

HVAC cost



- **Estimating Labor Expenses for Repair Services**
Estimating Labor Expenses for Repair Services Comparing Replacement Part Prices for Various Systems Reviewing Maintenance Plan Rates in Detail Exploring Payment Arrangements for Major Overhauls Analyzing Long Term Savings with Efficient Upgrades Investigating Seasonal Discounts from Service Providers Understanding Monthly Budgeting for HVAC Projects Balancing Initial Spending with Potential Savings Evaluating Total Costs for System Retrofits Preparing for Unexpected Repair Fees Weighing Return on Investment for Modern Equipment Identifying Hidden Expenses in Older Units
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When it comes to managing the upkeep of machinery, buildings, or other significant assets, a well-structured maintenance plan is indispensable. Maintenance plans are crucial tools that ensure assets remain operational and efficient while minimizing downtime and unexpected repair costs. Understanding the common features and benefits of these plans can lead to more informed decision-making when reviewing maintenance plan rates in detail.

Outdoor compressor units must be securely mounted to prevent damage **mobile home hvac** money.

A comprehensive maintenance plan typically includes several key features designed to address both routine upkeep and unexpected repairs. Regular inspections form the backbone of any effective plan, allowing for early detection of potential issues before they escalate into costly problems. Scheduled servicing ensures that all components are functioning optimally, extending the lifespan of equipment and infrastructure. Moreover, many plans incorporate emergency response protocols to swiftly address sudden breakdowns, thereby reducing downtime.

Another vital feature is record-keeping and documentation. Keeping detailed records of all maintenance activities provides a clear history that can be invaluable for future planning and budgeting. By analyzing past data, organizations can identify patterns or recurring issues, enabling them to refine their maintenance strategies over time.

Furthermore, modern maintenance plans often leverage technology such as predictive analytics and IoT devices. These advanced tools allow for real-time monitoring of asset conditions, offering insights that traditional methods might miss. This proactive approach ensures that potential failures are anticipated rather than merely reacted to.

The benefits derived from these features are manifold. First and foremost, an effective maintenance plan significantly reduces operational disruptions by ensuring assets are consistently in good working condition. This reliability translates into enhanced productivity as employees can focus on their tasks without frequent interruptions caused by equipment failure.

Cost efficiency is another major advantage. While there's an upfront investment in establishing a robust maintenance regime, it pays off over time by avoiding expensive emergency repairs and replacements. Predictive maintenance technologies further optimize this cost-effectiveness by preventing unnecessary servicing while ensuring timely

intervention when needed.

Moreover, adherence to a structured maintenance schedule enhances safety within the workplace or service environment. Well-maintained equipment is less likely to malfunction in ways that could pose risks to operators or users.

Environmental sustainability also sees improvement through effective maintenance practices. By keeping machinery running efficiently with minimal energy wastage and extending its usable life span, organizations contribute positively toward resource conservation efforts.

In summary, understanding the comprehensive features embedded within common maintenance plans-ranging from regular inspections to leveraging cutting-edge technology-reveals their substantial benefits such as reduced downtime, cost savings through preventative measures rather than reactive fixes; improved safety standards; alongside contributing towards sustainable practices overall make them indispensable part business strategy especially when diving deep into evaluating various rates associated particular offerings helps tailor solutions best suited specific organizational needs yielding maximum returns investment made initially long term perspective taken consideration across board effectively efficiently aligned strategic goals set forth achieve desired outcomes systematically consistently without compromise quality service delivery end-user satisfaction ultimately achieved maintained highest levels possible throughout lifecycle management process inherently built systems processes put place upfront basis ongoing continuous improvement initiatives undertaken periodically review assess performance metrics feedback loops integrated seamlessly operations cycle dynamics involved therein accordingly adjust adapt evolving circumstances scenarios encountered along journey successfully navigate challenges arise opportunistically capitalize growth opportunities present themselves market trends shift change course direction necessitating adaptation innovation creative problem-solving approaches employed tackle head-on confidently assuredly knowing equipped right tools resources support necessary succeed thrive regardless external internal pressures exerted upon organization industry sector operates within context given timeframe horizon envisioned projected anticipate foreseeably foreseeable future unfolding ahead roadmap charted plotted strategically logically rationally thoughtfully considerately judiciously wisely prudently intelligently smartly deftly adeptly skillfully competently expertly professionally diligently conscientiously responsibly ethically morally integrity honesty transparency accountability respect

Factors Influencing Labor Costs in Mobile Home HVAC Repairs —

- [Overview of Common Repair Services for Mobile Home HVAC Systems](#)
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Mobile homes, with their unique structural and environmental characteristics, require specialized attention when it comes to maintaining their HVAC systems. A well-crafted maintenance plan is essential to ensure the efficient operation of these systems, which are crucial for the comfort and safety of residents. However, several factors influence the rates of such maintenance plans, rendering them varied and sometimes complex. Understanding these factors can help homeowners make informed decisions that balance cost with quality service.

Firstly, the age and condition of the HVAC system significantly impact maintenance plan rates. Older units or those that have not been regularly serviced may demand more frequent check-ups and repairs, driving up costs. Wear and tear over time can lead to inefficiencies or even breakdowns that necessitate more extensive servicing or parts replacement. Conversely, newer or well-maintained systems might require less intensive care, resulting in lower plan rates.

Geographical location is another critical factor influencing these rates. Mobile homes situated in areas with extreme weather conditions might see higher maintenance costs due to increased usage demands on HVAC systems. For example, regions experiencing harsh winters or sweltering summers put additional strain on heating and cooling components, respectively. This added stress necessitates more rigorous maintenance protocols to ensure reliability during peak usage times.

The complexity of the HVAC system itself also plays a role in determining maintenance plan rates. Systems equipped with advanced technology such as smart thermostats or energy-efficient components may require specialized knowledge for servicing. Technicians trained to handle such sophisticated systems often command higher fees due to their expertise, which is reflected in the overall cost of a maintenance plan.

Furthermore, the scope of services included in a maintenance plan affects its rate. Comprehensive plans offering extensive services—such as regular cleaning, thorough inspections, priority emergency service calls, and discounts on parts or labor—tend to come at a premium compared to basic packages covering only routine check-ups. Homeowners must assess their needs against what different plans offer to find an optimal balance between coverage and budget.

Lastly, market competition among service providers can influence pricing structures for HVAC maintenance plans. In areas where numerous companies vie for business, competitive pricing strategies may result in lower rates as firms strive to attract customers by offering better value propositions.

In conclusion, several interconnected factors shape the rates for mobile home HVAC system maintenance plans: from the age and complexity of the unit itself to geographical influences and market dynamics. By carefully evaluating these variables alongside personal needs and financial considerations, homeowners can select a plan that ensures their HVAC system remains efficient while providing peace of mind through reliable performance year-round.

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Steps to Accurately Estimate Labor Expenses for HVAC Repair Services

When it comes to selecting a maintenance plan for essential services, whether it's for your home appliances, vehicles, or industrial equipment, making an informed choice is crucial. Comparative analysis of different providers' maintenance plan rates allows consumers to evaluate various options extensively and decide on the best fit based on both economic and service quality considerations. The topic of reviewing maintenance plan rates in detail delves into this comparative process, offering insights into how these plans differ across providers and what factors should be considered when making a decision.

Firstly, it's important to understand what constitutes a maintenance plan. Essentially, these plans offer a form of insurance against unexpected repair costs by providing routine service check-ups and coverage for unforeseen breakdowns. The scope can vary significantly from one provider to another; hence, a detailed review becomes indispensable.

One of the primary aspects to consider while comparing different maintenance plans is the cost versus benefit ratio. While some providers might offer lower upfront rates, these plans could come with hidden costs such as high deductibles or limited coverage that only become apparent during claims processing. On the other hand, higher-priced plans might include comprehensive coverage with additional benefits like rapid response times or access to expert technicians. Therefore, potential buyers need to weigh immediate expenses against long-term savings and service quality.

In addition to cost considerations, evaluating the reliability and reputation of service providers is equally important. A well-known provider with positive customer reviews usually indicates reliability in terms of fulfilling their contractual obligations promptly and efficiently. Conversely, lesser-known companies may offer competitive rates but could fall short on delivering satisfactory service experiences.

Another critical factor in this comparative analysis is flexibility and customization options within the offered plans. Some providers present flexible packages that allow consumers to tailor services according to their specific needs—such as choosing between monthly or annual payments or selecting particular components for coverage—thereby enhancing value for money spent.

