and risk premature failure.

Operation of an AC induction motor from a pulse-width-modulated (PWM) inverter causes extra motor heating due to harmonics. The signal of the inverter to the motor is an artificial sine wave. Motors operating from inverters may experience extra heating resulting in premature failure. Newer high efficiency (EPAct) and premium efficiency motors often have low temperature rise. A rule of thumb is that for every 10°C cooler a motor operates, its insulation life is doubled. Newer motors will also have insulation capable of handling the higher temperatures at which the motor operates when powered from an inverter. Many new motors have a Class F (155°C) insulation system whereas older motors may only be Class B (130°C). Most inverter-ready motors have a Class H system rated for 180°C operation.

Although the inverter will operate any three-phase AC induction motor, it is wise to purchase a motor with an insulation system that will handle the troublesome voltage spikes, which may be 1600 volts or more in applications with long motor-feeder cables. New inverter spike-resistant magnet wire provide more than 100 times more resistance to high-voltage spikes than standard magnet wire. Long wiring runs between the motor and inverter increase the high-voltage spikes by a condition called “voltage ring-up”. To mitigate this situation, line reactors or harmonic filters can be placed between the motor and control.

NEMA addresses operation of inverter-fed motors in its MG 1-1998 standards. Part 31 discusses specific-purpose motors for inverter-fed power supplies. It would be wise to select a motor that complies to MG 1-1998, Part 31.4.4.2 for voltage spikes as a minimum requirement.
Since most variable torque applications are similar, HVAC installations offer similar savings.

Constant torque applications such as conveyors don't offer the same energy savings as variable torque applications because power is only linear with speed. Again production improvements may be seen with the addition of ASDs. Changing out older, less efficient motors to current premium efficiency designs will reduce energy usage.

Many older conveyors are already adjustable speed, but powered by DC motors and SCR (thyristor) controls. Typically these DC drive systems have efficiencies in the 80-85% range compared to newer AC drives with efficiencies in the mid-90s. Power factor on DC drives may be in the 50% range whereas power factor for AC drives is approaching unity. Changing older DC SCR system to an AC Vector Drive can provide better performance than the old DC drive. The AC Vector with encoder feedback can provide constant torque from base speed all the way to zero speed. Besides the energy savings, the maintenance required by the brushes and commutator of the DC motor is eliminated (downtime and costs). A larger motor is sometimes required for low-speed, constant-torque applications.

Energy savings translate directly to the bottom line of any manufacturing facility. All of these technologies are proven, in use for 10 years or more. Many different suppliers build inverters, vector drives, and inverter-ready motors. Most difficulties encountered are simple and easily resolved.

Local distributors can help estimate savings and initial investment in equipment costs. Most manufacturers also have free cost/analysis software available to help calculate these savings. These computer programs calculate payback details based on the actual motors you have in your plant, duty cycles, and energy costs.

For questions or comments, contact John Malinowski at (501) 648-5909 or send e-mail to John_Malinowski@baldor.com.

Performance Optimization Tips

Field Measurements in Pumping Systems—Practicalities and Pitfalls

By Don Casada,
BestPractices Motor Systems, Oak Ridge National Laboratory
This article is the 4th in a series dealing with practical considerations and pitfalls of field measurements needed to understand pumping systems.

One by one, we're addressing the individual elements critical to understanding pumping system operation. But remember the importance of maintaining a system perspective, not just elements in isolation. In the words of Robert Browning (from A Grammarian's Funeral):

“Iimage the whole, then execute the parts—Fancy the fabric
Quite, ere you build, ere steel strike fire
from quartz,
Ere mortar dab brick!”

Does Your Car Have a Speedometer?

I recently led a PSAT1 workshop, and we discussed a scenario where no flow instrumentation was installed. Tom Angle, Director of Technology for Envirotech Pump, offered this insightful simile: “A pumping system without a flow meter is like a car without a speedometer.”

Tom further noted that we wouldn’t buy a car without a speedometer, but we routinely see pumping systems without flow meters. To see how out of whack this is, let’s do an operating cost comparison between a mid-size car and a small industrial pump.

