Natural Gas ...

A Cool Solution to the High Cost of Cooling

ESC
Energy Solutions Center

www.gasairconditioning.com

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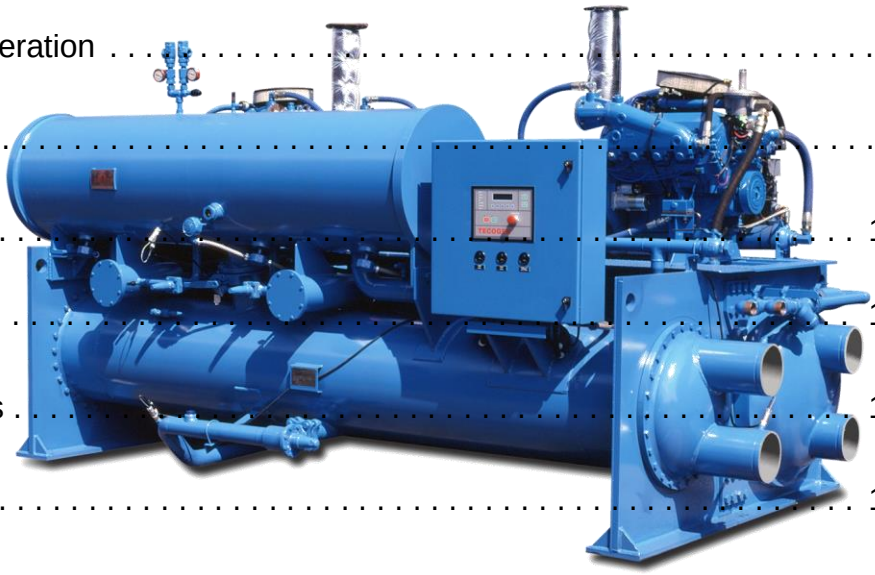


Let Natural Gas Solve Your Cooling Challenges

Natural gas enjoys a well-established and well-deserved reputation for efficiency, economy, reliable service, superior performance, and it's good for the environment. In fact, natural gas is the preferred energy for heating, water heating and cooking in most of today's homes and businesses.

Technology advances and changes in the energy industry are making natural gas your best choice for cooling as well.

Many manufacturers offer a diverse selection of time-tested gas cooling products, including engine-driven chillers, absorption chillers, gas heat pumps, refrigeration equipment, desiccant dehumidification and gas fired humidifiers. Natural gas cooling equipment is available in sizes to meet virtually every need—from air conditioning in residential homes to large-scale industrial refrigeration and process cooling.

Today's gas cooling equipment is efficient and economical. Gas systems typically save 50% over the cost of conventional electric cooling equipment. Working alone or in tandem with other systems such as electric chiller or combined heat and power plants, gas systems provide:

- Efficiency to effectively manage energy costs.
- Superior performance to satisfy the most demanding cooling requirements.
- Reliability to meet critical service needs or production schedules.
- No harmful emissions and far fewer pollutants than electric generation, helping to keep our environment clean.

If you're plagued by high cooling costs, unreliable energy service, environmental emissions, indoor air quality issues, or unacceptable equipment performance, natural gas cooling can be the solution. Natural gas has proven itself as a practical and cost effective partner with, or alternative to, electric cooling equipment.

IN THIS GUIDE …

You will learn about the many natural gas cooling options available to you and how you can benefit from them. We're confident that natural gas offers a solution to your toughest cooling challenges. You can find out more about today's natural gas cooling technologies by visiting www.gasairconditioning.com. Or, give your local gas utility representative a call today to discuss how natural gas can go to work for you.

Natural Gas …

Your Best Energy Value

for Cooling

Nationally in the commercial sector, approx. 10% of all energy consumed in commercial buildings is for cooling. Many businesses, especially those involved in chemicals, plastics and electronics, require large amounts of process cooling in addition to air conditioning for offices and production facilities. Most homeowner are enjoying the cool comfort of central air conditioning. American consumers spend an average of 10% of their total energy budget on cooling.

As the cost of electric rises, natural gas is your most economical energy choice. Today the variety and availability of highly efficient and economical natural gas cooling technologies is spurring increasing interest in natural gas as a cooling fuel. It provides energy users with a unique opportunity to take full advantage of the benefits offered by energy choice, energy management, and the efficiency and economy of natural gas.

Natural Gas Is Good for Your Budget

In summer, higher electric demand for air conditioning goes hand-in-hand with higher electric rates. For many businesses, the cost of electricity is made up of two components: the cost of the electricity consumed and the demand charge. When demand for electricity is high, demand charges can often exceed consumption costs, and high demand pushes more electric usage into the higher usage block charges. Natural gas reduces air conditioning operating and electric costs by dramatically reducing demand charges and electric consumption.

Life cycle costs are often much lower because of the savings in energy costs over the long useful life of natural gas cooling equipment. Because natural gas requires very little electricity, it frees up electric service in existing buildings for other applications. Electric service needs in new facilities can be dramatically reduced. Less electric demand also means less requirement and expense for emergency back-up generation.

Take Advantage of a Deregulated World

As the energy industry deregulates, opportunities exist to take advantage of time-of-use and real-time electric rates; to negotiate favorable rates based on the ability to level or reduce electric usage during high demand periods; and to benefit from the lowest energy rates available in a volatile energy market. One way to put energy bargains to work for you may be with a hybrid system. Hybrid plants combine both gas and electric chillers, letting natural gas take the lead when electric rates are high and then provide back-up cooling when electric rates are lower. This freedom to switch between gas and electric lets hybrid plant operators more efficiently manage their energy usage and costs.

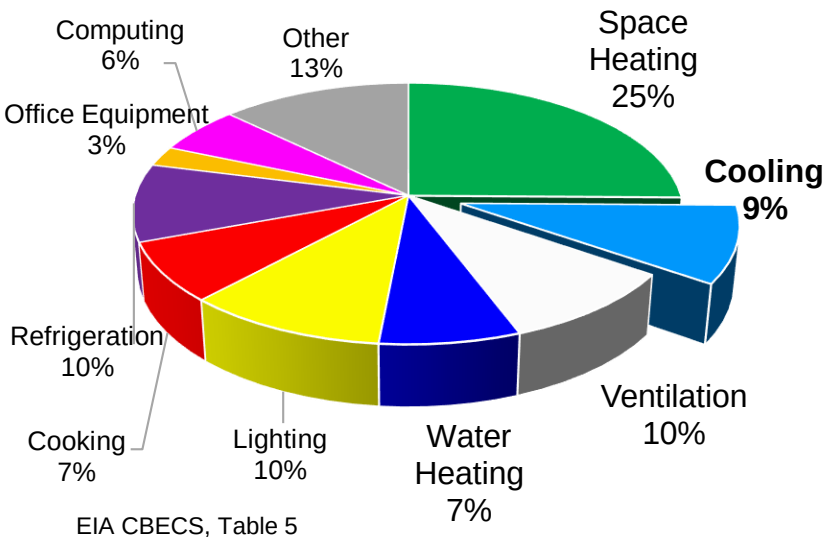
Natural Gas Is Good for the Environment

Natural gas is the cleanest of the fossil fuels and its use helps reduce harmful emissions that contribute to ozone-depleting greenhouse gases, acid rain, smog, solid wastes and water pollution. In absorption cooling equipment, plain water replaces harmful chemical refrigerants. Natural gas can improve indoor air quality when desiccants and natural gas humidification are used to maintain proper humidity levels, impeding the growth of disease-causing microbes, mold and mildew.

