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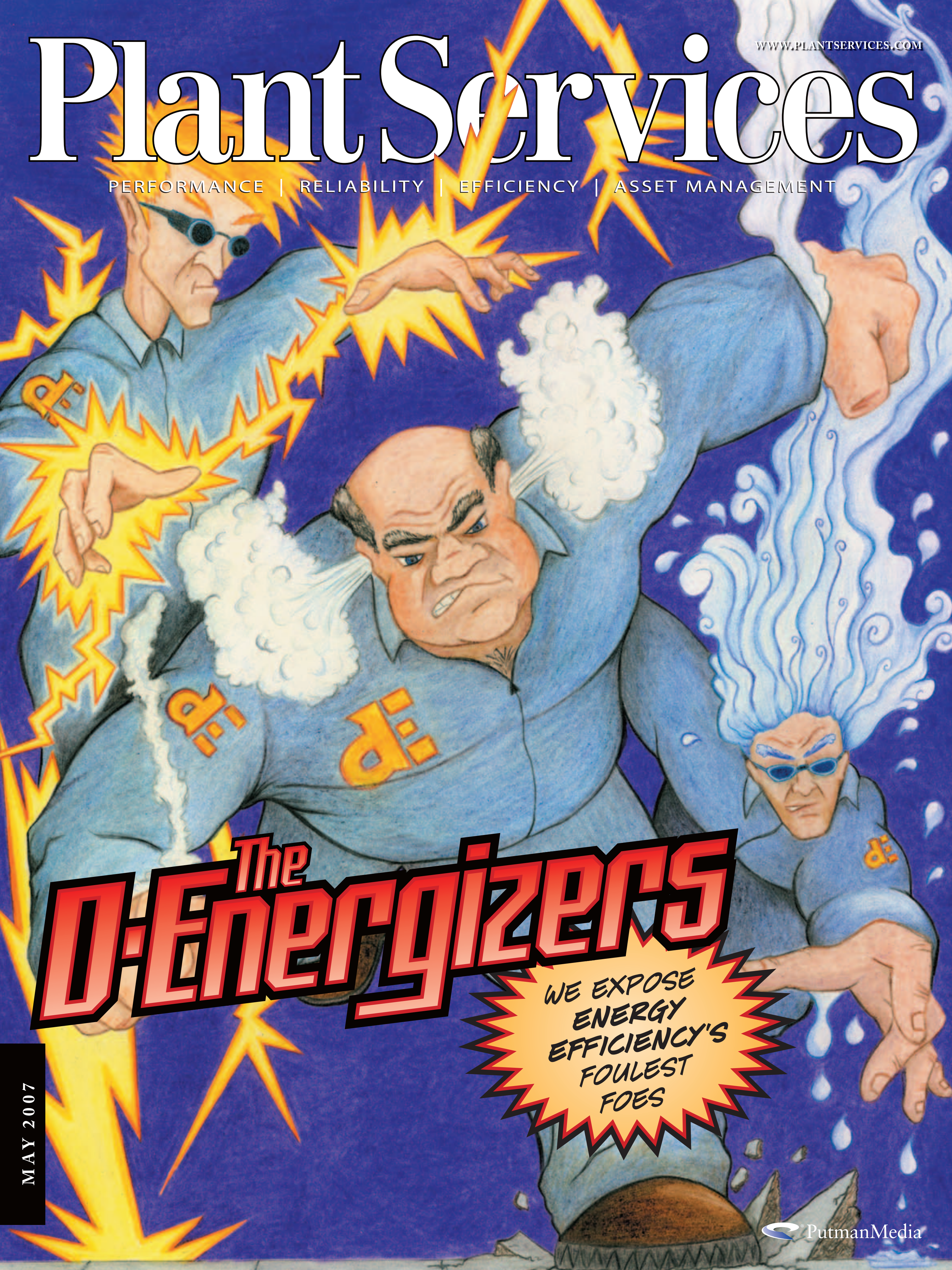

MAY 2007

PutmanMedia

Industry's perspective has come a long way from the '50s and '60s when it seemed we'd have an endless supply of cheap energy. Back then, Reddy Kilowatt promised nuclear power so inexpensive they wouldn't have to meter it, throwing half the energy of combustion out the smokestack was good enough, and Jed Clampett could strike oil just "shooting for some food."

The rapid rise of energy costs during the past few years, buttressed by concerns about energy security and climate change, support the widespread conclusion that we're entering an era in which energy productivity (energy cost per unit of production delivered to the customer) will loom ever larger as a factor in the bottom line and global competition.