Energy Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Automobile</th>
<th>25-hp pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel unit cost</td>
<td>$1.40/gallon</td>
<td>5 ¢/kWh</td>
</tr>
<tr>
<td>Annual usage</td>
<td>15,000 miles</td>
<td>6,132 hours</td>
</tr>
<tr>
<td>Power source effectiveness</td>
<td>25 miles per gallon</td>
<td>93% (motor efficiency)</td>
</tr>
<tr>
<td>Annual cost</td>
<td>$840</td>
<td>$6,150</td>
</tr>
</tbody>
</table>

Quite a contrast! If I doubled the gas mileage of my automobile to 50 miles per gallon, I’d save only a third of what I’d save if I dropped my pump load from 25 down to 20 horsepower. Doubling my car’s gas mileage would be a challenge, but a 20% improvement is often achievable in pumping systems—if system performance and requirements are well understood.

I suspect that 99% of the time you use your speedometer simply to avoid getting the “blue light special.” Consider how big a fine you pay to the local electric utility every day because you don’t know your pumping system’s speed.

I’m Appalled—No Meter’s Installed!

Pumping systems with no flow meters are very common, even in large industrial systems. Because energy costs usually overwhelm capital costs for pumping systems, the wisdom of building an unmetered system may be questionable. But given this reality, we’ll identify alternative approaches to estimating flow rate in such systems.2 Beginning with this issue, we’ll discuss three methods:

1) Use of head-capacity curve.
2) Volume change rate measurement.
3) Velocity head deduction.

As we begin to discuss these techniques, here is one final automobile analogy.

With my car on cruise control, I occasionally compare my odometer-indicated distance and speedometer-indicated speed with the distance and speed deduced from mileage markers and my wristwatch. Doing this, I can verify that my speed and mileage indications are reasonably accurate (assuming that my watch and the mileage markers are dependable).

Similarly, these flow-estimating techniques, though far from perfect, are worth considering, even when a flow meter is installed.

(continued on page 5)
Using the Head-Capacity Curve

Pump manufacturers develop head-capacity curves for generic pump models, based on test performance data. These curves are useful in selecting a pump for a particular service; they can also be used to estimate flow rate based on measured head.

Consider the pump configuration in Figure 1, and the head-capacity curve in Figure 2.

But What About?...

Now let’s flag a few assumptions inherent in this approach:

1) This pump’s original performance curve is identical to the generic curve.
2) The field performance is identical to the test facility performance.
3) Pump performance is not degraded from service wear or foreign material.
4) The actual rotating speed is 1750 rpm.

How many of these assumptions are likely to be valid?

For the first assumption, consider the Hydraulic Institute’s (HI) acceptance test tolerances for a pump in this general category, which allows the measured head to be up to 8% above that specified at the rated flow rate. Alternatively, the flow rate can be up to 10% above that specified at the rated head. This tolerance range alone gives an indication of the potential variability from pump to pump, and highlights the value of a certified test curve for the specific pump.

Field and test facility performance can differ for a variety of reasons; in this example, the discharge pressure is measured downstream of an expander and discharge header tee. There are losses across these components that would need to be accounted for.

The potential effects of service wear can be extremely variable, but the longer a pump has been in service, the less likely it will perform like new.

Fortunately, speed equality can be checked (for example, with a strobe light as shown in Figure 3) and accounted for, if different. We’ll illustrate how speed can be accounted for with ASDs. This is important, even when operating on a fixed speed motor.

Assume we find the rotational speed of the pump is 1780 rpm. Using pump affinity laws, the head-capacity curve can be adjusted upwards, as in Figure 4.

The flow rate at 160 ft on the 1780 rpm curve is 2570 gpm, about 7% more than estimated from the 1750 rpm curve. If the measured head had been 200 ft, the speed-related error would be dramatically greater—over 75% (700 vs. 1240 gpm)!