Natural Gas Is Good for Your Home or Business

You can count on natural gas to deliver the superior performance you require from your cooling equipment. Today's state-of-the-art natural gas cooling technologies are efficient, reliable, require little maintenance and last for years. They offer new possibilities for reducing energy consumption and managing energy costs for cooling in home use, commercial buildings, industrial processes, refrigeration, combined heat and power plants, and district cooling plants. Natural gas equipment is also recognized by the U.S. Green Building Council as an important resource in the design of environmentally friendly and energy efficient construction.

Commercial Buildings: Total Major Fuel Consumption (trillion Btu)

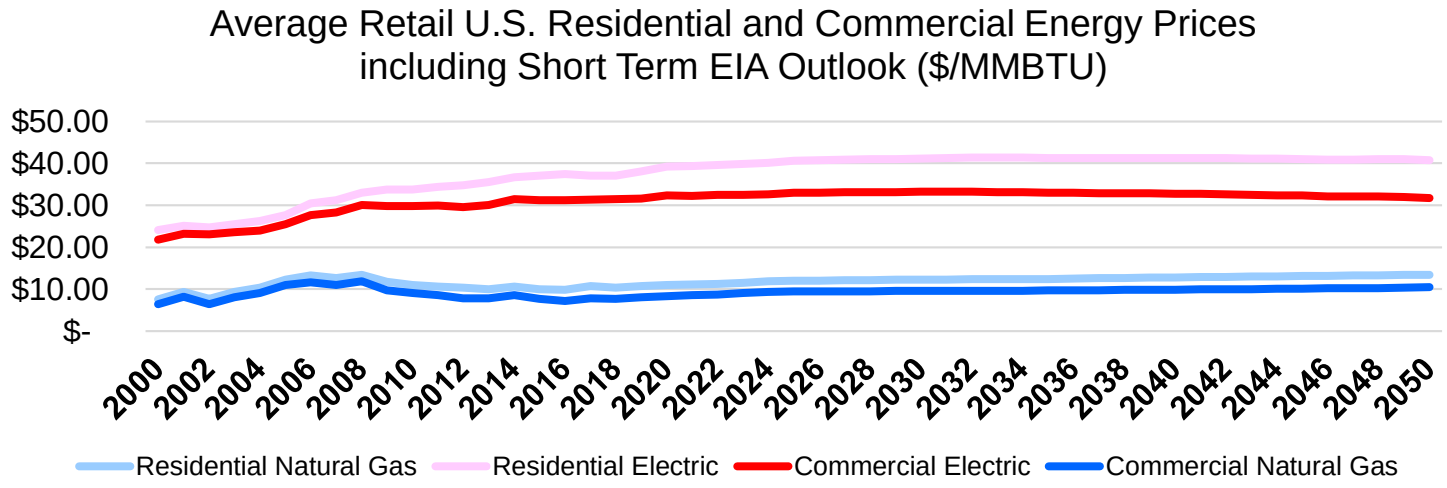


EIA CBECS, Table 5

Natural gas cooling offers these advantages:

- **Reduces monthly electric consumption and high operating costs**
- **Reduces electric peak demand charges**
- **Reduces costs over life-cycle of equipment through energy savings**
- **Saves on building's electric distribution costs and frees electric service for other uses**
- **Reduces need and cost for emergency back-up generation for critical cooling needs**
- **Long operating life**
- **Sizes suited to virtually any need from air conditioning to below-freezing storage**
- **Can be used green building certification**

Natural gas has historically been and is projected to be 1/3 of the cost of electric into the future



Gas Cooling is Economical

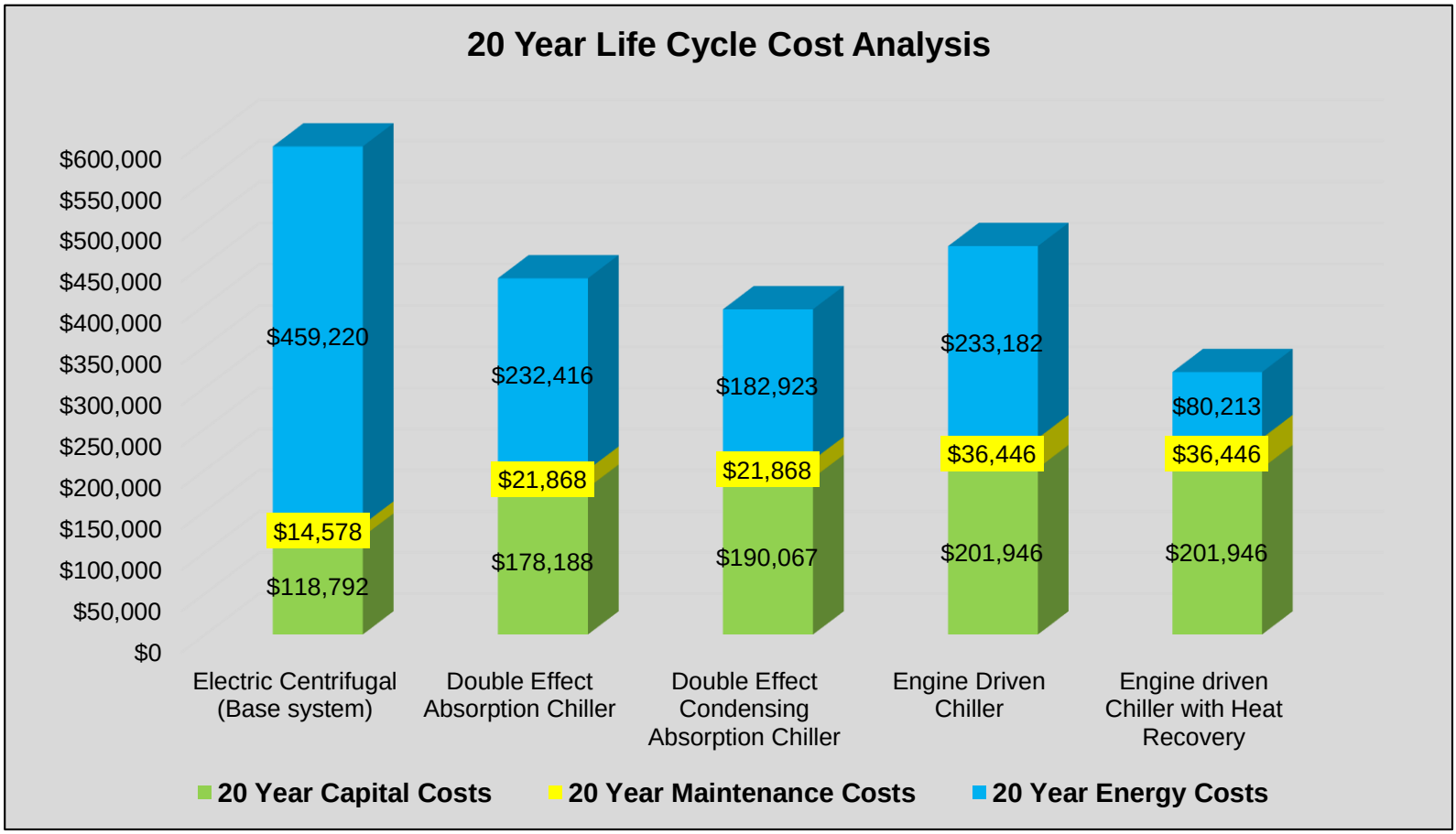
Life Cycle Costing Analysis compare various energy equipment costs including financing the installed costs, energy costs, and maintenance costs over the over the expected life of the equipment. Life Cycle Cost analyses are used to make sound financial decisions and used to set priorities. This type of analysis provides valuable information to determine best investments.

