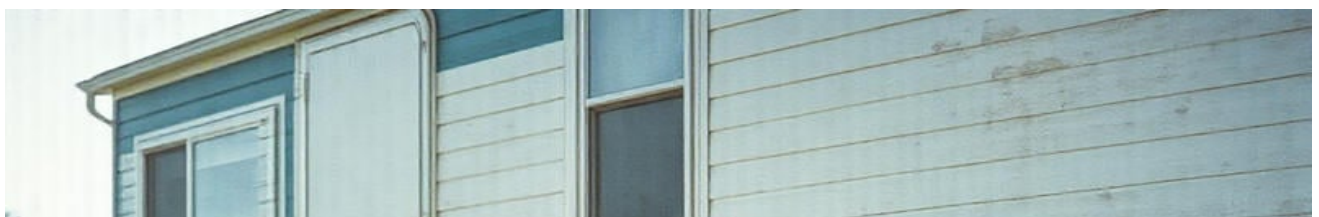


Air Quality



- **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**



Balancing Heat Needs in Mobile Homes Across Different Regions

Importance of Efficient Duct Layouts for Airflow

Mobile homes, often seen as a symbol of affordable living, present unique challenges when it comes to heating and cooling. The compact nature and sometimes less robust insulation of mobile homes require specialized HVAC systems to ensure comfort across various climates. Balancing heat needs in these dwellings is crucial, especially given the diverse weather conditions encountered across different regions.

To meet these demands, mobile home HVAC systems are specifically designed with features that cater to the structural nuances of manufactured housing. Vent placement impacts the effectiveness of heating and cooling in mobile homes **hvac for mobile home** energy conservation. Unlike traditional brick-and-mortar houses, mobile homes may have thinner walls and floors, necessitating efficient heating solutions that can rapidly warm up the space without wasting energy. A predominant choice for many mobile homeowners is a packaged unit system. These all-in-one systems combine both heating and cooling capabilities in a single unit, typically installed outside the home.

They are space-saving and deliver reliable performance tailored to the size and requirements of mobile homes.

In colder regions like the northern United States or Canada, maintaining warmth during harsh winters becomes paramount. Here, furnace-based HVAC systems might be more prevalent due to their effectiveness in delivering consistent heat even at low temperatures. These furnaces are often powered by natural gas or propane, providing a cost-effective solution compared to electric alternatives.

Conversely, in warmer climates such as those found in southern states or coastal areas, air conditioning takes precedence over heating needs. Heat pumps become an attractive option here due to their dual functionality; they offer cooling during hot months and can reverse operation to provide heat when temperatures drop slightly in winter months.

Regardless of the region, adequate insulation significantly impacts the efficiency of any HVAC system in a mobile home. Proper sealing around windows and doors prevents drafts and reduces energy consumption by ensuring that heated or cooled air remains inside for longer periods.

Moreover, advancements in technology have led to more sophisticated thermostats that allow homeowners greater control over their environment. Smart thermostats enable scheduling temperature adjustments based on occupancy patterns or remote modifications via smartphone apps—ensuring optimal use without unnecessary energy expenditure.

Additionally, routine maintenance plays an essential role in sustaining system efficiency regardless of climate conditions. Regular filter replacement, duct cleaning, and system check-ups help prevent breakdowns while enhancing performance throughout seasonal transitions.

Ultimately, balancing heat needs in mobile homes across different regions requires thoughtful consideration of local climate conditions alongside personal preferences for comfort and budget constraints. As technology continues evolving within this sector—bringing innovations like solar-powered units or eco-friendly refrigerants—the future promises even more efficient ways of managing indoor climates within these unique housing structures. By understanding specific requirements based on regional influences combined with proactive maintenance practices—mobile homeowners can achieve year-round comfort no matter where they reside on the map.

Balancing the heating needs in mobile homes across different regions is a challenge that underscores the profound impact of regional climate variations. Mobile homes, often characterized by their lightweight construction and limited insulation compared to traditional houses, are particularly sensitive to external temperature fluctuations. This sensitivity makes it imperative to understand how climate differences affect heating requirements, ensuring comfort and energy efficiency for residents.

The United States presents a diverse tapestry of climatic conditions, from the icy winters of the Midwest to the mild temperatures of the Southern states. These variations necessitate tailored approaches to heating mobile homes. In colder regions, such as the Northeast or upper Midwest, extreme winter temperatures demand robust heating solutions. Mobile home owners in these areas often rely on high-efficiency furnaces or heat pumps capable of delivering consistent warmth despite sub-zero conditions. Additionally, insulation plays a crucial role; enhancing wall and roof insulation can significantly reduce heat loss, making homes more energy-efficient and comfortable during harsh winters.

In contrast, mobile homes located in milder climates like those found in southern California or Florida face different challenges. While heating needs may not be as intense as those in colder regions, maintaining a comfortable indoor climate still requires attention during cooler months. Residents here might prioritize systems that offer flexibility—such as dual-purpose units that provide both air conditioning and heating—to accommodate

fluctuating seasonal temperatures efficiently.

Regional climate variations also influence energy consumption patterns and costs associated with heating mobile homes. In areas where fossil fuels are predominantly used for home heating, colder climates can lead to significant spikes in utility bills during winter months. Conversely, regions with less severe winters might experience more stable energy costs but could benefit from investment in alternative technologies like solar panels or geothermal systems that further enhance efficiency and sustainability.

The impact of climate on mobile home heating is not solely technical but also socio-economic. Lower-income households are disproportionately affected by high energy costs; thus, improving thermal performance through better insulation and efficient heating systems can alleviate financial burdens while contributing positively to environmental goals by reducing carbon emissions.

In conclusion, addressing the diverse heating needs of mobile homes across varying regional climates requires an understanding that transcends mere technical adjustments—it demands a holistic approach involving improved infrastructure, adoption of advanced technologies, and consideration for socio-economic factors. By embracing these strategies, we can ensure that all residents enjoy safe, warm environments regardless of their geographic location while promoting sustainability and resilience against changing climatic conditions.

Posted by on

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Techniques for Mapping Duct Layouts

Evaluating energy efficiency in mobile homes is a crucial endeavor, especially when considering the diverse climatic demands across different regions. Mobile homes, often viewed as affordable housing solutions, have historically been associated with poor insulation and higher energy consumption. However, advancements in building technologies and materials are changing this narrative, making energy efficiency an attainable goal even for these traditionally challenging structures.

Balancing heat needs in mobile homes involves understanding the unique challenges posed by various climates—from the frigid winters of northern regions to the scorching summers of the south. In colder climates, mobile homes must be equipped with adequate

insulation to prevent heat loss. This can be achieved through improved wall and roof insulation, double-glazed windows, and weather stripping around doors and windows. These measures not only reduce heating costs but also enhance comfort significantly during harsh winters.

Conversely, in warmer climates, the focus shifts towards minimizing heat gain. Reflective roofing materials can deflect sunlight, while thermal barriers within walls can help keep interiors cooler. Additionally, installing efficient air conditioning systems or even evaporative coolers can be beneficial in managing indoor temperatures without excessively high electricity bills.

The challenge lies in striking a balance between these heating and cooling needs while maintaining affordability—a central appeal of mobile homes. Energy-efficient upgrades might seem costly upfront; however, they offer long-term savings on utility bills and contribute positively to environmental sustainability by reducing overall energy consumption.

Moreover, government incentives for energy-efficient home improvements can alleviate initial financial burdens on homeowners. Programs that provide tax credits or rebates for installing solar panels or upgrading insulation make it easier for mobile home owners to invest in these essential modifications.

Ultimately, evaluating energy efficiency in mobile homes requires a multifaceted approach that considers regional climate variations alongside economic constraints faced by owners. By leveraging modern technology and design innovations tailored to specific geographical needs, we can ensure that mobile homes remain viable living options that offer both comfort and cost-effectiveness throughout all seasons. As society continues to prioritize sustainable living practices, improving the energy efficiency of mobile homes stands as both a practical necessity and an opportunity for innovation in housing solutions nationwide.





Tools and Technologies for Accurate Duct Mapping

Balancing heat needs in mobile homes across different regions presents a unique challenge due to the varying climates these homes encounter. Mobile homes, often designed with standard features, must adapt to extreme temperatures ranging from frigid northern winters to sweltering southern summers. To optimize heat distribution effectively, it is crucial to consider strategies tailored to these diverse climatic conditions.

In colder climates, retaining heat becomes paramount. One of the most effective strategies involves enhancing insulation. Upgrading walls, roofs, and floors with high-quality insulating materials can significantly reduce heat loss. Double-glazed windows and weather stripping around doors also play a critical role in maintaining warmth within the home. Additionally, installing programmable thermostats allows homeowners to efficiently manage heating systems by adjusting temperatures based on occupancy patterns and outdoor conditions.

Conversely, in warmer regions where cooling is essential, a different approach is required. Reflective roofing materials can deflect sunlight and reduce indoor temperatures significantly. Ventilation systems that promote airflow are vital; strategically placed vents and fans can expel warm air while drawing cooler air inside. Moreover, window treatments like reflective films or shades can prevent excessive solar gain.

For regions experiencing both extremes of temperature throughout the year, flexibility is key. Dual-purpose HVAC systems capable of both heating and cooling provide a versatile solution for mobile homes in such areas. These systems should be complemented by energy-efficient practices such as sealing leaks around windows and doors to prevent unwanted thermal exchange.

Energy sources also play an integral part in optimizing heat distribution. In many cases, incorporating renewable energy solutions such as solar panels can offer sustainable heating options without reliance on traditional fuel sources that may fluctuate in cost or

availability based on location.

