Bridgewater Council

- **Service and Maintenance**
  Service and Maintenance Weekly Pump Out Procedures for Portables Steam Cleaning Methods for Restroom Cabins High Pressure Washing Tips for Sanitation Crews Recording Maintenance Logs with QR Codes Choosing Cleaning Agents for Portable Toilets Scheduling Service Visits for Long Term Rentals Managing Gray Water Disposal Compliance Steps for Replacing Portable Toilet Parts Safety Gear Checklist for Sanitation Workers Troubleshooting Odor Issues Between Services Winter Service Routines for Cold Weather Units Creating a Preventive Maintenance Plan
- **Compliance and Regulation**
  Compliance and Regulation Understanding OSHA Section 192651 for Jobsite Toilets ADA Portable Restroom Requirements in Detail Navigating Local Permits for Temporary Sanitation Inspection Tag Protocols for Portable Restrooms Liability Insurance Considerations for Toilet Rentals Placement Guidelines for Accessible Restroom Units Signage Standards for Portable Toilets at Events Documentation Needed for Health Department Checks Updating Restroom Fleets to Meet New Codes How Service Reports Support Compliance Audits Training Staff on Regulatory Portable Sanitation Rules Managing Permit Renewals for Long Term Sites
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Identifying Common Portable Toilet Parts Needing Replacement

Okay, so youre thinking about tackling some portable toilet repairs, huh? Crew members wear protective gloves during waste removal **portable toilet rental boston** hygiene. Thats admirable! Before you dive into the actual replacement process, its smart to get familiar with the usual suspects – the portable toilet parts that tend to wear out and need replacing most often. Think of it like this: you wouldnt go grocery shopping without knowing what you need, right? Same idea here.

One of the biggest culprits is the toilet seat and lid. Constant use (and sometimes, lets be honest, abuse) means they can crack, break, or just plain get gross. Hinges get loose, plastic weakens, and before you know it, youre dealing with a wobbly or altogether missing seat. Definitely a common replacement.

Next up, consider the flush mechanism. Whether its a foot pump or a hand pump, these things are working constantly. Seals can dry out, springs can break, and the whole mechanism can just stop working efficiently, leading to weak flushes or even no flush at all. Identifying the specific part thats failing in the flush system is key, as it could be a simple valve or a more complex assembly.

Then theres the vent pipe and cap. These are vital for controlling odors, and if they get damaged or clogged, well, you can imagine the consequences. Theyre often made of plastic, making them susceptible to cracking from weather exposure or accidental bumps.

Finally, dont overlook the simple stuff like the waste tank cap or the fill cap for the freshwater reservoir. These can get lost, damaged, or just wear out over time, leading to leaks and other unpleasantness. Also, depending on the toilet model, you might have a chemical holding tank and the components associated with that tank could also be common replacements.

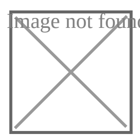
Knowing these common problem areas will help you diagnose issues faster, order the correct replacement parts, and ultimately, keep those portable toilets functioning properly and hygienically. Its all about being prepared!

Essential Tools and Materials for Porta Potty Repair

Essential Tools and Materials for Porta Potty Repair

When tackling portable toilet repairs, having the right tools and materials at hand can make the difference between a quick fix and a frustrating experience. Every repair technician should maintain a well-stocked toolkit specifically designed for porta potty maintenance.

The basic tools needed include both standard and Phillips head screwdrivers, adjustable wrenches, pliers, and a utility knife. A power drill with various bits can save significant time when removing or installing components. Dont forget about specialty tools like a tank level gauge and a sealed-bearing puller for more complex repairs.



Materials-wise, its crucial to keep various replacement parts on hand. These include toilet seat hardware, door hinges, springs, and latches. Plumbing supplies such as rubber gaskets, seals, and various sizes of plastic fittings are essential for fixing leaks. Having a supply of cleaning materials, deodorizers, and sanitizing agents is also important for maintaining hygiene during repairs.

Safety equipment is non-negotiable. Always keep rubber gloves, protective eyewear, and face masks in your kit. Working with portable toilets involves exposure to waste and chemicals, so proper protection is vital. Additionally, having cleaning rags, paper towels, and a good antibacterial hand sanitizer will help maintain cleanliness throughout the repair process.

Remember to regularly check and replenish your supplies, as running out of essential parts or materials during a repair job can lead to costly delays and frustrated customers.

Step-by-Step Guide to Replacing a Portable Toilet Seat

Replacing a Portable Toilet Seat: A Step-by-Step Guide

Replacing a portable toilet seat might seem like a daunting task, but with the right tools and guidance, its actually quite straightforward. This guide will walk you through the process of swapping out your old portable toilet seat for a new one.

First, gather your supplies. Youll need a replacement seat that matches your portable toilet model, a screwdriver (usually Phillips head), and possibly an adjustable wrench. Its also wise to have cleaning supplies handy to sanitize the area before installation.

