Alternative Heating and Cooling Systems

In this era of high energy costs, people are turning to alternative heating and cooling systems to reduce energy consumption without sacrificing comfort or other benefits.

Alternative heating methods and systems can take many forms. They include: Solid fuel burning appliances such as stoves, furnaces, and boilers, Waste oil heaters, Geothermal and water-source heat pumps, Solar heating systems, In-floor radiant heating systems, Direct-fired makeup units (DFMU)

Solid fuels such as wood and coal have been used for centuries to provide heat. Increased energy costs are forcing people to again look to these cheap and plentiful sources of energy.

Wood-burning stoves and fireplace inserts provide area heating or supplement a conventional heating system.

Wood stoves sold in the U.S. since 1998 must meet EPA smoke emission standards. If the stove is equipped with a catalytic element, smoke emissions cannot exceed 4.1 grams per hour.

Non-catalytic stoves cannot emit more than 7.5 grams of smoke per hour.

Only properly seasoned wood (preferably hardwoods) should be burned in wood-burning stoves.

Wood-burning furnaces can be used as the primary heat source in a structure, or used as a supplement to an existing forced-air furnace.

Furnaces used as supplementary heaters are basically wood-burning stoves with a sheet metal enclosure that allows air to circulate over the hot firebox. Often, they do not contain a circulating air blower.

The fan in the primary furnace moves air over the firebox of the supplementary heater. Modifications in the supply air plenum of the primary furnace are required to enable this operation.

Connecting a fan switch on the supplemental heater in parallel with the fan switch on the primary furnace allows either of the fan switches to automatically control the circulating fan.

A dual-fuel furnace is a gas or oil-fired furnace and a wood-burning furnace combined in one package.

Controls for a dual-fuel furnace provide automatic operation between the two fuels. For example, if the wood fire dies out and room temperature drops, the control will bring on the oil or gas burner.

Wood-burning boilers can be used as the primary heat source in a structure, or used as a supplement to an existing gas or oil-fired boiler.

Wood burning boilers are often installed in series with a gas or oil-fired boiler. As long as water temperature is maintained by the wood fire, the gas or oil-fired burner will not operate.

Connecting an aquastat on the supplemental boiler in parallel with the aquastat on the primary boiler allows either of the aquastats to automatically control the circulating pump.

Supplemental wood-burning boilers can be installed indoors next to an existing boiler. They can also be installed outdoors in a self-contained weatherproof structure complete with its own chimney.

A dual-fuel boiler, like a dual-fuel furnace, combines a wood-burning boiler and a gas or oil-fired boiler in one package.

Heating appliances that burn wood or other solid fuel have unique installation and maintenance requirements.

The clearance-to-combustibles requirements for wood burning appliances are more stringent than for gas or oil-fired appliances because they operate at higher temperatures. Distances tend to be much greater.

Wood stoves must maintain a 36” clearance from the top, sides, back, and front to any combustibles. The closest a stovepipe can be from combustibles is a distance equal to three times the diameter of the stovepipe.

Combustion air for a solid-fuel appliance can be provided by normal infiltration in a loosely constructed structure.

In tightly built structures, combustion air must be ducted in. As a rule of thumb, the combustion air duct should be at least equal in size to the chimney or vent of the appliance.

Solid-fuel appliances installed in confined spaces must be supplied with combustion air through combustion air and ventilation air grilles. The grilles are sized based on the input capacity of the appliance.

Corn and pellet stoves can be equipped with a direct vent that also serves as the combustion air source.

Wood and coal burning appliances must be vented either through a correctly sized, tile-lined masonry chimney or through a correctly sized all-fuel metal Type HT vent.

Special pellet venting pipe or Type PL vent is also available for venting corn and pellet stoves.

Follow the manufacturer’s instructions and comply with all national and local codes when installing wiring, piping, and ducts on solid-fuel appliances.

Store firewood outdoors, off the ground, and protected from weather. Coal is usually stored in bags, as is corn and wood pellets.

Wood-burning appliances create creosote that can accumulate on the inner surfaces of the stove, furnace, or chimney. Creosote must be removed periodically to reduce the chances of a chimney fire.

Clean the stove and chimney per the manufacturer's instructions. Special brushes may be required. Store all removed debris and ashes in a sealed metal container.

Waste oil heaters allow waste oil such as motor oil, transmission fluid, and cooking oil to be recycled as a heating fuel.

Waste oil burners are similar to conventional gun-type oil burners. They must be modified to burn the waste oil.

