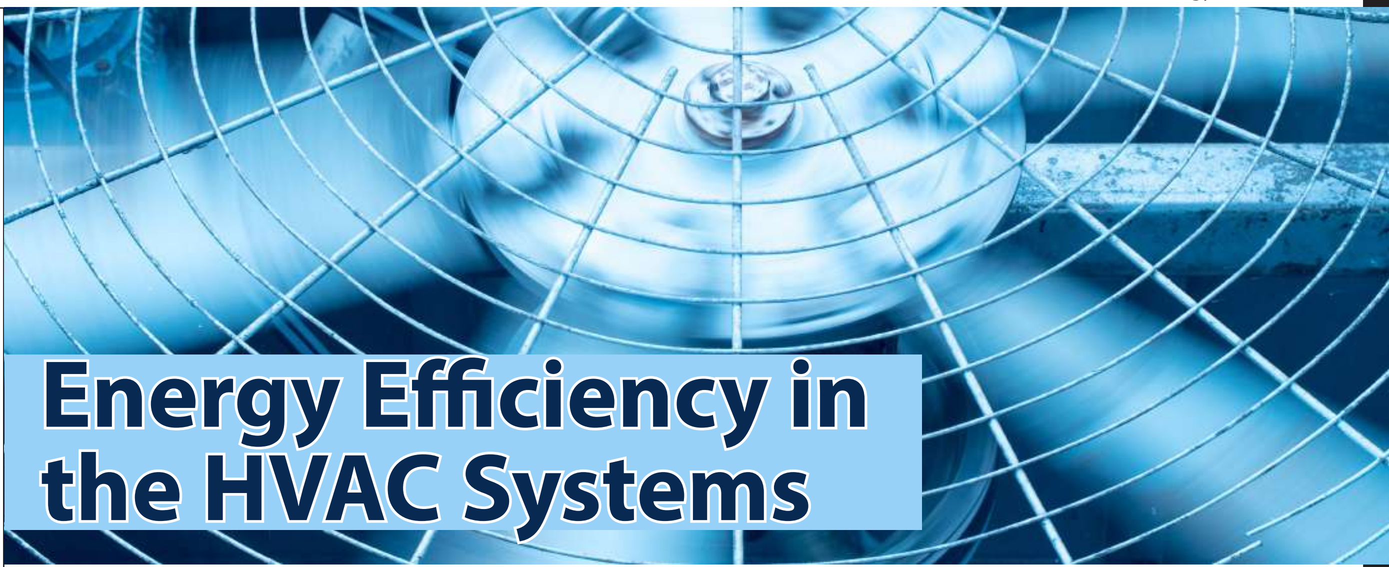
by Simon Mitchell, Energy & Technical Solutions Manager at Mitie Energy and Chris Norburn, Business Director at Cantec Energy Solutions Ltd



Energy Efficiency in the HVAC Systems

Heating, ventilation and air conditioning (HVAC) systems are an essential part of most modern buildings and can consume a large part of any energy used. They come in various shapes and sizes, and operating them to achieve more energy efficient systems requires the understanding of the technology as well as the environment they are used in. We have asked two energy management professionals to present operational insight into controls, optimisation and potential traps to avoid with HVAC systems to ensure their efficient operations.

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IN FOCUS: Heating Systems: Boilers – Natural-Gas Fired

SYSTEM IN PLACE:

Commercial gas fired heat generators, modern condensing boilers installed less than 10 years ago, but onto a system designed for the previous non-condensing boilers and operating at a lower efficiency. Providing Low Temperature Hot Water (LTHW) for space heating via Air Handling Units (AHUs) and Domestic Hot Water (DHW) via a Plate Heat Exchanger (PHE).

CURRENT CONTROLS & OPTIMISATION:

Building Management System (BMS) control provides an enable signal to each boiler as required to meet heating demand and sequences weekly rotation of lead boiler. LTHW flow temperature is set on the boilers' controls.

