TECH TIPS | A Bright Future for Chilled Beams

By Jerry Sipes, PH.D., P.E.

Building energy efficiency, sustainability, and interior aesthetics are concepts that at times may appear to be at odds with each other. The designer must balance those concepts while meeting the design goals of the building. Designers are always seeking more efficient methods of providing a comfortable and pleasing occupied space while meeting both budget restrictions and energy code requirements.

The energy codes are in continual modification with the goal of improved building energy efficiency. One metric that can be used to look at the ongoing changes in building energy codes is the Annual Energy Outlook 2014 published by the U.S. Energy Information Administration (EIA). The EIA estimates that between 2012 and 2040, commercial building energy consumption will grow by 0.6% per year, commercial floor space will increase an average of 1% per year, and the energy intensity (energy use per square foot) will decrease by 0.4% per year. This decrease is expected to come from federally mandated gains in equipment efficiency and reduced consumption by space heating, cooling, lighting, and plug loads. This data indicates that as time passes, it will become increasingly difficult to balance the energy code requirements, budget restrictions, and interior aesthetics.

What is the designer to do? Can the design goals be met while reducing energy?

Traditionally, the majority of buildings have used air movement to transfer both the fresh air and thermal energy needed to properly heat, cool, and ventilate our occupied spaces. Air is not a very energy dense media; to provide the necessary volume of thermal energy, a significantly higher volume of air is often required than the volume that is necessary to provide fresh air.

Due to the high volumes of air and the inherent inefficiency in moving air, it is becoming more challenging to use the traditional all-air HVAC design approach to meet the higher efficiency levels required by our increasingly restrictive energy codes. One way to find energy efficiency gains in the HVAC system is to consider alternative methods of providing and transporting thermal energy for heating and cooling. Designers are considering the use of water as the transport media for the bulk of the thermal energy transfer rather than just air. This is due to the ability of water to store significantly more thermal energy per unit volume than the same volume of air. Due to the higher energy density of water and higher pumping efficiency, it takes less transport energy (pump or fan) to move the same amount of thermal energy into and out of the occupied spaces with water than it would using air. Simply put, air is not very energy dense and costs more when used as the only media to provide all of the building's heating and cooling. Of course, a certain amount of air movement is required for the proper ventilation of the occupied space. It has been estimated that the use of an air-water HVAC system that provides only ventilation required air volumes can lead to a reduction in building brake-horsepower of 10 to 20% depending on the overall mechanical system design.

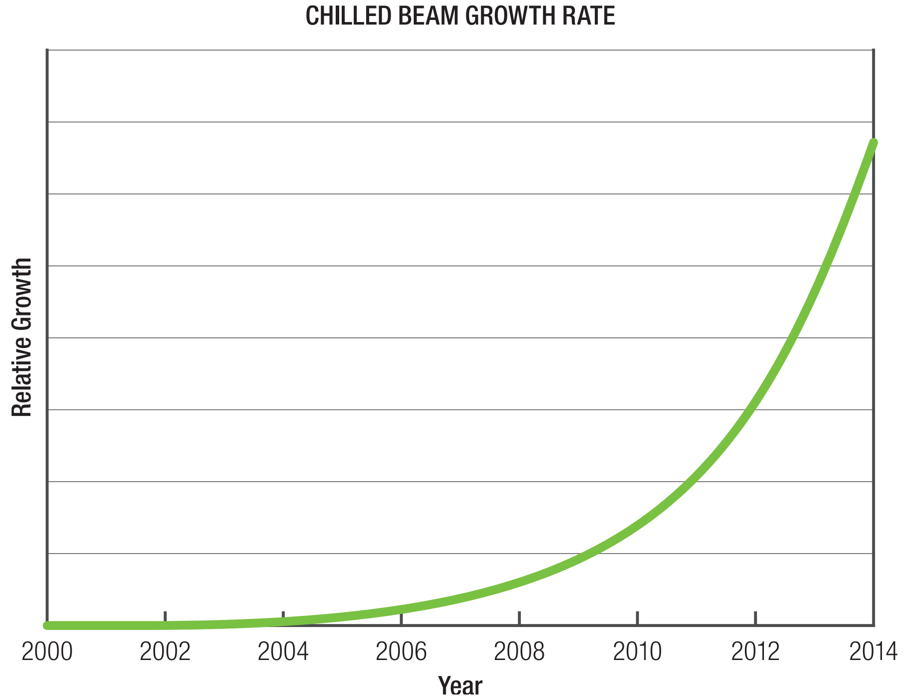

Figure 1: Relative growth of chilled beam projects in the United States

Active chilled beams are often considered as they incorporate the distribution of the ventilation air and use room air induced across a water coil to transfer sensible thermal energy (heating or cooling) to the occupied space.

When active chilled beams were first introduced to the North American market, there were limited choices for the designer to consider, and many times they did not meet the aesthetic and architectural integration goals. That being said, many solutions exist today to integrate active chilled beams seamlessly in the building of the most demanding customers.