The chart below shows a typical life cycle cost analysis for a 100 ton cooling system using average costs of gas and electric. All of the natural gas air-conditioning systems shown have lower life cycle costs than the electric system.

In addition to the natural gas air conditioning systems having a significantly lower life cycle cost compared to a electric centrifugal chiller, most of the gas cooling options have around a 4 year payback. Gas air conditioning systems provide positive cash flows from day one of operation with internal rates of return of approximately 25% or more.

Access the natural gas cooling and heat pump analysis tool at:

https://gasairconditioning.com/general-resources/tools/



Life Cycle Cost Analysis assumptions: 100 Ton cooling system running 1500 equivalent full load hours over 6 months of the year at starting rates of $.17/kWh electric usage, $10/kW electric demand & $7/MBTU natural gas. 20 year life cycle cost with 2% annual fuel and maintenance inflation rates and 5% cost of capital.

Protecting the Environment and Security of our Nation

Providing a healthy environment, maintaining a high standard of living and ensuring the safety of Americans are important issues. Climate change, ozone depletion, smog, and acid rain pose serious health problems. Diminishing energy resources, terrorism and unpredictable foreign policies threaten the economic vitality of U.S. businesses. Natural gas can significantly help reduce pollution, maintain a clean and healthy environment, and use a domestically produced energy source.

Natural Gas … Good for the Environment

Electric air conditioning systems draw power as needed to meet building needs and are very dependent on weather conditions. Cooling loads vary moment by moment and day by day and utilize the marginal power portion of the electric grid, not base load power. Base load power is mainly comprised of nuclear power that does not turn off and renewable sources of power that are producing power when the wind is blowing, or sun is shining. Base load power sources do not have the ability to ramp up and down to meat marginal demands for electric power, these marginal loads are met with fossil fuel power generation.

In 2018, the U.S. power generation mix included 35% that was supplied using natural gas power plants and 27% using coal plants. The Department of Energy's Annual Energy Outlook 2020 projects that natural gas will continue to meet 36% of power production in 2050 with coal dropping to 13% and renewables increasing from 19% today to 38% in 2050.

A lot of energy is lost in the generation of electric, transmission and distribution. In fact, only 36% of the energy that goes into creating electric is delivered to end users. Since electric cooling relies on marginal power from the grid, and the grid is only 36% efficient, this means gas cooling systems can save a tremendous amount of source fossil fuel energy use and related greenhouse gas emissions, in addition to saving you money.

… Good for North America

There is a continuing need to strengthen our energy position and national security. The United States & Canada have an abundant supply of natural gas which can reduce our demand for electricity helping to improve grid reliability and stability by reducing congestion and constraints on an already overtaxed grid. The underground natural gas transmission and distribution system is protected from damage that can be caused by weather or attacks, making it a secure, safe and reliable source of energy.

Using natural gas cooling helps reduce:

- Energy costs
- Demand on the electric grid
- The size back-up generator needed to provide space cooling during a blackout.

Building Green

Growing concerns over the impact that the design of new and existing buildings can have on the environment, efficient use of energy resources, building occupant health and comfort, and building profitability have led to the formation several green building certification programs such as:

- Green Globes from the Green Building Initiative (GBI)
- Leadership in Energy & Environmental Design from the U.S. Green Buildings Council (USGBC)
- Canadian Green Buildings Council (CaGBC)
- Energy Star
- Building Energy Quotient (bEQ) from ASHRAE
- Zero Energy Certification from New Buildings Institute

Taking a holistic approach to building design, these programs promote and recognize excellence in building practices through respective green building rating systems, which are voluntary, consensus-based, standards for certification of buildings that meet specified criteria for sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. In general, points are awarded based on adherence to the green building standards. Total points earned determine the level of certification. Increasingly, government agencies are using the rating system as a basis for incentives such as grants, tax credits, expedited permitting, or exemptions from certain restrictions.

Natural Gas and Green Buildings

Natural gas is the perfect complement to the goals of any green certification program. The cleanliness and efficiency of natural gas make it a strong partner in attaining Green Building certification. Natural gas can enhance the green building points awarded because:

- Natural gas equipment is highly efficient.
- Natural gas technologies offer energy efficiencies through waste heat recovery that exceed standard installations.
- Natural gas reduces energy and water usage.
- Natural gas is economical and saves on operating costs.
- Natural gas is environmentally friendly with far lower harmful emissions than alternatives fuels.
- Natural gas minimizes system losses compared to electricity produced in a central power plant.
- Natural gas chillers earn certification points in several categories, including Energy, Atmosphere & indoor environment and Innovation in Design.

Getting Down to Business with Residential Gas Air Conditioning

Cooling your home with electric air conditioning during the hot summer months, when electric rates are higher, can take a real bite out of your energy budget. As natural gas technology has advanced and as electricity costs continued to rise, business and industry increasingly turned to the economy of natural gas to control energy costs for cooling.

This same technology that benefits business owners is also available in small-size, packaged cooling units suitable for larger single-family homes, condominiums and townhouses.