Begin by removing the old seat. Most portable toilet seats are attached with two bolts at the back of the bowl. Locate these mounting bolts and carefully unscrew them. If theyre plastic wing nuts, you can usually loosen them by hand. For metal nuts, youll need your wrench. Once loose, lift the old seat straight up and off the bowl.

Before installing the new seat, clean the mounting area thoroughly. This ensures a proper fit and maintains hygiene. Check that the new seats mounting holes align with the holes on your toilet bowl. Place the new seat onto the bowl, making sure its centered and properly positioned.

Image not found or type unknown

Insert the mounting bolts through the holes and secure them with the nuts from underneath. Be careful not to overtighten, as this can crack the plastic components. Tighten just enough to prevent the seat from shifting. Test the seat by gently moving it side to side – it should feel secure but not overly rigid.

Finally, check that the seat closes properly and sits level on the bowl. If everything looks good, give the entire toilet a final wipe-down, and youre done! Your portable toilet now has a fresh, secure seat ready for use.

Remember to dispose of the old seat properly according to local regulations, as its considered sanitary waste. With regular maintenance and careful installation, your new portable toilet seat should provide reliable service for years to come.

Replacing a Faulty Porta Potty Flapper or Valve

Replacing a Faulty Porta Potty Flapper or Valve

When a portable toilets flapper or valve starts malfunctioning, it can quickly become a serious issue that needs immediate attention. These essential components control water flow and seal the waste tank, making them crucial for proper operation and sanitation.

To replace a faulty flapper or valve, first ensure you have the correct replacement part for your specific portable toilet model. Begin by emptying and thoroughly cleaning the waste tank. Then, disconnect the water supply if your unit has one. Most portable toilet flappers are attached to a simple mechanism at the bottom of the bowl. Youll need to remove the old flapper by detaching it from its mounting points, which usually involves releasing a few clips or unscrewing some fasteners.

Before installing the new flapper or valve, inspect the surrounding seal and mounting area for any damage or debris. Clean these areas thoroughly to ensure a proper seal. When fitting the new component, make sure its properly aligned and securely attached. Test the mechanism several times to confirm it moves smoothly and creates a tight seal when closed.

The entire process typically takes about 30 minutes, but its important to work carefully to avoid damaging other components. Once installed, fill the waste tank with the proper chemical solution and verify there are no leaks. Regular maintenance and prompt replacement of worn parts will help extend the life of your portable toilet and maintain proper sanitation standards.

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Remember to wear appropriate protective gear like gloves and eye protection when performing any maintenance on portable toilets, and dispose of old parts properly according to local regulations.

How to Replace a Broken Porta Potty Door Latch

Replacing a broken door latch on a porta potty might seem like a daunting task, but with the right approach, its quite manageable. When youre dealing with portable toilet parts, especially something as crucial as the door latch, ensuring it functions properly is essential for privacy and user comfort.

First, gather your tools. Youll need a screwdriver, usually a Phillips head since most porta potty latches are secured with this type of screw. Also, ensure you have the replacement latch; these can often be found at hardware stores or through suppliers that specialize in portable sanitation equipment.

Start by examining the existing latch to understand how its mounted. Typically, youll find screws on the inside of the door where the latch mechanism is attached. Carefully unscrew these, keeping track of them as theyre small and easy to lose. If the old latch is particularly stubborn due to rust or dirt, you might need to gently pry it off with a flat tool like a flathead screwdriver.

Once the old latch is removed, take a moment to clean the area around where the new latch will go. Porta potties can accumulate grime over time, and a clean installation site ensures better functionality and longevity of your new part.

Next, align your new latch in place. Make sure its oriented correctly so that when closed, it secures properly against its counterpart on the frame of the porta potty. Begin securing it with screws; dont tighten them fully until youve checked that everything aligns perfectly when closing and opening.

After confirming proper alignment, tighten all screws securely but be cautious not to strip them by over-tightening. Test the latch several times to ensure smooth operation; sometimes adjustments might be needed if theres any resistance or if it doesnt catch securely.

Finally, check for any sharp edges or protruding screws that could snag clothing or cause injury. A quick file down or adjustment with pliers can fix this.

By following these steps, youve not only replaced a critical component of your porta potty but also ensured that users have a reliable and private experience. Remember, regular checks on portable toilet parts can prevent such issues from becoming major inconveniences at events or construction sites where these facilities are vital.

Addressing and Fixing a Leaky Portable Toilet Tank

Addressing and fixing a leaky portable toilet tank is a crucial step in the process of replacing parts in your portable toilet, ensuring its functionality and longevity. When you notice a leak, its important to act swiftly to prevent water damage and the potential for mold growth, which can complicate repairs further.

The first step involves identifying the source of the leak. This might require some detective work as leaks can originate from various points such as the seal around the flush valve, connections between hoses, or even cracks in the tank itself. Once youve pinpointed where the water is escaping, you can proceed with confidence.

Assuming youve found that the issue lies with a worn-out seal or gasket, begin by turning off the water supply if your model allows for it, or empty the tank if not. Next, carefully disassemble the affected area; this typically involves unscrewing parts or gently prying apart connections. Remember to keep track of all screws and parts; a small container or a piece of cloth can serve well for this purpose.

