



- **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  
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## Streamlining Porta Potty Maintenance: The QR Code Advantage

### Streamlining Porta Potty Maintenance: The QR Code Advantage

Health departments may require permits for large gatherings **royal porta potty** dumpster.

In the realm of portable restroom maintenance, efficiency is key. Traditional methods of logging maintenance activities often involve paperwork, which can be cumbersome and prone to errors or loss. However, with the advent of technology, particularly QR codes, theres a revolutionary approach thats changing the game.

Imagine a scenario where each porta potty is equipped with a unique QR code. When a maintenance worker arrives at a unit, they simply scan this code with their smartphone or tablet. This action instantly brings up a digital log for that specific unit. Here lies the beauty of using QR codes for recording maintenance logs: its immediate, accurate, and reduces physical clutter.

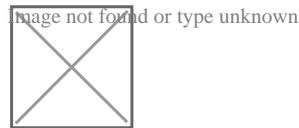
Firstly, this method ensures that every action taken on the porta potty-be it cleaning, restocking supplies, or performing repairs-is logged in real-time. Theres no need to wait until returning to an office to fill out forms; everything is done on-site. This not only speeds up the process but also increases accuracy since details are recorded as they happen.

Moreover, digital logs through QR codes offer an organized database accessible anytime. Managers can review maintenance history from anywhere, providing insights into usage patterns or recurring issues without sifting through stacks of paper records. This data-driven approach can help in forecasting needs for supplies or scheduling preventative maintenance before problems escalate.

Another significant advantage is accountability. Each entry into the log can be timestamped and linked to the individual who performed the scan. This creates a transparent record of who did what and when, fostering responsibility among staff members and making it easier to track performance or address any discrepancies if they arise.

The environmental impact is also noteworthy. By moving from paper to digital, we're reducing waste significantly. Over time, this small change could contribute to larger sustainability goals within companies operating large fleets of portable restrooms.

In conclusion, integrating QR codes into porta potty maintenance brings us into a new era of efficiency and precision in service management. It's a simple yet transformative tool that aligns modern technology with everyday operational needs, ensuring better service delivery while embracing eco-friendly practices. As more businesses recognize these benefits, we might just see QR codes become as standard as the units themselves in maintaining cleanliness and order in public sanitation facilities.



## **QR Code Integration: A Step-by-Step Guide for Rental Companies**

Let's face it, keeping track of maintenance on rental equipment can feel like herding cats. Spreadsheets, paper logs, scribbled notes – it's a recipe for chaos and, frankly, lost revenue. But what if I told you there's a simple, tech-savvy way to streamline the whole process? Enter QR code integration for recording maintenance logs.

Think of it this way: each piece of equipment gets its own unique QR code. Slap that code on the machine and suddenly, you've unlocked a direct portal to its maintenance history. No more digging through dusty files! Scan the code with a smartphone or tablet, and boom, you're looking at the equipment's entire service record.

Implementing this isn't as daunting as it sounds. First, you'll need a system – a database or software – to store your maintenance logs. Plenty of options exist, from simple spreadsheets to dedicated rental management software. Next, generate QR codes for each item. Many free online tools can do this. The important part is linking each QR code to the specific equipment's record in your chosen system.

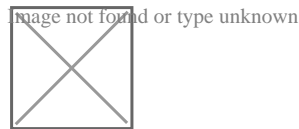
Once the codes are printed and attached, train your team. Show them how to scan the codes and input maintenance information directly into the system. This could include details about repairs, inspections, parts replaced, and even the technician who performed the work. The key is consistency. Make it a habit to record every maintenance action immediately.

The benefits are huge. Imagine instantly accessing a machine's repair history on-site to diagnose a problem. Think of the improved accuracy and reduced paperwork. And consider the enhanced accountability – you'll know exactly who did what and when. QR code integration isn't just about technology; it's about efficiency, accuracy, and ultimately, boosting your bottom line. So, ditch the chaos and embrace the QR code revolution. Your rental business will thank you.

## **Benefits of Digital Maintenance Logs for Porta Potty Businesses**

In the bustling world of porta potty businesses, where cleanliness and efficiency are paramount, digital maintenance logs have emerged as a game-changer. By integrating QR codes into their maintenance routines, these businesses can reap numerous benefits that streamline operations and enhance customer satisfaction.

First and foremost, the use of QR codes for recording maintenance logs drastically simplifies the documentation process. Instead of cumbersome paper logs that can get lost or damaged, employees can now scan a QR code affixed to each unit with their smartphones or portable devices. This action instantly pulls up a digital form where they can input details about the service performed, such as cleaning dates, repairs made, or supplies replenished. This not only saves time but also reduces human error associated with manual entries.



Another significant advantage is the real-time tracking capability that digital logs provide. With each scan, the data is uploaded to a centralized system accessible from any location. This means that business owners or managers can monitor the status of their fleet in real-time, ensuring no unit goes unserved for too long. It's particularly beneficial during large events or in expansive areas where units are spread out; managers can quickly check which units need attention without physically inspecting each one.

Moreover, digital logs offer enhanced organization and historical data management. Over time, these logs compile a comprehensive history for each porta potty unit. This historical data is invaluable for scheduling preventive maintenance, predicting when parts might need replacement based on usage patterns, and even for legal compliance if issues arise concerning service quality or safety standards.

The environmental impact should not be overlooked either. By moving away from paper records to digital formats, porta potty businesses contribute to reducing paper waste, aligning with modern eco-friendly practices which are increasingly important to consumers who value sustainability.

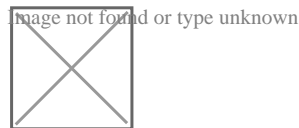
Lastly, customer trust is significantly bolstered by this technology. Knowing that their hygiene needs are being meticulously tracked and managed through modern technology reassures customers about the quality of service they receive. In case of any complaints or inquiries regarding cleanliness or maintenance schedules, businesses can quickly reference accurate records to resolve issues transparently.

