ENGINEERING UPDATE

FEBRUARY 2014 - **VOLUME 13**

THIS PACKAGE INCLUDES A COLLECTION OF ARTICLES FROM VOLUME 13 OF THE FEBRUARY 2014 ENGINEERING UPDATE.

TABLE OF CONTENTS:

ENGINEERING UPDATE

February 2014 | **Vol. 13**

RETROFITS WITH ACTIVE AND PASSIVE BEAMS

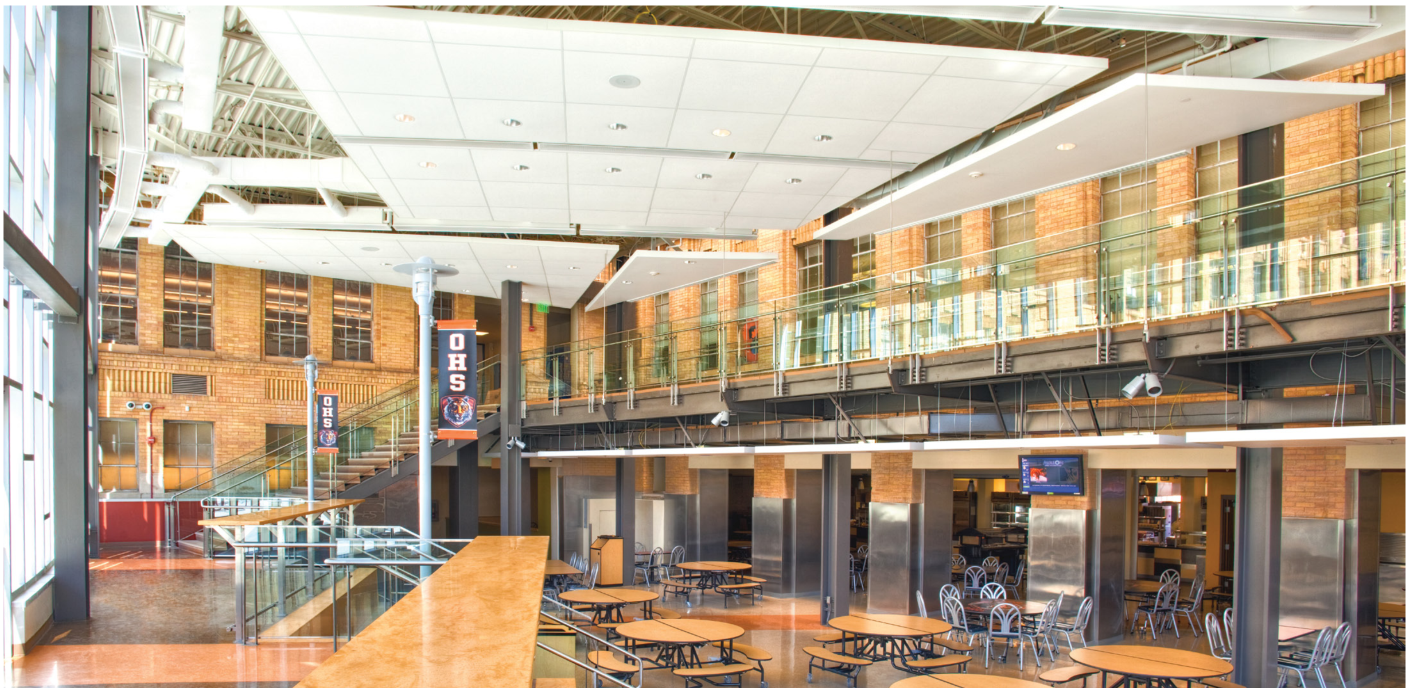


Figure 1 – **Ogden High School, Utah** – The low profile and high capacity of Price Active Beams makes them a good option for retrofit projects

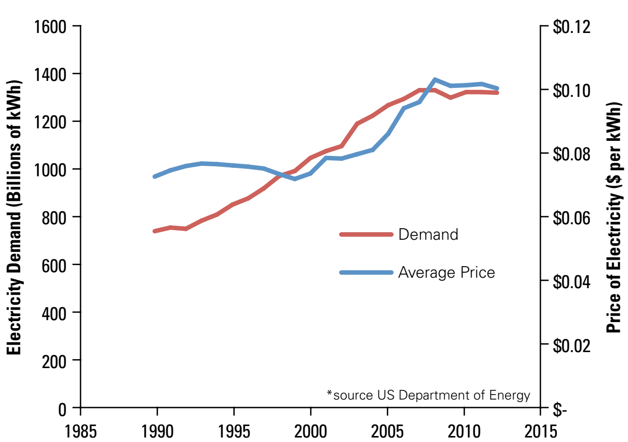


Figure 2 – Average price and use of electricity from 1990 to 2012

There is approximately 50 billion square feet of commercial space already in need of renovation[1], and according to the non-profit organization Architecture 2030, 75% to 85% of the buildings that will exist in urban areas in 2030 already exist today[2]. With the projected building market consisting of 45% green construction[3], there will most likely be a rise in the need for more efficient HVAC systems retrofitted to these existing structures.