Waste oil burners must be capable of handling the varying quality and physical characteristics of the different types of waste oils available.

Waste oil burners are often equipped with built-in heaters that are used to heat the waste oil to a uniform viscosity.

Waste oil can contain hazardous materials. For that reason, the EPA has rules governing the burning of waste oils. Local codes also must be followed when burning waste oils.

The type of waste oil burned may affect how often the burner requires cleaning and/or maintenance.

The Earth and the water in wells, lakes and ponds offer a stable heat source from which homes and other structures can be heated.

Ground-source or geothermal heat pumps extract heat from the Earth. This is done using coils of tubing containing non-toxic fluid buried in the ground to absorb the heat.

The tubing is buried from four to six feet in the ground. The heated fluid is pumped through a refrigerant-to-water heat exchanger where the heat is absorbed by the refrigerant.

Heat in the refrigerant is transferred to the air in the structure through the indoor coil and air handler of the heat pump.

The stable ground temperature results in a steady heat output from the heat pump. Supplemental electric heaters are rarely needed in a properly sized system.

Water source heat pumps operate like geothermal heat pumps in that they extract heat from a temperature-stable well, lake, or pond.

Water-source heat pumps require a good quality water supply. Poor quality water can clog or corrode the heat exchanger and other components in the water side of the system.

Solar heating systems capture the free heat energy of the sun and use it to heat homes and other structures.

Simple passive solar heating systems require two major components; large, south-facing windows, and thermal mass to collect and store the heat.

In passive solar hydronic heating systems, convection currents move heated water from a roof-mounted solar collector to a storage tank inside the structure.

In a passive thermosyphon system, temperature differences between the water in the storage tank and collector cause the water to flow.

The advantage of passive solar heating systems is simplicity. Their disadvantages include overheating of the structure on sunny days, and the inability to provide heat on cloudy days.

Active solar heating systems are more complex than passive systems. They use pumps, valves, and other devices to control the flow of fluid through the collectors and the rest of the system.

Indirect solar heating systems use an anti-freeze solution as the circulating fluid. They are often piped in series with existing hydronic heating systems where they act as a pre-heater for the water.

Active solar hydronic heating systems provide better temperature control due to their use of complex control systems. However, like all solar heating systems, they provide little or no heat on cloudy days or at night.

In a radiant heating system, the object is heated, not the air surrounding the object.

With in-floor radiant heating systems, electric resistance heating elements or pipes containing hot water are imbedded in or installed below the floor.

Below-the-floor resistive heating elements can take the form of pre-engineered heating mats.

The mats must be installed strictly in accordance with the manufacturer's instructions and all applicable codes. In many locations, electricians are required to perform the installation.

Electric heaters are also available in the form of resistive wire that has a watts-per-foot value. Once the heat loss of a room is determined, a length of wire that satisfies the heat loss can be determined.

Resistive wire is laid out in a serpentine pattern on top of the floor. Once in place, it is covered with a thin layer of concrete, ceramic tiles, or wood laminate.

In-floor electric radiant heating systems offer excellent comfort. However, since it is electric heat, it can be expensive to operate.

In-floor hydronic radiant loops can be installed on or under the floor in a serpentine pattern similar to electric radiant heating systems. Cross-linked PEX plastic tubing is often used to carry the hot water.

Radiant hydronic heating systems offer superior comfort, energy efficiency, and quiet operation. However, this type of system can be expensive to install.

Contaminated indoor air in commercial and industrial applications must be mechanically exhausted from the structure. This exhausted air must be replaced.

A direct-fired makeup air unit replaces the exhausted air with contaminant-free heated and filtered outdoor air.

Direct-fired makeup air units are usually gas-fired but contain no heat exchanger or flue vent. Combustion takes place directly in the primary airstream, allowing products of combustion to enter the building.

The high volume of makeup air entering the building is sufficient to dilute the products of combustion to a level that does not present a hazard.

The makeup air unit is interlocked with the exhaust system so that if the exhaust system fails, the makeup air unit shuts down.

Burners in the makeup air unit must be designed so that the entering airstream does not disturb the combustion process, but does collect sufficient combustion air to support the flame.

Since all heat produced by the burners remains in the airstream, direct-fired units operate at or near 100% combustion efficiency.

Cooling coils can be incorporated into a makeup air unit when the makeup air must be cooled and/or dehumidified.

Alternative cooling methods and systems include: Ductless split-system air conditioning systems, Computer room air conditioning systems, Valance cooling systems, Chilled-beam cooling systems, Evaporative coolers.

