

Heating, Ventilation and Air Conditioning (HVAC) systems: energy-efficient usage and technologies



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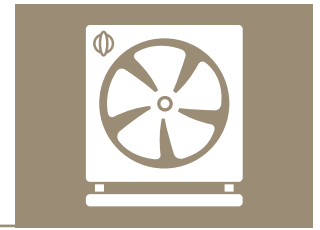
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Index

Heating, Ventilation and Air Conditioning (HVAC) systems: energy-efficient usage and technologies	1
Unpacking HVAC	2
Effective maintenance	3
Electricity-smart operating	4
Reducing dependency on HVAC systems	6
Saving energy through behaviour change	8
Switch to energy-efficient technologies	9
Addendum A: types of systems	10
The Eskom Energy Management Information Pack	12

Heating, Ventilation and Air Conditioning (HVAC) systems: energy-efficient usage and technologies

Three white icons on a dark brown background: a radiator with wavy lines above it, a fan, and a snowflake.

Whilst energy efficiency optimisation is becoming an increasingly important business strategy for managing costs and supporting environmental compliance, the way in which Heating, Ventilation and Air Conditioning (HVAC) systems are used could be thwarting companies' best intentions to save energy and money.

HVACs are subjected to more misuse than any other type of equipment in South Africa's business sector. Poor maintenance, lack of knowledge on how to use them efficiently, overuse, and the large number of old and inefficient systems at work in the sector, make HVACs a significant contributor to the country's demand for energy.

By virtue of their energy intensiveness, HVACs account for a large percentage of companies' energy costs; continued misuse can dramatically impact the effectiveness of companies' energy-saving projects and initiatives, which are mostly driven by the objective to reduce operating costs.

HVACs are the largest single end-use contributor to energy demand in the commercial sector, accounting for 26%. Next in line is lighting, accounting for 18%; and electric motors, accounting for 14% of consumption. In the industrial sector, HVACs account for 20% of energy consumption.

However, these systems' contribution to energy demand could be much higher. In Australia, for instance, which has similar temperature and climate ranges to those in South Africa, breakdowns in energy use often quote HVAC figures as high as 50%.

A white icon of a wallet with a card sticking out, set against a dark brown background.

Simple measures can achieve impressive savings. For instance, simply setting air-conditioners to operate in a 10-degree range of the temperature outside will reduce the unit's consumption - each degree Celsius can save from 8 to 10% on energy usage.

Replacing energy inefficient systems with energy-efficient alternatives, and using HVACs sparingly and smartly, offer huge opportunities for companies to save electricity - in many instances, these opportunities reduce operating costs and remain untapped and leave millions of Rands in potential cost savings untouched.

Tackling costs

By targeting HVAC systems as part of an overall energy management plan, electricity smart companies can ensure continued comfort and safety of their workers without incurring dramatic increases in energy costs.

Using the advice in this brochure will help you to optimise the energy efficiency of HVAC systems in your building by:

- Making regular maintenance a priority
- Doing continuous monitoring
- Ensuring electricity smart operating
- Adopting energy-saving behaviours and practices
- Switching to energy-efficient technologies.

Unpacking HVAC



Heating, Ventilation and Air Conditioning (HVAC) systems control temperature, humidity and quality of air in a building to a set of chosen or preferred conditions. To achieve this, systems need to transfer heat and moisture into and out of the air and control the level of air pollutants, either by directly removing it or by diluting it to acceptable levels.

- Heating is needed to increase the temperature in a space to compensate for heat loss.
- Ventilation is needed to supply air to a space and extract polluted air from it.
- Cooling is needed to lower temperature in a space where heat gains are caused by the sun, activity of people and the function of equipment.

Three central functions of Heating, Ventilation and Air Conditioning are interrelated to optimally provide thermal comfort, acceptable indoor air quality and ideal operating conditions within the boundaries of acceptable or reasonable costs.