WHY RETROFIT?

One of the most common reasons for retrofitting a building is a change in the space use. For example, increased equipment in laboratory and healthcare facilities or a conversion to an open plan office may have an effect on space loads and ventilation rates.

Changes in building codes are also a major driver for retrofits. As building codes have evolved, more focus has been placed on improving the energy efficiency of the existing building stock[4]. Retrofit projects, such as Ogden High School shown in Figure 1, typically work with the original structure, which was designed to meet the requirements of its day. This presents challenges and opportunities to improve the performance of the building as part of a major renovation.

Whether code requires it or not, there is a trend towards designing high performance systems due to the steady increase in the price of electricity over the past two decades[5] (Figure 2), as well as the recognized link between indoor environmental quality and productivity[6,7].

The Center for the Built Environment (CBE) found that building occupants describe standard HVAC systems (provided at move-in) as inadequate to meet functional requirements. Specific complaints included the inability of the system to handle occupant and equipment loads, space conversion requirements, and poor occupant comfort[8]. Indoor environmental quality (IEQ) plays an important role in occupant comfort and productivity. Several studies have shown that a well designed HVAC system that meets the thermal comfort requirements of the occupant can lead to increased productivity and decreased absenteeism[9,10,11].

Owners want to spend less on operational expense, as well as leverage the recognition and benefits of building "green" to attract employees. In addition to these savings, tax credits are also available for buildings that can demonstrate potential gains in energy efficiency[12]. Studies have also shown the economic cost-benefit of upgrading systems and the potential for reduced time in payback when comparing worker salaries and benefits to the cost and operation of the HVAC system[13].

Several technologies exist that can help improve IEQ and reduce energy use. Improved air quality can result from source control, air cleaning, increasing ventilation efficiency, and using outdoor air "economizers". Other strategies can be used to mitigate the energy impact of conditioning ventilation air, such as energy recovery, demand controlled ventilation, dynamic reset, or by dehumidifying and conditioning the outside air at the zone level with a fan terminal unit like the Price FDCOA. Upgrading the HVAC system to a current and reliable technology can lead to better control, lower airflows, and increased thermal comfort for tenants.

ACTIVE BEAMS

In an active beam, ventilation air is supplied to an integral plenum and then passes through nozzles at a relatively high velocity, which draws room (secondary) air through the coil where it is cooled or heated, mixed with the primary air, and discharged into the room (Figure 3). Through induction of room air, an active beam system diverts the majority of the sensible load to the chilled water system. Since water is more efficient at transporting heat, chilled beam systems are able to achieve higher capacities at the same airflow as all-air systems. A measure of this performance is known as the transfer effectiveness, or Btu/hcfm[14]. HVAC systems with a high transfer effectiveness tend to be more energy efficient and have superior IEQ (i.e. reduced draft and noise levels) when compared to traditional systems[15,16,17]. The reduction in supply air, and thereby fan energy[15,16], becomes obvious when comparing a typical all-air system transfer effectiveness of ~20 Btu/hcfm to that of an active beam system, which is typically ~75 Btu/hcfm.

Along with the increase in energy efficiency, active beams have other major benefits:

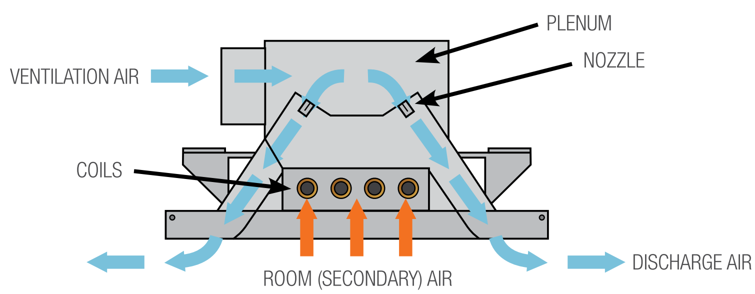


Figure 3 – Active beam operation

- **Reduced Maintenance** – chilled water supply temperatures are maintained above dew point, which means the coils do not condense. This eliminates the need for pre-filtering or condensation collection. Due to the fin spacing and elevated water temperatures, dust does not collect as frequently and typically requires an inspection and vacuuming of the coil every 1-3 years.
- **Smaller Mechanical Footprint** – because supply air is reduced to only what is required for ventilation and dehumidification, ductwork and AHU size can be reduced. In retrofits, there's also a gain in system capacity when using existing infrastructure.
- **20+ Year Lifespan** – Active beams also have a longer product lifespan, which means spending less on replacements throughout the life of the building.