Ultimately, successful heat management in mobile homes requires a multifaceted approach that considers regional climate variations and individual home characteristics. By employing strategic insulation techniques, enhancing ventilation for cooling efficiency, adopting flexible HVAC systems for dual-climate adaptability, and exploring renewable energy options, homeowners can achieve optimized heat distribution tailored specifically to their environmental context. This holistic strategy not only ensures comfort but also promotes energy efficiency—a critical consideration as we strive towards more sustainable living environments across all housing types and geographic locales.

Best Practices for Cleaner Airflow

In recent years, advancements in HVAC technology have played a pivotal role in transforming the living conditions within mobile homes, particularly when it comes to balancing heat needs across various regions. Mobile homes, often perceived as less insulated and more vulnerable to temperature fluctuations compared to traditional houses, have historically faced challenges in maintaining consistent indoor climates. However, modern HVAC innovations are bridging this gap by offering tailored solutions that address the unique heating and cooling demands of these dwellings.

One of the most significant advancements has been the development of mini-split systems. These ductless units provide customizable climate control on a room-by-room

basis, which is especially beneficial for mobile homes with their compact and often segmented layouts. Unlike traditional systems that may be too powerful or inefficient for smaller spaces, mini-splits offer precision without sacrificing efficiency. They allow homeowners to adjust temperatures according to specific needs and usage patterns, thereby optimizing energy consumption and reducing utility costs.

Another breakthrough is the integration of smart thermostats. These devices bring a high level of intelligence to HVAC systems by learning occupants' habits and preferences over time. In mobile homes located in diverse climatic regions—from the cold northern states to the warm southern areas—smart thermostats can automatically adjust settings based on weather predictions or occupancy patterns. This adaptability ensures that heating is neither excessive nor insufficient, enhancing comfort while minimizing energy waste.

Furthermore, improvements in insulation materials and techniques have complemented HVAC advancements by preventing unwanted heat exchange between the interior and exterior environments of mobile homes. High-performance insulation reduces thermal bridging and air leakage, ensuring that any heat generated is retained more effectively within the home during colder months. This synergy between robust insulation and advanced heating technologies creates an efficient ecosystem where less energy is required to maintain desired indoor temperatures.

Heat pumps also stand out as an innovative solution for balancing heat needs in different regions. Modern heat pumps are designed to operate efficiently even at lower temperatures than earlier models could handle. They draw heat from external sources like air or ground—even when it's cold outside—and transfer it inside, making them a versatile option for both heating and cooling throughout varying seasonal changes across different geographical locations.

In conclusion, advancements in HVAC technology are crucial for ensuring comfort and efficiency in mobile homes situated across different regions with varying climate

demands. Mini-split systems provide flexibility; smart thermostats offer intelligent management; improved insulation boosts system performance; and modern heat pumps deliver effective temperature regulation—all contributing significantly toward achieving balanced heating solutions tailored specifically for mobile home environments. As these technologies continue to evolve, we can expect further enhancements that will make mobile living not only more comfortable but also more sustainable for future generations.





Case Studies of Improved Air Quality in Mobile Homes

Balancing heat needs in mobile homes across different regions demands innovative and cost-effective solutions, as these structures often face unique challenges when it comes to temperature regulation. Mobile homes, by their very nature, are less insulated than traditional houses and can be more susceptible to external climate variations. This makes it essential for owners to find affordable ways to maintain comfortable temperatures year-round.

One fundamental strategy is enhancing the insulation of mobile homes. While this may seem like an upfront investment, the long-term savings on energy bills make it a cost-effective solution. Proper insulation minimizes heat loss during cold months and keeps the interior cool when temperatures rise. By upgrading windows to double-glazed options or adding thermal curtains, residents can significantly reduce energy consumption while maintaining comfort.

Another approach is utilizing programmable thermostats. These devices allow homeowners to set specific temperatures for different times of the day, ensuring that heating systems operate only when necessary. In regions where temperature fluctuations are common, this can lead to substantial savings on heating costs without sacrificing comfort.

For those living in particularly sunny areas, investing in solar panels can be a sustainable and economical choice. Solar power provides a renewable energy source that not only supports heating systems but also reduces overall electricity expenses. Although the initial installation might be costly, government incentives and decreasing technology prices have made solar panels more accessible than ever before.

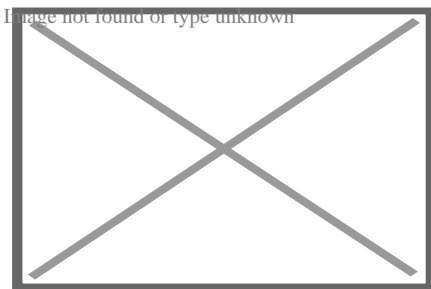
In addition, mobile home owners should consider using portable space heaters or mini-split HVAC systems tailored to their specific regional needs. These options offer targeted heating solutions that do not require extensive ductwork or permanent installations,

making them ideal for temporary or transitional housing situations.

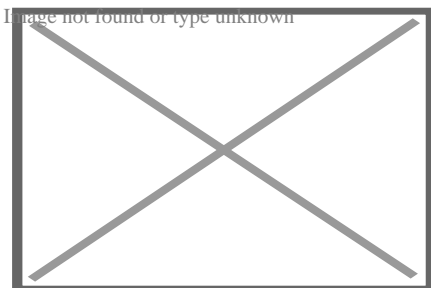
Finally, simple lifestyle adjustments can also contribute significantly to maintaining comfortable temperatures cost-effectively. Wearing layers indoors during colder months or employing ceiling fans in summer can help regulate body temperature without over-relying on mechanical systems.

In conclusion, balancing heat needs in mobile homes across diverse climates involves a combination of enhanced insulation, smart technology use, renewable energy adoption, adjustable heating solutions, and mindful lifestyle choices. By embracing these strategies, homeowners can achieve comfort while keeping costs under control—a truly cost-effective solution for all seasons and regions.

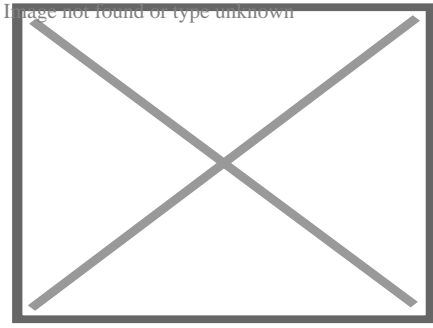
About Heating, ventilation, and air conditioning



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

[edit]

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

[edit]

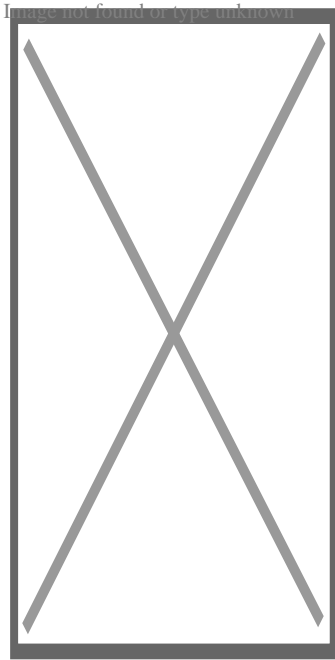
"Heater" redirects here. For other uses, see Heater (disambiguation).

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

[edit]



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

[edit]

Water/steam

[edit]

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

[edit]

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.

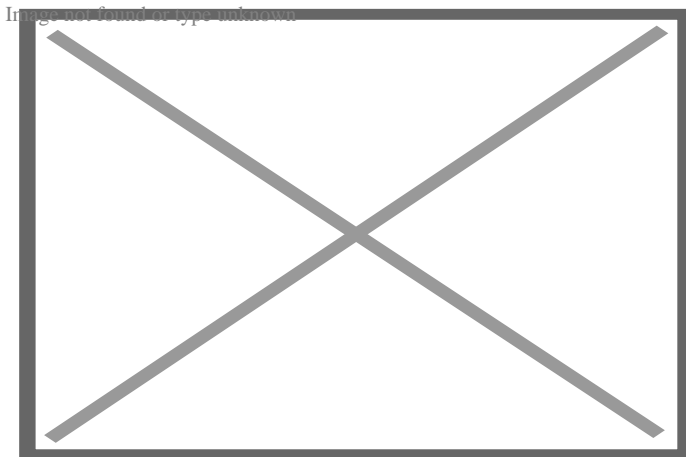
Although ventilation is an integral component of maintaining good indoor air quality, it may not be satisfactory alone.^[18] A clear understanding of both indoor and outdoor air quality parameters is needed to improve the performance of ventilation in terms of ...^[19] In scenarios where outdoor pollution 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]

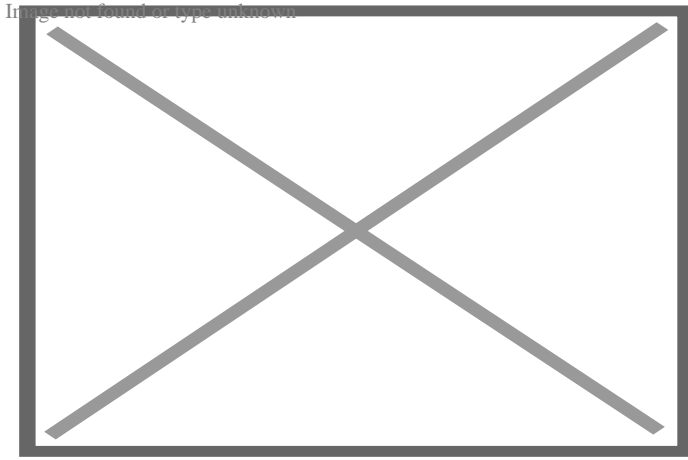
Mechanical or forced

[edit]

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.