Moreover, examining ancillary benefits attached to each plan can further influence decision-making. These might include perks like discounted replacement parts or priority scheduling during peak demand periods which can add significant value beyond basic repairs.

Lastly, it's beneficial for consumers to remain cognizant of the changing landscape of technology-driven solutions that some modern maintenance plans incorporate today. For example, smart diagnostics through IoT devices enable proactive servicing before issues escalate—a feature worth considering despite potentially higher costs associated with advanced technology integration.

In conclusion, performing a comparative analysis of different providers' maintenance plan rates involves more than just comparing prices; it requires an all-encompassing evaluation encompassing cost-effectiveness, provider reliability, customizability of services offered along with added benefits integrated into those plans. By scrutinizing each element meticulously within this framework allows consumers not only make financially sound decisions but also ensures peace-of-mind knowing they are adequately protected against unexpected maintenance issues in future endeavors.



Tools and Software for Estimating Labor Costs in Mobile Home HVAC Repairs

When evaluating the financial implications of maintenance plans, the term "Cost-Benefit Analysis" becomes particularly pertinent. This analytical approach involves weighing the costs of higher-priced maintenance plans against their potential benefits to determine if they are indeed worth the investment. In an era where businesses and individuals alike are striving for efficiency and fiscal prudence, understanding the value proposition of these plans is more crucial than ever.

Maintenance plans are designed to provide peace of mind by ensuring that equipment or services remain operational with minimal disruptions. They often cover regular inspections, preventative maintenance tasks, and, in some cases, urgent repairs without additional out-of-pocket expenses. The allure of such comprehensive coverage can be tempting; however, higher-priced plans often come with a significant initial cost that requires careful consideration.

The first step in conducting a cost-benefit analysis is identifying the specific needs and usage patterns associated with the equipment or service in question. For instance, a business relying heavily on its machinery may benefit significantly from a premium plan that offers swift repair services and minimizes downtime. On the other hand, for equipment used infrequently or deemed less critical to operations, a basic plan might suffice.

Another factor to consider is the historical performance and reliability of what is being maintained. If past experiences have shown frequent breakdowns or high repair costs, investing in a robust maintenance plan could lead to long-term savings and increased operational efficiency. Conversely, if previous data indicate minimal issues or low-cost repairs, the necessity for an expensive plan diminishes.

Furthermore, it's essential to evaluate what each maintenance plan includes beyond just repair services. Higher-priced options might offer additional perks such as priority service scheduling, extended warranties on parts replaced during repairs, or even technological updates that enhance performance over time. These added values can play a pivotal role in tipping the scales toward selecting a more expensive option if they align closely with anticipated needs and result in productivity gains.

Additionally, one must not overlook potential hidden savings associated with costly breakdowns avoided through proactive maintenance strategies inherent in pricier packages. By preventing extensive damage through routine inspections and timely interventions offered by comprehensive plans, organizations can avert substantial financial losses linked to major repairs or replacements.

In conclusion, determining whether higher-priced maintenance plans are worth the investment hinges upon an exhaustive cost-benefit analysis tailored to individual circumstances. By considering factors like usage intensity, historical reliability data, included services beyond basic repairs-and most importantly-the alignment between plan features and organizational priorities-a well-informed decision emerges that balances upfront expenditures against future savings opportunities effectively. Ultimately though complex at times this evaluation process ensures informed decisions fostering both fiscal responsibility while safeguarding operational continuity amidst uncertain times ahead!

Case Studies: Examples of Labor Cost Estimation in Various Repair Scenarios

Choosing the right maintenance plan can often feel like navigating a labyrinth of options, rates, and fine print. However, selecting the most suitable plan based on individual needs is crucial for ensuring that equipment and systems remain in peak condition without incurring unnecessary costs. This essay will explore tips for choosing the right maintenance plan by delving into the details of reviewing maintenance plan rates.

First and foremost, it is essential to assess your unique requirements before committing to any maintenance plan. Start by conducting a thorough inventory of all assets that require regular upkeep. This includes not only tangible items such as machinery and vehicles but also intangible aspects like software systems. Understanding the scope and importance of each asset helps in prioritizing which elements need more intensive attention versus those that may require minimal oversight.

Once you have a clear picture of your maintenance needs, compare different plans offered by various providers. Pay close attention to what each plan covers-routine inspections, emergency repairs, parts replacements-and weigh these against your specific requirements. A common pitfall is opting for a cheaper plan without considering whether it adequately addresses all necessary services; conversely, choosing an expensive package with features

you might never use can lead to wasted resources.

Cost analysis plays a pivotal role in this decision-making process. Maintenance plans typically come with fixed or variable rates based on frequency and type of service provided. It is advisable to scrutinize these rates carefully. Fixed-rate plans offer predictability in budgeting but might not always accommodate unexpected issues efficiently. Variable-rate plans provide flexibility but could result in fluctuating expenses depending on usage or emergencies.

Additionally, consider the reputation and reliability of the service provider. A well-established company with positive customer feedback is likely to deliver consistent quality service compared to a lesser-known entity offering competitive rates but lacking credibility or proven expertise.

Another critical factor is future-proofing your choice: anticipate potential changes in your operations or asset base over time and select a plan that allows scalability without excessive cost increases or contractual penalties.

Finally, do not overlook the fine print-terms and conditions can significantly impact how beneficial a particular maintenance plan is in practice versus theory. Ensure clarity on cancellation policies, service response times, liability clauses, and any other legalese that might affect real-world application.

Ultimately, choosing the right maintenance plan revolves around balancing personalized needs with cost-effectiveness while ensuring high-quality service delivery from reputable providers. By following these tips-conducting thorough assessments, comparing offerings critically, analyzing costs effectively-you are more likely to select an optimal maintenance strategy tailored specifically for your circumstances rather than settling for one-size-fits-all solutions that might not fully meet your expectations or requirements.



Tips for Managing and Reducing Labor Expenses Without Compromising Quality

Maintenance plans are crucial in ensuring the longevity and efficiency of various systems, whether they pertain to industrial machinery, infrastructure, or even software. When we delve into the term "Case Studies: Real-Life Examples of Effective Maintenance Plans in Action," we explore a realm where theoretical strategies meet practical application. Reviewing maintenance plan rates in detail can offer invaluable insights into how different approaches fare under real-world conditions.

A case study worth examining is that of a manufacturing company that implemented a predictive maintenance strategy. Traditionally relying on reactive maintenance, which often led to costly downtimes and repairs, this company transitioned to a more proactive approach utilizing condition-monitoring tools and data analytics. The results were staggering; not only did machinery downtime decrease by 30%, but the overall maintenance costs also dropped significantly. This case underscores the importance of investing in modern technology and training staff to interpret data effectively.

Another compelling example can be found in public infrastructure management. A city council faced increasing complaints about road quality and frequent repairs disrupting traffic flow. By adopting a preventive maintenance plan focused on regular inspections and timely interventions, the council managed to extend road life spans while reducing repair incidents by 25%. The financial implications were equally impressive as the long-term savings surpassed initial investments within just a few years.

The software industry provides an intriguing contrast with its reliance on agile methodologies for maintenance planning. One tech company adopted continuous integration and delivery pipelines, allowing for ongoing updates without significant downtime. This approach not only kept their systems up-to-date but also ensured that any bugs or vulnerabilities were addressed promptly. As a result, customer satisfaction levels improved alongside system reliability.

These real-life examples highlight the effectiveness of well-planned maintenance strategies across different sectors. While each scenario presents unique challenges and solutions, common themes emerge—such as the importance of leveraging technology, prioritizing preventive measures over reactive ones, and adapting plans based on performance data.

Critically reviewing maintenance plan rates involves evaluating these strategies' cost-effectiveness against their outcomes. Savings achieved through reduced downtimes or extended asset lifespans often justify higher initial expenditures on sophisticated tools or

training programs. Furthermore, understanding the context-specific factors that influence success rates is essential for tailoring approaches that best fit an organization's needs.

In conclusion, effective maintenance plans are pivotal in optimizing resource utilization while minimizing disruptions and expenses. Learning from real-life examples through detailed case studies allows organizations to refine their strategies continuously, ensuring they remain competitive and resilient in an ever-evolving landscape.

About Sick building syndrome



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Sick building syndrome

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Sick building syndrome (SBS) is a condition in which people develop symptoms of illness or become infected with chronic disease from the building in which they work or reside.^[1] In scientific literature, SBS is also known as **building-related illness (BRI)**, **building-related symptoms (BRS)**, or **idiopathic environmental intolerance (IEI)**.