DESIGN CONSIDERATIONS

In existing buildings, floor-to-floor height is fixed, requiring any planned modifications to fit within existing plenum space. The volume of space is often under pressure as designers optimize the ceiling height or type as a part of the renovation.

In many cases, the existing mechanical infrastructure, such as ductwork and piping, is re-used. This could be because of a budget constraints, construction schedule, or a phased renovation. For these reasons, the updated HVAC system would need to integrate with similar (or lower) airflow and static pressure as the legacy system. In cases where the distribution system may be reduced, risers and main ducts can be reduced in size to give more useable floor space.

In historical renovations, humidity control is a primary concern when utilizing the non-condensing chilled water coils used in chilled beams. Attention must be given to ensure that infiltration is accounted for. This is often accomplished by creating a tight façade in order to reduce the risk of infiltration. Active and passive beams may not be suitable in areas with high humidity loads, such as locker rooms or entry ways. In these spaces, a displacement ventilation system with a Price Intelligent Controller may be used to manage humidity levels effectively.

As a part of any renovation, consideration should be given to the control system. There is often an opportunity to upgrade the controls from pneumatic or electric controls to a DDC system. The advantages of using modern controls are well known, though it is worth pointing out that the use of certain control sequences, such as those employing variable air volume (VAV) or demand controlled ventilation (DCV), can further optimize or improve the energy savings realized with the beam system.

SUITABILITY

Chilled beam systems have the flexibility to be integrated into the existing infrastructure. When ceiling height is increased during renovations, plenum space is often reduced or removed completely, requiring the new product to fit within a smaller space than the element that was there previously.

Such was the case for 130 Bishop Allen Drive in Cambridge, MA, where the design team was tasked with incorporating the existing air handling unit into the design while still accounting for the increase in space loads. This multi-use office building presented an interesting challenge

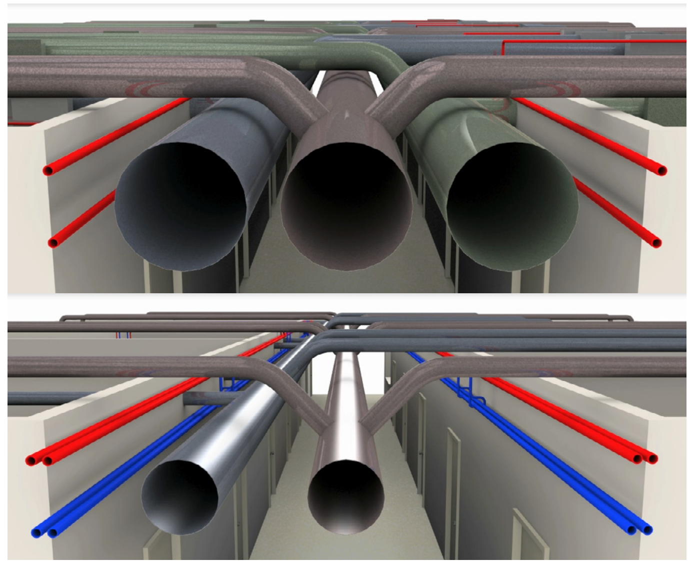


Figure 4 – Duct size comparison between an active beam and all-air system

to the team, as each floor was designed for a specific tenant and application. The existing ceiling grids on all the floors were removed to maximize the usable space and create a more open environment.

Through an iterative process of reviewing the loads in the space and minimum ventilation requirements, a combination of active and passive beams and chilled

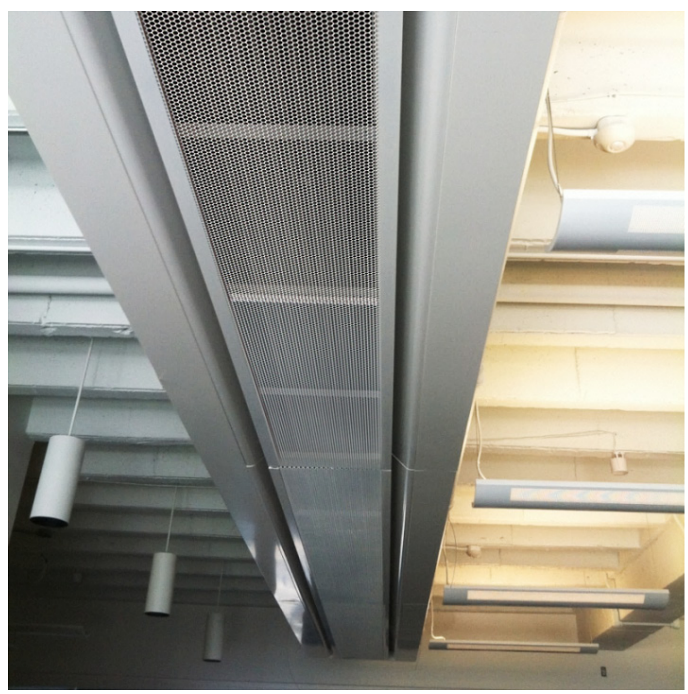


Figure 5 – Coanda wings and slimline coupling at 130 Bishop Allen

SECURITY ACTIVE BEAM

Figure 6 – Security active beam installed in patient room

In the psychiatric wing, a Price security chilled beam was chosen for its heavy gauge security face and staggered perforation pattern, which prevents access to the ductwork and internals, while still facilitating energy savings and occupant thermal comfort.