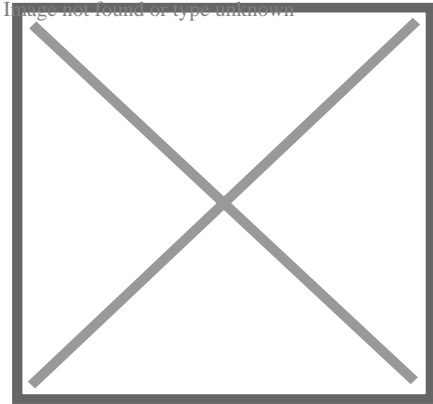
Kitchens and bathrooms typically have mechanical exhausts to control odors and sometimes humidity. Factors in the design of such systems include the flow rate (which is a function of the fan speed and exhaust vent size) and noise level. Direct drive fans are available for many applications and can reduce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

[edit]

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]

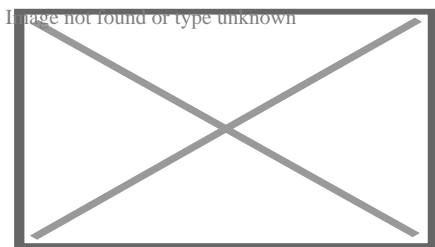
Room pressure can be either positive or negative with respect to outside the room. Positive pressure occurs when there is more air being supplied than exhausted, and is common to reduce the infiltration of outside contaminants.^[23]

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*]

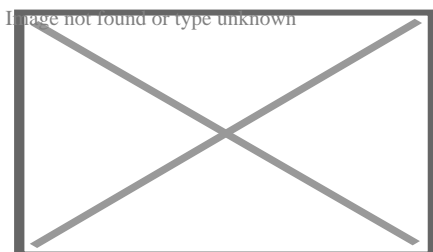
Air conditioning and refrigeration are provided through the removal of heat. Heat can be removed through radiation, convection, or conduction. The heat transfer medium is a refrigeration system, such as water, air, ice, and chemicals are referred to as refrigerants. A refrigerant is employed either in 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]

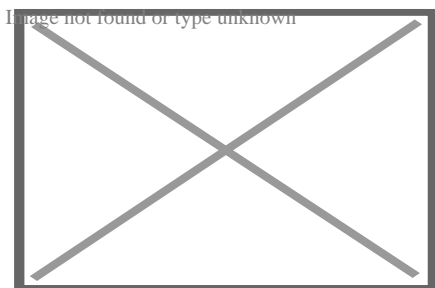
Main article: Demand controlled ventilation

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](#)
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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

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

**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

**Industry
organizations**

- BRE
- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC
- Indoor air quality (IAQ)

Health and safety

- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)

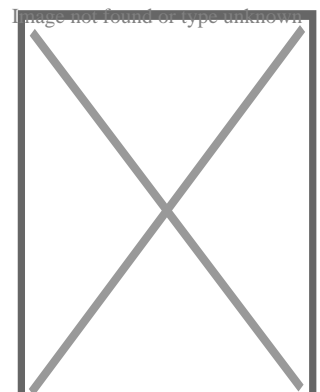
See also

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

- v
- t
- e

Home automation

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



- 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

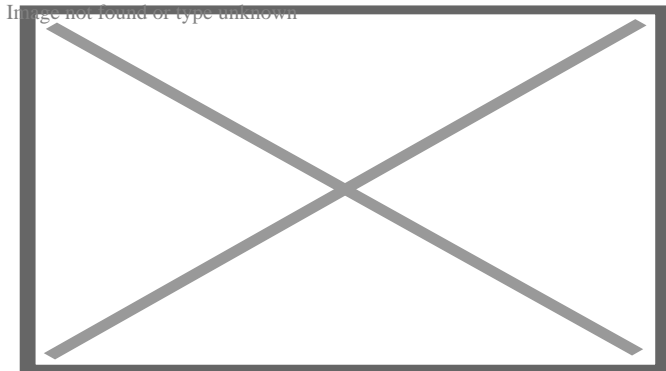
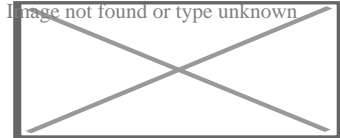
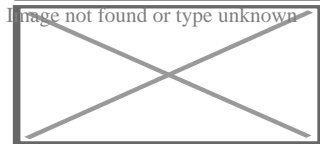
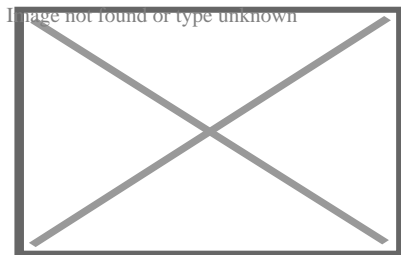
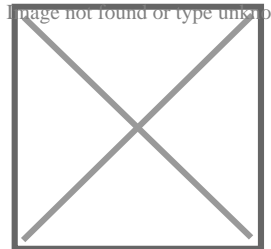
See also

[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](#)

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About Air conditioning

This article is about cooling of air. For the Curved Air album, see Air Conditioning (album). For a similar device capable of both cooling and heating, see heat pump. "a/c" redirects here. For the abbreviation used in banking and book-keeping, see Account (disambiguation). For other uses, see AC.



There are various types of air conditioners. Popular examples include: Window-mounted air conditioner (Suriname, 1955); Ceiling-mounted cassette air conditioner (China, 2023); Wall-mounted air

conditioner (Japan, 2020); Ceiling-mounted console (Also called ceiling suspended) air conditioner (China, 2023); and portable air conditioner (Vatican City, 2018).

Air conditioning, often abbreviated as **A/C** (US) or **air con** (UK),^[1] is the process of removing heat from an enclosed space to achieve a more comfortable interior temperature (sometimes referred to as 'comfort cooling') and in some cases also strictly controlling the humidity of internal air. Air conditioning can be achieved using a mechanical 'air conditioner' or by other methods, including passive cooling and ventilative cooling.^{[2][3]} Air conditioning is a member of a family of systems and techniques that provide heating, ventilation, and air conditioning (HVAC).^[4] Heat pumps are similar in many ways to air conditioners, but use a reversing valve to allow them both to heat and to cool an enclosed space.^[5]

Air conditioners, which typically use vapor-compression refrigeration, range in size from small units used in vehicles or single rooms to massive units that can cool large buildings.^[6] Air source heat pumps, which can be used for heating as well as cooling, are becoming increasingly common in cooler climates.

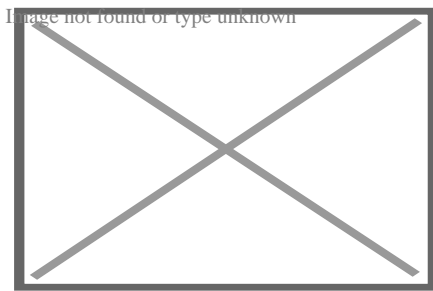
Air conditioners can reduce mortality rates due to higher temperature.^[7] According to the International Energy Agency (IEA) 1.6 billion air conditioning units were used globally in 2016.^[8] The United Nations called for the technology to be made more sustainable to mitigate climate change and for the use of alternatives, like passive cooling, evaporative cooling, selective shading, windcatchers, and better thermal insulation.

History

[edit]

Air conditioning dates back to prehistory.^[9] Double-walled living quarters, with a gap between the two walls to encourage air flow, were found in the ancient city of Hamoukar, in modern Syria.^[10] Ancient Egyptian buildings also used a wide variety of passive air-conditioning techniques.^[11] These became widespread from the Iberian Peninsula through North Africa, the Middle East, and Northern India.^[12]

Passive techniques remained widespread until the 20th century when they fell out of fashion and were replaced by powered air conditioning. Using information from engineering studies of traditional buildings, passive techniques are being revived and modified for 21st-century architectural designs.^[13]^[12]



An array of air conditioner condenser units outside a commercial office building

Air conditioners allow the building's indoor environment to remain relatively constant, largely independent of changes in external weather conditions and internal heat loads. They also enable deep plan buildings to be created and have allowed people to live comfortably in hotter parts of the world.^[14]

Development

[edit]

Preceding discoveries

[edit]

In 1558, Giambattista della Porta described a method of chilling ice to temperatures far below its freezing point by mixing it with potassium nitrate (then called "nitre") in his popular science book *Natural Magic*.^[15]^[16]^[17] In 1620, Cornelis Drebbel demonstrated "Turning Summer into Winter" for James I of England, chilling part of the Great Hall of Westminster Abbey with an apparatus of troughs and vats.^[18] Drebbel's contemporary Francis Bacon, like della Porta a believer in science communication, may not have been present at the demonstration, but in a book published later the same year, he described it as "experiment of artificial freezing" and said that "Nitre (or rather its spirit) is very cold, and hence nitre or salt when added to snow or ice intensifies the cold of the latter, the nitre by adding to its cold, but the salt by supplying activity to the cold of the snow."^[15]

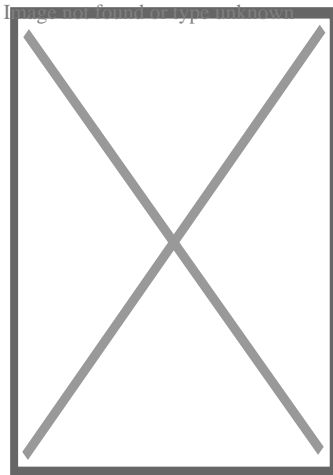
In 1758, Benjamin Franklin and John Hadley, a chemistry professor at the University of Cambridge, conducted experiments applying the principle of evaporation as a means to cool an object rapidly. Franklin and Hadley confirmed that the evaporation of highly volatile liquids (such as alcohol and ether) could be used to drive down the temperature of an object past the freezing point of water. They experimented with the bulb of a mercury-in-glass thermometer as their object. They used a bellows to speed up the evaporation. They lowered the temperature of the thermometer bulb down to $-14\text{ }^{\circ}\text{C}$ ($7\text{ }^{\circ}\text{F}$) while the ambient temperature was $18\text{ }^{\circ}\text{C}$ ($64\text{ }^{\circ}\text{F}$). Franklin noted that soon after they passed the freezing point of water $0\text{ }^{\circ}\text{C}$ ($32\text{ }^{\circ}\text{F}$), a thin film of ice formed on the surface of the thermometer's bulb and that the ice mass was about 6 mm ($1/4$ in) thick when they stopped the experiment upon reaching $-14\text{ }^{\circ}\text{C}$ ($7\text{ }^{\circ}\text{F}$). Franklin concluded: "From this experiment, one may see the possibility of freezing a man to death on a warm summer's day."^[19]