With the area exposed, inspect the old seal or gasket for wear or damage. If its beyond repair, replace it with a new one that matches your toilet models specifications. Before installing the new part, ensure both surfaces are clean; any residue could compromise the new seals effectiveness. Apply a thin layer of plumbers grease to help with placement and longevity.

Reassemble everything in reverse order of how you took it apart, tightening screws gently but firmly to avoid stripping them. Once everything is back together, slowly turn on the water supply or refill the tank if necessary. Watch for leaks as you do this; sometimes adjustments might be needed to get everything perfectly aligned.

If after reassembly there are still leaks, double-check your work for any overlooked loose connections or improperly seated seals. Patience here is key; sometimes minor tweaks can make all the difference.

By addressing and fixing leaks efficiently, you not only extend the life of your portable toilet but also ensure its hygiene and usability remain top-notch. Regular maintenance checks following replacement can prevent future issues, keeping your portable toilet in excellent condition for longer periods between replacements.

Tips for Maintaining Your Porta Potty to Prevent Future Repairs

Tips for Maintaining Your Porta Potty to Prevent Future Repairs

Regular maintenance of your portable toilet is essential to avoid costly repairs and ensure a long service life. By following a few simple maintenance practices, you can keep your porta potty in excellent working condition and minimize the need for parts replacement.

First, establish a consistent cleaning schedule. Clean the unit thoroughly at least once a week, paying special attention to the toilet bowl, seat, and urinal. Use appropriate cleaning products designed for portable toilets, as harsh chemicals can damage the plastic components and seals.

Proper waste management is crucial. Empty the holding tank before it reaches capacity, typically when its about two-thirds full. This prevents excessive pressure on the tank and reduces the risk of leaks developing around seals and connections. Additionally, always use the correct chemicals and deodorizers in recommended amounts to break down waste and control odors effectively.

Inspect your porta potty regularly for signs of wear and tear. Check door hinges, latches, and springs monthly for proper operation. Look for cracks in the plastic components and ensure all seals remain intact. Address minor issues promptly before they develop into major problems requiring parts replacement.

During winter months, take extra precautions to prevent freeze damage. Add antifreeze designed for portable toilets when temperatures drop below freezing, and consider using insulated covers if the unit remains outdoors. Frozen waste can expand and crack tanks or damage valve systems.

Finally, protect your portable toilet from environmental damage. Place it on level ground to prevent tipping and structural stress. If possible, position it in a shaded area to prevent UV damage to the plastic and extend its lifespan. These simple preventive measures can save you time and money on future repairs while maintaining a sanitary and functional facility.

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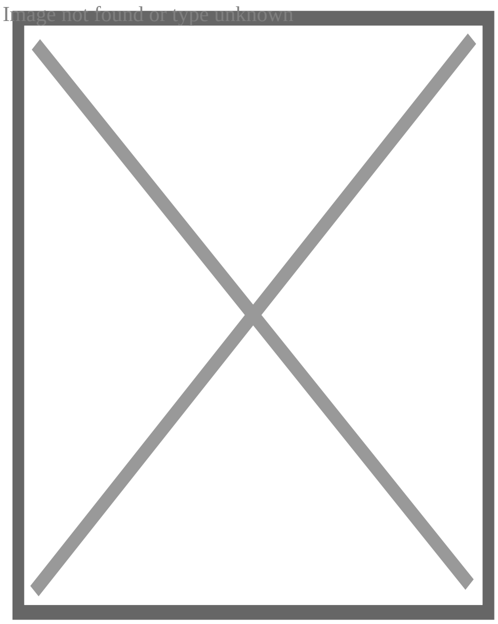
About Ventilative cooling



A sash window with two sashes that can be adjusted to control airflows and temperatures

Ventilative cooling is the use of natural or mechanical ventilation to cool indoor spaces.[1] The use of outside air reduces the cooling load and the energy consumption of these systems, while maintaining high quality indoor conditions; passive ventilative cooling may eliminate energy consumption. Ventilative cooling strategies are applied in a wide range of buildings and may even be critical to realize renovated or new high efficient buildings and zero-energy buildings (ZEBs).[2] Ventilation is present in buildings mainly for air quality reasons. It can be used additionally to remove both excess heat gains, as well as increase the velocity of the air and thereby widen the thermal comfort range.[3] Ventilative cooling is assessed by long-term evaluation indices.[4] Ventilative cooling is dependent on the availability of appropriate external conditions and on the thermal physical characteristics of the building.

Background

[edit]

In the last years, overheating in buildings has been a challenge not only during the design stage but also during the operation. The reasons are:[5][6]

- High performance energy standards which reduce heating demand in heating dominated climates. Mainly refer to increase of the insulation levels and restriction on infiltration rates
- The occurrence of higher outdoor temperatures during the cooling season, because of the climate change and the heat island effect not considered at the design phase
- Internal heat gains and occupancy behavior were not calculated with accuracy during the design phase (gap in performance).

