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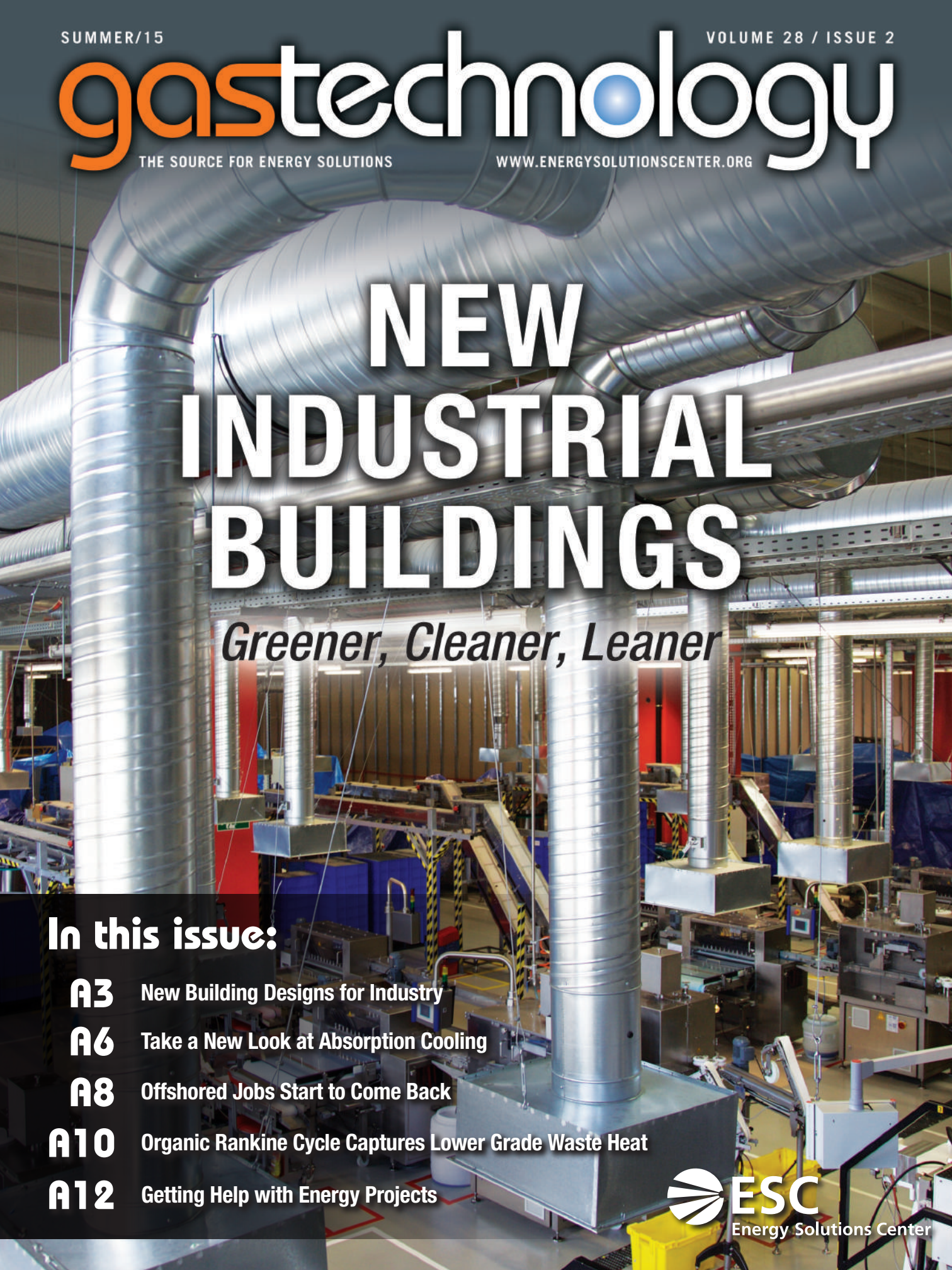


NEW INDUSTRIAL BUILDINGS

Greener, Cleaner, Leaner

In this issue:

ESC Energy Solutions Center

Liqui-Cel® MEMBRANE CONTACTORS

Advanced Dissolved Gas Control

Lower Your Operating & Maintenance Costs

Compact, Modular Design

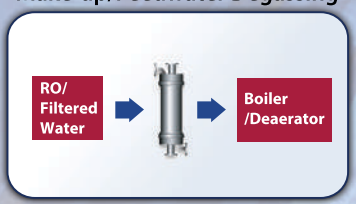
14-inch Industrial Deaeration System

Liqui-Cel® Membrane Contactors are used around the world to remove dissolved gases from water. They are capable of achieving < 1pbb O_2 and < 1ppm CO_2. Removing the oxygen and carbon dioxide can reduce deterioration of boilers and piping due to corrosion. Chemical usage may also be reduced which can decrease the blow down frequency due to scaling from chemical deposits. Carbon dioxide removal can improve efficiency and reduces chemical consumption in mixed bed or EDI technologies.

Deoxygenating HRSG feedwater during layup & start-up can prevent costly maintenance and downtime.

