Application opportunities for absorption chillers

YORK®

BY JOHNSON CONTROLS

Where there is **waste energy**, **there is** an application for an **absorption chiller**.

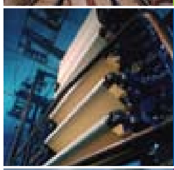
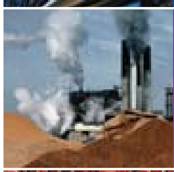
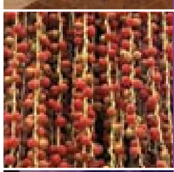
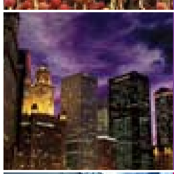
What are absorption chillers?

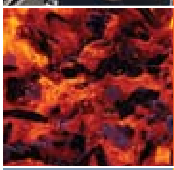
- Employs heat and a concentrated salt solution (lithium bromide) to produce chilled water.
- Eliminates ozone depleting refrigerants. Water is the refrigerant; lithium bromide is the absorbent.
- Uses the lithium bromide solution's high affinity for water (hygroscopic properties) to create a high vacuum in the evaporator/absorber. The vacuum causes the refrigerant (water) to boil at 2°C or 36°F.
- Absorption refrigeration cycle uses very little electricity compared to an electric motor-driven compression cycle chiller.
- Allows use of variable heat sources: directly using a gas burner, recovering waste heat in the form of hot water or low-pressure steam, or boiler-generated hot water or steam.
- Available in flexible configurations. The easy-to-read control panel can be connected to any building automation system for remote monitoring and control.

ParaFlow™ two-stage design for gas firing or high-pressure steam. Units can be driven by gas directly, or by high-pressure steam (2.8 to 8.8 bar or 40 to 128 psig). They can also output up to 82°C or 180°F hot water to serve as a high-temperature water heater.

IsoFlow™ single-stage design for hot water or low-pressure steam. Units can use low-pressure steam (up to 1 bar or 15 psig) or hot water up to 130°C or 266°F for cooling in an almost unlimited number of applications.

absorption chillers for an array of applications

	Industry	Available Energy	Absorption Application and Chiller Model Selection		
	**Petroleum and Chemical**	**Waste Heat**	Uses heat from desalting and distillation (fractionation) processes	For hot water or low-pressure steam: For direct firing or high-pressure steam:	**IsoFlow™** **ParaFlow™**
	**Brewery**	**Waste Heat**	Uses heat recovered from cookers and kettles	For hot water or low-pressure steam:	**IsoFlow™**
	**Printing**	**Hot Air**	Uses heat recovered from press drying units	For hot water:	**IsoFlow™**
	**Pulp Mill**	**Steam**	Uses heat from the combustion of bark and lignin	For low-pressure steam:	**IsoFlow™**
	**Palm Oil Production**	**Steam**	Uses heat recovered from sterilization, purification, and feed-stock preheating processes	For low-pressure steam:	**IsoFlow™**
	**District Energy**	**Steam**	Uses low- and high-pressure district steam	For low-pressure steam: For high-pressure steam:	**IsoFlow™** **ParaFlow™**
	**Incinerator**	**Hot Exhaust**	Uses recovered heat from hot exhaust	For hot water or low-pressure steam:	**IsoFlow™**

	Industry	Available Energy	Absorption Application and Chiller Model Selection		
	**Landfill Gas**	**Gas**	Uses heat from methane gas burners or methane-fired boilers	For hot water or low-pressure steam: For direct firing:	**IsoFlow™** **ParaFlow™**
	**Biogas**	**Gas**	Uses heat from methane gas burners or methane-fired boilers	For hot water or low-pressure steam: For direct firing:	**IsoFlow™** **ParaFlow™**
	**Coal Bed Methane**	**Gas**	Uses heat from methane gas burners or methane-fired boilers	For hot water or low-pressure steam: For direct firing:	**IsoFlow™** **ParaFlow™**
	**Combined Heat and Power (CHP)**	**Hot Exhaust** **Hot Water**	Uses heat recovered from exhaust gas and/or engine coolant	For hot water or low-pressure steam: For high-pressure steam:	**IsoFlow™** **ParaFlow™**
	**Geothermal**	**Hot Water** **Steam**	Recovers heat from geothermal wells that produce large volumes of hot fluid or steam	For hot water: For high-pressure steam:	**IsoFlow™** **ParaFlow™**
	**Solar**	**Hot Water**	Uses a solar-panel array as a sustainable energy source	For hot water:	**IsoFlow™**

Petroleum and Chemical

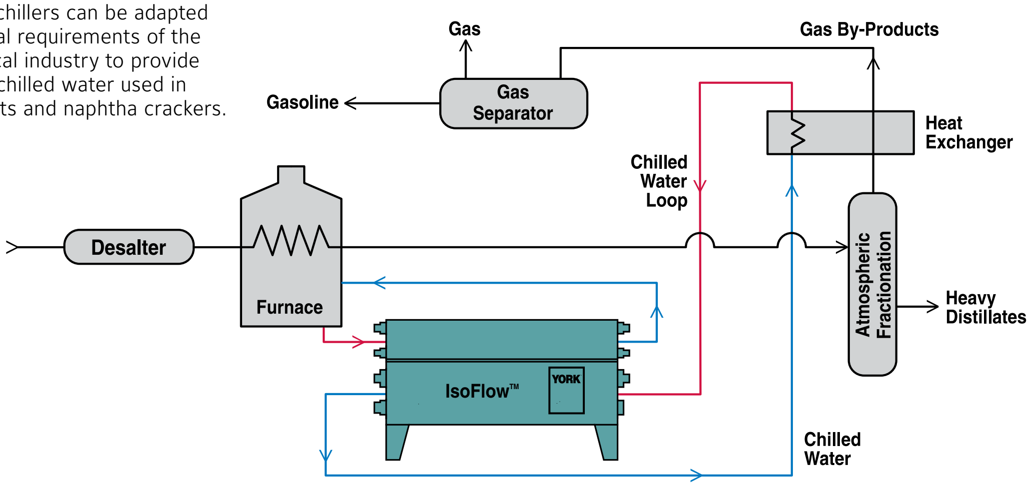
The Business Opportunity

In the past, the low cost of fuel and feedstock enabled the petrochemical industry to operate mechanical chillers affordably. But today's feedstock prices are creating opportunities for absorption chillers. Reflux condensers, condensate streams, product coolers, and process furnaces all produce heat that can drive absorption equipment. Where process plants generate their own steam as a utility, hot-condensate-steam or low-pressure-steam can also be used to operate absorption chillers.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a refinery.