The 19th century included many developments in compression technology. In 1820, English scientist and inventor Michael Faraday discovered that compressing and liquefying ammonia could chill air when the liquefied ammonia was allowed to evaporate.^[20] In 1842, Florida physician John Gorrie used compressor technology to create ice, which he used to cool air for his patients in his hospital in Apalachicola, Florida. He hoped to eventually use his ice-making machine to regulate the

temperature of buildings.^{[20][21]} He envisioned centralized air conditioning that could cool entire cities. Gorrie was granted a patent in 1851,^[22] but following the death of his main backer, he was not able to realize his invention.^[23] In 1851, James Harrison created the first mechanical ice-making machine in Geelong, Australia, and was granted a patent for an ether vapor-compression refrigeration system in 1855 that produced three tons of ice per day.^[24] In 1860, Harrison established a second ice company. He later entered the debate over competing against the American advantage of ice-refrigerated beef sales to the United Kingdom.^[24]

First devices

[edit]



Willis Carrier, who is credited with building the first modern electrical air conditioning unit

Electricity made the development of effective units possible. In 1901, American inventor Willis H. Carrier built what is considered the first modern electrical air conditioning unit.^{[25][26][27][28]} In 1902, he installed his first air-conditioning system, in the Sackett-Wilhelms Lithographing & Publishing Company in Brooklyn, New York.^[29] His invention controlled both the temperature and humidity, which helped maintain consistent paper dimensions and ink alignment at the printing plant. Later, together with six other employees, Carrier formed The Carrier Air Conditioning Company of America, a business that in 2020 employed 53,000

people and was valued at \$18.6 billion.^[30]^[31]

In 1906, Stuart W. Cramer of Charlotte, North Carolina, was exploring ways to add moisture to the air in his textile mill. Cramer coined the term "air conditioning" in a patent claim which he filed that year, where he suggested that air conditioning was analogous to "water conditioning", then a well-known process for making textiles easier to process.^[32] He combined moisture with ventilation to "condition" and change the air in the factories; thus, controlling the humidity that is necessary in textile plants. Willis Carrier adopted the term and incorporated it into the name of his company.^[33]

Domestic air conditioning soon took off. In 1914, the first domestic air conditioning was installed in Minneapolis in the home of Charles Gilbert Gates. It is, however, possible that the considerable device (c. 2.1 m × 1.8 m × 6.1 m; 7 ft × 6 ft × 20 ft) was never used, as the house remained uninhabited^[20] (Gates had already died in October 1913.)

In 1931, H.H. Schultz and J.Q. Sherman developed what would become the most common type of individual room air conditioner: one designed to sit on a window ledge. The units went on sale in 1932 at US\$10,000 to \$50,000 (the equivalent of \$200,000 to \$1,100,000 in 2023).^[20] A year later, the first air conditioning systems for cars were offered for sale.^[34] Chrysler Motors introduced the first practical semi-portable air conditioning unit in 1935,^[35] and Packard became the first automobile manufacturer to offer an air conditioning unit in its cars in 1939.^[36]

Further development

[edit]

Innovations in the latter half of the 20th century allowed more ubiquitous air conditioner use. In 1945, Robert Sherman of Lynn, Massachusetts, invented a portable, in-window air conditioner that cooled, heated, humidified, dehumidified, and filtered the air.^[37] The first inverter air conditioners were released in

1980–1981.^[38]^[39]

In 1954, Ned Cole, a 1939 architecture graduate from the University of Texas at Austin, developed the first experimental "suburb" with inbuilt air conditioning in each house. 22 homes were developed on a flat, treeless tract in northwest Austin, Texas, and the community was christened the 'Austin Air-Conditioned Village.' The residents were subjected to a year-long study of the effects of air conditioning led by the nation's premier air conditioning companies, builders, and social scientists. In addition, researchers from UT's Health Service and Psychology Department studied the effects on the "artificially cooled humans." One of the more amusing discoveries was that each family reported being troubled with scorpions, the leading theory being that scorpions sought cool, shady places. Other reported changes in lifestyle were that mothers baked more, families ate heavier foods, and they were more apt to choose hot drinks.^[40]^[41]

Air conditioner adoption tends to increase above around \$10,000 annual household income in warmer areas.^[42] Global GDP growth explains around 85% of increased air condition adoption by 2050, while the remaining 15% can be explained by climate change.^[42]

As of 2016 an estimated 1.6 billion air conditioning units were used worldwide, with over half of them in China and USA, and a total cooling capacity of 11,675 gigawatts.^[8]^[43] The International Energy Agency predicted in 2018 that the number of air conditioning units would grow to around 4 billion units by 2050 and that the total cooling capacity would grow to around 23,000 GW, with the biggest increases in India and China.^[8] Between 1995 and 2004, the proportion of urban households in China with air conditioners increased from 8% to 70%.^[44] As of 2015, nearly 100 million homes, or about 87% of US households, had air conditioning systems.^[45] In 2019, it was estimated that 90% of new single-family homes constructed in the US included air conditioning (ranging from 99% in the South to 62% in the West).^[46]^[47]

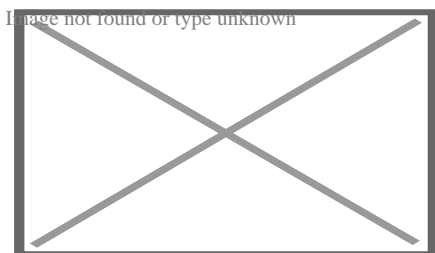
Operation

[edit]

Operating principles

[edit]

Main article: Vapor-compression refrigeration



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

Cooling in traditional air conditioner systems is accomplished using the vapor-compression cycle, which uses a refrigerant's forced circulation and phase change between gas and liquid to transfer heat.^{[48][49]} The vapor-compression cycle can occur within a unitary, or packaged piece of equipment; or within a chiller that is connected to terminal cooling equipment (such as a fan coil unit in an air handler) on its evaporator side and heat rejection equipment such as a cooling tower on its condenser side. An air source heat pump shares many components with an air conditioning system, but includes a reversing valve, which allows the unit to be used to heat as well as cool a space.^[50]

Air conditioning equipment will reduce the absolute humidity of the air processed by the system if the surface of the evaporator coil is significantly cooler than the dew point of the surrounding air. An air conditioner designed for an occupied space will typically achieve a 30% to 60% relative humidity in the occupied space.^[51]

Most modern air-conditioning systems feature a dehumidification cycle during which the compressor runs. At the same time, the fan is slowed to reduce the

evaporator temperature and condense more water. A dehumidifier uses the same refrigeration cycle but incorporates both the evaporator and the condenser into the same air path; the air first passes over the evaporator coil, where it is cooled^[52] and dehumidified before passing over the condenser coil, where it is warmed again before it is released back into the room.^[citation needed]

Free cooling can sometimes be selected when the external air is cooler than the internal air. Therefore, the compressor does not need to be used, resulting in high cooling efficiencies for these times. This may also be combined with seasonal thermal energy storage.^[53]

Heating

[edit]

Main article: Heat pump

Some air conditioning systems can reverse the refrigeration cycle and act as an air source heat pump, thus heating instead of cooling the indoor environment. They are also commonly referred to as "reverse cycle air conditioners". The heat pump is significantly more energy-efficient than electric resistance heating, because it moves energy from air or groundwater to the heated space and the heat from purchased electrical energy. When the heat pump is in heating mode, the indoor evaporator coil switches roles and becomes the condenser coil, producing heat. The outdoor condenser unit also switches roles to serve as the evaporator and discharges cold air (colder than the ambient outdoor air).

Most air source heat pumps become less efficient in outdoor temperatures lower than 4 °C or 40 °F.^[54] This is partly because ice forms on the outdoor unit's heat exchanger coil, which blocks air flow over the coil. To compensate for this, the heat pump system must temporarily switch back into the regular air conditioning mode to switch the outdoor evaporator coil *back* to the condenser coil, to heat up and defrost. Therefore, some heat pump systems will have electric resistance heating in the indoor air path that is activated only in this mode to compensate for the

temporary indoor air cooling, which would otherwise be uncomfortable in the winter.

Newer models have improved cold-weather performance, with efficient heating capacity down to $-14\text{ }^{\circ}\text{F}$ ($-26\text{ }^{\circ}\text{C}$).^[55]^[54]^[56] However, there is always a chance that the humidity that condenses on the heat exchanger of the outdoor unit could freeze, even in models that have improved cold-weather performance, requiring a defrosting cycle to be performed.

The icing problem becomes much more severe with lower outdoor temperatures, so heat pumps are sometimes installed in tandem with a more conventional form of heating, such as an electrical heater, a natural gas, heating oil, or wood-burning fireplace or central heating, which is used instead of or in addition to the heat pump during harsher winter temperatures. In this case, the heat pump is used efficiently during milder temperatures, and the system is switched to the conventional heat source when the outdoor temperature is lower.