sails was determined to be the most efficient approach. The system had the ability to run at minimum ventilation with very high induction ratios, thus improving transfer effectiveness to 149 BTUh/cfm.

The design of Price Active and Passive Beams allows for the products to be coupled together to create a seamless look, and helped reduce installation costs through the use of common plenums. Coanda wings were used to maintain air pattern out of the beams in the exposed ceiling application. Both of these options are shown in Figure 5.

The renovation of the pharmacy and patient wing at The Memorial Hospital and Health Care Center (MHHCC) in Jasper, Indiana is a great example of using active beams to improve the performance of a mechanical system while utilizing the existing distribution infrastructure. Memorial Hospital, opened in 1951, was looking to renovate these areas in order to create a safe, comfortable environment while reducing energy consumption and operating costs. The design team was faced with the challenge of renovating the pharmacy, which was served by an all-air system, and patient wings, which relied on perimeter fan coil units for heating and cooling. Specific challenges included extremely low floor-to-floor heights, restricted

Figure 7 – Active beam installed in Memorial Hospital pharmacy

plenum space, increased loads, and renovating while the building was still occupied. Another unique challenge was the security requirements of the psychiatric patient wing. The goal was to create a safe, comfortable environment while reducing energy consumption and operating costs.

After careful consideration, the design team concluded that Price Active Beams were the ideal solution for the project. The beam system combined with a Dedicated Outdoor Air System (DOAS) allowed the engineer to reduce the size of the air handler that would typically be used to service the space. The smaller piping in active beam systems also addressed the structural restrictions by eliminating the need for large ductwork. The volume of primary air supplied to the different areas was reduced by 30% to 60% when compared to a conventional overhead mixed air system. This resulted in a significant reduction in operating costs. Because room air was not being recirculated as in traditional systems, the active beam system was considered useful in reducing the risk of airborne infection through room cross contamination. With this installation, Memorial Hospital became one of the first hospitals in the United States to employ active beams in patient rooms.

LEGACY INDUCTION UNITS

A simple and effective way to improve building performance is to upgrade existing induction units. The induction units that were popular during the 60s and 70s are installed in large quantities in nearly every building type. These units can often be large, noisy, and less effective at meeting occupant comfort. Although they share a fundamental operating principle with active beams – using nozzles to induce air over a water coil – the modern embodiment is a more optimized and efficient design. The use of active beams in place of induction units may offer significant operational efficiency, thermal comfort, and reduced noise.

The advancement of the induction technology used in active chilled beams has led to a significant reduction in static pressure due to the method of induction. When looking at a typical induction unit system, the same load and ventilation requirements can typically be met at a much lower static pressure (see Figure 9).

This reduction in static pressure can often lead to an optimization of the air handler systems, reducing energy consumption. The reduction of static pressure also helps in the reduction of noise in the occupied space.

Figure 8 – Legacy induction unit

Two approaches can be used when replacing legacy induction units:

1. Direct replacement (new product integration in existing space)
2. Product reconfiguration (changing induction unit from floor to ceiling installation)

A direct replacement can be done with the Price ACBV. This active beam can be designed to occupy the same footprint as the legacy induction units. The ACBV can also be supplied with a casing to match the style of the original, use the old casing in some instances, or be reduced in size to free up valuable floor space. Furthermore, the unit can be customized to match the location of the original air and water connection in order to reduce field labor, allowing a quick swap by the maintenance personnel or mechanical contractor.

When replacing legacy induction units, the Price ACBV can be selected to function with the existing mechanical system (no change in chilled water temperature or airflow).

