LED WATCH

Morgan Pattison

LEDs FOR HORTICULTURE: MORE THAN MEETS THE EYE

Energy savings fuel much of the interest, but horticultural LEDs can provide a value add

We all know that LEDs are revolutionizing lighting. Although the technology is still only in its early days, LED lighting products have surpassed their conventional counterparts in terms of efficacy, lifetime, versatility, controllability and cost of ownership. And with new levels of control, the LED technology platform offers advancements in several new areas of lighting application. One such area is horticultural lighting.

Horticultural lighting, though, is at an even earlier stage than most other applications, and there remains a lot to learn. Just as the early days of general-illumination solid-state lighting (SSL) were likened to the Wild West because of the new possibilities coupled with a lack of standards and precedents, so now is horticulture lighting going through a similar phase. And as with all LED lighting applications, there's a shortage of scientific research to guide how we use the new levels of control.

Much of the interest in horticultural lighting is driven by the potential energy savings. Whereas lighting for general illumination helps us see in order to carry out our tasks, horticulture lighting is the essential fuel for plant growth, which makes the cost of lighting a much more significant part of the bottom line in horticulture than it is in general-illumination applications.

Most horticultural lighting in use today is high-pressure sodium (HPS), but LED lighting can already have a higher photosynthetic photon efficacy than HPS, in addition to having many other advantages. A recent U.S. Department of Energy (DOE) report examining the energy-saving potential of LED lighting in horticultural applications found, among other things, that based on current performance of top products, LED lighting offers 24% to 30% reduction in electricity consumption compared to conventional horticultural lighting technologies. The study concluded that if all horticultural lighting today was converted to LED technology, annual horticultural lighting consumption would be reduced to 3.6 TWh (from 5.9 TWh in 2017), which represents energy savings of 40%, or $240 million **(Table 1)**. (The DOE report is available online at *www.energy.gov/eere/ssl/energy-savings-potential-ssl-horticultural-applications*.)

The same technology advancements that are improving general illumination beyond energy savings are also being applied to the use of LEDs for horticulture. LED lighting technology enables a more highly controlled growth environment that can improve productivity and control of the horticultural product and may even enable new crops to be effectively produced in controlled environments. New levels of control over spectral power distribution, optical intensity distribution, form factor and active color tuning can be used to tailor the light to specific crops, improve productivity, and control aspects of plant growth such as height, bushiness, color and nutritional content. In addition, the new control can be used as a highly configurable research tool to rapidly refine our understanding of plant physiological responses to light.

OTHER BENEFITS

But the flow of benefits is not all one-sided, as horticultural lighting is driving a number of advances that will improve all lighting. For example, horticultural lighting is forcing us to rethink how product performance is reported. All general-illumination lamps and luminaires follow IES-LM-79 test protocols, with the spectral data collected in terms of optical watts at different wavelengths. For general illumination, these data are translated into lumens, but for horticulture they must be translated into a photon count. So the same basic testing can be relied on for both applications—even though

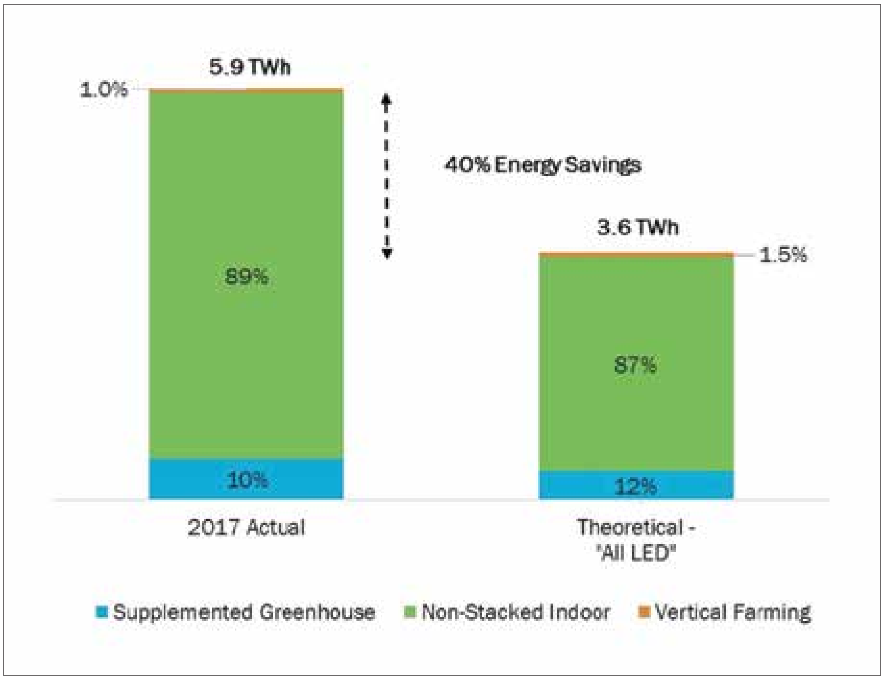

Table 1. 2017 annual energy consumption (TWh) of U.S. horticultural lighting.

a standardized test method for horticulture is still in the works. This also brings up the issue of action spectrum—which describes how the power-over-wavelength information gets translated into particular lighting metrics. The action spectrum that's been used almost exclusively for lighting until now has been the photopic eye response curve (which gives us the lumen). Plant action spectra are different from the eye response curve, which is causing us to rethink how lighting is designed for the particular application, and is paving the way for us to look at other action spectra as well—such as the melanopic response curve, the eye and behavioral response curves of different animals, and even the reflective response of objects that we want to see more clearly.

The action spectra for plants are based on various plant physiological responses, and different wavelengths of light can trigger growth, bushiness, flowering, nutritional content and more. However, current understanding of plant physiological responses to light is based on older research that didn't have the benefit of highly controllable LED technology. Researchers are hard at work developing a new understanding of plant physiological responses to light, which in turn will add to our understanding of how light affects the physiology of people and animals.

WHEN TO REPLACE?

The direct relationship between plant growth and light level is also causing us to rethink the reliability of LED products and the replacement cycle. The de facto characterization of LED lighting reliability in general illumination is L70 (the point at which a luminaire's output has degraded to 70% of its original output). But that threshold doesn't consider catastrophic failure rates and color shift, and likely is too low for horticultural applications. Some horticulture lighting products are now listing a L90 depreciation figure, which is more suitable for the needs of growers. Catastrophic failure rates and color shift will also be more closely monitored by growers, which could drive improved understanding of these reliability factors.

Horticultural lighting has also driven improvements in red LEDs, which are especially important to plant growth, and those improvements have also trickled down to amber LEDs. The net result has been to improve and expand the LED lighting palette, improving the performance of tunable luminaires that use these LEDs.

The horticulture market is beginning to accept LED technology, which undoubtedly will come to dominate those applications. Horticulture is also giving back to LED lighting by providing a new "lens" through which to think about and characterize light; by increasing our scientific understanding, which can add to our understanding of all physiological responses to light; and by driving new technological advancements that can improve general illumination. There are still barriers to adoption—primarily cost and uncertainty—but LED lighting will eventually enable produce that's fresher, more nutritious and more local.

A principal of SSLS, Inc., **Morgan Pattison** is senior technical advisor to the U.S. Department of Energy's Solid-State Lighting Program and lead author of DOE's Solid State Lighting R&D Plan.