Performance

[edit]

Main articles: coefficient of performance, Seasonal energy efficiency ratio, and European seasonal energy efficiency ratio

The coefficient of performance (COP) of an air conditioning system is a ratio of useful heating or cooling provided to the work required.^[57]^[58] Higher COPs equate to lower operating costs. The COP usually exceeds 1; however, the exact value is highly dependent on operating conditions, especially absolute temperature and relative temperature between sink and system, and is often graphed or averaged against expected conditions.^[59] Air conditioner equipment power in the U.S. is often described in terms of "tons of refrigeration", with each approximately equal to the cooling power of one short ton (2,000 pounds (910 kg) of ice melting in

a 24-hour period. The value is equal to 12,000 BTU_{IT} per hour, or 3,517 watts.^[60] Residential central air systems are usually from 1 to 5 tons (3.5 to 18 kW) in capacity.^[citation needed]

The efficiency of air conditioners is often rated by the seasonal energy efficiency ratio (SEER), which is defined by the Air Conditioning, Heating and Refrigeration Institute in its 2008 standard AHRI 210/240, *Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment*.^[61] A similar standard is the European seasonal energy efficiency ratio (ESEER).^[citation needed]

Efficiency is strongly affected by the humidity of the air to be cooled. Dehumidifying the air before attempting to cool it can reduce subsequent cooling costs by as much as 90 percent. Thus, reducing dehumidifying costs can materially affect overall air conditioning costs.^[62]

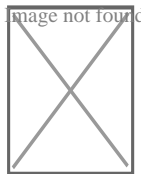
Control system

[edit]

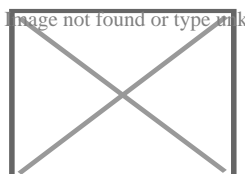
Wireless remote control

[edit]

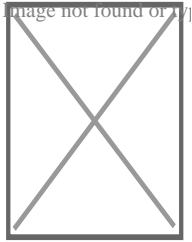
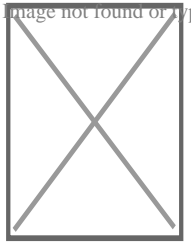
Main articles: Remote control and Infrared blaster



A
wireless
remote
controller



The infrared transmitting LED on the remote



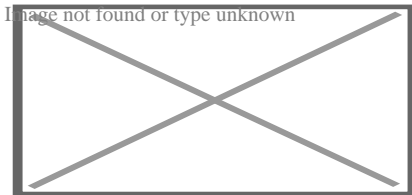
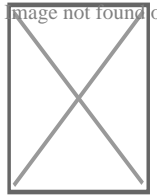
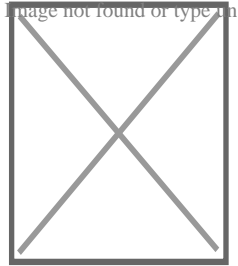
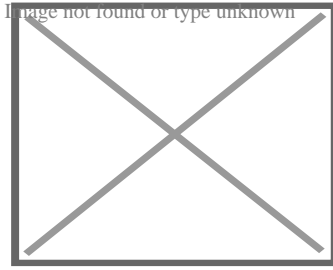
The infrared receiver on the air conditioner

This type of controller uses an infrared LED to relay commands from a remote control to the air conditioner. The output of the infrared LED (like that of any infrared remote) is invisible to the human eye because its wavelength is beyond the range of visible light (940 nm). This system is commonly used on mini-split air conditioners because it is simple and portable. Some window and ducted central air conditioners uses it as well.

Wired controller

[edit]

Main article: Thermostat



Several wired controllers (Indonesia, 2024)

A wired controller, also called a "wired thermostat," is a device that controls an air conditioner by switching heating or cooling on or off. It uses different sensors to measure temperatures and actuate control operations. Mechanical thermostats commonly use bimetallic strips, converting a temperature change into mechanical displacement, to actuate control of the air conditioner. Electronic thermostats, instead, use a thermistor or other semiconductor sensor, processing temperature change as electronic signals to control the air conditioner.

These controllers are usually used in hotel rooms because they are permanently installed into a wall and hard-wired directly into the air conditioner unit, eliminating the need for batteries.

Types

[edit]

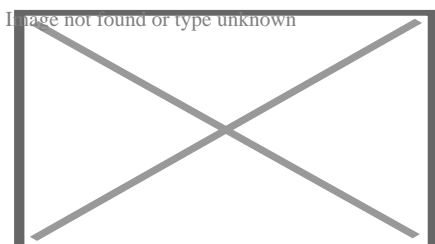
Types	Typical Capacity*	Air supply	Mounting	Typical application
Mini-split	small – large	Direct	Wall	Residential
Window	very small – small	Direct	Window	Residential
Portable	very small – small	Direct / Ducted	Floor	Residential, remote areas
Ducted (individual)	small – very large	Ducted	Ceiling	Residential, commercial
Ducted (central)	medium – very large	Ducted	Ceiling	Residential, commercial
Ceiling suspended	medium – large	Direct	Ceiling	Commercial
Cassette	medium – large	Direct / Ducted	Ceiling	Commercial
Floor standing	medium – large	Direct / Ducted	Floor	Commercial
Packaged	very large	Direct / Ducted	Floor	Commercial
Packaged RTU (Rooftop Unit)	very large	Ducted	Rooftop	Commercial

* where the typical capacity is in kilowatt as follows:

- very small: <1.5 kW
- small: 1.5–3.5 kW
- medium: 4.2–7.1 kW
- large: 7.2–14 kW
- very large: >14 kW

Mini-split and multi-split systems

[edit]



Evaporator, indoor unit, or terminal, side of a ductless split-type air conditioner

Ductless systems (often mini-split, though there are now ducted mini-split) typically supply conditioned and heated air to a single or a few rooms of a building, without ducts and in a decentralized manner.^[63] Multi-zone or multi-split systems are a common application of ductless systems and allow up to eight rooms (zones or locations) to be conditioned independently from each other, each with its indoor unit and simultaneously from a single outdoor unit.

The first mini-split system was sold in 1961 by Toshiba in Japan, and the first wall-mounted mini-split air conditioner was sold in 1968 in Japan by Mitsubishi Electric, where small home sizes motivated their development. The Mitsubishi model was the first air conditioner with a cross-flow fan.^{[64][65][66]} In 1969, the first mini-split air conditioner was sold in the US.^[67] Multi-zone ductless systems were invented by Daikin in 1973, and variable refrigerant flow systems (which can be thought of as larger multi-split systems) were also invented by Daikin in 1982. Both were first sold in Japan.^[68] Variable refrigerant flow systems when compared with central plant cooling from an air handler, eliminate the need for large cool air ducts, air handlers, and chillers; instead cool refrigerant is transported through much smaller pipes to the indoor units in the spaces to be conditioned, thus allowing for less space above dropped ceilings and a lower structural impact, while also allowing for more individual and independent temperature control of spaces. The outdoor and indoor

units can be spread across the building.^[69] Variable refrigerant flow indoor units can also be turned off individually in unused spaces.^[citation needed] The lower start-up power of VRF's DC inverter compressors and their inherent DC power requirements also allow VRF solar-powered heat pumps to be run using DC-providing solar panels.

Ducted central systems

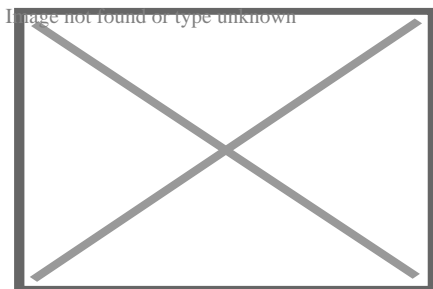
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Split-system central air conditioners consist of two heat exchangers, an outside unit (the condenser) from which heat is rejected to the environment and an internal heat exchanger (the evaporator, or Fan Coil Unit, FCU) with the piped refrigerant being circulated between the two. The FCU is then connected to the spaces to be cooled by ventilation ducts.^[70] Floor standing air conditioners are similar to this type of air conditioner but sit within spaces that need cooling.

Central plant cooling

[edit]

See also: Chiller



Industrial air conditioners on top of the shopping mall *Passage* in Linz, Austria

Large central cooling plants may use intermediate coolant such as chilled water pumped into air handlers or fan coil units near or in the spaces to be cooled which then duct or deliver cold air into the spaces to be conditioned, rather than ducting cold air directly to these spaces from the plant, which is not done due to the low density and heat capacity of air, which would require impractically large ducts. The chilled water is cooled by chillers in the plant, which uses a refrigeration cycle to cool water, often transferring its heat to the atmosphere even in liquid-cooled chillers through the use of cooling towers. Chillers may be air- or liquid-cooled.[⁷¹][⁷²]

Portable units

[edit]

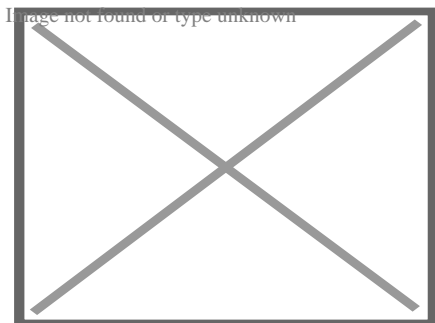
A portable system has an indoor unit on wheels connected to an outdoor unit via flexible pipes, similar to a permanently fixed installed unit (such as a ductless split air conditioner).

Hose systems, which can be *monoblock* or *air-to-air*, are vented to the outside via air ducts. The *monoblock* type collects the water in a bucket or tray and stops when full. The *air-to-air* type re-evaporates the water, discharges it through the ducted hose, and can run continuously. Many but not all portable units draw indoor air and expel it outdoors through a single duct, negatively impacting their overall cooling efficiency.