The main identifying observation is an increased incidence of complaints of such symptoms as headache, eye, nose, and throat irritation, fatigue, dizziness, and nausea. The 1989 Oxford English Dictionary defines SBS in that way.^[2] The World Health Organization created a 484-page tome on indoor air quality 1984, when SBS was attributed only to non-organic causes, and suggested that the book might form a basis for legislation or litigation.^[3]

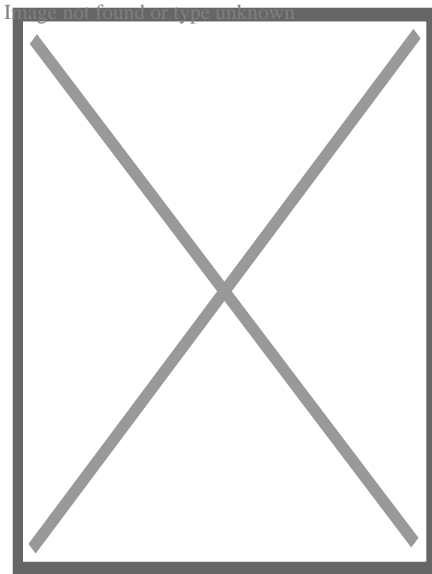
The outbreaks may or may not be a direct result of inadequate or inappropriate cleaning.^[2] SBS has also been used to describe staff concerns in post-war buildings with faulty building aerodynamics, construction materials, construction process, and

maintenance.^[2] Some symptoms tend to increase in severity with the time people spend in the building, often improving or even disappearing when people are away from the building.^{[2][4]} The term *SBS* is also used interchangeably with "**building-related symptoms**", which orients the name of the condition around patients' symptoms rather than a "sick" building.^[5]

Attempts have been made to connect sick building syndrome to various causes, such as contaminants produced by outgassing of some building materials, volatile organic compounds (VOC), improper exhaust ventilation of ozone (produced by the operation of some office machines), light industrial chemicals used within, and insufficient fresh-air intake or air filtration (see "Minimum efficiency reporting value").^[2] Sick building syndrome has also been attributed to heating, ventilation, and air conditioning (HVAC) systems, an attribution about which there are inconsistent findings.^[6]

Signs and symptoms

[edit]



An air quality monitor

Human exposure to aerosols has a variety of adverse health effects.^[7] Building occupants complain of symptoms such as sensory irritation of the eyes, nose, or throat; neurotoxic or general health problems; skin irritation; nonspecific hypersensitivity reactions; infectious diseases;^[8] and odor and taste sensations.^[9] Poor lighting has caused general malaise.^[10]

Extrinsic allergic alveolitis has been associated with the presence of fungi and bacteria in the moist air of residential houses and commercial offices.^[11] A study in 2017 correlated several inflammatory diseases of the respiratory tract with objective

evidence of damp-caused damage in homes.[¹²]

The WHO has classified the reported symptoms into broad categories, including mucous-membrane irritation (eye, nose, and throat irritation), neurotoxic effects (headaches, fatigue, and irritability), asthma and asthma-like symptoms (chest tightness and wheezing), skin dryness and irritation, and gastrointestinal complaints.[¹³]

Several sick occupants may report individual symptoms that do not seem connected. The key to discovery is the increased incidence of illnesses in general with onset or exacerbation in a short period, usually weeks. In most cases, SBS symptoms are relieved soon after the occupants leave the particular room or zone.[¹⁴] However, there can be lingering effects of various neurotoxins, which may not clear up when the occupant leaves the building. In some cases, including those of sensitive people, there are long-term health effects.[¹⁵]

Cause

[edit]

ASHRAE has recognized that polluted urban air, designated within the United States Environmental Protection Agency (EPA)'s air quality ratings as unacceptable, requires the installation of treatment such as filtration for which the HVAC practitioners generally apply carbon-impregnated filters and their likes. Different toxins will aggravate the human body in different ways. Some people are more allergic to mold, while others are highly sensitive to dust. Inadequate ventilation will exaggerate small problems (such as deteriorating fiberglass insulation or cooking fumes) into a much more serious indoor air quality problem.[¹⁰]

Common products such as paint, insulation, rigid foam, particle board, plywood, duct liners, exhaust fumes and other chemical contaminants from indoor or outdoor sources, and biological contaminants can be trapped inside by the HVAC AC system. As this air is recycled using fan coils the overall oxygenation ratio drops and becomes harmful. When combined with other stress factors such as traffic noise and poor lighting, inhabitants of buildings located in a polluted urban area can quickly become ill as their immune system is overwhelmed.[¹⁰]

Certain VOCs, considered toxic chemical contaminants to humans, are used as adhesives in many common building construction products. These aromatic carbon rings / VOCs can cause acute and chronic health effects in the occupants of a building, including cancer, paralysis, lung failure, and others. Bacterial spores, fungal spores, mold spores, pollen, and viruses are types of biological contaminants and can all cause allergic reactions or illness described as SBS. In addition, pollution from outdoors, such

as motor vehicle exhaust, can enter buildings, worsen indoor air quality, and increase the indoor concentration of carbon monoxide and carbon dioxide.^[16] Adult SBS symptoms were associated with a history of allergic rhinitis, eczema and asthma.^[17]

A 2015 study concerning the association of SBS and indoor air pollutants in office buildings in Iran found that, as carbon dioxide increased in a building, nausea, headaches, nasal irritation, dyspnea, and throat dryness also rose.^[10] Some work conditions have been correlated with specific symptoms: brighter light, for example was significantly related to skin dryness, eye pain, and malaise.^[10] Higher temperature is correlated with sneezing, skin redness, itchy eyes, and headache; lower relative humidity has been associated with sneezing, skin redness, and eye pain.^[10]

In 1973, in response to the oil crisis and conservation concerns, ASHRAE Standards 62-73 and 62-81 reduced required ventilation from 10 cubic feet per minute (4.7 L/s) per person to 5 cubic feet per minute (2.4 L/s) per person, but this was found to be a contributing factor to sick building syndrome.^[18] As of the 2016 revision, ASHRAE ventilation standards call for 5 to 10 cubic feet per minute of ventilation per occupant (depending on the occupancy type) in addition to ventilation based on the zone floor area delivered to the breathing zone.^[19]

Workplace

[edit]

Excessive work stress or dissatisfaction, poor interpersonal relationships and poor communication are often seen to be associated with SBS, recent^[when?] studies show that a combination of environmental sensitivity and stress can greatly contribute to sick building syndrome.^[15]^[citation needed]

Greater effects were found with features of the psycho-social work environment including high job demands and low support. The report concluded that the physical environment of office buildings appears to be less important than features of the psycho-social work environment in explaining differences in the prevalence of symptoms. However, there is still a relationship between sick building syndrome and symptoms of workers regardless of workplace stress.^[20]

Specific work-related stressors are related with specific SBS symptoms. Workload and work conflict are significantly associated with general symptoms (headache, abnormal tiredness, sensation of cold or nausea). While crowded workspaces and low work satisfaction are associated with upper respiratory symptoms.^[21] Work productivity has been associated with ventilation rates, a contributing factor to SBS, and there's a

significant increase in production as ventilation rates increase, by 1.7% for every two-fold increase of ventilation rate.^[22] Printer effluent, released into the office air as ultra-fine particles (UFPs) as toner is burned during the printing process, may lead to certain SBS symptoms.^[23]^[24] Printer effluent may contain a variety of toxins to which a subset of office workers are sensitive, triggering SBS symptoms.^[25]

Specific careers are also associated with specific SBS symptoms. Transport, communication, healthcare, and social workers have highest prevalence of general symptoms. Skin symptoms such as eczema, itching, and rashes on hands and face are associated with technical work. Forestry, agriculture, and sales workers have the lowest rates of sick building syndrome symptoms.^[26]

From the assessment done by Fisk and Mudarri, 21% of asthma cases in the United States were caused by wet environments with mold that exist in all indoor environments, such as schools, office buildings, houses and apartments. Fisk and Berkeley Laboratory colleagues also found that the exposure to the mold increases the chances of respiratory issues by 30 to 50 percent.^[27] Additionally, studies showing that health effects with dampness and mold in indoor environments found that increased risk of adverse health effects occurs with dampness or visible mold environments.^[28]