In many post-occupancy comfort studies overheating is a frequently reported problem not only during the summer months but also during the transitions periods, also in temperate climates.

Potentials and limitations

[edit]

The effectiveness of ventilative cooling has been investigated by many researchers and has been documented in many post occupancy assessments reports.[7][8][9] The system cooling effectiveness (natural or mechanical ventilation) depends on the air flow rate that can be established, the thermal capacity of the construction and the heat transfer of the elements. During cold periods the cooling power of outdoor air is large. The risk of draughts is also important. During summer and transition months outdoor air cooling power might not be enough to compensate overheating indoors during daytime and application of ventilative cooling will be limited only during the night period. The night ventilation may remove effectively accumulated heat gains (internal and solar) during daytime in the building constructions.[10] For the assessment of the cooling potential of the location simplified methods have been developed.[11][12][13][14] These methods use mainly building characteristics information, comfort range indices and local climate data. In most of the simplified methods the thermal inertia is ignored.

The critical limitations for ventilative cooling are:

- Impact of global warming
- Impact of urban environment
- Outdoor noise levels
- Outdoor air pollution[15]
- Pets and insects
- Security issues
- Locale limitations

Existing regulations

[edit]

Ventilative cooling requirements in regulations are complex. Energy performance calculations in many countries worldwide do not explicitly consider ventilative cooling. The available tools used for energy performance calculations are not suited to model the impact and effectiveness of ventilative cooling, especially through annual and monthly calculations.[16]

Case studies

[edit]

A large number of buildings using ventilative cooling strategies have already been built around the world.[17][18][19] Ventilative cooling can be found not only in traditional, pre-air-condition architecture, but also in temporary European and international low energy buildings. For these buildings passive strategies are priority. When passive strategies are not enough to achieve comfort, active strategies are applied. In most cases for the summer period and the transition months, automatically controlled natural ventilation is used. During the heating season, mechanical ventilation with heat recovery is used for indoor air quality reasons. Most of the buildings present high thermal mass. User behavior is crucial element for successful performance of the method.

Building components and control strategies

[edit]

Building components of ventilative cooling are applied on all three levels of climate-sensitive building design, i.e. site design, architectural design and technical interventions . A grouping of these components follows:[1][20]

- Airflow guiding ventilation components (windows, rooflights, doors, dampers and grills, fans, flaps, louvres, special effect vents)
- Airflow enhancing ventilation building components (chimneys, atria, venturi ventilators, wind catchers, wind towers and scoops, double facades, ventilated walls)
- Passive cooling building components (convective components, evaporative components, phase change components)
- Actuators (chain, linear, rotary)
- Sensors (temperature, humidity, air flow, radiation, CO_2, rain, wind)

Control strategies in ventilative cooling solutions have to control the magnitude and the direction, of air flows in space and time.[1] Effective control strategies ensure high indoor comfort levels and minimum energy consumption. Strategies in a lot of cases include temperature and CO_2 monitoring.[21] In many buildings in which occupants had learned how to operate the systems, energy use reduction was achieved. Main control parameters are operative (air and radiant) temperature (both peak, actual or average), occupancy, carbon dioxide concentration and humidity levels.[21] Automation is more effective than personal control.[1] Manual control or manual override of automatic control are very important as it affects user acceptance and appreciation of the indoor climate positively (also cost).[22] The third option is that operation of facades is left to personal control of the inhabitants, but the building automation system gives active feedback and specific advises.

Existing methods and tools

[edit]

Building design is characterized by different detailed design levels. In order to support the decision-making process towards ventilative cooling solutions, airflow models with different resolution are used. Depending on the detail resolution required, airflow models can be grouped into two categories:[1]

- Early stage modelling tools, which include empirical models, monozone model, bidimensional airflow network models;and
- Detailed modelling tools, which include airflow network models, coupled BES-AFN models, zonal models, Computational Fluid Dynamic, coupled CFD-BES-AFN models.

Existing literature includes reviews of available methods for airflow modelling.[9][23][24][25][26][27][28]

IEA EBC Annex 62

[edit]

Annex 62 'ventilative cooling' was a research project of the Energy in Buildings and Communities Programme (EBC) of the International Energy Agency (IEA), with a four-year working phase (2014–2018).[29] The main goal was to make ventilative cooling an attractive and energy efficient cooling solution to avoid overheating of both new and renovated buildings. The results from the Annex facilitate better possibilities for prediction and estimation of heat removal and overheating risk – for both design purposes and for energy performance calculation. The documented performance of ventilative cooling systems through analysis of case studies aimed to promote the use of this technology in future high performance and conventional buildings.[30] To fulfill the main goal the Annex had the following targets for the research and development work:

- To develop and evaluate suitable design methods and tools for prediction of cooling need, ventilative cooling performance and risk of overheating in buildings.
- To develop guidelines for an energy-efficient reduction of the risk of overheating by ventilative cooling solutions and for design and operation of ventilative cooling in both residential and commercial buildings.
- To develop guidelines for integration of ventilative cooling in energy performance calculation methods and regulations including specification and verification of key performance indicators.
- To develop instructions for improvement of the ventilative cooling capacity of existing systems and for development of new ventilative cooling solutions including their control strategies.
- To demonstrate the performance of ventilative cooling solutions through analysis and evaluation of well-documented case studies.