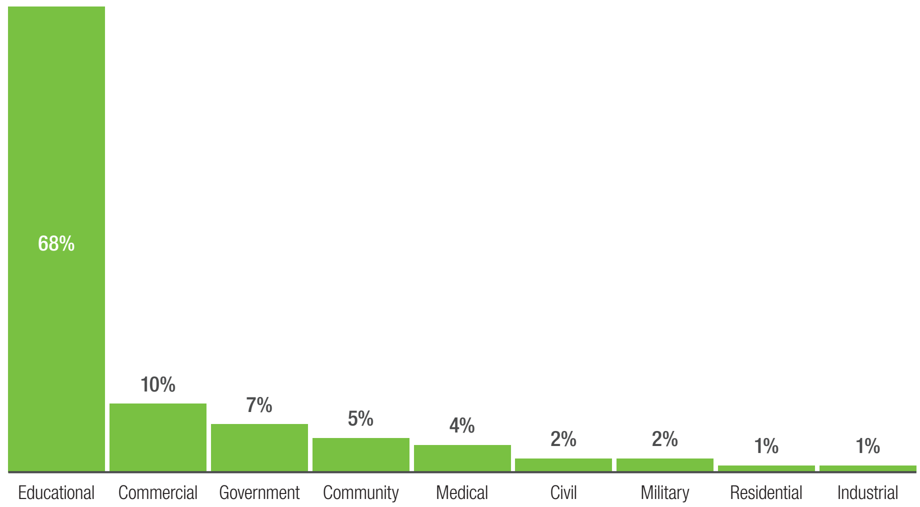

Table 1: Building types and percentage of total building types using chilled beams (2012 to 2014*)
*Data from 2014 was annualized based on 11 months of data from Reed Insight

BENEFITS/DRAWBACKS

Active chilled beams have both benefits and drawbacks that should be evaluated, and may not be appropriate for all building/ occupancy types.

Benefits:

- Chilled beams have no internal moving parts and have little to no maintenance requirements compared to the traditional all-air VAV system.
- A chilled beam system using a dedicated outdoor air system (DOAS) may see 25 to 65% less air movement required than the traditional all-air VAV system.
- Lowered volume of air compared to all-air systems can lead to reduced floor-to-floor height as chilled beams do not need as much interstitial space for ductwork and have smaller mechanical room footprint requirements.
- Due to the energy density of water compared to air, it takes about 1/10 of the energy to move the same amount of thermal energy with water than air.
- It is easier to achieve superior mixed air distribution with chilled beams which leads to higher levels of occupant thermal comfort.
- Quiet operation when primary air is kept to a minimum.

Drawbacks:

- Lack of familiarity of MEP engineers, contractors, occupants, and building owners with chilled beam technology.
- Most common perceived issue is risk of condensation.
- Building envelope should have good control of moisture infiltration.
- Chilled beams may occupy a higher percentage of ceiling area than traditional VAV.
- Space humidity sensors and condensate sensors are required for the best occupied space humidity control and least risk of condensation.
- Not appropriate for high-humidity (high latent load) spaces such as kitchens.
- Not appropriate for spaces that experience high air volume change such as laboratories with fume hoods.

RAPID GROWTH IN BEAM MARKET

Active chilled beams have been used in Europe for over 20 years and were initially used primarily in high-performance buildings in the United States. As energy efficient HVAC designs have become more common, many designers are using them in all types of buildings and finding that along with energy savings, occupant thermal comfort is also enhanced. The potential exists for chilled beams to have a significant role in both new construction and renovation of existing structures. Reed Construction Data indicates an increasing use of chilled beams in the U.S. market (see **Figure 1**). **Table 1** shows the types of buildings that chilled beams are being used in; some of the building types such as healthcare have really just started using chilled beams, as standards such as ASHRAE 170 *Ventilation of Health Care Facilities* now allow chilled beams in patient rooms.

BENEFITS OF REDUCED PRIMARY AIR VOLUME

Active beams can supply a significant portion of the sensible cooling or heating load of a building with a relatively low ventilation rate. In most commercial buildings, the ventilation rate required to condition the building can potentially be reduced by up to 75% of the ventilation normally required by an all-air system. A study by Dan Weiger[1] detailed the potential benefits of active chilled beams in a hospital setting. He found that chilled beam HVAC systems in non-invasive (non-surgical) spaces such as patient rooms and office areas have the potential to shorten the construction cycle and lower the cost, both initial and life-cycle.

On the scale of the overall system, the reduction in airflow will translate to a smaller air handler and smaller duct network. The reduction in system size may allow a lower floor-to-floor height as well as an increase in usable space on each floor due to reduced riser footprint. In certain building types such as healthcare facilities, reducing the congestion in the interstitial spaces will speed construction and allow for more useable floor area due to the significant reduction in the riser spaces needed. Weiger found that the cross sectional ductwork could be reduced by 75% with a corresponding

50% reduction of the material ductwork cost. The riser footprint was reduced by 50% and savings in the mechanical room footprint were estimated at 25%.

