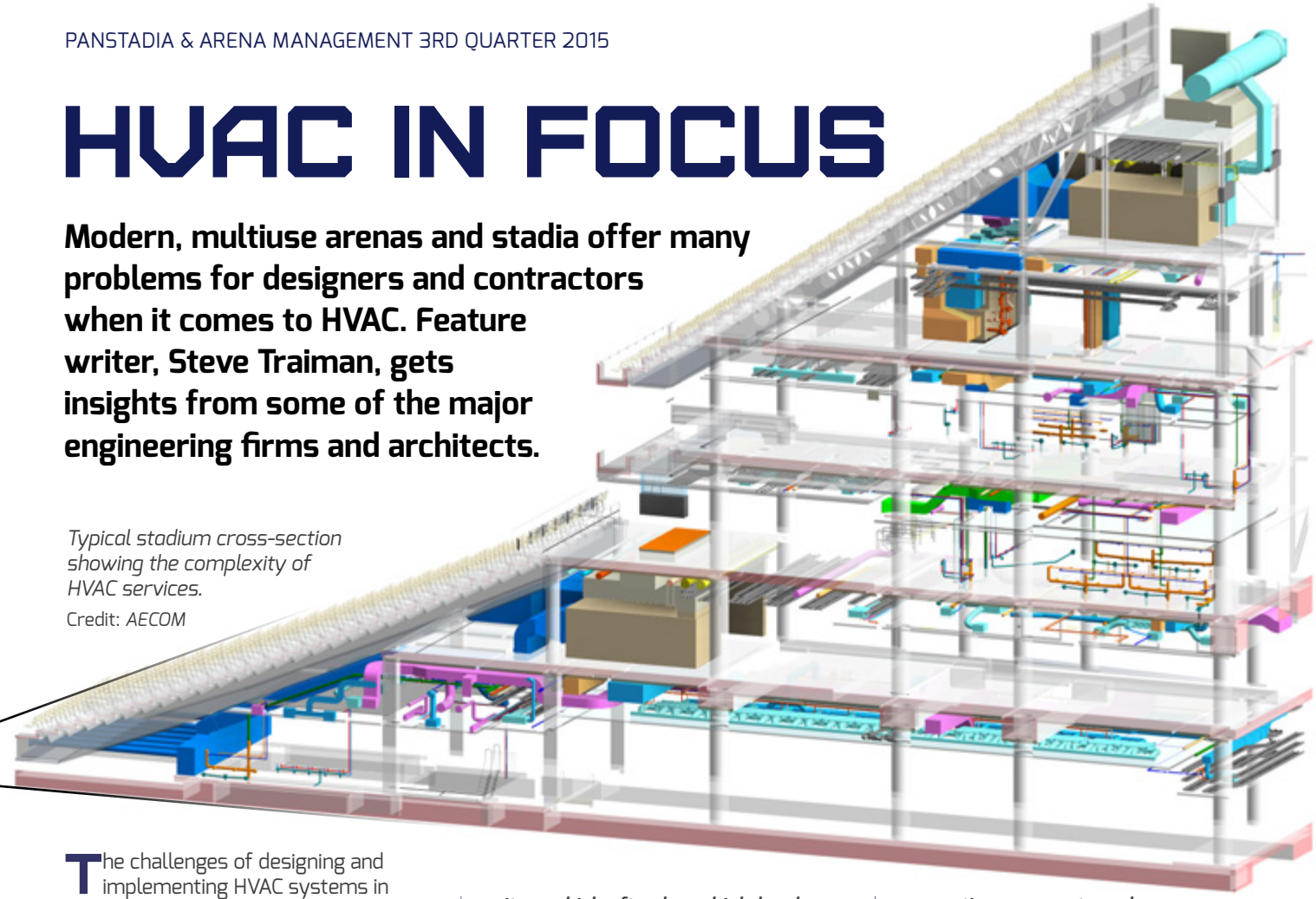
HVAC IN FOCUS

Modern, multiuse arenas and stadia offer many problems for designers and contractors when it comes to HVAC. Feature writer, Steve Traiman, gets insights from some of the major engineering firms and architects.



Typical stadium cross-section showing the complexity of HVAC services.
Credit: *AECOM*

The challenges of designing and implementing HVAC systems in stadia and arenas are wide-ranging and require specialist contractors, with their technical know-how. To 'lift the lid' on the subject, we have gained insights from a number of major engineering firms and sports architects to assist you with your next HVAC project.