It is often difficult to install a traditional ducted air conditioning system in some types of buildings. Room air conditioners or ductless split-system air conditioners are often used in these applications.

Ductless split systems are like conventional split-system air conditioners except the air handler is generally ductless. The air handlers can be mounted on the floor, high on a wall, or either on or in a ceiling.

Temperature control and control of other system functions is typically done with a hand-held remote control. Traditional room thermostats can also be used.

Ductless split systems are usually direct expansion (DX) systems. However some ductless spit systems supply chilled water to the air handlers.

Ductless split-system condensing units are designed as rectangular packages that resemble a standing suitcase.

Some ductless split-system condensing units contain the metering device. In that arrangement, the tube that normally carries liquid refrigerant to the air handler instead carries a low-temperature/low-pressure liquid/gas refrigerant mix.

Ductless split-system air handlers are available in a variety of types.

High-sidewall air handlers have a rectangular shape and are shallow in depth. They are typically attached to the wall on a mounting plate that also acts as a template for drilling installation holes in the wall for fasteners, wire, and refrigerant tubing.

Ceiling-mounted air handlers have many of the same characteristics as high-sidewall air handlers. They are often installed on the ceiling close to an outside wall to simplify condensate drainage. Other locations may require a condensate pump.

In-ceiling cassettes are mounted in drop ceilings. They can operate in a free-blow mode, but some models allow for limited attachment of ductwork. A condensate pump is almost always required.

Floor-mounted air handlers are typically installed along an outside wall for easy connection to the outdoor unit.

Some ductless split-system units allow for several air handlers in different zones to be connected to a single condensing unit.

To handle the varying capacity in multiple air handler installations, manufacturers use different capacity control schemes such as dual compressors, two-stage compressors, and variable-speed compressors.

Ductless split systems are installed and serviced similar to other split system products. Consult the manufacturer's installation and service instructions for any special requirements.

Air-cooled chillers can supply chilled water to single or multiple chilled water air handlers. In other respects, chilled water systems are similar to their direct-expansion counterparts.

Computers and other electronic equipment generate a lot of heat that must be removed to prevent equipment overheating. A variety of different equipment and methods are used to accomplish this.

Many computer rooms deliver cool, conditioned air from the space beneath a raised floor. The air moves up through perforated grates in the floor.

Air passes up through equipment cabinets where it picks up heat. The cabinets are arranged in a hot aisle/cold aisle configuration.

Cool air is available in the cold aisle, and heated air from the cabinets is dumped into the hot aisles. Return grilles in the ceiling return the air from the hot aisles to the air handler.

Freestanding air handlers are used to cool, dehumidify, and filter the air in equipment rooms.

Liquid chillers supply chilled water to air handlers used to cool individual rooms, cabinets, or racks.

Cooled equipment enclosures are self-contained cooled cabinets designed to house electronic equipment.

Spot coolers are portable packaged air conditioners, often on wheels, that can be moved to an area to provide temporary or supplemental localized cooling.

A valance cooling system is a ductless chilled-water cooling system that uses finned tube radiation installed around the perimeter of a room just below the ceiling. The tubing is enclosed beneath a decorative valance.

In addition to the finned tube radiation, each cooling unit has insulated chilled water supply and return lines, and a condensate pan beneath the finned tubing to capture and drain away condensate.

Warm room air rises to the cooled radiation. The air is cooled, gets heavier, and falls, setting up natural air currents in the room. No circulating fans are used with this system.

Valance cooling systems are very quiet and energy-efficient. However, like all hydronic systems, they are more expensive to install than forced-air systems.

Chilled-beam cooling systems have been used in Europe and Australia for several years. They are similar in some respects to valance cooling systems.

Units used to cool the room are long, finned tube radiators in an enclosure that resembles a beam, thus the name chilled beam. The two main types of chilled beam systems are active and passive.

Passive chilled beam systems use finned tube radiators located on the ceiling near outside walls. The radiators can be exposed or concealed beneath a suspended ceiling. Natural convection currents cool the room.

In passive systems, the chilled water supplied to the finned tubes must be slightly warmer than the dew point of the room air to prevent condensation from forming and dripping from the cooling units.

Active chilled beam systems use ducted, conditioned air to help induce airflow past the chilled beam units. Condensation is less likely to occur on the units in an active system.

Chilled-beam systems are quiet, energy efficient, offer excellent indoor air quality and are low maintenance.

Installation costs are high, partly because the technology is new to the U.S. and many contractors are unfamiliar with it.

