

Air Quality



- **Mapping Duct Layouts for Cleaner Airflow in Mobile Homes**
Mapping Duct Layouts for Cleaner Airflow in Mobile Homes Inspecting Vent Connections for Improved Air Quality Minimizing Drafts Through Sealed Mobile Home Duct Systems Scheduling Regular Cleanings for Mobile Home Ventilation Evaluating Filter Efficiency for Enhanced Mobile Home Air Quality Addressing Mold Risks in Mobile Home Ductwork Installing Air Purification Systems in Mobile Homes Checking Air Pressure to Reduce Allergens in Mobile Home Interiors Identifying Common Leaks in Flexible Mobile Home Ducts Balancing Humidity Levels for Healthier Mobile Home Air Considering UV Technology for Mobile Home Air Treatment Using Diagnostic Tools to Assess Air Quality in Mobile Homes
- **Preparing Mobile Home HVAC Units for Intense Summer Heat**
Preparing Mobile Home HVAC Units for Intense Summer Heat Protecting Mobile Home Furnaces During Low Temperature Periods Coping with Storm Related Damage to Mobile Home Air Conditioners Adjusting Climate Control in Mobile Homes for Coastal Humidity Handling Power Outages in Mobile Home Heating Systems Planning Winterization Steps for Mobile Home HVAC Equipment Adapting Mobile Homes to Rapid Seasonal Swings in Temperature Evaluating Wind Exposure Factors for Mobile Home AC Placement Addressing Extended Rainy Periods in Mobile Home Ventilation Considering Local Building Codes for Mobile Home Climate Adaptations Balancing Heat Needs in Mobile Homes Across Different Regions Checking Insurance Coverage for Storm Damaged Mobile Home AC Units

- **About Us**



One major challenge in maintaining mobile home furnaces in cold weather is insulation. Mobile homes typically have less insulation compared to traditional houses, making it easier for heat to escape and cold air to seep in. Mobile homes benefit from zoned HVAC systems for personalized comfort **hvac unit for mobile home** technician. This can cause the furnace to work overtime, leading to increased energy consumption and potential wear and tear on the system. To combat this, residents should consider adding additional insulation or using thermal curtains and window films to minimize heat loss.

Another issue is the limited space within mobile homes, which can cause difficulty in accessing the furnace for routine maintenance. Regular inspections are essential to

ensure all components are functioning correctly and efficiently. It's important to check the filters regularly as they can become clogged with dust and debris more quickly when the furnace is running constantly during colder months. A clean filter not only improves airflow but also enhances overall furnace efficiency.

Cold weather also increases the risk of frozen pipes in mobile homes, which could lead to severe damage if not addressed promptly. The furnace plays a key role in maintaining a consistent temperature that prevents pipes from freezing. Homeowners should ensure their heating systems are sufficiently robust to maintain warmth throughout extremely cold nights by checking thermostats and ensuring there are no leaks or drafts near doors and windows.

Moreover, power outages pose another threat during winter storms, potentially leaving a mobile home without heat for extended periods. Having a backup plan such as portable heaters or generators can help mitigate this risk and keep essential systems running until power is restored.

In conclusion, protecting mobile home furnaces during low-temperature periods involves addressing several critical challenges like insulation deficiencies, accessibility issues for maintenance, risks of frozen pipes, and preparedness for power outages. By taking preventive measures such as enhancing insulation, performing regular maintenance checks, safeguarding against frozen pipes, and preparing contingency plans for power failures, residents can ensure their heating systems remain operational throughout winter's chill. These steps not only protect the integrity of the furnace but also secure a warm and safe environment inside mobile homes during harsh weather conditions.

The significance of regular maintenance and inspection for mobile home furnaces, especially during low-temperature periods, cannot be overstated. Mobile homes, known for their compact design and efficient use of space, often rely on their heating systems to

provide warmth and comfort during the colder months. However, these systems require careful attention to ensure they function efficiently and safely.

Firstly, regular maintenance helps in identifying potential issues before they escalate into significant problems. Just like any other mechanical system, mobile home furnaces are susceptible to wear and tear over time. Components such as filters can become clogged with dust and debris, reducing airflow and forcing the system to work harder than necessary. This not only decreases efficiency but also increases the risk of breakdowns at critical times when you need heat the most. By scheduling routine check-ups, homeowners can replace or clean these components regularly, ensuring optimal performance.

Moreover, inspection can prevent hazardous situations that could arise from malfunctioning furnaces. A neglected furnace might develop cracks in its heat exchanger or experience gas leaks, both of which pose serious safety risks including carbon monoxide poisoning—a silent threat due to its colorless and odorless nature. Trained technicians conducting inspections are adept at spotting such dangers early on. They have the expertise required to make necessary repairs or adjustments that keep your furnace operating safely.

Another compelling reason for regular maintenance is energy efficiency. A well-maintained furnace uses less energy to produce the same amount of heat compared to one that is neglected. This not only translates into lower utility bills but also reduces the environmental footprint of your home by conserving energy resources.

Furthermore, extending the lifespan of your furnace through consistent care is economically wise. Replacing a furnace represents a significant investment that many would prefer to delay as long as possible. Regular servicing ensures that all parts are functioning as intended, thereby prolonging the life of the unit.

Finally, there is peace of mind in knowing that your heating system will reliably perform throughout winter's chill without unexpected interruptions or costly emergency repairs. This assurance stems from understanding that every effort has been made to keep your heating equipment in top shape.

In conclusion, protecting mobile home furnaces during low-temperature periods hinges heavily on regular maintenance and inspection practices. These proactive measures are essential not only for maintaining comfortable living conditions but also for ensuring safety and cost-effectiveness over time. Homeowners who prioritize these actions can face winter with confidence knowing their homes remain warm havens against the cold outside world.

Posted by on

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Techniques for Mapping Duct Layouts

As winter approaches, the challenge of maintaining warmth in mobile homes becomes increasingly significant. Mobile homes, with their unique structures and materials, often struggle to retain heat efficiently during low temperature periods. One crucial aspect of ensuring comfort and reducing energy consumption is enhancing furnace efficiency through effective insulation techniques.

Insulation acts as a barrier that minimizes heat exchange between the inside of a home and the cold outdoors. For mobile homes, which typically have less robust construction compared to traditional houses, optimizing insulation is vital. A well-insulated furnace can significantly reduce energy usage while keeping indoor temperatures comfortable.

The first step in insulating a mobile home furnace is to focus on ductwork. Leaky or poorly insulated ducts can lead to substantial heat loss before the warm air even reaches the living areas. Sealing joints and connections with mastic sealant or metal-backed tape ensures that air flows directly where it's needed without escaping into unheated spaces like crawlspaces or attics. Additionally, wrapping ducts in foil-faced fiberglass insulation further prevents heat loss.

Another critical area is the furnace cabinet itself. Installing an insulating blanket around the furnace can help maintain its internal temperature, allowing it to operate more

efficiently by reducing standby losses when the unit isn't actively heating. These blankets are designed to withstand high temperatures while providing a thermal barrier between the furnace and colder surrounding air.

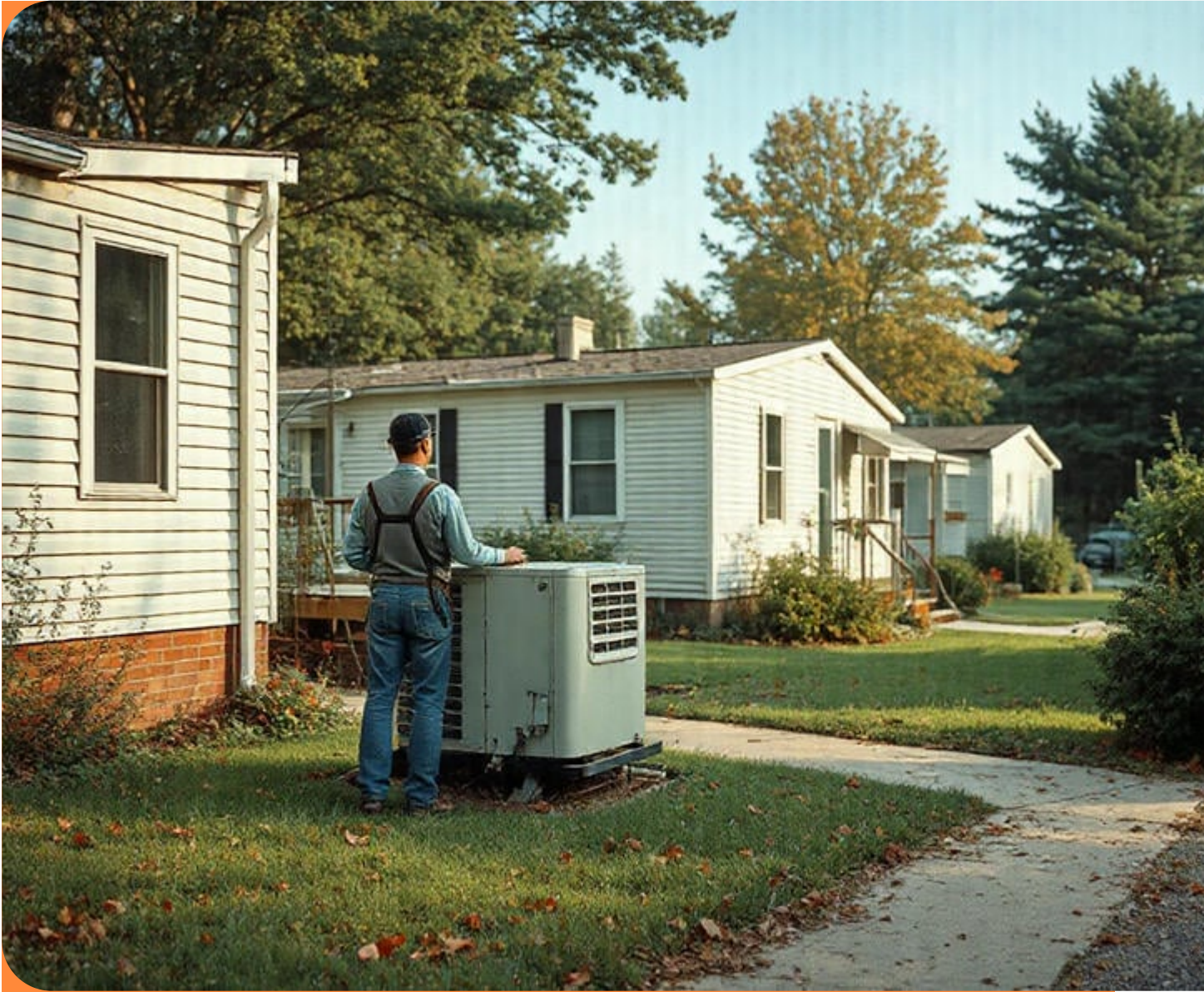
Furthermore, attention should be given to exterior walls and skirting around the mobile home. Adding rigid foam boards or spray foam insulation can enhance overall thermal resistance, thus reducing the burden on the furnace during frigid weather conditions. Skirting not only improves aesthetic appeal but also acts as a protective layer against drafts sweeping under the home.

Weatherstripping doors and windows is another simple yet effective technique for minimizing heat loss. By sealing gaps that allow cold air infiltration, homeowners can ensure that their furnaces work less strenuously to maintain desired indoor temperatures.

Beyond physical insulation measures, regular maintenance of mobile home furnaces plays an essential role in efficiency enhancement. Cleaning filters regularly ensures unobstructed airflow and optimal performance. Scheduling routine inspections by professionals helps identify potential issues early on before they escalate into costly repairs or inefficiencies.

In conclusion, protecting mobile home furnaces during low temperature periods requires a multifaceted approach centered around effective insulation techniques. From sealing ductwork and insulating cabinets to fortifying walls and skirting against drafts—each step contributes significantly toward enhancing furnace efficiency while ensuring cozy interiors throughout harsh winters without excessive energy expenditure. Embracing these strategies not only promotes comfort but also supports sustainable living practices by conserving valuable resources for future generations.





Tools and Technologies for Accurate Duct Mapping

Proper ventilation is a critical aspect of maintaining the efficiency and longevity of mobile home furnaces, especially during low temperature periods. As temperatures plummet, the demand on heating systems increases dramatically, often pushing them to their limits. Without proper ventilation practices, these furnaces can become overloaded, leading to potential malfunctions or even complete system failures. Understanding how to effectively ventilate your mobile home furnace can not only prevent such overloads but also ensure a warm and safe environment throughout the cold months.

The first step in protecting your mobile home furnace is ensuring that there is adequate airflow around the unit. Furnaces require a certain amount of space for air circulation to function optimally. Restricted airflow can cause the system to overheat as it struggles to draw enough air for combustion and heat exchange processes. Regularly check that vents and ducts are unobstructed by furniture, debris, or other household items.

In addition to keeping vents clear, it's essential to maintain clean air filters. Dirty or clogged filters impede airflow and force the furnace to work harder than necessary. This additional strain can lead to overheating and potential system failure. During winter months when usage is high, consider checking and replacing filters more frequently—typically every one to three months—to ensure proper airflow.

Another crucial factor in maintaining proper ventilation is inspecting the exhaust venting systems regularly. Exhaust gases must be expelled efficiently from your mobile home to avoid dangerous buildups of carbon monoxide or other hazardous gases inside living spaces. Ensure that all flue pipes are secure and free from blockages like nests or ice buildup.

Equally important is ensuring that intake vents are unobstructed so that fresh air can enter the system freely. Mobile homes often rely on external air sources for combustion processes in their furnaces; therefore blocked intake vents can disrupt this balance,

causing inefficient operation or triggering safety shutdowns due to improper combustion conditions.

Furthermore, consider incorporating additional ventilation aids such as attic fans or vent hoods if your setup allows for them. These can help regulate temperatures within your mobile home more evenly by drawing excess heat away from areas prone to overheating due to stagnant warm air pockets.

Finally, regular maintenance performed by a qualified technician plays an indispensable role in preventing system overload through proper ventilation practices. A professional inspection will typically involve cleaning components like burners and blowers while checking connections for leaks or damages which might affect airflow dynamics adversely.