HVAC systems vary widely in terms of size, functions they perform and the amount of energy they consume. Factors that influence energy usage include:

- The design, layout and operation of a building, affects how the external environment impacts on internal temperature and humidity levels
- HVAC systems will use more energy when the required indoor temperature and air quality - in extreme temperatures or in the case of operations where greater precision or more refined air quality is required
- The heat generated internally by lighting, equipment and people - all have an impact on how warm your building is, and the load on the HVAC system
- The design and efficiency of your HVAC system - older systems tend to be less energy-efficient
- How, when and for how long your HVAC system is operated every day
- How well the HVAC system is monitored and maintained.

Heating typically accounts for about half of the energy used in offices.

Heating costs rise by between 8 and 10% for each 1°C of overheating.

Types of systems

Please see Addendum A - included at the end of this brochure - for technical information on types of HVAC systems.



Effective maintenance

Proper maintenance of system components keep HVACs operating at peak efficiency - implement a maintenance programme to ensure that all components including motors, pumps, fans, compressors, ducting and filters are intact and working effectively.

This not only conserves energy but also helps to extend equipment life and prevent costly breakdowns.

Maintenance should be performed continuously on a regular scheduled basis - simple maintenance procedures can be undertaken in-house whilst more comprehensive maintenance interventions should be carried out by a qualified service provider - simple maintenance procedures include:

- Cleaning heat exchange surfaces
- Inspecting ductwork for air leakages - seal all leaks by taping or caulking
- Inspecting ductwork insulation - repair or replace as necessary
- Inspecting damper blades and linkages - adjust on a regular basis and clean the oil
- Cleaning or replacing air filters
- Inspecting and cleaning coils
- Inspecting coils and casings for leakage - seal all leaks
- Inspecting all room air outlets and inlets (diffusers, registers and grilles) - these should be kept clean and free of dirt and obstructions
- Lubricating motor and drive bearings
- Checking for over-voltage or low-voltage conditions on motors
- Checking excessive noise and vibration
- Keeping fan blades clean
- Inspecting piping for leakage at joints - repair as and when necessary
- Inspecting strainers and cleaning regularly
- Inspecting vents and remove all clogs - clogged vents retard efficient air elimination and reduce system efficiency
- Replacing leaking dampers on ventilation systems
- Ensuring condensing and evaporating devices are clean and well maintained - check that condensers are not obstructed by equipment or vegetation, for example
- Ensuring that the cooling plant is regularly maintained to avoid reduced levels of operational efficiency
- Replacing insulation on refrigerant pipework and paying specific attention to pipework located outside a building - insulation in poor conditions will affect the temperature of the refrigerant flowing through the system and, therefore, consumes more energy in maintaining the required temperature.

Electricity consumption can increase by up to 30% if regular maintenance is not undertaken.

Electricity-smart operating



Controlling how, when and why HVAC systems are operated can save significant amounts of electricity.

Minimise the temperature difference:

- Air conditioning systems will use more electricity when needed to maintain an internal temperature that is lower than the outside temperature - keep the thermostat within a 10-degree range of the outside temperature.
In summer, set the average building temperature to 23°C. In winter, maintain it in the 'golden zone' between 18 and 22°C.

Reduce the cooling load

The amount of electricity air conditioning systems use also depends on the cooling load - the amount of heat the system has to remove.

Reduce the cooling load on systems by:

- Installing Variable Speed Drives on HVAC fans and pumps - this allows motor-driven loads (such as fans and pumps) to operate in response to varying load requirements instead of simply operating in "on/off" mode
- Insulating the cooled space - implementing various measures such as ceiling insulation, window glazing, blinds, awnings and door sweeps will contribute to creating a thermally-efficient shell that can dramatically reduce the cooling load on HVAC systems whilst ensuring that comfortable internal temperatures are maintained
- Reducing warm air filtration into the cooled space - keep windows and doors closed when HVAC systems are in use
- Minimising the use of appliances and lighting - emitting heat, lights and equipment that are not required at any particular time should be switched off to help reduce the cooling load.

Energy-efficient lights like Compact Fluorescent Lamps (CFLs) and Light Emitting Diodes (LEDs) emit a lot less heat than normal incandescent bulbs - replace electricity heavy incandescent bulbs with energy savers to help reduce the cooling load on HVAC systems.