Evaporative coolers, often called swamp coolers, are used in many parts of the U.S. for comfort cooling. They do not operate using the refrigeration cycle.

Evaporative coolers operate on the principle that when water evaporates, heat is absorbed.

An evaporative cooler consists of a louvered cabinet containing a blower assembly, water absorbing pads, a water pump, water distribution system, and a float valve to control water level in the sump of the unit.

In operation, hot, dry, outdoor air is drawn over wet pads. The heat evaporates the water, cooling the air. The cooled air is then distributed throughout the structure.

No return air system is required because the unit takes in outdoor air. Evaporative coolers are only effective if the outdoor air has very low relative humidity. That is why they are popular in the hot, dry climate of the southwestern U.S.

Evaporative coolers are sometimes installed in parallel with a conventional packaged air conditioner, sharing a common supply duct.

Air conditioner and evaporative cooler using a common supply air duct.

The cooler operates when humidity is low, and the air conditioner operates when humidity is high. Dampers allow them to share the supply duct.

Evaporative coolers are less costly to install and are cheaper to operate compared to an air conditioner. However, they do increase water consumption, require constant maintenance, and provide poor comfort in high humidity conditions.

Energy-saving systems and devices capture, use, or redistribute waste heat.

Heat pump water heaters can be used to heat domestic water or swimming pools. Heaters for domestic water use a double-walled refrigerant-to-water heat exchanger to heat the water.

Heat pump water heaters offer excellent energy savings and can be easily installed indoors or outdoors. Their major disadvantage is higher initial cost compared to a conventional electric water heater.

Waste heat water heaters capture the rejected heat from air conditioning or refrigeration systems to heat domestic water.

This system is popular in restaurants and food processing plants where lots of waste heat is available.

A refrigerant-to-water heat exchanger must be installed in the refrigeration system piping to capture the waste heat.

Evaporative pre-coolers are similar to other evaporative coolers. They are used to lower the head pressure and reduce energy consumption of air conditioners. They are commonly used in hot, dry desert climates.

The pre-cooler coil is positioned in front of the condenser coil. Air drawn through the pre-cooler by the condenser fan is cooled as water evaporates. The cooler air passing over the condenser coil lowers head pressure.

Evaporative pre-coolers, like other evaporative coolers, are less effective as the outdoor relative humidity increases.

Air stratification results in warm, light air gathering near the top of high-ceilinged rooms. At the same time, cooler and heavier air gathers near the floor. This situation can create discomfort in the room.

By preventing air stratification, better comfort and energy efficiency can be realized.

Paddle fans located near the ceiling are a simple way to increase air movement in the room and reduce stratification. They are commonly used in residences and small businesses.

In commercial and industrial applications with very high ceilings, paddle fans are ineffective. In these applications, air turnover units are used.

Air turnover units are tall vertical air handlers that often contain heating and cooling sections.

The fans within the unit circulate and mix the air from the different levels in the room. At the same time, the air can have heat added or removed if necessary. This results in less energy needed to condition the air.

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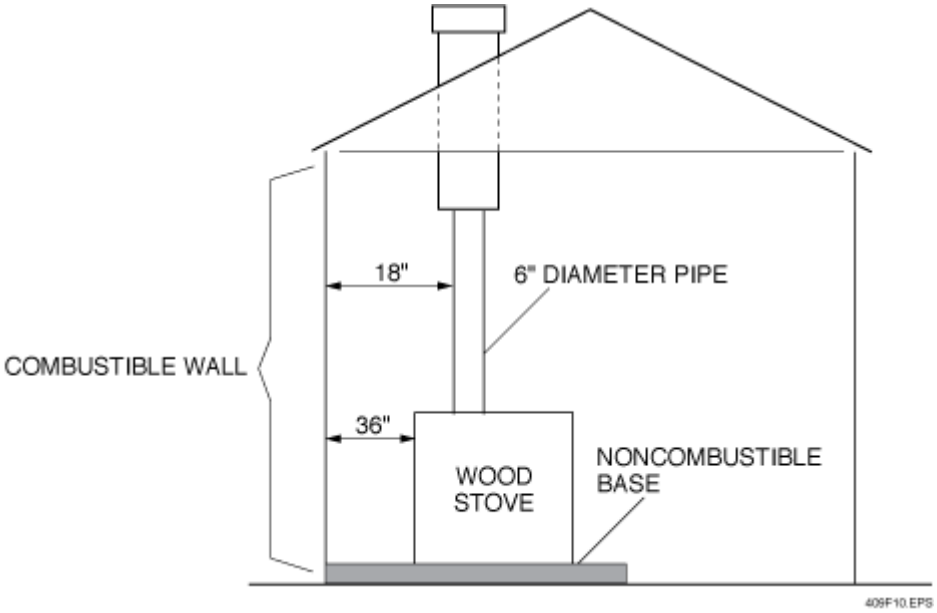
Wood stoves and fireplace inserts sold in the United States since 1988 must meet EPA smoke emission standards. If the stove is equipped with a catalytic element, smoke emissions cannot exceed 4.1 grams per hour. Non-catalytic stoves use a number of construction techniques such as internal baffles to enhance combustion and reduce smoke emissions. Non-catalytic stoves cannot emit more than 7.5 grams of smoke per hour. Stoves provide heat through radiation. Some stoves can be fitted with an optional circulating fan that moves air over the surface of the stove to pick up additional heat.



