Design Guide

Retrofitting Options For HVAC Systems In Live Performance Venues

Greener Live Performances

through energy efficiency

Heating, ventilation and air conditioning (HVAC) systems are major energy consumers in live performance venues. For this reason, HVAC systems provide an opportunity for significant energy efficiency improvements.

As HVAC systems are major pieces of equipment, they are typically designed by a specialist engineer or your architect before a building is constructed. This guide does not discuss design of new HVAC systems, but instead focusses on opportunities for energy savings which could be made by retrofitting existing HVAC systems.

This guide addresses:

- what to consider before retrofitting?
- typical equipment upgrades, and
- other energy saving devices that can be retrofitted to your existing HVAC system.

Before you commence reading this factsheet it is recommended that you obtain a copy of your HVAC system plans. These would have been provided by your architect or engineer when it was installed. Talk to your maintenance / engineering team about what in the system has already been upgraded or replaced.

What To Consider Before Retrofitting?

The ultimate purpose of any HVAC retrofit is to decrease operating and maintenance costs through increased energy efficiency.

As HVAC systems are major pieces of plant for a venue, replacing or upgrading any components of the system should be carefully evaluated prior to implementation.

Retrofitting your HVAC system can be a complex process, which is why an audit of your particular system's energy efficiency should be undertaken before making any decisions. This evaluation should begin with careful testing of current components and controls.

Measuring your system's performance against the optimal performance rates stipulated for the appliance (typically available online) will help you to identify areas which may require retrofitting to improve efficiency. Install temporary meters to the main units to track consumption of each unit over a period of time and record usage against venue usage to better understand where most energy is being consumed in your system.

Is your current unit or system correctly sized and located?

The sizing of your system is important because an undersized air conditioning system will be ineffective, and while an oversized system will cool or heat an area very quickly, it may also expend extra energy cycling on and off resulting in higher operating and maintenance costs.

At the time of initial instalment, HVAC service providers will estimate the cooling and/or heat loads to determine sizing requirements. Check if such calculations have been done for your HVAC system and if so, whether they are still appropriate. That is, if a HVAC unit was sized for a large theatre, which has now been split into two smaller venues, the system requirements will have changed.

The location of a HVAC unit can also affect its efficiency. In evaluating the location of your unit or system it is important to consider:

- Shading and air flow: Condenser coils should be located in a cool, shaded area. Air should be able to flow freely around the condenser and not be obstructed.
- Accurate thermostat readings: Temperature settings are maintained by locating the thermostat away from direct heat sources such as windows or heat emitting fixtures (e.g. coffee machines).

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- Adequately sized air supply ducts for fresh air and proper changeover rates.
- Heat loss is reduced by minimising piping and duct lengths, and installing insulation in areas of high temperature differences.
- Noise created by the system (indoors and outdoors) is minimised.
- Adequate access space is provided for maintenance.

Is your unit or system suitable for variable operating conditions?

- It is important to consider the different operating conditions of your venue. Performance spaces are high occupancy areas (persons per m_2), which means the HVAC system has to deal with the heat loads and CO_2 emissions from a large number of patrons as well as the heat emitted from stage lighting.[1]
- If your air conditioning system will be operating through periods when the cooling or heating requirements (or loads) will vary considerably, then the system's compressors should be able to operate effectively at part and full loads. If the compressor in your current HVAC system cannot operate efficiently at part loads, you could investigate replacing the compressor, or installing a variable speed drive (VSD) that will adjust the compressor's motor speed to match the changing load.

Case Study: Malthouse Theatre

Malthouse Theatre has recently replaced their A/C unit. This retrofit has reduced the theatre's environmental impacts as the old system was running on a refrigerant called R22, a major contributor to greenhouse gas emissions. The system is designed to be much more energy efficient than the 20 year old model and allows for greater control through zoning and timers across the venue. The system also makes efficient use of return air and the materials of the new system lead to better air quality. Looking at it holistically, maintenance and repair costs have been greatly reduced as have Workplace Health and Safety concerns, since access for the new unit is in a safer position. While Malthouse Theatre cannot quantify the energy usage of the unit itself, overall reductions in their energy bill since unit replacement have proven that the retrofit increased the energy efficiency of the venue significantly.

[1] *Refer to our resources on energy efficient lighting design for more information*

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Equipment Upgrades

How old is your HVAC system?