In conclusion, incorporating QR codes into maintenance logging for porta potty services offers a multitude of benefits from operational efficiency to customer satisfaction. As technology continues to evolve, embracing such innovations not only keeps businesses competitive but also sets new standards in service delivery within the industry.

## **Choosing the Right QR Code System for Your Porta Potty Fleet**

### Choosing the Right QR Code System for Your Porta Potty Fleet

Managing a fleet of portable toilets requires efficient tracking and maintenance systems, and QR codes have emerged as a valuable tool for this purpose. When selecting a QR code system for your porta potty fleet, several key factors need careful consideration to ensure optimal performance and ease of use.



First, consider the durability of the QR code labels. Portable toilets face harsh weather conditions and frequent cleaning with chemical solutions, so you'll need weather-resistant, UV-protected labels that can withstand these challenges. High-quality vinyl or polyester labels with protective lamination typically offer the best longevity.

The QR code system should also integrate seamlessly with your existing maintenance management software. Look for solutions that allow your field technicians to quickly scan codes and access service histories, maintenance schedules, and cleaning logs through their mobile devices. The system should enable real-time updates and provide instant access to important information like last service date, reported issues, and scheduled maintenance.

Another crucial aspect is the simplicity of the system. Your maintenance staff should be able to scan and update information with minimal training. The interface should be intuitive and mobile-friendly, allowing technicians to quickly log their work and move on to the next unit.

Consider also the scalability of the system. As your fleet grows, the QR code solution should easily accommodate additional units without requiring significant changes to your existing processes. The system should also provide comprehensive reporting capabilities to help you track maintenance patterns and make informed decisions about fleet management.

By carefully evaluating these factors, you can select a QR code system that enhances your maintenance operations and improves the overall efficiency of your porta potty fleet management.

### **Troubleshooting Common Issues with QR Code Maintenance Tracking**

Alright, so you've jumped on the QR code maintenance tracking bandwagon. Smart move! Streamlining things, going paperless, all that good stuff. But let's be honest, sometimes these systems can throw a wrench in the works. You're not alone if you're hitting a snag or two. Let's talk about some common hiccups and how to get back on track.

One of the first headaches people run into is scan-ability. Faded QR codes, damaged labels, or even just poor lighting can make the darn things impossible to read. Think about it: those little squares are packed with data, and if they're not pristine, your scanners going to struggle. The fix? Regular inspections! Seriously, make it part of your routine to check the condition of your QR codes. Replace damaged ones immediately, and use durable, weather-resistant labels to begin with. Also, consider the placement. Are they in direct sunlight? Are they constantly getting splashed with grease or water? A little foresight goes a long way.

Then there's the database disconnect. You scan the code, but the system doesn't recognize the asset or the maintenance history is outdated. Ugh. This usually boils down to a sync problem or a data entry error somewhere along the line. Double-check your connections, make sure your software is up-to-date, and train your team on proper data entry procedures. A little extra attention to detail here can save you a lot of frustration later.

And let's not forget the user adoption issue. You might have the fanciest system in the world, but if your technicians aren't using it correctly, it's useless. People resist change, plain and simple. Make the process as intuitive as possible, provide clear instructions, and be patient. Highlight the benefits – how it makes their jobs easier, reduces paperwork, and ultimately leads to a more efficient workflow. Sometimes, a little encouragement and positive reinforcement are all it takes to get everyone on board.

Finally, think about security. QR codes themselves aren't inherently secure; they're just links to data. Make sure your system has proper authentication and authorization protocols to prevent unauthorized access or modification of maintenance logs. You don't want just anyone messing with your records!

QR code maintenance tracking is a powerful tool, but like any tool, it requires proper maintenance and attention. By proactively addressing these common issues, you can keep your system running smoothly and reap the full benefits of this technology. Good luck!

## **Maximizing Efficiency: Integrating QR Codes with Existing Management Systems**

### Maximizing Efficiency: Integrating QR Codes with Existing Management Systems

In today's fast-paced maintenance environments, seamlessly integrating QR codes with existing management systems has become a game-changer for organizations seeking to streamline their operations. By thoughtfully implementing QR code technology alongside current maintenance tracking methods, companies can significantly enhance their efficiency while minimizing disruption to established workflows.

The beauty of QR code integration lies in its simplicity and adaptability. Rather than completely overhauling existing systems, maintenance teams can gradually incorporate QR codes to complement their current processes. For instance, placing QR codes on equipment allows technicians to instantly access maintenance histories, technical

documentation, and log new repairs using their smartphones – all while maintaining records in the organizations established database.

This hybrid approach offers the best of both worlds: the speed and convenience of mobile access through QR codes, combined with the reliability and familiarity of existing management systems. Maintenance managers can continue using their preferred software while benefiting from real-time data entry and reduced paperwork. The key to successful integration is ensuring proper synchronization between QR code-generated data and the main system, creating a seamless flow of information that enhances rather than complicates the maintenance logging process.

By carefully planning the integration and providing adequate training to staff, organizations can maximize the efficiency gains from QR code implementation while maintaining the stability of their proven management systems. This strategic approach not only improves maintenance operations but also provides a foundation for future technological advancements in facility management.

### **Real-World Examples: Success Stories in Porta Potty Maintenance**

Lets be honest, porta potties arent exactly glamorous. But keeping them clean and functional? Thats essential for events, construction sites, and just about anywhere people gather when permanent facilities arent available. And in todays world, smart technology can make even the humblest job a whole lot more efficient. Enter QR codes and digital maintenance logs. Sounds simple, right? Well, the real-world impact can be significant.