	Chilled Water Temp °F	Nominal Length in.	airflow cfm	Static Pressure in. eg	Water Flow Rate gpm	Total Sensible capacity mbh
Legacy Induction Unit	50	48	75	1.27	1.5	6.7
Price ACBV	50	48	75	0.68	1.4	6.7
Price ACBV	57	60	75	0.92	2	6.7

Table 1 – Scenarios for replacement with Price ACBV

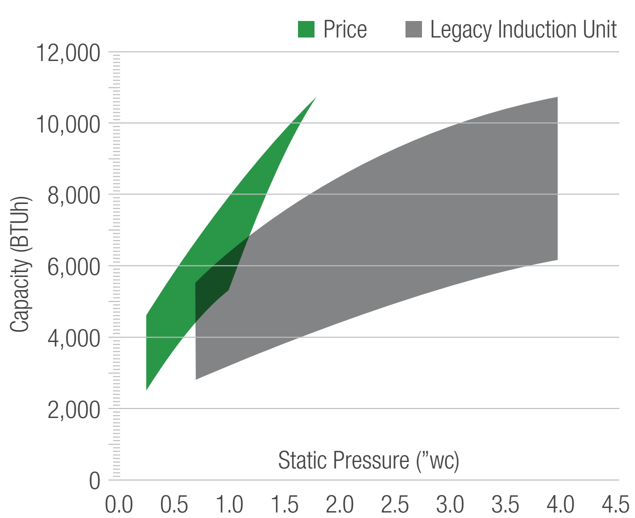


Figure 9 – Static pressure comparison

Figure 10 – ACBV Unit

The main benefit is a drastic reduction in static pressure (see Table 1). Alternatively, the designer can leverage the improved efficiency to select the beam to operate at non-condensing temperatures, which can maximize the use of wet side economizers, or central loops. Since an increase in chilled water temperature will also lead to a decrease in performance, changes in the design parameters may be required to maintain the same output.

As shown in Table 1, an increase of 12 inches to the unit's nominal length is typically sufficient to meet the original capacity without increasing the air volume supplied to the beam.

Induction units can also be completely replaced by a more traditional ceiling mounted active chilled beam. For example, the Price ACBL-HE or ACBM can be used when a complete retrofit of the space is done. In addition to a significant improvement in the building's energy efficiency, this change can free a significant portion of the floor space, which means more rentable square footage, as well as modernizing the look of the building.

In both cases, Price Active Beams have been designed with maintenance in mind, with features such as:

- Easily accessible coil and air pressure port
- Optional lint screen
- Optional stainless steel drain pan

The Fraunhofer Building Technology Showcase in Boston, MA is one instance of a heritage building being retrofitted and modernized to meet today's codes. The design team faced many stringent requirements associated with the preservation of heritage buildings. Infiltration is common in heritage buildings due to the outdated façade[22]. This was a primary concern when evaluating the types of

Figure 11 – Fraunhofer lobby

systems that would be used within the building, especially when considering hydronic systems. Fraunhofer wanted to utilize cutting edge technology in a variety of space types throughout the building. These spaces had varying ranges of occupancy and provided a number of unique challenges.

The design and contracting team took steps to ensure that the building envelope was sealed[22], along with water temperature control through mixing stations on each floor. In the lobby, a high capacity convection unit was integrated into the façade to address the higher solar load. This product allowed the architect to maintain the historical aesthetic and hide it as part of the window mullion, as seen in Figure 12. A conference room on the third floor presented additional challenges: the ceiling could not have HVAC equipment installed in it, and the room also had a strict noise requirement. A floor mounted hybrid displacement/active beam (ACBC) installed along the perimeter was the best solution for this space. Returns were integrated into the active beams in the areas that allowed ceiling installation in order to reduce the number of elements and maximize the use of plenum space.

SUMMARY

As building codes continue to become more stringent, it will become increasingly important for HVAC replacements to reduce energy use. Extensive research has already shown that chilled beams are a viable alternative to the older, less efficient systems. Active beams offer the same or better capacity at lower static pressures and noise levels, and can reduce equipment size while being integrated to match the look, or a custom look, of the existing infrastructure.