In terms of identifying some of the key challenges, ME Engineers' Principal and CEO, Michael Hart, advised: ***"Sporting venues present many unique challenges in HVAC design. Unique and highly aesthetic architectural and structural systems mean we have to work creatively with the architects and structural engineers to design and distribute our systems, sometimes driving our very system selections... complex operations that require tremendous system flexibility... to adapt design concepts to extreme climates... and, most certainly, by limited budgets and very tight construction schedules, which require quick decision-making and synergistic analysis."***

Principal, Jeff Sawarynski, added: ***"Some of the more challenging experiences I've faced are related to humidity control (or lack thereof) in open-air stadiums. We have to help owners, architects and contractors understand it may be impossible to control humidity in interior spaces with operable windows and transient populations – like club lounges and suites, which often have high-level finishes that must be appropriate for high humidity, and wide temperature and humidity swings when necessary. Facility personnel may need to learn how to operate systems prior to, during, and after an event to limit the effects of humidity fluctuation on materials."***

THE CHALLENGES OF HVAC IN SPORTS VENUES

Highlighting another challenge, Sawarynski advised: ***"Another common challenge is how we size our central plants (i.e. chilled water, heating water) or system capacities when central plants are not appropriate. Sports venues tend to operate across multiple weather seasons and tend to host numerous partial-house events. Therefore, they operate at extreme 'part load', where only a portion of system capacity is needed much of the time. The HVAC system must be scaled appropriately to allow it to function at extremely low loads, and also at the planned 'worst' full-load condition.***

"The most complex projects tend to be those with the widest array of events and operating conditions in extreme climates. As an example, the 73,000-seat University of Phoenix Stadium, home of the NFL Cardinals, hosts a full NFL season and Super Bowls, conventions, concerts and corporate events. It may have the roof open or closed, the playing field inside or outside, operating in mild winter weather or extreme desert heat. Our approach must consider all these possibilities. Any limitations built into the systems to lower construction cost must be clearly conveyed to the owner during design, so they can make an informed decision and understand which future operating situations may be problematic."

For another example, Baylor McLane Stadium Populous Project Architect, Sherri Privatera, noted: ***"With the intense summer heat in Waco, we knew a shade canopy would be important. Working with ME Engineers, we used computer programs to determine the most effective shape, and a wind study by RWDI confirmed the design approach to maximize breeze circulation. The 38 serrated walls around the stadium have proved an excellent solution along with the shade canopy. The 147,000ft^2 canopy structure, from 75-125ft deep, shades as much of the seating as possible."***

THE ROLE OF THE BUILDING SERVICES ENGINEER

AECOM Global Sports' Building Engineering Lead, Peter Ayres, observed: ***"Not so long ago, the building***

services engineer was the bridesmaid of the professional team when it came to stadium and arena design. It was a bit of heating and cooling in the directors' box in the main stand, and little more than plumbing for the toilets, some emergency lighting and a few power points for the burger stands for the rest of the stadium.

"But all that has changed, driven by a variety of factors, including:

Spectator expectations: With changes in demographics and the increase in corporate offerings with the competing lure of televised sports, spectators expect and demand higher levels of comfort and convenience.

Premium facilities: Modern stadia offer fans a variety of match day experiences, particularly in their choice of food and beverage (F&B). This generates a need for climate control spaces and a wider variety of F&B outlets throughout the building, not just in the traditional 'main stand'.

Non match day revenue: The potential to provide non match day functions, such as conference facilities, catered events and other visitor attractions, such as museums and club shops, has become fundamental to creating a sustainable business case for large modern stadia. These functions require a completely different level of building services to the traditional open concourse.

Technology: A state-of-the-art stadium demands a huge level of services infrastructures to support the demands of HDTV broadcasting, integrated sight and sound systems, mobile communications and stadium control systems.

Resilience: Sport is big business and a blackout during a crucial match could cost millions. Multiple levels of resilience are required to protect broadcast and sponsorship revenues, especially for global events.

"Throw in the provision of cooling to keep players and spectators safe and comfortable in extreme environments as sport becomes more and more globalised, and what you have is an extremely complex, high performance building. This places huge demands on HVAC building services engineers, not only to design energy efficient systems to deliver the required performance levels in a wide variety of spaces, many of which are very difficult to control, but also to integrate the vast array of plant and distribution networks into geometrically complex building forms."