Many portable air conditioners come with heat as well as a dehumidification function.[⁷³]

Window unit and packaged terminal

[edit]



Through-the-wall PTAC units, University Motor Inn, Philadelphia

Main article: Packaged terminal air conditioner

The packaged terminal air conditioner (PTAC), through-the-wall, and window air conditioners are similar. These units are installed on a window frame or on a wall opening. The unit usually has an internal partition separating its indoor and outdoor sides, which contain the unit's condenser and evaporator, respectively. PTAC systems may be adapted to provide heating in cold weather, either directly by using an electric strip, gas, or other heaters, or by reversing the refrigerant flow to heat the interior and draw heat from the exterior air, converting the air conditioner into a heat pump. They may be installed in a wall opening with the help of a special sleeve on the wall and a custom grill that is flush with the wall and window air conditioners can also be installed in a window, but without a custom grill.^[74]

Packaged air conditioner

[edit]

Packaged air conditioners (also known as self-contained units)^[75]^[76] are central systems that integrate into a single housing all the components of a split central system, and deliver air, possibly through ducts, to the spaces to be cooled. Depending on their construction they may be outdoors or indoors, on roofs (rooftop units),^[77]^[78] draw the air to be conditioned from inside or outside a

building and be water or air-cooled. Often, outdoor units are air-cooled while indoor units are liquid-cooled using a cooling tower.^{[70][79][80][81][82][83]}

Types of compressors

[edit]

Compressor types	Common applications	Typical capacity	Efficiency	Durability	Repairability
Reciprocating	Refrigerator, Walk-in freezer, portable air conditioners	small – large	very low (small capacity) medium (large capacity)	very low	medium
Rotary vane	Residential mini splits	small	low	low	easy
Scroll	Commercial and central systems, VRF	medium	medium	medium	easy
Rotary screw	Commercial chiller	medium – large	medium	medium	hard
Centrifugal	Commercial chiller	very large	medium	high	hard
Maglev Centrifugal	Commercial chiller	very large	high	very high	very hard

Reciprocating

[edit]

Main article: Reciprocating compressor

This compressor consists of a crankcase, crankshaft, piston rod, piston, piston ring, cylinder head and valves. ^[*citation needed*]

Scroll

[edit]

Main article: Scroll compressor

This compressor uses two interleaving scrolls to compress the refrigerant.^[84] it consists of one fixed and one orbiting scrolls. This type of compressor is more efficient because it has 70 percent less moving parts than a reciprocating compressor. ^[*citation needed*]

Screw

[edit]

Main article: Rotary-screw compressor

This compressor use two very closely meshing spiral rotors to compress the gas. The gas enters at the suction side and moves through the threads as the screws rotate. The meshing rotors force the gas through the compressor, and the gas exits at the end of the screws. The working area is the inter-lobe volume between the male and female rotors. It is larger at the intake end, and decreases along the length of the rotors until the exhaust port. This change in volume is the compression. ^[*citation needed*]

Capacity modulation technologies

[edit]

There are several ways to modulate the cooling capacity in refrigeration or air conditioning and heating systems. The most common in air conditioning are: on-off cycling, hot gas bypass, use or not of liquid injection, manifold configurations of multiple compressors, mechanical modulation (also called digital), and inverter technology. ^[*citation needed*]

Hot gas bypass

[edit]

Hot gas bypass involves injecting a quantity of gas from discharge to the suction side. The compressor will keep operating at the same speed, but due to the bypass, the refrigerant mass flow circulating with the system is reduced, and thus the cooling capacity. This naturally causes the compressor to run uselessly during the periods when the bypass is operating. The turn down capacity varies between 0 and 100%.^[⁸⁵]

Manifold configurations

[edit]

Several compressors can be installed in the system to provide the peak cooling capacity. Each compressor can run or not in order to stage the cooling capacity of the unit. The turn down capacity is either 0/33/66 or 100% for a trio configuration and either 0/50 or 100% for a tandem. ^[*citation needed*]

Mechanically modulated compressor

[edit]

This internal mechanical capacity modulation is based on periodic compression process with a control valve, the two scroll set move apart stopping the compression for a given time period. This method varies refrigerant flow by changing the average time of compression, but not the actual speed of the motor. Despite an excellent turndown ratio – from 10 to 100% of the cooling capacity, mechanically modulated scrolls have high energy consumption as the motor continuously runs.^[*citation needed*]

Variable-speed compressor

[edit]

Main article: Inverter compressor

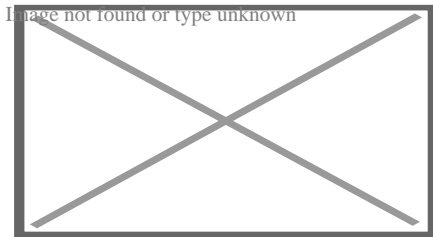
This system uses a variable-frequency drive (also called an Inverter) to control the speed of the compressor. The refrigerant flow rate is changed by the change in the speed of the compressor. The turn down ratio depends on the system configuration and manufacturer. It modulates from 15 or 25% up to 100% at full capacity with a single inverter from 12 to 100% with a hybrid tandem. This method is the most efficient way to modulate an air conditioner's capacity. It is up to 58% more efficient than a fixed speed system.^[*citation needed*]

Impact

[edit]

Health effects

[edit]



Rooftop condenser unit fitted on top of an Osaka Municipal Subway 10 series subway carriage. Air conditioning has become increasingly prevalent on public transport vehicles as a form of climate control, and to ensure passenger comfort and drivers' occupational safety and health.

In hot weather, air conditioning can prevent heat stroke, dehydration due to excessive sweating, electrolyte imbalance, kidney failure, and other issues due to hyperthermia.^{[8][86]} Heat waves are the most lethal type of weather phenomenon in the United States.^{[87][88]} A 2020 study found that areas with lower use of air conditioning correlated with higher rates of heat-related mortality and hospitalizations.^[89] The August 2003 France heatwave resulted in approximately 15,000 deaths, where 80% of the victims were over 75 years old. In response, the French government required all retirement homes to have at least one air-conditioned room at 25 °C (77 °F) per floor during heatwaves.^[8]

Air conditioning (including filtration, humidification, cooling and disinfection) can be used to provide a clean, safe, hypoallergenic atmosphere in hospital operating rooms and other environments where proper atmosphere is critical to patient safety and well-being. It is sometimes recommended for home use by people with allergies, especially mold.^{[90][91]} However, poorly maintained water cooling towers can promote the growth and spread of microorganisms such as *Legionella pneumophila*, the infectious agent responsible for Legionnaires' disease. As long as the cooling tower is kept clean (usually by means of a chlorine treatment), these

health hazards can be avoided or reduced. The state of New York has codified requirements for registration, maintenance, and testing of cooling towers to protect against Legionella.^[92]

Economic effects

[edit]

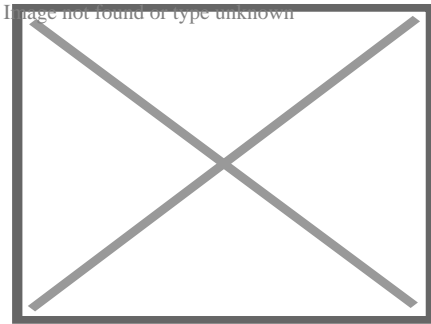
First designed to benefit targeted industries such as the press as well as large factories, the invention quickly spread to public agencies and administrations with studies with claims of increased productivity close to 24% in places equipped with air conditioning.^[93]

Air conditioning caused various shifts in demography, notably that of the United States starting from the 1970s. In the US, the birth rate was lower in the spring than during other seasons until the 1970s but this difference then declined since then.^[94]] As of 2007, the Sun Belt contained 30% of the total US population while it was inhabited by 24% of Americans at the beginning of the 20th century.^[95] Moreover, the summer mortality rate in the US, which had been higher in regions subject to a heat wave during the summer, also evened out.^[7]

The spread of the use of air conditioning acts as a main driver for the growth of global demand of electricity.^[96] According to a 2018 report from the International Energy Agency (IEA), it was revealed that the energy consumption for cooling in the United States, involving 328 million Americans, surpasses the combined energy consumption of 4.4 billion people in Africa, Latin America, the Middle East, and Asia (excluding China).^[8] A 2020 survey found that an estimated 88% of all US households use AC, increasing to 93% when solely looking at homes built between 2010 and 2020.^[97]

Environmental effects

[edit]



Air conditioner farm in the facade of a building in Singapore

Space cooling including air conditioning accounted globally for 2021 terawatt-hours of energy usage in 2016 with around 99% in the form of electricity, according to a 2018 report on air-conditioning efficiency by the International Energy Agency.^[8] The report predicts an increase of electricity usage due to space cooling to around 6200 TWh by 2050,^{[8][98]} and that with the progress currently seen, greenhouse gas emissions attributable to space cooling will double: 1,135 million tons (2016) to 2,070 million tons.^[8] There is some push to increase the energy efficiency of air conditioners. United Nations Environment Programme (UNEP) and the IEA found that if air conditioners could be twice as effective as now, 460 billion tons of GHG could be cut over 40 years.^[99] The UNEP and IEA also recommended legislation to decrease the use of hydrofluorocarbons, better building insulation, and more sustainable temperature-controlled food supply chains going forward.^[99]

Refrigerants have also caused and continue to cause serious environmental issues, including ozone depletion and climate change, as several countries have not yet ratified the Kigali Amendment to reduce the consumption and production of hydrofluorocarbons.^[100] CFCs and HCFCs refrigerants such as R-12 and R-22, respectively, used within air conditioners have caused damage to the ozone layer.[[]

^{101]} and hydrofluorocarbon refrigerants such as R-410A and R-404A, which were designed to replace CFCs and HCFCs, are instead exacerbating climate change.[[]
^{102]} Both issues happen due to the venting of refrigerant to the atmosphere, such as during repairs. HFO refrigerants, used in some if not most new equipment, solve both issues with an ozone damage potential (ODP) of zero and a much lower global warming potential (GWP) in the single or double digits vs. the three or four digits of hydrofluorocarbons.[[]^{103]}