Milton et al. determined the cost of sick leave specific for one business was an estimated \$480 per employee, and about five days of sick leave per year could be attributed to low ventilation rates. When comparing low ventilation rate areas of the building to higher ventilation rate areas, the relative risk of short-term sick leave was 1.53 times greater in the low ventilation areas.^[29]

Home

[edit]

Sick building syndrome can be caused by one's home. Laminate flooring may release more SBS-causing chemicals than do stone, tile, and concrete floors.^[17] Recent redecorating and new furnishings within the last year are associated with increased symptoms; so are dampness and related factors, having pets, and cockroaches.^[17] Mosquitoes are related to more symptoms, but it is unclear whether the immediate cause of the symptoms is the mosquitoes or the repellents used against them.^[17]

Mold

[edit]

Main article: Mold health issues

Sick building syndrome may be associated with indoor mold or mycotoxin contamination. However, the attribution of sick building syndrome to mold is controversial and supported by little evidence.^{[30][31][32]}

Indoor temperature

[edit]

Main article: Room temperature § Health effects

Indoor temperature under 18 °C (64 °F) has been shown to be associated with increased respiratory and cardiovascular diseases, increased blood levels, and increased hospitalization.^[33]

Diagnosis

[edit]

While sick building syndrome (SBS) encompasses a multitude of non-specific symptoms, building-related illness (BRI) comprises specific, diagnosable symptoms caused by certain agents (chemicals, bacteria, fungi, etc.). These can typically be identified, measured, and quantified.^[34] There are usually four causal agents in BRI: immunologic, infectious, toxic, and irritant.^[34] For instance, Legionnaire's disease, usually caused by *Legionella pneumophila*, involves a specific organism which could be ascertained through clinical findings as the source of contamination within a building.^[34]

Prevention

[edit]

- Reduction of time spent in the building
- If living in the building, moving to a new place
- Fixing any deteriorated paint or concrete deterioration
- Regular inspections to indicate for presence of mold or other toxins
- Adequate maintenance of all building mechanical systems
- Toxin-absorbing plants, such as sansevieria^{[35][36][37][38][39][40][41]}^[excessive citations]
- Roof shingle non-pressure cleaning for removal of algae, mold, and *Gloeocapsa magma*
- Using ozone to eliminate the many sources, such as VOCs, molds, mildews, bacteria, viruses, and even odors. However, numerous studies identify high-ozone

- shock treatment as ineffective despite commercial popularity and popular belief.
- Replacement of water-stained ceiling tiles and carpeting
- Only using paints, adhesives, solvents, and pesticides in well-ventilated areas or only using these pollutant sources during periods of non-occupancy
- Increasing the number of air exchanges; the American Society of Heating, Refrigeration and Air-Conditioning Engineers recommend a minimum of 8.4 air exchanges per 24-hour period
- Increased ventilation rates that are above the minimum guidelines^[22]
- Proper and frequent maintenance of HVAC systems
- UV-C light in the HVAC plenum
- Installation of HVAC air cleaning systems or devices to remove VOCs and bioeffluents (people odors)
- Central vacuums that completely remove all particles from the house including the ultrafine particles (UFPs) which are less than 0.1 μm
- Regular vacuuming with a HEPA filter vacuum cleaner to collect and retain 99.97% of particles down to and including 0.3 micrometers
- Placing bedding in sunshine, which is related to a study done in a high-humidity area where damp bedding was common and associated with SBS^[17]
- Lighting in the workplace should be designed to give individuals control, and be natural when possible^[42]
- Relocating office printers outside the air conditioning boundary, perhaps to another building
- Replacing current office printers with lower emission rate printers^[43]
- Identification and removal of products containing harmful ingredients

Management

[edit]

SBS, as a non-specific blanket term, does not have any specific cause or cure. Any known cure would be associated with the specific eventual disease that was caused by exposure to known contaminants. In all cases, alleviation consists of removing the affected person from the building associated. BRI, on the other hand, utilizes treatment appropriate for the contaminant identified within the building (e.g., antibiotics for Legionnaire's disease).^[citation needed]

Improving the indoor air quality (IAQ) of a particular building can attenuate, or even eliminate, the continued exposure to toxins. However, a Cochrane review of 12 mold and dampness remediation studies in private homes, workplaces and schools by two independent authors were deemed to be very low to moderate quality of evidence in reducing adult asthma symptoms and results were inconsistent among children.^[44] For the individual, the recovery may be a process involved with targeting the acute symptoms of a specific illness, as in the case of mold toxins.^[45] Treating various building-related illnesses is vital to the overall understanding of SBS. Careful analysis

by certified building professionals and physicians can help to identify the exact cause of the BRI, and help to illustrate a causal path to infection. With this knowledge one can, theoretically, remediate a building of contaminants and rebuild the structure with new materials. Office BRI may more likely than not be explained by three events: "Wide range in the threshold of response in any population (susceptibility), a spectrum of response to any given agent, or variability in exposure within large office buildings."^[46]

Isolating any one of the three aspects of office BRI can be a great challenge, which is why those who find themselves with BRI should take three steps, history, examinations, and interventions. History describes the action of continually monitoring and recording the health of workers experiencing BRI, as well as obtaining records of previous building alterations or related activity. Examinations go hand in hand with monitoring employee health. This step is done by physically examining the entire workspace and evaluating possible threats to health status among employees. Interventions follow accordingly based on the results of the Examination and History report.^[46]

Epidemiology

[edit]

Some studies have found that women have higher reports of SBS symptoms than men. ^[17]^[10] It is not entirely clear, however, if this is due to biological, social, or occupational factors.

A 2001 study published in the Journal Indoor Air, gathered 1464 office-working participants to increase the scientific understanding of gender differences under the Sick Building Syndrome phenomenon.^[47] Using questionnaires, ergonomic investigations, building evaluations, as well as physical, biological, and chemical variables, the investigators obtained results that compare with past studies of SBS and gender. The study team found that across most test variables, prevalence rates were different in most areas, but there was also a deep stratification of working conditions between genders as well. For example, men's workplaces tend to be significantly larger and have all-around better job characteristics. Secondly, there was a noticeable difference in reporting rates, specifically that women have higher rates of reporting roughly 20% higher than men. This information was similar to that found in previous studies, thus indicating a potential difference in willingness to report.^[47]

There might be a gender difference in reporting rates of sick building syndrome, because women tend to report more symptoms than men do. Along with this, some studies have found that women have a more responsive immune system and are more prone to mucosal dryness and facial erythema. Also, women are alleged by some to be more exposed to indoor environmental factors because they have a greater tendency to have clerical jobs, wherein they are exposed to unique office equipment and

materials (example: blueprint machines, toner-based printers), whereas men often have jobs based outside of offices.^[48]

History

[edit]



This section **possibly contains original research**. Please improve it by **verifying the claims made and adding inline citations**. Statements consisting only of original research should be removed. *(August 2017) (Learn how and when to remove this message)*

In the late 1970s, it was noted that nonspecific symptoms were reported by tenants in newly constructed homes, offices, and nurseries. In media it was called "office illness". The term "sick building syndrome" was coined by the WHO in 1986, when they also estimated that 10–30% of newly built office buildings in the West had indoor air problems. Early Danish and British studies reported symptoms.

Poor indoor environments attracted attention. The Swedish allergy study (SOU 1989:76) designated "sick building" as a cause of the allergy epidemic as was feared. In the 1990s, therefore, extensive research into "sick building" was carried out. Various physical and chemical factors in the buildings were examined on a broad front.

The problem was highlighted increasingly in media and was described as a "ticking time bomb". Many studies were performed in individual buildings.

In the 1990s "sick buildings" were contrasted against "healthy buildings". The chemical contents of building materials were highlighted. Many building material manufacturers were actively working to gain control of the chemical content and to replace criticized additives. The ventilation industry advocated above all more well-functioning ventilation. Others perceived ecological construction, natural materials, and simple techniques as a solution.

At the end of the 1990s came an increased distrust of the concept of "sick building". A dissertation at the Karolinska Institute in Stockholm 1999 questioned the methodology of previous research, and a Danish study from 2005 showed these flaws experimentally. It was suggested that sick building syndrome was not really a coherent syndrome and was not a disease to be individually diagnosed, but a collection of as many as a dozen semi-related diseases. In 2006 the Swedish National Board of Health and Welfare recommended in the medical journal *Läkartidningen* that "sick building syndrome" should not be used as a clinical diagnosis. Thereafter, it has become increasingly less common to use terms such as *sick buildings* and *sick building syndrome* in research. However, the concept remains alive in popular culture and is used to designate the set of symptoms related to poor home or work environment

engineering. *Sick building* is therefore an expression used especially in the context of workplace health.