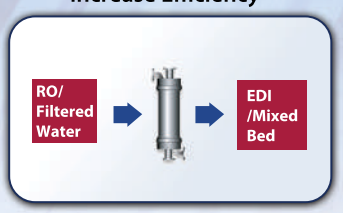
- *Quick start-Up*
- *Deoxygenation at ambient temperature* - ***Energy Savings***

Chemical Free
Make-up/Feedwater Degassing



- **Alleviate Pitting and Corrosion**
  O_2 removal in feedwater and make-up loops
- **Improve Ion Exchange Efficiency**
  CO_2 removal to reduce mixed bed regeneration frequency
- **Minimize Chemical Use**
  Reduce employee exposure and lower disposal costs

Increase Efficiency



MEMBRANA
A POLYPORE COMPANY

For more information and to discuss your application contact us at
Liqui-Cel.com

The Hilmar Cheese Company, Inc. facility in California received the Platinum LEED level, the highest ranking. The 55,000 sq. ft. facility features advanced process heat recovery systems, self-adjusting lighting, supplemental daylighting systems, and many other green building features. A solar collection system supplies 25% of building electric power. All photos courtesy: U.S. Green Building Council.

ENERGY-SMART INDUSTRIAL ARCHITECTURE

New Challenges, New Solutions

TODAY'S FACTORIES AND WAREHOUSES ARE DIFFERENT FROM THE DESIGNS OF ONLY 20 YEARS AGO. Evolving industrial building codes, increased robotic operations, heightened ventilation requirements, and new energy technologies have changed the look and feel of these facilities. Further, many owners are looking not only at improving operating efficiency, but also at reducing the building carbon emission profile. Changes have been evolutionary, but the result has been a new industrial architectural standard.

Rooftop Energy Systems in Newer Buildings

Newer manufacturing facilities are usually built on a single level to allow linear lift-truck or conveyor movement of materials and products. This results in HVAC equipment usually being located on building rooftops, which means packaged systems. This includes heating, electric cooling, plus dehumidification and sometimes humidification functions.

Most commonly, new building heating systems in North America use natural gas as a primary fuel, sometimes with an assist from solar collectors. In some cases, process waste heat can also be used for space heating. The use of natural gas reduces total energy usage and means less equipment is necessary for emission control than with coal or heavy petroleum fractions as fuel.

Increased Ventilation Brings Energy Challenges

For a manufacturing plant, a primary function is building ventilation. ASHRAE Standard 62 sets acceptable indoor air quality standards and prescribes appropriate ventilation rates. The standard has been in place since 1973, and has periodically been modified, each time usually with lower acceptable contamination levels and greater ventilation requirements. The ASHRAE standard is often adopted as code by state and local agencies. This tightened regulation of the indoor working environment necessitates dramatically more workplace ventilation.

Local, state or provincial, and federal occupational health agencies also set additional strict specific standards for air contaminants, including carbon monoxide, ozone, volatile organics, formaldehyde, silicone, glues, epoxies and other air contaminants of special concern. These tightened requirements result in enormous amounts of building air being exhausted rather than recirculated, with a consequent potential penalty of building heat or cooling loss. Often air contaminants are also routed through a thermal oxidizer to eliminate harmful emissions.

Engineers and architects are specifying exchanger systems for thermal recovery from these exhausts. Process ventilation exhausts are frequently combined and routed through heat exchangers for this temperature recovery, with a counterflow of building makeup ventilation air. This temperature recovery function can either be on the operating floor level in a mechanical space, suspended from the ceiling, or on the rooftop.

A closed loop water system at the Hilmar Cheese Company utilizes the cheese manufacturing water reclamation pond as an integral component of the HVAC pre-heating system.

Onsite Electric Generation Increasing

Because of rising energy costs, high electric demand charges, and a desire for improved supply reliability, owners increasingly ask building planners to include combined heat and power (CHP) systems in building plans. This option is particularly attractive in industrial operations where significant process heat is needed and can be provided by a natural gas-fired engine or gas turbine generator set. CHP is most attractive when it can be incorporated in the actual building design, putting the generation byproduct heat close to the process application.

Another option is to use the byproduct heat from electric generation to supply an absorption chiller for space or process cooling purpose. This approach is discussed in another article in this issue. With CHP, total energy utilization can approach 90% thermal efficiency. Even with a reliable CHP system, most industrial buildings are also designed for a utility interconnection, both for purposes of redundant supply, and possible sale of surplus site power back to the utility.

Daylighting Returns

Lighting is another area where building designs are changing. In some ways, the newest industrial buildings harken back to early 20th century designs because they use extensive rooftop or window daylighting to supplement high-efficiency lighting systems that utilize LED or halogen lighting equipment. Sophisticated lighting controls often switch lighting on only when the area is occupied, and are programmed to adjust for varying light levels and needs through the day.

An important influence for evolving industrial building practices is the U.S. Green Building Council (USGBC), a non-profit organization that was formed in 1973 with a goal of transforming the way buildings are designed and operated. In Canada, the Canada Green Building Council fulfills the same role. The Councils sponsor the influential Leadership in Energy and Environmental Design (LEED) certification program. The program has developed standards for new buildings that encompass a wide range of energy and environmental issues. In the beginning, many LEED projects were commercial, institutional, or office facilities, but over the years many industrial facilities have also become involved in the LEED design, construction and scoring process.

Growing Involvement with LEED Process

According to Stefanie Young, Director, Technical Solutions for USGBC, there is growing interest in the LEED process and standards by the industrial sector. "USGBC is seeing a substantial uptake from the manufacturing sector in addressing the need to create greener, healthier, more efficient manufacturing facilities." She notes that accelerating this trend are organizations that understand the connection between business sustainability and environmental sustainability.

Young indicates that ten years ago, there were fewer than 100 industrial or manufacturing facilities registered under the LEED green building rating system. She says, "Today there are over 2,300 projects registered or certified, indicating a large positive shift in the design and operations of these buildings. These include many buildings owned and operated by brands we interact with on a daily basis: Coca-Cola, PepsiCo, Mars, Kraft, Boeing, Hewlett Packard, Intel Corp., Colgate-Palmolive, Armstrong and Johnson Controls." She indicates that all of these companies are using LEED to certify their buildings' design and ongoing operations while seeing a quick return on their investment.