In conclusion, implementing proper ventilation practices is essential not only for preventing system overload but also enhancing overall furnace efficiency during low temperature periods within mobile homes. By ensuring sufficient space around units for circulation, maintaining clean filters along with clear intake/exhaust pathways—and supplementing with periodic professional maintenance—you'll safeguard both your heating equipment's functionality as well as occupants' safety throughout those chilly winter months ahead.

Best Practices for Cleaner Airflow

Extreme temperatures, particularly during the winter months, pose significant challenges for those living in mobile homes. These structures are often more vulnerable to the elements due to their construction and insulation standards. Consequently, protecting mobile home furnaces becomes a critical task to ensure both safety and comfort during low temperature periods.

First and foremost, regular maintenance of your furnace is essential. Before the onset of winter, it's advisable to have a professional inspect and service your heating system. This includes cleaning or replacing filters, checking thermostats, and inspecting the unit's overall condition. A well-maintained furnace operates more efficiently and is less likely to break down when you need it most.

Insulating your mobile home effectively can also make a significant difference. Due to the thin walls typical of many mobile homes, heat loss can be substantial. Adding extra insulation can help retain warmth inside your home. Focus on sealing windows, doors, and any other potential drafts with weather stripping or caulk. Additionally, insulating underneath your mobile home can prevent cold air from penetrating through the floor.

Another tip for ensuring furnace efficiency is to invest in a programmable thermostat. This allows you to set specific temperatures for different times of the day or night, optimizing energy use while ensuring comfort when you're at home or asleep. During extremely cold spells, keeping the temperature slightly higher than usual might be prudent as a preventive measure against freezing pipes.

In extreme temperatures, it's also wise to have alternative heat sources ready as part of your emergency preparedness plan. Space heaters or electric blankets can provide temporary relief if your primary heating system fails. However, always prioritize safety by following manufacturer guidelines and maintaining adequate ventilation.

Finally, keep an emergency kit stocked with essentials such as blankets, non-perishable food items, water supplies, flashlights with extra batteries, and first-aid supplies. If there's a power outage or if you must remain indoors due to severe weather conditions outside, these items will help sustain you until normalcy resumes.

In conclusion, preparing for extreme cold in a mobile home setting requires meticulous attention to furnace maintenance and broader household insulation strategies. By taking proactive steps now—ensuring proper upkeep of heating systems and bolstering insulation—you'll not only protect your furnace but also enhance overall resilience against harsh winter conditions while safeguarding family welfare throughout these testing times.



Case Studies of Improved Air Quality in Mobile Homes

As winter chills descend upon us, the importance of maintaining a warm and comfortable home becomes paramount, especially for those residing in mobile homes. Mobile homes, due to their construction and design, often face unique challenges during low temperature periods. One critical component that requires vigilant attention is the furnace, vital for ensuring consistent warmth throughout these colder months. This is where smart thermostats play an indispensable role in monitoring and controlling mobile home furnaces.

Smart thermostats have revolutionized the way we manage our home heating systems. Unlike traditional thermostats, which require manual adjustment and offer limited functionality, smart thermostats provide a wealth of features designed to optimize comfort while enhancing energy efficiency. For mobile homes, this technological advancement translates into improved protection for furnaces during severe cold spells.

The primary advantage of smart thermostats lies in their ability to learn and adapt to a household's heating patterns. By analyzing daily routines and preferences over time, these devices can automatically adjust settings to maintain an ideal indoor climate without excessive strain on the furnace. This adaptability is crucial for mobile homes where insulation may not be as robust as that found in traditional houses. By preventing

unnecessary fluctuations in temperature, smart thermostats help reduce wear and tear on furnaces, thereby extending their operational lifespan.

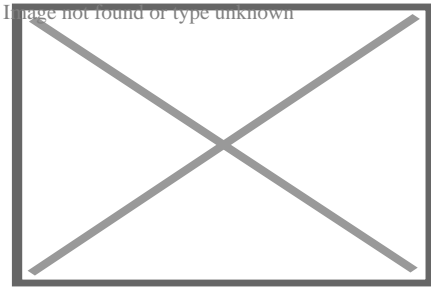
Moreover, remote accessibility features offered by smart thermostats empower homeowners with unprecedented control over their heating systems. Through smartphone apps or web interfaces, users can monitor real-time data about their home's temperature from anywhere in the world. If a sudden drop in outdoor temperatures occurs while one is away from home – perhaps during an unexpected cold front – adjustments can be made remotely to ensure the furnace maintains adequate warmth within the home environment.

Another significant benefit of utilizing smart thermostat technology is its capacity for energy conservation. These devices are equipped with sensors that detect when rooms are occupied or vacant; thus they can regulate heating accordingly by reducing output when no one is present saving both energy consumption costs as well as lessening environmental impacts associated with fossil fuel usage typical among older furnace models common within many mobile homes.

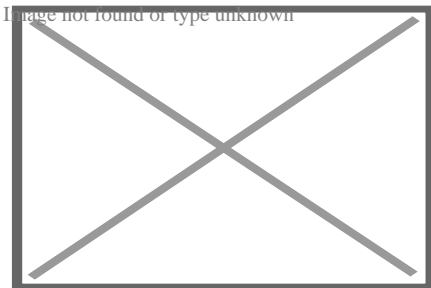
Furthermore, integrating these intelligent devices into broader smart home ecosystems allows them even greater functionality via interconnections like weather forecasts integration: predicting upcoming frigid conditions enables proactive management strategies such as pre-heating spaces before significant drops occur outside safeguarding against potential damage caused by freezing temperatures impacting internal plumbing systems commonly vulnerable within this type housing structure too!

In conclusion: Smart thermostats represent an essential tool not only optimizing comfort but also playing pivotal roles protecting mobile home furnaces amid low-temperature periods through adaptive learning capabilities remote access features efficient resource utilization predictive analytics interconnectedness other components ecosystem overall enhancing resilience sustainability modern living environments facing increasingly

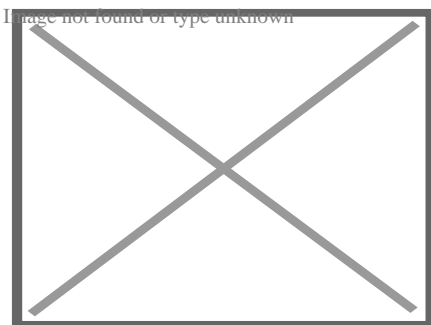
About Heating, ventilation, and air conditioning



Rooftop HVAC unit with view of fresh-air intake vent



Ventilation duct with outlet diffuser vent. These are installed throughout a building to move air in or out of rooms. In the middle is a damper to open and close the vent to allow more or less air to enter the space.



The control circuit in a household HVAC installation. The wires connecting to the blue terminal block on the upper-right of the board lead to the thermostat. The fan enclosure is directly behind the board, and the filters can be seen at the top. The safety interlock switch is at the bottom left. In the lower middle is the capacitor.

Heating, ventilation, and air conditioning (HVAC) is the use of various technologies to control the temperature, humidity, and purity of the air in an enclosed space. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a subdiscipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. "Refrigeration" is sometimes added to the field's abbreviation as **HVAC&R** or **HVACR**, or "ventilation" is dropped, as in **HACR** (as in the designation of HACR-rated circuit breakers).

HVAC is an important part of residential structures such as single family homes, apartment buildings, hotels, and senior living facilities; medium to large industrial and office buildings such as skyscrapers and hospitals; vehicles such as cars, trains, airplanes, ships and submarines; and in marine environments, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

Ventilating or ventilation (the "V" in HVAC) is the process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, carbon dioxide, and other gases. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air. Methods for ventilating a building are divided into *mechanical/forced* and *natural* types.^[1]

Overview

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The three major functions of heating, ventilation, and air conditioning are interrelated, especially with the need to provide thermal comfort and acceptable indoor air quality within reasonable installation, operation, and maintenance costs. HVAC systems can be used in both domestic and commercial environments. HVAC systems can provide ventilation, and maintain pressure relationships between spaces. The means of air delivery and removal from spaces is known as room air distribution.^[2]

Individual systems

[edit]

See also: HVAC control system

In modern buildings, the design, installation, and control systems of these functions are integrated into one or more HVAC systems. For very small buildings, contractors normally estimate the capacity and type of system needed and then design the system, selecting the appropriate refrigerant and various components needed. For larger buildings, building service designers, mechanical engineers, or building services engineers analyze, design, and specify the HVAC systems. Specialty mechanical contractors and suppliers then fabricate, install and commission the systems. Building permits and code-compliance inspections of the installations are normally required for all sizes of buildings

District networks

[edit]

Although HVAC is executed in individual buildings or other enclosed spaces (like NORAD's underground headquarters), the equipment involved is in some cases an extension of a larger district heating (DH) or district cooling (DC) network, or a combined DHC network. In such cases, the operating and maintenance aspects are simplified and metering becomes necessary to bill for the energy that is consumed, and in some cases energy that is returned to the larger system. For example, at a given time one building may be utilizing chilled water for air conditioning and the warm water it returns may be used in another building for heating, or for the overall heating-portion of the DHC network (likely with energy added to boost the temperature).^[3]^[4]^[5]

Basing HVAC on a larger network helps provide an economy of scale that is often not possible for individual buildings, for utilizing renewable energy sources such as solar heat,^[6]^[7]^[8] winter's cold,^[9]^[10] the cooling potential in some places of lakes or seawater for free cooling, and the enabling function of seasonal thermal energy

storage. By utilizing natural sources that can be used for HVAC systems it can make a huge difference for the environment and help expand the knowledge of using different methods.

History

[edit]

See also: Air conditioning § History

HVAC is based on inventions and discoveries made by Nikolay Lvov, Michael Faraday, Rolla C. Carpenter, Willis Carrier, Edwin Ruud, Reuben Trane, James Joule, William Rankine, Sadi Carnot, Alice Parker and many others.^[11]

Multiple inventions within this time frame preceded the beginnings of the first comfort air conditioning system, which was designed in 1902 by Alfred Wolff (Cooper, 2003) for the New York Stock Exchange, while Willis Carrier equipped the Sacketts–Wilhems Printing Company with the process AC unit the same year. Coyne College was the first school to offer HVAC training in 1899.^[12] The first residential AC was installed by 1914, and by the 1950s there was "widespread adoption of residential AC".^[13]

The invention of the components of HVAC systems went hand-in-hand with the Industrial Revolution, and new methods of modernization, higher efficiency, and system control are constantly being introduced by companies and inventors worldwide.

Heating

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"Heater" redirects here. For other uses, see Heater (disambiguation).

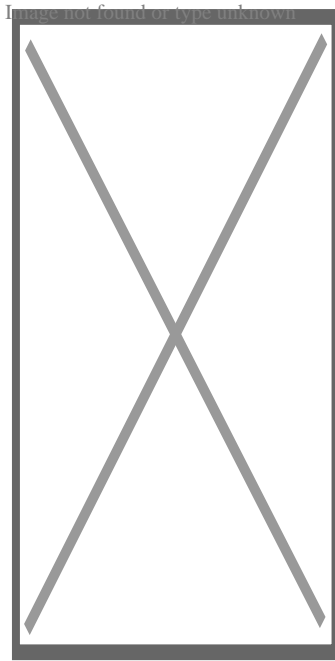
Main article: Central heating

Heaters are appliances whose purpose is to generate heat (i.e. warmth) for the building. This can be done via central heating. Such a system contains a boiler, furnace, or heat pump to heat water, steam, or air in a central location such as a

furnace room in a home, or a mechanical room in a large building. The heat can be transferred by convection, conduction, or radiation. Space heaters are used to heat single rooms and only consist of a single unit.

Generation

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Central heating unit

Heaters exist for various types of fuel, including solid fuels, liquids, and gases. Another type of heat source is electricity, normally heating ribbons composed of high resistance wire (see Nichrome). This principle is also used for baseboard heaters and portable heaters. Electrical heaters are often used as backup or supplemental heat for heat pump systems.

The heat pump gained popularity in the 1950s in Japan and the United States.^[14] Heat pumps can extract heat from various sources, such as environmental air, exhaust air from a building, or from the ground. Heat pumps transfer heat from outside the structure into the air inside. Initially, heat pump HVAC systems were only used in moderate climates, but with improvements in low temperature operation and reduced loads due to more efficient homes, they are increasing in popularity in

cooler climates. They can also operate in reverse to cool an interior.

Distribution

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Water/steam

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In the case of heated water or steam, piping is used to transport the heat to the rooms. Most modern hot water boiler heating systems have a circulator, which is a pump, to move hot water through the distribution system (as opposed to older gravity-fed systems). The heat can be transferred to the surrounding air using radiators, hot water coils (hydro-air), or other heat exchangers. The radiators may be mounted on walls or installed within the floor to produce floor heat.

The use of water as the heat transfer medium is known as hydronics. The heated water can also supply an auxiliary heat exchanger to supply hot water for bathing and washing.

Air

[edit]

Main articles: Room air distribution and Underfloor air distribution

Warm air systems distribute the heated air through ductwork systems of supply and return air through metal or fiberglass ducts. Many systems use the same ducts to distribute air cooled by an evaporator coil for air conditioning. The air supply is normally filtered through air filters^[*dubious* – *discuss*] to remove dust and pollen particles.^[15]

Dangers

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The use of furnaces, space heaters, and boilers as a method of indoor heating could result in incomplete combustion and the emission of carbon monoxide, nitrogen oxides, formaldehyde, volatile organic compounds, and other combustion byproducts. Incomplete combustion occurs when there is insufficient oxygen; the inputs are fuels containing various contaminants and the outputs are harmful byproducts, most dangerously carbon monoxide, which is a tasteless and odorless gas with serious adverse health effects.^[16]

Without proper ventilation, carbon monoxide can be lethal at concentrations of 1000 ppm (0.1%). However, at several hundred ppm, carbon monoxide exposure induces headaches, fatigue, nausea, and vomiting. Carbon monoxide binds with hemoglobin in the blood, forming carboxyhemoglobin, reducing the blood's ability to transport oxygen. The primary health concerns associated with carbon monoxide exposure are its cardiovascular and neurobehavioral effects. Carbon monoxide can cause atherosclerosis (the hardening of arteries) and can also trigger heart attacks. Neurologically, carbon monoxide exposure reduces hand to eye coordination, vigilance, and continuous performance. It can also affect time discrimination.^[17]

Ventilation

[edit]

Main article: Ventilation (architecture)

See also: Duct (flow)

Ventilation is the process of changing or replacing air in any space to control the temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide, and to replenish oxygen. It plays a critical role in maintaining a healthy indoor environment by preventing the buildup of harmful pollutants and ensuring the circulation of fresh air. Different methods, such as natural ventilation through windows and mechanical ventilation systems, can be used depending on the building design and air quality needs. Ventilation often refers to the intentional delivery of the outside air to the building indoor space. It is one of the

most important factors for maintaining acceptable indoor air quality in buildings.