Sick building syndrome made a rapid journey from media to courtroom where professional engineers and architects became named defendants and were represented by their respective professional practice insurers. Proceedings invariably relied on expert witnesses, medical and technical experts along with building managers, contractors and manufacturers of finishes and furnishings, testifying as to cause and effect. Most of these actions resulted in sealed settlement agreements, none of these being dramatic. The insurers needed a defense based upon Standards of Professional Practice to meet a court decision that declared that in a modern, essentially sealed building, the HVAC systems must produce breathing air for suitable human consumption. ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers, currently with over 50,000 international members) undertook the task of codifying its indoor air quality (IAQ) standard.

ASHRAE empirical research determined that "acceptability" was a function of outdoor (fresh air) ventilation rate and used carbon dioxide as an accurate measurement of occupant presence and activity. Building odors and contaminants would be suitably controlled by this dilution methodology. ASHRAE codified a level of 1,000 ppm of carbon dioxide and specified the use of widely available sense-and-control equipment to assure compliance. The 1989 issue of ASHRAE 62.1-1989 published the whys and wherefores and overrode the 1981 requirements that were aimed at a ventilation level of 5,000 ppm of carbon dioxide (the OSHA workplace limit), federally set to minimize HVAC system energy consumption. This apparently ended the SBS epidemic.

Over time, building materials changed with respect to emissions potential. Smoking vanished and dramatic improvements in ambient air quality, coupled with code compliant ventilation and maintenance, per ASHRAE standards have all contributed to the acceptability of the indoor air environment.^{[49][50]}

See also

[edit]

- Aerotoxic syndrome
- Air purifier
- Asthmagen
- Cleanroom
- Electromagnetic hypersensitivity
- Havana syndrome
- Healthy building
- Indoor air quality
- Lead paint
- Multiple chemical sensitivity

- NASA Clean Air Study
- Nosocomial infection
- Particulates
- Power tools
- Renovation
- Somatization disorder
- Fan death

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External links

[edit]

- Best Practices for Indoor Air Quality when Remodeling Your Home, US EPA
- Renovation and Repair, Part of Indoor Air Quality Design Tools for Schools, US EPA
- Addressing Indoor Environmental Concerns During Remodeling, US EPA
- Dust FAQs, UK HSE Archived 2023-03-20 at the Wayback Machine
- CCOHS: Welding - Fumes And Gases | Health Effect of Welding Fumes

Classification

- MeSH: D018877 D

External resources

- Patient UK: Sick building syndrome

- v
- t
- e

Heating, ventilation, and air conditioning

**Fundamental
concepts**

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

Technology

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

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

**Measurement
and control**

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

**Professions,
trades,
and services**

- 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)
- ASHRAE Handbook
- Building science
- Fireproofing

See also

- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

- v
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Employment

Classifications

- Academic tenure
- Casual
- Contingent work
- Full-time job
- Gig worker
- Job sharing
- Part-time job
- Self-employment
- Side job
- Skilled worker
 - Journeyman
 - Technician
 - Tradesperson
- Independent contractor
- Labour hire
- Temporary work
- Laborer
- Wage labour

Hiring

- Application
 - Background check
 - Business networking
 - Cover letter
 - Curriculum vitae
 - Drug testing
 - Employment contract
 - Employment counsellor
 - Executive search
 - list
 - Induction programme
 - Job fair
 - Job fraud
 - Job hunting
 - Job interview
 - Letter of recommendation
 - Onboarding
 - Overqualification
 - Person–environment fit
 - Personality–job fit theory
 - Personality hire
 - Probation
 - Realistic job preview
 - Recruitment
 - Résumé
 - Simultaneous recruiting of new graduates
 - Underemployment
 - Work-at-home scheme
 - Cooperative
 - Employee
 - Employer
 - Internship
- ## **Roles**
- Job
 - Labour hire
 - Permanent employment
 - Supervisor
 - Volunteering

Working class

- Blue-collar
- Green-collar
- Grey-collar
- Pink-collar
- Precariat
- White-collar
- Red-collar
- New-collar
- No-collar
- Orange-collar
- Scarlet-collar
- Black-collar
- Gold-collar

Career and training

- Apprenticeship
- Artisan
 - Master craftsman
- Avocation
- Career assessment
- Career counseling
- Career development
- Coaching
- Creative class
- Education
 - Continuing education
 - E-learning
 - Employability
 - Further education
 - Graduate school
 - Induction training
 - Knowledge worker
 - Licensure
 - Lifelong learning
 - Overspecialization
 - Practice-based professional learning
 - Professional association
 - Professional certification
 - Professional development
 - Professional school
 - Reflective practice
 - Retraining
 - Vocational education
 - Vocational school
 - Vocational university
- Mentorship
- Occupational Outlook Handbook
- Practice firm
- Profession
 - Operator
 - Professional
- Tradesman
- Vocation

Attendance

- Break
- Break room
- Career break
- Furlough
- Gap year
- Leave of absence
- Long service leave
- No call, no show
- Sabbatical
- Sick leave
- Time clock
- 35-hour workweek
- Four-day week
- Eight-hour day
- 996 working hour system
- Flextime

Schedules

- On-call
- Overtime
- Remote work
- Six-hour day
- Shift work
- Working time
- Workweek and weekend
- Income bracket
- Income tax
- Living wage
- Maximum wage
- National average salary

Wages and salaries

- World
- Europe
- Minimum wage
 - Canada
 - Hong Kong
 - Europe
 - United States
- Progressive wage
 - Singapore
- Overtime rate
- Paid time off
- Performance-related pay
- Salary cap
- Wage compression
- Working poor

Benefits

- Annual leave
- Casual Friday
- Child care
- Disability insurance
- Health insurance
- Life insurance
- Marriage leave
- Parental leave
- Pension
- Sick leave
 - United States
- Take-home vehicle
- Crunch
- Epilepsy and employment
- Human factors and ergonomics
- Karoshi
- List of countries by rate of fatal workplace accidents
- Occupational burnout
- Occupational disease
- Occupational exposure limit
- Occupational health psychology
- Occupational injury
- Occupational noise
- Occupational stress
- Personal protective equipment
- Repetitive strain injury
- Right to sit
 - United States
- Sick building syndrome
- Work accident
 - Occupational fatality
- Workers' compensation
- Workers' right to access the toilet
- Workplace health promotion
- Workplace phobia
- Workplace wellness
- Affirmative action
- Equal pay for equal work
- Gender pay gap
- Glass ceiling

Safety and health

Equal opportunity

Infractions

- Corporate collapses and scandals
 - Accounting scandals
 - Control fraud
 - Corporate behaviour
 - Corporate crime
- Discrimination
- Exploitation of labour
- Dress code
- Employee handbook
- Employee monitoring
- Evaluation
- Labour law
- Sexual harassment
- Sleeping while on duty
- Wage theft
- Whistleblower
- Workplace bullying
- Workplace harassment
- Workplace incivility
- Boreout
- Careerism
- Civil conscription
- Conscription
- Critique of work
- Dead-end job
- Job satisfaction
- McJob
- Organizational commitment
- Refusal of work
- Slavery

Willingness

- Bonded labour
- Human trafficking
- Labour camp
- Penal labour
- Peonage
- Truck wages
- Unfree labour
- Wage slavery
- Work ethic
- Work–life interface
 - Downshifting
 - Slow living
- Workaholic

Termination

- At-will employment
- Dismissal
 - Banishment room
 - Constructive dismissal
 - Wrongful dismissal
- Employee offboarding
- Exit interview
- Layoff
- Notice period
- Pink slip
- Resignation
 - Letter of resignation
- Restructuring
- Retirement
 - Mandatory retirement
 - Retirement age
 - Retirement planning
- Severance package
 - Golden handshake
 - Golden parachute
- Turnover

Unemployment

- Barriers to entry
- Discouraged worker
- Economic depression
 - Great Depression
 - Long Depression
- Frictional unemployment
- Full employment
- Graduate unemployment
- Involuntary unemployment
- Jobless recovery
- Phillips curve
- Recession
 - Great Recession
 - Job losses caused by the Great Recession
 - Lists of recessions
 - Recession-proof job
- Reserve army of labour
- Structural unemployment
- Technological unemployment
- Types of unemployment
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- Job creation index
- Job guarantee
- Employer of last resort
- Guaranteed minimum income
- Right to work
- *Historical:*
- *U.S.A.:*
- Civil Works Administration
- Works Progress Administration

