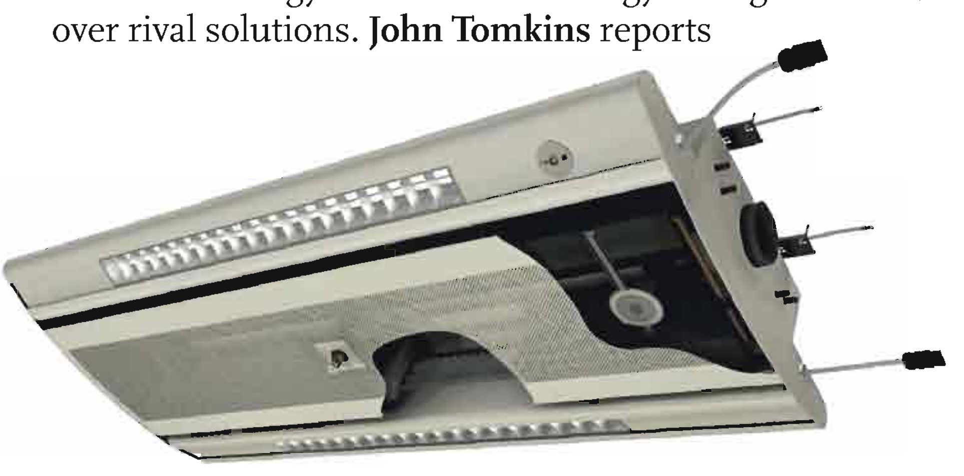
Ceiling the DEAL

A report from the Chilled Beam and Ceiling Association has compared the performance of heating, ventilation and air conditioning systems and found that chilled beam technology could achieve energy savings of 17-22% over rival solutions. **John Tomkins** reports



This summer the government finally unveiled the long-awaited changes to Part L of the Building Regulations, covering energy efficiency of new and refurbished homes and non-domestic buildings. Compliance with the regulations will require a 6% improvement in energy efficiency standards for new homes, and a 9% improvement for non-domestic buildings on 2010 regulations. Minimum energy efficiency standards for non-domestic buildings will also be strengthened when specific building services work, including air conditioning and lighting, is carried out.

While the changes, which come into place on 6 April 2014, are not as demanding as the original government proposal for a 20% uplift for non-domestic buildings (with 11% as the lower option), they will nevertheless force designers to examine the energy consumption of their building services solutions closely.

Building no.	Location	VAV fan coil		Passive chilled beams		Active chilled beams	
		Consumption (kWh)	CO_2 emission (kg)	Consumption (kWh)	CO_2 emission (kg)	Consumption (kWh)	CO_2 emission (kg)
1	London	198,897	92,203	173,037	78,644	163,756	73,828
	Birmingham	185,447	84,217	159,717	70,747	150,598	66,002
2	London	404,008	189,191	346,557	159,182	327,919	149,525
	Birmingham	375,536	172,884	317,825	142,774	299,479	133,244
3	London	392,231	183,131	338,129	154,846	319,457	145,177
	Birmingham	365,010	167,389	311,031	139,187	292,599	129,630
4	London	800,175	377,178	679,824	314,497	642,348	295,106
	Birmingham	742,509	345,003	621,389	281,945	584,320	262,748

Figure 1: HVAC plant annual consumption and CO_2 emissions.

It is timely, then, that the government announcement was closely followed by the results of a study commissioned by the Chilled Beam and Ceiling Association (CBCA) that compared the performance of various heating, ventilation and air conditioning (HVAC) systems. The CBCA study, carried out by consultant Environmental Design Solutions Ltd (EDSL) using its Thermal Analysis Software (Tas), revealed potential energy savings of 17-22% with chilled beam technology, against variable air volume (VAV) fan coil systems.

It is hardly surprising that the report has opened up a debate between the various equipment camps. Indeed, following publication of the report, HEVAC's Fan Coil Group has announced that it is to issue its own paper defining the advantages that it believes a fan coil system can offer.