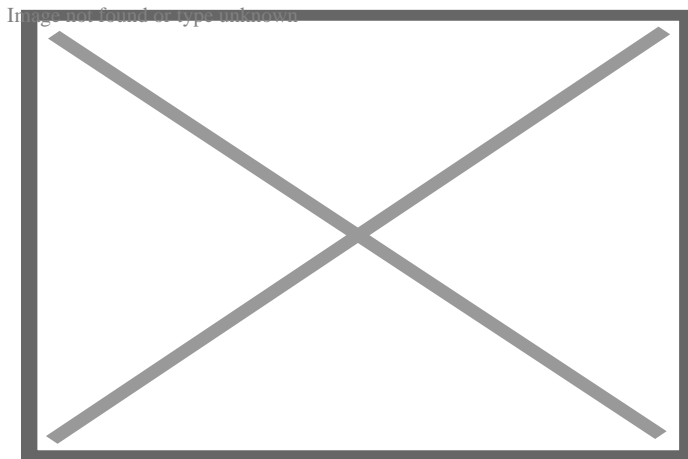
Although ventilation is an integral component of maintaining good indoor air quality, it may not be satisfactory alone.^[18] A clear understanding of both indoor and outdoor air quality parameters is needed to improve the performance of ventilation in terms of ...^[19] In scenarios where outdoor pollution would deteriorate indoor air quality, other treatment devices such as filtration may also be necessary.^[20]

Methods for ventilating a building may be divided into *mechanical/forced* and *natural* types.^[21]

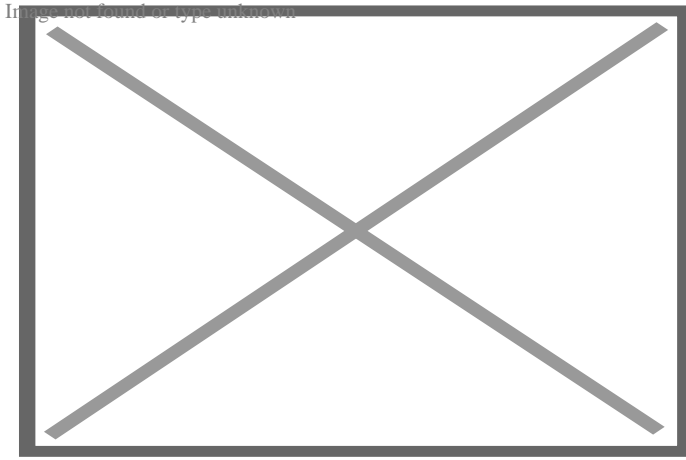
Mechanical or forced

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Further information: Ventilation (architecture) § Mechanical systems



HVAC ventilation exhaust for a 12-story building



An axial belt-drive exhaust fan serving an underground car park. This exhaust fan's operation is interlocked with the concentration of contaminants emitted by internal combustion engines.

Mechanical, or forced, ventilation is provided by an air handler (AHU) and used to control indoor air quality. Excess humidity, odors, and contaminants can often be controlled via dilution or replacement with outside air. However, in humid climates more energy is required to remove excess moisture from ventilation air.

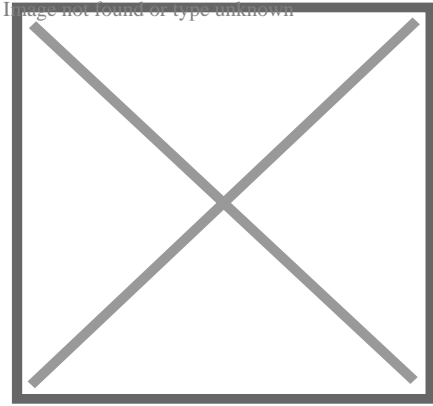
Kitchens and bathrooms typically have mechanical exhausts to control odors and sometimes humidity. Factors in the design of such systems include the flow rate (which is a function of the fan speed and exhaust vent size) and noise level. Direct drive fans are available for many applications and can reduce maintenance needs.

In summer, ceiling fans and table/floor fans circulate air within a room for the purpose of reducing the perceived temperature by increasing evaporation of perspiration on the skin of the occupants. Because hot air rises, ceiling fans may be used to keep a room warmer in the winter by circulating the warm stratified air from the ceiling to the floor.

Passive

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Main article: Passive ventilation



Ventilation on the downdraught system, by impulsion, or the 'plenum' principle, applied to schoolrooms (1899)

Natural ventilation is the ventilation of a building with outside air without using fans or other mechanical systems. It can be via operable windows, louvers, or trickle vents when spaces are small and the architecture permits. ASHRAE defined Natural ventilation as the flow of air through open windows, doors, grilles, and other planned building envelope penetrations, and as being driven by natural and/or artificially produced pressure differentials.^[1]

Natural ventilation strategies also include cross ventilation, which relies on wind pressure differences on opposite sides of a building. By strategically placing openings, such as windows or vents, on opposing walls, air is channeled through the space to enhance cooling and ventilation. Cross ventilation is most effective when there are clear, unobstructed paths for airflow within the building.

In more complex schemes, warm air is allowed to rise and flow out high building openings to the outside (stack effect), causing cool outside air to be drawn into low building openings. Natural ventilation schemes can use very little energy, but care must be taken to ensure comfort. In warm or humid climates, maintaining thermal comfort solely via natural ventilation might not be possible. Air conditioning systems are used, either as backups or supplements. Air-side economizers also use outside air to condition spaces, but do so using fans, ducts, dampers, and control systems to introduce and distribute cool outdoor air when appropriate.

An important component of natural ventilation is air change rate or air changes per hour: the hourly rate of ventilation divided by the volume of the space. For example, six air changes per hour means an amount of new air, equal to the volume of the space, is added every ten minutes. For human comfort, a minimum of four air changes per hour is typical, though warehouses might have only two. Too high of an air change rate may be uncomfortable, akin to a wind tunnel which has thousands of changes per hour. The highest air change rates are for crowded spaces, bars, night clubs, commercial kitchens at around 30 to 50 air changes per hour.^[22]

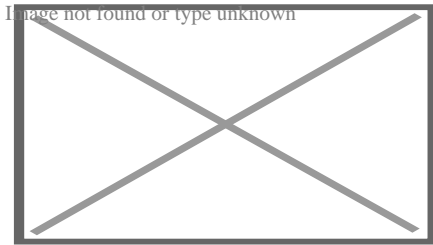
Room pressure can be either positive or negative with respect to outside the room. Positive pressure occurs when there is more air being supplied than exhausted, and is common to reduce the infiltration of outside contaminants.^[23]

Airborne diseases

[edit]

Natural ventilation ^[24] is a key factor in reducing the spread of airborne illnesses such as tuberculosis, the common cold, influenza, meningitis or COVID-19. Opening doors and windows are good ways to maximize natural ventilation, which would make the risk of airborne contagion much lower than with costly and maintenance-requiring mechanical systems. Old-fashioned clinical areas with high ceilings and large windows provide the greatest protection. Natural ventilation costs little and is maintenance free, and is particularly suited to limited-resource settings and tropical climates, where the burden of TB and institutional TB transmission is highest. In settings where respiratory isolation is difficult and climate permits, windows and doors should be opened to reduce the risk of airborne contagion. Natural ventilation requires little maintenance and is inexpensive.^[25]

Natural ventilation is not practical in much of the infrastructure because of climate. This means that the facilities need to have effective mechanical ventilation systems and or use Ceiling Level UV or FAR UV ventilation systems.



Alpha Black Edition – Sirair Air conditioner with UVC (Ultraviolet Germicidal Irradiation)

Ventilation is measured in terms of Air Changes Per Hour (ACH). As of 2023, the CDC recommends that all spaces have a minimum of 5 ACH.^[26] For hospital rooms with airborne contagions the CDC recommends a minimum of 12 ACH.^[27] The challenges in facility ventilation are public unawareness,^[28]^[29] ineffective government oversight, poor building codes that are based on comfort levels, poor system operations, poor maintenance, and lack of transparency.^[30]

UVC or Ultraviolet Germicidal Irradiation is a function used in modern air conditioners which reduces airborne viruses, bacteria, and fungi, through the use of a built-in LED UV light that emits a gentle glow across the evaporator. As the cross-flow fan circulates the room air, any viruses are guided through the sterilization module's irradiation range, rendering them instantly inactive.^[31]

Air conditioning

[edit]

Main article: Air conditioning

An air conditioning system, or a standalone air conditioner, provides cooling and/or humidity control for all or part of a building. Air conditioned buildings often have sealed windows, because open windows would work against the system intended to maintain constant indoor air conditions. Outside, fresh air is generally drawn into the system by a vent into a mix air chamber for mixing with the space return air. Then the mixture air enters an indoor or outdoor heat exchanger section where the air is to be cooled down, then be guided to the space creating positive air pressure. The percentage of return air made up of fresh air can usually be manipulated by

adjusting the opening of this vent. Typical fresh air intake is about 10% of the total supply air.^[*citation needed*]

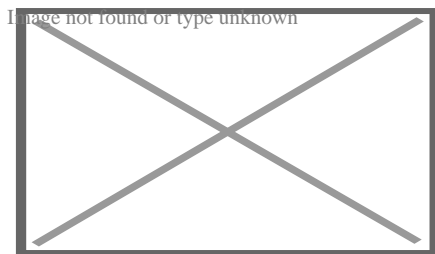
Air conditioning and refrigeration are provided through the removal of heat. Heat can be removed through radiation, convection, or conduction. The heat transfer medium is a refrigeration system, such as water, air, ice, and chemicals are referred to as refrigerants. A refrigerant is employed either in a heat pump system in which a compressor is used to drive thermodynamic refrigeration cycle, or in a free cooling system that uses pumps to circulate a cool refrigerant (typically water or a glycol mix).

It is imperative that the air conditioning horsepower is sufficient for the area being cooled. Underpowered air conditioning systems will lead to power wastage and inefficient usage. Adequate horsepower is required for any air conditioner installed.

Refrigeration cycle

[edit]

Main article: Heat pump and refrigeration cycle



A simple stylized diagram of the refrigeration cycle: 1) condensing coil, 2) expansion valve, 3) evaporating coil, 4) compressor

The refrigeration cycle uses four essential elements to cool, which are compressor, condenser, metering device, and evaporator.

- At the inlet of a compressor, the refrigerant inside the system is in a low pressure, low temperature, gaseous state. The **compressor** pumps the refrigerant gas up to high pressure and temperature.

- From there it enters a heat exchanger (sometimes called a **condensing coil** or condenser) where it loses heat to the outside, cools, and condenses into its liquid phase.
- An **expansion valve** (also called metering device) regulates the refrigerant liquid to flow at the proper rate.
- The liquid refrigerant is returned to another heat exchanger where it is allowed to evaporate, hence the heat exchanger is often called an **evaporating coil** or evaporator. As the liquid refrigerant evaporates it absorbs heat from the inside air, returns to the compressor, and repeats the cycle. In the process, heat is absorbed from indoors and transferred outdoors, resulting in cooling of the building.

In variable climates, the system may include a reversing valve that switches from heating in winter to cooling in summer. By reversing the flow of refrigerant, the heat pump refrigeration cycle is changed from cooling to heating or vice versa. This allows a facility to be heated and cooled by a single piece of equipment by the same means, and with the same hardware.

Free cooling

[edit]

Main article: Free cooling

Free cooling systems can have very high efficiencies, and are sometimes combined with seasonal thermal energy storage so that the cold of winter can be used for summer air conditioning. Common storage mediums are deep aquifers or a natural underground rock mass accessed via a cluster of small-diameter, heat-exchanger-equipped boreholes. Some systems with small storages are hybrids, using free cooling early in the cooling season, and later employing a heat pump to chill the circulation coming from the storage. The heat pump is added-in because the storage acts as a heat sink when the system is in cooling (as opposed to charging) mode, causing the temperature to gradually increase during the cooling season.

Some systems include an "economizer mode", which is sometimes called a "free-cooling mode". When economizing, the control system will open (fully or partially) the outside air damper and close (fully or partially) the return air damper. This will cause fresh, outside air to be supplied to the system. When the outside air is cooler than the demanded cool air, this will allow the demand to be met without using the mechanical supply of cooling (typically chilled water or a direct expansion "DX" unit), thus saving energy. The control system can compare the temperature of the outside air vs. return air, or it can compare the enthalpy of the air, as is frequently done in climates where humidity is more of an issue. In both cases, the outside air must be less energetic than the return air for the system to enter the economizer mode.

Packaged split system

[edit]

Central, "all-air" air-conditioning systems (or package systems) with a combined outdoor condenser/evaporator unit are often installed in North American residences, offices, and public buildings, but are difficult to retrofit (install in a building that was not designed to receive it) because of the bulky air ducts required.^[32] (Minisplit ductless systems are used in these situations.) Outside of North America, packaged systems are only used in limited applications involving large indoor space such as stadiums, theatres or exhibition halls.

