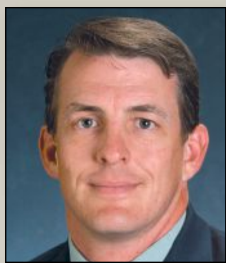
MEP Roundtable



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Data centers' intricate design

Data centers are important structures that hold vital information for businesses, schools, public agencies, and private individuals. If these mission critical facilities aren't properly designed and equipped, the gear inside and the data the servers handle is at risk.

CSE: What's the No. 1 trend you see today in data center design?

Tim Chadwick: Scalability would be the top trend we have been seeing for the past 3 or more years, and it continues today. The challenge with designing for data centers is creating a facility designed to last for 15 to 20 years whose technologies will refresh or be changed out every 3 to 5 years. We are guessing at what the latest in server and storage design technologies will hold 4 to 5 years into the future. People are challenged when predicting the next generation, so looking that far out means you have to build a facility that can adjust on the fly and handle a wide variety of changes in technology or even in company growth/expansion.

Barton Hogge: That is removing as many infrastructure dependencies as possible—and seeing water as a critical utility to be treated as seriously as backup power; clients are requesting designs that have little or no dependency on water usage. Smaller-scaled and lower-density sites can achieve this with reasonable ease, while sites with high-density and HPC applications are continuing to rely on the efficiencies of water as a heat-rejection source, but are investing more often in local storage systems.

Bill Kosik: Cloud computing has really reshaped how data centers traditionally were realized. In most instances, cloud computing moves the computer power out of the customer's facilities and into cloud computing providers. However, sensitive business-critical applications will typically remain in the customer's facilities. In certain circumstances, the power and cooling demands in a customer's data center facility could be reduced or filled in by other types of computer requirements. Conversely, the cloud computing providers' data centers are growing in power and cooling demand. This requires strategic decisions on how computer, storage, and networking systems should behave under highly varying loads; there cannot be any negative impact on the business outcome, and they must operate in a highly energy- and cost-efficient manner.

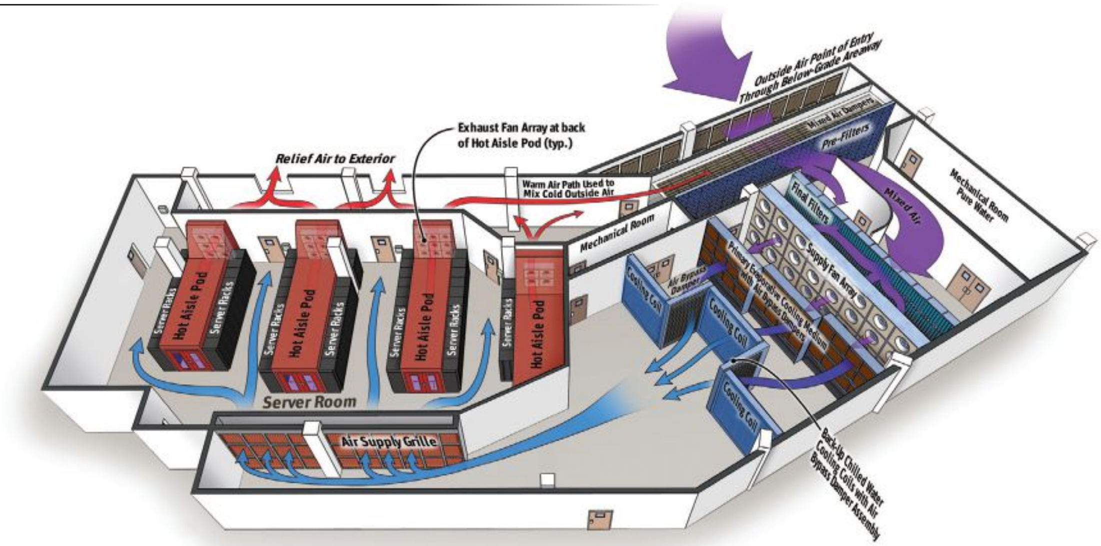
Keith Lane: I see energy efficiency as the No. 1 trend. On the electrical side, we are seeing more efficient uninterruptible power supply (UPS) systems, 400/230 V system transformers, and topologies that allow for more efficient loading of the electrical components. On the mechanical side, we are seeing increased cold-aisle temperatures, increased delta T, outside-air economizers, and hot-aisle containment. On the information technology (IT) side, the 230 V electrical systems also increase the efficiency of the servers. UPS battery technology is also improving. We are seeing absorbed-glass-mat and pure-lead batteries as well as advances in battery-monitoring systems.

Robert Sty: I would say one of the latest design trends is the reduction in UPS battery storage. With standby generator technology allowing faster start-up and sync times (in many instances, less than 20 seconds), data center managers are far more comfortable moving from 15-minute battery storage to a few minutes, or even embracing flywheel technologies.

CSE: What trends should engineers be aware of for data centers or data closets in mixed-use buildings?