CASE STUDY: U.S. BANK STADIUM

Jon Vollmer, Director of Preconstruction for Harris Mechanical – a division of Harris Companies, advised: ***"As of this past July 1st, our HVAC work was 60% complete on the US$1.06bn, 73,000-capacity U.S. Bank Stadium, opening next July as the new home of the NFL Minnesota Vikings in Minneapolis."*** Vollmer also confirmed that about 90% of the building's air handling units were already set in place; at least 16 of these will provide temporary heating and cooling by autumn/fall 2015.

He continued: ***"The venue is a one-of-a-kind project designed by architect HKS. The building's signature roofline is meant to evoke the bow of a traditional Viking ship. The clear, ethylene tetrafluoroethylene (ETFE) roof will be the largest of its kind in the world and will give fans the feeling of an outdoor stadium, while protecting them from Minnesota's unpredictable weather.***

"The stadium's unique design presented special challenges to our team. The angled walls, unexpected contours and discontinuous floor plan meant HVAC installation had to be carefully thought out. Connections between the concrete floor structure and exterior wind bracing structure were also a complicating factor."

TEAMWORK AND COORDINATION

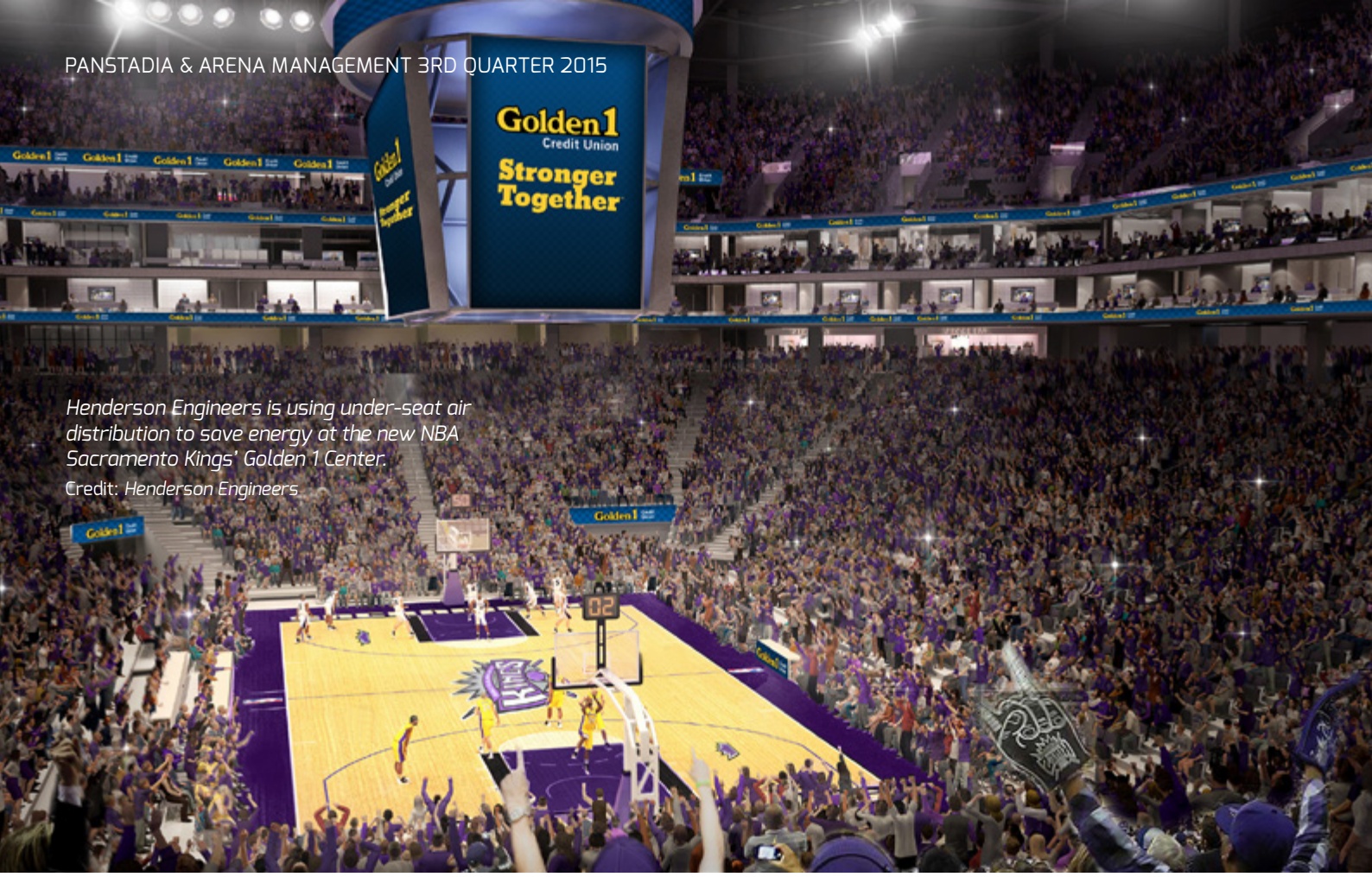
Adam Grahek, Project Manager for Harris on the U.S. Bank Stadium, added: ***"One of the stadium's highest profile HVAC challenges was installing the upper bowl ductwork. This enormous and complex piece had to be installed at the top of the ceiling structure. In order to stay on schedule, we were able to work with the steel erectors to place our ductwork on the catwalks before they were raised. This teamwork and coordination was crucial to Harris's success."***