Adjust control set points

Proper maintenance control is essential for optimal HVAC system operation. Situations may prevail where the existing controls are not appropriate or are not capable of controlling the systems properly - a symptom of this may be as simple as a thermostat that fails to effectively control comfort levels in an occupied space.

Choose HVAC units with thermostat controls and programmable timers - programmable thermostats can also be installed in place of standard thermostats.

Raise evaporator temperature (suction pressure)

The amount of electricity demanded by an air conditioning compressor, is also determined by the difference between the evaporator and the condenser temperature (or pressure) - if the system can tolerate a little increase in temperature at the evaporator, an opportunity exists to reduce compressor power. Consult an air-conditioner specialist to check if your system will tolerate an adjustment to the evaporator temperature.

Lower condensing temperature (discharge pressure)

An opportunity to lower compressor power exists through lowering the condensing temperature. However, since compressors are fine tuned systems, be cautious when considering adjustments to operating conditions. Consult an air-conditioner specialist to check if your system will tolerate an adjustment to the condensing temperature.

Keep units cool

Providing cooler air to condensers can help compressors operate more efficiently. Rooftop cooling units containing compressors and condensers generally draw air near the rooftop; cooler air may be available just a bit higher - at 1,2 to 1,5 metres off the roof.

Keep units cool by:

- Installing condenser units on the southern side of a building
- Positioning units to avoid direct sunlight during the day
- Ensuring sufficient natural cross-ventilation over the condenser unit to remove any hot air more effectively
- Avoiding installing condenser units in closed or confined areas where hot air might accumulate
- Providing enough vents for hot air to escape
- Installing whirley birds to remove hot air efficiently.

Set time controls to match occupancy

Check that controls are appropriately set and displaying the correct time and date - adjust if necessary to ensure heating and cooling only operate when and where required. Optimal start- and stop-controls can be used to minimise after hours operation.

Don't allow heating and cooling at the same time

Set controls to give a wide temperature gap at which heating and cooling systems turn on - a gap of around 4 to 5°C between the heating and cooling thermostat set points will create a comfortable 'dead band'. This will help to keep occupants comfortable and increase cost savings. Unless this measure is implemented, both systems may operate simultaneously and waste electricity and money.

Myth

Turning air conditioning thermostats down as low as possible, cools the building more quickly.

Reality

Temperature drops at the same rate but then 'overshoots', making it uncomfortable for staff and wasting electricity at the same time. If controls are not co-ordinated, the temperature could even go low enough for the heating system to be switched on.

Remedy

Set thermostats correctly and educate staff to dispel this myth. Where possible, as a last resort, protect thermostats and prevent tampering.

Reducing dependency on HVAC systems



By harnessing natural 'free energy' to heat, cool and ventilate a building, companies can reap substantial energy cost savings - it is not always necessary for HVAC systems to operate all the time.

Passive heating, ventilation and cooling - harnessing natural energy to save power

Making the most of natural ventilation is a simple and cost effective way to achieve substantial energy cost savings. This requires taking control of heat from the sun with ventilation so that nature provides a majority of fresh air and manages temperature levels. Natural ventilation relies on air flow through openings into a room or building, preferably from opposite sides - this also applies to rising hot air being replaced with cooler air sucked in through windows or vents from a lower level.

When cooling is required in a building - if it is cooler outside than inside - simply open doors, vents and windows. This will increase air flow, reduce heat and, possibly, provide all the ventilation that is needed.

Air-conditioner fans can also be used to draw in and circulate, cool air from outside during early morning hours.

Some buildings are equipped with mixed mode systems, which use a combination of both natural and mechanical systems - mechanical systems kick-in only when needed.

Always be aware that opening windows in air conditioned buildings may increase the amount of electricity used by the system.

Reduce overheating

Before installing cooling equipment, always identify where excess heat is coming from - sunlight, office equipment, lighting and refrigeration are often the main sources. Consider shading windows on the outside or replacing window panes with special heat reflective glass to prevent heat build-up. Alternatively, internal daylight blinds enable

natural light to enter offices by redirecting it onto the ceiling, thereby alleviating any discomfort felt by the occupants from direct daylight - many daylight blinds also have perforated blades to not obstruct employees' view of the outside.