Think about a large outdoor festival. Hundreds, maybe thousands of attendees. Without meticulous porta potty maintenance, things can get unpleasant, fast. Imagine a scenario before QR codes. Paper logs, susceptible to weather, easily lost, and often illegible, are the norm. A worker checks a unit, scribbles a note about needing more toilet paper, and maybe remembers to tell someone later. Maybe. With QR codes, however, its a different story. Each unit has a unique code. The maintenance worker scans it with a smartphone or tablet, instantly accessing the units history and a digital checklist. Did it need cleaning this morning? Was the hand sanitizer refilled? All logged in real-time, time-stamped, and readily available to supervisors.

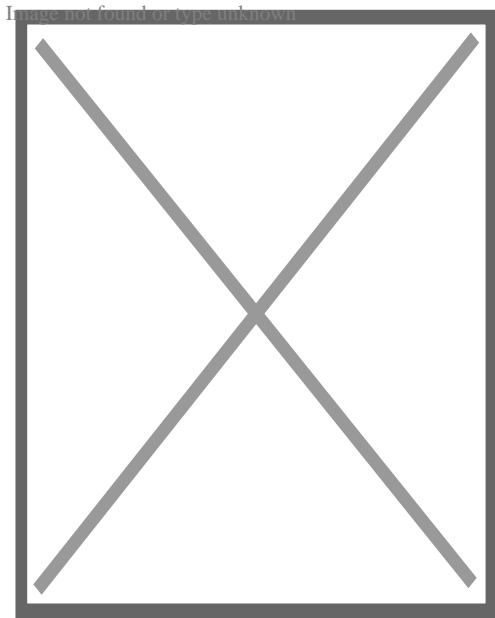
One company providing portable sanitation services noticed a dramatic improvement in customer satisfaction after implementing a QR code system. Before, clients would complain



about missed cleanings or empty supplies. Now, with verifiable digital records, they could demonstrate consistent service and proactively address any issues. Another construction company reported a decrease in complaints from workers and a reduction in the spread of illness on site. Simply put, cleaner porta potties meant happier, healthier employees.

The success stories aren't just about avoiding negative outcomes. They're about optimization. By analyzing the data collected through the QR code system, companies can identify patterns. Which units need cleaning more frequently? Which locations require more frequent restocking of supplies? This data allows for targeted resource allocation, reducing unnecessary trips and saving time and money. It's about moving from reactive maintenance to proactive management, ensuring porta potties are not just clean, but consistently well-maintained. These are just a few examples of how a seemingly small technological upgrade can have a surprisingly large impact on a very important, albeit unglamorous, industry.

## 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.<sup>[1]</sup> 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).<sup>[2]</sup> 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.<sup>[3]</sup> Ventilative cooling is assessed by long-term evaluation indices.<sup>[4]</sup> 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:<sup>[5]</sup><sup>[6]</sup>

- 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.<sup>[7]</sup><sup>[8]</sup><sup>[9]</sup> 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.<sup>[10]</sup> For the assessment of the cooling potential of the location simplified methods have been developed.<sup>[11]</sup><sup>[12]</sup><sup>[13]</sup><sup>[14]</sup> 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<sup>[15]</sup>
- 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.<sup>[16]</sup>

## Case studies

[edit]

A large number of buildings using ventilative cooling strategies have already been built around the world.<sup>[17][18][19]</sup> 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:<sup>[1][20]</sup>

- 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<sub>2</sub>, rain, wind)

Control strategies in ventilative cooling solutions have to control the magnitude and the direction, of air flows in space and time.<sup>[1]</sup> Effective control strategies ensure high indoor comfort levels and minimum energy consumption. Strategies in a lot of cases include temperature and CO<sub>2</sub> monitoring.<sup>[21]</sup> 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.<sup>[21]</sup> Automation is more effective than personal control.<sup>[1]</sup> 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).<sup>[22]</sup> 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

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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:<sup>[1]</sup>

- 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.<sup>[9][23][24][25][26][27][28]</sup>

## IEA EBC Annex 62

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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).<sup>[29]</sup> 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.[<sup>30</sup>] 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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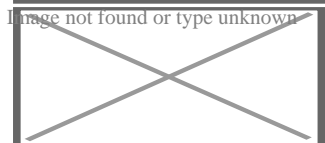
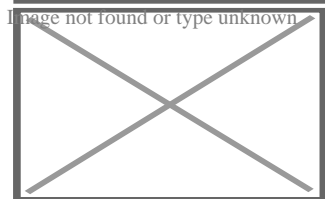
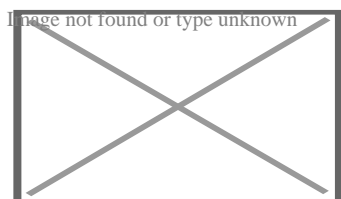
Hygiene is a collection of methods executed to preserve health and wellness. According to the World Health And Wellness Organization (WHO), "Health describes conditions and techniques that aid to preserve health and wellness and stop the spread of illness." Personal health refers to preserving the body's sanitation. Health activities can be organized into the following: home and everyday hygiene, personal health, clinical health, sleep health, and food hygiene. Home and everyday health includes hand washing, respiratory system hygiene, food hygiene in your home, health in the cooking area, health in the bathroom, washing hygiene, and clinical health in the house. And additionally ecological health in the culture to stop all type of microorganisms from penetrating into our homes. Many individuals correspond hygiene with "cleanliness", yet health is a wide term. It includes such personal routine choices as how regularly to take a shower or bath, laundry hands, trim finger nails, and wash clothing. It additionally consists of focus to keeping surfaces in the home and workplace tidy, including restroom facilities. Adherence to normal hygiene methods is usually considered as a socially liable and commendable actions, while ignoring proper hygiene can be regarded as unclean or unsanitary, and might be considered socially unacceptable or ill-mannered, while also presenting a threat to public health and wellness.