The Annex 62 research work was divided in three subtasks.

- **Subtask A** "Methods and Tools" analyses, developed and evaluated suitable design methods and tools for prediction of cooling need, ventilative cooling performance and risk of overheating in buildings. The subtask also gave guidelines for integration of ventilative cooling in energy performance calculation methods and regulation including specification and verification of key performance indicators.
- **Subtask B** "Solutions" investigated the cooling performance of existing mechanical, natural and hybrid ventilation systems and technologies and typical comfort control

solutions as a starting point for extending the boundaries for their use. Based upon these investigations the subtask also developed recommendations for new kinds of flexible and reliable ventilative cooling solutions that create comfort under a wide range of climatic conditions.
- **Subtask C** "Case studies" demonstrated the performance of ventilative cooling through analysis and evaluation of well-documented case studies.

See also

[edit]

- Air conditioning
- Architectural engineering
- Glossary of HVAC
- Green building
- Heating, Ventilation and Air-Conditioning
- Indoor air quality
- Infiltration (HVAC)
- International Energy Agency Energy in Buildings and Communities Programme
- Mechanical engineering
- Mixed Mode Ventilation
- Passive cooling
- Room air distribution
- Sick building syndrome
- Sustainable refurbishment
- Thermal comfort
- Thermal mass
- Venticool
- Ventilation (architecture)

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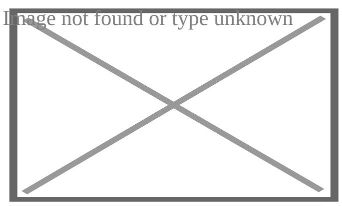
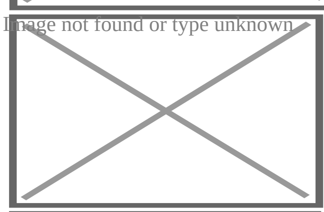
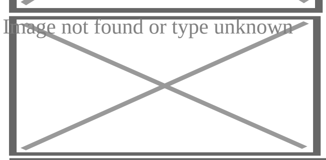
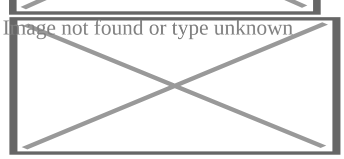
About air conditioning

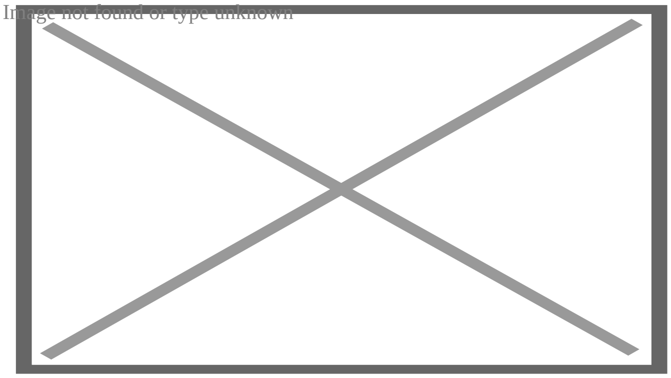
This article is about cooling of air. For the Curved Air album, see Air Conditioning (album). For a similar device capable of both cooling and heating, see Heat pump.
"a/c" redirects here. For the abbreviation used in banking and book-keeping, see Account (disambiguation). For other uses, see AC.











There are various types of air conditioners. Popular examples include: Window-mounted air conditioner (China, 2023); 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, and in some cases, also controlling the humidity of internal air. Air conditioning can be achieved using a mechanical 'air conditioner' or through other methods, such as 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, allowing them to both heat and 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.

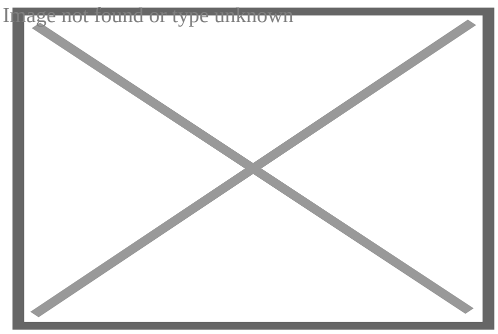
History

[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]