Corporations Make Efficiency a Policy Priority

Young points out that while some manufacturers are building more efficient units

Newer manufacturing systems typically have complex systems for collection of emissions from individual process exhausts, as well as overall building exhaust and heat recovery devices.

ESC Energy Solutions Center

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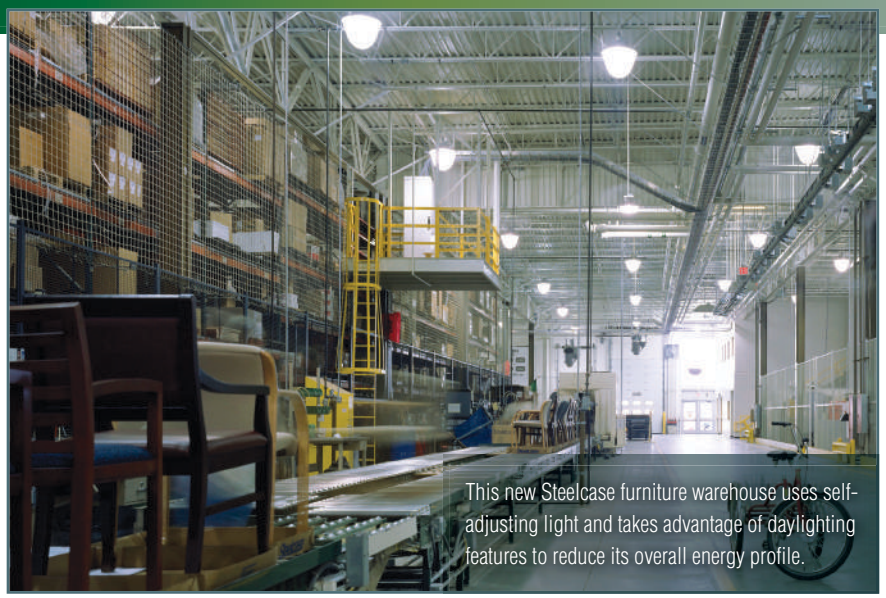


This new Steelcase furniture warehouse uses self-adjusting light and takes advantage of daylighting features to reduce its overall energy profile.

or investing in retrofits simply in response to current or anticipated government regulations, many are making better building practices part of their corporate policy. She notes, "This can be attributed to increasing demand from savvy consumers that are drawn to brands that promote strong sustainability policies, as well as the tremendous leadership of forward-looking executives across an increasing number of industries."

Young points out that there is a growing understanding that improved facilities can significantly reduce a company's carbon emission impact. "It used to be that purchasing green power RECs or carbon offsets were the only ways." She explains that for industries that are genuinely interested in making an improvement, there's a growing appreciation that improved mechanical plants, building envelopes, and a rigorous commissioning process are important.

She adds, "Additional LEED measures implemented at the site level can include designs to encourage carpooling, biking to work, and electric vehicle charging. This allows them to address impacts created by their employees and visitors traveling to the sites, which tend to be in remote, industrial areas away from public transit and residential neighborhoods."

DOE Better Buildings Program

Another institutional force for building efficiency improvement is the U.S. DOE's Better Buildings Initiative, which recruits energy users, including industrial users, to become partners in a program of committing to building energy improvements, and publication of their progress along this road. An example of this program is Cummins Inc., a global leader in power systems. Cummins committed to a 25% reduction in its energy usage (per revenue dollar) by 2015, and has reached that goal.

At its Jamestown, NY engine plant, the company undertook a comprehensive energy rework. The project included a 2 MWe solar installation capable of generating about one-third of the plant's energy requirement on sunny days. The project also included installing three regenerative dynamometers, capable of generating electric power sufficient to supply surplus to the nearby city. The Jamestown project has reduced plant energy usage by 33%.

Another Better Buildings showcase project has been done by program partner J.R. Simplot, a large national food and agribusiness company. The project is a new 420,000 square foot state-of-the-art potato processing plant that will incorporate multiple energy saving technologies while processing millions of pounds of potato products annually.

Improvements include advanced refrigeration systems, improved pipe insulation, and improved methods for compressed air operations. A new regenerative thermal oxidizer, boiler stack, and fryer exhaust system will recover by-product heat. It is anticipated that this plant will contribute significantly to the company's overall goal of reducing energy usage by 25%.

Facilities Designed for Efficiency

Whether the facility is processing potatoes, building engines, or performing nearly any other industrial task, energy efficiency is increasingly a high priority. The achievement of this goal is within reach for most industries, and the solutions are often a combination of reduction of energy waste, upgrading process equipment, capturing byproduct energy and prudent use of renewable energy resources. Clean natural gas often plays a major role. The result is industrial buildings that look different, contribute less to the global carbon load, and help reduce the cost of production by using less energy. It's a changed and still-changing world. **GT**

MORE info

CANADA GREEN BUILDING COUNCIL
www.cagbc.org

DOE BETTER BUILDINGS PROGRAM
http://energy.gov/eere/better-buildings

ENERGY SOLUTION CENTER – BUILDING EFFICIENCY
www.naturalgasefficiency.org/index_industrial.htm

U.S. GREEN BUILDING COUNCIL
www.usgbc.org

Today Absorption Cooling Makes Sense

It's Time to Take a Second Look

SOMETIMES IT MAKES SENSE TO REVIEW THE CURRENT VALIDITY OF CHOICES MADE IN THE PAST, because basic premises may have changed. A good example of this is previous decisions to choose electric chillers over absorption machines. Each area and application is different, but in many places the absorption solution has become much more attractive and will bear reconsideration for your next chiller selection.