Using a process known as absorption chilling, these air conditioners replace ozone-depleting chlorofluorocarbons (CFCs) by using water and an environmentally safe solution for cooling. Improved efficiency is achieved by capturing and reusing the heat that is released during the absorption process.

Independent zone control means more uniform temperatures and greater comfort. Variable speed operation enhances performance and saves you money. Absorption chillers are a proven technology offering long life—exceeding 20 years.

How Does Absorption Cooling Work?

Residential natural gas air conditioners are small absorption chillers that operate on the same principles as larger units designed for commercial and industrial use. An absorption chiller uses a refrigerant, absorbent and heat to create a cooling effect. The air-cooled chillers utilize environmentally safe ammonia and water to create a stream of chilled water. This chilled water circulates through your home via a piping system, eliminating the need for ductwork and making the system well suited to homes with centralized baseboard heating. The chilled water can also be used in a conventional, residential ducted central air conditioning system.

Compared to electric air conditioning, natural gas cooling offers these advantages:

- **Efficient and economical – reduces energy use and quickly pays for itself**
- **Multiple zone comfort control**
- **Minimal ductwork – adaptable to centralized baseboard heating**
- **Environmentally friendly ammonia/water absorption process**
- **Low maintenance – no compressors and few moving parts**
- **Long life – exceeding 20 years**
- **Safe, quiet operation**

Natural Gas Cooling…

Makes Good Sense for

Commercial Buildings

Hospitals, restaurants, supermarkets and hotels/motels use a lot of cooling during the hot summer season. In many instances, cooling is needed 24 hours a day, 365 days a year. Office buildings, retail stores, shopping malls, churches and schools also have large and expensive cooling demands, primarily during daytime hours. These and many other commercial enterprises struggle to balance the high cost of cooling with the need to provide comfort and a quality indoor environment for customers and employees. Natural gas air conditioning can help owners and managers of commercial buildings manage their energy costs for cooling. Additionally, many government agencies and commercial building designers recognize the contribution of natural gas equipment to attaining green building certification.

Whether cooling solely with natural gas equipment or in tandem with electric, steam or hot water in a hybrid system, today's natural gas absorption, engine-driven, heat pumps, steam-turbine drive chillers, desiccant dehumidification and humidification equipment assure your business superior performance, reliability, flexibility and economy.

Absorption chillers perform quietly, efficiently and economically without harming the environment. For even greater economy, they can operate on waste heat supplied by engine-driven chillers, or steam or hot water from other processes within your business. Failities with large boilers that produce steam for winter heating and year-round sterilization or process heat can capitalize on lower summer boiler demands by using steam-fired absorption chillers.

Engine-driven chillers are equally effective for a variety of cooling requirements and come in sizes to meet virtually any cooling task. Engine-driven chillers are especially adaptable to operations where heat recovery can help reduce costs.

Desiccant dehumidification is the answer to the cost and comfort problems caused by over-chilling to compensate for excess humidity. Employees and customers will be more comfortable at higher temperatures when humidity levels are reduced. Desiccant dehumidification also benefits supermarkets with less frost build-up on products and equipment, and it keeps ice rinks free of fog.

Gas fired humidifiers add in that much needed humidity to protect furniture, flooring, wall coverings, antiquities, and books/paper products, all while improving IAQ, and reducing the potential for sick building syndrome.

Natural gas cooling equipment offers a complete package of comfort and efficiency for commercial building owners and operators.

Today's Industries Rely on the Economy, Reliability and Flexibility of Natural Gas Cooling

Industrial facilities require cooling for the comfort of workers and the proper operation of sensitive production equipment. For some industries, cooling is an essential ingredient to the production process. Natural gas equipment comes in sizes and types to economically and reliably handle even the most rigorous and varied cooling jobs of both large and small industrial operations.

Natural gas can play an important role in meeting the specialized cooling requirements of today's hi-tech industries. Pharmaceuticals, electronics, precision machining, surface treating, printing, food processing and many other operations require precisely regulated environments.

Gas engine and some absorption chillers can cool process brine or glycols to below 32ºF. For industries that generate steam, hot water or recoverable heat, absorption chillers can be an extremely cost effective cooling choice. Excess boiler steam or recovered heat from an on-site power generation system is an economical fuel for steam-turbine drive or absorption chillers. With sizes ranging up to a few hundred tons of cooling capacity, engine-driven cooling equipment is equally adaptable to space conditioning, process cooling and low-temperature refrigeration.

Gas-fired desiccant dehumidification and humidification can help maintain the temperature and humidity conditions necessary for proper performance of digitally controlled equipment and quality control in production processes for plastics, pharmaceuticals, and candy making just to name a few.

Energy intensive industries can benefit from the reliability and flexibility of hybrid cooling systems that combine the best benefits of gas and electric technologies or combined heat and power systems for dependable, low-cost electric and thermal energy.

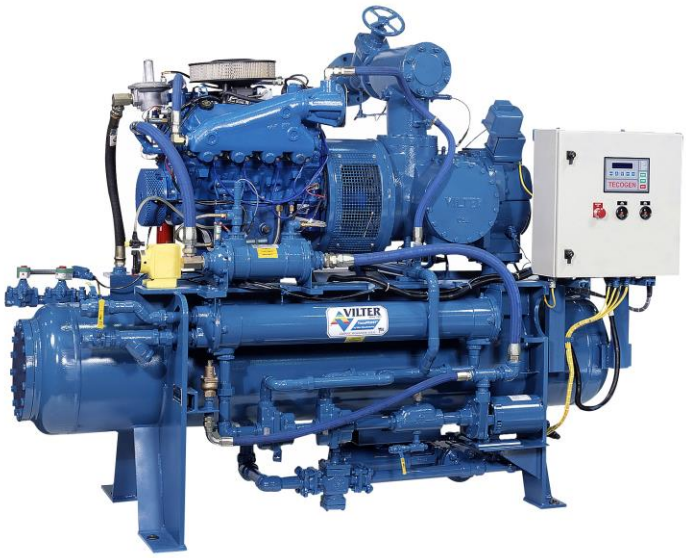
Natural gas cooling for industry offers these advantages:

- **Provides precise temperature and humidity control for sensitive equipment and processes**
- **Most industries already have natural gas service to their facility making it easier and less costly to install gas cooling equipment**
- **Dual-fuel capabilities let industrial facilities take advantage of lower summer and interruptible gas rates**
- **Natural gas is reliable for critical and essential operations**
- **Takes full advantage of every energy dollar through the use of excess boiler steam or hot water capacity, heat recovery and combination gas/electric hybrid systems**
- **Environmentally friendly**

From Cold Storage to Sub-Zero Freezing,

Natural Gas Can Handle

Your Refrigeration Needs



Many commercial and industrial operations require refrigeration at temperature levels from 32ºF to – 60ºF. From cold storage for warehousing beverages and food products to sub-zero refrigeration for freezing and maintaining meats, food processors rely on modern refrigeration technology.