Absorption chillers can be adapted to the special requirements of the petrochemical industry to provide a source of chilled water used in ethylene units and naphtha crackers.



Application Factors

Refineries, petrochemical, and chemical processing plants can easily apply an IsoFlow™ chiller thanks to multiple heat sources that can generate steam of at least 0.3 bar or 5 psig or produce hot water above 80°C or 175°F. Due to significant variations in plant design, it is difficult to identify a common type of application. In general, any process will benefit if it can operate more efficiently and economically with water supplied at temperatures colder than that obtained from a cooling tower.

In a refinery, chilling the lean oil and unstabilized naphtha, propane, butane, and propylene can significantly increase recovery rates. The process streams are cooled in the absorption chiller unit, which is driven by the latent heat in the hot vapor. In this case, an absorption chiller will replace both a product condenser and a mechanical refrigeration system, greatly reducing the wear and repair associated with mechanical cooling equipment.

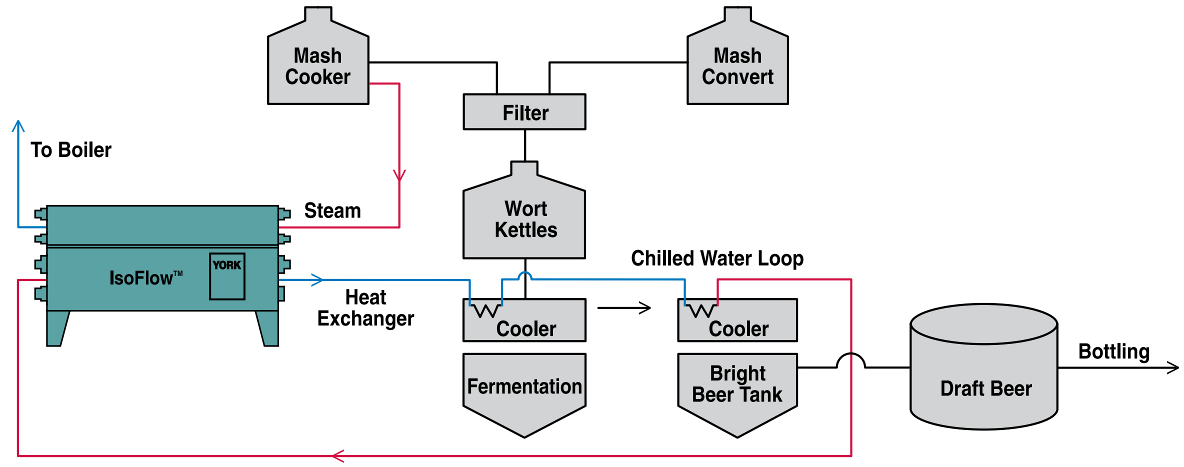
Brewery

The Business Opportunity

As in other process industries, improving energy efficiency is appealing to breweries when it translates into reducing their operating costs. Yet, many traditional breweries and newer microbreweries also value broader environmental reasons, because they are sensitive to how their energy use impacts the image of their brand as natural and wholesome. Consequently, breweries are open to using absorption chillers to reduce their energy footprint. Large facilities with cogeneration/CHP may also consider using an absorption chiller to exploit waste heat.

Where to Look

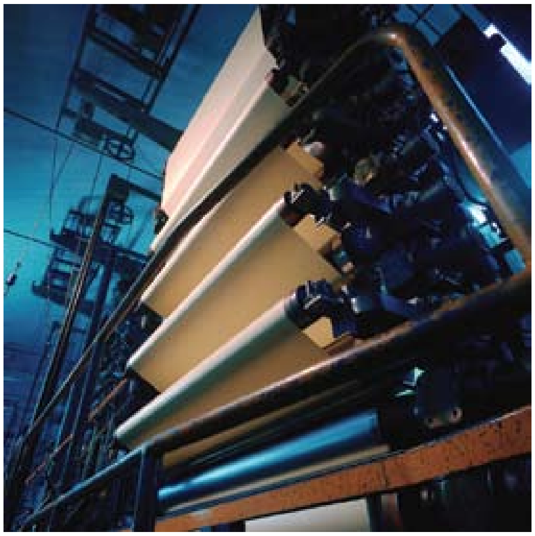
The following schematic shows how an absorption chiller can be integrated into a brewery.



Application Factors

A brewery can drive an IsoFlow™ chiller by reusing the steam produced to sterilize bottles, to produce domestic hot water, to heat buildings, and to drive the process. Heat can be recovered from various stages of the process, such as the mash cooker and wort kettle. The chilled-water output can then be used in the brewing process after the boiling stage when the resulting liquid, known as "wort," must be quickly cooled below 32°C or 90°F to prevent bacteria growth.

Temperature determines the type of beer: 20°C or 68°F for ales, 10°C or 50°F for lagers. Besides wort coolers, absorption chillers can be used to cool fermenters and bright beer tanks. After the fermentation period, refrigeration is required while beer is aged at near-freezing temperatures for 2 to 8 weeks. Some breweries employ a cogeneration plant, which can provide steam to drive an IsoFlow™ absorption chiller during summertime by recovering heat that would be wasted during the warmer months.