Figure 12 – Façade convection unit

REFERENCES

1. Buildings Energy Data Book. US Department of Energy. 3.2.1 Total Commercial Floorspace and Number of Buildings, by Year
2. Architecture 2030 and Edward Mazria.
3. McGraw-Hill Construction Research and Analytics, Construction Market Forecasting Service: Fourth Quarter 2012 Report, December 2012.
4. Laustsen, J. (2008). Energy efficiency requirements in building codes, energy efficiency policies for new buildings. International Energy Agency (IEA).
5. US Department of Energy - *http://www.eia.gov/electricity/*
6. Clements-Croome, D (2005). Creating the Productive Workplace. Thomas Telford, London.
7. Wargocki P, Seppänen O (2006). Indoor Climate and Productivity in Offices. REHVA Guidebook No.6. REHVA Secretariat, P.O.Box 82, B-1200 Brussels 20, Belgium.
8. Office Tenant Needs Study CBE October 1999. - *http://www.cbe.berkeley.edu/research/pdf_files/SMurr_Tenant1999.pdf*
9. Kroner WM & Stark-Martin JA, 1992. Environmentally responsive workstations and office worker productivity. Proceedings of Indoor Climate and Productivity, June 23-26.
10. REHVA, 2006. REHVA Guideline no. 6. Indoor Climate an Productivity in Offices. REHVA Brussels, Belgium.
11. Wyon DP. 2000. Individual control at each workplace: the means and the potential benefit, in : Clements-Croome D (ed.) 200. Creating the productive workplace. E & FN SPON, London, New York.
12. US Department of Energy - *http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_comm_tax_credit.pdf*
13. ASHRAE. (2011). ASHRAE Position Document on Indoor Air Quality. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.
14. Rimmer, J. Active Beams Selection Criteria Transfer Effiency.
15. Roth, K., Dieckmann, J., Zogg, R., & Brodrick, J. (2007). Chilled beam cooling. ASHRAE JOURNAL,49(9), 84.
16. Alexander, D., & O'Rourke, M. (2008). Design considerations for active chilled beams. ASHRAE Journal, 50(9), 50-58.
17. Rumsey, P. and J. Weale. 2007. "Chilled beam in labs: eliminating reheat & saving energy on a budget." ASHRAE Journal 49(1):18–25.
18. ASHRAE. (2004b). Standard 62.1-2004— Ventilation for acceptable indoor air quality. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.
19. ASHRAE. (2010). Standard 62.1-2010—Ventilation for acceptable indoor air quality. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.
20. Price Industries Limited. (2011). Engineer's HVAC Handbook, Edition 1: A Comprehensive Guide to HVAC Fundamentals. Winnipeg, MB: Price Industries Limited.
21. ASHRAE. (1992). Standard 55-1992—Thermal Environmental Conditions for Human Occupancy. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.
22. Henley, Jo Ellen and Antonio Aguilar (2011). Improving Energy Efficiency in Historic Buildings. Preservation Brief 3, National Park Service

RESOURCES

Webinar:
Retrofit Opportunities with Active and Passive Beams

Case Studies:
Memorial Hospital and Health Care Center
Ogden High School

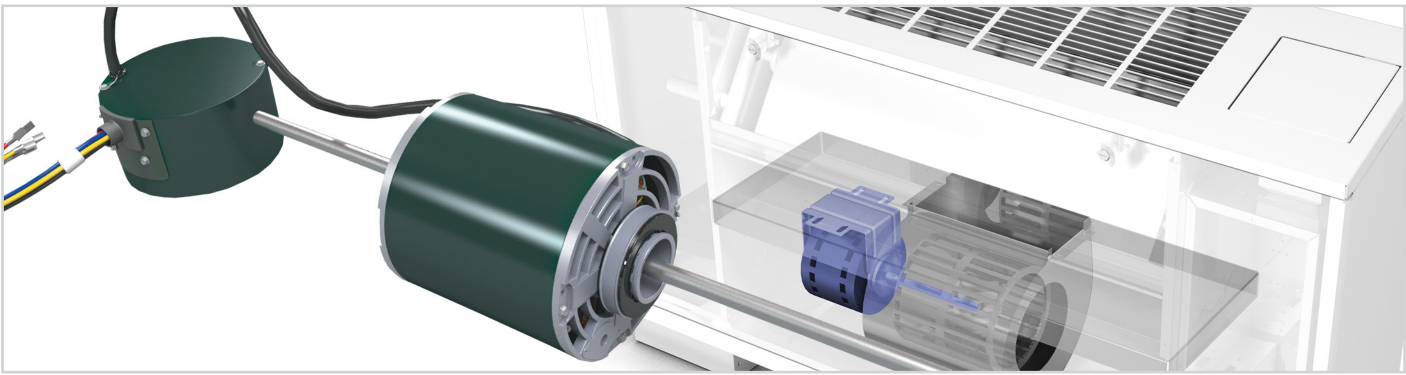
Brochure:
Price Chilled Beams

For more information contact:
beamteam@price-hvac.com

ENGINEERING UPDATE

February 2014 | **Vol. 13**

PRODUCT FEATURE:
PRICE VERTICAL FAN COILS FEATURE 78% EFFICIENT MOTORS



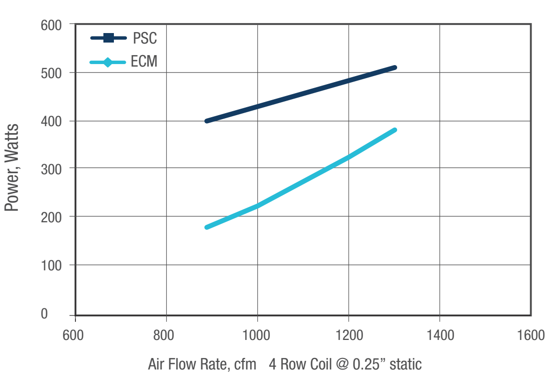
By Tom Peeples– Director, Program Management, Air Moving Products

Price Industries announces electrically commutated, brushless DC motors (ECM) for veritcal fan coils as an option to PSC (Permanent Split Capacitor).

