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SERIES **14** | MODULE **04** | **AIR CONDITIONING**

Saving energy in air conditioning systems

By Paul Bennett CEng CDir

Air conditioning can add 50 per cent to the eventual running costs in buildings attributed to energy and maintenance costs. It is therefore an important area for energy managers to focus upon. In many cases air conditioning can be the highest priority area to unlock energy savings.

An air conditioning system within a building is a system of treating air to provide a combination of filtration, temperature control, humidity control and air movement for the comfort of occupants, or, in the case of a data centre for a process.

Not only are air conditioning systems expensive to run, they can be a source of constant complaints. Complaints can arise from building occupancies being too hot, too cold, cause draughts and deliver poor air quality. The correct operation and set up of an air conditioning system will not only deliver energy savings but can also provide a healthier environment leading to more productive building occupants.

Another important consideration when looking at the relationship between air conditioning and energy is its adaptability to climate change. Climate change is causing the external environment in the UK to become warmer and wetter and both factors cause air conditioning systems to work harder and longer and increase its overall energy demand. So in order to save energy not only do we need to make the air conditioning system more efficient but we need to offset energy increases due to climate change. Seen another way, achieving energy savings can free up capacity on air conditioning systems to cope with climate change adaptability.

There are many types of air conditioning systems and the range and variants can be confusing. In this section we will simplify the various types of system and provide some clarity.

• **Centralised air systems** – These comprise constant volume, variable air volume and dual duct systems. Generally these systems will have a centralised air handling unit(s) and chiller(s). An air handling unit is a large 'box' or series of 'boxes' that contains supply and extract fans, filters, ducts, heating / cooling coils, and dampers to control the flow of air. These systems may include humidifiers and heat recovery devices. A chiller is a machine that uses refrigerant to produce a cooling medium. In air conditioning systems this medium is generally transferred using either water in large pipes or refrigerant in small pipes. Both systems usually terminate at a cooling coil in an air handling unit. Heating for air treatment is usually provided using low-pressure hot water (LPHW) from a gas/oil boiler system, or, from heat pumps using refrigerant. These usually terminate at a heating coil in the air handling unit. The many components of the air conditioning system will be controlled by a BMS outstation or by some local controls. Air is distributed throughout the building using air ducting and supply/extract into spaces using grilles and diffusers.

• **Partially centralised air/water systems** – These comprise centralised air handling units as described above with localised reheat, induction, fan coil or unitary heat pumps. In general these systems will have a central air handling system providing partially treated air to different zones in a building. Each zone within the building will have a local 'mini' air handling unit that finally treats the air to the need of the space controls. The local 'mini' air handling unit can provide fans, filters, heating / cooling coils and grilles and diffusers to supply/extract air into a space. The complexity of these systems begins to increase as there are more control

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components such as values, dampers, actuators and control sensors to maintain and control correctly.

• **Local systems** – Examples of local systems are through-wall packages, split unit packages, individual reversible heat pumps and variable refrigerant flow rate cassettes. These systems are in simple terms a 'mini' air handling unit located within the space. These are usually installed where centralised space for an air conditioning plant cannot be afforded or as a retrofit installation where air conditioning has become a requirement. Local controls are normally provided in a wall mounted controller or hand held remote control.

Energy audits identify the potential to save energy in buildings by identifying energy saving measures.

In reality very few air conditioning systems operate efficiently. In most cases there is scope to reduce energy demands from 5-25 per cent and in some cases even more. This is because air conditioning systems:

• **may not have the appropriate control software provided** – it may be operating to a set or parameters that are no longer relevant or were never relevant;• the control set points have been changed at some point by building users or maintenance contractors. Examples of which are time schedules, air temperature settings and invertor settings (for variable speed drives);• the control equipment has not been maintained to a good standard. Examples include valves and actuators that are stuck open or closed, dirty filters that restrict air flow, dirty and unhealthy ductwork and poor maintenance scheduling; and

• **malicious acts can occur in air conditioning systems**, hard as it might be to believe. Examples include screwdrivers forcing open or shut dampers left in position and ducts being blocked with bricks.

It can be seen why an energy audit is much needed. However, before embarking on an energy audit it should be checked if the system has already been audited. There are three key legislative requirements for air conditioning systems these are:• Air Conditioning Inspections - The Energy Performance of Buildings Regulations (Certificates and Inspections) in England and Wales requires that all air conditioning systems with an effective output of over 12kW must be regularly inspected by an energy assessor. The inspections must be no more than 5 years apart. The standard for these inspections is the CIBSE TM44 "Inspection of Air Conditioning Systems". The air conditioning inspection should include opportunities to save energy.