As Contributing Editor Peter Garforth has explained in detail starting October, 2005 in our Energy Expert series (see sidebar, "More resources at www.PlantServices.com"), systematically increasing your company's energy productivity requires a comprehensive strategy built on solid understanding of each facility's consumption, usage, criticality to the business and vulnerability in the market.

But how big are the potential savings, how fast might they come and where are they commonly found? Of course, there's no single answer that fits every facility, but the experts we consulted put the finger on three major villains: electrical, boiler and compressor/pump/fan systems. We've renamed this evil trio the Zapper, the Steamer and the Leakster, respectively and as a group, we dub them the D-Energizers. These villains break down into a number of areas where major wasted energy dollars usually lurk. Individually, or as a team, they're out to sabotage your plant's energy resources. If you want to be the hero at your plant and rid your world of the D-Energizers, get your utility belt ready and follow along.

What are you paying?

The first step in any rehabilitation is acknowledging a problem. Recognize that these D-Energizers exist and lurk around every corner. While you and your purchasing department might be well aware that you need to pay more attention to energy, the folks in charge of using it often are oblivious, and most plants don't have the detailed consumption information they need to get started. The first step to raising awareness and getting actionable data is to monitor consumption. Catching the D-Energizers in the act is the place to start.

"If a plant is monitoring energy and water usage, they're really ahead of the game," says Cassie Quaintance, energy market segment manager, Schneider Electric (www.us.schneider-electric.com). "If not, they need to install instrumentation. You have to be armed with information to be given the green light on projects."

Consumption data can support negotiations with power companies. "Attention to rates, tariffs, time-of-day and peak shaving on the supply side can provide some really quick hits with good return on investment that can finance changes on the demand side," Quaintance says, "and the demand side requires detailed energy analysis."

If you perceive the need for a monitoring system as a significant obstacle, think of it as a tool not only for targeting cost reduction opportunities, but for enlisting energy users in the cause, Quaintance says. "It's difficult to put an ROI on a monitoring system, but we find that just putting one in place can make people aware and reduce consumption by 5% to 7%."

Table 1: Crime doesn't pay

	DOE average motor	High-efficiency motor	NEMA Premium motor
Efficiency	93.5%	95%	96.2%
Electrical cost/year*	$104,839	$103,184	$101,869
Annual savings		$1,655	$2,943
20-year lifetime			$58,860

*Energy costs for a 200-hp, four-pole motor (24/7, $0.075/kWh)

Inefficient motors

Enter the Zapper. He's fast and out to sap the motors at your plant by making them run at less than peak performance. Because you're reading this, you've probably seen a lot about industrial motor efficiency, so I'll be brief. Consider motor efficiency first if large motors run many hours under heavy loads (Table 1).

For average motor applications, replace single-phase motors with three-phase motors. Where a typical single-phase motor is operating at 80% efficiency, a premium single-phase is 86.5%, a typical three-phase is 87.5%, and a NEMA Premium three-phase is 90.2%. If only a single phase is available, consider using an inverter and a three-phase motor.

The U.S. DOE estimates annual savings of 62 billion kWh to 104 billion kWh (15 million metric tons to 26 million metric tons of CO_2) would result from implementing motor-related best practices (see sidebar, "DOE's hit list"). But if we only replace motors on failure, this will take 15 years to 20 years. Make life-cycle cost a factor in every motor decision and, when in doubt, spend more for the most efficient motor you can lay your hands on to keep the Zapper away.

Partial loads

The Zapper loves equipment running at lower than its design load. Pumps, fans, compressors, many other kinds of driven equipment, motors and power transformers are designed for maximum efficiency at a specified output. Whenever that's more than you need or you control output by throttling, you're almost certainly wasting energy. If you never need full output, it might make sense to downsize the driver.