ECMs are available in voltages from 120 – 277V and can be programmed for control with either three discrete 24V speeds or a 0-10V analog input for full variable airflow. The ECM features increased efficiency (70-78%) compared to a standard PSC motor (12%-45%), and will adjust speed and torque automatically to maintain design air volumes, regardless of external static pressure.

This offering is designed to directly compete with competitors such as IEC`s Eco-Intelligent motors.

Watts vs. CFM



PRODUCT FEATURES

- Increased energy efficiency (78% vs. 45%)
- Longer life due to lower operating temperature
- Higher static and airflow capabilities
- Increased turndown and lower noise
- Lower power consumption and better relative humidity control when automatically controlled to reduce fan speed at part load conditions
- Single or double extended shaft designs for vertical and horizontal fan coil application.
- Microprocessor based controller
- Remote speed control with BAS input
- Options for VAV Operation

CONTACT YOUR PRICE REPRESENTATIVE EARLY IN YOUR PROJECT DESIGN FOR BEST RESULTS.

LOW FLOW SELECTIONS ARE AVAILABLE IN THE PRICE ALL-IN-ONE SOFTWARE.

FACTORY ENGINEERS ARE AVAILABLE TO ASSIST WITH SPECIAL SELECTIONS.

CONTACT FANCOILS@PRICE-HVAC.COM

ENGINEERING UPDATE

February 2014 | **Vol. 13**

TECH TIP: RAISING THE BAR ON ENERGY EFFICIENCY AND OCCUPANT THERMAL COMFORT

By Jerry Sipes, Ph.D., P.E. – Vice President of Engineering

Increased focus on sustainability and the environmental impact of energy use has resulted in natural ventilation becoming an attractive option for many buildings. Historically, prior to the development of forced air conditioning, buildings used natural ventilation to provide fresh air and maintain thermal comfort. Design of traditional natural ventilation strategies relies on the wind and buoyancy-driven stack effect to move ventilation air through the building. The energy consumption of a naturally ventilated building can be less than half that of a fully air-conditioned, mechanically ventilated one, while maintaining an acceptable level of occupant comfort. Figure 1 shows the energy consumption of the San Francisco Federal Building, which utilizes natural ventilation around 75% of the year.

With careful attention early in the design, a natural or hybrid ventilation system can be a viable option for many systems and climates. As our energy codes evolve, more consideration of hybrid solutions will be necessary to obtain the higher levels of energy savings. Natural ventilation combined with radiant heating and cooling can be a very energy efficient solution with a high level of occupant satisfaction.

ASHRAE Research Project 884 demonstrated that occupants in naturally ventilated spaces tend to be comfortable even when conditions vary from what is classically considered comfortable. This expanded comfort range can be attributed to the occupants having control over their local environment and the expectation that when it is warmer outside, it will be warmer inside.

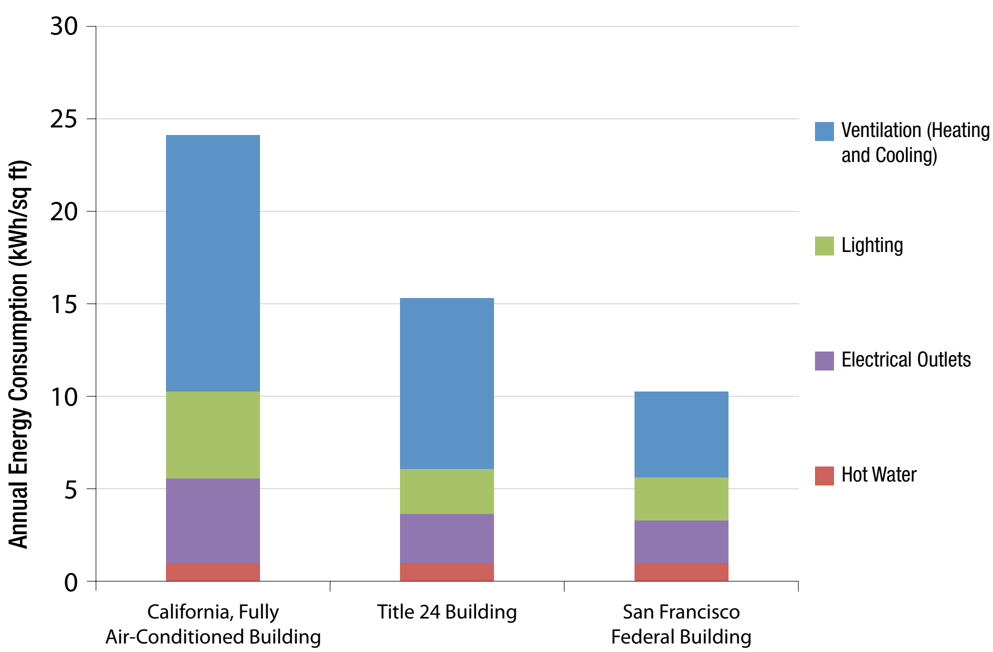


Figure 1: Annual energy consumption comparison for the San Francisco Federal Building. (Source: Natural Ventilation in High Rise Office Buildings, Salib and Wood. 2013)

