LaboratoryDesign Lighting

Lighting the path to efficient lab design

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Open lab at UC Riverside School of Medicine Research Building showing clerestory windows with motorized shades and manual wood shutters. Image: Lara Swimmer

The goal of any lab planner is to make labs as safe, functional and comfortable as possible. And one of the larger issues in regards to researchers' comfort is lighting. However, not only is lighting a comfort issue in labs, but it's also a sustainability issue.

Today, energy codes and energy-efficiency programs, such as LEED, are driving lab planners and architects to pursue energy-conscious design. And while HVAC systems consume about 70% of a lab's energy, electrical and lighting loads consume around 30%.

So, what steps can be taken to optimize user comfort and a sustainable lab? Below are four methods to help achieve these feats.

Lab lighting/fixture trends

LED lighting has increased in usage over the past three years for both overhead and task lighting, as labs are becoming more humanistic. And, although LED lighting is more expensive than a T5 fluorescent fixture, the long-term cost savings due to the LED's efficiency outweighs the initial first costs.

Technical advances in LED technology and their fixtures have opened new lab applications. Color rendering of the technology has improved over the past three years. And with more lighting vendors providing viable options, LED technologies have become more competitive.

"On the technical side, direct current systems and controllers enable dimming without the micro pulsations (flickering) that limited LED use in many areas, such as animal facilities, are now commonly available and being used," says Jeffrey Zynda, Associate Principal, Science Practice Leader, Payette.

As part of an overall trend toward energy use reduction in labs, LED fixtures help reduce the lighting power density (LPD) and direct electricity use for lighting, but also help reduce heat rejection from lighting sources indirectly assisting the cooling demand reduction. These technology advances also contribute to the growing trend in task/ambient lighting strategies.

Small LED task lighting has become a significant factor in providing user-controlled lighting at the bench, while allowing for lower general lighting. "The new task lights are so small, they can be invisibly incorporated in lab furniture," says Bernard Dooley, Director of Laboratory Planning, Goody Clancy.

Dimmable drivers coupled with high-efficacy LEDs today provide attractive financial payback through luminaire energy efficiency and tailored lighting control schemes. "Long-term operations and maintenance costs are further reduced through extended LED lamp life and maintained lumen output," says Byron Sutherly, AIA, CDT, Senior Project Architect, Hixson Architecture, Engineering Interiors.

LED technology emits visible light in a narrow spectral band, and can produce "white light" through a red-blue-green array or phosphor-coated blue LED lamp. The benefits of the technology include: compact size, long life, ease of maintenance, resistance to breakage and vibration and lack of infrared or ultraviolet emissions, as well as the ability to be dimmed and to provide color control. The lamps usually last 40,000 to 100,000 hours, depending on color and can currently achieve efficiencies of 80 mean lumens per Watt (LPW) or higher.

However, in terms of LPW, or the measure of light source efficacy, traditional fluorescent lamp and ballast design is not behind us. By pairing energy-saving fluorescent lamps with extra high-efficiency electronic program-start ballasts, efficacies as high as 95 to 110 mean LPW can be achieved.

Applying high-efficiency linear fluorescent technologies helps reduce the LPD throughout entire lab spaces, cutting the total connected electric lighting load. These high-efficiency technologies also increase lamp life from 20,000 hours to 36,000 hours, reducing replacement and disposal costs.

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A prototypical lighting design was incorporated which featured a custom designed LED task light which is integral to the top shelf of the casework. Each bench had its own task light with a motion sensor maximizing the potential for energy savings. Image: Rachellynn Schoen courtesy of Payette

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The debate between T5 and T8 fluorescent lamps continues in lab design. However, according to Labs21, T5 fluorescent lamps are the choice for new construction builds and high-bay labs. T5 fluorescent lamps can also yield better optical control and greater luminaire efficiency compared to T8s. T5 fluorescent lamps are also better in terms of reduced material use, consuming 60% less glass and phosphor material and up to 50% less packaging when compared to T8 and T12 lamps.

In labs with permanent furniture, suspended fluorescent T5/T8 direct/indirect lighting is still the most cost-effective way to illuminate a space. These technologies free up space on the ceiling for utilities and chilled beam technology, which is required in the middle rows. In labs with flexible furniture, "rows of fluorescent linear recessed, or 1 ft by 4 ft or 2 ft by 4 ft, direct volumetric systems can be used," says Nick Mazzolini, Electrical Engineer, Newcomb & Boyd. "Fluorescent 2 ft by 2 ft aren't as efficient so aren't used."

Are incandescent lighting sources now a ripple in the past? Many A/E/C firms believe the incandescent lamp has seen its day and can currently only find use in commercial applications.

Yet, according to Carlos Perez-Rubio, RA, LEED AP, Lab Planner, HERA Laboratory Planners, there's still room for incandescent lighting. "There are still tasks where color temperature is critical, areas where bulbs are used in solar research and other areas," says Perez-Rubio.

