Beyond LEED, Sustainable Laboratory Design

Flad Architects

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The U.S. Green Building Council's LEED® (Leadership in Energy and Environmental Design) Green Building Rating System™ has furthered the pursuit of sustainability, generating increased efforts by both owners and the construction industry to develop new ways of reducing the environmental footprint of a variety of facilities, including laboratories. However, to move beyond the goal of merely reducing that footprint, and choosing to eliminate a facility's environmental impact altogether, requires the incorporation of new technologies, the exploration of new design approaches, and the modification of user behaviors.

In recent years, Flad Architects has been asked to address unusual situations faced by our clients while creating facilities to meet higher levels of sustainable design criteria. Incremental solutions were not enough to fully address these challenges, requiring the design team to develop uncommon strategies to redefine what a truly sustainable laboratory would be.

Through a series of discussions, we clarified our own beliefs about sustainability and LEED's use as a tool to reduce a facility's environmental impact. However effective the LEED program is at moving the market toward more sustainable building practices, we identified that the goal of the program is not to completely mitigate a facility's environmental impact. To actually create a sustainable facility, it must, in fact, fully sustain itself. Therefore, a sustainable facility, by definition, must meet the following criteria:

- Net-Zero Energy Use
- Net-Zero Water Use
- Net-Zero Carbon Footprint
- Zero Waste During Construction & Operation

If we assume these combined goals are possible, there are a multitude of questions to be addressed. What solutions can compensate for the high energy loads and ventilation of laboratories? What would it take to produce all the needed energy on site, as well as enough energy to sell back to the grid to result in a net-zero balance? If it is actually possible to achieve these goals with the technologies available today, would it be financially feasible?

During our search for the answers to these questions, it became apparent that these endeavors also required a more holistic response from the operators and designers of the laboratories, while remaining engaged in the fiscal realities of the projects. The entire project team must increase its focus on finding innovative ways to do more, while reducing energy use and minimizing waste. Each tactical investment must demonstrate an equivalent return by reducing energy consumption or the environmental impact on the site.

This paper addresses those challenges and the new frontiers available once a project sets goals beyond LEED Platinum.

Two projects embodying these challenges were a confidential client's Renewable Energy Laboratory (REL) in Kuala Lumpur, Malaysia, and Stony Brook University's Advanced Energy Research and Technology Center (AERTC) in New York.

The REL is intended to lead the world in the research of biomass conversion, as well as the development of other renewable energy sources available near the equator. The facility needed to reflect the client's commitment to sustainability by moving beyond the confines of LEED

and striving to be an exemplary model of environmental responsibility. In addition to the challenges found in any research facility, we had to address the challenges posed by the tropical, equatorial zone. As energy usage is greater in this hot and humid climate, the REL faced increased energy costs. Challenges also included preparing a laboratory for sustainable operations in a developing country. Our primary strategy to address these challenges was to generate as much on-site renewable energy as possible to off-set the facility's consumption.

Stony Brook University's goal for the AERTC was to create an energy research complex that reached beyond the goal of LEED Platinum. The primary challenge posed by this project was that the facility was to be located on a site without a municipal sewer system, forcing the design team to implement strategies to minimize chemical lab waste and to develop systems for dealing with that waste on-site.

When faced with projects such as these two examples, the design team must move beyond a standard approach, addressing the challenges with high performance design, safety philosophies, and behavioral changes; seeking strategies with compounding effects.

High Performance Design

To achieve the most energy efficient facility, the design team must ensure architectural and mechanical systems are fully integrated – working in tandem, to achieve more than either system could achieve functioning independently. This partnership between systems results from several factors, including an integrated design plan incorporating passive design strategies, daylight integration, and expert lab and office planning, among others.

Integrated Design Plan

The first step to fulfilling a strong sustainable agenda is incorporating that agenda into the Integrated Design Plan (IDP). Rather than simply taking the established business objectives and moving forward with the design, this process engages all parties involved with the project in a visioning session at the outset, to establish the benchmarks, metrics, and standards toward which the project will aim. By involving the client leadership, project management, design team, and both the facility users and operators at the beginning of the process, everyone is fully informed of the business objectives, design strategies, and desired outcome involved with the project and can participate in shaping the necessary tactics to pursue those objectives.

This process is carried through the duration of the project, affording the opportunity for the building's performance strategy to evolve and adapt to usage demands throughout the expected life of the building. Using this process to unify the vision and form consensus lays the groundwork for the success of the entire project.

Passive Design

By optimizing the use of natural environmental climate factors, passive design can significantly reduce the facility's dependence on active mechanical systems. High quality passive design includes identifying and incorporating heating, cooling, and ventilation opportunities that are specific to the building's climate, location, and program.