The products of many businesses depend on cold temperatures to assure quality and safety. These include ice rinks and ice production, chemical and petrochemical process systems, plastics processors, and chilled water needs for the automotive and pharmaceuticals industries.

Natural gas engine-driven systems and ammonia-water absorption systems are proving to be an economical and effective answer to the cooling needs for commercial and industrial refrigeration. Engine-driven units range in sizes from 25 tons to a few hundred tons with commercial refrigeration packages featuring: standard compressor packages up to 150 hp.

Today's natural gas engine-driven refrigeration equipment is especially beneficial where there is a need for heat recovery for container sterilization, general cleaning purposes, space heating and other thermal energy uses. Heat from the engine jacket and exhaust gases can be recovered and put to work wherever thermal energy is needed.

Natural gas engine-driven industrial refrigeration equipment offers economic benefits through its electrical peak-shaving capabilities. Significant advances in engine technology, microprocessor controls and engine compressor compatibility make the package of engine-driven equipment very attractive today.

At any temperature, natural gas is an efficient and economical choice for your refrigeration needs.

Natural gas refrigeration offers these advantages/features:

- **Lower operating costs**
- **Variable speed for efficient part load operation**
- **Engine heat recovery for domestic hot water and other thermal energy needs**
- **Long operating life**
- **Environmentally friendly**
- **Initial costs quickly offset by energy savings**
- **Temperatures of 32ºF to – 60ºF**
- **Sizes from 25 tons to 5000 tons**

Gas Heat Pumps

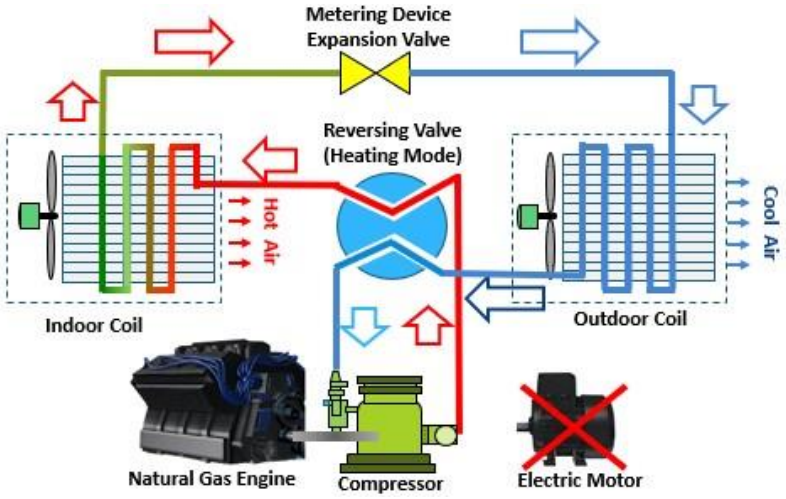
Gas Heat pump(GHP) options are available today that provide heating, hot water and cooling for residential, commercial & industrial customers. These systems utilize natural gas making them very reliable and energy efficient.

Heat pumps are systems that transfer thermal energy from a heat source to a heat sink. The thermal energy is moved in a direction that is opposite to the direction of spontaneous heat flow. Heat pumps use energy to accomplish the desired transfer of thermal energy from heat source to heat sink. In short, a heat pump running in heating mode is nothing more than a standard air conditioner running in reverse, so instead of rejecting heat to the outdoors when cooling, it is extracting heat from the outdoor air and transferring that heat to the indoor space.

These primary benefit of a gas fired heat pump is that it can produce heating or hot water at efficiencies well over 100% while also offering up gas cooling. Heating efficiencies are often in the range of 140%.

GHPs can be configured as air source, water source, or ground source (geo-thermal) systems. Gas-Fired Heat Pumps are an innovative answer to traditional air-conditioning units, offering owners high efficient heating & cooling solutions.

Schematic of an engine driven GHP in heating mode:



Types of gas heat pumps:

GHPs can utilize a vapor compression cycle similar to electric heat pumps, use an absorption cycle, or a thermal compression cycle. The common denominator in all GHPs is that the refrigeration flow cycle can be reversed and heat can be moved from the odors to the indoors.

Electric heat pumps are limited in their ability to maintain high efficiency while heating when it is cold outside. Electric heat pumps stop working when the outdoor temperature drops to the mid 30ºF and back-up (emergency) electric resistance heat kick in. GHPs can recover heat from combustion and do not suffer the limitations expressed by electric heat pumps.

GHP advantages

Gas heat pumps are an economical, environmentally responsible alternative to high electric costs and electric demand charges. These systems provide significant operating cost savings that can easily offset equipment cost. Depending on natural gas and electric rates and demand charges, payback periods for the various heat pump technologies vary, but can often range from two to four years.

Best locations for gas heat pumps:

- **Larger Residential Homes**
- **Schools**
- **Hospitals**
- **Apartment Buildings**
- **Office Buildings**
- **Nursing Homes**
- **Hotels**
- **Restaurants**
- **Retailers**

For more information on GHPs, go to:

www.gasheatpumps.com

Gas Absorption Chillers –

An Absorbing Idea for Cooling

Although absorption chillers are an ideal and frequent choice for large commercial buildings, today's technology is well suited to a variety of large and small cooling jobs. Small packaged chillers in sizes down to 5 tons deliver cool comfort in single-family homes without many of the drawbacks of electric air conditioning.

Absorption chillers are just as effective at meeting the extreme, often round-the-clock, cooling needs of hospitals and hotels/motels. Schools, government buildings, retail establishments such as malls and restaurants have high daytime cooling needs when electric rates are high. Absorption chillers significantly reduce electric consumption and cost, especially high peak demand charges.

The chillers work equally well either in a dedicated gas cooling system or in large plants as part of a hybrid system where cooling needs are shared with gas, electric or steam-driven chillers. Whatever the size or demands of the cooling job, absorption chillers deliver some important benefits for home and business owners.

Absorption chillers deliver superior performance.

A significant feature of the absorption chiller is that it is "powered" by heat. This makes it an especially good choice in situations where heat, from an engine or a production process, can be recovered and used to economically provide cooling. For businesses with hybrid plants that combine engine-driven chillers with absorption equipment, waste heat generated by the engine-driven equipment can be put to use by the absorption chiller.

Buildings heated by boilers can make more efficient use of the boiler by using it during summer months to operate an absorption chiller. This makes it easier to control boiler operation and gets the most out of your boiler, especially if the boiler operates year round.