Wood-burning stoves, furnaces, and boilers must be vented, either through a correctly sized, tile-lined masonry chimney or through a correctly sized all-fuel Type HT metal vent (Figure 13). Type HT vents are rated to handle temperatures as high as 1000°F. When installing a Type HT vent, do not mix components

from a different manufacturer's Type HT vent. Mixing components may create an unsafe condition. The agency rating of the assembled vent is only valid if rated components from the same manufacturer are used. Never vent a wood-burning stove, furnace, or boiler through a chimney or vent serving a fireplace or other fuel-burning appliance such as a gas or oil furnace. When installing a Type HT vent, follow the manufacturer's installation instructions and all appropriate local and national codes. Corn and wood pellet stoves generally do not have flue temperatures that are as high as those of conventional wood stoves. For that reason, they can be directly vented through a sidewall using the vent kit supplied by the stove manufacturer. Special pellet venting pipe or Type PL vent, is also available for venting corn and pellet stoves. A corn or pellet stove may be vented through an existing vent or fireplace chimney as long as it is not being used to vent another appliance and does not violate local codes.

Wood-burning appliances should be cleaned and maintained in accordance with the manufacturer's instructions. Maintenance items include oiling motors, checking belts, and replacing filters. When wood burns, it can create creosote that can build up on the internal surfaces of the stove, furnace, and chimney. Creosote is combustible, and can ignite if left to accumulate. Once ignited, creosote can burn with the intensity of a blowtorch, permanently damaging the stove and/or vent and possibly causing a structure fire. For that reason, all wood-burning appliances must be inspected and cleaned when creosote buildup is noted. Since creosote buildup varies between installations, there is no hard and fast rule for inspection intervals. It is not uncommon to have to clean a wood stove and/or chimney every few weeks.

The quality and physical properties of waste oil can vary significantly. For example, used motor oil is significantly different from used french-fry oil. The fuel handling system and the burner itself must be capable of handling these variables. Filters are required to remove various contaminants in the waste oil. Waste oil burners often have a built-in heater that heats the waste oil to maintain a uniform viscosity. Compressed air, supplied by a built-in air compressor or by an outside source is required to help atomize the fuel. The atomized fuel is typically ignited by a high-voltage spark from the ignition transformer. An oil burner primary control using a cad cell flame detector provides a safety shutoff if a flame is not established. Installation and venting of waste oil heaters is similar to conventional oil-fired heaters. Always read the manufacturer's installation literature before proceeding.

Burning waste oil can provide significant cost savings but there are negative aspects as well. The Environmental Protection Agency (EPA) has rules that cover the burning of waste oil. For example, regulations govern the conditions under which waste oil containing certain types of contaminants can be burned. Local codes may regulate or restrict the burning of waste oil. Some waste oils will contain excessive contaminants and/or burn dirtier than other oils, resulting in decreased intervals between scheduled maintenance and more frequent equipment breakdowns. The negative aspects as well as the potential cost savings should be carefully weighed before installing a waste oil heater.

Ground-source or geothermal heat pumps extract heat from the ground. They use coils of tubing containing a non-toxic fluid buried in the ground to absorb the heat. The heated fluid is pumped indoors to a refrigerant-to-water heat exchanger where the heat is absorbed by the refrigerant. The heat is then moved to the coil in an air handler where it is rejected into the structure. In summer, when cooling is

required, the coil in the air handler acts as an evaporator and absorbs heat in the refrigerant. The refrigerant-to-water heat exchanger acts as a condenser, giving up heat to the fluid. The heated fluid is then pumped through the ground loop where it gives up the heat extracted from the structure to the ground. Geothermal heat pumps that heat water are also available. They can heat water for domestic use, for heating in a hydronic heating system, to heat swimming pools, and to melt snow from driveways. The most common geothermal installation method is to dig a series of four- to six-foot-deep trenches in which coils of tubing are buried. If the property is too small for this type of installation, a series of closely spaced deep holes can be drilled into which the tubing can be inserted.