Robert C. Eichelman: In a mixed-use building, there are inherent risks to a data center that aren't present in a dedicated data center

Figure 1: **Currently operating with a PUE of less than 1.1, the Fred Hutchinson Cancer Research Center 1100 Eastlake Data Center draws 100% outside supply air for "free cooling" during roughly 90% of annual operating hours. Courtesy: Affiliated Engineers Inc.**



facility. Steps must be taken to minimize these risks and to ensure that tenants, and the systems that support them, have the least possible impact on critical operations. To this end, all electrical and mechanical infrastructure that is required to maintain power and cooling to critical IT equipment should be dedicated to the data center. Ideally, this would include dedicated electrical services, generators, chiller plants, fuel-oil systems, and all related downstream distribution and equipment. Equipment should be located in dedicated spaces that are accessible only to authorized data center personnel.

In cases where separate electrical services are not practical, steps should be taken to ensure that faults on the tenant system do not affect the data center. This should be considered in the overcurrent protective device coordination study for the facility. Utilities that serve other tenants or the building as a whole (such as distribution piping, sanitary and roof drains, fire protection piping, electrical feeders and branch circuits, and telecommunications cabling systems) should never pass through the computer room or data center support spaces. The floor slab above the data center should be completely sealed, without any penetrations, to ensure that water does not migrate into the data center if a flooding condition were to occur on an upper floor. Security measures, beyond those that are common for a data center, should be considered at the common entrance to the facility; this could include personnel and vehicle screening, access controls, intrusion detection, and video surveillance systems. A dedicated building for a data center is always preferred.

Sty: For many of our commercial-enterprise clients, their headquarters buildings contain a main distribution facility (MDF), an independent distribution facility, and other server rooms that have similar uptime requirements to their main enterprise data centers. These requirements can drive additional mechanical, electrical, and plumbing (MEP) infrastructure for the base buildings that would not have been in the original program of requirements for the space, or not part of the original core and shell infrastructure.

Lane: Increased power densities and modularity of the systems. Over the years, we have seen the average kilowatt per rack increase from 1 kW/rack to more than 10 kW/rack. We are seeing much more than 10 kW/rack in some higher-density areas within the data center. Coordinating the electrical and mechanical systems as well as both the UPS battery type and code-required battery electrolyte containment/ventilation within small data closets with space limitations is critical.

Chadwick: Current generations of server or IT storage equipment can handle higher inlet-air temperatures and humidity than typical occupied spaces. These higher inlet temperatures mean that a combined HVAC system serving offices and data centers cannot be optimized for both needs. To achieve

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the optimum efficiencies, separate HVAC systems are needed. This has always been true, but now the higher temperatures have opened up new cooling technologies and new economizer strategies to further enhance efficiencies. The typical direct-expansion cooled computer room air conditioning (CRAC) unit is no longer the best solution in most applications.

CSE: Describe a modular data center you've worked on recently, including any unique challenges and their solutions.

Debra Vieira: For this project, the client required a combination of traditional raised-floor data center space with the ability to add eight modular data centers (MDCs) in the future for quick deployment of IT equipment. The data center incorporated a façade consisting of plate-metal screens with a pattern of openings to create a "moire" effect. To keep costs down, the MDCs were designed to be installed outdoors; however, they had to integrate with the architectural form of the data center. To conceal the MDCs, we designed a 2-story structure that followed the form of the data center but allowed for airflow and shading of the MDCs. However, it was not enclosed to prevent rain and dust from penetrating the structure. Within the structure, we stacked

Figure 2: The design of this 7th-floor data center, handled by engineers from AlfaTech Consulting Engineers, includes a built-up cooling system. Courtesy: AlfaTech Consulting Engineers

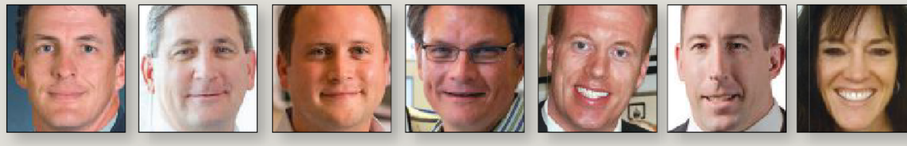
the MDCs and provided redundant power and cooling from the main data center that housed the UPSs and generation systems.

Hogge: We recently completed a greenfield prefabricated modular data center for a technical college. The facility was designed to support 90 kW of IT load across nine cabinets. The facility included in-row cooling units and hot-aisle containment for a cooling system and a modular UPS system with N+1 modules. The facility also is supported by an adjacent pad-mounted generator. The project included the bidding of the facility and the associated site work. Developing a performance bidding document that would allow multiple vendors to propose on a significant variety of approaches to meeting the project requirements—and allow flexibility for modification after installation at the site—was a challenge.

Chadwick: All of our current projects for enterprise or co-location data center clients include modularity in some way. In some cases, modular mechanical and electrical systems (or skids) are included. In other cases, we are seeing modular construction of the data center racks, rows, power, and IT distribution. Finally, modularity could be achieved with the whole data center built in containers or other modular structures that allow for rapid deployment and relocations.