• **F-Gas** - The Kyoto protocol requires European member states to carry out Fluorinated greenhouse gas inspections (F-Gas). These are enforced by The European Community Regulation 842/2006 and is underpinned in the UK by the Fluorinated Greenhouse Gases Regulations 2009 (SI 2009/261). The F-Gas regulations are mostly concerned with limiting refrigerant gas leakage.

• **ESOS** – ESOS is a mandatory energy assessment scheme for organisations who are mid-sized. Commercial organisations who fall into the requirements of the Governments ESOS scheme (Energy Savings Opportunity Scheme) will have had energy audits to BS EN 16247-1 – "Energy Audits" completed in early 2016. The ESOS audit should include energy saving opportunities for air conditioning systems.

Therefore, before commencing on an energy audit it is well worth checking what documentation and energy saving recommendations already exist for the air conditioning system.

Assuming that no audit has been carried out, or a further audit is required, the general protocol for providing an energy audit would be to:
• obtain and review all relevant background information including operating and maintenance manuals, ESOS energy report, F-Gas report and Air Conditioning Inspection report;
• obtain energy data for the air conditioning system. Ideally using sub meters or if not available using a power monitor;
• reference the energy data to the main utility meter data. Where possible analysis should be made over a day, week, season and year. Where data is not available, a top down approach using occupancy data and BMS time scheduling could be used to prepare an estimate of actual use against the units power use factors and this compared to the overall energy profile of the building to confirm switch profiles;
• interview key building occupants, maintenance contractor and any other who influences the operation of the system. This is to simply understand how the building occupants use the building and how the controls operation should be aligned, and, or to assess if behaviour change is needed;• develop a standard operating protocol of how the system should operate for the current building users; and
• inspect the air conditioning system to CIBSE TM44 and follow the energy audit methodology of BS EN 16247-1.

The typical energy savings found in air conditioning systems include the following measures:

Building fabric heat gains/losses

Measures to minimise the heat gains and losses in a space or building can reduce the basic need for heating and cooling in the first place. They can be simple or complex and can range from:
• air leakage improvements - sealing gaps around windows, doors, and roof/wall joints;
• solar control (fitting external blinds/shades to windows or solar film);
• control of high heat gain equipment in a space - time control on heat producing equipment in a space or moving out of a space;
• flexible working – less people in a space means less human heat generated;• refurbish lighting – for example LED lighting generates less heat gain than fluorescent systems;

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• thermal insulation – pipework in spaces, in roofs, walls and improved glazing.

An often-missed opportunity is to develop a building-user-focused standard operating procedure that sets out how the building should be used. This can include operating modes and related plant operations for activities such as cleaning. The standard operating procedure can also include set points, dead-bands, and ventilation rates for different activities e.g. cleaning hours' reduced ventilation rates versus fully occupied 100 per cent ventilation rates.

Control measures

These measures seek to best and most efficiently control the air conditioning systems using the control system. They include:• replacing the entire control system – old or inadequate control system replacement;• re-commissioning the entire BMS control system – retaining the existing controls but new control software and full re-commissioning. This could include an element of mixed mode operation and free cooling using natural or mechanical ventilation prior to full air conditioning. This could also include isolating the humidifiers since in the UK humidity control is rarely needed. Another good example is the provision of zonal control; and• re-setting the control system – Changing set points and control parameters such as time, temperature, humidity, summertime floating set points, optimum fresh air ventilation rates, re-locating sensors to avoid false readings. This should also include the control dead-band is set so that heating and cooling systems cannot fight (i.e. operate simultaneously).

Capital expenditure projects

These can range from a low cost to a high cost technology improvement. They can include the retrofitting of ventilation heat recovery devices e.g. plate heat exchanger, thermal wheel, mixing box, run around coils or variable speed drives controlling fan speed/ high efficiency motors (costing a few or tens of thousands of pounds) to full plant replacement e.g. air handling/ chiller/boiler replacement (costing tens or hundreds of thousands of pounds).

Maintenance measures

These include cleaning or replacing dirty air filters, repairing/replacing faulty control sensors/actuators, ensuring the free movement of mechanical control elements and the replacement of thermal insulation removed by previous maintenance actions.