An alternative to packaged systems is the use of separate indoor and outdoor coils in split systems. Split systems are preferred and widely used worldwide except in North America. In North America, split systems are most often seen in residential applications, but they are gaining popularity in small commercial buildings. Split systems are used where ductwork is not feasible or where the space conditioning efficiency is of prime concern.^[33] The benefits of ductless air conditioning systems include easy installation, no ductwork, greater zonal control, flexibility of control, and quiet operation.^[34] In space conditioning, the duct losses can account for 30% of energy consumption.^[35] The use of minisplits can result in energy savings in space conditioning as there are no losses associated with ducting.

With the split system, the evaporator coil is connected to a remote condenser unit using refrigerant piping between an indoor and outdoor unit instead of ducting air directly from the outdoor unit. Indoor units with directional vents mount onto walls, suspended from ceilings, or fit into the ceiling. Other indoor units mount inside the ceiling cavity so that short lengths of duct handle air from the indoor unit to vents or diffusers around the rooms.

Split systems are more efficient and the footprint is typically smaller than the package systems. On the other hand, package systems tend to have a slightly lower indoor noise level compared to split systems since the fan motor is located outside.

Dehumidification

[edit]

Dehumidification (air drying) in an air conditioning system is provided by the evaporator. Since the evaporator operates at a temperature below the dew point, moisture in the air condenses on the evaporator coil tubes. This moisture is collected at the bottom of the evaporator in a pan and removed by piping to a central drain or onto the ground outside.

A dehumidifier is an air-conditioner-like device that controls the humidity of a room or building. It is often employed in basements that have a higher relative humidity because of their lower temperature (and propensity for damp floors and walls). In food retailing establishments, large open chiller cabinets are highly effective at dehumidifying the internal air. Conversely, a humidifier increases the humidity of a building.

The HVAC components that dehumidify the ventilation air deserve careful attention because outdoor air constitutes most of the annual humidity load for nearly all buildings.^[36]

Humidification

[edit]

Main article: Humidifier

Maintenance

[edit]

All modern air conditioning systems, even small window package units, are equipped with internal air filters.^[*citation needed*] These are generally of a lightweight gauze-like material, and must be replaced or washed as conditions warrant. For example, a building in a high dust environment, or a home with furry pets, will need to have the filters changed more often than buildings without these dirt loads. Failure to replace these filters as needed will contribute to a lower heat exchange rate, resulting in wasted energy, shortened equipment life, and higher energy bills; low air flow can result in iced-over evaporator coils, which can completely stop airflow. Additionally, very dirty or plugged filters can cause overheating during a heating cycle, which can result in damage to the system or even fire.

Because an air conditioner moves heat between the indoor coil and the outdoor coil, both must be kept clean. This means that, in addition to replacing the air filter at the evaporator coil, it is also necessary to regularly clean the condenser coil. Failure to keep the condenser clean will eventually result in harm to the compressor because the condenser coil is responsible for discharging both the indoor heat (as picked up by the evaporator) and the heat generated by the electric motor driving the compressor.

Energy efficiency

[edit]

HVAC is significantly responsible for promoting energy efficiency of buildings as the building sector consumes the largest percentage of global energy.^[37] Since the 1980s, manufacturers of HVAC equipment have been making an effort to make the systems they manufacture more efficient. This was originally driven by rising energy costs, and has more recently been driven by increased awareness of environmental issues. Additionally, improvements to the HVAC system efficiency can also help

increase occupant health and productivity.^[38] In the US, the EPA has imposed tighter restrictions over the years. There are several methods for making HVAC systems more efficient.

Heating energy

[edit]

In the past, water heating was more efficient for heating buildings and was the standard in the United States. Today, forced air systems can double for air conditioning and are more popular.

Some benefits of forced air systems, which are now widely used in churches, schools, and high-end residences, are

- Better air conditioning effects
- Energy savings of up to 15–20%
- Even conditioning^[citation needed]

A drawback is the installation cost, which can be slightly higher than traditional HVAC systems.

Energy efficiency can be improved even more in central heating systems by introducing zoned heating. This allows a more granular application of heat, similar to non-central heating systems. Zones are controlled by multiple thermostats. In water heating systems the thermostats control zone valves, and in forced air systems they control zone dampers inside the vents which selectively block the flow of air. In this case, the control system is very critical to maintaining a proper temperature.

Forecasting is another method of controlling building heating by calculating the demand for heating energy that should be supplied to the building in each time unit.

Ground source heat pump

[edit]

Main article: Geothermal heat pump

Ground source, or geothermal, heat pumps are similar to ordinary heat pumps, but instead of transferring heat to or from outside air, they rely on the stable, even temperature of the earth to provide heating and air conditioning. Many regions experience seasonal temperature extremes, which would require large-capacity heating and cooling equipment to heat or cool buildings. For example, a conventional heat pump system used to heat a building in Montana's -57 °C (-70 °F) low temperature or cool a building in the highest temperature ever recorded in the US— 57 °C (134 °F) in Death Valley, California, in 1913 would require a large amount of energy due to the extreme difference between inside and outside air temperatures. A metre below the earth's surface, however, the ground remains at a relatively constant temperature. Utilizing this large source of relatively moderate temperature earth, a heating or cooling system's capacity can often be significantly reduced. Although ground temperatures vary according to latitude, at 1.8 metres (6 ft) underground, temperatures generally only range from $7\text{ to }24\text{ °C}$ ($45\text{ to }75\text{ °F}$).

Solar air conditioning

[edit]

Main article: Solar air conditioning

Photovoltaic solar panels offer a new way to potentially decrease the operating cost of air conditioning. Traditional air conditioners run using alternating current, and hence, any direct-current solar power needs to be inverted to be compatible with these units. New variable-speed DC-motor units allow solar power to more easily run them since this conversion is unnecessary, and since the motors are tolerant of voltage fluctuations associated with variance in supplied solar power (e.g., due to cloud cover).

Ventilation energy recovery

[edit]

Energy recovery systems sometimes utilize heat recovery ventilation or energy recovery ventilation systems that employ heat exchangers or enthalpy wheels to recover sensible or latent heat from exhausted air. This is done by transfer of energy from the stale air inside the home to the incoming fresh air from outside.

Air conditioning energy

[edit]

The performance of vapor compression refrigeration cycles is limited by thermodynamics.^[39] These air conditioning and heat pump devices *move* heat rather than convert it from one form to another, so *thermal efficiencies* do not appropriately describe the performance of these devices. The Coefficient of performance (COP) measures performance, but this dimensionless measure has not been adopted. Instead, the Energy Efficiency Ratio (*EER*) has traditionally been used to characterize the performance of many HVAC systems. EER is the Energy Efficiency Ratio based on a 35 °C (95 °F) outdoor temperature. To more accurately describe the performance of air conditioning equipment over a typical cooling season a modified version of the EER, the Seasonal Energy Efficiency Ratio (*SEER*), or in Europe the ESEER, is used. SEER ratings are based on seasonal temperature averages instead of a constant 35 °C (95 °F) outdoor temperature. The current industry minimum SEER rating is 14 SEER. Engineers have pointed out some areas where efficiency of the existing hardware could be improved. For example, the fan blades used to move the air are usually stamped from sheet metal, an economical method of manufacture, but as a result they are not aerodynamically efficient. A well-designed blade could reduce the electrical power required to move the air by a third.^[40]

Demand-controlled kitchen ventilation

[edit]

Main article: Demand controlled ventilation

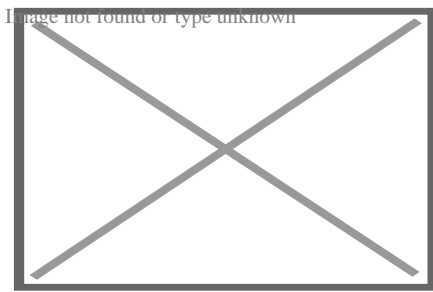
Demand-controlled kitchen ventilation (DCKV) is a building controls approach to controlling the volume of kitchen exhaust and supply air in response to the actual

cooking loads in a commercial kitchen. Traditional commercial kitchen ventilation systems operate at 100% fan speed independent of the volume of cooking activity and DCKV technology changes that to provide significant fan energy and conditioned air savings. By deploying smart sensing technology, both the exhaust and supply fans can be controlled to capitalize on the affinity laws for motor energy savings, reduce makeup air heating and cooling energy, increasing safety, and reducing ambient kitchen noise levels.^[41]

Air filtration and cleaning

[edit]

Main article: Air filter




Air handling unit, used for heating, cooling, and filtering the air

Air cleaning and filtration removes particles, contaminants, vapors and gases from the air. The filtered and cleaned air then is used in heating, ventilation, and air conditioning. Air cleaning and filtration should be taken in account when protecting our building environments.^[42] If present, contaminants can come out from the HVAC systems if not removed or filtered properly.

Clean air delivery rate (CADR) is the amount of clean air an air cleaner provides to a room or space. When determining CADR, the amount of airflow in a space is taken into account. For example, an air cleaner with a flow rate of 30 cubic metres (1,000 cu ft) per minute and an efficiency of 50% has a CADR of 15 cubic metres (500 cu ft) per minute. Along with CADR, filtration performance is very important when it comes to the air in our indoor environment. This depends on the size of the particle or fiber, the filter packing density and depth, and the airflow rate.^[42]

Circulation of harmful substances

[edit]

 This section **needs expansion**. You can help by adding to it. (*October 2024*)

Poorly maintained air conditioners/ventilation systems can harbor mold, bacteria, and other contaminants, which are then circulated throughout indoor spaces, contributing to ...^[43]

Industry and standards

[edit]

The HVAC industry is a worldwide enterprise, with roles including operation and maintenance, system design and construction, equipment manufacturing and sales, and in education and research. The HVAC industry was historically regulated by the manufacturers of HVAC equipment, but regulating and standards organizations such as HARDI (Heating, Air-conditioning and Refrigeration Distributors International), ASHRAE, SMACNA, ACCA (Air Conditioning Contractors of America), Uniform Mechanical Code, International Mechanical Code, and AMCA have been established to support the industry and encourage high standards and achievement. (UL as an omnibus agency is not specific to the HVAC industry.)

The starting point in carrying out an estimate both for cooling and heating depends on the exterior climate and interior specified conditions. However, before taking up the heat load calculation, it is necessary to find fresh air requirements for each area in detail, as pressurization is an important consideration.

International

[edit]

ISO 16813:2006 is one of the ISO building environment standards.^[44] It establishes the general principles of building environment design. It takes into account the need

to provide a healthy indoor environment for the occupants as well as the need to protect the environment for future generations and promote collaboration among the various parties involved in building environmental design for sustainability. ISO16813 is applicable to new construction and the retrofit of existing buildings.^[45]

The building environmental design standard aims to:^[45]

- provide the constraints concerning sustainability issues from the initial stage of the design process, with building and plant life cycle to be considered together with owning and operating costs from the beginning of the design process;
- assess the proposed design with rational criteria for indoor air quality, thermal comfort, acoustical comfort, visual comfort, energy efficiency, and HVAC system controls at every stage of the design process;
- iterate decisions and evaluations of the design throughout the design process.

United States

[edit]

Licensing

[edit]

Main article: Section 608 EPA Certification

In the United States, federal licensure is generally handled by EPA certified (for installation and service of HVAC devices).

Many U.S. states have licensing for boiler operation. Some of these are listed as follows:

- Arkansas ^[46]
- Georgia ^[47]
- Michigan ^[48]
- Minnesota ^[49]
- Montana ^[50]
- New Jersey ^[51]

- North Dakota [⁵²]
- Ohio [⁵³]
- Oklahoma [⁵⁴]
- Oregon [⁵⁵]

Finally, some U.S. cities may have additional labor laws that apply to HVAC professionals.

Societies

[edit]

See also: American Society of Heating, Refrigerating and Air-Conditioning Engineers

See also: Air Conditioning, Heating and Refrigeration Institute

Many HVAC engineers are members of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). ASHRAE regularly organizes two annual technical committees and publishes recognized standards for HVAC design, which are updated every four years.^[56]

Another popular society is AHRI, which provides regular information on new refrigeration technology, and publishes relevant standards and codes.

Codes

[edit]

Codes such as the UMC and IMC do include much detail on installation requirements, however. Other useful reference materials include items from SMACNA, ACGIH, and technical trade journals.

American design standards are legislated in the Uniform Mechanical Code or International Mechanical Code. In certain states, counties, or cities, either of these codes may be adopted and amended via various legislative processes. These codes are updated and published by the International Association of Plumbing and

Mechanical Officials (IAPMO) or the International Code Council (ICC) respectively, on a 3-year code development cycle. Typically, local building permit departments are charged with enforcement of these standards on private and certain public properties.

Technicians

[edit]

HVAC Technician

Occupation

Occupation type Vocational

Activity sectors Construction

Description

Education required Apprenticeship

Related jobs Carpenter, electrician, plumber, welder

An **HVAC technician** is a tradesman who specializes in heating, ventilation, air conditioning, and refrigeration. HVAC technicians in the US can receive training through formal training institutions, where most earn associate degrees. Training for HVAC technicians includes classroom lectures and hands-on tasks, and can be followed by an apprenticeship wherein the recent graduate works alongside a professional HVAC technician for a temporary period.^[57] HVAC techs who have been trained can also be certified in areas such as air conditioning, heat pumps, gas heating, and commercial refrigeration.