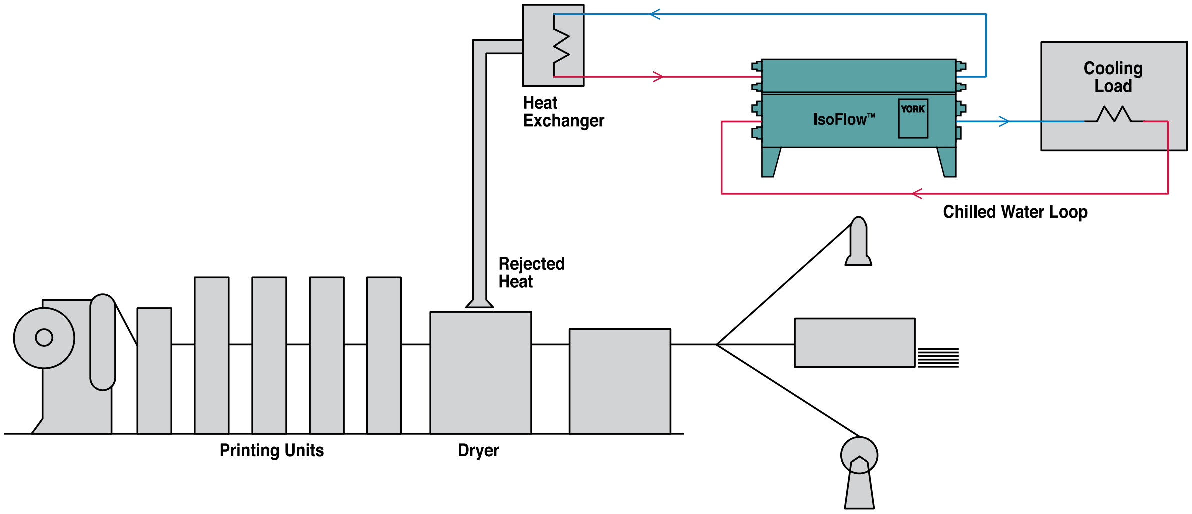
Printing

The Business Opportunity

Air conditioning is used in printing plants to reduce energy costs to make the plant more competitive, but also to create a stable environment for the press and the paper. In some cases, chilled water is also required by the press itself. An absorption chiller can be employed when heat is available in the form of hot air used to dry "heatset" inks employed in large-volume, high-speed, offset-web presses incorporating large dryer ovens. In order to control emissions of volatile organic compounds (VOCs), thermal oxidizers are often used. This process adds heat to the already usable hot exhaust gas, compounding the opportunity for heat recovery.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a heatset web printing process.



Application Factors

Web presses are comprised of several printing units that apply ink to paper traveling in a continuous line. To set and dry the ink, heat is applied in a drying oven, which evaporates the solvents in the ink at temperatures above 149°C or 300°F. Emerging from the drying oven, the web passes into a chill roll section comprised of a series of rollers containing cool water.

During chilling, web temperature is reduced to about 32°C or 90°F, which is cool enough to set the binder and pigment. Stationary heat recovery units located at the dryer unit can recover up to 75% of the thermal energy contained in the exhaust air. This recovered heat can be used to drive an IsoFlow™ absorption chiller, which dramatically reduces the amount of electricity used to cool the facility.

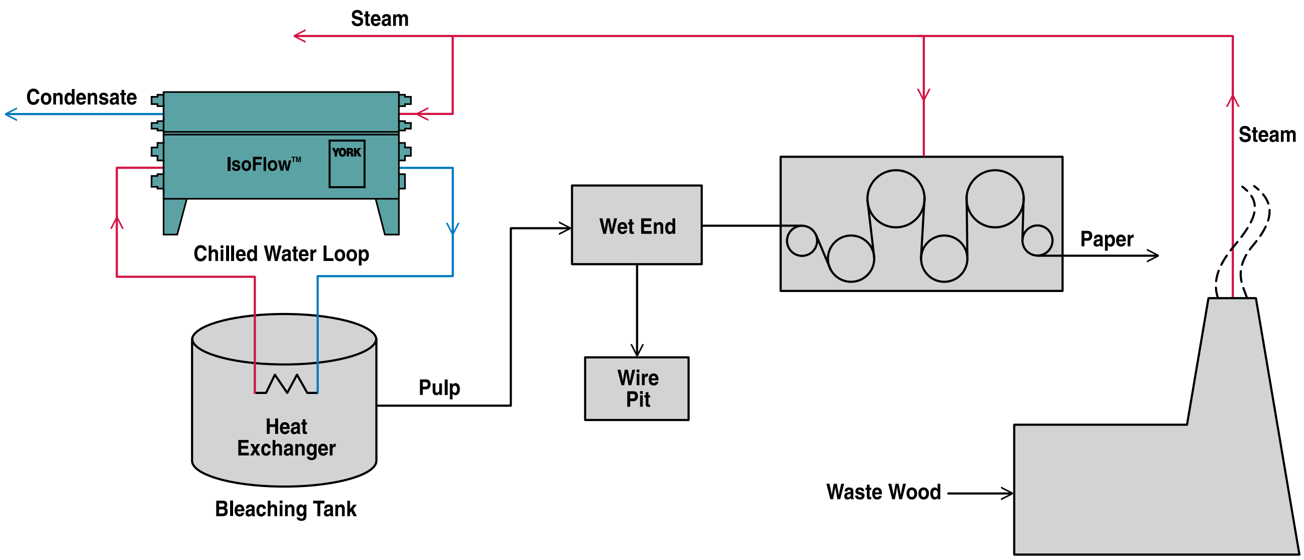
Pulp Mill

The Business Opportunity

To become more environmentally friendly, pulp mills are adapting an Elemental Chlorine-Free (ECF) bleaching operation that can utilize absorption chillers to supply chilled water for bleaching. In the ECF process, chlorine dioxide (ClO_2) is created at the site. The ClO_2 gas is readily absorbed in an aqueous solution at 4.5°C or 40°F, but leaves the solution at higher temperatures. Using steam generated by bark and other wood waste, an absorption chiller can supply chilled water to hold ClO_2 in solution, which otherwise is a major challenge in warm weather.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a pulp mill.



Application Factors

A pulp mill uses waste products—bark, chips, etc.—to generate steam. In warm weather when the process demands less heat, the steam can be used to drive an IsoFlow™ absorption chiller. Thus, in summer when the temperature of the natural water supply rises to a temperature that prevents ClO_2 gas absorption, the chiller can operate without the need to increase steam production.

Pulp mills use water drawn from a stream or lake, which rise in temperature during the Spring season. When above 12°C or 54°F, this water must be cooled before it can be used in the ECF process.

An IsoFlow™ chiller is employed to create chilled water distributed in a closed loop to a heat exchanger in the bleaching tank. The heat exchanger absorbs heat to allow the bleaching agents to remain in solution.