Using Heat for Cooling

Absorption chillers use the thermal energy in hot water or steam to power a reaction that chills water to feed a central chilled water cooling system. This technology is time-tested and used in facilities around the world. In recent years, some of the advantages of absorption have become more prominent, making it a very attractive choice for applications where, 20 years ago, electric chillers were the rule.

Broad USA is one of several providers of absorption chillers in the United States and Canada, and offers a wide range of machine types in sizes from 40 to 3,300 refrigeration tons. According to Doug Davis from Broad, there currently is increasing interest in absorption chillers for hospitals, schools and universities, and some large industrial energy users. One such industrial user is Roche Pharmaceuticals. Davis notes, "Roche has elected to no longer use chemical refrigerants on its sites, so they are selecting absorbers for their facilities in the U.S.A." Why are these kinds of major energy users attracted to the absorption process?

Perhaps the first consideration is that the operating costs of electric chillers have increased dramatically in many areas. Electric utilities not only have significantly increased energy rates, but also are increasing electric demand charges. Demand charges are calculated in various ways, but the most typical is the use of peak usage during a 15 minute interval each month. In many facilities, the demand charge may represent 30% to 70% of the monthly bill during the summer months.

Avoid Peak Demand Charges

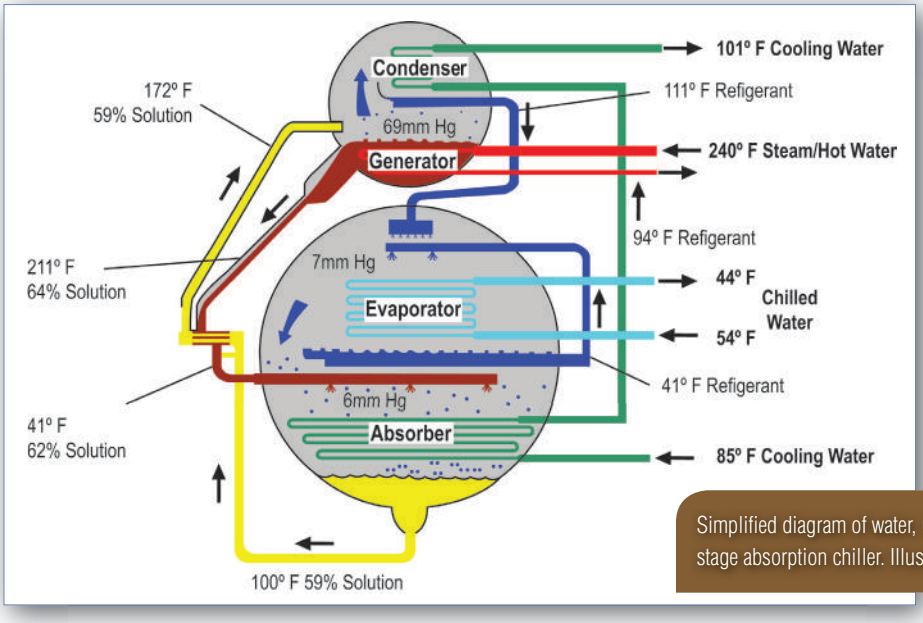
In many commercial, industrial and institutional facilities, electric chillers make the single greatest contribution to those summer peaks, when demand charges are usually the highest. New electric chillers are more efficient, and certain other strategies can help reduce that demand contribution, but electric chiller demand is still a major contributor.

Absorption chillers, on the other hand, have a comparatively small electric demand – just that needed for pumps and perhaps cooling tower fans. An absorption chiller typically has electric demand less than 10% of its same-sized electric alternative. With rising demand charges, it can be a money-saving choice.

Energy Source May Already Be There

Another aspect worth considering is that absorption chillers can often use byproduct hot water or steam from other manufacturing or electric generation equipment on the site. The energy input is heat, and if you don't use it, you lose it. The absorption chiller should be selected and sized based on the flow and temperature of this byproduct heat. According to Davis, single-stage absorbers can effectively use hot water at temperatures as low as 190° F. He adds that single-stage steam absorption chillers can use steam at pressures as low as 5 psig, and two-stage machines as low as 60 psig.

Further, even if you can't use a byproduct heat stream, many facilities have steam or hot water boiler capacity already on site that is underused during the cooling season. It's frustrating to see an industrial plant venting steam because the boiler's minimum firing rate is greater than the plant demand for steam. By using this capacity to supply a chiller, you not only avoid the expense of a dedicated boiler, but



Simplified diagram of water, refrigerant and chilled water flows with a single stage absorption chiller. Illustration courtesy: Energy Solutions Center

This single stage steam absorption chiller from Broad U.S.A. is available in sizes from 40 to 3,300 tons and operates on steam pressures from 60 to 150 psi. Photo courtesy: Broad U.S.A.

you allow those existing boilers to operate more efficiently.

Moderate Natural Gas Prices

We've talked about rising electric energy and demand charges, often with increases greater than the general rate of inflation. With natural gas as the thermal source, your facility can take advantage of the stability of natural gas prices. In some locations, you may even be able to take advantage of interruptible natural gas rates during the summer season, when interruptions are usually rare. Work with your natural gas utility to get the optimum rate.

Another place absorption is a great choice is when you have installed a natural gas-fired combined heat and power (CHP) electric generation plant on your site. Generator engines and especially gas turbines have significant potential for byproduct heat that can supply an absorption chiller with some or even all of its needed thermal input. The same CHP heat stream that provides building heat in the winter can provide building cooling in the summer.