BY PAUL STUDEBAKER, CMRP, EDITOR IN CHIEF

Obey the laws

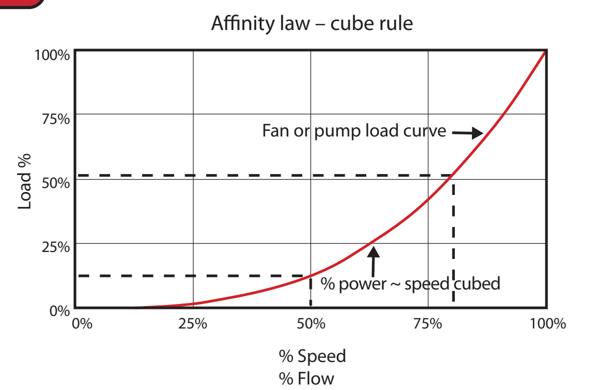

FIGURE 1. FOR CENTRIFUGAL PUMPS AND FANS, AFFINITY LAWS SAY FLOW IS PROPORTIONAL TO MOTOR SPEED WHILE POWER IS PROPORTIONAL TO MOTOR SPEED CUBED. (BALDOR)

If specified output is needed only part of the time and output can be varied by motor speed, a variable-speed drive (VSD) might offer rapid payback. For centrifugal pumps, fans and compressors, affinity laws show that flow is proportional to motor speed, pressure is proportional to motor speed squared and power is proportional to motor speed cubed (Figure 1).

VSDs aren't just for big compressor motors. Candidates include centrifugal pumps and fans used for supply and return air, chilled water and hot water from boilers to coils and cooling towers. "One of our typical plants will have, for every 100,000 sq.ft., five or six air handlers, each with a 10-hp to 15-hp supply fan and 5-hp return fan; 10 hp to 15 hp on cooling towers and a network of five to 15 pumps to and from chillers, boilers and cooling towers," says Ivan Spronk, AC drive product line manager, Schneider Electric. The equipment is sized to keep things cool on the hottest days and warm on the coldest days, but there are only perhaps 20 extremely warm or cold days in a year. On the other 345 days, it could operate at lower capacity.

"The affinity laws show that you can get 80% of the flow with 50% of the power," says Spronk. For example, consider a 20-hp motor that runs 2,600 hours a year, at 100% power 25% of the time, 80% power 50% of the time and 60% power 25% of the time, "At $0.10/kWh, the annual savings is $1,700, and a conservative payback figure is 18 months to 20 months."

When VSDs are used instead of flow control valves or air inlet guide throttles, "It's not as straightforward to calculate the savings, but you also save on valve and guide maintenance," say Spronk.

Drives also can serve as sensors to monitor motor run time and kilowatts used to document reductions, to get real-time feedback on energy use for managing demand charges, and for lowering peak loads. For instance, demand might be set by a 300-hp compressor motor that starts at the same time every day. A drive can soft-start the compressor and reduce the peak load.

Citing a DOE study that says 44% of motors in industrial facilities operate at 40% or less of full load and are operating inefficiently, John Hurst, director of engineering at Power Efficiency Corp. (www.powerefficiency.com) claims that there are only two ways to reduce the energy an underloaded motor uses: change speeds with a VFD or use his company's technology.

The Power Efficiency Motor Efficiency Controller keeps the motor running at full RPM and monitors the power consumption. When the voltage and current sine waves diverge greatly (phase lag increases), the motor is lightly loaded and operating inefficiently. The unit reduces current and voltage while maintaining RPM. When load increases, the controller increases power. It also serves as a soft start and has outputs for power monitoring. Results on a 40-hp "up" escalator at Caesar's Palace are shown in Figure 2. If you have experience with this or similar energy-saving devices, please send comments to me at pstudebaker@putman.net.

Power transformers also often run at less than full load. "Surveys show that the typical loading of low-voltage, dry-type transformers on a 24-hour average basis is between 15% and 35% percent of full load rating," says Thomas Patzner, LV transformer product marketing manager, Schneider Electric. Transformers manufactured after January 1, 2007, meet new federal standards for higher energy efficiency. His company has reduced coil and core losses to increase energy efficiency. Compared to non-NEMA TP1-compliant models, Patzner says a typical Square D energy-efficient transformer pays back in five to six years at $.075 per kWh, and will recover its cost during its life expectancy.

Control theft

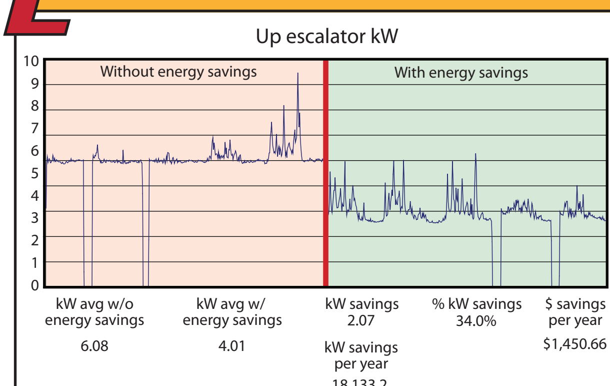

FIGURE 2. POWER CONSUMPTION OF AN OFTEN LIGHTLY-LOADED 40 HP "UP" ESCALATOR AT CAESAR'S PALACE IN LAS VEGAS WAS REDUCED 34%, RESULTING IN ANNUAL SAVINGS OF $1,450 AND A PAYBACK OF 22 MONTHS. (POWER EFFICIENCY CORP.)