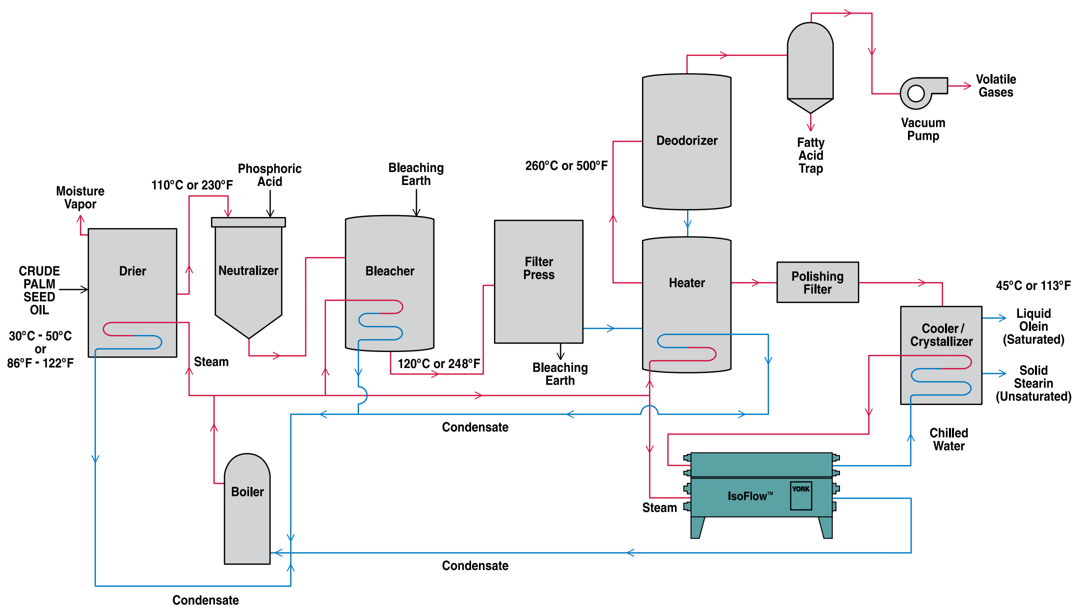
Palm Oil Production

The Business Opportunity

The oil palm tree, native to Africa, has been successfully planted in regions within 20 degrees of the equator. Oil palm tree farms can be found in Africa, South America, Malaysia, Indonesia, and Australia with the majority of the world's palm oil being produced in Malaysia and Indonesia. The oil palm tree produces a reddish fruit the size of a plum and grows in large clusters. The fruit oil is processed as an edible cooking oil, and is relatively low in saturated fats compared to traditional vegetable oils. The seed, within the fruit, possesses an oil that is high in saturated fats and is used to make processed foods, soap, and cosmetics. Recently, in some countries such as Australia, palm oil has been used in the production of biodiesel fuel.

Where to Look

The following schematics show how absorption chillers can be integrated into a palm-seed oil processing plant.



Application Factors

The palm fruit bunches, fresh from the tree, are sterilized and threshed to separate the fruit. The fruit and seed is mashed and pressed to squeeze out the oil. This crude oil is shipped to a processing plant where chemicals, filters, along with heat and cooling are used to refine the crude oil. Absorption chillers are employed in the process to cool and separate the Olein (saturated) oil from the Stearin (unsaturated) oil. The chilled water is also used to comfort cool the facility. Heat to drive the IsoFlow™ chiller can be obtained from the steam used to sterilize the fruit and/or steam used to process the crude oil.

District Energy

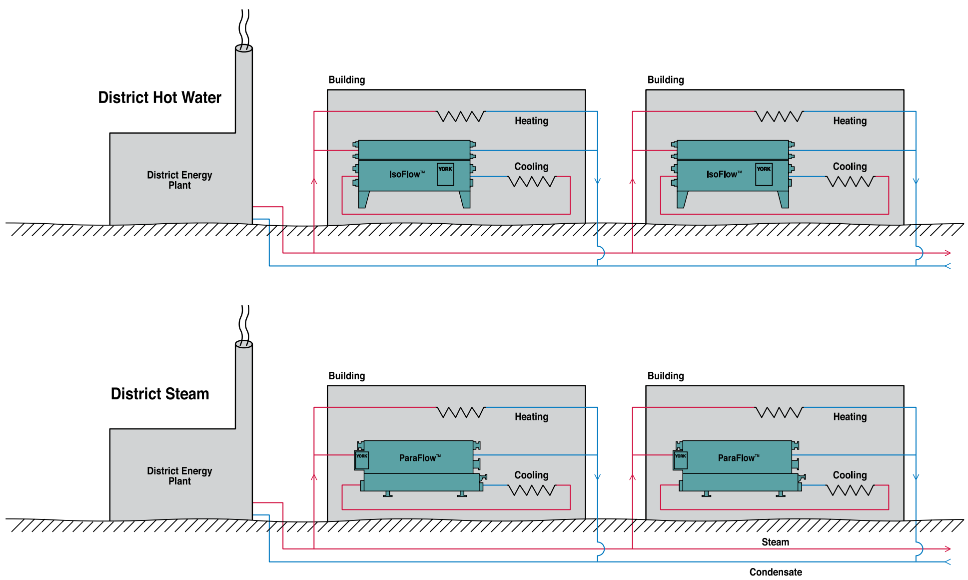
The Business Opportunity

The idea behind "district energy" is to pool customers together so energy can be generated closer to the point of use, avoiding 70% of the energy wasted during generation, transmission, and distribution over the grid. Accordingly, district energy plants are sited in universities, military campuses, or large cities, with major North American cities operating district energy plants for over 100 years. Locating closer to demand opens up the possibility of using heat from generation to drive an absorption chiller. Steam and hot water produced by the district energy plant can easily be delivered underground to surrounding buildings, along with natural gas and electricity.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a district energy application.

Integrating absorption chillers into a district energy plant lets customers utilize a chilled water supply without the capital expense of dedicated electric chillers. In making efficient use of heat from generation, this approach increases energy efficiency, reduces air pollution, combats global warming, and decreases emissions of refrigerants.