New Absorption Chiller Features

Yet another reason why absorption is becoming even more attractive is the designs of newer absorption chillers, with higher operating efficiency, greater reliability than even before, and simplified operation and maintenance requirements. Davis notes that another benefit is that with today's low-pressure absorption chillers, it is not necessary to have an operating engineer on duty while the chiller is operating. This is a huge benefit in locations such as New York City.

According to a report from the U.S. Department of Energy, absorption chiller systems running on waste heat can be a cost-effective replacement for another chiller type. The report recommends determining the cost-effectiveness by taking the following steps:

- Conduct a plant survey to identify sources and availability of waste steam.
- Determine cooling load requirements and the cost of meeting those requirements with existing mechanical chillers or new installations.
- Obtain installed cost quotes for a waste-steam absorption chiller.
- Conduct a life-cycle cost analysis to determine if the waste-steam absorption chiller meets your company's cost-effectiveness criteria.

MORE info

BROAD U.S.A.
www.broadusa.com

CARRIER CHILLERS
www.carrier.com/building-solutions/en/us/products/chillers

DOE – ABSORPTION COOLING
www.energy.gov/sites/prod/files/2014/05/f16/steam14_chillers.pdf

ENERGY SOLUTIONS CENTER – NATURAL GAS COOLING
www.gasairconditioning.org

YORK CHILLERS (JOHNSON CONTROLS)
www.york.com

Direct-Fired Chillers Another Option

In situations where there is not a water or steam capability on site, manufacturers offer direct-fired absorption chillers, with steam generation capability included in the chiller package. The boiler section is closely optimized to the chiller section. In the winter, this same boiler can provide steam for space heat and humidification. Direct fired chillers are available in a variety of sizes from several manufacturers.

Remember to Include the Absorption Option

Don't assume that an electric chiller is the only option. Is absorption the right choice? It is essential to do a complete evaluation, and get help from an engineer who has familiarity with absorption systems. Don't rely on decisions made 10 or 20 years ago. The rules have changed, and many of them now favor the absorption option. **GT**

Direct-fired chiller from Broad U.S.A. in sizes from 40 to 3,300 tons provides building or process cooling as well as heating and hot water. This unit is available with a dual fuel (natural gas/oil) burner and features NOx emissions less than 10 ppm. Photo courtesy: Broad U.S.A.

Offshored Jobs Coming Home?

Hopeful Signs of Reshoring

THE PERIOD OF THE 1990S UP TO 2010 SAW MANY INDUSTRIES IN THE U.S. AND CANADA decide to move at least part of their manufacturing and distribution operations overseas, especially to China or other Asian countries. The reasons were numerous, and the effect was not helpful to the domestic economies in North America. However, there are indications that this trend of "offshoring" has slowed, and in some cases, operations that were moved overseas are being "reshored" -- relocated back to their countries of origin. The reasons for this change are numerous, but the outlook is hopeful.

Some Guesswork Involved

Getting data on trends in offshoring and reshoring is challenging, and getting credible projections on possible future trends is impossible. Few industrial companies wish to give out data about future plant location or hiring intentions, so a lot of guesswork takes place. There's little disagreement that there was a great flood of offshoring in the earlier years of this century. It is useful to evaluate some of the many reasons for offshoring, and consider whether they will apply as strongly in the future. Further, we can look at conditions in the U.S. and Canada to see if they might encourage returning industry.

An organization that is deeply involved in encouraging the return of offshored jobs to the United States is called Reshoring Initiative, founded by Harry Moser, former President of machine tool maker GF AgieCharmilles. Moser found it critical to form an industry-led initiative to demonstrate that offshoring is not always the best economic decision for U.S. industries.

Moser attributes the offshoring trend 2001-2010 to several influences: China's low wages, compounded by currency manipulation; growth of the Internet and container shipping; companies' strategies to cut to their core competence which did not always include manufacturing; locating plants based on labor price alone instead of total cost; consumer demand for the lowest product price regardless of origin and quality; high corporate tax rates; and a lack of adequate skilled manufacturing workforce in the U.S.

Labor Costs a Driver

Lower labor costs can be a powerful influence, particularly for industries whose products or services are highly labor-intensive, especially when extended labor training is not required. Examples of such industries might be assembling and packaging complex devices, especially where robotic assembly is not practical. In fact, labor costs in China, India, Mexico, Eastern Europe, and South America are often significantly lower.

In addition to access to lower cost and abundant labor, some companies have found significant incentives from overseas governments, at both the local and national levels. Government assistance might come in the form of labor recruitment and training, sites for plants, assistance in housing, favorable tax treatment, and outright grants and loans.

Getting Closer to Markets

Many North American companies have significant potential for growing markets for their products in Europe, Asia or South America, and it is efficient to move part of the production stream closer to the market. This improved market responsiveness is sometimes coupled with the desire to move manufacturing closer to the sources of raw materials. An example might be furniture manufacturing, where it can make sense to build furniture at locations closer to where the wood, fabric and other components are produced, rather than shipping these materials to North America for manufacturing then returning them to an offshore market.

Spreading Location Risks

For some companies, another consideration is the desire to diversify manufacturing locations to spread the risk of catastrophic work stoppages from weather, earthquakes, floods, civil unrest, or any other event. This consideration is especially important for warehousing facilities, where access to effective surface transportation is essential.

Other reasons for offshoring have motivated specific industries, and certain companies. It might be their desire to get away from what is perceived as overly stringent environmental or workplace regulation, a wish to partner with specific overseas suppliers or customers, or to take advantage of certain currency or banking opportunities not available in the country of origin. Very commonly, companies have moved some but not all their manufacturing, warehousing or supply chain operations offshore.