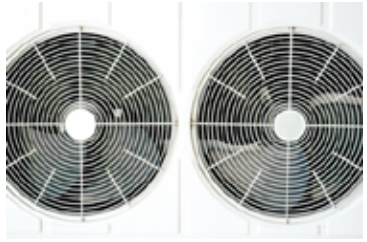
Typically, the 'functional life' of a HVAC system is 10-15 years. That means the testing conducted by the system manufacturers has indicated that under normal operating conditions, its components will be worn beyond repair after 10-15 years.

So, if your HVAC system is more than 10 years old, it's time to consider replacement. When weighing up the capital cost of replacement, consider that new units can reduce energy costs by 20 - 40 per cent.[i]

In a newer system, components which need more frequent maintenance can also help to identify areas which are not functioning at optimal rates.

HVAC components which typically require upgrading include: [ii]

- Drives and motors on pumps, fans, electronic valves, chillers, etc.
- Air handling units,
- Chiller coils, and
- Boilers (or Heaters).



Source: FreeDigitalPhotos.net by anankkml

Are you using Variable Speed Drives (VSD) across your HVAC system?

Installing variable speed drives on supply and return air fans can save energy in HVAC systems by adjusting the speed of fan motors to match the volume of air required to be moved through the building.

Variable speed drives can also be used in:

- Primary chilled water pumps.
- Secondary chilled water pumps.
- Condenser water pumps.
- Heating pumps.
- Motor output fans.
- Cooling tower fans.

Installing a VSD in a cooling tower fan not only reduces energy consumed by the fan, but can also improve energy efficiency of the chiller compressor.

Retrofitting VSDs can be a very simple and cost effective improvement. By optimising fan and pump speeds, energy costs can be reduced significantly. [iii]

Traditionally, VSDs were viable only if the system was designed as a VAV (variable air volume) system (see Air Handling Unit section). However, advances in control algorithms allow you to implement a VSD in any type of air conditioning system. Depending on the control algorithm and the humidity requirements in the space, the anticipated energy saved can reach 45 per cent of the fan energy. [iv]

Are your motors energy efficient?

Motors are used for pumps, fans, chillers and in a number of further HVAC equipment. Typically, motors are rewound once they fail; however, the energy efficiency of rewound motors drops with each rewind (on average efficiency decreases by about one percent after each rewind [v]). Do not rewind motors unless there is a guarantee of the efficiency. [vi] While rewinding a motor is about 60 to 80 per cent cheaper than a new standard motor, the capital cost for a new motor may be lower than the energy costs of a rewound motor over time. [vii] Replacing standard motors with newer and more efficient models may pay out considering that motors are extensively used throughout the system.

Do you have variable air volume (VAV) Air handling units (AHU)?

Air handling units condition and distribute air throughout a building in order to maintain indoor air qualities such as oxygen and CO2 levels, humidity and temperature.

AHUs have a number of components including mixing dampers, air filters, heating and cooling coils, fans, motors and noise attenuators.

Output of AHUs can be measured as constant air volume or variable air volume. If you have a constant air volume AHU, consider converting to variable air volume (VAV) as these systems can regulate the supply of conditioned air depending on the venue's occupancy and the heating or cooling required for the space.

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How old is your Chiller system?

Chillers are large energy consumers within HVAC systems. When considering the value of retrofitting the chillers in an existing system, it is important to remember the capital costs will be balanced by reduced energy costs over the new chiller's expected lifespan. [viii] If your chiller is more than 15 years old, an upgrade should be considered [ix]. Check whether your chiller uses refrigerants that have been phased out or are in the process of being phased out[2].

Chiller efficiency can be improved by measures outlined below:

- Replace old chillers with a water-cooled turbo compressor fitted with a VSD. This can improve energy efficiency by up to 400 per cent [x].
- Adjust the capacity of the chiller. A smaller capacity chiller should be used in low load conditions, and a larger chiller for high load conditions. Operating a chiller at part-load conditions reduces the efficiency of a conventional fixed speed chiller.
- Replace expansion valves (for reciprocating compressors). If the expansion valve is electromechanical, replace it with an electronic valve. This can improve efficiency by around 15 per cent.
- Use a chiller that has the necessary communication interfaces to allow implementation of modern energy saving strategies through control systems or building management systems (BMS). Remote set point control allows for controlling the output of the chiller through automatic control systems.
- Provide adequate cooling capacity for the cooling tower. It is common practice to design the cooling tower to a minimum capacity. However if it becomes undersized due to changed conditions or usage patterns, then increasing the cooling tower capacity will also increase the chiller efficiency.

Are you using condensing boilers?