Bad lighting

Here, the Zapper uses his electric personality, mercilously cutting into your power to dim the lights. Paybacks on improving lighting efficiency depend tremendously on the existing system and how it's used. "There are two ways to reduce lighting costs and they are complementary," says Andy Foerster, director of Square D Lighting Control Business, Schneider Electric (www.us.schneider-electric.com), "lighting controls that turn them off or dim them for daylighting, and more efficient light sources."

Controls tend to be the more cost-effective option where full brightness isn't required much or in all areas. Where lights must be on more of the time, fixture efficiency dominates.

Controls can turn lights off, on or dim them using a predetermined plan, occupancy or light-level sensors (for daylighting tasks). They can reduce power consumption on notice for demand curtailment rate programs. Instead of leaving lights on 24/7 for security, controls can turn them on at the first sign of trouble for first responders.

"Control systems fit into existing panels," says Foerster. "Networking them allows local metering that lets you see where you are and identify the best potential for fixture improvements. They also let you document results for rebates."

Fixture efficiencies have improved significantly during the past few years, allowing fewer watts to do more. "We used to plan 4 W per sq.ft.," says Foerster, "now it's 1 to 1.5 for offices, 2.5 to 3 for manufacturing."

Foerster says lighting accounts for as much as 43% of a facility's electrical load, including commercial aand industrial applications. Payback is often a year or less, "sometimes much less."

The Zapper is fast and works overtime to keep the plant in the dark.

Old boilers

Enter the Steamer. He uses his incredible bulk to sweat the efficiency out of your boilers. According to the U.S. DOE, steam generation accounts for nearly one-third of the total U.S. manufacturing energy consumption, and almost 80% percent of the boilers in the United States are nearing 30-years-old or older. "Chances are good you're working with a boiler that's not operating at optimal efficiency," says Daniel Willems, P.E., vice president, product development for Cleaver-Brooks (www.cleaverbrooks.com), "possibly only in the 75% to 80% range."

The other 20% to 25% of the energy input is lost as blowdown, radiation, convection and hot flue gas. "The most impactful energy savings can be grouped into two main categories: heat recovery equipment and controls," Willems says. Heat recovery retrofits include economizers, air pre-heaters, "and coming to market this year, a transport membrane," Willems says. Control options include O_2 trim, parallel positioning and variable-speed drives.

Estimates for costs and paybacks for efficiency-improving modifications to a typical 600-hp boiler are shown in Table 2. Replacing a single modulating motor with dedicated actuators for fuel and air controls reduces excess oxygen requirements 2% to 5% for a 2% efficiency improvement. "As a general rule, boiler efficiency increases by 1% for each 2% reduction in excess oxygen," Willems says. On a 600-hp boiler, "That equates to a savings of $10,700 per year based on a 50% average load 12 hours per day and a fuel cost of $10/MM BTU."

An oxygen sensor/transmitter in the exhaust gas can be used to trim the air damper or gas valve to minimize excess air, giving another 1% to 2% efficiency.

Using a VSD to run a 50-hp blower motor at 40 hp, 12 hours per day, with a load factor of one and motor efficiency of 86%, will save $3,360 per year at $0.10/kWh.

Economizers transfer energy from the boiler exhaust gas to the boiler feed water, typically increasing boiler efficiency by 2.5% to 4%, depending on the type of heat transfer surfaces and the allowable pressure drop. As a general rule, every 40°F reduction in boiler gas temperature increases efficiency by 1%.

Combustion air must be heated to combustion temperatures. Preheated air requires less fuel, boiler efficiency is increased. Air preheaters transfer heat from the boiler exhaust to the combustion air, and can increase efficiency about 1.5%.

"Transport membranes are in the final stages of development and will be available within the next year," says Willems. "They recover both latent and sensible heat from the boiler exhaust and dehumidify it at the same time. At a recent beta site, combining this membrane with an economizer and controls gave system efficiencies greater than 94%, far surpassing the typical 75% to 77%." Combining a transport membrane condenser with an economizer and updated controls can result in a total efficiency gain of 10%.