Hydrofluorocarbons would have raised global temperatures by around 0.3–0.5 °C (0.5–0.9 °F) by 2100 without the Kigali Amendment. With the Kigali Amendment, the increase of global temperatures by 2100 due to hydrofluorocarbons is predicted to be around 0.06 °C (0.1 °F).[[]^{104]}

Alternatives to continual air conditioning include passive cooling, passive solar cooling, natural ventilation, operating shades to reduce solar gain, using trees, architectural shades, windows (and using window coatings) to reduce solar gain.[[]*citation ne*

Social effects

[edit]

Socioeconomic groups with a household income below around \$10,000 tend to have a low air conditioning adoption,[[]^{42]} which worsens heat-related mortality.[[]^{7]} The lack of cooling can be hazardous, as areas with lower use of air conditioning correlate with higher rates of heat-related mortality and hospitalizations.[[]^{89]} Premature mortality in NYC is projected to grow between 47% and 95% in 30 years, with lower-income and vulnerable populations most at risk.[[]^{89]} Studies on the correlation between heat-related mortality and hospitalizations and living in low socioeconomic locations can be traced in Phoenix, Arizona,[[]^{105]} Hong Kong,[[]^{106]} China,[[]^{106]} Japan,[[]^{107]} and Italy.[[]^{108]}[[]^{109]} Additionally, costs concerning health care can act as another barrier, as the lack of private health insurance during a 2009

heat wave in Australia, was associated with heat-related hospitalization.^[109]

Disparities in socioeconomic status and access to air conditioning are connected by some to institutionalized racism, which leads to the association of specific marginalized communities with lower economic status, poorer health, residing in hotter neighborhoods, engaging in physically demanding labor, and experiencing limited access to cooling technologies such as air conditioning.^[109] A study overlooking Chicago, Illinois, Detroit, and Michigan found that black households were half as likely to have central air conditioning units when compared to their white counterparts.^[110] Especially in cities, Redlining creates heat islands, increasing temperatures in certain parts of the city.^[109] This is due to materials heat-absorbing building materials and pavements and lack of vegetation and shade coverage.^[111] There have been initiatives that provide cooling solutions to low-income communities, such as public cooling spaces.^{[8][111]}

Other techniques

[edit]

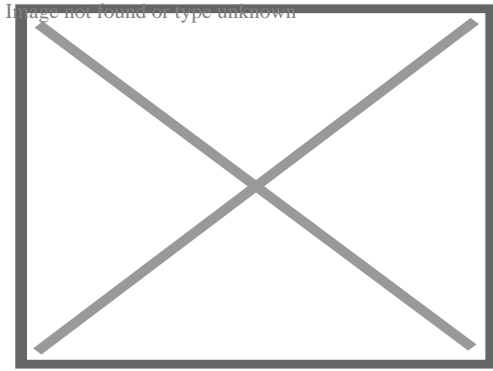
Buildings designed with passive air conditioning are generally less expensive to construct and maintain than buildings with conventional HVAC systems with lower energy demands.^[112] While tens of air changes per hour, and cooling of tens of degrees, can be achieved with passive methods, site-specific microclimate must be taken into account, complicating building design.^[12]

Many techniques can be used to increase comfort and reduce the temperature in buildings. These include evaporative cooling, selective shading, wind, thermal convection, and heat storage.^[113]

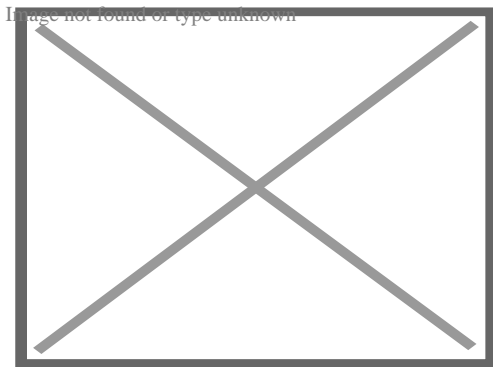
Passive ventilation

[edit]

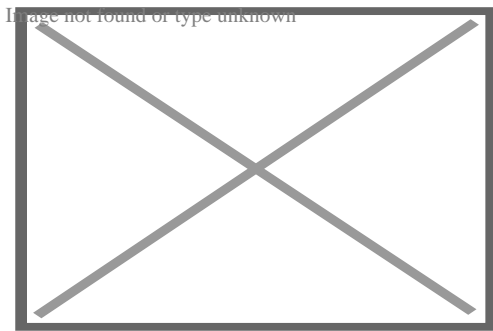
This section is an excerpt from Passive ventilation.[edit]



The ventilation system of a regular earthship



Dogtrot houses are designed to maximise natural ventilation.



A roof turbine ventilator, colloquially known as a 'Whirly Bird' is an application of wind driven ventilation.

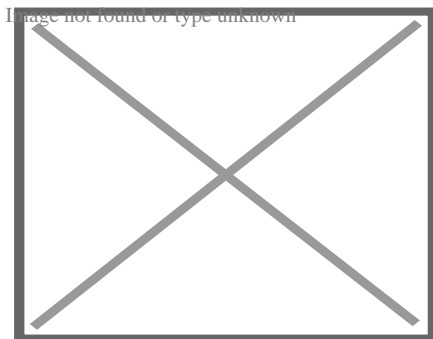
Passive ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure differences arising from natural forces.

There are two types of natural ventilation occurring in buildings: *wind driven ventilation* and *buoyancy-driven ventilation*. Wind driven ventilation arises from the different pressures created by wind around a building or structure, and openings being formed on the perimeter which then permit flow through the building. Buoyancy-driven ventilation occurs as a result of the directional buoyancy force that results from temperature differences between the interior and exterior.^[114] Since the internal heat gains which create temperature differences between the interior and exterior are created by natural processes, including the heat from people, and wind effects are variable, naturally ventilated buildings are sometimes called "breathing buildings".

Passive cooling

[edit]

This section is an excerpt from Passive cooling.[edit]

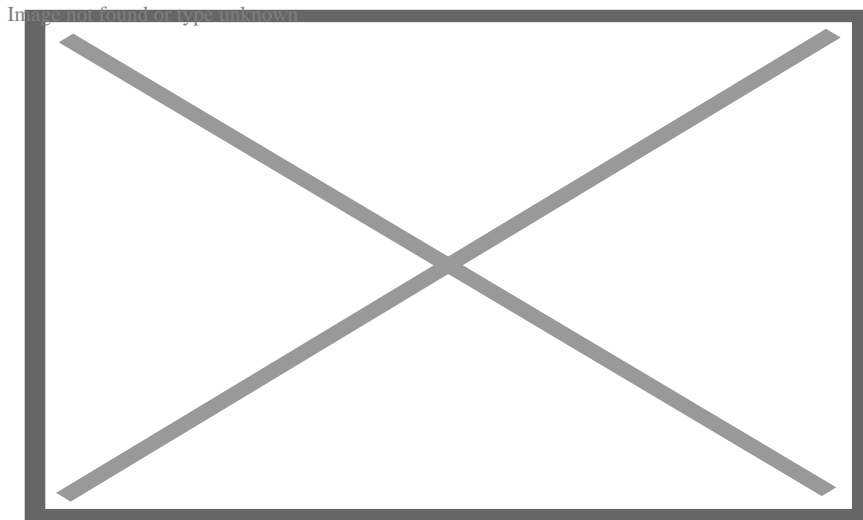


A traditional Iranian solar cooling design using a wind tower

Passive cooling is a building design approach that focuses on heat gain control and heat dissipation in a building in order to improve the indoor thermal comfort with low or no energy consumption.^[115]^[116] This approach works either by preventing heat from entering the interior (heat gain prevention) or by removing heat from the building (natural cooling).^[117]

Natural cooling utilizes on-site energy, available from the natural environment, combined with the architectural design of building components (e.g. building envelope), rather than mechanical systems to dissipate heat.^[118] Therefore, natural cooling depends not only on the architectural design of the building but on how the site's natural resources are used as heat sinks (i.e. everything that absorbs or dissipates heat). Examples of on-site heat sinks are the upper atmosphere (night sky), the outdoor air (wind), and the earth/soil.

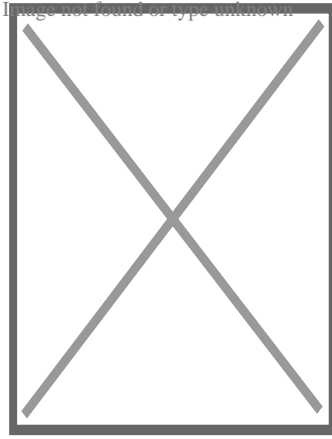
Passive cooling is an important tool for design of buildings for climate change adaptation – reducing dependency on energy-intensive air conditioning in warming environments.^{[119][120]}



A pair of short windcatchers (*malqaf*) used in traditional architecture; wind is forced down on the windward side and leaves on the leeward side (*cross-ventilation*). In the absence of wind, the circulation can be driven with evaporative cooling in the inlet (which is also designed to catch dust). In the center, a *shuksheika* (roof lantern vent), used to shade the qa'a below while allowing hot air rise out of it (*stack effect*).^[11]

Daytime radiative cooling

[edit]



Passive daytime radiative cooling (PDRC) surfaces are high in solar reflectance and heat emittance, cooling with zero energy use or pollution.^[121]

Passive daytime radiative cooling (PDRC) surfaces reflect incoming solar radiation and heat back into outer space through the infrared window for cooling during the daytime. Daytime radiative cooling became possible with the ability to suppress solar heating using photonic structures, which emerged through a study by Raman et al. (2014).^[122] PDRCs can come in a variety of forms, including paint coatings and films, that are designed to be high in solar reflectance and thermal emittance.^{[121][123]}

PDRC applications on building roofs and envelopes have demonstrated significant decreases in energy consumption and costs.^[123] In suburban single-family residential areas, PDRC application on roofs can potentially lower energy costs by 26% to 46%.^[124] PDRCs are predicted to show a market size of ~\$27 billion for indoor space cooling by 2025 and have undergone a surge in research and development since the 2010s.^{[125][126]}

Fans

[edit]

Main article: Ceiling fan

Hand fans have existed since prehistory. Large human-powered fans built into buildings include the punkah.