Application Factors

District energy plants can use many fuels—coal, wood, natural gas, oil or waste-heat from a local process. Regardless of energy type, there is always an abundance of heat that can be recovered to drive an absorption chiller. Where high-quality energy sources are available; natural gas, oil, propane, or other petroleum sources, a ParaFlow™ double-effect chiller can be applied, because it is very efficient. This chiller can also be powered by medium pressure steam. In cases where low-pressure steam below 1.0 bar or 15 psig or hot water above 80°C or 175°F is available, then an IsoFlow™ chiller can be used. An alternative scheme is to produce chilled water in the district energy plant and distribute both the hot and chilled water as necessary. See the CHP section for this application.

Incinerator

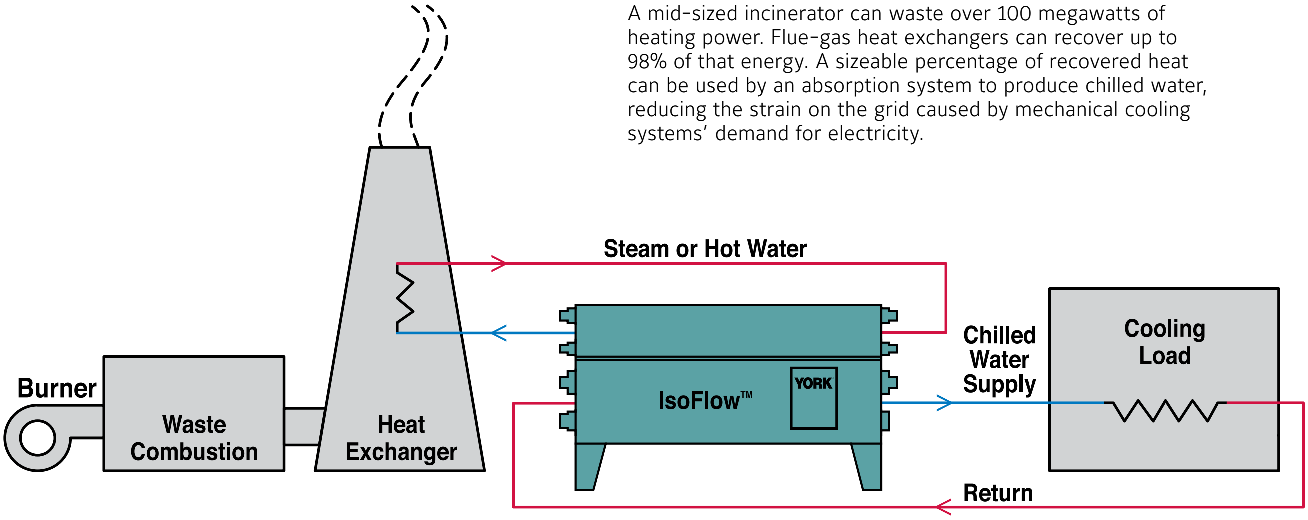
The Business Opportunity

Throughout the world, high-temperature incineration is used to destroy a wide range of combustible waste products–residential garbage, medical waste, scrap material–as well as waste from food and manufacturing processes. Large-scale incinerator plants can serve entire communities and cities, with specialized waste stations handling materials transported from distant locations. Regardless of the facility, the large amount of recoverable heat can be used to drive multiple absorption chillers to provide economical cooling.

Where to look

The following schematic shows how an absorption chiller can be integrated into an incinerator plant.

A mid-sized incinerator can waste over 100 megawatts of heating power. Flue-gas heat exchangers can recover up to 98% of that energy. A sizeable percentage of recovered heat can be used by an absorption system to produce chilled water, reducing the strain on the grid caused by mechanical cooling systems' demand for electricity.



Application Factors

One manufacturing facility burns wood scraps and recovers the heat to drive an IsoFlow™ absorption chiller to provide free cooling to their facility. A food processor burns waste husks and plant fiber to fuel a boiler that generates steam to drive an IsoFlow™ chiller used to cool the process. In other applications, an absorption chiller can be driven by steam diverted from a firetube boiler fueled by the incineration of cellulose and other organic material. Another incinerator technology utilizes a heat exchanger to generate steam or hot water from hot exhaust. For very large waste exhaust systems, multiple generators can be employed to produce large volumes of steam to drive multiple absorption chillers.

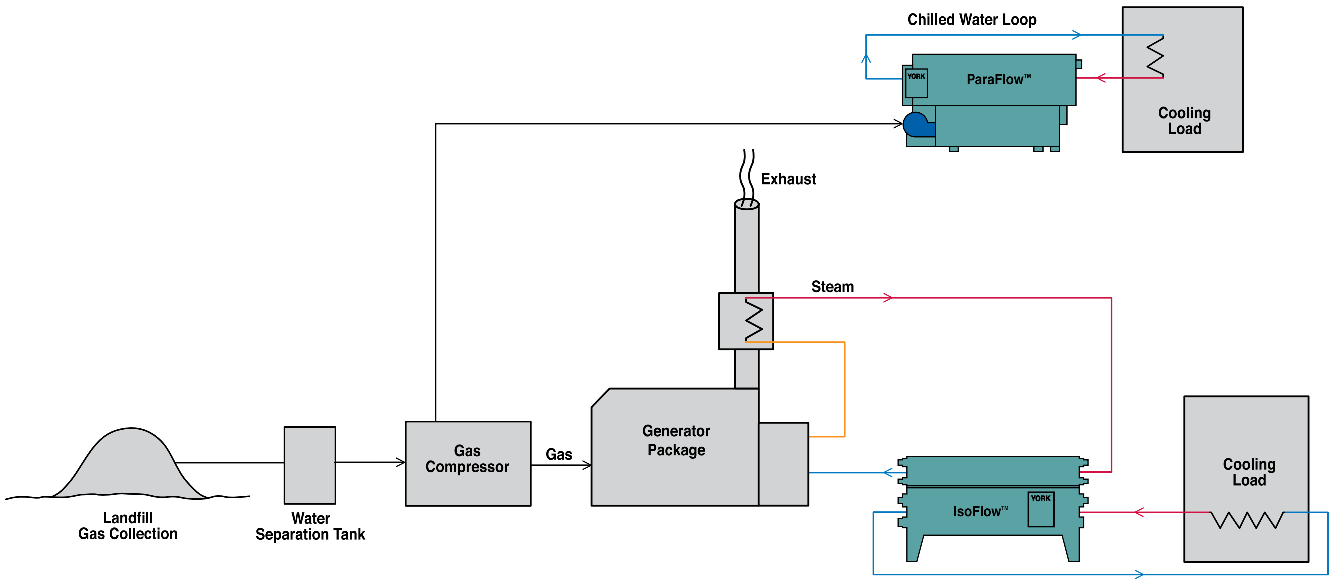
Landfill Gas

The Business Opportunity

Methane gas is a major contributor to the greenhouse effect and global warming. It is a by-product of landfills, waste treatment plants, and decomposition processes. Fortunately, methane can be captured and used to drive absorption chillers. This solution positively impacts global warming, because absorption chillers can be used for cooling instead of chillers that consume electricity produced by coal-burning utilities.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a landfill gas plant.



