EXAMINING HIGHER EDUCATION FACILITIES: SUSTAINABLE BUILDINGS AND ENERGY EFFICIENCY

By Consulting-Specifying Engineer

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As technology advances in every field, the college and university students being prepped for future careers in those fields need the tech they're learning with to keep up. That presents unique challenges for the engineers working on such structures—specifying advanced systems that satisfy the unique needs of each institution. Here, professionals with experience in the area offer advice on how to tackle such facilities and receive top marks in regard to sustainable buildings and energy efficiency.

John Holbert, PE, LEED AP, Senior Principal/Client Executive, IMEG Corp. (http://www.imegcorp.com), Rock Island, Ill.

Donald Horkey, PE, LEED AP, Principal, DLR Group (http://www.dlrgroup.com/home/), Minneapolis

Kent Locke, PE, NCEES, Associate Principal/Branch Manager, Bailey Edward (http://www.baileyedward.com), Fox River Grove, Ill.

Dennis P. Sczomak, PE, LEED AP, Senior Vice President, Peter Basso Associates (https://www.peterbassoassociates.com), Troy, Mich.

Jason Sylvain, PE, Partner, National Higher Education Practice Leader, AKF Group LLC (http://akfgroup.com), New York City

Matthew Wiechart, PE, CxA, LEED AP, CEM Principal/Senior Mechanical Engineer, TLC Engineering for Architecture Inc. (http://www.tlc-engineers.com/Pages/building-and-architecture-home.aspx), Orlando, Fla.

CSE: What unusual systems or features are owners requesting to make their facilities more efficient-for example, thermal energy storage or combined heat and power (CHP)?

Holbert: One of our university clients in a Southern state integrated chilled-water thermal storage via an agreement with an energy service company (ESCO). The ESCO installs and operates the thermal storage system, realizing revenues through optimizing time-of-use electricity rates, weather conditions, and a demand-response agreement with the local utility. This university also is integrating solar PV on its campuses. An interesting future idea could be leveraging the thermal storage tanks as a battery to store excess PV generation.

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Wiechart: Cogeneration and trigeneration are constant discussion items. Understanding base loading of an absorption chiller, distribution of large-scale natural gas, and opportunities for hydronic reheat can make these systems attractive. Chilled-water storage also is used to provide for redundancy and peak energy-load shaving.

Sylvain: We have seen varied approaches as of late. Some clients have focused on carbon and low-energy/renewable systems, while others have focused on energy costs and resiliency. To respond to the latter, we have been asked to evaluate and implement CHP in a number of locations. CHP provides an attractive energy cost and demand savings while offering a campus additional resilient power capability and allowing for more uptime in the event of an extended grid outage.

Holbert: It seems more projects are pursuing developer-led and financed projects for energy efficiency and renewable energy. These types of projects can be a win for owners if critical aspects of the agreements are properly aligned. The ESCO agreement risks for HVAC systems seem to be relatively well-known since they have been around for a while. Leasing owner space for renewable energy generation is new. Some aspects to consider are the terms of the agreement and turnover to the owner, optimizing the size and location of the system to gain the best value, and understanding the value of the space that is being turned over to the developer. For example, developers often prefer to place PV in open fields to reduce cost; however, the owner needs to consider the value of that land for the future. PV systems can tie up land throughout a useful life that can reach 50 years.

Wiechart: The sophistication of the building automation system and the verification of the system is provided on university and college jobs where other project types do not have that level of sophistication.

CSE: What types of sustainable features or concerns might you encounter on such facilities that you wouldn't on other projects?

Sylvain: This varies depending on the client's approach, but real and measured energy usage index (EUI) and peak energy draw is a consistent theme we have been seeing. Owners in general, and universities specifically, seem to be more concerned with how much energy they will actually be using than they are with how much theoretical savings a predesign model shows against a theoretical baseline.

CSE: What types of renewable or alternative energy systems have you recently specified to provide power for college or university projects? This may include photovoltaics, wind turbines, etc. Describe the challenges and solutions.

Sylvain: In addition to the gas-fired CHP mentioned earlier, we recently have had a number of university clients implement large-scale PV renewable energy systems, both at a campus scale, at William Patterson University, Wayne, N.J., and on a building scale, for a building in pursuit of net zero energy at Millersville University, Pa.