A general rule of thumb: The more energy-efficient office equipment and lighting are the less heat it produces.

Night cooling

This is usually done in places with low humidity, an established technique where cool night air is passed through a building to remove heat that has accumulated during the day. Although more heat will be absorbed the following day, a cooled building fabric will produce lower internal temperatures. The movement of cool night air may be natural or fan assisted, a technique that leads to a reduction in HVAC use and lower energy costs.



Consider zoning your building and save

Many buildings are serviced by an overall HVAC system, while having problematic areas with different time and temperature requirements. A solution is to 'zone' your building by installing separate time and temperature controls for individual areas - zoned areas can provide better conditions as occupants will have greater control over their respective environments. It is also an effective energy cost saving measure as HVACs can then be turned down or off in unused or unoccupied zones.

Use air-conditioners on demand

Another effective energy cost saving measure is to only use air-conditioners in occupied rooms. The best way to ensure that air-conditioners are not left on unnecessarily in unoccupied rooms is by installing occupancy or movement sensors. These detect when someone enters a room and then activate the system. Once the room has been left vacant for a certain period of time the air-conditioner shuts down.

As with lights, air-conditioners are often left on unnecessarily when people leave offices and meeting rooms - everyone expects that someone else will do the switching off but, more often than not, nobody does.

With incidences of power outages late afternoons just before closing time, people leave work for home forgetting that air-conditioners were running before the power outage. This causes air-conditioners to spring back to life once power is restored and, therefore, consume electricity unnecessarily throughout the night.

Case study: Megawatt Park

Eskom's head office in Sunninghill, Johannesburg, is becoming one of South Africa's premier examples of energy efficiency - a model for commerce and industry. Energy efficiency interventions between 2008 and 2011 at the complex included:

- Installing a chilled beam air conditioning system that uses water - instead of circulating cold air - to remove heat from a room
- Setting the average temperature in the complex to 23°C as opposed to the previous 22°C
- Using extractor fans during summer months to flush out built up heat and draw in cool air from the outside - this enables the air conditioning chillers to be switched on about three hours later in the morning
- Minimising the use of boilers in winter by using retained heat to keep the complex warm in the morning; boilers are used for only about one to two hours to heat water - thereafter, pumps are switched on manually to circulate heated water throughout the building.

From the inception of a comprehensive energy efficiency programme in 2007 to March 2014, Megawatt Park achieved an impressive 9% reduction in monthly energy use.

Saving energy through behaviour change



Good housekeeping, understanding the thermal needs of staff in your building and educating the people who are responsible for HVAC on how to optimise the system's operation will contribute to a reduction in your energy costs.

Adjust your system

At times it makes sense to use the outside temperature to adjust the conditions inside your building. However, when the HVAC system is on, it is possible to save up to one third on energy costs by reducing the amount of outside air that enters a building. It is always better to adjust the system rather than to open a door or window and let heated or cooled air out - when it is too hot, people tend to open windows or doors to make their space more comfortable. Ensure that staff understands the implications of opening windows and doors when air-conditioners are in use - try adjusting the thermostats instead.

Turn off and power down

Electrical equipment and lights emit heat and can contribute to the heating and cooling load on HVAC systems. Try limiting the time that equipment is switched on and, where possible, use 'power-down' facilities on copiers, faxes, printers and computers during the day. Dim or switch off lighting if there is sufficient daylight and use as little light at night as possible.

Train staff on how to operate air conditioning units and heating controls

Staff should receive guidance on recommended operating temperatures and how to set heating or cooling units correctly. Louvres - movable slats to guide cool or heated air - are a feature on most air conditioning systems; staff should be able to operate these to maintain comfortable temperature levels.

Display instructions on individual units and ensure that remote controls have accessible and obvious storage spaces.

Ensure controls are in place and HVAC system operation reflects demand

HVAC loads vary at different times and in different parts of a building throughout the day. Well set time controls should ensure that systems only operate when and where required during core business hours. It is also crucial to regularly check settings - many systems are set incorrectly because 'someone has made a short-term adjustment and then forgotten about it'.