Application Factors

Landfill gas is generated by the anaerobic decomposition of cellulose and other organic matter contained underground. Wells are drilled into landfills to remove the gas, which is about 50% methane. Landfill gas contains 20 to 31 MJ/m³ or 500 to 800 Btu/ft³ compared to 39 MJ/m³ or 1000 Btu/ft³ for natural gas. This gas fuels an engine-generator set or gas turbine to produce electricity and can also directly fuel a boiler to produce hot water or steam. Heat from the generator, or steam and hot water from the boiler, can drive an IsoFlow™ absorption chiller to produce chilled water for cooling. Another consideration is to utilize a ParaFlow™ direct-fired absorption chiller and supply the landfill gas directly to the absorber. In this case, a special burner is used, and the landfill may need constituent reductions to remove water, sulfur, etc.

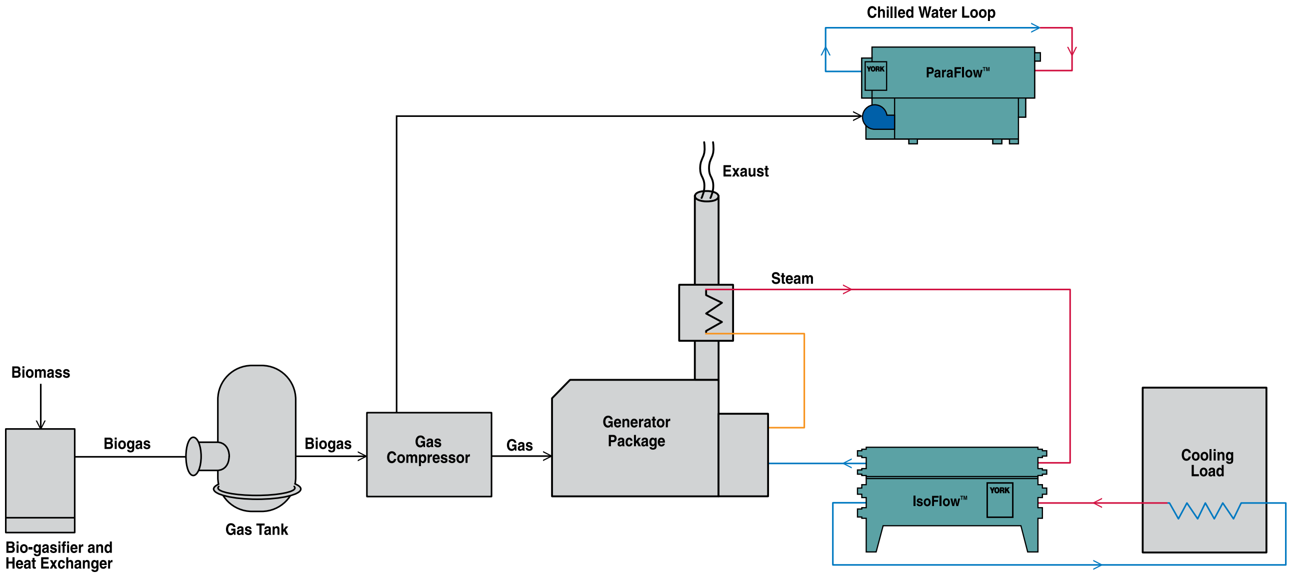
Biogas

The Business Opportunity

Methane gas is a major contributor to the greenhouse effect and global warming. It is a by-product of waste treatment plants, anaerobic digesters and other decomposition processes that handle municipal sewage, animal manure, garbage, and food processing waste. Fortunately, methane can be captured and used to drive absorption chillers. This solution positively impacts global warming because absorption chillers can be used for cooling instead of chillers that consume electricity produced by coal-burning utilities.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a biogas treatment plant.



Application Factors

Biogas is derived from anaerobic digester technology that can yield 55 to 80% methane. Biogas contains 20 to 31 MJ/m³ or 500 to 800 Btu/ft³ compared to 39 MJ/m³ or 1000 Btu/ft³ for natural gas. This gas fuels an engine-generator set or gas turbine to produce electricity and can also directly fuel a boiler to produce hot water or steam. Heat from the generator, or steam and hot water from the boiler, can drive an IsoFlow™ absorption chiller to produce chilled water for cooling. Another consideration is to utilize a ParaFlow™ direct-fired absorption chiller and supply the biogas directly to the absorber. In this case, a special burner is used, and the biogas may need constituent reductions to remove water, sulfur, etc.