Wiechart: Much of our work is in Florida, where the prevailing winds can shift from day to day-if there is a prevailing wind. Therefore, wind turbines are not efficient uses of capital due to poor return. PV panels are the preference, and as technology increases in efficiency and costs are minimized, these systems will become even more prevalent.

Holbert: We have seen the most activity with solar PV systems. Primarily because prices have fallen, they provide a very visible sustainability commitment, and they are an attractive investment for specialized developers. Some universities enter into offsite power-purchase agreements for wind energy. These can provide a large carbon offset for the university that is less complex, fast to procure, and often less costly than campus energy efficiency efforts and onsite renewable energy systems.

CSE: What are some of the challenges or issues when designing for water use in such facilities?

Wiechart: Large campuses have issues with their water usage and capacities. The implementation of using reclaimed or greywater helps them with those capacity issues. Proper distribution and minimal sterilization must occur, but these issues are fairly easy to mitigate. The use of beige toilets and sinks in lieu of white helps mitigate the staining that sometimes occurs with these systems.

Holbert: Water has always taken a back seat to energy. This is often due to cost; for some facilities, water is even free. We do not anticipate this being the case in the future, as water availability is decreasing in many geographies. One of the issues that arises is that water and energy consumption often can compete; evaporation of water often is used to make HVAC equipment more efficient. In other cases, they can work together. Water from dehumidification is clean and can be returned to water-consuming systems. Water storage seems to be a driving factor-it is expensive, large, and heavy to store. It also needs to be cleaned for use in the facility. This is more expensive to do onsite than at a public water-treatment plant. New technologies that are efficient, have a small footprint, and can be used in real time (without large storage needs) have the potential to make a big impact on this topic.

Sylvain: The water challenges we have focused on recently are energy-related or focused on reuse for mechanical systems. The energy focus has been in the form of domestic hot-water generation, using renewable (solar), condensing boilers, and combined building heating/domestic plants. The reuse focus has been on building-collected or a sitewide collection of stormwater, which can be treated and used as cooling tower make-up water for a district plant.

CSE: How has the demand for energy recovery technology influenced the design for these kinds of projects?

Sczomak: I would say that the demand for energy efficiency has influenced the design for college/university projects, which in turn has driven the demand for energy recovery. Increased use of energy recovery from exhaust air is being driven by energy codes, which in recent years have greatly increased the requirements. At the building and campus plant level, on certain college/university projects we have been implementing heat recovery in the form of heat pump chillers to very efficiently address the times when both heating and cooling are required in a building. Unlike a typical water-source heat pump system, in which separate heat pumps operate simultaneously to address simultaneous heating and cooling requirements in a building, a single heat pump chiller draws heat from the building's chilled-water system and transfers it to the heating hot-water system, which is a much more efficient way of addressing simultaneous heating and cooling needs when loads are balanced.

Wiechart: Energy recovery has increased dramatically as energy codes have become more stringent. The use of enthalpy wheels from recovery has become a common design practice. Educating owners regarding the maintenance of this equipment is the key to long-term success and continued energy conservation.

Locke: The energy recovery products have evolved rapidly and are making an impact on energy use. The educational facilities require large quantities of ventilation that must be exhausted. Through the use of these devices, the ventilation air can be preheated or precooled to provide normal entering-air conditions while reducing the heating and cooling plant equipment sizes.

Sylvain: This has had the biggest impact on existing buildings that are retrofitting/upgrading mechanical systems. Specifically, it is often a challenge to efficiently and effectively fit energy recovery systems and supply and return distribution into the constraints inherent in an existing building. We have had to get creative with how and where we recover energy, what medium is used, and how we prioritize the exhaust/relief airstreams to recover from.

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Holbert: Energy recovery is common practice in many climate zones-and required by codes and standards in certain climate zones. For airside energy recovery, this pushes the design toward dedicated outdoor-air systems. These systems also save a lot of reheat energy for the project. For projects with high air-change requirements (thus high reheat loads) like labs and health care projects, we see waterside energy recovery as an effective option to save energy.