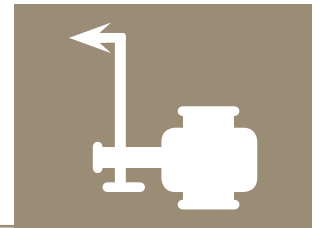
Controlling how and when HVACs are operated can save significant amounts of power - follow these guidelines and encourage all employees to do the same:

- Close windows while the air-conditioner is running
- Only switch on air-conditioners in rooms that are occupied
- Switch off units 30 minutes before leaving the office.
- Adjust blinds and curtains in rooms that receive direct sunlight rather than powering up the air-conditioner.

Start saving today!

Refer to the HVAC action checklist at the end of this brochure and tick the boxes.

Switch to energy-efficient technologies



Consider replacing old HVAC systems - new systems offer enhanced control functionality and can use up to 50% less electricity than energy-intensive systems. Savings on the day-to-day running costs of electricity saving systems can quickly recoup the investment in energy-efficient HVAC technology solutions.

Upgrading and refurbishing

When putting in a new HVAC system, always choose the most energy-efficient technology solution you can afford and one that fits your building's requirements - avoid simply exchanging like with like, in the belief that it will minimise disruptions to your business.

When replacing inefficient components also avoid simply exchanging like with like - ensure that the replacement is of the highest possible efficiency.

Consider:

- Replacing conventional boilers with condensing boilers
- Replacing standard motors with high efficiency motors
- Investing in Variable Speed Drives (VSDs) for motors to match speed with output demand
- Investing in direct drive pumps and fans, which are more efficient than those that are belt driven
- Opportunities for heat recovery and recirculation in your building
- Installing a Building Energy Management System (BMS or BEMS), which offers close control and monitoring of building services performance, including Heating, Ventilation and Air Conditioning. Displayed on a computer screen in real time and allowing system performance to be monitored and settings to be changed quickly and easily, BEMS can reduce energy costs by up to 10%.

Seek advice

Always seek advice from HVAC system specialists before you upgrade or refurbish.

HVAC system action checklist: Start reducing your energy costs today

√	Action
	Reduce the need - switch off unnecessary equipment during the day and, especially, after hours to reduce heat build-up in your building (unless your building is 'night-cooling').
	Consider installing automatic controls to ensure equipment stays off.
	Set higher switch-on temperatures for cooling and lower switch-on temperatures for heating - a temperature control gap or 'dead band' between heating and air conditioning of about 5°C will improve occupants' comfort, cut operating costs and reduce wear and tear on both systems.
	Look into areas that appear too hot or too cold and consider localised thermostatic controls.
	Check for draughts, especially around poor fitting windows and doors - install draught-proofing to reduce heat loss and increase staff comfort.
	Check insulation levels and increase it wherever practical to reduce the need for heating.
	Walk around your building at different times of the day and during different seasons to see how and when systems are on - check time and temperature settings.
	Take advantage of free-cooling - where outside temperatures are colder than the required internal temperature you can ventilate the building with fresh air. ('Night cooling' is especially efficient in summer).

Addendum A: types of systems

Individual systems

The design, installation and control of Heating, Ventilation and Air Conditioning functions are usually integrated into one or more HVAC systems. For very small buildings, contractors usually select the systems and equipment to be installed. For larger buildings, building service designers, mechanical engineers or building services engineers specify the systems according to buildings' requirements. Building permits and code compliance inspections of installations are normally required for all sizes of buildings.

District networks

Although HVACs operate 'individually' in buildings, the equipment involved is sometimes an extension of a larger District Heating (DH) or District Cooling (DC) network, or a combined DHC network. For example, at a given time one building may be utilising chilled water for air conditioning and the warm water it returns may be used in another building for heating, or for the overall heating portion of the DHC network.

Heaters

Heaters are appliances used solely for warming a building. A central heating system provides warmth to the whole interior of a building (or portion of a building) from one point. It contains a boiler, furnace or heat pump to heat water, steam or air at a central location such as a furnace room.

When combined with other systems to control a building's climate, a central heating system may form part of a fully integrated HVAC (Heating, Ventilation and Air Conditioning) system.