Grahek also explained: ***"Planning for maintenance access is another difficulty in an asymmetrical building. We have been in close contact with the City of Minneapolis to plan equipment access, as in some cases ductwork needs to be shifted to create more room. If the work cannot not be kept at ladder height, Harris has been building service platforms for access."***

Vollmer added: ***"Pre-planning, pre-fabrication and computer modelling were critical parts of the project planning that helped us stay in front of the construction schedule. First identifying and focusing on the largest risks and most difficult scopes of work kept us from holding up any of general contractor, Mortenson's, critical path items. Adhering to our core building approach principles allowed us to break it up into manageable parts.***

"In keeping with original goals, all mechanical systems are being modelled, fabricated and preassembled before arriving at the stadium, with 80% of prefabricated skids now on-site and in place. Tested systems are helping to alleviate space issues and work continues within the tight schedule. All told, the U.S. Bank Stadium contains 22 miles of HVAC piping and 2.4 million pounds of HVAC ducts. Overall, the project is on schedule to meet its completion goal of July 2016." »

U.S. Bank Stadium's upper bowl 84-inch-round ductwork installation presented Harris Mechanical with a major challenge.
Credit: *Harris Mechanical*



Henderson Engineers is using under-seat air distribution to save energy at the new NBA Sacramento Kings' Golden 1 Center.
Credit: *Henderson Engineers*

CASE STUDY: GOLDEN 1 CENTER

"As mechanical engineers, our biggest challenge with modern arenas is to bridge the desire for energy efficiency with the physical limitations of the equipment used to condition the building," emphasised Kevin Lewis, Vice President of Henderson Engineers. *"The effectiveness of cooling equipment has reached a point where it gets slightly better over time, but with diminishing returns.*

"Since arenas are now multi-purpose oriented, it's even more important to ensure that HVAC engineering is done in a flexible way. This often has the largest implications for the control system, especially if an arena is used extensively. Adjusting the facility from basketball to hockey to a concert provides a challenge as each scenario requires different set points to maintain the correct environment. A robust control system that is fully-integrated throughout the facility often provides the best chance for success in terms of the building condition and long-term sustainability."

Lewis continued: *"For the new US$477m, 17,500-seat Golden 1 Center in Sacramento, California, opening autumn/fall 2016 as the new home of the NBA Kings, one strategy we incorporated was the utilisation of under-seat air distribution. Providing the air beneath the patrons' seats allowed the use of a 'higher leaving' air temperature, saving energy. This strategy delivers a cleaner environment as dirty air rises to the top of the arena where it's returned back to the unit. Additionally, it allows for almost instantaneous cooling to the patrons, eliminating the need to pre-cool the arena hours in advance.*

"With more new arenas targeting LEED certification, vital concerns related to HVAC include diminishing returns on further efficiency of equipment; other methods, including natural ventilation, different air delivery method, controls optimisation; run time of facility – energy recovery; Central Plant Theory; and, for hockey, humidity control and air throw.

"While most sustainable thinking happens during arena design, we have found that as big of a difference, if not more, can be made after an arena is open. We focus on working with the building owners and operators long after the project is finished to guarantee the designed systems are working as they should. We partner with building management to provide commissioning and energy monitoring services, adding value to the end-user."