	Manufacturing Jobs/Year			
	2003	2013	% Change	Feasible 2016
New offshoring*	~150,000*	30-50,000*	-70%	20,000
New reshoring	2,000*	30-40,000**	+1,500%	70,000
Net reshoring	-148,000	~0	-100%	+50,000

*Estimate / **Calculated

According to Reshoring Initiative, this table illustrates the dramatic shift in offshored versus reshored jobs between 2003 and 2013. Illustration courtesy: Reshoring Initiative

Trend has Shifted

In any case, in the period 2001-2010, the trend was strongly toward offshoring. We began to wonder if it would continue until there was no industrial base left in North America. In actuality, economists and labor force experts have noted that the offshoring trend has slowed. Some companies are bringing capacity back to the U.S. and Canada. Reshoring seems to be happening, especially in specific industries. There are certain reasons why this seems to be occurring.

Harry Moser attributes the reshoring trend to numerous changes: "Rising Chinese wages, increased use of total cost analysis, automation, general awareness of the costs, risks and strategic impacts that had earlier been ignored, and the U.S. advantage in natural gas and electricity costs."

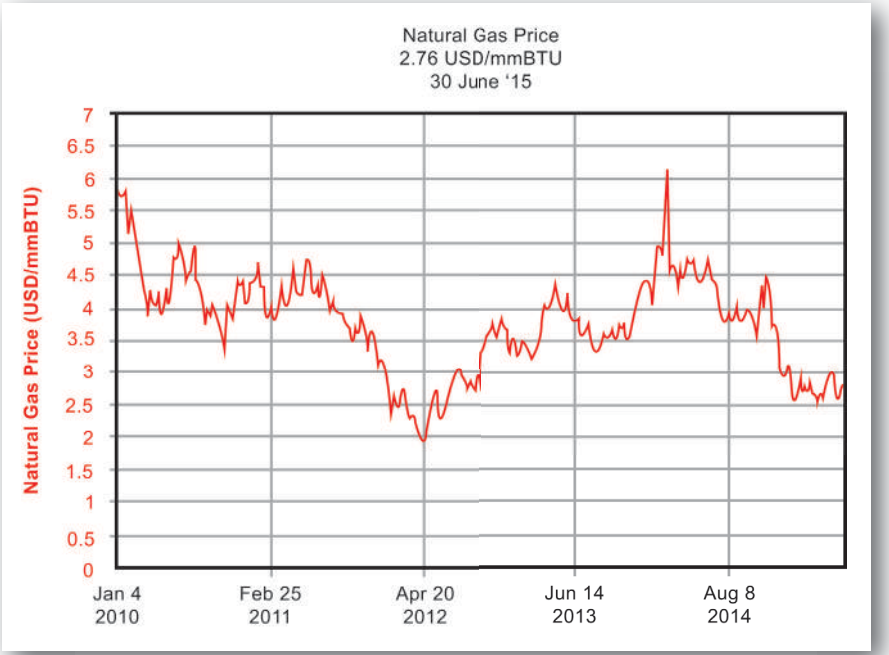


Chart illustrates low and stable natural gas prices in the U.S. 2010-2015. Chart courtesy: infomine.com

Labor Cost Advantage Fading

The labor cost comparison that favors China versus North America has diminished as Chinese labor costs are going up more dramatically than here. Also, some North American companies have a better understanding that labor cost encompasses more than the hourly wages. Consideration also has to be given to job training expense, communication challenges, and in some cases lack of a worker pool with adequate technical skills.

Moser and others have stressed the importance of considering the total cost of production in deciding between offshore and reshored facilities. In fact the Reshoring Initiative website includes a detailed calculator to help with this evaluation. This online calculator is found at: http://www.reshorenow.org/tco-estimator/ Moser states, "Our user database suggests that companies that decide only on price ignore about 23% of the total cost and that about 25% of what is offshored would return if companies used total cost instead of price."

Energy Cost Benefit for Reshoring

As Moser points out, with increasing production of oil and natural gas in this country, there have emerged significant opportunities for production cost reduction through lower energy bills. This is especially important for industries where the labor component is not as important as natural resources and energy costs. Examples of this might be chemical, fertilizer, plastics, metallurgical and forest product industries. The relatively low and stable price of natural gas 2008-2015 has been particularly significant for Canada and the U.S. in their increasing abilities to hold and repatriate energy intensive industries. In 63 of the cases that Reshoring Initiative has studied, owners cite natural gas price and availability as influences on their decision to reshore.

Range of Industries Involved

Of the cases studied, the industrial classification that had the largest number of jobs involved was Transportation Equipment (33 cases), followed by Electrical Equipment, Appliances, Components (58), Computer/Electronic Products (25), Machinery (20), Apparel/Textiles (46), and Fabricated Metal Products (39). These six categories reported represented a total of 33,581 jobs. In general, Moser feels that the product types that make good candidates for reshoring are large, heavy products; those where rapid market response is needed, design changes are frequent, those that have a high reliance on intellectual property, those that are energy intensive, and those where generally higher labor skills are required.

The desire of manufacturers to locate some of their production near markets will probably remain as strong as ever, as will the desire to locate nearer the sites of raw material production inputs. Likewise the desire to spread the risk of plant shutdowns by forces outside the company control will continue to be a factor. But there clearly has been a reversal of the trend seen earlier this century. We are seeing significant changes from earlier trends, and it is one that all U.S. and Canadian manufacturers might profitably consider. **GT**

MORE info

CANADA LABOUR COST COMPARISONS
www.statcan.gc.ca

RESHORING INITIATIVE
www.reshorenow.org

U.S. BUREAU OF LABOR STATISTICS/
INTERNATIONAL LABOR COST COMPARISONS
www.bls.gov/data/#international

U.S. ENERGY INFORMATION AGENCY/
INTERNATIONAL ENERGY COST COMPARISONS
www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm#"

ORGANIC RANKINE CYCLE

Useful Power from Lower-Grade Waste Heat

INCREASINGLY, INDUSTRIAL AND INSTITUTIONAL ENERGY USERS LOOK FOR WAYS TO EXTRACT MORE USEFUL ENERGY FROM EACH FUEL DOLLAR SPENT. A key solution is to utilize byproduct heat from industrial processes. One challenge has always been low-grade waste heat. By using the Organic Rankine Cycle (ORC), even relatively low-grade byproduct heat can be economically converted to valuable electric power.