"Many boiler rooms have steam and condensate return lines that aren't completely insulated," Willems says. A 4-in. diameter pipeline at 150 psig, 100 ft. long, without insulation will lose 850 MM BTU/year. "Approximately 90% of this loss can be saved by adding insulation," he says. Smaller additional savings can be obtained by insulating condensate return lines, boiler feed water lines and other piping runs.

Blowdown heat recovery systems typically recover about 3% efficiency by using the energy normally lost during blowdowns to preheat feed water.

DOE's Hit List

- Use NEMA Premium motors
- Improve rewind practices
- Reduce system loads (5% to 60% savings)
- Control motor speeds (30% to 80% savings)
- Match equipment to the load (5% to 30% savings)
- Upgrade component efficiencies (2% to 10% savings)
- Maintain motors and equipment (2% to 30% savings)
- Downsize oversized motors

Improving the heat transfer on the combustion side of boiler tubes can improve boiler efficiency as much as 20%, according to Fuel Efficiency LLC (www.fuelefficiencyllc.com), which offers automatic boiler tube cleaning and combustion gas flow improvement systems.

Faulty or leaking steam traps and other leaks contribute mightily to steam system losses – for more information, see "Steam systems and efficiency" in "More resources…"

Compressed air

Enter the Leakster. Last but not least, he's a shapeshifter, who shows up anywhere a leak can waste energy. Any compressed air system yields only 10% to 15% of its energy consumption as compressed air – the rest is lost as heat (Figure 3). "Of the 10% to 15%, production typically only receives 50% because of leaks, artificial demand and inappropriate use," says Frank Moskowitz, technical services and educational manager, Draw Professional Services (www.drawproservices.com), a wholly owned subsidiary of Atlas Copco.

"Artificial demand is typically caused by excess pressure, which increases consumption by unregulated uses, leaks, etc.," Moskowitz says. "Inappropriate use is something that can be done any other way," such as with a motor, blower, mechanical action, etc.

Many plants focus efforts to reduce compressed air energy costs on the supply side – the attention-getting compressors themselves. But best results come from looking first at the demand side to minimize pressures and reduce waste. "Repairing leaks might be costly, but reducing the pressure is easy and reduces leak rates," Moskowitz says. "ROI can be immediate."

Criminal consumption

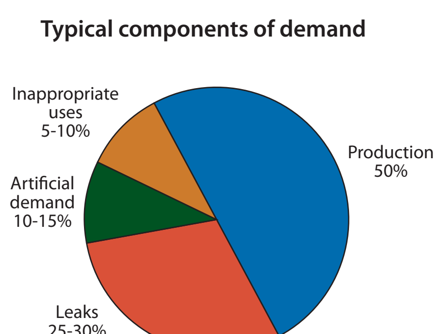

FIGURE 3. Compressed air systems yield only 10% to 15% of consumed energy as compressed air, and typically half of that is lost to leaks, artificial demand and inappropriate use. (Draw Professional Services)

Table 2: Arrest boiler waste

Project	Parts	Installation	Annual savings
Parallel positioning	$5,000	$2,000	$10,700
O_2 trim	$12,000	$5,000	$5,000-10,000
Variable-speed drive	$5,000	$1,000	$3,400
Economizer	$10,000	$8,000	$13,000-21,000
Air preheater	$8,000	$4,000	$8,000
Piping insulation	$2,000	$2,000	$7,700
Blowdown heat recovery	$7,000	$2,000	$15,000

Example: Natural gas-fired 600 hp boiler, average load 50% 12 hours/day and 4-in. diameter pipeline at 150 psig, 100 ft. long, $10/MM BTU (Cleaver-Brooks)

For example, air cylinders often actuate heavy loads in one direction but much lighter loads on the return stroke, but are fed the same pressure for both directions. "Using a stacking pressure regulator allows two pressure levels and saves air," says Ed Bickel, sales manager, Bosch Rexroth Pneumatic Div. (www.boschrexroth.com).

Air-driven pumps are anathema to efficiency purists, but sometimes they're the only option. If used, they should be chosen to be as efficient as possible. "Our EXP model eliminates blow-by during off or stalled conditions, and the air motor design minimizes dead space to reduce wasted air," says Charles (Oakley) Roberts, marketing manager, diaphragm pumps, Ingersoll Rand (www.ingersollrand.com). "A single large pump can save thousands of dollars per year."