ABOUT ME ENGINEERS

ME Engineers, Inc. has an exceptional record with more than 30 years of designing sports and entertainment facilities. Our portfolio includes 175 sports projects in 14 countries; 60 professional league venues and 8 with retractable roofs. Chase Ballpark in Phoenix, completed in 1998, was the first major fully air-conditioned retractable roof seating bowl in the world. Nationals Park was the first LEED-NC certified professional venue. We draw from this rich experience and deep knowledge base to develop balanced solutions to common and emerging design issues; from sustainability and legacy needs to schedule and phasing constraints to extreme climate conditions.

In addition to HVAC and electrical power design in stadia, ME Engineers provides specialty-engineering services including energy and airflow modelling, award-winning architectural lighting design, low-voltage/infrastructure fibre optic cabling design, and specialised sports lighting. We have authored technical reports and standards for the NFL, NBA, NHL, MLB, and MLS in the U.S., as well as for FIFA, World Cup Cricket and Olympics worldwide.

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HVAC UPGRADES AT BRIDGESTONE ARENA

Mike Rogers, Senior Principal at Smith Seckman Reid (SSR), used their work on the Bridgestone Arena, home of the NHL Nashville Predators, as an example of the challenges in HVAC and how to overcome them.

Rogers said: ***"The original design eliminated desiccant dehumidification systems, traditional in the southern U.S. to deal with elevated humidity levels. This was to save initial costs and there was no NHL team. SSR began with a basic Opportunity Assessment to identify energy conservation opportunities, in conjunction with an analysis of the existing seating bowl environment and its effect on the ice sheet. The NHL has defined guidelines for environmental control within the seating bowl, as well as ice floor temperature, and thus hardness. For most of the season this was not an issue, but when the Predators made the playoffs into June, the building was not capable of meeting NHL requirements. In the playoffs, the Predators were spending a lot on temporary chillers and the elevated humidity within the bowl can degrade the playing surface, making it softer and slower for play.***

SSR's chiller installation at Nashville's Bridgestone Arena. Credit: SSR

"Our challenge was to solve the environmental shortcomings in the seating bowl and reduce overall energy consumption, within the funding method. The Predators were using Energy Conservation Bonds, which require a specific payback period based on energy costs savings, usually less than five years. Adding additional cooling and dehumidification is not an energy saving measure, so we had to cut energy costs in other areas to make up the difference. We narrowed the targets down to key areas of Energy and Water conservation: Dehumidification of the arena seating bowl; lighting control system installation; HVAC control system upgrades and improvements; lighting efficiency improvements; efficient wash sink faucets and toilets in the public restrooms; and efficient urinals in the men's restrooms.

"Bowl dehumidification was accomplished with low-temperature chillers and additional low-temperature cooling coils to the Bowl Air Handling units. This additional capacity allowed implementation for a dehumidification control strategy, drying out the bowl air and providing a much-improved playing surface."

Rogers said in conclusion: ***"Fine tuning and upgrading the building's HVAC controls provided nearly two-thirds of the overall cost reduction, with a payback in less than three years. The balance of energy savings came from upgrading the lighting system controls and changing over 1,000 fixtures to high efficiency units – with a payback in***

SSR's Bridgestone Arena Bowl dehumidification improved fan comfort and ice surface for NHL Predators playoff games.
Credit: *Nashville Predators*

less than four years. The Tennessee Valley Authority (TVA) provides incentives for lighting control and efficiency improvements, and we received nearly USD$100,000 from the TVA as an incentive. The entire project was funded with Energy Conservation Bonds and calculated payback will be less than five years. Considering nearly half the overall cost of was in the addition of bowl dehumidification, this is quite a feat."

THE LAST WORD

When meeting the challenges of HVAC in sports venues, the last word went to ME Engineers' Michael Hart, who summed up: ***"Cost is a key challenge, as many sports venues have a limited number of events, so it's often difficult to justify large expenditures for complex or highly-efficient HVAC systems. It may not operate enough to realise appropriate payback for this investment. In turn, with a limited HVAC budget, it can be very challenging to design systems that meet the aesthetic, operational and efficiency goals of the project. In order for the design team to provide quality and useful feedback on system alternatives, owners/developers must have an accurate understanding of the events a given venue will host and must also understand the limits of the HVAC system their budget can accommodate."*** ■