One last potential “gotcha” in using pump head to estimate flow rate is that the velocity head component must be included. But since the velocity head can only be determined once the flow rate is known, we must use an iterative solution.

In this case, the velocity head component is small (about 0.7 ft), but that is not always the case.

In the next issue, we will cover the other two methods of estimating flow rate in unmetered systems.

Comments/questions welcome by e-mail: a85@ornl.gov

1 PSAT—Pumping System Assessment Tool, a DOE software product available as a free download at: http://public.ornl.gov/psat.
2 Clamp-on, ultrasonic flow meters are available that are non-intrusive. My experience with externally mounted ultrasonic meters has been mixed. I’m not aware of a report on independent testing of such flow meters under real-world conditions, but encourage readers to provide feedback in this regard.
3 See ANSI/HI 2.6-1994, Vertical Pump Tests, Section 2.6.5.3.
4 There is a way to avoid the iteration — but we’ll leave that for a future column.
Maximize Your ASD Application with ASDMaster

Control of process equipment using electronic adjustable speed drives (ASDs) offers significant opportunity to save energy and improve operations. However, the effects of ASDs on process systems are not always well understood. To simplify the process of learning about, analyzing, and specifying an ASD application, the Electric Power Research Institute (EPRI) Adjustable Speed Drive Demonstration Office (ASDO), in cooperation with the Bonneville Power Administration, developed the ASDMaster software. Designed with the layperson in mind, ASDMaster provides a suite of educational materials and software tools for people with little or no experience applying ASDs, to experienced ASD application engineers looking for accurate, user friendly analysis software.

How Does it Work?

ASDMaster is a windows-based software package consisting of six different modules designed to educate and assist users in the proper application of ASDs. A software instruction module and text are included to educate users on the process effects, technology, and power quality issues associated with ASDs. Analysis tools assist users in the accurate, total systems-based analysis of the energy and production benefits associated with ASDs. A simultaneous analysis is performed on constant speed controls for comparison. ASDMaster also contains a specification tool that assists users in writing a solid performance specification for an ASD, just by answering the appropriate questions and filling in the blanks. Finally, ASDMaster’s database module directs users to manufacturers with ASDs that can meet their needs, generating a bid-list and contact information with just a few button-clicks.

Where to Get Your Copy

To order your copy of ASDMaster, or to receive more information about the product, call the EPRI ASDO today at 1-800-982-9294.

Adjustable Speed Drive Application Workshops

If you are an end user, utility, or motor manufacturer, the Adjustable Speed Drive Application workshops can help you in your job. These workshops address the fundamentals of ASDs and offer a demonstration of the ASDMaster software. The workshops are offered in co-sponsorship with OIT Allied Partners.

Attend one of the following:

- April 25 in Marlboro, MA, MA Toxics Use Reduction Institute.
  Call Ann Berlin Blackman at (978) 934-2124.
- May 9 in Greensburg, PA, PA DEP Allegheny Power.
- May 23 in Manchester, NH, State of NH Wastecap Resource Conservation Network.
  Call Erin Wheeler at (360) 754-1097, ext.104.

Soliciting Help

OIT’s Industrial Assessment Center (IAC) program is soliciting ABET accredited engineering schools across the country to help small and medium size manufacturers save money and improve productivity. The Industrial Assessment Centers, at present, are located at 30 universities across the country. Teams of engineering faculty and students from the centers conduct, at no cost, industrial assessments and provide recommendations to small and medium size manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy. Recommendations from industrial assessments have averaged about $55,000 in potential annual savings for these manufacturers.

Solicitations will be sent to the Department Heads and Deans of Engineering at all ABET accredited schools. Call Gwen Looby at (215) 387-1535, ext. 221, for more information.

Mark Your Calendar for...

...the 4th OIT Industrial Energy Efficiency Symposium and Exposition. Set for February 19-22 in 2001, this event will help U.S. industry prepare to compete globally. Learn from recognized experts who will share their perspectives on the competitive challenges awaiting U.S. manufacturers and hear their potential solutions for success in global markets. The exhibit hall will feature over 150 booths highlighting technologies under development, emerging cutting-edge processes, and other results of collaborative partnerships. Join other manufacturers, government R&D managers, corporate R&D directors, university researchers, national laboratory scientists, representatives from the financial community and many more at this exciting Expo, to be held in Washington, D.C.