CSE: High-performance design strategies have been shown to have an impact on the performance of the building and its occupants. What value-add items are you adding to these kinds of facilities to make the buildings perform at a higher and more efficient level?

Horkey: High-performance strategies are usually a combination of load reduction, energy efficiency, and load matching. We have a dedicated team of performance analysts who are engaged in the design process to quantify the impact of design features on ongoing performance and gain insights into the return on investment and lifecycle cost of each measure, with the aim of providing predicted performance data for actionable intelligence. They analyze various strategies' impacts on the overall design including:

- Load reduction-Programming, high-performance envelope, and rightsized glazing.
- Energy efficiency-LED lighting, condensing boilers, dedicated outdoor-air systems, energy recovery, and heat pumps.
- Load matching-Automatic lighting and receptacle controls, demand-control ventilation, efficient control strategies, ongoing fault detection and diagnostics.

Holbert: It seems the past 10 years have focused on HVAC system technologies as primary drivers to enable low energy use. More recently, we are increasing focus on passive strategies first and then supplementing these with active HVAC systems. New analysis approaches have enabled thermal and daylight autonomy studies to greatly inform the architecture. These approaches first optimize how well the building performs using its own orientation and mass without the use of HVAC and lighting. This results in a great improvement in the thermal and visual comfort of the occupant from the beginning. HVAC and lighting systems are then leveraged to supplement and create a highly desirable indoor environment. With HVAC systems, we still focus on keeping them simple by centralizing maintenance to specific building areas or systems. This allows specialized owner staff or a single maintenance contract to handle the more complex components of the building while allowing generalized maintenance to remain familiar and simple for in-house maintenance staff. A few examples include variable refrigerant flow (VRF) systems, highly efficient VAV, or centralized water-to-water heat pumps with distributed terminal units and a dedicated outdoor-air system.

Sylvain: The list can be broad, but one of the first things that comes to mind is building data for the occupants, specifically thermal-comfort, air-quality, and energy-usage information presented in a way that makes them see the quality of the space they inhabit and shows the energy impact of the decisions they make.

Wiechart: Absorptive air-filtration devices that minimize volatile organic compounds (VOCs) and carbon dioxide allow the building to be properly "cleaned" while minimizing ventilation. These designs provide comfort and are energy-efficient, which are goals of high-performance buildings. High-performing buildings also use controls to automatically set back systems, which include temperature, lighting, and even power to save energy while not affecting typical human behaviors.

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CSE: What level of performance are you being asked to achieve, such as WELL Building Standards, LEED certification, net zero energy, Passive House, or other guidelines? Describe a project and its goals.

Locke: LEED certification seems to be the basis of our design effort for most projects. Whether the building will be certified, Gold, Silver, or Platinum is a varying factor. The design incorporates the necessary systems to achieve the particular rating, then the university has the option to submit and actually obtain the certification.

Wiechart: LEED Gold has become the typical standard for most of our higher ed clients. Green Globe certification is asked for colleges and universities that have less stringent sustainability goals. Net zero is discussed, but it is often discarded due to budget concerns.

Sylvain: We have been implementing all of the above. LEED continues to be the common standard in higher education, as LEED v4 has come into effect. We have seen WELL Building more on the commercial office side, but with aspects of it, particularly related to occupant health and air quality, coming up across all sectors. Net zero has become increasingly more of a common and achievable goal, which is encouraging. We have yet to engage on a full Passive House certification project of large scale, but many projects we work on are taking lessons from Passive House and implementing envelope-performance goals and strategies that are a direct result of it.

Horkey: Higher education facilities should accommodate and facilitate the curriculum by providing environments where occupants can thrive and also use the building itself as a teaching tool. High-performance certifications demonstrate thought leadership and commitment to high performance and can be important for attracting talent. For the relatively transient population, signage and plaques are an impactful way to communicate this. Another valuable outcome of such certifications is that they are a formalized way of documenting best practices; the efforts made in the design process are documented to apply for certification approval, which can then be incorporated into the curriculum or other educational documents. At the start of a project, our company uses its trademarked VALUES (Viewing Architecture Through the Lens of User Experience) workshops to set key performance goals. Following a series of charrettes, an outcome of this framework is a curated list of client-specific performance goals, which include a performance certification such as WELL, LEED, NZE, Passive House, RESET, Fitwel, Green Globes, or another certification based on the client values defined by key stakeholders. We have dedicated experts in each of these certifications that can ensure there is a focus on certifications throughout the design process, and often clients elect to use the VALUES checklist, depending on budget. Our dedicated building-performance team also provides a three tiers post-occupancy evaluation, which is an optional additional service on request.