Absorption cooling offers many other important advantages. Because it uses no compressor and has few moving parts, an absorption chiller produces less noise and vibration than electric chillers. Patients in hospitals, students in schools, and occupants of offices and eldercare facilities appreciate the quiet operation of gas absorption cooling. The relatively simple design of absorption chillers also requires less maintenance.

Because natural gas reduces your overall electric requirements, you save money when building a new facility by installing less electric service. In existing buildings, absorption cooling frees up electric service for other uses. You'll also need much less emergency back-up electric generation for absorption chillers than would be required to keep electric equipment running.

Absorption chillers are easily installed in the same amount of space as an electric chiller and boiler.

The Absorption Process

Absorption chillers operate similarly to conventional vapor compression chillers except that heat provides the

work normally done by an electrically powered compressor. The heat can be derived directly from natural gas combustion or indirectly from gas-heated steam or water, or from the recovery of waste heat, depending on the type of absorption chiller used.

The process uses non-toxic lithium bromide as an absorbent and water, an environmentally safe alternative to CFCs, as a refrigerant. Cooling is accomplished through a cycle of evaporation, absorption, regeneration and condensation. Only a very small amount of electricity is used to drive a pump in the condensing cycle so electric consumption and peak demand charges are reduced and replaced with low-cost natural gas or waste heat as the primary energy source

Absorption cooling offers so many advantages it just makes sense to consider natural gas absorption chillers for your cooling needs.

Single- or Double-Effect Absorption Chillers?

Absorption chillers currently available include single-effect and double-effect units. A single-effect absorption chiller can be indirectly powered by hot water or low-pressure steam, making it very effective for heat recovery applications. Double-effect absorption chillers are fired directly with gas or use medium-pressure steam.

The primary difference between single- and double-effect chillers is the addition of a second generator and condenser on double-effect models. This results in a significant increase in cooling capacity from the double-effect chiller for the same heat input required by a single-effect cycle.

Chiller-Heaters

Some models are able to provide heating as well as cooling, eliminating the need for a boiler.

Typical absorption chillers feature:

- **Gas, steam or hot water fueled**
- **Modern electronic controls**
- **Quiet operation**
- **Long service life**
- **Ability to use elevated cooling tower temperatures**
- **Automated operation**
- **Simple design with few moving parts**
- **Maintenance contracts and extended warranties at costs comparable to electric equipment**
- **Some absorption chillers can be used as boilers, producing up to 203ºF hot water and eliminating the need and cost of separate boilers**

Natural Gas

Engine-Driven Cooling –

The Cooling Workhorse

For flexibility and versatility, gas engine-driven chillers can't be beat. Chillers are available in a wide range of sizes, able to perform virtually any cooling task from air conditioning offices, hospitals, schools, retail shopping malls and other commercial and industrial buildings to providing cold or sub-freezing refrigeration to dairies, wineries, food processors, cold-storage warehouses and ice producers.

Due to the very high efficiency of natural gas engine-driven chillers, they lower operating costs by as much as 30% to 60% compared to conventional electric chillers. Using natural gas in the summer, when demand is lower, avoids the very high electric demand charges and "time of day" rates associated with electric chillers.

Gas engine-driven chillers are ideal for retrofit or replacement applications. Their footprint is comparable to an electric chiller and they are easy to disassemble for access to a mechanical room if necessary.

In facilities where air conditioning is critical, such as hospitals, natural gas engine-driven chillers are an excellent choice. Hospitals maintain emergency generators to support vital services when the power goes out as required by law, but the power needs of electric chillers tax most back-up generators. Water cooled natural gas chillers require only a small amount of single-phase power to keep vital services running during blackouts.

In addition to using low-cost natural gas, thereby saving on the operating cost and peak demand charges of electric systems, engine-driven chillers provide added efficiency and economy through heat recovered from the engine-jacket coolant and the engine exhaust gases.

Many businesses require hot water for heat, domestic water or process use. This heat can be supplied efficiently and economically using heat recovered from an engine-driven chiller. Thus, the hot water is generated without additional fuel consumption.

Another important feature of the engine-driven chiller is variable speed operation which allows it to follow the cooling load without cycling on and off, providing high-efficiency under part load conditions, saving money on energy.

Typical engine-driven chillers feature:

- **Air-cooled and water-cooled models**
- **Heat recovery capabilities**
- **Modern electronic controls**
- **On-board diagnostics**
- **Remote monitoring**
- **Use same cooling towers, pumps and piping as electric systems**
- **Variable speed operation**
- **Sizes from 25 to 5000 Tons**

Operates Like an Electric Chiller with the Added Benefits of Natural Gas

Like an electric-powered chiller, natural gas engine-driven cooling uses a vapor compression refrigeration cycle, except in a gas system an engine replaces the electric motor. This gives the gas chiller three important advantages: 1) avoids electric demand charges, therefore lowers operating cost, 2) variable speeds for more effective part load operation and 3) recovery of waste heat from the engine jacket and exhaust gas supply that can be used to efficiently supply hot water for other heating needs.

The chiller consists of four main components: the compressor, condenser, expansion valve and evaporator. As in absorption cooling, the chiller cools a stream of chilled water and then sends it to individual air coils, which in turn, cool and dehumidify the air. The chiller uses a reciprocating engine that can be either air-cooled or water-cooled.

Natural gas engine-driven chillers offer these advantages:

- **Lower energy bills**
- **High part-load efficiency**
- **Ability to recover engine and exhaust waste heat for space or water heating without using additional energy**
- **Use of "fit for purpose" natural gas engines assuring high reliability**
- **Saves on building's electric distribution costs and frees electric service for other uses**
- **Optimum performance from electronic controls that efficiently handle part load operation without cycling on and off**
- **Reduced need and cost for emergency back-up generation for critical cooling needs**
- **Can operate during blackouts with minimal power requirements**
- **Long operating life**
- **Environmentally friendly – no CFCs and reduced CO_2 emissions compared to electricity**
- **Initial costs offset by energy savings**
- **Sizes suited to virtually any need from air conditioning to below-freezing storage**
- **Similar footprint size as electric chillers, allowing for easy replacement**
- **Can be used for Green Building credits**

Natural gas cooling equipment offers a complete package of comfort and efficiency for commercial building owners and operators.

Steam-Turbine Drive Chillers

Maximize The Use Of Your Boiler

Like an engine-driven chiller, steam-turbine driven cooling equipment can also be used to drive a compressor, usually for large (700+ tons) cooling jobs. Steam-turbine drive cooling uses medium pressure steam (usually 100 to 200 psig) to turn a compressor in a traditional refrigerant vapor compression cycle.