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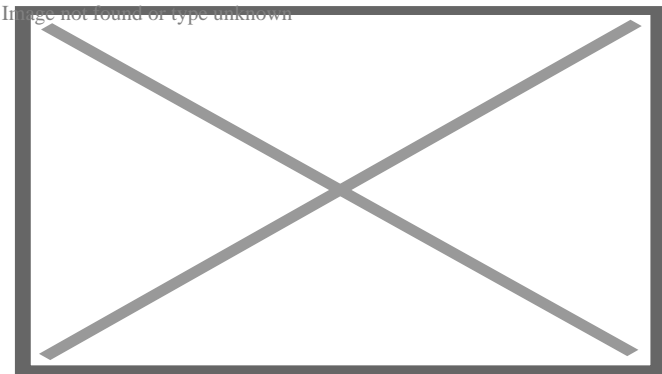
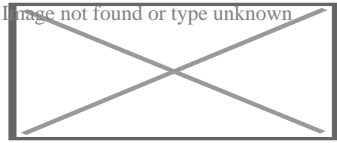
## About air conditioning

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),<sup>[1]</sup> 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.<sup>[2][3]</sup> Air conditioning is a member of a family of systems and techniques that provide heating, ventilation, and air conditioning (HVAC).<sup>[4]</sup> 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.<sup>[5]</sup>

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.<sup>[6]</sup> Air source heat pumps, which can be used for heating as well as cooling, are becoming increasingly common in cooler climates.

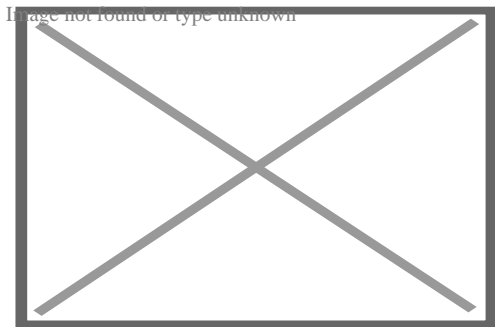
Air conditioners can reduce mortality rates due to higher temperature.<sup>[7]</sup> According to the International Energy Agency (IEA) 1.6 billion air conditioning units were used globally in 2016.<sup>[8]</sup> The United Nations called for the technology to be made more sustainable to mitigate climate 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.<sup>[9]</sup> 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.<sup>[10]</sup> Ancient Egyptian buildings also used a wide variety of passive air-conditioning techniques.<sup>[11]</sup> These became widespread from the Iberian Peninsula through North Africa, the Middle East, and Northern India.<sup>[12]</sup>

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.<sup>[13]</sup><sup>[12]</sup>



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.<sup>[14]</sup>

## 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*.<sup>[15]</sup><sup>[16]</sup><sup>[17]</sup> In 1620, Cornelis Drebbel demonstrated "Turning Summer

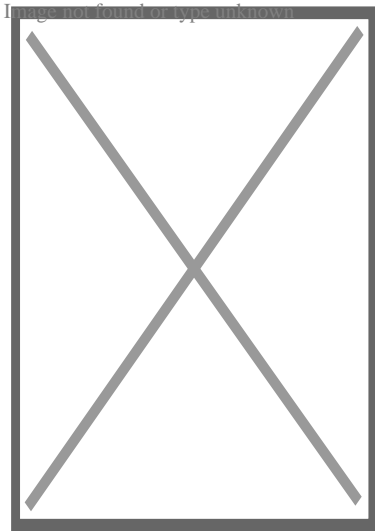
into Winter" for James I of England, chilling part of the Great Hall of Westminster Abbey with an apparatus of troughs and vats.<sup>[18]</sup> Drebbel's contemporary Francis Bacon, like della Porta a believer in science communication, may not have been present at the demonstration, but in a book published 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."<sup>[15]</sup>

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  $-14^{\circ}\text{C}$  ( $7^{\circ}\text{F}$ ) while the ambient temperature was  $18^{\circ}\text{C}$  ( $64^{\circ}\text{F}$ ). Franklin noted that soon after they passed the freezing point of water  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ), 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  $-14^{\circ}\text{C}$  ( $7^{\circ}\text{F}$ ). Franklin concluded: "From this experiment, one may see the possibility of freezing a man to death on a warm summer's day."<sup>[19]</sup>

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.<sup>[20]</sup> 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.<sup>[20][21]</sup> He envisioned centralized air conditioning that could cool entire cities. Gorrie was granted a patent in 1851,<sup>[22]</sup> but following the death of his main backer, he was not able to realize his invention.<sup>[23]</sup> 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.<sup>[24]</sup> 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.<sup>[24]</sup>

## 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.<sup>[25][26][27][28]</sup> In 1902, he installed his first air-conditioning system in the Sackett-Wilhelms Lithographing & Publishing Company in Brooklyn, New York.<sup>[29]</sup> 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.<sup>[30][31]</sup>

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.<sup>[32]</sup> 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.<sup>[33]</sup>

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<sup>[20]</sup> (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.)<sup>[20]</sup> A year later, the first air conditioning systems for cars were offered for sale.<sup>[34]</sup> Chrysler Motors introduced the first practical semi-portable air conditioning unit in 1935,<sup>[35]</sup> and Packard became the first automobile manufacturer to offer an air conditioning unit in its cars

in 1939.<sup>[36]</sup>

## 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.<sup>[37]</sup> The first inverter air conditioners were released in 1980–1981.<sup>[38][39]</sup>

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.<sup>[40][41]</sup>

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

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.<sup>[8][43]</sup> 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.<sup>[8]</sup> Between 1995 and 2004, the proportion of urban households in China with air conditioners increased from 8% to 70%.<sup>[44]</sup> As of 2015, nearly 100 million homes, or about 87% of US households, had air conditioning systems.<sup>[45]</sup> 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.<sup>[46][47]</sup>