Implementation of measures

The energy-saving measures or opportunities should be fully scheduled with full technical details backing up each measure with associated energy savings, costs and payback periods. Capital intensive opportunities should include life cycle cost analysis which take into account energy savings, maintenance and asset life.

The schedule should be intelligently reviewed and prioritised and a hierarchy followed that suits the organisation in question. This may include an understanding of the organisational priorities, investment hurdle rates, culture and behaviours.

Implementation will require a level of investment – this can be high or low. The low investment measures can usually best be adopted by instructing the maintenance contractors (in the case of controls fixes). High investment may require a business case to be submitted for board approval. In this case the business case must sell all aspects of the measure and clearly communicate all of the benefits of energy cost savings, maintenance cost savings, impact on employee health, wellbeing and productivity, adaptation to climate change and compliance with legislation. A well-constructed argument has a much stronger chance of approval than a poor one.

To achieve best practice, a project sponsor (or champion) may be required who can drive the project forward, communicate between all parties and instruct the various parties into action.

Finally, a good project management methodology should be adopted using Prince II principles. Good project management will ensure that adequate time is afforded to final system commissioning and witness checks that systems are well commissioned.

Monitoring of energy savings

Following the successful implementation of energy saving measures it is vital that the before and after energy savings are accurately recorded and understood. It is important to understand if the measure is performing well or badly and subsequent investigations can be arranged. For example, is it that the measure was wrong for the situation or has it been badly installed or commissioned?

Communication of the success and failures should be made between all stakeholders.

Air conditioning can add 50 per cent to the eventual running costs in buildings attributed to energy and maintenance costs. The potential to save energy in air conditioning systems is suggested at 5-25 per cent and sometimes higher. The benefits of saving energy in air conditioning schemes also impacts the buildings climate adaptability and occupants health and wellbeing.

Sources

• EiBI's Continuing Professional Development programme Fundamental Series 9 module 2, June 2011 – air conditioning & low energy systems.
• EiBI's CDP Fundamentals Series 12 module 1 air conditioning and low energy systems, May 2014.
• Energy efficiency in buildings CIBSE Guide F.
• Heating, ventilation, air conditioning and refrigeration CIBSE Guide B
• Fluorinated Greenhouse Gases Regulations 2009 (SI 2009/261).
• CIBSE TM44 Air Conditioning

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AIR CONDITIONING

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

QUESTIONS

1) Air conditioning can add what percentage to the eventual running costs in buildings attributed to energy and maintenance costs?

☐ 10% ☐ 30% ☐ 50% ☐ 40%

2) Which one of the following is an example of a centralised air conditioning system?

- ☐ DX cooling
- ☐ Fan in wall
- ☐ Induction
- ☐ Constant volume

3) What is the standard for Inspections for Air Conditioning System?

- ☐ BRE 345
- ☐ CIBSE TM44
- ☐ BE EN 16247-1
- ☐ F Gas

4) What is the principle benefit of an energy audit?

- ☐ To understand the buildings M&E systems
- ☐ To understand maintenance costs of AC systems
- ☐ To identify energy saving measures and opportunities
- ☐ To comply with mandatory air conditioning legislation

5) What is the principle purpose of the F Gas Regulations?

- ☐ To reduce refrigerant gas leakage
- ☐ To increase refrigerant volumes
- ☐ To incentivise energy efficiency
- ☐ To improve air conditioning performance

6) What is the specific energy saving potential in air conditioning systems as indicated in this article?

- ☐ 50%
- ☐ 1%
- ☐ Between 5-15% sometimes less
- ☐ Between 5-25% sometimes more

7) Which one of the following is an example of a fabric energy saving measure?

- ☐ Air leakage repairs to building envelope
- ☐ Re-commissioning controls set points
- ☐ Re-locating temperature sensors
- ☐ Thermal wheel heat recovery device

8) What one of the following is an example of a technology energy saving measure?

- ☐ Variable speed drive (VSD)
- ☐ Dead band
- ☐ Floating set point
- ☐ Replacement of dirty air filters

9) Which one of the following is a control energy saving measure?

- ☐ Solar shades
- ☐ Software upgrade and re-commission
- ☐ High efficiency motors
- ☐ Chiller replacement

10) What is the one fundamental key purpose of monitoring energy performance following implementation?

- ☐ To enable energy audits
- ☐ To commission VSDs
- ☐ To verify predicted energy savings
- ☐ To enable payment to contractors

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