In the case of REL, providing shade for the building was of paramount concern, due to the equatorial location, so our plan incorporated a two-tiered approach. First, a solar shading canopy was created at the roof level to shade both indoor and outdoor spaces. The canopy was created through the incorporation of a large photovoltaic array to not only shade the area but capture sunlight and transform it into energy used to cool the building and provide power. Second, we integrated a green roof into the facility to provide additional insulation, prevent a heat island effect, and reduce storm water run-off.

To achieve the greatest impact, each design strategy used multiple tactics to address environmental issues. This

multidimensional approach, with different systems performing dual and triple duty, allowed for solutions that were easy to maintain and had no mechanical dependence.

Daylighting

Establishing a balance between luminance and illumination involves calculated environmental analysis. By reducing the building's dependency on artificial light, we can effectively reduce the building's energy loads, creating opportunities for interior daylight, as well as creating views of the outdoors which contribute to the occupants well being and productivity.

The design team must perform an analysis of the real occupancy patterns of the building to ensure enough light is available when needed, and also to ensure areas are not over lit when they are not occupied. This analysis must include the use of sophisticated technology to measure, understand, and predict the way light will be utilized within the space for both function and quality.

This modeling can often lead to changes in the form and orientation of the building to make natural light available throughout the facility, ensuring a healthier and more productive work space.

Lab & Office Planning

In the case of the AERTC and other northern hemisphere sites, architectural planning concepts can also contribute toward additional energy savings. For example, by placing high ventilation labs on the south side of the facility, laboratory air change rates will already be addressing solar heat gain loads imposed on the south elevation. Additionally, in the winter, high sensible load labs facing north can contribute toward heating a space, further reducing demands on the building for heating loads. By locating some conference functions either within or adjacent to labs, it may be possible to reduce the overall volume of laboratory zoning while maintaining the flexibility of the lab space.

During this process, it is important to seek different heating and cooling strategies for office spaces, as offices need fewer air changes than labs. It is also important to seek opportunities to condition these and other non-ventilation demanding spaces using water instead of air, as it requires less energy to move water through the facility. As offices have a different definition of flexibility, we can consider utilizing more hydronic conditioning, as well as considering displacement heating and natural ventilation.

Safety Philosophies

Moving beyond design consideration, there are great opportunities available through reevaluating an organization's safety protocols and procedures by introducing energy concerns into the decision matrix. A balance must be achieved between user safety and energy use. Instead of addressing safety issues with a one-size-fits-all approach, a calculated management of safety issues must be developed based on the intricacies of the specific facility and guided by an agreed-upon safety philosophy.

Ventilation & Air Conditioning

Ventilation and air conditioning are the dominant energy consumers in a lab and their requirements are primarily driven by safety concerns. The two most promising strategies to reduce energy use are the proper control of air changes in the lab and new fume hood designs.

By designing demand-driven systems and enabling users to turn off equipment, a large amount of the energy used in the laboratory can be eliminated. This can be accomplished through the use of occupancy sensors and automatic sash shut-offs. Another tactic for energy savings is reducing the capacity of the system by accurately diversifying lab occupation and fume hood operations. Not only can this reduce energy use, it can reduce the owner's initial investment.

Although building owners often ask to have the air handling system accommodate 80 to 95 percent hood usage, studies have shown that laboratory air handling systems are consistently over designed, well beyond the needed capacity. In the majority of labs, 75 to 85 percent of fume hoods are not being used at any given time, but are operating and using a significant amount of energy.

The only way to calculate the safe and appropriate air flow rate is through the use of computational fluid dynamic modeling. With computer models, we can understand the performance requirements of the space, while designing a laboratory that minimizes energy use and maintains a healthy environment for the staff.

A ductless fume hood acts much like a biosafety cabinet in that it filters the air before circulating it back into the room environment. When we can safely incorporate this energy efficient device into the lab, we could reduce conditioning loads by orders of magnitude through minimizing the exhaust rate. There are many obstacles remaining before use of the new fume hoods will be widely accepted. Filters must be changed regularly and certain volatile, small molecule compounds cannot be filtered by these hoods. Only a motivated user team will make the effort to change their procedures to maintain the equipment and effectively manage its use.

Behavioral Changes

True changes to our environmental footprint will require behavioral changes in the way we use laboratories and resources. Operation and user behavior will have the largest effects on resource use over the lifespan of the facility.