United Kingdom

[edit]

The Chartered Institution of Building Services Engineers is a body that covers the essential Service (systems architecture) that allow buildings to operate. It includes the electrotechnical, heating, ventilating, air conditioning, refrigeration and plumbing

industries. To train as a building services engineer, the academic requirements are GCSEs (A–C) / Standard Grades (1–3) in Maths and Science, which are important in measurements, planning and theory. Employers will often want a degree in a branch of engineering, such as building environment engineering, electrical engineering or mechanical engineering. To become a full member of CIBSE, and so also to be registered by the Engineering Council UK as a chartered engineer, engineers must also attain an Honours Degree and a master's degree in a relevant engineering subject.^[citation needed] CIBSE publishes several guides to HVAC design relevant to the UK market, and also the Republic of Ireland, Australia, New Zealand and Hong Kong. These guides include various recommended design criteria and standards, some of which are cited within the UK building regulations, and therefore form a legislative requirement for major building services works. The main guides are:

- Guide A: Environmental Design
- Guide B: Heating, Ventilating, Air Conditioning and Refrigeration
- Guide C: Reference Data
- Guide D: Transportation systems in Buildings
- Guide E: Fire Safety Engineering
- Guide F: Energy Efficiency in Buildings
- Guide G: Public Health Engineering
- Guide H: Building Control Systems
- Guide J: Weather, Solar and Illuminance Data
- Guide K: Electricity in Buildings
- Guide L: Sustainability
- Guide M: Maintenance Engineering and Management

Within the construction sector, it is the job of the building services engineer to design and oversee the installation and maintenance of the essential services such as gas, electricity, water, heating and lighting, as well as many others. These all help to make buildings comfortable and healthy places to live and work in. Building Services is part of a sector that has over 51,000 businesses and employs represents 2–3% of the GDP.

Australia

[edit]

The Air Conditioning and Mechanical Contractors Association of Australia (AMCA), Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH), Australian Refrigeration Mechanical Association and CIBSE are responsible.

Asia

[edit]

Asian architectural temperature-control have different priorities than European methods. For example, Asian heating traditionally focuses on maintaining temperatures of objects such as the floor or furnishings such as Kotatsu tables and directly warming people, as opposed to the Western focus, in modern periods, on designing air systems.

Philippines

[edit]

The Philippine Society of Ventilating, Air Conditioning and Refrigerating Engineers (PSVARE) along with Philippine Society of Mechanical Engineers (PSME) govern on the codes and standards for HVAC / MVAC (MVAC means "mechanical ventilation and air conditioning") in the Philippines.

India

[edit]

The Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) was established to promote the HVAC industry in India. ISHRAE is an associate of

ASHRAE. ISHRAE was founded at New Delhi^[58] in 1981 and a chapter was started in Bangalore in 1989. Between 1989 & 1993, ISHRAE chapters were formed in all major cities in India.^[citation needed]

See also

[edit]

- Air speed (HVAC)
- Architectural engineering
- ASHRAE Handbook
- Auxiliary power unit
- Cleanroom
- Electric heating
- Fan coil unit
- Glossary of HVAC terms
- Head-end power
- Hotel electric power
- Mechanical engineering
- Outdoor wood-fired boiler
- Radiant cooling
- Sick building syndrome
- Uniform Codes
- Uniform Mechanical Code
- Ventilation (architecture)
- World Refrigeration Day
- Wrightsoft

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External links

[edit]

-  Media related to Climate control at Wikimedia Commons
- v
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Heating, ventilation, and air conditioning

**Fundamental
concepts**

- Air changes per hour
- Bake-out
- Building envelope
- Convection
- Dilution
- Domestic energy consumption
- Enthalpy
- Fluid dynamics
- Gas compressor
- Heat pump and refrigeration cycle
- Heat transfer
- Humidity
- Infiltration
- Latent heat
- Noise control
- Outgassing
- Particulates
- Psychrometrics
- Sensible heat
- Stack effect
- Thermal comfort
- Thermal destratification
- Thermal mass
- Thermodynamics
- Vapour pressure of water

- Absorption-compression heat pump
- Absorption refrigerator
- Air barrier
- Air conditioning
- Antifreeze
- Automobile air conditioning
- Autonomous building
- Building insulation materials
- Central heating
- Central solar heating
- Chilled beam
- Chilled water
- Constant air volume (CAV)
- Coolant
- Cross ventilation
- Dedicated outdoor air system (DOAS)
- Deep water source cooling
- Demand controlled ventilation (DCV)
- Displacement ventilation
- District cooling
- District heating
- Electric heating
- Energy recovery ventilation (ERV)
- Firestop
- Forced-air
- Forced-air gas
- Free cooling
- Heat recovery ventilation (HRV)
- Hybrid heat
- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling
- Passive daytime radiative cooling
- Passive house

Technology

- Air conditioner inverter
- Air door
- Air filter
- Air handler
- Air ionizer
- Air-mixing plenum
- Air purifier
- Air source heat pump
- Attic fan
- Automatic balancing valve
- Back boiler
- Barrier pipe
- Blast damper
- Boiler
- Centrifugal fan
- Ceramic heater
- Chiller
- Condensate pump
- Condenser
- Condensing boiler
- Convection heater
- Compressor
- Cooling tower
- Damper
- Dehumidifier
- Duct
- Economizer
- Electrostatic precipitator
- Evaporative cooler
- Evaporator
- Exhaust hood
- Expansion tank
- Fan
- Fan coil unit
- Fan filter unit
- Fan heater
- Fire damper

**Measurement
and control**

- Air flow meter
- Aquastat
- BACnet
- Blower door
- Building automation
- Carbon dioxide sensor
- Clean air delivery rate (CADR)
- Control valve
- Gas detector
- Home energy monitor
- Humidistat
- HVAC control system
- Infrared thermometer
- Intelligent buildings
- LonWorks
- Minimum efficiency reporting value (MERV)
- Normal temperature and pressure (NTP)
- OpenTherm
- Programmable communicating thermostat
- Programmable thermostat
- Psychrometrics
- Room temperature
- Smart thermostat
- Standard temperature and pressure (STP)
- Thermographic camera
- Thermostat
- Thermostatic radiator valve

**Professions,
trades,
and services**

- Architectural acoustics
- Architectural engineering
- Architectural technologist
- Building services engineering
- Building information modeling (BIM)
- Deep energy retrofit
- Duct cleaning
- Duct leakage testing
- Environmental engineering
- Hydronic balancing
- Kitchen exhaust cleaning
- Mechanical engineering
- Mechanical, electrical, and plumbing
- Mold growth, assessment, and remediation
- Refrigerant reclamation
- Testing, adjusting, balancing
- AHRI
- AMCA
- ASHRAE
- ASTM International
- BRE
- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC
- Indoor air quality (IAQ)
- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)

**Industry
organizations**

Health and safety

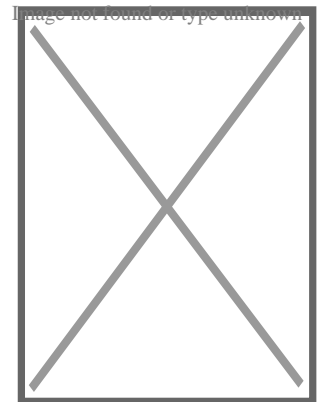
See also

- ASHRAE Handbook
- Building science
- Fireproofing
- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

- v
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Home automation

| | |
|-----------------------------|---|
| Elements | <ul style="list-style-type: none"> ○ Actuators ○ Hardware controllers ○ Sensors |
| | <ul style="list-style-type: none"> ○ Cable (xDSL) ○ Optical fiber ○ Powerline |
| Interconnection type | <p>Wired</p> <ul style="list-style-type: none"> ○ PLCBUS ○ Universal powerline bus (UPB) ○ X10 <p>Wireless</p> <ul style="list-style-type: none"> ○ Radio frequency ○ Bluetooth ○ Bluetooth Low Energy ○ DECT ○ EnOcean ○ GPRS ○ MyriaNed ○ One-Net ○ Thread ○ UMTS ○ Wi-Fi ○ Zigbee ○ Z-Wave |
| | <p>Both</p> <ul style="list-style-type: none"> ○ Infrared (Consumer IR) ○ Insteon ○ KNX ○ Matter |
| System | <p>Device interconnection</p> <ul style="list-style-type: none"> ○ Bluetooth ○ Bluetooth Low Energy ○ FireWire ○ IrDA |



- Audio and video
- Heating, ventilation, and air conditioning
- Lighting control system
- Other systems

Tasks

- Robotics
- Security
- Thermostat automation

- Gateway
- Smart home hub
- Costs

Other

- Mesh networking
- Organizations
- Smart grid

See also

Home of the future

Building automation

Floor plan

Home automation

Home energy monitor

Home network

Home server

House navigation system

INTEGER Millennium House

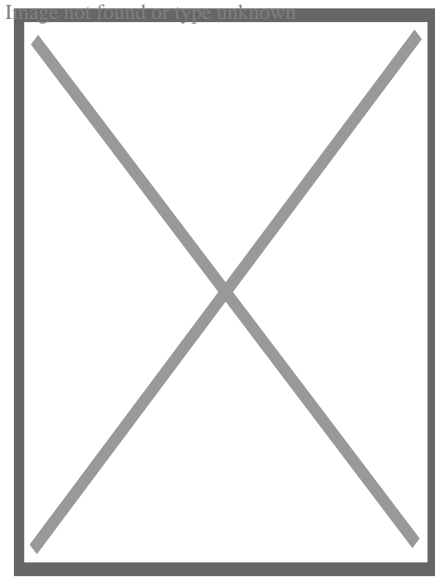
The House for the Future

Ubiquitous computing

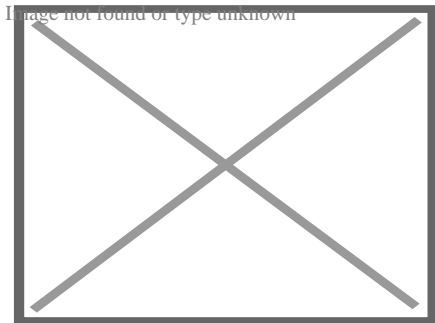
Xanadu Houses

Authority control databases: **National**  **Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany**  **o Germany** **o Germany**

This article is about devices used to heat and potentially also cool a building (or water) using the refrigeration cycle. For more about the theory, see Heat pump and refrigeration cycle. For details of the most common type, see air source heat pump. For a similar device for cooling only, see air conditioner. For heat pumps used to keep food cool, see refrigerator. For other uses, see Heat pump (disambiguation).



External heat exchanger of an air-source heat pump for both heating and cooling



Mitsubishi heat pump interior air handler wall unit

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Part of a series on

Sustainable energy

A car drives past 4 wind turbines in a field, with more on the horizon

Image not found or type unknown



Energy conservation

- Arcology
- Building insulation
- Cogeneration
- Compact fluorescent lamp
- Eco hotel
- Eco-cities
- Ecohouse
- Ecolabel
- Efficient energy use
- Energy audit
- Energy efficiency implementation
- Energy recovery
- Energy recycling
- Energy saving lamp
- Energy Star
- Energy storage
- Environmental planning
- Environmental technology
- Fossil fuel phase-out
- Glass in green buildings
- Green building and wood
- Green building
- Heat pump
- List of low-energy building techniques
- Low-energy house
- Microgeneration
- Passive house
- Passive solar building design
- Sustainable architecture
- Sustainable city
- Sustainable habitat
- Sustainable refurbishment
- Thermal energy storage

Renewable energy

- Biofuel
 - Sustainable
- Biogas
- Biomass
- Carbon-neutral fuel
- Geothermal energy
- Geothermal power
- Geothermal heating
- Hydropower
 - Hydroelectricity
 - Micro hydro
 - Pico hydro
 - Run-of-the-river
 - Small hydro
- Marine current power
- Marine energy
- Tidal power
 - Tidal barrage
 - Tidal farm
 - Tidal stream generator
- Ocean thermal energy conversion
- Renewable energy transition
- Renewable heat
- Solar
- Wave
- Wind
 - Community
 - Farm
 - Floating wind turbine
 - Forecasting
 - Industry
 - Lens
 - Outline
 - Rights
 - Turbine

Sustainable transport

- Green vehicle
 - Electric vehicle
 - Bicycle
 - Solar vehicle
 - Wind-powered vehicle
- Hybrid vehicle
 - Human-electric
 - Twike
 - Plug-in
- Human-powered transport
 - Helicopter
 - Hydrofoil
 - Land vehicle
 - Bicycle
 - Cycle rickshaw
 - Kick scooter
 - Quadracycle
 - Tricycle
 - Velomobile
 - Roller skating
 - Skateboarding
 - Walking
 - Watercraft
- Personal transporter
- Rail transport
 - Tram
- Rapid transit
 - Personal rapid transit
-  Category
-  Renewable energy portal

A **heat pump** is a device that consumes energy (usually electricity) to transfer heat from a cold heat sink to a hot heat sink. Specifically, the heat pump transfers thermal energy using a refrigeration cycle, cooling the cool space and warming the warm space.^[1] In cold weather, a heat pump can move heat from the cool outdoors to warm a house (e.g. winter); the pump may also be designed to move heat from the house to the warmer outdoors in warm weather (e.g. summer). As they transfer heat rather than generating heat, they are more energy-efficient than other ways of heating or cooling a home.^[2]

A gaseous refrigerant is compressed so its pressure and temperature rise. When operating as a heater in cold weather, the warmed gas flows to a heat exchanger in the indoor space where some of its thermal energy is transferred to that indoor space, causing the gas to condense to its liquid state. The liquified refrigerant flows to a heat exchanger in the outdoor space where the pressure falls, the liquid evaporates and the temperature of the gas falls. It is now colder than the temperature of the outdoor space being used as a heat source. It can again take up energy from the heat source, be compressed and repeat the cycle.

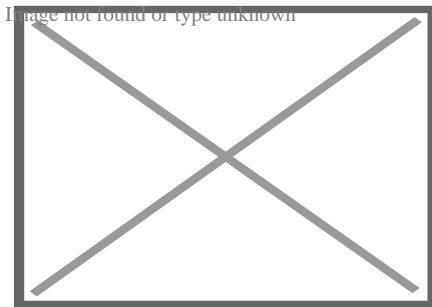
Air source heat pumps are the most common models, while other types include ground source heat pumps, water source heat pumps and exhaust air heat pumps.^[3] Large-scale heat pumps are also used in district heating systems.^[4]

The efficiency of a heat pump is expressed as a coefficient of performance (COP), or seasonal coefficient of performance (SCOP). The higher the number, the more efficient a heat pump is. For example, an air-to-water heat pump that produces 6kW at a SCOP of 4.62 will give over 4kW of energy into a heating system for every kilowatt of energy that the heat pump uses itself to operate. When used for space heating, heat pumps are typically more energy-efficient than electric resistance and other heaters.