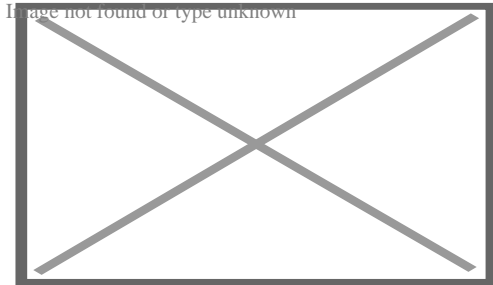
## Operation

[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.<sup>[48][49]</sup> 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.<sup>[50]</sup>

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.<sup>[51]</sup>

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<sup>[52]</sup> and dehumidified, before passing over the condenser coil, where it is warmed again before it is released back into the room.<sup>[citation needed]</sup>

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.<sup>[53]</sup>

## 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.<sup>[54]</sup> 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).<sup>[55][54][56]</sup> 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.<sup>[57]</sup><sup>[58]</sup> 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.<sup>[59]</sup> 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<sub>IT</sub> per hour, or 3,517 watts.<sup>[60]</sup> Residential central air systems are usually from 1 to 5 tons (3.5 to 18 kW) in capacity.<sup>[citation needed]</sup>

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*.<sup>[61]</sup> A similar standard is the European seasonal energy efficiency ratio (ESEER).<sup>[citation needed]</sup>

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.<sup>[62]</sup>

## Control system

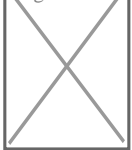
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# Wireless remote control

[edit]

Main articles: Remote control and Infrared blaster

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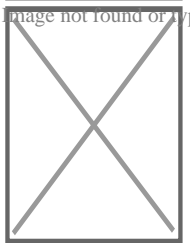
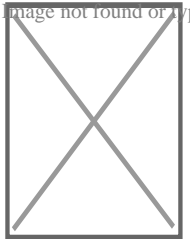
A  
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The infrared transmitting LED on the remote



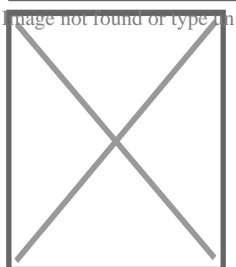
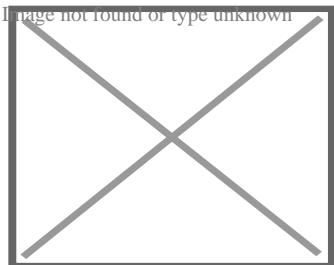
The infrared receiver on the air conditioner

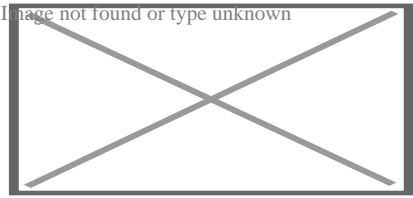
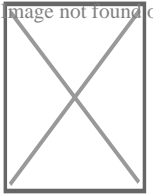
This type of controller uses an infrared LED to relay commands from a remote control to the air conditioner. The output of the infrared LED (like that of any infrared remote) is invisible to the human eye because its wavelength is beyond the range of visible light (940 nm). This system is commonly used 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

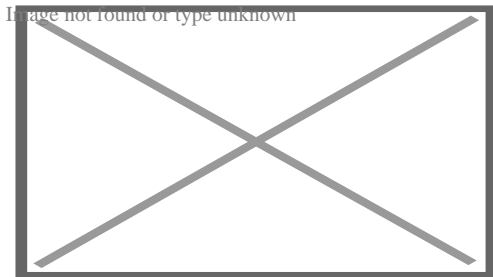
Packaged	very large	Direct / Ducted	Floor	Commercial
Packaged RTU (Rooftop Unit)	very large	Ducted	Rooftop	Commercial

\* 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.<sup>[63]</sup> 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.<sup>[64][65][66]</sup> In 1969, the first mini-split air conditioner was sold in the US.<sup>[67]</sup> 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.<sup>[68]</sup> 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.<sup>[69]</sup> Variable refrigerant flow indoor units can also be turned off individually in unused spaces.<sup>[citation needed]</sup> 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

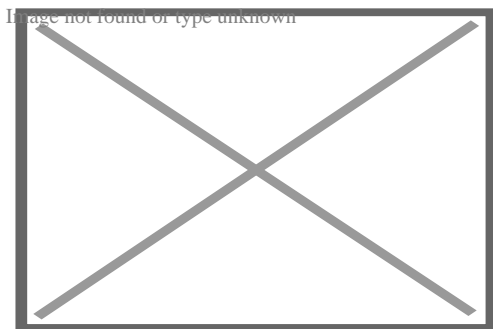
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Split-system central air conditioners consist of two heat exchangers, an outside unit (the condenser) from which heat is rejected to the environment and an internal heat exchanger (the evaporator, or Fan Coil Unit, FCU) with the piped refrigerant being circulated between the two. The FCU is then connected to the spaces to be cooled by ventilation ducts.<sup>[70]</sup> 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.[<sup>71</sup>][<sup>72</sup>]

## 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).

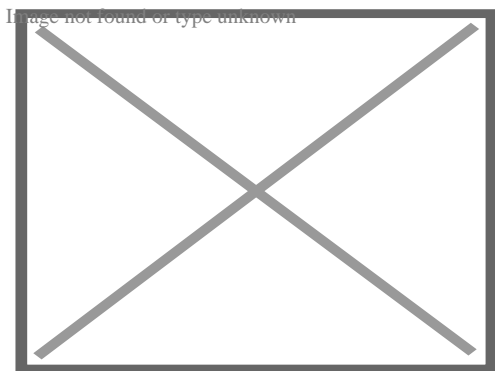
Hose systems, which can be *monoblock* or *air-to-air*, are vented to the outside via air ducts. The *monoblock* type collects the water in a bucket or tray and stops when full. The *air-to-air* type re-evaporates the water, discharges it through the ducted hose, and can run continuously. Many but not 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.[<sup>73</sup>]