Lane: We are implementing a lot of modularity into data centers. This includes modularity of the electrical components within a brick-and-mortar data center and also individual modular data center pods. Both types of systems have their place in the modern data center environment. UPS systems can be integrated with plug-and-play modularity from both the inverter/rectifier and the battery systems. Additionally, capacity and/or redundancy can be built into a well-engineered electrical distribution system to reduce upfront cost while allowing for expansion in the future. Modularity can also decrease initial power-usage effectiveness (PUE), resulting in more energy efficiency throughout the life of the data center.

Sty: Modular data centers (containerized or prefabricated solutions) can be highly effective in the right application. This could be mobile/temporary command centers or supplementing IT functions for a group located in an existing building that does not have the existing MEP infrastructure to support it. We are currently investigating the use of a single containerized system for



a new network node on a university campus. The solution is very clean, efficient, and cost-effective. The challenge of a containerized approach can be in large-scale (multimegawatt) applications. Modular solutions are designed to support a certain density and cannot take advantage of the "unused" or spare capacity of the adjacent container. Because it is extremely difficult to predict the actual IT requirements of the space, there is a large potential to strand power and cooling with the containerized systems. A traditional data center has that potential as well, but by right-sizing the mechanical and electrical components, it is far less likely.

CSE: Please explain some of the codes, standards, and guidelines you use. Which codes/standards should engineers be most aware of in their design?

Sty: Designers should be knowledgeable of the current local codes as they are legal minimum standards for facility design; but they are just that, the minimum level of design and construction. Some facilities (depends on the owner) justify meeting the requirements of physical security set by the Interagency Security Committee. ASHRAE, the U.S. Green Building Council (USGBC), and The Green Grid all have standards relating to energy efficiency that designers should be familiar with and implement. The Uptime Institute has set the bar for reliability standards in their Tier certification process.

Vieira: As an electrical engineer, the codes that I most frequently reference for U.S.-based projects are the NFPA 70: National Electrical Code, NFPA 70E: Standard for Electrical Safety in the Workplace, NFPA 101: Life Safety Code, and NFPA 110: Standard for Emergency and Standby Power Systems. Compliance with these codes creates an electrical system that is safe to operate and maintain. Adherence to data center industry guidelines—such as Uptime Institute Tier classification system or the level-based topology found in ANSI/TIA-942, Telecommunications Infrastructure Standard for Data Centers—varies based on project requirements. Rarely does a data center design meet the strict definitions of a tier/level.

Eichelman: There are several standards that are written specifically for data centers. These include NFPA 75: Standard for the Fire Protection of Information Technology Equipment; NFPA 70, Articles 645 and 708; Uptime Institute Data Center Site Infrastructure Tier Standard Topology; TIA-942; USGBC LEED v4; and ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings. NFPA and ASHRAE standards are typically, but not always, referenced directly by the applicable building code for a project, but are considered best practices nonetheless. Uptime Institute, TIA, and USGBC standards offer best practices, depending on the nature, reliability requirements, and energy efficiency goals of the facility. Executive Order EO 13693, issued by the White House, includes specific requirements related to energy consumption for all existing and new federal data centers.

Hogge: Beyond the obvious code-mandated requirements, engineers and owners should discuss best-practice standards when creating the owner project requirements. The Uptime Institute, TIA-942, ASHRAE TC9.9, and The Green Grid are commonly cited standards. It is important that the team agree on strict interpretation of standards, or what we call "guiding principles." Oftentimes, the budget, space constraints, and values of the end user will already direct the design to follow the spirit of a standard within the practical limits. Clear understanding among all stakeholders is extremely important as the project moves through design, commissioning, and operation.

Chadwick: ASHRAE TC9.9 is continually updating engineers on the capabilities of server and storage equipment. The first question that needs to be asked for data center cooling is always what will the inlet temperature/humidity be for the design? This impacts the entire cooling strategy. ASHRAE Standard 90.4P, Energy Standard for Data Centers and Telecommunications Buildings, will be the minimum efficiency standard for data centers when it is released this summer (release pending final reviews). This standard will establish the minimum performance. As with the original issuance of ASHRAE 90.1, Standard 90.4 is aimed to set the bar at an achievable, but not overly burdensome level. Over time, these standards will be incrementally

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Figure 3: This data center in Prineville, Ore., features a mechanical air-handling system with evaporative cooling pumps and spray nozzles. Courtesy: AlfaTech Consulting Engineers

tightened to drive improvements in efficiency. This is, of course, a minimum standard; there are many examples of data center designs that greatly exceed these standards.

CSE: How have International Building Code, NFPA, ASHRAE, and other codes affected your work on such projects? What are some positive/negative aspects of these guides?

Kosik: What I have found is that the facilities and IT industries have typically developed design approaches to solve specific issues. From these solutions, standards and guidelines are published; this process combines the experience gained from the "real-world" applications and the knowledge of how standards and guidelines are established to ensure applicability to a wide range of project types. Also, in many instances, the industry organization responsible for publishing the standards and guidelines will invite a team of industry experts to form a committee to assist in writing the technical documentation.

Chadwick: The current codes were not necessarily written with the unique needs and requirements of data centers in mind. That is why there is such a strong need for the new ASHRAE 90.4 standard. Some prescriptive requirements in the current codes are in stark contrast with some of the specific needs of data centers. |cse|

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