For larger on-site power generation systems (Combined Heat and Power or CHP) greater than 1MW, use of steam produced by the prime mover's hot exhaust maximizes overall system efficiency. This steam is an ideal energy source for steam-turbine powered chillers. In addition, boilers sized for winter heating loads can be put to work efficiently year round when used to generate steam for summer cooling. When used where low-cost or waste steam is available, steam-turbine chillers have a significant advantage. Concerns about energy supplies, costs and emissions are eliminated because, if the CHP system or boiler is sized for winter heating requirements, it should be capable of providing adequate steam capacity to meet summer cooling needs.

Two basic types of steam-turbine drive chillers are available: back pressure and condensing. More traditional condensing designs offer the highest cooling efficiency, but back pressure styles provide a source of low-pressure steam which can be put to work for a process or heating use. Either design is less costly to operate than electric chillers.

Steam-turbine chillers are suitable for process cooling as well as comfort air conditioning. The chemical, pharmaceutical, paper and textile industries can benefit from the use of steam-turbine drive cooling as can many hotels, hospitals, and combined heat and power plants.

Steam-turbines use conventional refrigeration technology, so temperatures below 32^{o}F are achievable for process applications requiring a cooling fluid at low temperatures. Steam-turbine powered chillers offer the advantage of superior efficiency due to their variable speed operation.

Typical steam-driven chillers feature:

- **Modern, easy-to-use controls**
- **Variable speed operation**
- **Comparable in size to an electric chiller**
- **Automatic start up**
- **Capable of integrating easily with most building and process management systems**

Natural gas steam-driven cooling offers these advantages:

- **Uses existing boiler system – maximizes year round use of boiler system**
- **Maximizes overall efficiency for power generation**
- **Lower peak electric demand**
- **Requires minimal maintenance**
- **Quiet**

Desiccant Dehumidification –

Wrings Excess Moisture from Indoor Air

Desiccant dehumidification works with your cooling equipment to remove excess moisture from incoming ventilation air. Since dry air is easier to cool, the cooling equipment operates more efficiently, reducing wear and tear on the equipment and saving on energy costs. Also, since there is no need to overcool to reduce the effects of humidity, occupants feel more comfortable.

Desiccant dehumidification operates primarily on natural gas and uses only a small amount of electricity. So using a natural gas desiccant dehumidification system during the summer when the costs of electricity and peak demand charges are high further reduces overall energy costs.

As a team, desiccant dehumidification and your natural gas cooling equipment can save money on energy costs, eliminate the need for excess cooling capacity, reduce the negative effects on human health and equipment caused by excess moisture, and improve production processes. Desiccant dehumidification also addresses these unique humidity control challenges:

- **Supermarkets** eliminate frost build-up on frozen foods, freezer case coils and freezer case doors; reduce sweat on refrigerated cases; significantly reduce electricity usage
- **Offices and retail stores** eliminate sick building syndrome; lower relative humidity; and improve indoor air quality
- **Hotels/Motels** eliminate mold, mildew and musty odors
- **Industrial processes** eliminate problems in the manufacture of moisture-sensitive products
- **Ice rinks** improve ice quality, prevent rust and mildew, and prevent the formation of fog
- **Hospitals** provide flexible temperature and humidity controls for operating rooms and minimize bacterial growth
- **Restaurants** improve customer comfort and eliminate odors
- **Schools and theaters** counteract the effects of human respiration in densely populated facilities
- **Confectionary manufacturing** eliminate machinery clogs caused by the absorption of moisture in sugar
- **Eldercare facilities** set higher cooling temperatures for the comfort of older, sedentary residents while maintaining comfort of active employees
- **Pharmaceutical manufacturing** maintain high production levels and long shelf life in the lower humidity levels necessary for the production of pharmaceuticals
- **Refrigerated warehouses** keep loading docks dry, safe and operating at peak speeds by eliminating frozen water vapor on floors, walls and ceilings

Natural gas desiccant equipment controls humidity and makes your cooling system more economical to operate.

How a desiccant dehumidification system works

The process of desiccant dehumidification is relatively simple. The desiccant dehumidifies the air by absorbing or adsorbing (depending on the type of desiccant material used) excess moisture, then regenerates the desiccant so it can repeat the process. The desiccant can be either a liquid (undergoes a physical or chemical change as it absorbs moisture) or a solid (adsorbs by collecting moisture on its surface).

In a typical solid or dry desiccant system, the desiccant material is mounted on a rotating wheel. As the wheel turns, the desiccant passes alternately through the incoming air where the moisture is adsorbed and then through a regenerating zone where the desiccant is dried and the moisture expelled to a separate flow of outgoing air. During regeneration, the desiccant is heated by natural gas to drive off the moisture. The wheel continues to rotate and the adsorbent process is repeated.

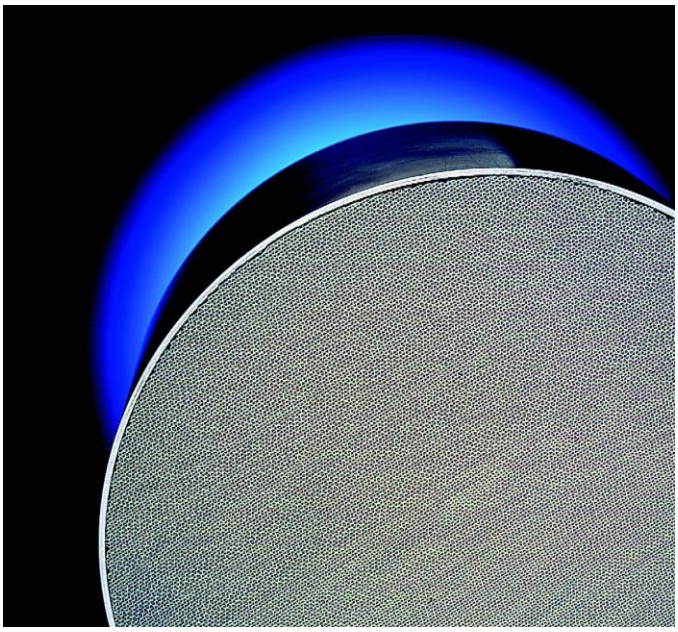
Like a dry desiccant system, a liquid desiccant system relies on the ability of certain materials to absorb moisture from air. In a liquid system, the moist incoming air passes over a high-surface area medium containing the liquid desiccant solution, usually lithium chloride. As the moisture absorbs into the desiccant liquid, the diluted lithium chloride solution flows to a heat exchanger where the heat from a gas-fired burner removes the moisture, re-concentrating the solution. The regenerated desiccant solution then flows back to the medium for re-use.