How to Register

You may register online at www.oitrexp4.com or call (877) OIT-7967 to obtain a registration form.
The energy consumed by the PWM drive is only 4% less than the EC drive. Why is this? The simple reason is that the affinity laws are the dominant factor—the shaft power required at 50% fan speed is only 1/8 of what it was at full speed. With this load profile, it would be very difficult to justify replacing a functional, less efficient EC drive with a new PWM drive. A different conclusion might be reached with a different load profile; the point is that efficiency comparisons don’t tell the whole story.

Beyond the Affinity Laws

Now that we’ve shown why the affinity laws tend to dominate the picture in centrifugal loads, it is worth extending our focal length a bit more to see a system picture. A very common mistake made in developing rough estimates of energy reduction by applying adjustable speed drives is to simply use the affinity laws.

Assume we have a pump that is operated simply to fill a tank. The tank supplies the system (by gravity) continuously, but the pump only has to run 12 hours a day to keep the tank full. According to the affinity laws, if we slowed the pump down to 50% speed, the flow rate would drop to half and the power would drop by a factor of eight. If we ran the pump at half speed for 24 hours a day instead of at full speed for 12 hours a day, the energy consumption would go down by a factor of four, right? Wrong.

If the system had no static head, the logic would be fine; but in many pumping systems, static head is a significant part of the overall system head. For example, as shown in Figure 3, the pump operates at about 3350 gpm and 50 ft of head when operated at full speed. However, when it is slowed to half speed, the flow rate is 0 gpm; in other words, the pump function has switched from a water mover to a water heater. The simple reason is that the system has static head—in this case, about half of the head at full speed is static.

Table 2 shows the power for the two load conditions, and annual electrical energy and expense, assuming an energy cost of $0.05/kWh.

Table 2. Power, Energy, and Cost Comparison

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>Full-speed kW</th>
<th>Half-speed kW</th>
<th>Annual cost, $1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM</td>
<td>43</td>
<td>6</td>
<td>296</td>
</tr>
<tr>
<td>EC</td>
<td>43</td>
<td>12</td>
<td>309</td>
</tr>
</tbody>
</table>

The energy consumed by the PWM drive is

![Figure 3. Electric power vs. speed.](image)

Looking Out the Top of the Lens

In many industrial operations, adjustable speed drives can be beneficial. There are many details that must be considered in implementing drives. But these examples have illustrated how too narrow a focus on individual component performance and the failure to see the system as a whole can lead to significant errors.

While the examples used here are just that—examples—they are in their essential nature. Preference is given to letters relating to articles that appeared in the previous two issues. Letters may be edited for clarity, length, and style.

Letters to the Editor

Energy Matters welcomes your typewritten letters and e-mails. Please include your full name, address, association, 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 our readers on related technical topics, comments, or criticisms/corrections of a technical nature.

Go Online for Extra News and Updates

Find more articles and resources on this issue’s theme—ASD Technologies—by visiting the Energy Matters Extra Web site. From here, you can also link to a Web-based Combined Heat and Power (CHP) analysis tool to screen a potential CHP site. Then, access the Office of Industrial Technologies’ (OIT’s) new online discussion database to post your comments or questions about CHP. Universities will find a new solicitation announcement with the details on applying for participation in OIT’s Industrial Assessment Center program. Go to Energy Matters Extra at www.motor.doe.gov/emextra.

Naming Names

David Gaw of the Washington State University Energy Program took the Name Game Challenge (November/December issue of Energy Matters Extra) and correctly identified 19 of the 25 historical energy champions hidden within a story by Don Casada. Our thanks and congratulations to Mr. Gaw for his effort. Check out the answers in the current edition of Energy Matters Extra—and watch for other energy-related quizzes in future editions.
Coming Events

**Fundamentals of Compressed Air Systems**
- April 19, in Northhampton, MA, New England Electric, MA Electric.
  Call Anita Hagspiel at (508) 421-7221.