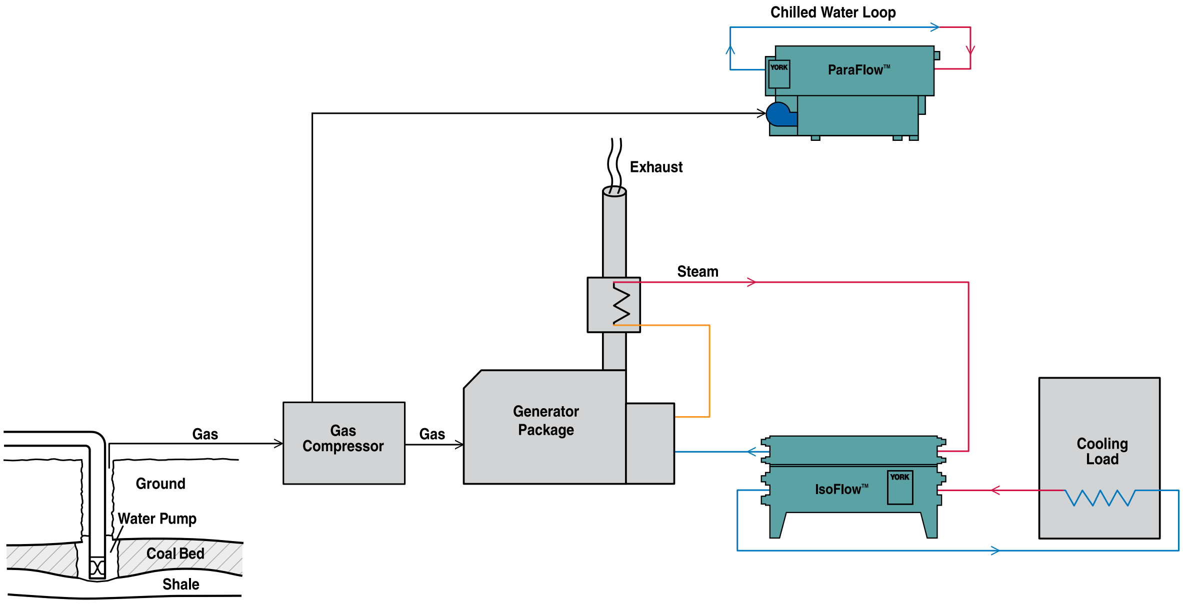
Coal Bed Methane

The Business Opportunity

Methane, a natural gas found in coal beds, was once considered a hazardous by-product of the coal-mining process. Now due to the rising cost of crude oil, it is considered a valuable energy resource. Coal bed methane is fairly easy to collect, and its extraction has far less environmental impact than coal mining. While coal bed methane wells typically do not produce a high volume flow of gas compared to natural gas wells, their production life can be extensive, often exceeding 40 years. The heat content of coal bed methane gas is similar to natural gas at 37.3 mega joules per cubic meter or 1000 Btu per cubic foot. Coal bed methane is relatively free of contaminants and can be used with little or no refinement.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a coal bed methane plant.



Application Factors

The extraction process of coal bed methane is to drill a well down to the coal vein which is typically below the water table, add a casing to the well, pump out the water and capture the rising methane gas. Removing water from the well reduces the pressure on the coal, thus releasing the methane gas inherent to the coal mineral.

The methane gas is then collected, compressed, and transported via pipeline or tanker truck to the end user. The methane gas can be used to fuel a boiler to produce hot water or steam providing winter time heat and driving an absorption chiller for summertime cooling. The methane could also be piped to a direct-fired absorber, omitting the boiler thus allowing a more efficient use of the fuel.

Combined Heating & Power (CHP)

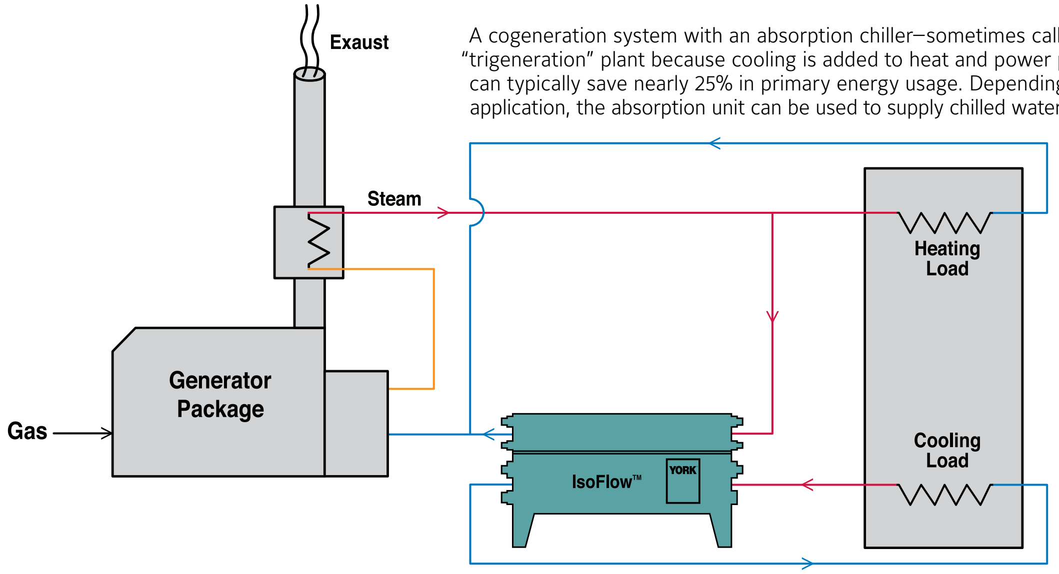
The Business Opportunity

As electricity costs rise, producing power at the point of use is far more economical and reliable than generating and transmitting electricity from a remote power plant. In fact, a facility operating a local cogeneration or Combined Heating and Power (CHP) plant that produces electricity and heat is about three times more efficient, and it reduces greenhouse gases by similar amounts. But to realize these benefits, all the heat by-products of cogeneration must be used all the time. Using the heat from a CHP system is usually straightforward during winter, but this same heat can be used in summer months to drive an absorption chiller to provide chilled water for cooling.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a CHP application.

A cogeneration system with an absorption chiller—sometimes called a "trigeneration" plant because cooling is added to heat and power production—can typically save nearly 25% in primary energy usage. Depending on the application, the absorption unit can be used to supply chilled water and hot water.



Application Factors

In a Combined Heating & Power plant, the prime mover is used to run a generator to produce electricity. The prime mover (engine or turbine) gives off a large proportion of heat in the form of engine coolant and exhaust gases. This thermal energy is captured and used to provide a source for either heating or, when used with an IsoFlow™ chiller, cooling. Careful sizing of the CHP system is necessary to match the CHP outputs to the building cooling, heating and power requirements as they change. The economics and environmental benefits of CHP are maximized when all the thermal and electrical output is utilized throughout the year so no energy goes to waste.