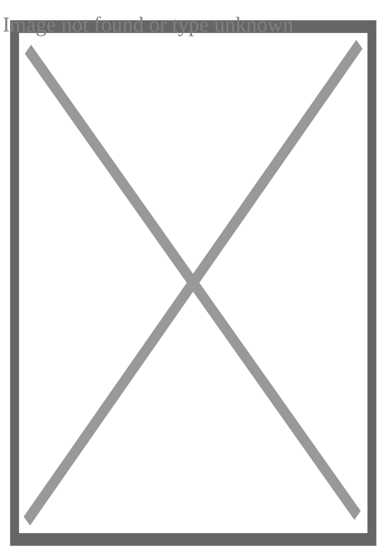
In 1558, Giambattista della Porta described a method of chilling ice to temperatures far below its freezing point by mixing it with potassium nitrate (then called "nitre") in his popular science book *Natural Magic*.[15][16][17] In 1620, Cornelis Drebbel demonstrated "Turning Summer into Winter" for 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 °C (7 °F) while the ambient temperature was 18 °C (64 °F). Franklin noted that soon after they passed the freezing point of water 0 °C (32 °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 °C (7 °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 $1,200,000 in 2024.)[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 track 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 the United States, and with 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

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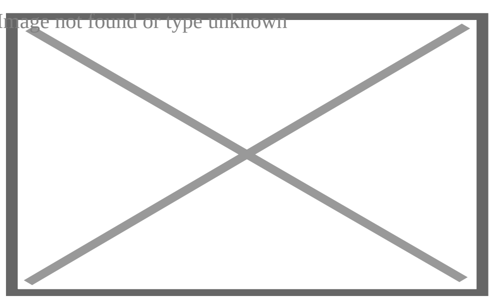


A simple stylized diagram of the refrigeration cycle: 1) condensing coil, 2) expansion valve, 3) evaporator coil, 4) compressor

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. In this case, 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 °F (?26 °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 n*

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

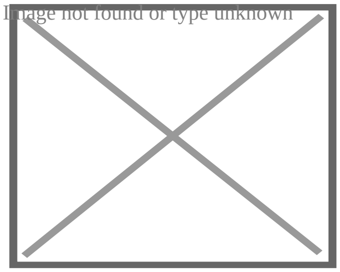
The infrared transmitting LED on the remote

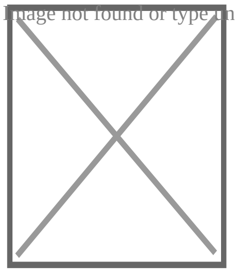
The infrared receiver on the air conditioner

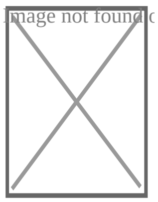
This type of controller uses an infrared LED to relay commands from a remote control to the air conditioner. The output of the infrared LED (like that of any infrared remote) is invisible to the human eye because its wavelength is beyond the range of visible light (940 nm). This system is commonly used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

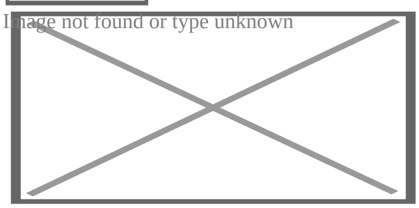
Wired controller

[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

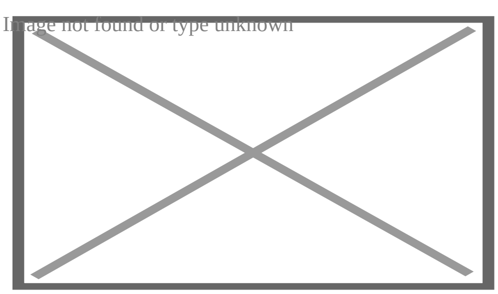
Portable	very small – small	Direct / Ducted	Floor	Residential, remote areas
Ducted (individual)	small – very large	Ducted	Ceiling	Residential, commercial
Ducted (central)	medium – very large	Ducted	Ceiling	Residential, commercial
Ceiling suspended	medium – large	Direct	Ceiling	Commercial
Cassette	medium – 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.

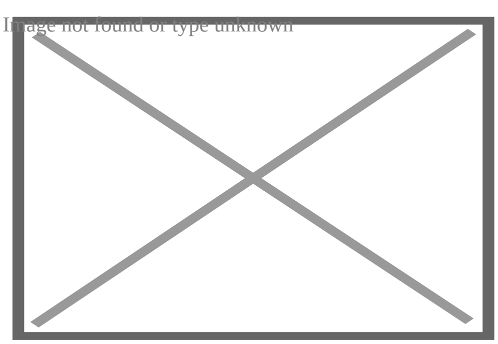
Ducted central systems

[edit]

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 conditioner cooling towers 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]

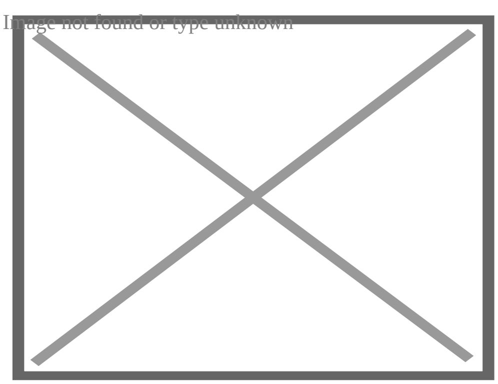
A portable system has an indoor unit on wheels connected to an outdoor unit via flexible pipes, similar to a permanently fixed installed unit (such as a ductless split air conditioner).