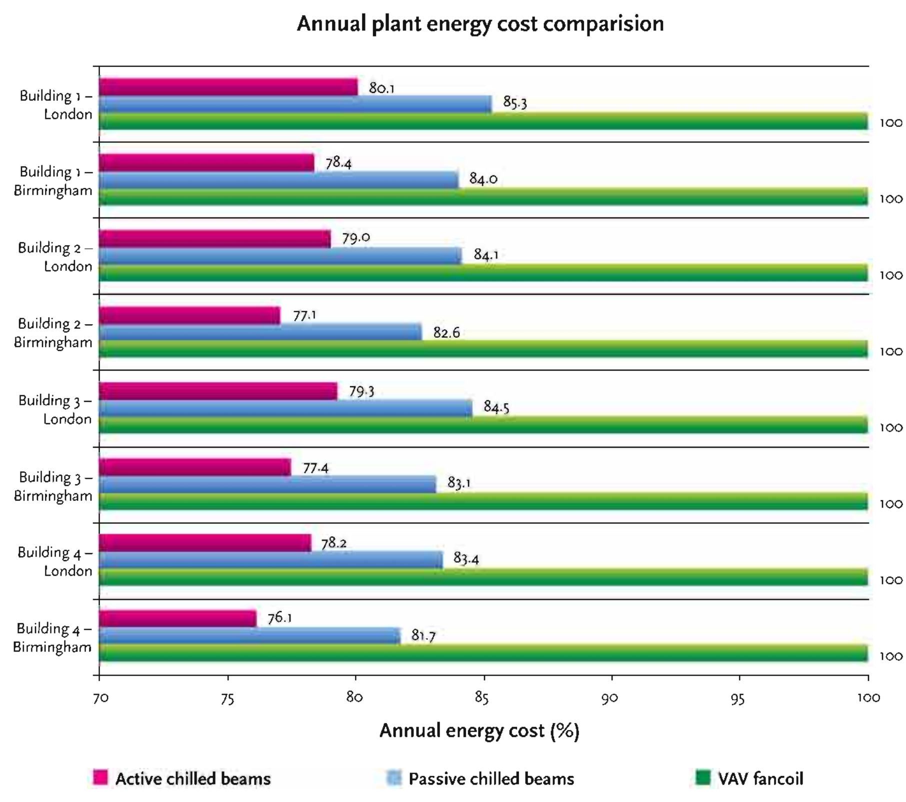


Figure 2: Annual plant energy cost consumption

'We welcome the debate the report is creating, as these findings mean the market can now ascertain for itself the conclusions that can be drawn from this study,' says Andrew Jackson, chairman of the CBCA.

'This is timely for the industry to examine the options for cooling technology in order to assess the most energy efficient solutions. As an industry, it is important we share knowledge to help design or refurbish buildings to perform more efficiently. Chilled beam technology offers a viable solution – it is technology that is available today and proven to enable energy savings.'

The EDSL study simulated the dynamic thermal performance of four differently-sized office buildings, and compared the energy consumption, CO_2 emissions and the running costs of different HVAC systems within these office buildings. The three systems analysed were:

- VAV fan coil units with EC motors and specific fan power (SFP) of 0.25 W/l/s
- Passive chilled beams (95% convective/5% radiant)
- Active chilled beams

The buildings modelled have Part L notional constructions and glazing percentages. The models have been zoned as specified in the National Calculation Methodology (NCM) modelling guide and incorporate 6m perimeter zones, which enabled different solar gains to be analysed. EDSL has looked at the effects of building location in terms of free cooling by ensuring that a location with limited free cooling possibilities was modelled (London) as well as an average central location (Birmingham). Weather data used was an average year from the past 20 years, as published by CIBSE.

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Each HVAC system included a high efficiency chiller, which supplies chilled water to the terminal units being analysed. An air source heat pump supplies heating and cooling to the direct expansion (DX) coils in the air handling unit (AHU), which includes heat recovery – the AHU for all systems is sized to provide the minimum fresh air requirements, in accordance with NCM methodology for an office.