## 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.<sup>[74]</sup>

## Packaged air conditioner

[edit]

Packaged air conditioners (also known as self-contained units)<sup>[75][76]</sup> 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),<sup>[77][78]</sup> 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.<sup>[70][79][80][81][82][83]</sup>

### 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)	very low	medium
			medium (large capacity)		
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. <sup>[*citation needed*]</sup>

## Scroll

[edit]

Main article: Scroll compressor

This compressor uses two interleaving scrolls to compress the refrigerant.<sup>[84]</sup> 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. <sup>[*citation needed*]</sup>

## 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. <sup>[*citation needed*]</sup>

### 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. <sup>[*citation needed*]</sup>

## 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%.<sup>[85]</sup>

## 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.<sup>[*citation needed*]</sup>

## 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.<sup>[*citation needed*]</sup>

## Variable-speed compressor



[edit]

Main article: Inverter compressor

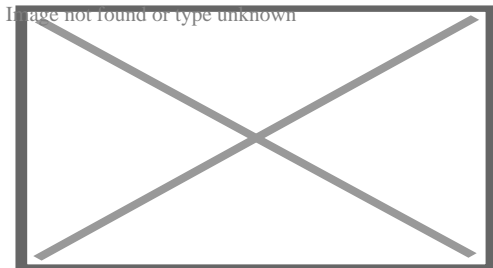
This system uses a variable-frequency drive (also called an Inverter) to control the speed of the compressor. The refrigerant flow rate is changed by the change in the speed of the compressor. The turn down ratio depends on the system configuration and manufacturer. It modulates from 15 or 25% up to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

## 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.<sup>[8]</sup><sup>[86]</sup> Heat waves are the most lethal type of weather phenomenon in the United States.<sup>[87]</sup><sup>[88]</sup> A 2020 study found that areas with lower use of air conditioning correlated with higher rates of heat-related mortality and hospitalizations.<sup>[89]</sup> 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.<sup>[8]</sup>

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.<sup>[90][91]</sup> 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.<sup>[92]</sup>

## Economic effects

[edit]

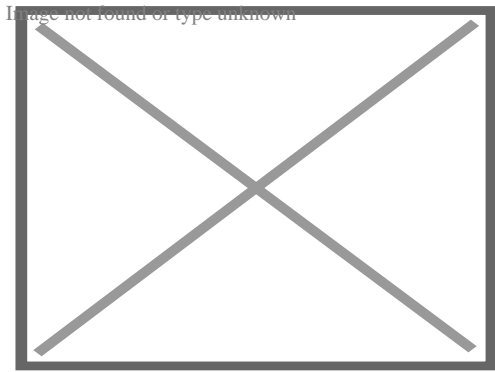
First designed to benefit targeted industries such as the press as well as large factories, the invention quickly spread to public agencies and administrations with studies with claims of increased productivity close to 24% in places equipped with air conditioning.<sup>[93]</sup>

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.<sup>[94]</sup> 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.<sup>[95]</sup> 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.<sup>[7]</sup>

The spread of the use of air conditioning acts as a main driver for the growth of global demand of electricity.<sup>[96]</sup> 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).<sup>[8]</sup> 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.<sup>[97]</sup>

## 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.<sup>[8]</sup> The report predicts an increase of electricity usage due to space cooling to around 6200 TWh by 2050,<sup>[8][98]</sup> 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.<sup>[8]</sup> 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.<sup>[99]</sup> 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.<sup>[99]</sup>

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.<sup>[100]</sup> CFCs and HCFCs refrigerants such as R-12 and R-22, respectively, used within air conditioners have caused damage to the ozone layer,<sup>[101]</sup> and hydrofluorocarbon refrigerants such as R-410A and R-404A, which were designed to replace CFCs and HCFCs, are instead exacerbating climate change.<sup>[102]</sup> 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.<sup>[103]</sup>

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).<sup>[104]</sup>

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.<sup>[citation needed]</sup>

# Social effects

[edit]

Socioeconomic groups with a household income below around \$10,000 tend to have a low air conditioning adoption,<sup>[42]</sup> which worsens heat-related mortality.<sup>[7]</sup> 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.<sup>[89]</sup> Premature mortality in NYC is projected to grow between 47% and 95% in 30 years, with lower-income and vulnerable populations most at risk.<sup>[89]</sup> Studies on the correlation between heat-related mortality and hospitalizations and living in low socioeconomic locations can be traced in Phoenix, Arizona,<sup>[105]</sup> Hong Kong,<sup>[106]</sup> China,<sup>[106]</sup> Japan,<sup>[107]</sup> and Italy.<sup>[108]</sup><sup>[109]</sup> 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.<sup>[109]</sup>

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.<sup>[109]</sup> 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.<sup>[110]</sup> Especially in cities, Redlining creates heat islands, increasing temperatures in certain parts of the city.<sup>[109]</sup> This is due to materials heat-absorbing building materials and pavements and lack of vegetation and shade coverage.<sup>[111]</sup> There have been initiatives that provide cooling solutions to low-income communities, such as public cooling spaces.<sup>[8]</sup><sup>[111]</sup>

## Other techniques

[edit]

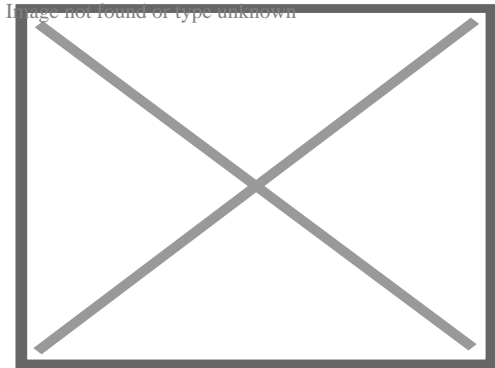
Buildings designed with passive air conditioning are generally less expensive to construct and maintain than buildings with conventional HVAC systems with lower energy demands.<sup>[112]</sup> While tens of air changes per hour, and cooling of tens of degrees, can be achieved with passive methods, site-specific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