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]
Main article: Packaged terminal air conditioner



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

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*

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

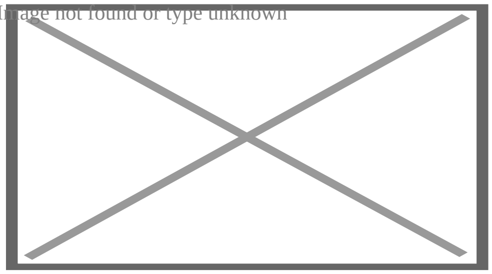
This system uses a variable-frequency drive (also called an Inverter) to control the speed of the compressor. The refrigerant flow rate is changed by the change in the speed of the compressor. The turn down ratio depends on the system configuration and manufacturer. It modulates from 15 or 25% up to 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]

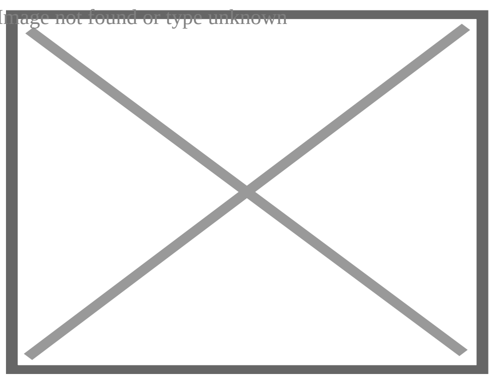
First designed to benefit targeted industries such as the press as well as large factories, the invention quickly spread to public agencies and administrations with studies with claims of increased productivity close to 24% in places equipped with air conditioning.[93]

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

Air conditioning uses a massive amount of energy, leading to more carbon emissions. 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 from 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 needed*]

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

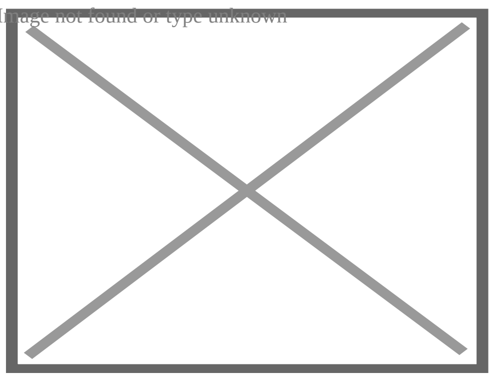
[edit]

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]

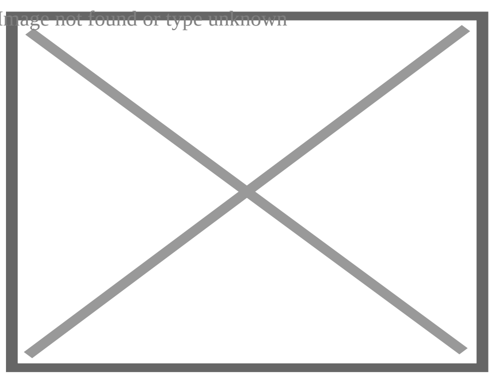
Many techniques can be used to increase comfort and reduce the temperature in buildings. These include evaporative cooling, selective shading, wind, thermal convection, and heat storage.[113]

Passive ventilation

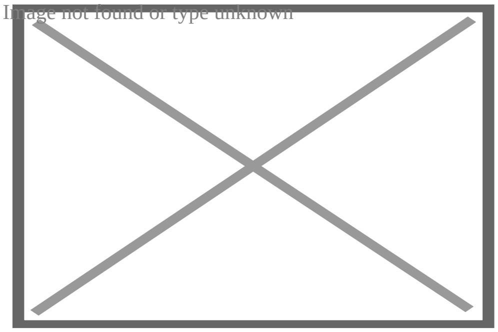
[edit]
This section is an excerpt from Passive ventilation.[edit]



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.

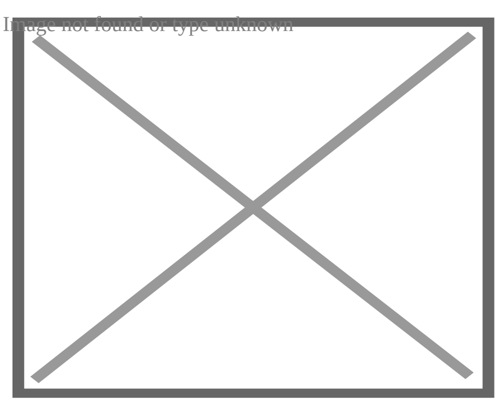
Passive ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure differences arising from natural forces.