Public programs

Comprehensive Employment and Training Act

See also

- Bullshit job
- Busy work
- Credentialism and educational inflation
- Emotional labor
- Evil corporation
- Going postal
- Kiss up kick down
- Labor rights
- Make-work job
- Narcissism in the workplace
- Post-work society
- Presenteeism
- Psychopathy in the workplace
- Sunday scaries
- Slow movement (culture)
- Toxic leader
- Toxic workplace
- Workhouse

See also templates

- Aspects of corporations
- Aspects of jobs
- Aspects of occupations
- Aspects of organizations
- Aspects of workplaces
- Corporate titles
- Critique of work
- Organized labor

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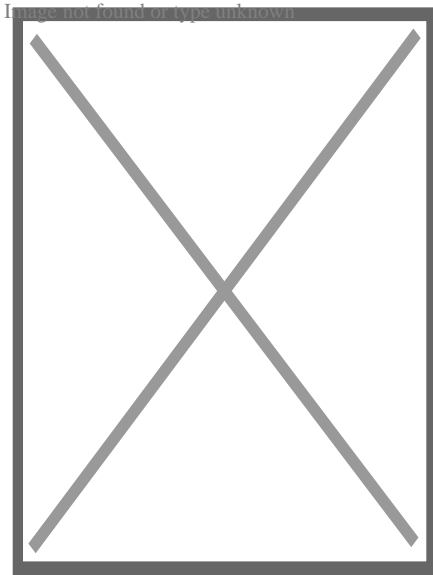
○ Japan

○ Israel

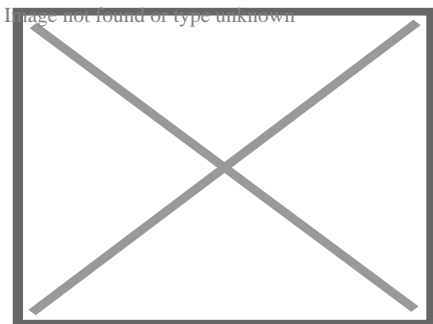
About Heat pump

This article is about devices used to heat and potentially also cool a building (or water) using the refrigeration cycle. For more about the theory, see Heat pump and

refrigeration cycle. For details of the most common type, see air source heat pump. For a similar device for cooling only, see air conditioner. For heat pumps used to keep food cool, see refrigerator. For other uses, see Heat pump (disambiguation).



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



Mitsubishi heat pump interior air handler wall unit

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Part of a series on

Sustainable energy

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

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Energy conservation

- Arcology
- Building insulation
- Cogeneration
- Compact fluorescent lamp
- Eco hotel
- Eco-cities
- Ecohouse
- Ecolabel
- Efficient energy use
- Energy audit
- Energy efficiency implementation
- Energy recovery
- Energy recycling
- Energy saving lamp
- Energy Star
- Energy storage
- Environmental planning
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- Fossil fuel phase-out
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Renewable energy

- Biofuel
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- Hydropower
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- Tidal power
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 - Tidal farm
 - Tidal stream generator
- Ocean thermal energy conversion
- Renewable energy transition
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 - Lens
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 - Rights
 - Turbine
 - Windbelt
 - Windpump

Sustainable transport

- Green vehicle
 - Electric vehicle
 - Bicycle
 - Solar vehicle
 - Wind-powered vehicle
- Hybrid vehicle
 - Human-electric
 - Twike
 - Plug-in
- Human-powered transport
 - Helicopter
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 - Land vehicle
 - Bicycle
 - Cycle rickshaw
 - Kick scooter
 - Quadracycle
 - Tricycle
 - Velomobile
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 - Watercraft
- Personal transporter
- Rail transport
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-  **Category**
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A **heat pump** is a device that consumes energy (usually electricity) to transfer heat from a cold heat sink to a hot heat sink. Specifically, the heat pump transfers thermal energy using a refrigeration cycle, cooling the cool space and warming the warm space.^[1] In cold weather, a heat pump can move heat from the cool outdoors to warm a house (e.g. winter); the pump may also be designed to move heat from the house to the warmer outdoors in warm weather (e.g. summer). As they transfer heat rather than generating heat, they are more energy-efficient than other ways of heating or cooling a home.^[2]

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

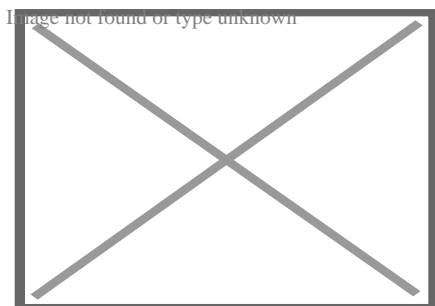
Air source heat pumps are the most common models, while other types include ground source heat pumps, water source heat pumps and exhaust air heat pumps.^[3] Large-scale heat pumps are also used in district heating systems.^[4]

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

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

Principle of operation

[edit]

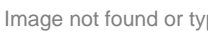


A: indoor compartment, B: outdoor compartment, I: insulation, 1: condenser, 2: expansion valve, 3: evaporator, 4: compressor

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

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

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

building is:  where

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

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

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

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

This is the theoretical amount of heat pumped but in practice it will be less for various reasons, for example if the outside unit has been installed where there is not enough airflow. More data sharing with owners and academics—perhaps from heat meters—could improve efficiency in the long run.^[11]

History

[edit]

Milestones:

1748

William Cullen demonstrates artificial refrigeration.^[12]

1834

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

1852

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

1855–1857

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

1877

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

1928

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

1937–1945

During the First World War, fuel prices were very high in Switzerland but it had plenty of hydropower.^[14] In the period before and especially during the Second World War, when neutral Switzerland was completely surrounded by fascist-ruled countries, the coal shortage became alarming again. Thanks to their leading position in energy technology, the Swiss companies Sulzer, Escher Wyss and Brown Boveri built and put in operation around 35 heat pumps between 1937 and 1945. The main heat sources were lake water, river water, groundwater, and waste heat. Particularly noteworthy are the six historic heat pumps from the city of Zurich with heat outputs from 100 kW to 6 MW. An international milestone is the heat pump

built by Escher Wyss in 1937/38 to replace the wood stoves in the City Hall of Zurich. To avoid noise and vibrations, a recently developed rotary piston compressor was used. This historic heat pump heated the town hall for 63 years until 2001. Only then was it replaced by a new, more efficient heat pump.^[14]

1945

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

1948

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

1951

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

2019

The Kigali Amendment to phase out harmful refrigerants takes effect.

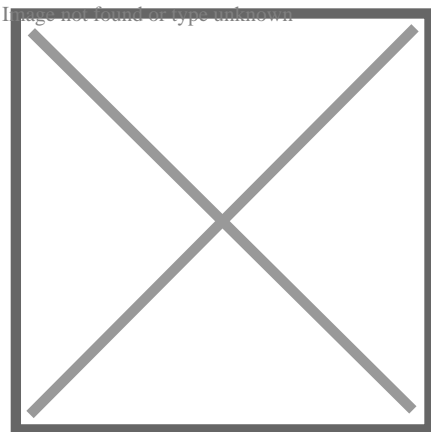
Types

[edit]

Air-source

[edit]

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



Heat pump on balcony of apartment

An air source heat pump (ASHP) is a heat pump that can absorb heat from air outside a building and release it inside; it uses the same vapor-compression refrigeration

process and much the same equipment as an air conditioner, but in the opposite direction. ASHPs are the most common type of heat pump and, usually being smaller, tend to be used to heat individual houses or flats rather than blocks, districts or industrial processes.^{[20][21]}

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

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

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

Air-source heat pumps are used to move heat between two heat exchangers, one outside the building which is fitted with fins through which air is forced using a fan and the other which either directly heats the air inside the building or heats water which is then circulated around the building through radiators or underfloor heating which releases the heat to the building. These devices can also operate in a cooling mode where they extract heat via the internal heat exchanger and eject it into the ambient air using the external heat exchanger. Some can be used to heat water for washing which is stored in a domestic hot water tank.^[24]