The reduction in riser and mechanical room footprints frees that area to be used in revenue generating activities such as patient rooms. It is possible that the reduction in riser footprint could allow for an additional patient room on each floor with in essence no additional cost when compared to using a traditional all-air HVAC system (see **Figure 2**).

In healthcare applications, when the system is designed to provide 100% fresh air at code required volumes to patient rooms, the return duct may actually not be needed as the exhaust air volume from the patient room bathroom often matches the room supply leading to other cost savings (see **Figures 3 and 4**).

CONCLUSION

Active chilled beams have a bright future due to their energy efficiency and potential lowered floor-to-floor height, smaller ductwork, and reductions in riser and mechanical room footprints.

The use of active chilled beams in the North American market is ramping up and in my estimate, becoming a main design option for all types of buildings, not just the high-performance buildings that they were first used in when introduced to the U.S. market in the early 2000s.

For more information on chilled beams, condensate, induction, and other topics related to the use of active chilled beams, please visit priceindustries.com or contact a Price application engineer.

[1]Weiger, D. (2009). Master's Thesis entitled "The John Hopkins Hospital New Clinical Building", Penn State University, University Park, PA, Department of Architectural Engineering

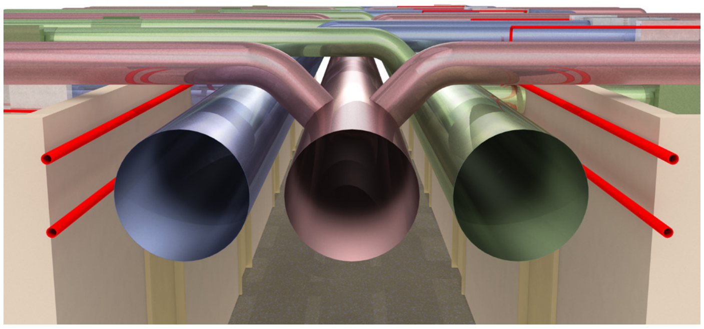

Figure 3: Hospital patient room hall interstitial space for an all-air system (supply duct, exhaust duct, and return duct)

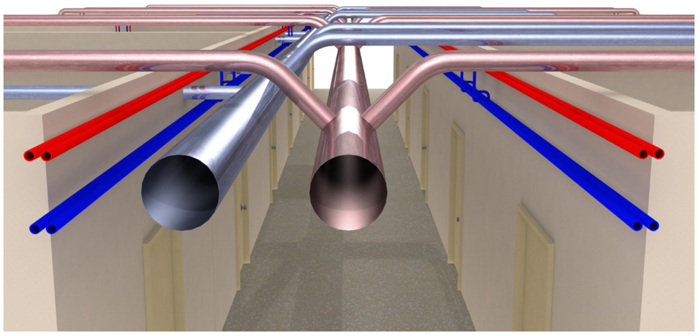

Figure 4: Hospital patient room hall interstitial space for an active chilled beam application (supply duct, exhaust duct, and chilled water piping)

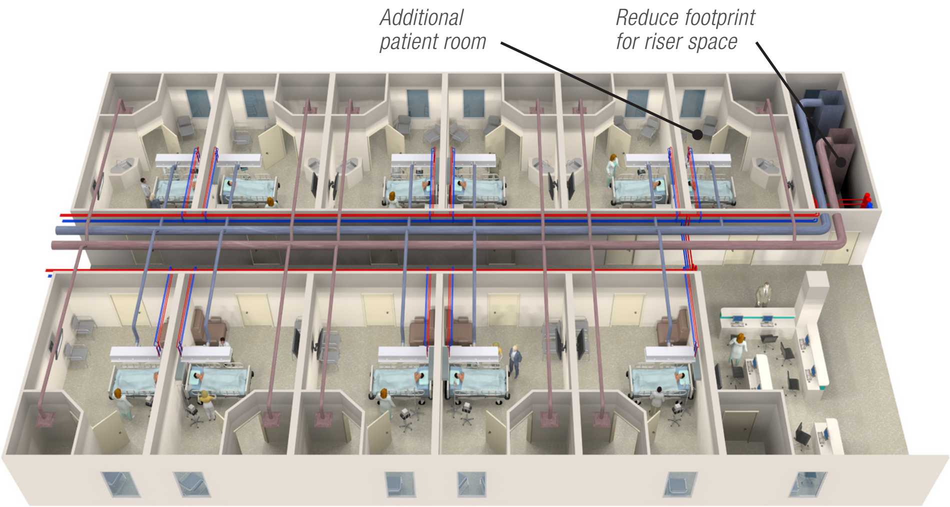

Figure 2: Reduced riser and mechanical room space requirements could allow for an additional patient room on each floor