LESSONS LEARNT FROM OPERATING THE SYSTEM:

Condensing boilers have been available for over 40 years with uptake in the UK commercial market only taking off after Building Regulations (Part L2B: Conservation of fuel and power – Existing buildings other than dwellings, 2000) came into effect in April 2006. This increased the minimum heat generators' seasonal efficiency and made it more difficult to use non-condensing replacements. With a focus on minimising CapEx cost, replacement heat generators were selected that could operate with the highest efficiency in condensing mode but never have, as the system design and controls were not adapted to allow cool system water to reach the boilers' return connections. Once installed, it is often too difficult to optimise these boilers and allow them to operate in condensing mode thus valuable energy is wasted.

FUTURE CHANGES:

This common situation could frustrate plans to decarbonise buildings, making upgrades more difficult. Additionally, maintenance of the building services has often been given a low priority and the building operator may be looking for Net Zero on the cheap without addressing maintenance backlogs.

However, with the right strategy, elements such as the heat emitters could be replaced to allow operation with lower flow temperatures, and controls could be upgraded compensating the flow temperature to the outside air delivering savings now through more efficient operation, but also future-proofing the system for heating via heat pumps or a heat network connection.

IN FOCUS: Heating systems: Heat Pumps (HP)

SYSTEM IN PLACE:
Air Source Heat Pump (ASHP) replacement of gas-fired heat generators in LTHW system providing space heating via AHUs and DHW via a PHE. Maintenance of the HP is via a service agent with the rest of the heating system maintained by in-house maintenance operatives.

CURRENT CONTROLS & OPTIMISATION:
BMS enables HP's proprietary control system that controls its compressors and fans. BMS controls AHUs and heating circulators.

LESSONS LEARNT FROM OPERATING THE SYSTEM:
Needing to decarbonise in line with the company's Net Zero strategy, end of life gas-fired heat generators (boilers) are replaced with a packaged ASHP system. As the original flow temperature cannot be achieved by the HP, the AHU coils have been replaced with larger heat transfer surface area coils. A convenient outside location close to the plant room was available here, but often the large and heavy outdoor units can be difficult to accommodate. The circulators were resized to allow for operation at higher flow rates due to the narrower deltaT.

Understanding that the HP was able to heat the DHW but not to the temperature required for pasteurisation, point of use electric water heaters were considered, but the existing calorifier was retained with a higher output immersion element providing top up heating when required for legionella control. This helped to minimise the additional capital expense of the low carbon upgrade compared to replacing the boilers only.

Site maintenance teams needed training on the new heat pump and its controls to understand how to manage it for best efficiency rather than treating it as an electric version of the boilers that they were familiar with.

FUTURE UPGRADES:
Once installed, the heat pump systems were shown to be delivering carbon emissions' savings, but operational costs had increased significantly, especially in cold weather when HP was operating at a lower Coefficient of Performance (CoP).

Optimisation helped to improve the HP's performance reducing operational costs but this would have been more difficult if the BMS had not been integrated with the HP's control system as is often the case.

Taking advice from specialists, the company selected heat pumps using refrigerant R32 as a good balance between its performance, Global Warming Potential (GWP), toxicity and flammability. The company is aware that the EU F-Gas phasedown will restrict the use of higher GWP refrigerants, and as the market matures there could be a wider range of available technologies for the next building upgrade.

The common theme is that heating equipment replacement has the potential to deliver significant energy efficiency improvements, saving money and carbon if done well. But often value engineering, a limited budget based on an underestimate of the changes required, lack of communication between stakeholders and timescales dictated by the risk of failure rather than planned replacement conspire to undermine the potential benefits.

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IN FOCUS: BMS and Asset Integration

SYSTEM IN PLACE:
The site is a large retail outlet where the BMS system has been integrated with Heat pumps, Air Conditioning (AC) and Variable Refrigerant Volume (VRV) units, Packaged AHU, lighting controls, PV systems and smart meter networks. Integration includes both Modbus and BACnet communications.

The sitewide communication - multiple control panels - is via the customer's internal IP network in collaboration with the customer's IT department. The site is 5 years old and has a monthly maintenance regime in place. The site has remote connectivity with full proactive monitoring via a remote service package.