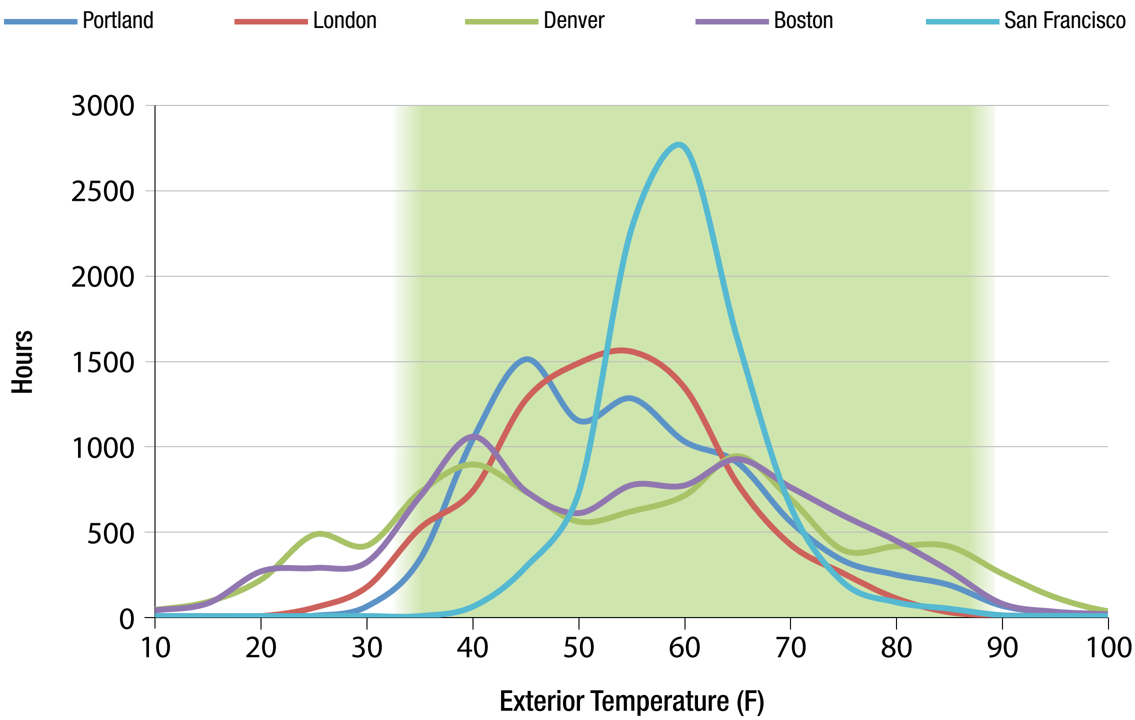


Figure 2: Hybrid natural ventilation opportunity for multiple climates

ASHRAE Standard 55 includes a method of determining thermal comfort in naturally ventilated spaces based on adaptive thermal comfort. This method allows for a wider range of acceptability limits where occupants can open or close windows and vary closing in response to the indoor and outdoor conditions.

Evaluating the suitability of a location for natural ventilation involves examining the number of hours the exterior air temperature is between 50°F and 78°F. This is the range where a natural ventilation system provides the largest benefit. Examining the extremes beyond this range determines whether a natural ventilation strategy makes sense, or if a hybrid system is required. It should be noted that for the ambient temperature range of 35°F to 50°F some form of auxiliary heat, such as radiant, will most likely be required. Looking at energy balance analyses of typical spaces shows that there is often enough heat generated in the space that could be used to warm entering ambient air at temperatures as low as 45°F. For the ambient temperature range of 78°F to 90°F some form of auxiliary cooling, such as radiant, may be required. Figure 2 above shows the opportunity for natural ventilation in various climates.

Every building has thermal mass, which is either designed explicitly into the structure in the form of exposed concrete, or just through the normal building materials and finishes. This mass can be leveraged in warm seasons to offset the total cooling load through night cooling. Cooler night air can be used to reject heat accumulated during the peak loads of occupied hours. On warm days, as internal temperatures rise, the building material absorbs heat, reducing further rises in the internal temperatures. The heat is then purged with lower temperature night air from the building material when the space is not occupied. The use of thermal mass within a building can provide significant benefits in terms of both thermal comfort and energy use.