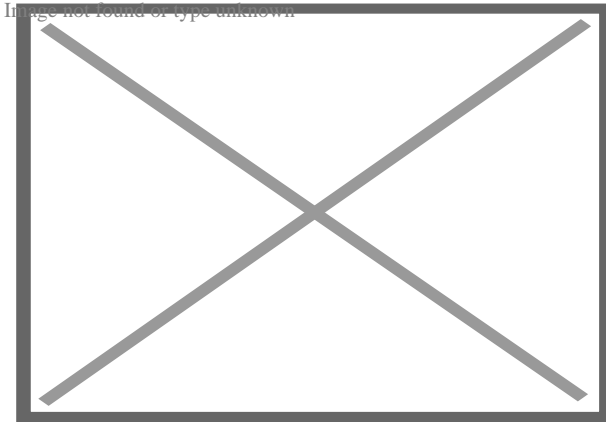
Air-source heat pumps are relatively easy and inexpensive to install, so are the most widely used type. In mild weather, coefficient of performance (COP) may be between 2 and 5, while at temperatures below around 7 °C (45 °F) an air-source heat pump may still achieve a COP of 1 to 4.^[25]

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

Ground source

[edit]

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



A heat pump in combination with heat and cold storage

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

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

Heat recovery ventilation

[edit]

Main article: Heat recovery ventilation

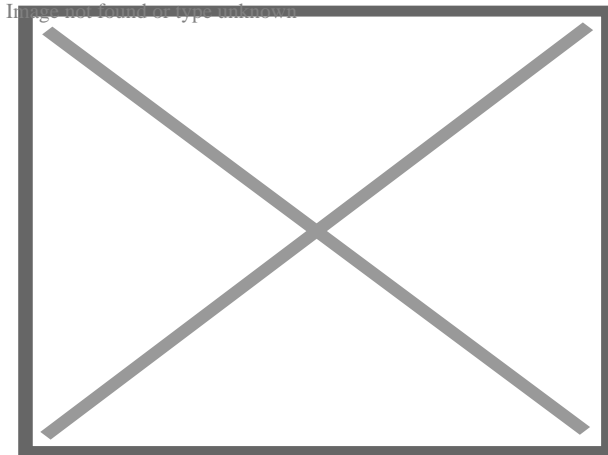
Exhaust air heat pumps extract heat from the exhaust air of a building and require mechanical ventilation. Two classes exist:

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

Solar-assisted

[edit]

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



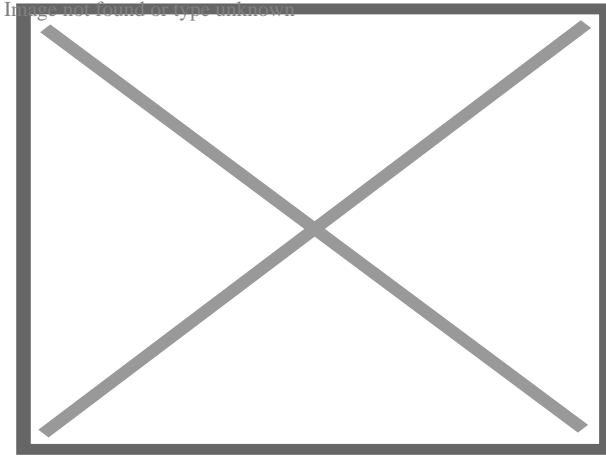
Hybrid photovoltaic-thermal solar panels of a SAHP in an experimental installation at Department of Energy at Polytechnic of Milan

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

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

Water-source

[edit]



Water-source heat exchanger being installed

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

Others

[edit]

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

Electrocaloric heat pumps are solid state.^[35]

Applications

[edit]

The International Energy Agency estimated that, as of 2021, heat pumps installed in buildings have a combined capacity of more than 1000 GW.^[4] They are used for heating, ventilation, and air conditioning (HVAC) and may also provide domestic hot water and tumble clothes drying.^[36] The purchase costs are supported in various countries by consumer rebates.^[37]

Space heating and sometimes also cooling

[edit]

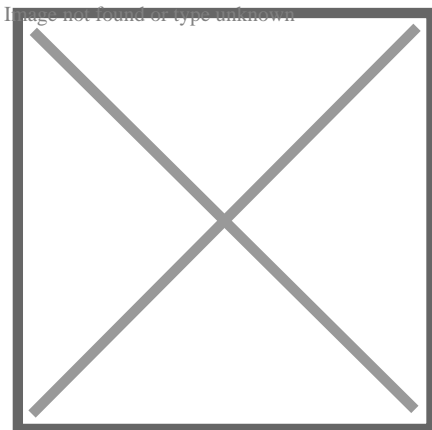
In HVAC applications, a heat pump is typically a vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of *heat flow* (thermal energy movement) may be reversed. The reversing valve switches the direction of refrigerant through the cycle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

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

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

Window mounted heat pump

[edit]



Saddle-style window mounted heat pump 3D sketch

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

Water heating

[edit]

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

District heating

[edit]

Large (megawatt-scale) heat pumps are used for district heating.^[43] However as of 2022 about 90% of district heat is from fossil fuels.^[44] In Europe, heat pumps account for a mere 1% of heat supply in district heating networks but several countries have targets to decarbonise their networks between 2030 and 2040.^[4] Possible sources of heat for such applications are sewage water, ambient water (e.g. sea, lake and river water), industrial waste heat, geothermal energy, flue gas, waste heat from district cooling and heat from solar seasonal thermal energy storage.^[45] Large-scale heat pumps for district heating combined with thermal energy storage offer high flexibility for the integration of variable renewable energy. Therefore, they are regarded as a key technology for limiting climate change by phasing out fossil fuels.^[45]^[46] They are also a crucial element of systems which can both heat and cool districts.^[47]

Industrial heating

[edit]

There is great potential to reduce the energy consumption and related greenhouse gas emissions in industry by application of industrial heat pumps, for example for process heat.^[48]^[49] Short payback periods of less than 2 years are possible, while achieving a

high reduction of CO₂ emissions (in some cases more than 50%).^{[50][51]} Industrial heat pumps can heat up to 200 °C, and can meet the heating demands of many light industries.^{[52][53]} In Europe alone, 15 GW of heat pumps could be installed in 3,000 facilities in the paper, food and chemicals industries.^[4]

Performance

[edit]

Main article: Coefficient of performance

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

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

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

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

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

COP variation with output temperature

Pump type and source	Typical use	COP variation with output temperature				
		35 °C (e.g. heated screed floor)	45 °C (e.g. heated screed floor)	55 °C (e.g. heated timber floor)	65 °C (e.g. radiator or DHW)	(e.g. a
High-efficiency air-source heat pump (ASHP), air at 20 °C [56]		2.2	2.0	1.8	1.6	1.5
Two-stage ASHP, air at 20 °C [57]	Low source temperature	2.4	2.2	1.9	1.7	1.6
High-efficiency ASHP, air at 0 °C [56]	Low output temperature	3.8	2.8	2.2	2.0	1.8
Prototype transcritical CO ₂ (R744) heat pump with tripartite gas cooler, source at 0 °C [58]	High output temperature	3.3	3.0	2.8	4.2	3.5
Ground-source heat pump (GSHP), water at 0 °C [56]		5.0	3.7	2.9	2.4	2.1
GSHP, ground at 10 °C [56]	Low output temperature	7.2	5.0	3.7	2.9	2.6

Theoretical Carnot cycle limit, source ?20 °C	5.6	4.9	4.4	4.0
Theoretical Carnot cycle limit, source 0 °C	8.8	7.1	6.0	5.2
Theoretical Lorentzen cycle limit (CO ₂ pump), return fluid 25 °C, source 0 °C ^[58]	10.1	8.8	7.9	7.1
Theoretical Carnot cycle limit, source 10 °C	12.3	9.1	7.3	6.1

Carbon footprint

[edit]

The carbon footprint of heat pumps depends on their individual efficiency and how electricity is produced. An increasing share of low-carbon energy sources such as wind and solar will lower the impact on the climate.

heating system	emissions of energy source	efficiency	resulting emissions for thermal energy
heat pump with onshore wind power	11 gCO ₂ /kWh ^[59]	400% (COP=4)	3 gCO ₂ /kWh
heat pump with global electricity mix	436 gCO ₂ /kWh ^[60] (2022)	400% (COP=4)	109 gCO ₂ /kWh

natural-gas thermal (high efficiency)	201 gCO ₂ /kWh ^[61]	90% ^[citation needed]	223 gCO ₂ /kWh
heat pump			
electricity by lignite (old power plant) and low performance	1221 gCO ₂ /kWh ^[61]	300% (COP=3)	407 gCO ₂ /kWh

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

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

Operation

[edit]