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.<sup>[113]</sup>

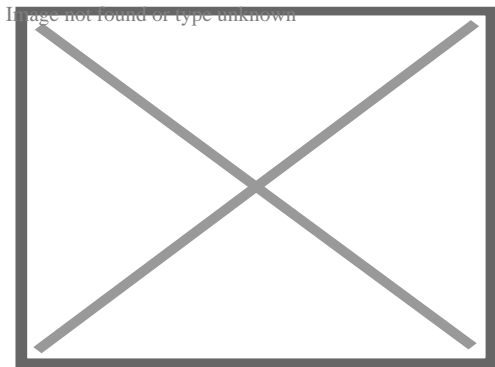
# Passive ventilation

[edit]

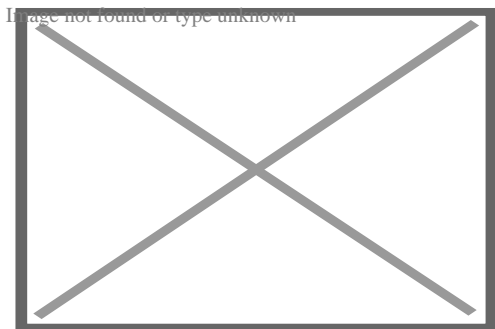
This section is an excerpt from Passive ventilation.[edit]



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.

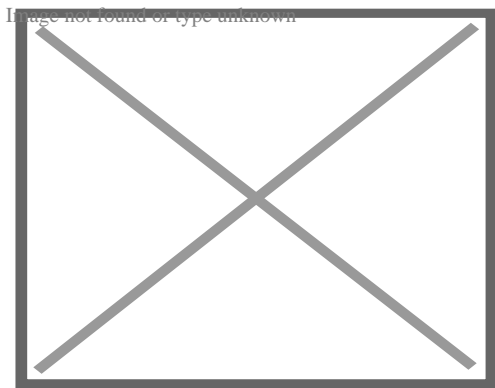
There are two types of natural ventilation occurring in buildings: *wind driven ventilation* and *buoyancy-driven ventilation*. Wind driven ventilation arises from the different pressures created by wind around a building or structure, and openings being formed on the perimeter which then permit flow 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.<sup>[114]</sup>

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.<sup>[edit]</sup>



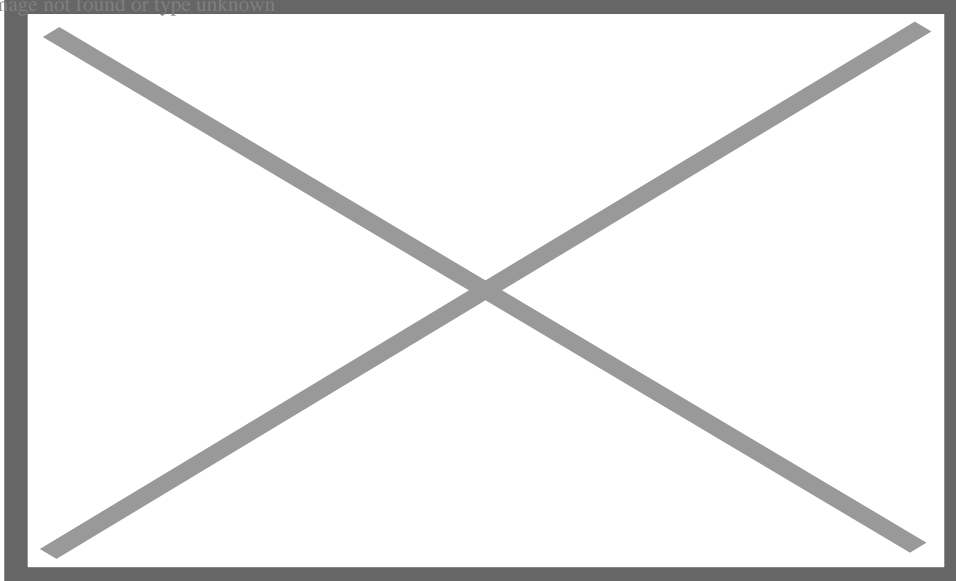
A traditional Iranian solar cooling design using a wind tower

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.<sup>[115][116]</sup> This approach works either by preventing heat from entering the interior (heat gain prevention) or by removing heat from the building (natural cooling).<sup>[117]</sup>

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.<sup>[118]</sup> 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.<sup>[119][120]</sup>

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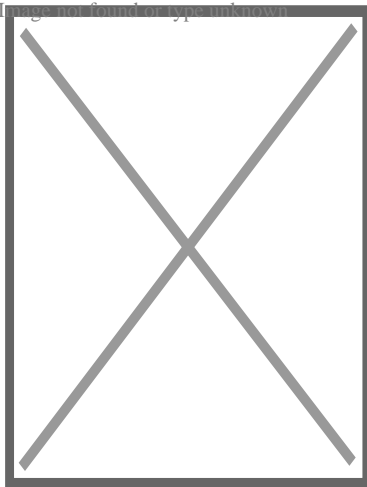


A pair of short windcatchers (*malqaf*) used in traditional architecture; wind is forced down on the windward side and leaves on the leeward side (*cross-ventilation*). In the absence of wind, the circulation can be driven with evaporative cooling in the inlet (which is also designed to catch dust). 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*).<sup>[11]</sup>

## 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.<sup>[121]</sup>

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).<sup>[122]</sup> 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.<sup>[121][123]</sup>