Because of their high efficiency and the increasing share of fossil-free sources in electrical grids, heat pumps are playing a role in climate change mitigation.^{[5][6]} Consuming 1 kWh of electricity, they can transfer 1^[7] to 4.5 kWh of thermal energy into a building. The carbon footprint of heat pumps depends on how electricity is generated, but they usually reduce emissions.^[8] Heat pumps could satisfy over 80% of global space and water heating needs with a lower carbon footprint than gas-fired condensing boilers: however, in 2021 they only met 10%.^[4]

Principle of operation

[edit]



A: indoor compartment, B: outdoor compartment, I: insulation, 1: condenser, 2: expansion valve, 3: evaporator, 4: compressor

Main articles: Heat pump and refrigeration cycle and Vapor-compression refrigeration

Heat flows spontaneously from a region of higher temperature to a region of lower temperature. Heat does not flow spontaneously from lower temperature to higher, but it can be made to flow in this direction if work is performed. The work required to transfer a given amount of heat is usually much less than the amount of heat; this is the motivation for using heat pumps in applications such as the heating of water and the interior of buildings.^[9]

The amount of work required to drive an amount of heat Q from a lower-temperature reservoir such as ambient air to a higher-temperature reservoir such as

$$W = \frac{Q}{\text{COP}}$$

the interior of a building is: where

- W is the work performed on the working fluid by the heat pump's compressor.
- Q_H is the heat transferred from the lower-temperature reservoir to the higher-temperature reservoir.
- COP is the instantaneous coefficient of performance for the heat pump at the temperatures prevailing in the reservoirs at one instant.

The coefficient of performance of a heat pump is greater than one so the work required is less than the heat transferred, making a heat pump a more efficient form of heating than electrical resistance heating. As the temperature of the higher-temperature reservoir increases in response to the heat flowing into it, the coefficient of performance decreases, causing an increasing amount of work to be required for each unit of heat being transferred.^[9]

The coefficient of performance, and the work required by a heat pump can be calculated easily by considering an ideal heat pump operating on the reversed Carnot cycle:

- If the low-temperature reservoir is at a temperature of 270 K (−3 °C) and the interior of the building is at 280 K (7 °C) the relevant coefficient of performance is 27. This means only 1 joule of work is required to transfer 27 joules of heat from a reservoir at 270 K to another at 280 K. The one joule of work ultimately ends up as thermal energy in the interior of the building so for each 27 joules of heat that are removed from the low-temperature reservoir, 28 joules of heat are added to the building interior, making the heat pump even more attractive from an efficiency perspective.^[note 1]
- As the temperature of the interior of the building rises progressively to 300 K (27 °C) the coefficient of performance falls progressively to 9. This means each joule of work is responsible for transferring 9 joules of heat out of the low-temperature reservoir and into the building. Again, the 1 joule of work ultimately ends up as thermal energy in the interior of the building so 10 joules of heat are added to the building interior.^[note 2]

This is the theoretical amount of heat pumped but in practice it will be less for various reasons, for example if the outside unit has been installed where there is not enough

airflow. More data sharing with owners and academics—perhaps from heat meters—could improve efficiency in the long run.[¹¹]

History

[edit]

Milestones:

1748

William Cullen demonstrates artificial refrigeration.[¹²]

1834

Jacob Perkins patents a design for a practical refrigerator using dimethyl ether.[¹³]

1852

Lord Kelvin describes the theory underlying heat pumps.[¹⁴]

1855–1857

Peter von Rittinger develops and builds the first heat pump.[¹⁵]

1877

In the period before 1875, heat pumps were for the time being pursued for vapour compression evaporation (open heat pump process) in salt works with their obvious advantages for saving wood and coal. In 1857, Peter von Rittinger was the first to try to implement the idea of vapor compression in a small pilot plant. Presumably inspired by Rittinger's experiments in Ebensee, Antoine–Paul Piccard from the University of Lausanne and the engineer J. H. Weibel from the Weibel–Briquet company in Geneva built the world's first really functioning vapor compression system with a two–stage piston compressor. In 1877 this first heat pump in Switzerland was installed in the Bex salt works.[¹⁴][¹⁶]

1928

Aurel Stodola constructs a closed–loop heat pump (water source from Lake Geneva) which provides heating for the Geneva city hall to this day.[¹⁷]

1937–1945

During the First World War, fuel prices were very high in Switzerland but it had plenty of hydropower.[¹⁴]

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In the period before and especially during the Second World War, when neutral Switzerland was completely surrounded by fascist-ruled countries, the coal shortage became alarming again. Thanks to their leading position in energy technology, the Swiss companies Sulzer, Escher Wyss and Brown Boveri built and put in operation around 35 heat pumps between 1937 and 1945. The main heat sources were lake water, river water, groundwater, and waste heat. Particularly noteworthy are the six historic heat pumps from the city of Zurich with heat outputs from 100 kW to 6 MW. An international milestone is the heat pump built by Escher Wyss in 1937/38 to replace the wood stoves in the City Hall of Zurich. To avoid noise and vibrations, a recently developed rotary piston compressor was used. This historic heat pump heated the town hall for 63 years until 2001. Only then was it replaced by a new, more efficient heat pump.^[14]

1945

John Sumner, City Electrical Engineer for Norwich, installs an experimental water-source heat pump fed central heating system, using a nearby river to heat new Council administrative buildings. It had a seasonal efficiency ratio of 3.42, average thermal delivery of 147 kW, and peak output of 234 kW.^[18]

1948

Robert C. Webber is credited as developing and building the first ground-source heat pump.^[19]

1951

First large scale installation—the Royal Festival Hall in London is opened with a town gas-powered reversible water-source heat pump, fed by the Thames, for both winter heating and summer cooling needs.^[18]

2019

The Kigali Amendment to phase out harmful refrigerants takes effect.

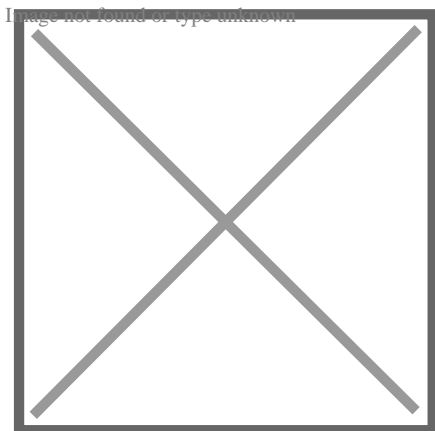
Types

[edit]

Air-source

[edit]

This section is an excerpt from Air source heat pump.[edit]



Heat pump on balcony of apartment

An air source heat pump (ASHP) is a heat pump that can absorb heat from air outside a building and release it inside; it uses the same vapor-compression refrigeration process and much the same equipment as an air conditioner, but in the opposite direction. ASHPs are the most common type of heat pump and, usually being smaller, tend to be used to heat individual houses or flats rather than blocks, districts or industrial processes.^[20]^[21]

Air-to-air heat pumps provide hot or cold air directly to rooms, but do not usually provide hot water. *Air-to-water* heat pumps use radiators or underfloor heating to heat a whole house and are often also used to provide domestic hot water.

An ASHP can typically gain 4 kWh thermal energy from 1 kWh electric energy. They are optimized for flow temperatures between 30 and 40 °C (86 and 104 °F), suitable for buildings with heat emitters sized for low flow temperatures. With losses in efficiency, an ASHP can even provide full central heating with a flow temperature up to 80 °C (176 °F).^[22]

As of 2023 about 10% of building heating worldwide is from ASHPs. They are the main way to phase out gas boilers (also known as "furnaces") from houses, to avoid their greenhouse gas emissions.^[23]

Air-source heat pumps are used to move heat between two heat exchangers, one outside the building which is fitted with fins through which air is forced using a fan

and the other which either directly heats the air inside the building or heats water which is then circulated around the building through radiators or underfloor heating which releases the heat to the building. These devices can also operate in a cooling mode where they extract heat via the internal heat exchanger and eject it into the ambient air using the external heat exchanger. Some can be used to heat water for washing which is stored in a domestic hot water tank.^[24]

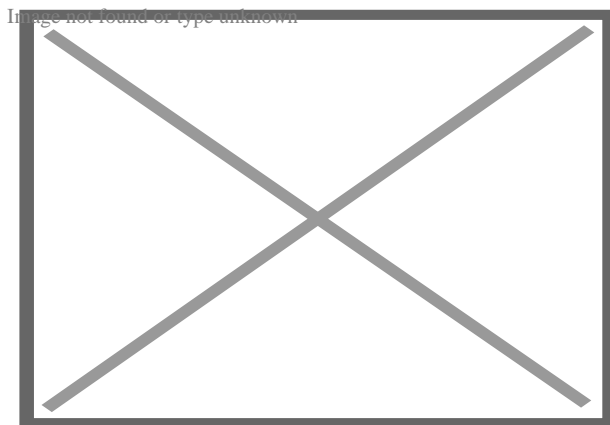
Air-source heat pumps are relatively easy and inexpensive to install, so are the most widely used type. In mild weather, coefficient of performance (COP) may be between 2 and 5, while at temperatures below around $-8\text{ }^{\circ}\text{C}$ ($18\text{ }^{\circ}\text{F}$) an air-source heat pump may still achieve a COP of 1 to 4.^[25]

While older air-source heat pumps performed relatively poorly at low temperatures and were better suited for warm climates, newer models with variable-speed compressors remain highly efficient in freezing conditions allowing for wide adoption and cost savings in places like Minnesota and Maine in the United States.^[26]

Ground source

[edit]

This section is an excerpt from Ground source heat pump.[edit]



A heat pump in combination with heat and cold storage

A ground source heat pump (also geothermal heat pump) is a heating/cooling system for buildings that use a type of heat pump to transfer heat to or from the ground,

taking advantage of the relative constancy of temperatures of the earth through the seasons. Ground-source heat pumps (GSHPs) – or geothermal heat pumps (GHP), as they are commonly termed in North America – are among the most energy-efficient technologies for providing HVAC and water heating, using far less energy than can be achieved by burning a fuel in a boiler/furnace or by use of resistive electric heaters.

Efficiency is given as a coefficient of performance (CoP) which is typically in the range 3 – 6, meaning that the devices provide 3 – 6 units of heat for each unit of electricity used. Setup costs are higher than for other heating systems, due to the requirement to install ground loops over large areas or to drill bore holes, and for this reason, ground source is often suitable when new blocks of flats are built.^[27] Otherwise air-source heat pumps are often used instead.

Heat recovery ventilation

[edit]

Main article: Heat recovery ventilation

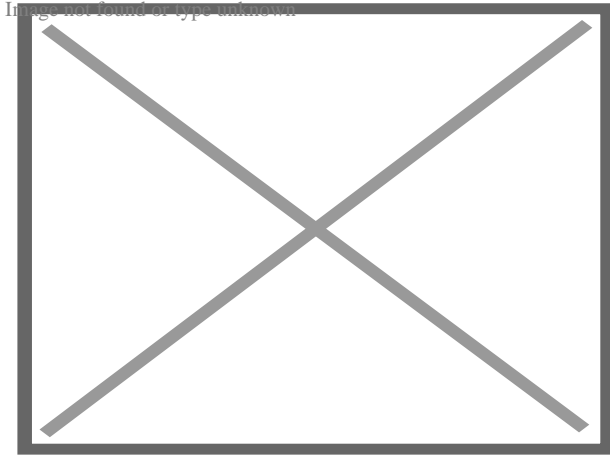
Exhaust air heat pumps extract heat from the exhaust air of a building and require mechanical ventilation. Two classes exist:

- Exhaust air–air heat pumps transfer heat to intake air.
- Exhaust air–water heat pumps transfer heat to a heating circuit that includes a tank of domestic hot water.

Solar-assisted

[edit]

This section is an excerpt from Solar-assisted heat pump.[edit]



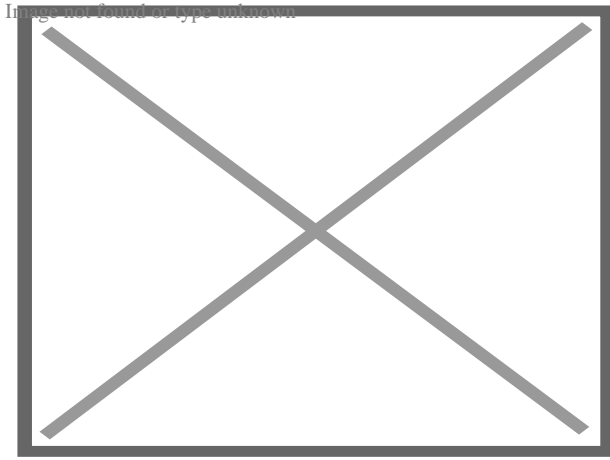
Hybrid photovoltaic–thermal solar panels of a SAHP in an experimental installation at Department of Energy at Polytechnic of Milan

A solar-assisted heat pump (SAHP) is a machine that combines a heat pump and thermal solar panels and/or PV solar panels in a single integrated system.^[28] Typically these two technologies are used separately (or only placing them in parallel) to produce hot water.^[29] In this system the solar thermal panel performs the function of the low temperature heat source and the heat produced is used to feed the heat pump's evaporator.^[30] The goal of this system is to get high coefficient of performance (COP) and then produce energy in a more efficient and less expensive way.

It is possible to use any type of solar thermal panel (sheet and tubes, roll-bond, heat pipe, thermal plates) or hybrid (mono/polycrystalline, thin film) in combination with the heat pump. The use of a hybrid panel is preferable because it allows covering a part of the electricity demand of the heat pump and reduce the power consumption and consequently the variable costs of the system.