**Adjustable Speed Drive Application Training**
- April 25 in Marlboro, MA, MA Toxics Use Reduction Institute.
  Call Ann Berlin Blackman at (978) 934-2124.
- May 9 in Greensburg, PA, PA DEP Allegheny Power.
- May 23 in Manchester, NH, State of NH Wastecap Resource Conservation Network.
  Call Erin Wheeler at (360) 754-1097, ext. 104.

**Pump Systems/Pumping System Assessment Tool Workshop**
- April 26 in Marlboro, MA, MA Toxics Use Reduction Institute.
  Call Ann Berlin Blackman at (978) 934-2124.
- May 1 in Westbrook, CT, BJM Corp.
  Call Anna Maksimova at (360) 754-1097, ext. 100.

**NC State University, Industrial Extension Service Workshops**
- Cooling Tower Operations, April 25 in Atlantic Beach, NC.
- Energy-Efficient Lighting, April 26 in Atlantic Beach, NC.
- Preventive Maintenance, April 27 in Atlantic Beach, NC.
- Energy-Efficient Motors, May 5 in Atlantic Beach, NC.
- Certified Energy Manager, May 8-9 in Raleigh, NC. (2 days, 8:30 a.m.-4:00 p.m.)

All events last from 9:00 a.m. till 4:00 p.m. For more information, contact Jim Parker at (919) 515-5438, or at jim_parker@ncsu.edu.

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**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.motor.doe.gov

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- Scott Hutchins, Boston, MA, (617) 565-9765
- Julie Pollitt, Chicago, IL, (312) 886-8571
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- Julia Oliver, Seattle, WA, (510) 637-1952
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In 1987, Malden Mills, a 2-million-square-foot mill in Massachusetts, had installed a Combined Heat and Power (CHP) system to generate electricity from the waste heat of its production process. This system was part of a larger effort by companies and institutions to harness the energy from waste and by-products to reduce their energy costs. The CHP system was designed by a group of universities and industry leaders known as the MIT-Penn State Advanced Turbine System (ATS) Program. The system was intended to demonstrate the feasibility of using industrial waste heat to produce electricity, and it was a significant step towards the widespread implementation of CHP technology.

The CHP system at Malden Mills consisted of two advanced gas turbines that were able to produce 2.5 megawatts of electricity and 1.4 million pounds of steam each hour. The company was able to recover 95% of the energy from the waste heat, which was then used to power the mill's operations. This resulted in significant cost savings for the company, as well as environmental benefits, as the CHP system reduced the mill's reliance on fossil fuels.

In 1994, one year after the system was commissioned, both of the gas turbines were retrofitted with technology that allowed them to operate on natural gas. This was part of a larger trend towards the use of natural gas as a more efficient and cleaner alternative to fossil fuels. The CHP system at Malden Mills was a significant milestone in the development of CHP technology, and it served as a model for other companies looking to reduce their energy costs and environmental impact.

For more information on CHP technology and its potential for reducing emissions and improving energy efficiency, see the article “Combined Heat and Power—Power Production for the New Millennium” in the July 1999 issue of Malden Mills CHP Success Stories—Paving the Way for the Future.
With CHP developers and users to identify, bring together key state and local officials, and on-site applications. This will result in a net energy savings of 2.176 Tbtus, 37 million metric tons carbon dioxide, and 4 million tons of nitrogen oxide emissions by 2020—an increase of 50% goal: Double the amount of power generated. A coalition of those responsible for the siting, permitting, and interconnection barriers that raise the costs of CHP development. Outreach activities have occurred in New Mexico (May 2000), Ohio (September 2000), Tennessee, Washington, California, New York, and Vermont. These efforts have resulted in grants from the Department of Energy CHP goal: Double the amount of power generated. A coalition of those responsible for the siting, permitting, and interconnection barriers that raise the costs of CHP development. Outreach activities have occurred in New Mexico (May 2000), Ohio (September 2000), Tennessee, Washington, California, New York, and Vermont. 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The Technologies That Make CHP Tick

Cogeneration

Cogeneration is a promising energy-use option that combines electricity and heat production from a single energy input. Cogeneration can reduce overall energy costs, lower emissions, and conserve fuel. It is the most efficient and environmentally sound way to produce electricity and heat. The output of a single energy conversion process is used to produce both electricity and heat within the same piece of equipment.