All systems included a boiler with an efficiency of 90% and DX performance was taken from a typical Mitsubishi VRF heat recovery unit.

The annual plant energy running cost savings achieved using chilled beams can be seen in Figures 1 and 2. Figure 2 is split for each particular building and shows the available annual running cost saving, expressed as a percentage against the VAV fan coil system benchmark (100%).

Reduced energy consumption

The completed energy study modelling shows that both the passive and active beams' energy consumption is lower than the VAV fan coil system; the average annual energy cost saving over the buildings for both locations is approximately 17% annually for the passive chilled beam and approximately 22% on average for the active chilled beam over the VAV fan coil system modelled.

Interestingly, the passive chilled beam system's energy consumption was slightly higher than the active beam. This was primarily because the passive beam's displacement ventilation system requires a higher fresh air supply temperature to meet occupant comfort.

Both systems had the same fixed AHU SFPs. The increased air supply temperature on the modelled displacement ventilation system results in increased energy usage on the fresh air re-heat DX, circuit and in less airside cooling being available. Therefore, at certain times of the year, where outside conditions effectively allow the active beams to have a higher level of 'free' airside cooling than a passive system, the passive system will have to make up any shortfall of airside cooling via waterside cooling, which results in a slight increase in the chiller's energy consumption.

Additional energy savings can be achieved by increasing the chilled water flow and return temperatures to the chilled beam units – the relationship between water flow temperature and chiller coefficient of performance (COP).

Cost v energy reduction

Recent advances in chilled beam design have delivered high performance beams. These could be used in a highly efficient way by keeping the same quantity of units on a project as you would using conventional beams, but opting to use elevated water temperatures of a few degrees above the industry standard of 14°C flow – this will reduce energy consumption as highlighted during this energy study. For every 1°C above 14°C flow temperature, there is a potential reduction of around 3-4% on the overall system energy consumption.

However, if capital cost reduction is the driver, rather than energy reduction, the use of high output beams as high efficiency units could be used to reduce the quantity of active beams when compared with traditional units. If going down this road, designers should be mindful of guidelines for occupancy comfort (*CIBSE Guide A: Environmental Design*).

The CBCA Technical Fact Sheet 2 – *EDSL Tas Energy Study Summary Findings* is now available at: **www.feta.co.uk/hevac/specialist-groups/chilled-beams-ceiling-association** CJ

A FAIR COMPARISON?

In the study, the VAV fan coil terminal fan had an SFP of 0.25W/l/s at 100% volume flow rate, and was typically running at half that flow rate with VAV turn down to minimum fresh air for respiratory being 20% of the design volume.

'This was not necessarily an ideal combination, says Alan Jones, managing director of EDSL.

'Since the issue of the energy study comparison, we have carried out an alternative simulation with a turn down to 60% air flow, which is more typical, and have used an enhanced SFP of 0.2W/l/s for the VAV fan coil units to represent the best-performing VAV fan coil units available. This resulted in an overall reduction in total system fan energy of 2.5% and netted out at 1% overall reduction in the VAV fan coil system's energy consumption, thus narrowing the gap from approximately 22% to 21% more energy consumption associated with VAV fan coils, as opposed to active chilled beams.'

The fundamental difference in the specifications was the chilled water supply temperature: 6°C-12°C for the fan coil and 14°C-17°C for the active chilled beam. 'We were asked to use these temperatures to represent the most widely used practice, and to create a typical baseline as both VAV fan coils and active chilled beams can respectively elevate their chilled water flow temperature from their respective base lines,' says Jones.

'The improvements in chiller COP and amount of DX cooling offered by the high chilled water temperature is – and was – the fundamental difference in energy consumption for the alternative systems,' says Jones, adding that the VAV fan coil terminal fans are so efficient that they have a secondary effect on relative energy use. 'I believe the energy use debate is mainly down to chilled water supply temperature,' says Jones.