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Keeping Our Foot on the Efficacy Accelerator

Although the impressive efficacy gains made by light-emitting diode (LED) products over the last few years fall well short of the U.S. Department of Energy's (DOE) ultimate targets, they've already surpassed the limits of conventional lighting in nearly all applications—which might prompt some people to say "good enough" and question the value of further improvements.

In response, the DOE has published *LED Efficacy: What America Stands to Gain*,[1] a white paper that gives five compelling reasons to continue improving the efficacy of LED lighting:

- **Better lighting:** With higher LED efficacy, more light can be produced with less power at lower operating temperatures, allowing manufacturers and designers to reduce the source size, the number of LEDs, the power input, and the amount of heat generated, as well as to increase the light output for a given source size. This paves the way for improved lighting performance (including color quality, beam control, glare reduction, and lifetime), lowered costs, and the addition of new services through integration of controls and intelligence.
- **Lower initial costs:** LED lighting products have the lowest lifecycle costs in most applications, but their initial costs are still higher than those of competing technologies. Continued R&D will make many LED products less expensive than their conventional counterparts on a first-cost basis and give them an even better lifecycle cost value. The key is efficacy, which manufacturers estimate has been responsible for one-third of the cost reductions achieved in LED lighting so far. Decreasing the number of LED packages needed to deliver a given light output reduces the cost of the power supply by enabling lower input power, minimizes the amount of heatsinking needed, and allows for simplification of the optical system.
- **Broad-based scientific and technological advances:** Research into ways to improve LED efficacy has already led to breakthroughs in such areas as materials science, semiconductor physics, quantum dots, and optics and is likely to have significant crossover into still other applications. For example, gallium nitride (GaN) electronic devices, which were an offshoot of efforts related to improving the efficacy of LEDs, are emerging as high-efficiency power converters for large-scale photovoltaic and wind-power-generation facilities and will probably also be used in most hybrid and electric vehicles.
- **Stronger U.S. manufacturing:** Efficacy R&D could improve the competitiveness of U.S. manufacturers, who have focused on producing high-value, high-brightness LEDs. The lower-cost, mid-power LEDs produced by Asian manufacturers suffer more from efficiency droop at higher current densities and thus require more LEDs to achieve typical lighting levels than do high-brightness LEDs. R&D to mitigate droop would enable high-brightness LED packages to run at even higher flux levels, reducing their cost per lumen and altering the cost-performance tradeoffs between high- and mid-power LEDs.
- **Huge energy savings:** Without a concerted effort to boost efficacy, market pressures would likely halt performance gains for decades. But if the DOE's LED efficacy targets of 250 lm/W for devices and 200 lm/W for luminaires are reached, the country will achieve annual savings of 5.1 quads of primary energy by 2035, yielding an astounding $50 billion in annual cost savings in today's dollars.

Realizing the full energy-savings potential of LED lighting will require not just a continued focus on efficacy but also an emphasis on high-quality, cost-competitive products that gain wide market acceptance. The marketplace has embraced LED lighting products for applications where they offer performance and long-term cost advantages over conventional technologies.

But the value proposition needs to be made even more compelling, so that—as has been the case with smartphones—early adopters will want to upgrade to products that have enhanced performance. Making LEDs more efficacious will provide the headroom for manufacturers to do just that.

[1] www.energy.gov/eere/ssl/downloads/led-efficacy-what-america-stands-gain