Hot water heating systems

In hot water heating systems, piping transports heat to a building's rooms. Most modern hot water heating systems have a circulator - which is a pump - to move hot water through the distribution system. The heat can be transferred to the surrounding air using radiators, hot water coils (hydro-air) or other heat exchangers. The heated water can also supply an auxiliary heat exchanger to supply hot water for bathing and washing.

Warm air systems

Warm air systems distribute heated air - and return air - through metal or fibreglass ducts. Many systems use the same ducts to distribute air cooled by an evaporator coil for air conditioning. The air supply is typically filtered through air cleaners to remove dust and pollen particles.

Dual duct

These systems mix the outside air with return air through dampers, which is then split into hot and cold ducts. The air moving through the hot duct is heated by heating coils and the air moving through the cold duct is cooled through conditioning coils. In each portion of the building the air is controlled by mixing it from the two ducts, which is regulated in the mixing box controlled by a thermostat.

Single duct

Just like with the dual duct, return air and outside air are blown through a single cold air duct by a supply fan. The cooled air is then moved through a heating unit - typically a hot water coil - before it enters the room.

Air-conditioners

An air conditioning system, or a stand-alone air-conditioner, provides cooling and humidity control for all or part of a building by removing heat through radiation, convection or conduction. A vent generally draws fresh air from outside into an indoor heat exchanger section, creating positive air pressure. The percentage of fresh air can usually be manipulated by adjusting the opening of the vent.

Free cooling systems

Free cooling systems can have very high efficiencies and are sometimes combined with seasonal thermal energy storage so that the cold of winter can be used for summer air conditioning. Common storage mediums are deep aquifers or a natural underground rock mass accessed via a cluster of small diameter, heat exchanger equipped boreholes. Some systems with small storages are hybrids, using free cooling early in the cooling season and later employing a heat pump to chill the circulation coming from energy storage.

Split systems

These systems, although most often seen in residential applications, are gaining popularity in small commercial buildings. The evaporator coil is connected to a remote condenser unit using refrigerant piping between an indoor and outdoor unit instead of ducting air directly from the outdoor unit. Indoor units with directional vents mount onto walls, suspend from ceilings or fit into ceilings. Other indoor units mount inside the ceiling cavity so that short lengths of duct handle air from the indoor unit to vents or diffusers around buildings' rooms.

Dehumidifiers

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

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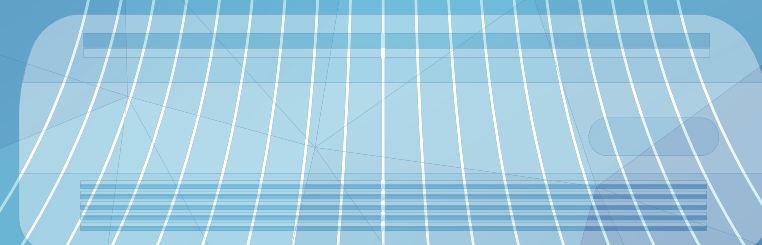
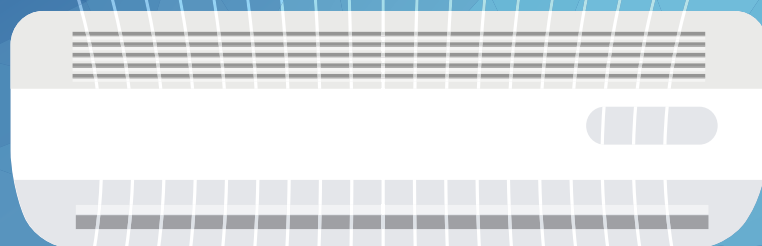
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The Eskom Energy Management Information Pack comprises:



Energy management action plan	Brochure 1
Business case for energy efficiency	Brochure 2
How to do a walk-through energy assessment: methodology and checklist	Brochure 3
Creating an energy awareness programme: behavioural change at work	Brochure 4
HVAC systems: energy-efficient use and technologies	Brochure 5
Energy-efficient solutions: an overview of technologies	Brochure 6
Green growth cycle: energy efficiency in support of competitiveness	Brochure 7





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