CURRENT CONTROLS & OPTIMISATION:
The BMS has been engineered to control and monitor the site's HVAC assets and plant – the main focus is on the design to provide the below benefits.

1. Improve and then maintain the site's energy performance and carbon emissions.

2. Ensure staff and visitor health, wellbeing and comfort at all times.

3. Improve maintenance efficiencies – both labour and costs, to reduce reactive call outs and negate the need for manual interventions by site staff.

4. Provide online and site dashboards to inform the owners and the occupants on how the building is performing from both an energy and environmental aspect.

5. Critical alarms proactively report via the online portal, email and GSM - to ensure issues are dealt with immediately (to meet agreed KPIs) to reduce impact on the site's environment and energy performance. Proactive alarms report directly to the portal as well as the customer's engineering helpdesk and out of hours call out engineers' mobiles.

6. The network of smart meters report proactively with alarms should any areas and/or assets exceed agreed energy thresholds set up – including PV generation plants.

7. The customer and its approved supply chain has full access to the online portal and monitoring dashboards.

LESSONS LEARNT FROM OPERATING THE SYSTEM:
BMS systems are intended to control and monitor a site fully to ensure maximum energy performance is as designed, to ensure best environmental conditions within, and to keep wastage (cost and consumption) costs to a minimum.

To receive the maximum benefits from a BMS design – the system should control and monitor all aspects and assets associated with how the building operates – this includes heating, ventilation, air conditioning, lighting, renewables, on site generation, utilities and environmental monitoring (including air quality). Aligned to this can be added more Facilities Management assets such as fire, security and compliance monitoring (emergency lighting and legionella checks, etc).

Sadly – mainly due to designs, specifications and costs – BMS

systems mainly consist of HVAC only.

The main cause of reduced specifications and designs is the fact most BMS systems are installed on a return-on-investment business case. This is where the problem is – how the business case is created and what features and benefits are being sold. In the main, the business case is reporting on savings to be made from energy reduction only. However, in principle, a BMS business case now covers many aspects for improving a customer's bottom line profit. In addition to reduction in energy costs, the below viable cost saving should also be factored into the business case:

- Improvement in maintenance efficiencies.
- Improved life cycle costs.
- Improved staff comfort and wellbeing (less absences and improved staff performance).
- Improved energy procurement and reduced fixed charges.
- Assistance with legislation and compliance mandates.

Originally, the site being discussed didn't have full integration but had systems in a 'silo' set up – controlled independently of each other. This had a negative effect on the building's systems and performance as it negated the opportunity for a more demand led control strategy being implemented. Since full integration was implemented, we can now control the heating, ventilation and air-conditioning all in tandem with each other rather than as it was before, fighting against each other. For example, we now have 'dead-band' control where heating can't be used when cooling is enabled and we can now ensure we use the free heating/cooling available from the external ambient conditions.

The system also didn't have proactive alarm reporting and all alarms were reporting to a desk top located in the plant room – which wasn't accessed easily or regularly, and meant issues went unnoticed for long periods between site maintenance visits. The results now show a reduction in call outs, plant failure down time and improved internal environmental conditions for the staff.

Before remote connectivity and monitoring was instigated, the customer was experiencing a lot of 'unnecessary' call outs for non-critical and/or simple system changes (set point adjustments, etc). This became expensive and increased the embedded carbon emissions associated with call out travelling. The remote monitoring reduced both with immediate effect.

FUTURE UPGRADES:
Now the site has been re-engineered as detailed – all with the aim of improving the energy performance and maintenance efficiencies – savings of over 20% are being realised and maintained. The savings are now being reinvested - 'save to invest to save' approach - to allow for more energy efficiency measures to be implemented - business cases now being discussed for below projects:

- Heat recovery systems.
- Utility (gas and water) monitoring.
- Additional monitoring.

Author's profile: Chris is a fully trained and qualified Electrical Engineer and a certified Low Carbon Consultant with affiliations to multiple industry organisations such as The Energy Institute, ESTA, CIBSE, Chamber of Commerce, and The UK Engineering Council amongst many others. Chris had, up until forming Cantec E.S, held Operations Director and Business Management roles for multiple large energy management companies during the previous 20 years.