Rankine Cycle a Foundation of Power Plants

The Rankine Cycle, developed by the Scottish engineering genius William Rankine, is the fundamental principle used in the design of vapor engines such as steam powered reciprocating and turbine engines. It describes the role of heat in the phase change between liquid and vapor, and the potential of this phase change to generate mechanical power for electric generation. For decades, mechanical engineers have used the Rankine Cycle calculations to design turbogenerators.

The principle limitation on the use of water as the base fluid in an engine is the need for relatively high heat levels to accomplish the phase change, because of the high boiling point of water. Thus if a heat exchanger is used to collect process waste heat, the temperature of the heat must be significantly above the boiling point of water. The water-steam phase change is not usable for lower temperature sources.

Lower Temperature Working Fluid

However, an interesting option is the use of what is called the Organic Rankine Cycle (ORC), where the working fluid has a phase change at a lower temperature. A variety of organic liquids have much lower boiling points, and thus can develop useful pressures to spin a turbine using much lower temperature thermal sources. In recent decades, the ORC has been developed to generate electric power from heated liquids from solar ponds, geothermal sources, industrial process fluids, and from the exhaust streams of conventional steam cycles.

The thermal efficiency of the ORC is often quite low, but when it is being used in combinaion with a thermal stream that would otherwise be wasted, it helps improve the efficiency equation. This applies especially given the increasingly high cost of central-station electricity, and the need to extract maximum energy from purchased fuels. In this scenario the ORC will increasingly be adopted by industrial and institutional energy users.

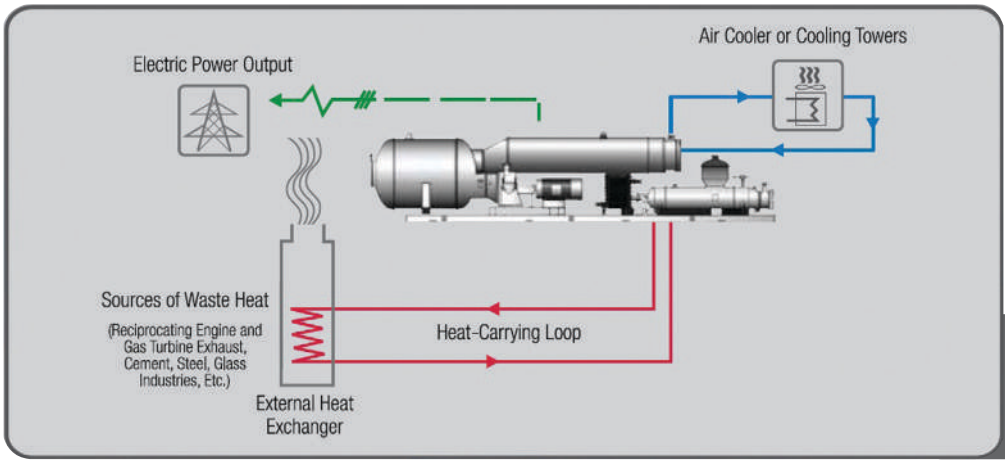
Italian Firm an Industry Leader

One of the leaders in the development and promotion of ORC technology is Turboden, a group company of Mitsubishi Heavy Industries. The company is headquartered in Brescia, Italy and markets this technology worldwide. Turboden has manufactured turbogenerators using ORC technology since 1980, and offers systems ranging in size from 200 kWe output up to 3 MWe. They have extensive experience using byproduct heat streams from industries including cement-making, glass furnaces, forest products, and electric generation using exhaust streams from engines and combustion turbines.

Clotilde Rossi de Schio is Manager for Sales and Development for Turboden in North America. She points out that these turbogenerators take advantage of the lower temperature limit for economic energy extraction. “In order to give a general indication, a ballpark figure can be 100° C [212° F] for liquid sources and about 140° C [284° F] for exhaust gases.” This is significantly lower than is practical with a water/steam cycle.

Wide Range of Industrial Heat Sources

A wide range of industries have potential for electric generation using byproduct heat. Rossi points out, “Typical industries that are looking for heat recovery options are energy intensive industries such as cement, steel, aluminum, refractories, glass and chemicals. Another attractive source is as a bottoming [final heat recovery] cycle for gas turbines and gas en-



Simplified diagram of an organic Rankine cycle plant for heat recovery and electric generation. Illustration courtesy: Turboden

An organic Rankine cycle plant is used for heat recovery and electric generation at this cement manufacturing plant in Morocco. Photo courtesy: Turboden

gines." She adds, "Any heat source in the form of gas, liquid or steam can be a good candidate for heat recovery, independent of where the heat is coming from."

She notes, "Turboden utilizes different families of organic fluids, depending on client needs and preferences (e.g. non-flammable) and on thermodynamic properties. They can be siloxanes, hydrocarbons or refrigerants. They are typically used at operating temperatures far from their cracking points, therefore we can consider their lifetime to be 20+ years."