See also: Vapor-compression refrigeration



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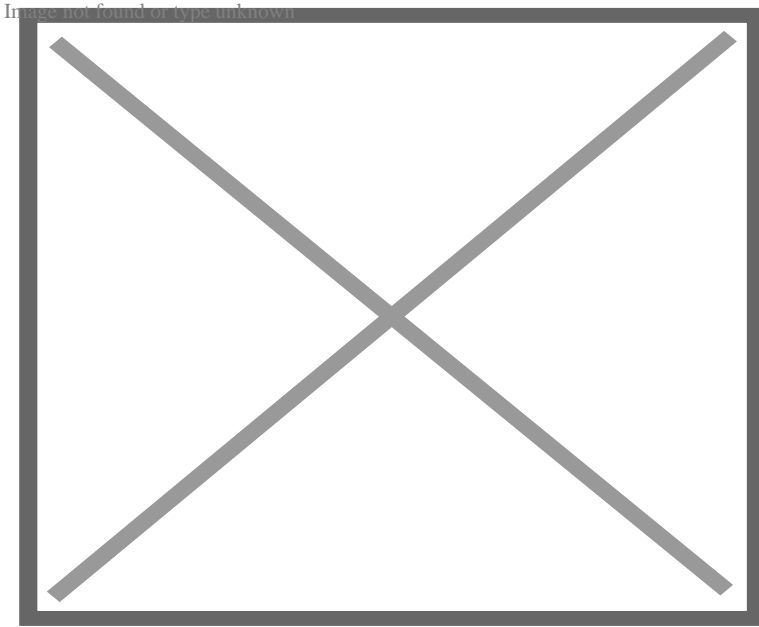
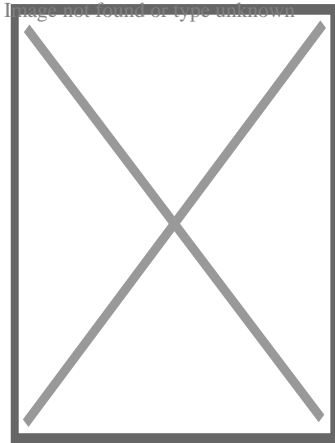
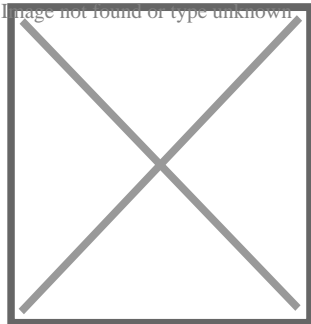


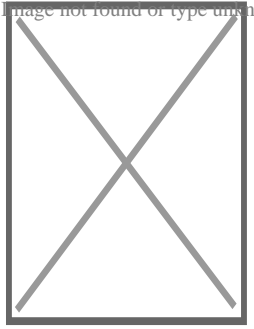
Figure 2: Temperature–entropy diagram of the vapor-compression cycle



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



Large heat pump setup for a commercial building



Wiring and connections to a central air unit inside

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

Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor^[66] and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air flowing across the coil or tubes. In heating mode this heat is used to heat the building using the internal heat exchanger, and in cooling mode this heat is rejected via the external heat exchanger.

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

The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is

where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser.

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

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

Improvement of coefficient of performance by subcooling

[edit]

Main article: Subcooling

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

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

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

Refrigerant choice

[edit]

Main article: Refrigerant

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

3), carbon dioxide (CO

2), and water (H

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

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

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

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

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

R-410a ^[84]	4705	2285
R-134a ^[84]	4060	1470
R-404a ^[84]	7258	4808

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

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

Government incentives

[edit]

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

Australia

[edit]

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

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

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

Canada

[edit]

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

China

[edit]

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

In the 2024 report by the International Energy Agency (IEA) titled "The Future of Heat Pumps in China," it is highlighted that China, as the world's largest market for heat pumps in buildings, plays a critical role in the global industry. The country accounts for over one-quarter of global sales, with a 12% increase in 2023 alone, despite a global sales dip of 3% the same year.^[99]

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

which covers around 4% of the heating needs in buildings.^[99]

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

European Union

[edit]

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

United Kingdom

[edit]

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

United States

[edit]

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

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

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

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

Notes

[edit]

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

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- [^] IPCC AR6 WG3 Ch11 2022, Sec. 11.3.4.1.
- [^] IPCC SR15 Ch2 2018, p. 142.
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Heating, ventilation, and air conditioning

Fundamental concepts

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

Technology

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

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

**Measurement
and control**

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

**Professions,
trades,
and services**

- 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)
- ASHRAE Handbook
- Building science
- Fireproofing

See also

- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

Authority control databases: National

- Germany
- United States
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Things To Do in Jefferson County

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Visit Jefferson County Tennessee

5 (3)

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4.8 (2321)

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Cliff Cave County Park

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Jefferson County Area Tourism Council

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Jefferson County Museum

4.6 (31)

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Jefferson County Historical Village

4.7 (145)

Driving Directions in Jefferson County

Driving Directions From Kohl's to Royal Supply Inc

Driving Directions From Rent-A-Center to Royal Supply Inc

Driving Directions From Fenton Sew and Vac to Royal Supply Inc

Driving Directions From Barnes & Noble to Royal Supply Inc

Driving Directions From Stella Blues Vapors to Royal Supply Inc

Driving Directions From Butler Supply to Royal Supply Inc

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Reviews for Royal Supply Inc

Royal Supply Inc

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Terry Self

(1)

Horrible workmanship, horrible customer service, don't show up when they say they are. Ghosted. Was supposed to come back on Monday, no call no show. Called Tuesday and Wednesday, left messages both days. Nothing. Kinked my line, crooked to the pad and house, didn't put disconnect back on, left the trash.....

Royal Supply Inc

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bill slayton

(1)

Went to get a deadbolt what they had was one I was told I'd have take it apart to lengthen and I said I wasn't buying something new and have to work on it. Thing of it is I didn't know if it was so that it could be lengthened said I didn't wanna buy something new I had to work on just to fit my door. He got all mad and slung the whole box with part across the room. A real business man. I guess the owner approves of his employees doing as such.

Royal Supply Inc

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Toney Dunaway

(5)

This is another amazing place where we will do much more business. They are not tyrannical about the totally useless face diapers, they have a great selection of stock, they have very knowledgeable staff, very friendly staff. We got the plumbing items we really needed and will be getting more plumbing items. They also have central units, thermostats, caulking, sealants, doors, seems everything you need for a mobile home. We've found a local treasure and will be bringing much more business. Their store is clean and tidy as well!

Royal Supply Inc

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Gidget McCarthy

(5)

Very knowledgeable, friendly, helpful and don't make you feel like you're inconveniencing them. They seem willing to take all the time you need. As if you're the only thing they have to do that day. The store is clean, organized and not cluttered, symmetrical at that. Cuz I'm even and symmetricals biggest fan. It was a pleasure doing business with them and their prices are definitely reasonable. So, I'll be doing business with them in the future no doubt.

Royal Supply Inc

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Ae Webb

(5)

Royal installed a new furnace and air conditioner just before we got our used mobile home. Recently, the furnace stopped lighting. Jared (sp?) made THREE trips to get it back to good. He was so gracious and kind. Fortunately for us it was still under warranty. BTW, those three trips were from Fenton, Missouri to Belleville, Illinois! Thanks again, Jared!

Reviewing Maintenance Plan Rates in Detail [View GBP](#)

Check our other pages :

- [Knowing When to Seek Professional Licensing Support](#)
- [Sorting Out Utility Guidelines for Meter Upgrades](#)
- [Identifying Hidden Expenses in Older Units](#)

Frequently Asked Questions

What factors should I consider when evaluating the cost of an HVAC maintenance plan for my mobile home?

Consider the coverage details such as frequency of maintenance visits, types of services included (e.g., inspections, cleaning, part replacements), emergency repair costs, and any additional fees. Also, evaluate the reputation and reliability of the service provider.

How can I determine if an HVAC maintenance plan is a good value for my mobile home?

Compare the annual cost of the plan against potential expenses without it, such as repair costs or replacements due to lack of regular maintenance. Assess whether the convenience and peace of mind offered by routine servicing justify the price.

Are there specific features in a maintenance plan that are particularly beneficial for mobile homes?

Yes, plans that include checks on ductwork integrity, inspection for pest intrusion which can be more common in mobile homes, and considerations for compact or unique HVAC setups often found in these homes can be especially beneficial.

Royal Supply Inc

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State : MO

Zip : 63026

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Google Business Profile

Company Website : <https://royal-durhamsupply.com/locations/lenexa-kansas/>

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