Tim Evans, Laboratory Design Principal, SRG Partnership Inc., echoes this belief. "One possible outlier application for incandescent sources is in nanoscale imaging labs where the requirement for minimizing electro-magnetic interference (EMI) from lighting during image capture is essential," says Evans. The control of EMI in LED and fluorescent fixtures are improving, but remains problematic for these environments. However, the incandescent sources should be combined with other, more efficient sources for periods of time when EMI isn't an issue for the instruments.

Task/ambient approach

Gone are the days of 100 footcandles (fc) at the bench level throughout labs. These days were driven by the bad color quality of previous fluorescent lamp lighting available. However, through the years, the quality of fluorescent lamps and LEDs have improved. With this, most researchers are satisfied with around 50 to 65 fc at the bench.

Task/ambient lighting solutions are now commonplace in labs, and are typically carried out in labs that require different lighting requirements. However, many labs still have higher than needed levels of ambient lighting. And, at times, these ambient light sources aren’t integrated with daylighting via full-range automatic dimming.

To increase building performance and sustainability, high-efficiency electric lighting with low power density (or Watts per square foot) provides modest amounts of ambient lighting. In conjunction with well-designed task lighting, this can reduce LPD below code allowance. The allowance for labs is currently 1.4 W/sf according to IESNA Standard 90.1 (the energy code referenced by LEED). Other technologies and techniques, such as LED lamps, linear fluorescent T5 lamps, chilled beam-integrated luminaires, universal dimmers and daylighting can get LPD at or below 1.0 W/sf.

Let the light in

Part of humanizing labs is providing researchers with views. Although there aren’t direct studies on a researcher’s productivity gains from daylit spaces, most lab owners agree that an outdoor connection and connection to day and night cycles are important to lab personnel. The ability to look out a window and observe the weather or the time of day deeply impacts researchers and helps keep their circadian rhythm.

And while happy researchers are of great importance, special attention must be paid to the research performed and the type, location and quantity of windows in a given lab space. Labs such as biocontainment typically don’t have windows or outside views (they resemble bunkers, except in certain exceptions like the Plowright Building or the Eva J. Pell Laboratory for Advanced Biological Studies). In lab environments, the ideas of glare, heat gains and privacy also must be evaluated.

Nothing beats natural light as it’s free, however it must be controlled. Technology such as light shelves, black out curtains and automatic shading systems must be discussed with users early in the design process, as well as siting of a building. “Some research labs will require absolute control of the light coming in as opposed to teaching labs where it’s a more open environment,” says Mazzolini.

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Performance testing of motorized shade controls for UC Riverside School of Medicine Research Building. Image: SRG

Glare control is critical for effective daylighting. "The brightness of the exterior environment often creates contract ratios that are uncomfortable," says Evans. "And direct sunlight penetration into a space should be avoided when possible." There are many strategies available for solar control, each requiring attention to detail and particular attention to control systems. Today, many motorized shade manufacturers offer sophisticated control systems that combine predictive algorithms for the position of the sun in the sky and the effect of adjoining buildings and terrain with active adaptation to actual sun and sky conditions.

One of the easiest ways to properly implement a daylighting strategy is to specify a photosensor directly into lab lighting fixtures. While not all manufacturers offer this option, according to Mazzolini it's worth finding this option due to how easy it is to adjust. One sensor can be daisy chained to other ballasts in the same zone through low-voltage wiring.

A second option is to provide a photosensor that's connected to a lighting control system and then programming which zones of luminaires to dim. "This option requires careful commissioning and it's important the lighting designer be involved during set up to determine appropriate light levels," says Mazzolini.

However, either technique can be used for fixtures within 15-ft of a window. This is the daylight zone where most savings can be achieved.

Understanding occupancy

The greatest potential for lighting energy savings is to turn off the lights completely when not needed. Occupancy sensors are now mandated by energy code in most labs. These sensors serve three basic functions: automatically turn lights on when a lab becomes occupied; keep the lights on without interruption while the lab is occupied; and turn the lights off within a preset time period after the lab is vacated. Overall, the use of occupancy sensors within a lab setting can reduce lighting energy by 10 to 30%, if they are implemented correctly. Payback on the technology can be seen one to two years after implementation.

Two popular technologies are currently used for occupancy sensors: passive infrared (PIR) and ultrasonic. PIR sensors are trigged by the movement of a heat-emitting body through their field of view. PIR sensors can't see through opaque walls or partitions and can't see around corners. Occupants must be in direct line-of-site of the sensor for optimal use. Ultrasonic sensors, on the other hand, emit an inaudible sound pattern that's disrupted by any moving object altering the signal returning to the sensor (Doppler principle). These sensors are suited for spaces where line-of-sight view to the occupant isn't always available, as the sensor detects even minor motion better than PIR sensors.

These controls can be used in conjunction with dimming or daylight controls to keep the lights in a lab from turning off completely when unoccupied, or to keep the lights off when daylight is plentiful and the lab is occupied.

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