PDRC applications on building roofs and envelopes have demonstrated significant decreases in energy consumption and costs.<sup>[123]</sup> In suburban single-family residential areas, PDRC application on roofs can potentially lower energy costs by 26% to 46%.<sup>[124]</sup> 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.<sup>[125][126]</sup>

## 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.<sup>[127]</sup> :â€š99,â€š151,â€š233â€šIn 747, Emperor Xuanzong (r. 712–762) of the Tang dynasty (618–907) had the Cool Hall (*Liang Dian* 凉殿) 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.<sup>[127]</sup> :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.<sup>[13]</sup>

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.<sup>[13]</sup> This technique is over 3,700 years old in the Middle

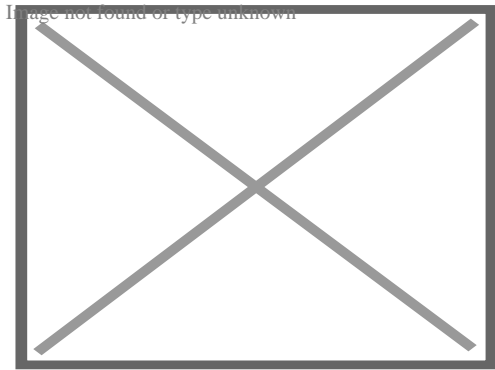


East.<sup>[128]</sup> Harvesting outdoor ice during winter and transporting and storing for use in summer was practiced by wealthy Europeans in the early 1600s,<sup>[15]</sup> and became popular in Europe and the Americas towards the end of the 1600s.<sup>[129]</sup> This practice was replaced by mechanical 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.<sup>[11]</sup> Evaporative cooling also makes the air more humid, which can be beneficial in a dry desert climate.<sup>[130]</sup>

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.<sup>[131]</sup>

### See also

[edit]

- Air conditioning paradox
- Air filter

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

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Wikiversity has learning resources about ***Refrigeration and air conditioning***

- 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
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## Heating, 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

- 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

## Technology

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

**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

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

## Types

## See also

- Appliance plug
- Appliance recycling

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## Roofs

### Roof shapes

- Arched roof
- Barrel roof
- Board roof
- Bochká 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

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Electronics

## **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

Authority control databases: National  Germany Edit this at Wikidata  
 ○ Czech Republic

About Royal Porta Johns

Driving Directions in Plymouth County

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41.95517988369, -71.024040697865

Starting Point

Royal Porta Johns

Destination

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### **Driving Directions**

41.942238177463, -71.065213449748

Starting Point

Royal Porta Johns

Destination

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### **Driving Directions**

41.981847900205, -71.001876260894

Starting Point

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Destination

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### **Driving Directions**

41.962854085438, -71.04091025038

Starting Point

Royal Porta Johns

Destination

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### **Driving Directions**

42.012650864841, -71.032671051474

Starting Point

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### **Driving Directions**

42.094551507665, -71.149943873399

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### **Driving Directions**

42.003687040962, -70.972960957357

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### Driving Directions

41.987487768424, -71.076189119876

Starting Point

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### **Driving Directions**

42.013075924126, -70.924712336811

Starting Point

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### Driving Directions

42.026467135479, -71.181421946547

Starting Point

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[71.129962582483,25.2z/data=!4m6!3m5!1s0x89e48f0bdb75549d:0x9ac1c8405242e765!8m2!3d42.0232265](https://www.google.com/maps/place/Royal+Porta+Johns/@42.057192898441,-71.129962582483,25.2z/data=!4m6!3m5!1s0x89e48f0bdb75549d:0x9ac1c8405242e765!8m2!3d42.023226571.0537696!16s%2F)

[71.0537696!16s%2F](https://www.google.com/maps/place/Royal+Porta+Johns/@42.057192898441,-71.129962582483,25.2z/data=!4m6!3m5!1s0x89e48f0bdb75549d:0x9ac1c8405242e765!8m2!3d42.023226571.0537696!16s%2F)

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[71.120478416321,25.2z/data=!4m6!3m5!1s0x89e48f0bdb75549d:0x9ac1c8405242e765!8m2!3d42.0232265](https://www.google.com/maps/place/Royal+Porta+Johns/@42.051805619842,-71.120478416321,25.2z/data=!4m6!3m5!1s0x89e48f0bdb75549d:0x9ac1c8405242e765!8m2!3d42.023226571.0537696!16s%2F)

[71.0537696!16s%2F](https://www.google.com/maps/place/Royal+Porta+Johns/@42.051805619842,-71.120478416321,25.2z/data=!4m6!3m5!1s0x89e48f0bdb75549d:0x9ac1c8405242e765!8m2!3d42.023226571.0537696!16s%2F)

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- [Training Staff on Regulatory Portable Sanitation Rules](#)

## Frequently Asked Questions

How does a QR code system track porta potty maintenance?

The QR code on each unit is scanned by maintenance staff using a smartphone, which logs the date, time, and type of service performed in a digital database.

What maintenance information is typically recorded through the QR system?

Cleaning completion, supply restocking, waste removal, repairs made, and sanitization status are recorded with timestamps and staff identification.

Can customers verify when the porta potty was last serviced?

Yes, many QR systems allow customers to scan the code with their phones to view the last service date and maintenance history of the specific unit.

How does QR code tracking improve service quality?

It ensures accountability, provides proof of service, enables real-time tracking, and helps maintain consistent cleaning schedules and standards.

What happens if the QR code becomes damaged or unreadable?

Backup numerical codes are typically provided beneath the QR code, and replacement QR codes can be quickly generated and applied to maintain tracking continuity.

Royal Porta Johns

Phone : 17744442014

City : West Bridgewater

State : MA

Zip : 02379

Address : 400, West Street

## **Google Business Profile**

Company Website : [\*\*https://royalportajohns.com/\*\*](https://royalportajohns.com/)

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