Water-source

[edit]



Water-source heat exchanger being installed

A water-source heat pump works in a similar manner to a ground-source heat pump, except that it takes heat from a body of water rather than the ground. The body of water does, however, need to be large enough to be able to withstand the cooling effect of the unit without freezing or creating an adverse effect for wildlife.^[31] The largest water-source heat pump was installed in the Danish town of Esbjerg in 2023.^[32]^[33]

Others

[edit]

A thermoacoustic heat pump operates as a thermoacoustic heat engine without refrigerant but instead uses a standing wave in a sealed chamber driven by a loudspeaker to achieve a temperature difference across the chamber.^[34]

Electrocaloric heat pumps are solid state.^[35]

Applications

[edit]

The International Energy Agency estimated that, as of 2021, heat pumps installed in buildings have a combined capacity of more than 1000 GW.^[4] They are used for heating, ventilation, and air conditioning (HVAC) and may also provide domestic hot

water and tumble clothes drying.^[36] The purchase costs are supported in various countries by consumer rebates.^[37]

Space heating and sometimes also cooling

[edit]

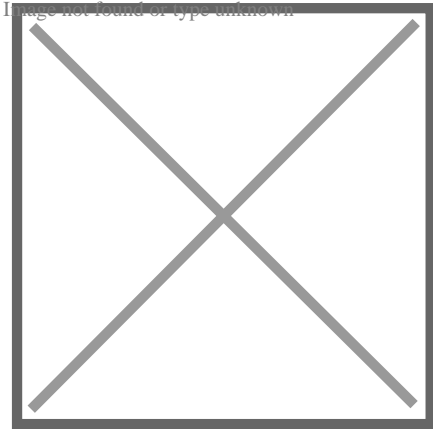
In HVAC applications, a heat pump is typically a vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of *heat flow* (thermal energy movement) may be reversed. The reversing valve switches the direction of refrigerant through the cycle and therefore the heat pump may deliver either heating or cooling to a building.

Because the two heat exchangers, the condenser and evaporator, must swap functions, they are optimized to perform adequately in both modes. Therefore, the Seasonal Energy Efficiency Rating (SEER in the US) or European seasonal energy efficiency ratio of a reversible heat pump is typically slightly less than those of two separately optimized machines. For equipment to receive the US Energy Star rating, it must have a rating of at least 14 SEER. Pumps with ratings of 18 SEER or above are considered highly efficient. The highest efficiency heat pumps manufactured are up to 24 SEER.^[38]

Heating seasonal performance factor (in the US) or Seasonal Performance Factor (in Europe) are ratings of heating performance. The SPF is Total heat output per annum / Total electricity consumed per annum in other words the average heating COP over the year.^[39]

Window mounted heat pump

[edit]



Saddle-style window mounted heat pump 3D sketch

Window mounted heat pumps run on standard 120v AC outlets and provide heating, cooling, and humidity control. They are more efficient with lower noise levels, condensation management, and a smaller footprint than window mounted air conditioners that just do cooling.^[40]

Water heating

[edit]

In water heating applications, heat pumps may be used to heat or preheat water for swimming pools, homes or industry. Usually heat is extracted from outdoor air and transferred to an indoor water tank.^[41]^[42]

District heating

[edit]

Large (megawatt-scale) heat pumps are used for district heating.^[43] However as of 2022 about 90% of district heat is from fossil fuels.^[44] In Europe, heat pumps account for a mere 1% of heat supply in district heating networks but several countries have targets to decarbonise their networks between 2030 and 2040.^[4] Possible sources of heat for such applications are sewage water, ambient water (e.g. sea, lake and river water), industrial waste heat, geothermal energy, flue gas, waste heat from district cooling and heat from solar seasonal thermal energy storage.^[45]

Large-scale heat pumps for district heating combined with thermal energy storage offer high flexibility for the integration of variable renewable energy. Therefore, they are regarded as a key technology for limiting climate change by phasing out fossil fuels.^[45]^[46] They are also a crucial element of systems which can both heat and cool districts.^[47]

Industrial heating

[edit]

There is great potential to reduce the energy consumption and related greenhouse gas emissions in industry by application of industrial heat pumps, for example for process heat.^[48]^[49] Short payback periods of less than 2 years are possible, while achieving a high reduction of CO₂ emissions (in some cases more than 50%).^[50]^[51] Industrial heat pumps can heat up to 200 °C, and can meet the heating demands of many light industries.^[52]^[53] In Europe alone, 15 GW of heat pumps could be installed in 3,000 facilities in the paper, food and chemicals industries.^[4]

Performance

[edit]

Main article: Coefficient of performance

The performance of a heat pump is determined by the ability of the pump to extract heat from a low temperature environment (the *source*) and deliver it to a higher temperature environment (the *sink*).^[54] Performance varies, depending on installation details, temperature differences, site elevation, location on site, pipe runs, flow rates, and maintenance.

In general, heat pumps work most efficiently (that is, the heat output produced for a given energy input) when the difference between the heat source and the heat sink is small. When using a heat pump for space or water heating, therefore, the heat pump will be most efficient in mild conditions, and decline in efficiency on very cold days. Performance metrics supplied to consumers attempt to take this variation into

account.

Common performance metrics are the SEER (in cooling mode) and seasonal coefficient of performance (SCOP) (commonly used just for heating), although SCOP can be used for both modes of operation.^[54] Larger values of either metric indicate better performance.^[54] When comparing the performance of heat pumps, the term *performance* is preferred to *efficiency*, with coefficient of performance (COP) being used to describe the ratio of useful heat movement per work input.^[54] An electrical resistance heater has a COP of 1.0, which is considerably lower than a well-designed heat pump which will typically have a COP of 3 to 5 with an external temperature of 10 °C and an internal temperature of 20 °C. Because the ground is a constant temperature source, a ground-source heat pump is not subjected to large temperature fluctuations, and therefore is the most energy-efficient type of heat pump.^[54]

The "seasonal coefficient of performance" (SCOP) is a measure of the aggregate energy efficiency measure over a period of one year which is dependent on regional climate.^[54] One framework for this calculation is given by the Commission Regulation (EU) No. 813/2013.^[55]

A heat pump's operating performance in cooling mode is characterized in the US by either its energy efficiency ratio (EER) or seasonal energy efficiency ratio (SEER), both of which have units of BTU/(h·W) (note that 1 BTU/(h·W) = 0.293 W/W) and larger values indicate better performance.

COP variation with output temperature

| | |
|-----------------------------|-----------------------------|
| | 35 °C |
| Pump type and source | (e.g. |
| Typical use | heated screed floor) |

High-
efficiency
air-source
heat pump
(ASHP), air
at -20 °C[
56]

2.2

Two-stage
ASHP, air Low source
at -20 °C[temperature
57]

2.4

High-
efficiency Low output
ASHP, air temperature
at 0 °C[^{56]}

3.8

Prototype
transcritical
CO

₂ (R744)

heat pump High output
with temperature

3.3

tripartite
gas cooler,
source at
0 °C[^{58]}

Ground-
source

heat pump
(GSHP),
water at
0 °C[^{56]}

5.0

~\AE'~\AE™~\AE~\AE~\AE,-â,,ç~\AE'~\AE,-Â ~\AEç~\AE~\AE-~\AE

| | | |
|---|---------------------------|------|
| GSHP, ground at 10 °C ^[56] | Low output temperature | 7.2 |
| Theoretical Carnot cycle limit, source -20 °C | | 5.6 |
| Theoretical Carnot cycle limit, source 0 °C | | 8.8 |
| Theoretical Lorentzen cycle limit (CO 2 pump), return fluid 25 °C, source 0 °C ^[58] | | 10.1 |
| Theoretical Carnot cycle limit, source 10 °C | | 12.3 |

Carbon footprint

[edit]

The carbon footprint of heat pumps depends on their individual efficiency and how electricity is produced. An increasing share of low-carbon energy sources such as

wind and solar will lower the impact on the climate.

| heating system | emissions of energy source | efficiency | resulting emissions for thermal energy |
|--|--|----------------------------------|--|
| heat pump with onshore wind power | 11 gCO ₂ /kWh ^[59] | 400% (COP=4) | 3 gCO ₂ /kWh |
| heat pump with global electricity mix | 436 gCO ₂ /kWh ^[60] (2022) | 400% (COP=4) | 109 gCO ₂ /kWh |
| natural-gas thermal (high efficiency) | 201 gCO ₂ /kWh ^[61] | 90% ^[citation needed] | 223 gCO ₂ /kWh |
| heat pump electricity by lignite (old power plant) and low performance | 1221 gCO ₂ /kWh ^[61] | 300% (COP=3) | 407 gCO ₂ /kWh |

In most settings, heat pumps will reduce CO₂ emissions compared to heating systems powered by fossil fuels.^[62] In regions accounting for 70% of world energy consumption, the emissions savings of heat pumps compared with a high-efficiency gas boiler are on average above 45% and reach 80% in countries with cleaner electricity mixes.^[4] These values can be improved by 10 percentage points, respectively, with alternative refrigerants. In the United States, 70% of houses could reduce emissions by installing a heat pump.^[63]^[4] The rising share of renewable electricity generation in many countries is set to increase the emissions savings from heat pumps over time.^[4]

Heating systems powered by green hydrogen are also low-carbon and may become competitors, but are much less efficient due to the energy loss associated with hydrogen conversion, transport and use. In addition, not enough green hydrogen is expected to be available before the 2030s or 2040s.^[64]^[65]

Operation

[edit]

See also: Vapor-compression refrigeration



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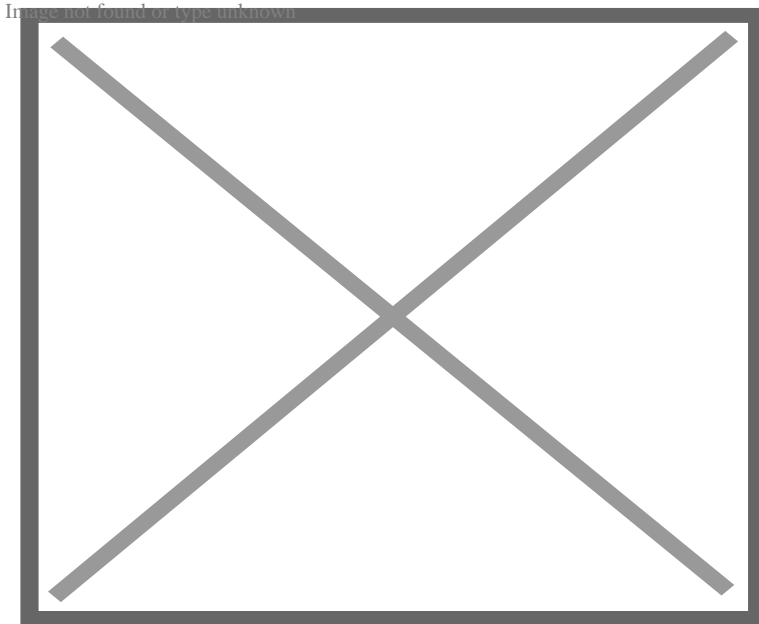
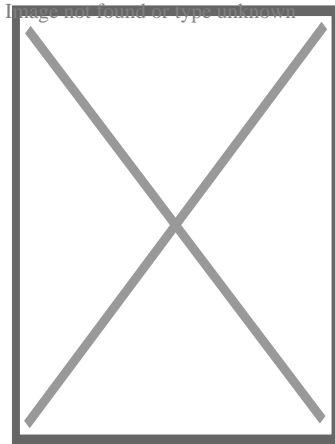
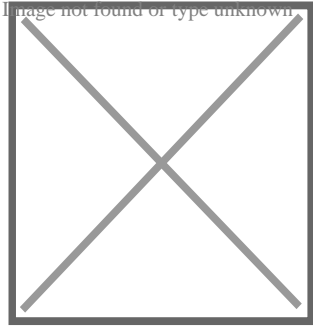


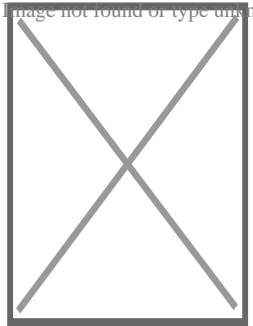
Figure 2: Temperature–entropy diagram of the vapor–compression cycle



An internal view of the outdoor unit of an Ecodan air source heat pump



Large heat pump
setup for a
commercial building



Wiring and
connections to
a central air unit
inside

Vapor-compression uses a circulating refrigerant as the medium which absorbs heat from one space, compresses it thereby increasing its temperature before releasing it in another space. The system normally has eight main components: a compressor, a reservoir, a reversing valve which selects between heating and cooling mode, two thermal expansion valves (one used when in heating mode and the other when used in cooling mode) and two heat exchangers, one associated with the external heat source/sink and the other with the interior. In heating mode the external heat exchanger is the evaporator and the internal one being the condenser; in cooling mode the roles are reversed.

Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor^[66] and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state

known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air flowing across the coil or tubes. In heating mode this heat is used to heat the building using the internal heat exchanger, and in cooling mode this heat is rejected via the external heat exchanger.

The condensed, liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto-refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and-vapor refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.

The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser.

To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor.

Over time, the evaporator may collect ice or water from ambient humidity. The ice is melted through defrosting cycle. An internal heat exchanger is either used to heat/cool the interior air directly or to heat water that is then circulated through radiators or underfloor heating circuit to either heat or cool the buildings.

Improvement of coefficient of performance by subcooling

[edit]

Main article: Subcooling

Heat input can be improved if the refrigerant enters the evaporator with a lower vapor content. This can be achieved by cooling the liquid refrigerant after condensation. The gaseous refrigerant condenses on the heat exchange surface of the condenser. To achieve a heat flow from the gaseous flow center to the wall of the condenser, the temperature of the liquid refrigerant must be lower than the condensation temperature.

Additional subcooling can be achieved by heat exchange between relatively warm liquid refrigerant leaving the condenser and the cooler refrigerant vapor emerging from the evaporator. The enthalpy difference required for the subcooling leads to the superheating of the vapor drawn into the compressor. When the increase in cooling achieved by subcooling is greater than the compressor drive input required to overcome the additional pressure losses, such a heat exchange improves the coefficient of performance.^[67]

One disadvantage of the subcooling of liquids is that the difference between the condensing temperature and the heat-sink temperature must be larger. This leads to a moderately high pressure difference between condensing and evaporating pressure, whereby the compressor energy increases.