User Adaptation

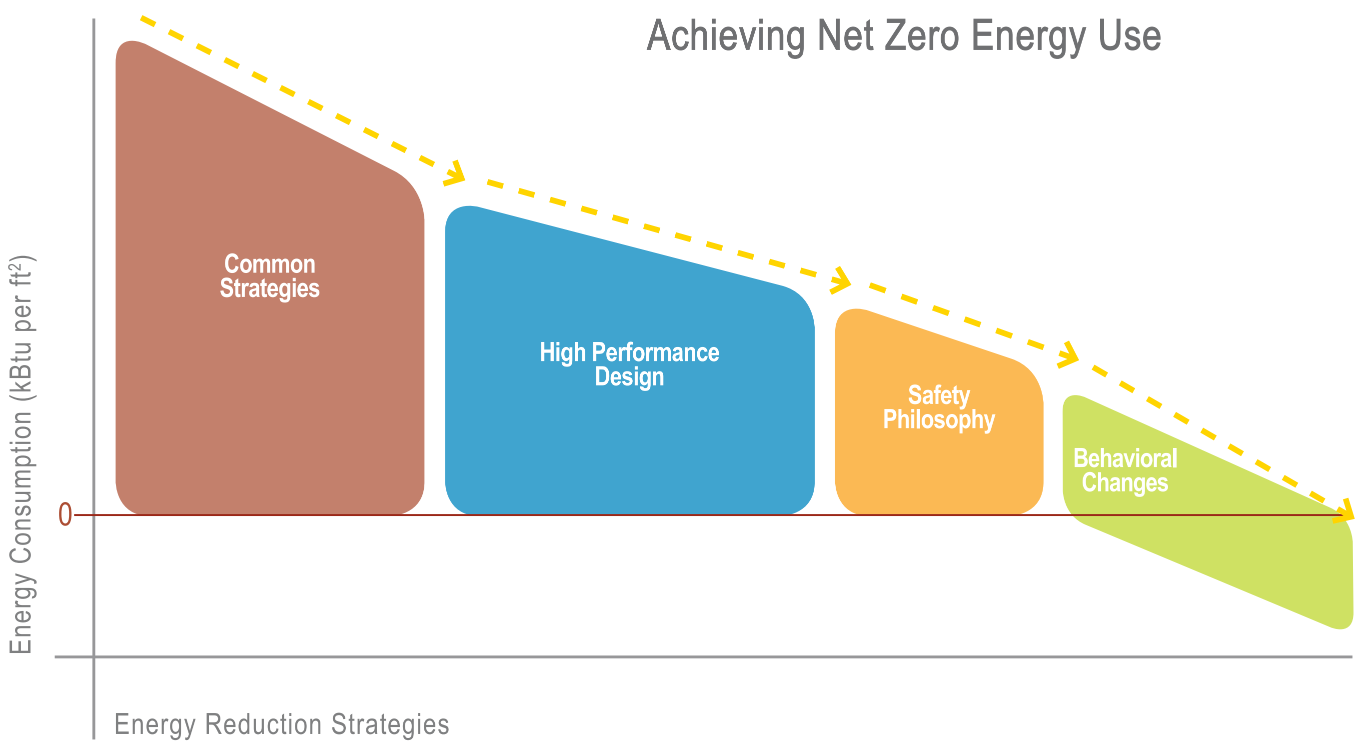
Beyond design and planned safety processes, the greatest challenge faced by any facility is modifying the behaviors of the people who use it on a day-to-day basis. Making people aware of the processes and procedures to get the most out of the facility is only the first step in changing their behavior over the long term. Systems must be in place to measure and track energy utilization patterns and their impact on the facility, correcting inefficient behaviors and giving users incentives to improve. The systems must be designed to react to the user's demands. Individual staff can be extremely motivated to improve their resource consumption and should be rewarded for careful behavior by returning savings to the team for other expenses. Over the life of the building, the users themselves will need to track the energy use of the facility to identify opportunities to increase its efficiency as techniques and technologies improve.

Integrating the lab utilization demands in the design process allows a designer to uncover potential improvements in many ways. For example, containment of lab waste and water conservation are possible today to a degree that water waste can be minimized to almost zero. While many might find this an impediment in their working productivity it also creates opportunities to provide more flexible laboratory layouts. Movable sinks that are serviced from above are possible and again relieve us from a fixed type of infrastructure that is costly to maintain and modify.

Conclusion

To achieve an actual sustainable laboratory, we must take a holistic view of the project. Lab design must be approached from a broad perspective, maintaining the vision and business goals of the users while analyzing the laboratory operations to locate every opportunity for cost and energy savings. Each strategy requires planning, forward thinking, constant modeling, measuring, and management as the project unfolds.

By moving beyond common strategies, incorporating high performance design, thoroughly integrating a safety philosophy, and modifying the behavior of the users, a design team can create a facility that moves beyond LEED metrics and is truly sustainable.



Flad Architects

Flad Architects has earned a reputation for outstanding client service, fiscal responsibility, and design excellence over its 80-year history. Specializing in the planning and design of innovative science facilities for academic, healthcare, government, and corporate science and technology clients, Flad is nationally known and honored for its planning and design expertise. In addition to traditional architectural services, Flad provides strategic facility planning and programming, laboratory planning, interior design, landscape architecture, and structural engineering.

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