Holbert: We have seen a decrease in requests for LEED certification, owners starting to ask about WELL (we have four projects underway), and an increase in requests for net zero. Passive House is starting to enter the commercial and multifamily market but not yet on campuses, in our experience. It seems that performance-based design and post-occupancy monitoring/fault detection are the emerging trends. More owners are starting to specify EUI goals in the RFP and follow-up monitoring during operation. The continuous monitoring then keeps this on track and provides a bridge between designers, contractors, and facility operators. An example of this can be found in this video.

CSE: What are the challenges of incorporating more energy-efficient solutions for these projects while also accommodating other requests, such as staying within a certain budget, completing the design on time, and making sure these systems are well-maintained after they're implemented?

Wiechart: The challenge with every college or university is the communication and goals within every group working on the project. Typically, there is a facility group that is charged with building a project with a determined budget and program. There also are maintenance and sustainability groups that have initiatives to have sustainable and long-term maintainable systems. These tend to conflict. Job conversations of alternatives and options among the different groups are critical for success and buy-in from all parties. Compromise among all the groups occurs to satisfy an overall goal for each project.

Sylvain: These challenges are ever-present. Higher-performance goals can add complications to this discussion, and high-performance metrics that are tracked post-occupancy can certainly add risk and challenge to the designer. However, balancing performance, budget, schedule constraints, and maintenance are consistent challenges that have really been there since the start of the MEP industry. The higher-performance goals are just focusing the discussion a bit more now than in the past.

Horkey: Maintaining the balance between design innovation, efficiency solutions, budget, schedule, and maintainability will always be the challenge to the design profession. Working as an integrated design firm alongside integrated construction and owner teams is the best way to ensure that we meet the goals of energy efficiency solutions. We stress cost-transferring budgeting for decision-making. We are always striving for the optimal balance. For example, improving the building envelope to allow for the mechanical and electrical infrastructure to be the smallest possible. As an integrated team, we work with architects, contractors, and owners to maximize the mechanical and electrical spaces so there is adequate space to do the required maintenance. We also work closely with operation staff to ensure that they are being trained during project turnover and during the warranty period.

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Sczomak: A key to implementing energy-efficient systems into any project is early integration into the design process so that they can be synergized with other building systems, which typically results in lower overall cost and higher overall efficiency. Another key is to develop design concepts enough so that early phase cost estimates can be as accurate as possible. This does not mean that you have to get into detailed layouts of systems. Rather, it means having a solid concept of major system components and a strong conceptual estimating process that can fill in the details from a cost-estimating standpoint. Lastly, most colleges and universities have many buildings and sometimes millions of square feet to maintain, so it is imperative to address future maintenance concerns early on with facilities operations and maintenance staff.

Holbert: The main challenge is that they are viewed as optional and discussed too late in the design process. An alternative approach is to include them as a requirement in the project RFP as described above. This approach specifies the required outcome and allows the design and construction team to come up with the best design solution to meet the goals and achieve it in operations.

Locke: The energy code continues to be updated and is becoming more in line with LEED standards. The deviation between the two is becoming smaller, thus requiring implementation of additional strategies to obtain the end goal, which drives the cost higher and puts a strain on the budget.

CSE: Have you had an opportunity to specify a system in which dorms or other buildings competed to be the most energy-efficient? Describe the kiosks, measurement tools, or other systems used to track and display sustainability and teach the student population.

Sylvain: We have done a few of these types of systems for offices and classroom suites, creating competition among classes to minimize their energy consumption. The measurement tools are related to the suites by energy submeters, which track and compare lighting and plug-load usage for each. These are available on a web-based interface/dashboard, which is displayed at central stations in the school as well as within the classrooms where it can be used in the curriculum.

Wiechart: I have designed dorms, but there were not any tools for the students to be more energy-efficient by changing behaviors (turning systems off or setting back).

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