CHP systems can be fueled by a variety of energy sources, including natural gas, coal, and waste fuels. Microturbine technology is still in the early stages of development and is not widely available. There are currently no CHP systems available that can burn coal, biomass, or other renewable fuels.

The CHP Web site is rapidly becoming a national clearinghouse for information on CHP policies, markets, and technologies. One of the new features being developed on the CHP Web site is an online discussion forum that will allow users to share information and experiences about CHP projects.


Harnessing the energy of a CHP system can be a very simple process. If your proposed application looks promising after the initial screening, the next step is to begin preliminary design. At this point, the CHP Web site can provide a detailed evaluation. To make it simple and easy to use, the CHP Web site includes many assumptions and considerations. PEM fuel cells, the most promising of all the fuel cell technologies, are used for generation requirements of 500 kW or more. They are compact, lightweight, and simple to operate, gas turbines have the flexibility and output required for machine drive applications that do not require the full power of a gas turbine.
near-term actions to accelerate the use of CHP systems was the development and
promotion of new technologies to make
CHP internationally.

Interactive symposium showcasing cogeneration,
distributed power, and district energy activ-
ities throughout the world. Interactive pan-
diums from 20 countries attended the sym-
posium. "Microturbines," used for generation
of recovered heat and power production.

A summary of such resources can be found
in the Appendix. CHP technologies are numerous. Some of
the most promising after the initial screening, the
combination of simple, efficient, and reliable.

The next step is a more detailed feasibility
assessment. For example, it uses average
steam turbine is added to convert steam to
electricity and steam. (Many industries used in industrial and utility settings to pro-
duce power on sites that have space limitations. Waste heat recovery devices require less maintenance and do not dependency on usage. Generally, oil bearings last
longer and are less prone to catastrophic
failure, whereas ceramic bearings are cheaper
to manufacture and more suitable for
operations requiring high temperature and
efficiency. Ceramic bearings are also used in
driving machines to reduce friction and
wear. Ceramic bearings improve reliability and
life expectancy, which is very important for
machine drive applications that do not require
as much weight as for other types of bearings.

The Microturbine Technologies

A Microturbine is a turbine that can be
installed in a building, on a rooftop, or even
in a vehicle. They are small-scale, low
pressure, high-temperature turbines that
produce electricity with a 30% efficiency,
(3) your new equipment will increase your
running and maintenance costs if the new
system is not properly installed or operated.

The Microturbine is a promising technology
because it is both simple and efficient. It
requires less maintenance and does not
require an oil system and pump. Single
shaf ted or split-shaft designs are available
with different types of Microturbines, and
each type offers unique benefits.

The Microturbine is also a compact size, light
weight, opportunities for machine drive appli-
cations.

The Microturbine advantages compared to other small-scale power

Institutions, large industrial establishments,
and commercial buildings have used recip-
cranking engine, reciprocal with high thermal
power-to-volume ratio makes it appealing
for applications where precise emissions and efficiency can
be controlled with ease. Microturbines are ideal for small-scale
applications requiring high efficiency, reliability, and low
noise. They are used in industrial and utility settings,
including chemical, power, gas, and
combustion systems. Both fuel cell types have
been used in a variety of applications,
including residential, commercial, and institutional
buildings. PEM fuel cells, the most
cost-effective and reliable, are used for
building-level applications such as
residential heating and cooling systems.