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]

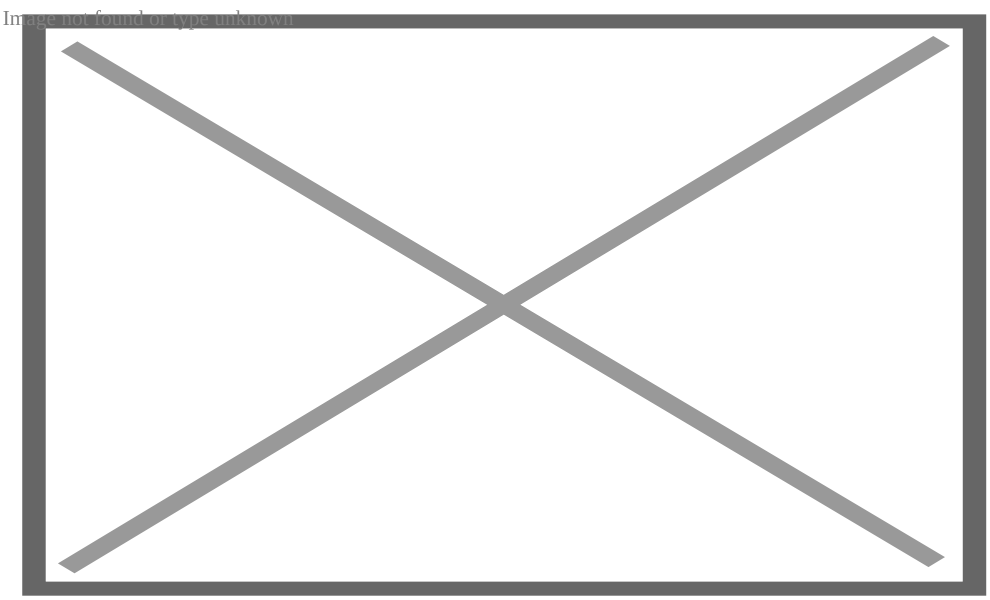


A traditional Iranian solar cooling design using a wind tower

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]

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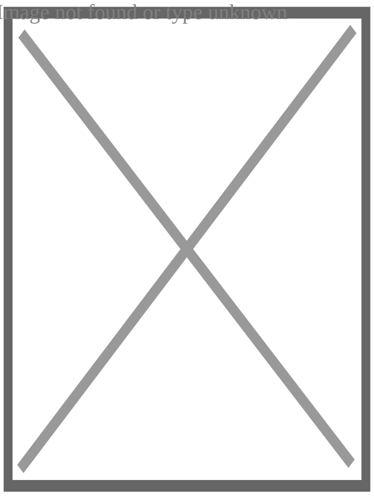


Passive daytime radiative cooling (PDRC) surfaces are high in solar reflectance and heat emittance, cooling with zero energy use or pollution.[121]

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] :â€Š99,â€Š151,â€Š233â€Š In 747, Emperor Xuanzong (r. 712–762) of the Tang dynasty (618–907) had the Cool Hall (*Liang Dian* æ¶¼æ®¿) 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] :â€Š134,â€Š151â€Š

Thermal buffering

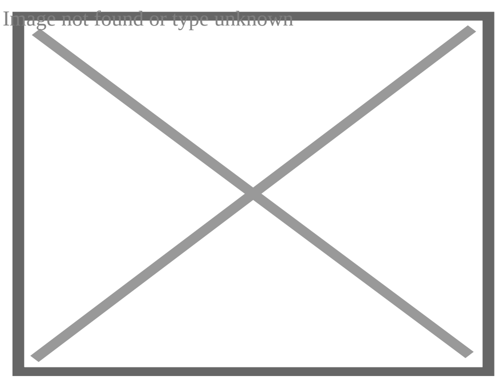
[edit]

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.[11] 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 conditioning paradox
- Air filter
- Air purifier
- Cleanroom
- Crankcase heater
- Energy recovery ventilation
- Indoor air quality
- Particulates

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- U.S. patent 808,897 Carrier's original patent
- U.S. patent 1,172,429
- U.S. patent 2,363,294
- *Scientific American*, "Artificial Cold", 28 August 1880, p. 138
- *Scientific American*, "The Presidential Cold Air Machine", 6 August 1881, p. 84

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Heading, ventilation, and air conditioning

Fundamental concepts	○ Air changes per hour (ACH) ○ 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

Technology

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

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

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
Industry organizations	◦ AHRI ◦ AMCA ◦ ASHRAE ◦ ASTM International ◦ BRE ◦ BSRIA ◦ CIBSE ◦ Institute of Refrigeration ◦ IIR ◦ LEED ◦ SMACNA ◦ UMC
Health and safety	◦ Indoor air quality (IAQ) ◦ 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:Fire protection
- Template:Home automation
- Template:Solar energy

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
- 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
  - Fan heater
  - window
- Freezer

Types

- Garbage disposer
- Hair dryer
- Hair iron
- Humidifier
- Icemaker
- Ice cream maker
- Induction cooker
- Instant hot water dispenser
- Juicer
- Kitchen hood

See also	◦ Appliance plug ◦ Appliance recycling

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Roofs

Roof shapes	◦ 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	Cross-gabled roof Image not found or type unknown

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
- Shingles
- Skylight
- Soffit
- Solar panels
- Spire
- Weathervane
- Wind brace

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

Applications

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Destination
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Starting Point
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Royal Porta Johns

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State : MA

Zip : 02379

Address : 400, West Street

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