The 2nd-century Chinese inventor Ding Huan of the Han dynasty invented a rotary fan for air conditioning, with seven wheels 3 m (10 ft) in diameter and manually powered by prisoners.^[127]

In 747, Emperor Xuanzong (r. 712–762) of the Tang dynasty (618–907) had the Cool Hall (*Liang Dian*

) built in the imperial palace, which the *Tang Yulin* describes as having water-powered fan wheels for air conditioning as well as rising jet streams of water from fountains. During the subsequent Song dynasty (960–1279), written sources mentioned the air conditioning rotary fan as even more widely used.^[127]

Thermal buffering

[edit]

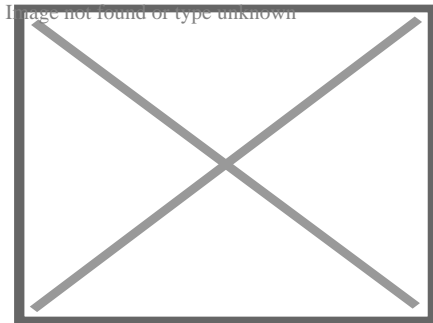
In areas that are cold at night or in winter, heat storage is used. Heat may be stored in earth or masonry; air is drawn past the masonry to heat or cool it.^[13]

In areas that are below freezing at night in winter, snow and ice can be collected and stored in ice houses for later use in cooling.^[13] This technique is over 3,700 years old in the Middle East.^[128] Harvesting outdoor ice during winter and transporting and storing for use in summer was practiced by wealthy Europeans in the early 1600s,^[15] and became popular in Europe and the Americas towards the end of the 1600s.^[129] This practice was replaced by mechanical compression-cycle icemakers.

Evaporative cooling

[edit]

Main article: Evaporative cooler



An evaporative cooler

In dry, hot climates, the evaporative cooling effect may be used by placing water at the air intake, such that the draft draws air over water and then into the house. For this reason, it is sometimes said that the fountain, in the architecture of hot, arid climates, is like the fireplace in the architecture of cold climates.^[1] Evaporative cooling also makes the air more humid, which can be beneficial in a dry desert climate.^[130]

Evaporative coolers tend to feel as if they are not working during times of high humidity, when there is not much dry air with which the coolers can work to make the air as cool as possible for dwelling occupants. Unlike other types of air conditioners, evaporative coolers rely on the outside air to be channeled through cooler pads that cool the air before it reaches the inside of a house through its air duct system; this cooled outside air must be allowed to push the warmer air within the house out through an exhaust opening such as an open door or window.^[131]

See also

[edit]

- Air filter

- Air purifier
- Cleanroom
- Crankcase heater
- Energy recovery ventilation
- Indoor air quality
- Particulates

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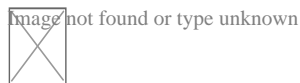
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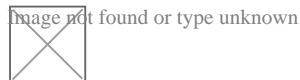
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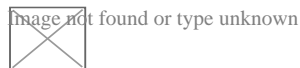
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- U.S. patent 808,897 Carrier's original patent
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Heating, ventilation, and air conditioning

**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

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

**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

**Industry
organizations**

- BRE
- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC
- Indoor air quality (IAQ)

Health and safety

- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)

See also

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

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Home appliances

- Air conditioner
- Air fryer
- Air ioniser
- Air purifier
- Barbecue grill
- Blender
 - Immersion blender
- Bread machine
- Bug zapper
- Coffee percolator
- Clothes dryer
 - combo
- Clothes iron
- Coffeemaker
- Dehumidifier
- Dishwasher
 - drying cabinet
- Domestic robot
 - comparison
- Deep fryer
- Electric blanket
- Electric drill
- Electric kettle
- Electric knife
- Electric water boiler
- Electric heater
- Electric shaver
- Electric toothbrush
- Epilator
- Espresso machine
- Evaporative cooler
- Food processor
- Fan
 - attic
 - bladeless
 - ceiling

See also

- Appliance plug
- Appliance recycling

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Roofs

- Arched roof
- Barrel roof
- Board roof
- Bochka roof
- Bow roof
- Butterfly roof
- Clerestory
- Conical roof
- Dome
- Flat roof
- Gable roof
- Gablet roof
- Gambrel roof
- Half-hipped roof
- Hip roof
- Onion dome
- Mansard roof
- Pavilion roof
- Rhombic roof
- Ridged roof
- Saddle roof
- Sawtooth roof
- Shed roof
- Tented roof

Roof shapes**Cross-gabled roof**

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Roof elements

- Air conditioning unit
- Attic
- Catslide
- Chimney
- Collar beam
- Dormer
- Eaves
- Flashing
- Gable
- Green roof
- Gutter
- Hanging beam
- Joist
- Lightning rod
- Loft
- Purlin
- Rafter
- Ridge vent
- Roof batten
- Roof garden
- Roofline
- Roof ridge
- Roof sheeting
- Roof tiles
- Roof truss
- Roof window
- Skylight
- Soffit
- Solar panels
- Spire
- Weathervane
- Wind brace

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Electronics

Branches

- Analogue electronics
- Digital electronics
- Electronic engineering
- Instrumentation
- Microelectronics
- Optoelectronics
- Power electronics
- Printed electronics
- Semiconductor
- Schematic capture
- Thermal management
- 2020s in computing
- Atomtronics
- Bioelectronics
- List of emerging electronics
- Failure of electronic components
- Flexible electronics

Advanced topics

- Low-power electronics
- Molecular electronics
- Nanoelectronics
- Organic electronics
- Photonics
- Piezotronics
- Quantum electronics
- Spintronics

**Electronic
equipment**

- Air conditioner
- Central heating
- Clothes dryer
- Computer/Notebook
- Camera
- Dishwasher
- Freezer
- Home robot
- Home cinema
- Home theater PC
- Information technology
- Cooker
- Microwave oven
- Mobile phone
- Networking hardware
- Portable media player
- Radio
- Refrigerator
- Robotic vacuum cleaner
- Tablet
- Telephone
- Television
- Water heater
- Video game console
- Washing machine

- Audio equipment
- Automotive electronics
- Avionics
- Control system
- Data acquisition
- e-book
- e-health
- Electromagnetic warfare
- Electronics industry
- Embedded system
- Home appliance
- Home automation
- Integrated circuit

Applications

- Home appliance
 - Consumer electronics
 - Major appliance
 - Small appliance
- Marine electronics
- Microwave technology
- Military electronics
- Multimedia
- Nuclear electronics
- Open-source hardware
- Radar and Radio navigation
- Radio electronics
- Terahertz technology
- Wired and Wireless Communications

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- Germany

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- Czech Republic

About Durham Supply Inc

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Things To Do in Tulsa County

Photo

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Tulsa Zoo

4.5 (10481)

Photo

Image not found or type unknown

Woodward Park and Gardens

4.7 (2580)

Photo

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Tours of Tulsa

4.9 (291)

Photo

Image not found or type unknown

Route 66 Historical Village

4.4 (718)

Photo

Bob Dylan Center

4.9 (245)

Photo

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The Blue Dome

4.5 (60)

Driving Directions in Tulsa County

Driving Directions From Catoosa to Durham Supply Inc

Driving Directions From Tulsa VA Behavioral Medicine Clinic to Durham Supply Inc

Driving Directions From Dollar General to Durham Supply Inc

https://www.google.com/maps/dir/Catoosa/Durham+Supply+Inc/@36.188987,-95.745817,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sChIJlyDaONL1tocRAFQS_6MxGv95.745817!2d36.188987!1m5!1m1!1sChIJDzPLSlrytocRY_EaORpHGro!2m2!1d-95.8384781!2d36.1563128!3e0

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Driving Directions From Tours of Tulsa to Durham Supply Inc

Driving Directions From Bob Dylan Center to Durham Supply Inc

Driving Directions From Tulsa Air and Space Museum & Planetarium to Durham Supply Inc

Driving Directions From Tulsa Air and Space Museum & Planetarium to Durham Supply Inc

Driving Directions From Woodward Park and Gardens to Durham Supply Inc

Driving Directions From Gathering Place to Durham Supply Inc

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Reviews for Durham Supply Inc

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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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.

Balancing Heat Needs in Mobile Homes Across Different Regions [View GBP](#)

Frequently Asked Questions

How do regional climate variations impact the heat needs of mobile homes?

Regional climate variations dictate the intensity and duration of heating requirements, with colder regions necessitating more robust heating solutions, while milder climates may require less intensive systems.

What are the most efficient HVAC systems for mobile homes in different climates?

In colder regions, heat pumps and high-efficiency furnaces are ideal for their superior performance. In moderate climates, a ductless mini-split system can efficiently provide both heating and cooling.

How can insulation affect the heating efficiency in mobile homes across different regions?

Proper insulation reduces heat loss in cold climates and maintains cool air during warmer months, leading to energy savings and improved comfort regardless of geographic location.

What role does mobile home size play in selecting an appropriate HVAC system?

The size determines the capacity needed for effective heating; larger homes require systems with greater output to evenly distribute warmth without overworking the unit.

How can programmable thermostats enhance energy efficiency for mobile home occupants in varying climates?

Programmable thermostats allow users to schedule temperature adjustments according to daily routines, optimizing energy use by reducing unnecessary heating when not needed.

Royal Supply Inc

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State : OK

Zip : 73149

Address : Unknown Address

Google Business Profile

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

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