Proven Reliability

Because of the relatively long experience with this technology, and the fact that these turbogenerators operate at relatively low temperatures, they are highly reliable. Rossi indicates that Turboden's experience is that with all installed units, average availability is greater than 98%.

She explains that units can be operated automatically and are normally unmanned. An annual service of one week per year of predictive maintenance is recommended. Turboden's website includes a calculator to provide an estimate of the power generation potential of various thermal streams, with the input of character, volume and temperature of the stream.

GE Clean Cycle® Technology

Another manufacturer that has commercialized ORC technology for heat recovery or other applications is General Electric, with their Clean Cycle® technology. This product is a turbine-powered ORC generation package rated at 50 kWe, and scalable to 1 MWe or more with multiple units. It is particularly suitable for heat recovery from engine or turbine exhausts.

Alternative to the Turbine

Another intriguing application was described by Michael Newell, CEO of Ener-G-Rotors at a recent Technology & Market Assessment Forum, sponsored by the Energy Solutions Center. The New York firm has developed a unique rotary technology for extracting energy using the ORC with an alternative method to a turbine design. According to Newell, the product is nearing commercialization. Its advantage is significantly lower cost per kWe of capacity than with the use of turbines in smaller scale applications.

According to Newell, their ORCA™ unit will be rated at about 50kWe and will be able to generate electricity from waste heat at a cost of three to four cents per kWh. He indicates this will offer a two-year payback in many applications, and has the potential to reduce CO_2 emissions by 28 tons per year.

Newell cites the forest products and paper industries as two examples of industrial operations that have large volumes of low-grade steam that would be highly suitable for Ener-G-Rotors applications.

A view of an installed Turboden ORC heat recovery application for electric generation. Photo courtesy: Turboden

The company is having conversations with a large number of industries for possible field applications.

Heat Recovery to Lower Emissions

Heat recovery is receiving increased attention as a means of getting better use of the energy dollar as well as reducing carbon emissions. The Organic Rankine Cycle is an interesting option, with a growing number of applications for industrial, utility and institutional energy users who have lower temperature byproduct heat streams. The commercial offerings continue to increase in size and number. Your consulting engineer can help your make an assessment of its suitability for your application. **GT**

MORE info

ENER-G-ROTORS
http://ener-g-rotors.com

GENERAL ELECTRIC CLEAN CYCLE
www.ge-distributedpower.com/solutions-applications/heat-recovery-solutions-orc

ORMAT TECHNOLOGIES, INC.
www.ormat.com

TURBODEN
www.turboden.eu

Finding Help with Energy Projects

Hundreds of Assistance Programs

"WHERE CAN I GO FOR HELP WITH THIS ENERGY PROJECT?" This question is asked many times by business managers and project engineers. Because of the federated-type governments of the U.S. and Canada, answers can be complicated and will vary from state to state, province to province. Further, most natural gas distribution companies have customer assistance programs, specialized rates and sometimes even project grants, but these vary from state to state, or even within certain economic incentive zones. The key is finding the opportunities, and then asking for help.

Major energy-related facility improvements, such as installing a boiler economizer, can often receive grant, engineering or loan assistance from government or utilities. Photo courtesy: Resource Recovery Company.

Project Payback Often Critical

Typically, owners of commercial, institutional and industrial facilities decide whether to proceed with energy improvement projects based on simple payback – how many months or years it will take for the improvement to pay for itself. A payback in six months is relatively easy to sell: One taking eight or ten years is tougher unless the owner is quite sure the facility will still be in use at that time, and investment dollars are available. Even if the dollars are there, the energy project has to compete with other potential uses like process efficiency improvements or facility expansion plans.

Shortening the Payback

Here's where government and utility consulting and incentive programs can help shorten the payback. One example is interruptible gas rates. Many gas suppliers – both regulated distribution companies and third party suppliers – offer attractive rates for gas users who will agree to tolerate periodic interruptions of service. An example might be replacing an electric or oil-fired piece of equipment with a natural gas device on an attractive interruptible rate. Ask your gas supplier about interruptible rates, and get details on exactly what your commitment would be. Some suppliers use the service interruption very infrequently but offer a significant discount. This could further shorten the energy improvement project payback.

Another possibility is actual incentive payments from federal or state energy or environmental agencies, or from your utilities themselves. These incentive programs are intended to encourage owners to take energy improvement steps now rather than waiting. Programs include direct grants, tax credits, financing assistance and project engineering assistance.

MORE info

SMALL BUSINESS ADMINISTRATION ENERGY AND ENVIRONMENTAL GRANTS AND LOANS
www.sba.gov/content/environmental-grants-loans

U.S. ENVIRONMENTAL PROTECTION AGENCY GREEN BUILDING REQUIREMENTS
www.epa.gov/oaintrnt/projects/requirements.htm

Finding Current Incentives

Programs are numerous, but are constantly changing so it's important to know you are acting on current program requirements. Often your project engineer or your utility customer representative can help you find these.

Another great resource for U.S. owners searching for help is this website:
http://energy.gov/eere/femp/energy-incentive-programs

Canadian owners can similarly benefit from this website:
www.nrcan.gc.ca/energy/funding/efficiency/4947

These resources summarize federal, state, provincial and utility incentive programs for improving facility energy efficiency. Payback should not be the only criterion for embarking on a facility energy efficiency project. Such projects may also improve your compliance with present or future environmental regulation, and may increase your energy supply security status. If you are considering embarking on such a program and are looking for a partner, your own gas utility, along with the website tools shown above, may be the right place to put in your shovel. **GT**

energy solutions center websites

www.aircompressor.org
www.cleanboiler.org
www.energysolutionscenter.org
www.naturalgasefficiency.org
www.gasairconditioning.org
www.understandingchp.com

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