You can download a calculator software tool to see the potential savings. If you're not convinced, the company will come to your facility and show you a side-by-side comparison of its EXP with your current pump (Figure 4). "We prove the pump does what we say it does," says Mark Jermeay, marketing manager, fluid solutions, Ingersoll Rand. "We take an air tank and flowmeter to the customer's site and compare pumps." Payback can be a year or less.

A few cubic centimeters of compressed air can save a lot of energy (and trouble) with solenoid valves. "Direct-acting solenoid valves use 30 W to 40 W when new and 60 W or more as they age," Bickel says. "Air-piloted valves use much less energy [about 0.5 W] and they rarely burn out a coil. It adds up to big savings – 20% to 60% of valve energy, depending on the duty cycles – plus eliminating the labor to change coils."

New equipment is nice, but never underestimate the value of regular maintenance for controlling energy costs. "One of the biggest culprits is compressors working too hard and losing flow through dirty air filters," says Bickel. "People never check them, or they wait until they look dirty, which is usually several months too late. The same goes for filters at equipment."

The key is to understand the system. "I was at a gold mine in Nevada that had a mix of some of the world's most efficient compressors – reciprocating, rotary and a variable-speed," Moskowitz says, "but the reciprocating compressor was running at part load and the variable-speed was running flat out. I adjusted the pressure to fully load the reciprocating compressor and reduce the load on the variable-speed. That cut 90 kW with half a turn of a wrench.

Choose weapons wisely

FIGURE 4. MATT BRIGNAC (AGI), LYLE SHOUP (INGERSOLL RAND) AND BILL O'TOOLE (AGI) CONDUCT AN ON-SITE, SIDE-BY-SIDE AIR CONSUMPTION COMPARISON OF ARO EXP AND EXISTING DIAPHRAGM PUMPS. (INGERSOLL RAND)

"Then, we realized one compressed air pipe led down into an unused hole. We shut off the valve to that pipe, which cut off 2,000 CFM. The variable-speed compressor shut down completely. The company is saving $500,000 a year – I charged them $1,500."

Process control

Here the D-Energizers join forces for a multifaceted attack. There are big potentials for those in process industries, especially plants with cogeneration facilities. "We look at a wide variety of customers at various maturities," says Mike Bliss, business development manager, process solutions, Honeywell (www.honeywell.com). "Those that haven't invested can save 5% to 7%, from tens of thousands to millions of dollars. The hardest part is to understand how to get it narrowed down to the highest-ROI, lowest-risk opportunities."

Paybacks range from "10 years to 12 years for lighting, which is low-risk and low-investment," Bliss says, "to a few months for advanced process controls, but it takes a higher level of expert to identify them."

For example, lime-kiln optimization or thermomechanical pulping projects "typically pay off in three months," says Rick Van Fleet, consultant, advanced controls, Honeywell. Higher energy costs can give the green light to projects that wouldn't have made the cut a few years ago. "Improved control of temperatures and reaction rates can reduce variability, but cost justification might not be easy to identify," Van Fleet says. "Using energy, it's a no-brainer."

Plants with cogeneration facilities or in areas where electricity rates depend on the time of day can decide whether to restrict production during high-rate periods. "How can an operator make an economic decision?" says Van Fleet. "Considering fuel source costs and their cogeneration contract, should they be making any product at all? It might be most economical – profitable – to stop the plant, or bank inventory overnight to avoid peak electricity costs."

Buildings

Again, the D-Energizers team up to steal away the maximum amount of energy from your plant. HVAC, refrigeration, doors, windows and insulation are areas where fast paybacks and high returns are less common, but if you're fixing it anyway, do it with energy efficiency in mind. And at any given time, you're probably fixing a roof.

"Cool roofs are a major initiative for energy savings and a definite candidate for inclusion in a Green Building initiative for any facility where air-conditioning loads are a factor," says Arlan Koppel, president, Topps Products, Inc. (www.toppsproducts.com). "Highly solar-reflective roof surfaces result in a significantly cooler roof surface. Roof maintenance with a highly reflective white coating can save both energy costs and maintenance costs that, in turn, reduce the life-cycle costs of roof restoration significantly."

Koppel says a reflective coating can reduce roof surface temperatures by as much as 100°F, which reduces the amount of air-conditioning equipment needed by reducing peak cooling demand by 10% to 15%, and air-conditioning energy consumption by as much as 60%. It also increases roof life by preventing UV damage, maintaining more constant temperatures and reducing thermal shock of cold rains on hot roofs.

Recognize when the D-Energizers are at work collectively or individually, and get them under control to be a hero at your plant. ⊗