The other water source method directly pumps water from a well, lake, or pond and circulates it through a refrigerant-to-water heat exchanger where the heat from the water is extracted. A disadvantage of this scheme is that if the quality of the water is poor, it can clog or corrode the refrigerant-to-water heat exchanger and any other components in the water side of the system.

The family cat is aware of passive solar heating. On winter days, cats can be found stretched out on the carpet in front of a south-facing window. The rays of the sun warm both the carpet and the cat. Passive solar heating systems both capture and store solar energy. Simple passive systems require two major components: large, south-facing windows, and thermal mass to collect and store the heat. In the United States, the sun is low in the southern sky during winter. Large south-facing windows allow the sun to enter the room where it is captured in a greenhouse effect and heats the thermal mass.

Traditional hydronic heating systems use radiators to supply heat to individual rooms. In-floor hydronic radiant loops can be installed in the floor in a manner similar to electric radiant heating systems. The radiant loop takes the place of a traditional radiator. Cross-linked polyethylene (PEX) plastic tubing is used in this type of system. Metal reflectors are often installed beneath the tubing to direct the radiant heat upward.

Each valance cooling unit consists of a section or sections of finned-tube radiation, similar to that used in baseboard hydronic heating systems. Each unit is equipped with an insulated chilled-water supply and return line. A zone valve may be installed in the supply line. Beneath the finned-tube section is a pan to catch the condensate and drain it away for disposal. The condensate pan is often a part of the decorative valance. In operation, chilled water flows through the coil on a call-for-cooling from the low-voltage room thermostat. The signal energizes the circulator pump and the zone valve, if so equipped. As the radiation cools, it cools the air surrounding the radiation, causing the air to fall. This sets up natural air currents in the room allowing warm air to rise to the ceiling where it cools, then falls, repeating the cycle. No circulating fans are used in the system. A separate system is normally used to provide ventilation and air filtration.

In passive systems, the chilled water supplied to the finned elements has to be slightly warmer than the dew point of the room air to prevent condensation from forming and dripping from the cooling units on the ceiling.

Chilled-beam systems are noted for their energy efficiency. They also offer quiet operation, excellent indoor air quality, and low maintenance due to their small number of moving parts. Disadvantages

include high installation costs compared to more conventional systems. Because this technology is new to the United States, many HVAC contractors may be unfamiliar with it. Those that are familiar with the technology charge a premium for their expertise.

An evaporative cooler consists of a louvered cabinet containing a blower assembly, water-absorbing pads, a water pump and water distribution system, and a float valve to control water level in the sump of the unit. In operation, the pump distributes water to the pad or pads to wet them. The blower assembly draws hot, outdoor air across the wet pads. The water on the pads absorbs heat from the air as the water evaporates. This cools and adds moisture to the air.

Heat pump water heaters – Can be used to heat domestic water or swimming pools. Waste heat water heaters– Capture the rejected heat from air conditioning or refrigeration systems to heat domestic water. Evaporative pre-coolers– Used to lower the head pressure and reduce energy consumption of air conditioners. Air turnover systems – Redistribute stratified air within a space, balancing the room temperature and saving energy.

A heat pump electric water heater (Figure 46) uses a refrigerant-to-water heat exchanger to heat the water. The heat pump unit is positioned atop a conventional electric water heater tank. It contains a small compressor, evaporator coil, a small evaporator fan, and other components. In operation, the compressor runs and supplies metered refrigerant to the evaporator coil. The evaporator fan draws ambient air across the coil, where it absorbs heat. Refrigerant is returned to the compressor where it is compressed and then sent to the condenser coil. This coil is a refrigerant-to-water heat exchanger immersed in the water storage tank. The heat that was absorbed in the evaporator is rejected to the water, causing it to be heated.

When a compressor has to work harder, it consumes more energy. High head pressure caused by a high ambient temperature increases the load on the compressor and can make it work harder. If the compressor can be made to work less under the same ambient conditions, power consumption will drop. In hot, dry desert areas, evaporative pre-coolers can be used to cool the air before it enters the condenser coil. Cooler air entering the condenser causes head pressure to drop. This in turn causes the compressor to consume less power.