Many HVAC systems include a boiler for building heating. When assessing replacement or refurbishment of your current boiler/water heater, consider the cost of energy used by the boiler through its expected lifetime [xi].

Water heaters with modulating burner control (as opposed to burner on-off control) can improve energy efficiency at part loads by allowing more time for heat transfer against a lower temperature difference, and by having less air-purging cycles.

Consider replacing conventional boilers with condensing boilers where possible. Condensing boilers use waste heat of flue gases to pre-heat the cold water entering the boiler. Their design encourages the condensation of flue gases; however, to allow for condensation, the return water entering the boiler from the heating circuit needs to be below the dew point of flue gases, which is at 55°C.

As return water temperatures in conventional boilers are considerable higher (at 71-82°C), retrofitting condensing boilers to existing heating systems requires further adjustments. [xii] Such adjustments may involve specially designing heating circuits to allow for cooler water to return to the boiler or by adjusting the sizing of the heat exchangers to suit the required duties. [xiii]

[2] Check out the following website to learn more about refrigerants in Australia: www.refrigerantsaustralia.org

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If return temperatures are adequate and the boiler is monitored, controlled and maintained effectively, condensing boilers can reduce gas consumption by up to 15 per cent. [xiv] The comparably high cost for energy efficient boilers usually entails a reasonable return on investment through savings on gas.

Source: Dunnd74 at en.wikipedia

Energy Saving Devices

Additional devices which may improve the energy efficiency of your HVAC system include energy saving features such as:

- thermostats,
- economisers,
- motion sensors, and
- night purging vents.

Programmable thermostats

Programmable thermostats allow automation of HVAC systems and can increase energy efficiency. Features of programmable thermostats include:

- automatically turning the unit 'off' when set temperature has been reached, and
- using timers to adjust the building's occupancy schedules and thus avoiding heating or cooling unoccupied spaces. This can save 10- 20 per cent of HVAC running costs without sacrificing comfort [xv].

When installing thermostats, choosing the right location is crucial. Avoid exposure to direct sunlight or other heat sources such as lights or other electrical appliances.

Air-side Economisers

As economisers make use of cooler outdoor air to cool buildings they may not be appropriate for hot and humid climates. That said they may help venues in parts of Australia with lower, drier ambient air temperatures, to reduce HVAC energy costs.

Economisers use air from the outside for cooling instead of using refrigeration equipment to cool re-circulated air.[xvi] When outdoor temperatures are lower than return air temperatures in cooling modes, cooling coils can be turned off and chiller energy consumption can be reduced.

Economisers for boiler heat recovery

If you have a non-condensing boiler in place, economisers can be retrofitted to your conventional boiler to achieve condensing efficiencies through heat recovery. Economisers are heat exchange devices that save energy by using the warm exhaust gases from the boiler to preheat the water used to fill the boiler.

Motion sensors

Installing motion sensors in less frequently used areas such as change rooms and storage rooms can save energy as air conditioning will only be turned 'on' when a space is occupied.

Night purge ventilation

Night purge ventilation expels the warm air which builds up over the day. This saves energy by pre-cooling thermal mass of the building overnight, so the HVAC system does not need to work as hard in the morning to reach set temperatures.

This type of ventilation system is most efficient for climates where night temperatures are below 20-23°C, and the temperature fluctuations between day and night are relatively high. Incorporating night purge ventilation into your HVAC design can increase energy efficiency significantly; especially as there are no added costs for running the system once it has been installed. System instalment may include operable or automated windows, roof vents and trickle vents.

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Endnotes

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vi Department of Climate Change and Energy Efficiency, 2012. Guide to Best Practice & Maintenance & Operation of HVAC Systems for Energy Efficiency by Lasath Lecamwasam, John Wilson and David Chokolich (GHD)*http://ee.ret.gov.au/energy-efficiency/non-residential-buildings/heating-ventilation-and-air-conditioning-hvac/guide-best-practice-maintenance-operation-hvac-systems-energy-efficiency*

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viii The Energy Efficiency Exchange Website, 2013. Opportunities: Heating, Ventilation and Air Conditioning, *http://eex.gov.au/technologies/heating-ventilation-and-air-conditioning/opportunities/#Select_the_right_water_chiller_system*

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xiii Department of Climate Change and Energy Efficiency, 2013. Factsheet Boiler Efficiency *http://ee.ret.gov.au/sites/default/files/documents/05_2013/HVAC-FS-boiler-efficiency.pdf*

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