PEM fuel cells achieve efficiencies in the range of
70-90%, making them ideal for
smallscale applications. Microturbines are
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In 1957, Malden Mills had developed a plan for a 2.2-MW natural gas-fired CHP system on its Cambridge campus. At that time, the university had need for reliable power while saving MIT $5.4 million a year. The project was allowed to move forward only after the university completed a detailed environmental study and demonstrated that its innovative system had lower net emissions relative to the state-approved fossil fuel-fired CHP system. The system continues to produce clean, reliable power while saving MIT $3,500 per day levied on MIT by the local utility and generating steam for heating, air conditioning, and process needs while cutting its annual energy bill by 40%. In addition, by making it possible to maintain power during an outage, CHP reduces the probability of service interruptions.

To build on this success, the Massachusetts Department of Environmental Protection (DEP) emphasized CHP to its consumers. If these fees are applied to those loads above a certain threshold, the system owner may proceed with the installation of a CHP system. An additional financial barrier to CHP installations is existing tax policy in many states. With the passage of the Energy Policy Act in 2005, Congress made it more attractive for large commercial and industrial establishments to install CHP systems. The act offered a 10-year tax credit equal to 30% of the cost of the CHP system and exempted CHP generators from such exit fees. In a restructured environment, these fees will be open to competition and arbitrary fees. In a restructured environment, these fees will be open to competition and arbitrary fees.

While this example pertains to a commercial establishment, the same barriers exist for the installation of CHP systems in the utility sector. The United States has only a few large baseload CHP projects, and they are in the developmental stage and are expected to be online in the next five years. Fuel cells are also in a prototype phase. There are several drivers for development of new fuel cell technologies, including a desire for reduced air emissions, reduced fuel cost, and decreased dependence on foreign oil.

An additional barrier to be overcome is treatment of CHP projects by the grid. Currently, the grid operates to maintain power during an outage. While this is a valid objective, it is not always efficient, especially when the source of emissions is remote. If CHP is the only source of emissions from a specific source, this approach does not credit CHP with the emissions reductions associated with its installation. CHP can also be used in industrial settings. An independent analysis found that its innovative system had lower net emissions by an additional 40%. The project was allowed to move forward only after the university completed a detailed environmental study and demonstrated that its innovative system had lower net emissions relative to the state-approved fossil fuel-fired CHP system. The system continues to produce clean, reliable power while saving MIT $3,500 per day levied on MIT by the local utility and generating steam for heating, air conditioning, and process needs while cutting its annual energy bill by 40%. In addition, by making it possible to maintain power during an outage, CHP reduces the probability of service interruptions.

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Malden Mills Textile Plant

CHP Success Stories—Paving the Way for the Future

In the late 1980s, the Massachusetts Institute of Technology (MIT), faced with enormous costs for electricity, water, and heat, began a comprehensive energy study with the expectation that it would result in significant energy savings.

In 1989, Malden Mills, a 2.2-million-square-foot textile mill located that stands at the forefront of textile technology, was purchasing its steam and electricity from a nearby natural gas-fired power plant. Fortunately, the facility was not only unable, but financially unable, to compete against low-cost electricity.

In 1997, Massachusetts legislation created a new financial incentive called the Massachusetts Combined Heat and Power (CHP) Program that would provide funding for new CHP systems. As HWMA resources, the Massachusetts CHP Program provided funding for new CHP systems. As HWMA

In addition to economic benefits, CHP has demonstrated substantial environmental benefits as well. A 22 MW natural gas CHP system installed by NiSource, Inc. at a major retail pharmacy chain, has reduced greenhouse gas emissions by 40%

In the fall of 1999, MIT's new 94% efficient solar microturbine with CHP can also be used in industrial settings. Commercial building, microturbines that utilize fuel cells are also in a prototype stage.

The microturbine's key selling points are performance, reliability, and fuel flexibility. Microturbines can use a variety of fuels, including natural gas, fuel oil, and LP gas.

Conclusion

Overcoming obstacles to widespread use of CHP requires a diverse array of technologies and approaches to be developed and applied. Some of these technologies are already commercially available, while others are still in the early stages of development. The key to success is a combination of technological innovation and policy support.