Typical desiccant dehumidification systems feature:

- **Makeup air heat recovery**
- **HEPA filtration**

Natural gas desiccant dehumidification offers these advantages:

- **Increases comfort of building occupants**
- **Reduces growth of disease-causing microbes**
- **Controls odors, mold and mildew**
- **Eliminates condensation**
- **Prevents damage to furnishings, carpeting, tiles, and other building materials**
- **Saves energy**
- **Reduces operating cost of electric chillers**
- **Reduces conventional cooling capacity**
- **Ensures more precise temperature and humidity control**



Humidification Adds Moisture

to Dry Air

Too little moisture in the indoor air can be just as harmful as too much. It can aggravate asthma and other allergy and respiratory-related illnesses and adversely effect high-tech medical equipment, computers, and other electronic equipment. In some industrial processes with a high risk of danger due to static electricity, low humidity can be dangerous.

Boilers dedicated to providing humidity are an expensive option for small facilities or those that would not otherwise need a boiler, and electric steam humidifiers are expensive to operate. Water treatment chemicals can be introduced to the space for both of these systems.

Natural gas humidifiers moisturize dry indoor air by heating water to create steam that is introduced into the incoming air stream and absorbed by the air just a few feet from the entry point. As a result, ducts stay dry, preventing water buildup that can cause odors and create an environment for the growth of bacteria. Unlike many boilers, natural gas humidifiers require no chemicals and they operate for a fraction of the cost of electric steam humidifiers.

Natural Gas Humidifiers – Moist steam without the disadvantages of a boiler

In a natural gas humidifier, the gas burners boil water to make steam, which is distributed throughout the area to be humidified via an air handling system or remote blower. They use regular tap or treated water and require only a single-phase 120-volt connection. The humidifiers are designed to minimize steam pressure build-up to no more than what is needed to deliver the steam. Additionally, they do not require the chemicals necessary for treatment of boiler water.

Typical natural gas humidifiers feature:

- **Single-phase 120-volt electric connection**
- **Low NOx burners with modulated input**
- **Chemical-free operation**
- **Controls compatible to most building management systems**
- **80% efficiency, or higher efficiency condensing models available**

Natural gas humidification offers these advantages:

- **Inhibit growth of disease-causing microbes**
- **Alleviate environmental antagonism of asthma and allergy-related illnesses**
- **Contribute to health and comfort of building occupants**
- **Reduce employee absenteeism and increase employee productivity**
- **Protect expensive equipment and furnishings**
- **Cost-effective alternative where no boiler exists**
- **Eliminate dangers of static electricity**
- **Allows HVAC system to operate at max efficiency**

Hybrid Cooling Systems Give You Virtually Total Energy Flexibility

With the uncertainties of energy prices, the high cost of electric demand charges, and the opportunities to negotiate more favorable electric rates due to electric deregulation, businesses with energy flexibility are in an ideal position to adapt quickly to changes in the marketplace and take advantage of the best energy buys. This is especially true for businesses that rely on cooling during the hot summer months when electric rates are higher and peak demand charges can often exceed electric consumption costs.

Hybrid systems offer the flexibility you need to optimize the economical operation of your cooling plant by combining two or more different types of equipment in a single plant.

For example, a hybrid system may incorporate both natural gas engine-driven and electric chillers working in tandem for optimal performance and savings. Such a plant would allow the gas chillers to handle the majority of the cooling load during periods when electric rates or demand charges are higher. If the electric rates and demand charges drop below the economics of natural Gas, the electric chillers can assume primary responsibility for cooling. Automated controls make it easy to optimize equipment operation for maximum energy and money savings. And, with natural gas as a backup, you're never without cooling during a power outage.

Another common hybrid configuration is a combination of technologies such as engine-driven chillers and absorption chillers. This combination allows you to operate your gas absorption chillers at almost no cost using waste heat from the engine-driven equipment.

Hybrid systems offer these advantages:

- **Lower overall cooling costs**
- **Fuel-choice flexibility during service interruptions**
- **Equipment first-cost offset by savings**
- **Strengthens electric rate negotiating position due to decreased load profile**
- **Improved redundancy**
- **Automated controls optimize plant efficiency**

Hybrid systems optimize the economical operation of your cooling plant.

Combined Heat and Power – Make the Most of Your Energy Dollars

The centralized production of power by electric utilities is an inherently inefficient process. On average, only about a third of the fuel used to generate electricity in a centralized power plant is converted into usable energy. The remainder is lost as wasted heat.

A combined heat and power (CHP) system overcomes this inefficiency by integrating power generating and heat recovery technologies into a single, highly efficient, and economical system. Located at or near your business, CHP can satisfy all or part of your electricity requirements, minimizing or eliminating the uncertainties of volatile electric rates, high peak demand charges or unreliable electric service.

More importantly, CHP captures the heat normally lost during the production of electricity and turns it into usable energy for cooling – using absorption for smaller systems (1 MW) or steam-turbine chillers for larger systems (>1 MW) – and other uses of thermal energy such as water heating, sterilization and space heating.

Combined heat and power systems are an efficient and economical alternative to purchasing electricity from the local power utility. They are especially suited to facilities with high thermal loads, consistent electric and thermal energy requirements, and round-the-clock operations.

Campus institutions, such as universities and hospitals, often benefit from aggregating energy needs in a district energy CHP system. Advances in reciprocating engines and small combustion turbines with sizes under 50 kW now make it feasible for small, single-building users to take advantage of CHP technology.

Additionally, because CHP uses natural gas, a clean and dependable source of energy, it is more environmentally friendly than electricity produced using coal or oil, and it is always there when you need it.

CHP systems offer these important advantages:

- **Lowers energy costs**
- **Reduces peak electric energy costs and demand charges**
- **Significantly reduces emissions of NOx, SOx and CO_2**
- **Reduces or eliminates dependence on electric utility**
- **Design options range from large district energy systems for multi-building complexes to 5 kW packaged systems for smaller buildings**

More information can be found at: www.understandingchp.com

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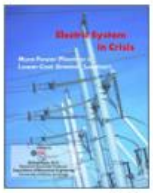
Natural gas cooling
A natural choice!

Over the last decade, manufacturers made significant advances in developing and producing a new generation of natural gas refrigeration, cooling, and humidity control equipment. As a result, today's natural gas cooling options can offer:

- **Lower operating costs**
- **Reduced demand charges**
- **Quick payback on equipment purchases**
- **Improved indoor air quality**
- **A plentiful, domestic energy source**
- **Innovative financing plans and rebates from manufacturers, local gas companies and government entities**
- **Improved reliability of the electric grid, especially during the high summer demand period**
- **A cleaner, healthier environment**



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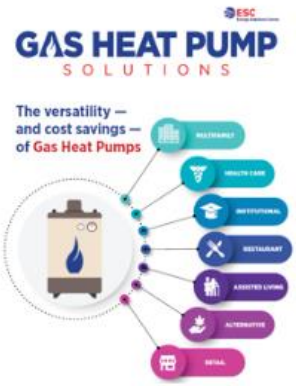

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