Refrigerant choice

[edit]

Main article: Refrigerant

Pure refrigerants can be divided into organic substances (hydrocarbons (HCs), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), hydrofluoroolefins (HFOs), and HCFOs), and inorganic substances (ammonia (NH

3), carbon dioxide (CO

2), and water (H

2O)^[68].[^{69]} Their boiling points are usually below -25 °C.^[70]

In the past 200 years, the standards and requirements for new refrigerants have changed. Nowadays low global warming potential (GWP) is required, in addition to all the previous requirements for safety, practicality, material compatibility, appropriate atmospheric life,^[clarification needed] and compatibility with high-efficiency products. By 2022, devices using refrigerants with a very low GWP still have a small market share but are expected to play an increasing role due to enforced regulations,^[71] as most countries have now ratified the Kigali Amendment to ban HFCs.^[72] Isobutane (R600A) and propane (R290) are far less harmful to the environment than conventional hydrofluorocarbons (HFC) and are already being used in air-source heat pumps.^[73] Propane may be the most suitable for high temperature heat pumps.^[74] Ammonia (R717) and carbon dioxide (R-744) also have a low GWP. As of 2023 smaller CO₂ heat pumps are not widely available and research and development of them continues.^[75] A 2024 report said that refrigerants with GWP are vulnerable to further international restrictions.^[76]

Until the 1990s, heat pumps, along with fridges and other related products used chlorofluorocarbons (CFCs) as refrigerants, which caused major damage to the ozone layer when released into the atmosphere. Use of these chemicals was banned or severely restricted by the Montreal Protocol of August 1987.^[77]

Replacements, including R-134a and R-410A, are hydrofluorocarbons (HFC) with similar thermodynamic properties with insignificant ozone depletion potential (ODP) but had problematic GWP.^[78] HFCs are powerful greenhouse gases which contribute to climate change.^[79]^[80] Dimethyl ether (DME) also gained in popularity as a refrigerant in combination with R404a.^[81] More recent refrigerants include difluoromethane (R32) with a lower GWP, but still over 600.

| refrigerant | 20-year GWP | 100-year GWP |
|-------------------------------|-------------|-------------------|
| R-290 propane ^[82] | 0.072 | 0.02 |
| R-600a isobutane | | 3 ^[83] |
| R-32 ^[82] | 491 | 136 |
| R-410a ^[84] | 4705 | 2285 |

| | | |
|------------------------|------|------|
| R-134a ^[84] | 4060 | 1470 |
| R-404a ^[84] | 7258 | 4808 |

Devices with R-290 refrigerant (propane) are expected to play a key role in the future.^{[74][85]} The 100-year GWP of propane, at 0.02, is extremely low and is approximately 7000 times less than R-32. However, the flammability of propane requires additional safety measures: the maximum safe charges have been set significantly lower than for lower flammability refrigerants (only allowing approximately 13.5 times less refrigerant in the system than R-32).^{[86][87][88]} This means that R-290 is not suitable for all situations or locations. Nonetheless, by 2022, an increasing number of devices with R-290 were offered for domestic use, especially in Europe.^[citation needed]

At the same time,^[when?] HFC refrigerants still dominate the market. Recent government mandates have seen the phase-out of R-22 refrigerant. Replacements such as R-32 and R-410A are being promoted as environmentally friendly but still have a high GWP.^[89] A heat pump typically uses 3 kg of refrigerant. With R-32 this amount still has a 20-year impact equivalent to 7 tons of CO₂, which corresponds to two years of natural gas heating in an average household. Refrigerants with a high ODP have already been phased out.^[citation needed]

Government incentives

[edit]

Financial incentives aim to protect consumers from high fossil gas costs and to reduce greenhouse gas emissions,^[90] and are currently available in more than 30 countries around the world, covering more than 70% of global heating demand in 2021.^[4]

Australia

[edit]

Food processors, brewers, petfood producers and other industrial energy users are exploring whether it is feasible to use renewable energy to produce industrial-grade heat. Process heating accounts for the largest share of onsite energy use in Australian manufacturing, with lower-temperature operations like food production particularly well-suited to transition to renewables.

To help producers understand how they could benefit from making the switch, the Australian Renewable Energy Agency (ARENA) provided funding to the Australian Alliance for Energy Productivity (A2EP) to undertake pre-feasibility studies at a range of sites around Australia, with the most promising locations advancing to full feasibility studies.^[91]

In an effort to incentivize energy efficiency and reduce environmental impact, the Australian states of Victoria, New South Wales, and Queensland have implemented rebate programs targeting the upgrade of existing hot water systems. These programs specifically encourage the transition from traditional gas or electric systems to heat pump based systems.^{[92][93][94][95][96]}

Canada

[edit]

In 2022, the Canada Greener Homes Grant^[97] provides up to \$5000 for upgrades (including certain heat pumps), and \$600 for energy efficiency evaluations.

China

[edit]

Purchase subsidies in rural areas in the 2010s reduced burning coal for heating, which had been causing ill health.^[98]

In the 2024 report by the International Energy Agency (IEA) titled "The Future of Heat Pumps in China," it is highlighted that China, as the world's largest market for heat pumps in buildings, plays a critical role in the global industry. The country

accounts for over one-quarter of global sales, with a 12% increase in 2023 alone, despite a global sales dip of 3% the same year.^[99]

Heat pumps are now used in approximately 8% of all heating equipment sales for buildings in China as of 2022, and they are increasingly becoming the norm in central and southern regions for both heating and cooling. Despite their higher upfront costs and relatively low awareness, heat pumps are favored for their energy efficiency, consuming three to five times less energy than electric heaters or fossil fuel-based solutions. Currently, decentralized heat pumps installed in Chinese buildings represent a quarter of the global installed capacity, with a total capacity exceeding 250 GW, which covers around 4% of the heating needs in buildings.^[99]

Under the Announced Pledges Scenario (APS), which aligns with China's carbon neutrality goals, the capacity is expected to reach 1,400 GW by 2050, meeting 25% of heating needs. This scenario would require an installation of about 100 GW of heat pumps annually until 2050. Furthermore, the heat pump sector in China employs over 300,000 people, with employment numbers expected to double by 2050, underscoring the importance of vocational training for industry growth. This robust development in the heat pump market is set to play a significant role in reducing direct emissions in buildings by 30% and cutting PM2.5 emissions from residential heating by nearly 80% by 2030.^[99]^[100]

European Union

[edit]

To speed up the deployment rate of heat pumps, the European Commission launched the Heat Pump Accelerator Platform in November 2024.^[101] It will encourage industry experts, policymakers, and stakeholders to collaborate, share best practices and ideas, and jointly discuss measures that promote sustainable heating solutions.^[102]

United Kingdom

[edit]

As of 2022: heat pumps have no Value Added Tax (VAT) although in Northern Ireland they are taxed at the reduced rate of 5% instead of the usual level of VAT of 20% for most other products.^[103] As of 2022 the installation cost of a heat pump is more than a gas boiler, but with the "Boiler Upgrade Scheme"^[104] government grant and assuming electricity/gas costs remain similar their lifetime costs would be similar on average.^[105] However lifetime cost relative to a gas boiler varies considerably depending on several factors, such as the quality of the heat pump installation and the tariff used.^[106] In 2024 England was criticised for still allowing new homes to be built with gas boilers, unlike some other counties where this is banned.^[107]

United States

[edit]

Further information: Environmental policy of the Joe Biden administration and Climate change in the United States

The High-efficiency Electric Home Rebate Program was created in 2022 to award grants to State energy offices and Indian Tribes in order to establish state-wide high-efficiency electric-home rebates. Effective immediately, American households are eligible for a tax credit to cover the costs of buying and installing a heat pump, up to \$2,000. Starting in 2023, low- and moderate-level income households will be eligible for a heat-pump rebate of up to \$8,000.^[108]

In 2022, more heat pumps were sold in the United States than natural gas furnaces.^[109]

In November 2023 Biden's administration allocated 169 million dollars from the Inflation Reduction Act to speed up production of heat pumps. It used the Defense Production Act to do so, because according to the administration, energy that is better for the climate is also better for national security.^[110]

Notes

[edit]

1. ^ As explained in Coefficient of performance TheoreticalMaxCOP = $(\text{desiredIndoorTempC} + 273) \div (\text{desiredIndoorTempC} - \text{outsideTempC}) = (7+273) \div (7 - (-3)) = 280 \div 10 = 28$ [10]
2. ^ As explained in Coefficient of performance TheoreticalMaxCOP = $(\text{desiredIndoorTempC} + 273) \div (\text{desiredIndoorTempC} - \text{outsideTempC}) = (27+273) \div (27 - (-3)) = 300 \div 30 = 10$ [10]

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Heating, ventilation, and air conditioning

**Fundamental
concepts**

- Air changes per hour
- Bake-out
- Building envelope
- Convection
- Dilution
- Domestic energy consumption
- Enthalpy
- Fluid dynamics
- Gas compressor
- Heat pump and refrigeration cycle
- Heat transfer
- Humidity
- Infiltration
- Latent heat
- Noise control
- Outgassing
- Particulates
- Psychrometrics
- Sensible heat
- Stack effect
- Thermal comfort
- Thermal destratification
- Thermal mass
- Thermodynamics
- Vapour pressure of water

- Absorption-compression heat pump
- Absorption refrigerator
- Air barrier
- Air conditioning
- Antifreeze
- Automobile air conditioning
- Autonomous building
- Building insulation materials
- Central heating
- Central solar heating
- Chilled beam
- Chilled water
- Constant air volume (CAV)
- Coolant
- Cross ventilation
- Dedicated outdoor air system (DOAS)
- Deep water source cooling
- Demand controlled ventilation (DCV)
- Displacement ventilation
- District cooling
- District heating
- Electric heating
- Energy recovery ventilation (ERV)
- Firestop
- Forced-air
- Forced-air gas
- Free cooling
- Heat recovery ventilation (HRV)
- Hybrid heat
- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling
- Passive daytime radiative cooling
- Passive house

Technology

- Air conditioner inverter
- Air door
- Air filter
- Air handler
- Air ionizer
- Air-mixing plenum
- Air purifier
- Air source heat pump
- Attic fan
- Automatic balancing valve
- Back boiler
- Barrier pipe
- Blast damper
- Boiler
- Centrifugal fan
- Ceramic heater
- Chiller
- Condensate pump
- Condenser
- Condensing boiler
- Convection heater
- Compressor
- Cooling tower
- Damper
- Dehumidifier
- Duct
- Economizer
- Electrostatic precipitator
- Evaporative cooler
- Evaporator
- Exhaust hood
- Expansion tank
- Fan
- Fan coil unit
- Fan filter unit
- Fan heater
- Fire damper

**Measurement
and control**

- Air flow meter
- Aquastat
- BACnet
- Blower door
- Building automation
- Carbon dioxide sensor
- Clean air delivery rate (CADR)
- Control valve
- Gas detector
- Home energy monitor
- Humidistat
- HVAC control system
- Infrared thermometer
- Intelligent buildings
- LonWorks
- Minimum efficiency reporting value (MERV)
- Normal temperature and pressure (NTP)
- OpenTherm
- Programmable communicating thermostat
- Programmable thermostat
- Psychrometrics
- Room temperature
- Smart thermostat
- Standard temperature and pressure (STP)
- Thermographic camera
- Thermostat
- Thermostatic radiator valve

**Professions,
trades,
and services**

- Architectural acoustics
- Architectural engineering
- Architectural technologist
- Building services engineering
- Building information modeling (BIM)
- Deep energy retrofit
- Duct cleaning
- Duct leakage testing
- Environmental engineering
- Hydronic balancing
- Kitchen exhaust cleaning
- Mechanical engineering
- Mechanical, electrical, and plumbing
- Mold growth, assessment, and remediation
- Refrigerant reclamation
- Testing, adjusting, balancing
- AHRI
- AMCA
- ASHRAE
- ASTM International
- BRE
- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC
- Indoor air quality (IAQ)
- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)

**Industry
organizations**

Health and safety

See also

- ASHRAE Handbook
- Building science
- Fireproofing
- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

- Germany
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Things To Do in Tulsa County

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The Cave House

4.6 (249)

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Bob Dylan Center

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The Blue Dome

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Philbrook Museum of Art

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Oxley Nature Center

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Driving Directions From Bob Dylan Center to Durham Supply Inc

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Driving Directions From Route 66 Historical Village to Durham Supply Inc

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Reviews for Durham Supply Inc

Durham Supply Inc

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Dennis Champion

(5)

Durham supply and Royal supply seems to find the most helpful and friendly people to work in their stores, we are based out of Kansas City out here for a few remodels and these guys treated us like we've gone there for years.

Durham Supply Inc

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B Mann

(5)

I was in need of some items for a double wide that I am remodeling and this place is the only place in town that had what I needed (I didn't even try the other rude place)while I was there I learned the other place that was in Tulsa that also sold mobile home supplies went out of business (no wonder the last time I was in there they were VERY RUDE and high priced) I like the way Dunham does business they answered all my questions and got me the supplies I needed, very friendly, I will be back to purchase the rest of my items when the time comes.

Durham Supply Inc

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Ty Spears

(5)

Bought a door/storm door combo. Turns out it was the wrong size. They swapped it out, quick and easy no problems. Very helpful in explaining the size differences from standard door sizes.

Durham Supply Inc

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Gerald Clifford Brewster

(5)

We will see, the storm door I bought says on the tag it's 36x80, but it's 34x80. If they return it.....they had no problems returning it. And it was no fault of there's, you measure a mobile home door different than a standard door!

Protecting Mobile Home Furnaces During Low Temperature Periods [View GBP](#)

Royal Supply Inc

Phone : +16362969959

City : Oklahoma City

State : OK

Zip : 73149

Address : Unknown Address

Google Business Profile

Company Website : <https://royal-durhamsupply.com/locations/oklahoma-city-oklahoma/>

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