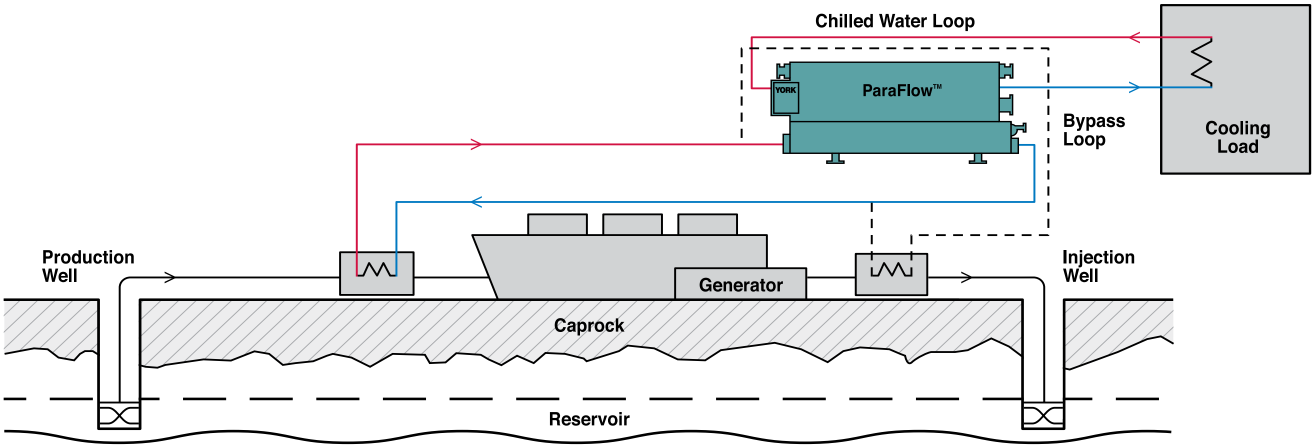
Geothermal

The Business Opportunity

Geothermal generating plants provide a natural, inexpensive alternative to generating steam with fossil fuels. Large-scale geothermal projects are becoming increasingly common around the world. These locales have geothermal reservoirs that create steam from the Earth's magma and hot, dry rock. Technological advancements, such as Enhanced Geothermal System (EGS), are encouraging geothermal generation in other locales. Steam used to drive the generator turbine can also drive an absorption chiller to provide cooling.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a geothermal generating plant.



Application Factors

Power plants convert hydrothermal fluids into electricity using three geothermal technologies: dry steam, flash (fluids above 182°C or 360°F), and binary cycle. Dry steam power plants use geothermal steam to drive the turbine directly. With the other two methods, a production well is drilled into a known geothermal reservoir. Heat from subterranean rock layers is utilized by injecting water through natural fractures. The hot liquid emerging from the underground reservoir is pumped to the surface to drive steam turbine generators. This hot fluid is also converted into steam to drive the generator turbine and an IsoFlow™ or ParaFlow™ absorption chiller.

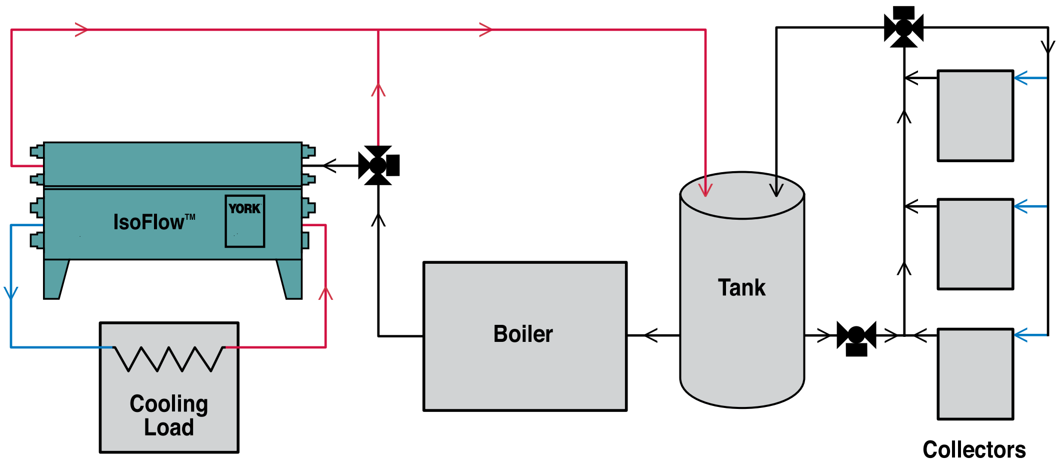
Solar

The Business Opportunity

Because solar energy is free of CO_2, SO_2, NO_x, and other smoke-stack emissions, it is a very environmentally friendly form of energy for heating and cooling. Solar collectors can be set up on covered parking areas, covered walkways, or top of buildings. Combining solar and absorption-chiller technology provides the most energy-efficient and quietest source of chilled water. Advanced solar collection technology makes it possible to generate hot water or steam to drive single-or double-effect absorption chillers. Although the first cost is high compared to conventional chillers, the payback period can be less than five years due to government incentive programs and the increasing cost of electricity.

Where to Look

The following schematic shows how an absorption chiller can be integrated into a solar application.



Application Factors

The typical solar system produces hot water for heating and domestic hot water. Hot water or fluid can also be generated to drive an absorption chiller to handle the peak or the complete cooling load. When used with a solar thermal energy system, the absorption chiller must be selected to operate at the normal working temperatures of the solar-collector array. Typically, the system will also incorporate a hot water storage tank and boiler that can provide hot water on cloud-covered days. An IsoFlow™ single-effect chiller can be applied with 88°C or 190°F hot water or higher; a ParaFlow™ double-effect chiller can be used with steam above 174°C or 345°F for the highest possible solar-energy utilization. Although absorption chillers in a solar application still use electricity to pump refrigerant, the power consumed will be negligible compared to a conventional compressor system.

Rethink. Many commercial, institutional and industrial facilities generate waste energy, it is time to rethink what is done with this energy. **Recycle.** The waste energy, hot water, steam and gas, can be captured and recycled as valuable secondary energy. **Reuse.** As secondary energy, it can be used to create chilled water for comfort conditioning or process cooling. **Reduce.** The net contribution is a reduction of the overall demand on the electric grid and minimizing the environmental impact of power generation.

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