New Energy-Saving Fiber Optic Lighting System Lights Up Public Spaces

Challenge

Accent lighting accounts for 0.19 quadrillion Btus (quads) of energy used each year in the United States. It differs from general lighting in that the light is more directed, comes in smaller lumen packages, requires more specific color characteristics, and uses instant on/re-strike with no detectable delay between switching. The most common accent light is the 50W MR-16 halogen, which is used in the majority of accent lighting because it delivers the centerbeam candle power (CBCP) and cone angle desirable for most applications. CBCP ranges from 1200 to 20000, with a range of 40 to 8 degrees of cone angle between "flood" and "high-bay spot" accent light applications. The CBCP and cone angle are chosen in order to get a desired brightness ratio (typically 3:1 or more) between the object being illuminated and the ambient light.

As public sentiment and regulations are driving consumers toward lighting choices that save energy and reduce environmental impacts, new solutions that meet these lighting requirements are needed. However, they must also have a low first cost—the biggest challenge for energy efficient lighting systems for all applications. More energy efficient technologies existed, but did not satisfy both technical and cost requirements. The major problem for compact fluorescent (CFL) lamps is low brightness, which means that a tight beam cannot be formed. The major problem for metal halide (MH) lamps is the inability to scale to very low wattages and the prohibitive cost of buying one lamp and one ballast per light point.

Innovating Solutions

Energy Focus received DOE EERE SBIR Phase I and II funding for two separate projects to tackle these challenges. The first project was aimed at developing the crucial instant-on feature of the lights. The second sought to lower the cost of producing the lighting system so that the technology would be more competitive with standard technologies from a first-cost standpoint.

In Phase I of the first project, a series of lamp and ballast design tests were conducted to determine the starting characteristics needed to have instant light-starting while preserving 80% of system efficiency. Lamp parameters that were tested included electrode design, fill gas type, and fill gas pressure. Ballast characteristics such as starting pulse voltage, pulse width, pulse repetition, and minimum warm-up drive current were also determined in this phase. In Phase II, final lamp parameters were determined through structured engineering tests on lamp body size, wall thickness, and inner wall shape. The gas and electrodes were optimized for manufacturability, and the ballast concept was developed into a manufacturable design.

In Phase I of the second project, the goal was to reduce the cost of a high intensity discharge distributed accent lighting systems by optimizing fabrication of the system's plastic optical fiber component, reducing the cost per point below conventional halogen sources. Eight new polymer processing approaches aimed at reducing cure time were identified and assessed, with two of the alternatives offering dramatically reduced post-extrusion processing time and lower costs. In Phase II, the two reduced-cost polymer processing alternatives were further developed.

Energy Focus received additional support for developing these new lighting solutions from other U.S. government agencies, including the Departments of Defense and Commerce. In 2006, the company installed its lighting systems in engineering control rooms, hangar bays, berths, welldecks, and weatherdeck locations on three U.S. Navy ships, replacing fluorescent and incandescent lighting. Nine-month sea trials were then conducted, demonstrating lower maintenance costs with no failures during the tials, increased lifetime, increased efficiency to greater than 30 lumens per Watt, and improved lighting (daylight spectrum).

DOE Small Business Innovation Research (SBIR) support enabled Energy Focus to develop a breakthrough lighting technology that delivers light comparable to conventional lamps while using significantly less energy per lumen, reducing watts per square foot without sacrificing light levels. As a result of DOE SBIR and other government funding, EFO (efficient fiber optics) Lighting Systems can deliver as much as 80% energy savings over halogen or other incandescent lighting with the instant-on ability of a halogen lamp. Because EFO uses only one lamp and one ballast for multiple light points, the cost is comparable to that for halogen systems.

Energy Focus, Inc. (Solon, Ohio) designs, develops, manufactures, and markets fiber optic lighting systems for a wide range of uses in the general commercial and pool and spa markets. The company's EFO lighting system was first introduced in 2004. The company sells both EFO lighting systems and traditional fiber optic lighting systems. Their markets include energy efficient accent lighting, specialty decorative and special effects lighting, LED lighting systems, and underwater pool and spa lighting systems.

www.energyfocusinc.com

A case study from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy SBIR program, providing competitive grants for scientific excellence and technological innovation to advance critical American priorities and build a strong national economy – one small business at a time.

Fiber Optic Lighting System Saves Energy

The EFO system is in use in warehouses; accent, display, and special effects lighting; underwater pool and spa lighting; and other commercial applications. Using supermarkets as a case in point, advantages of EFO ICE (Energy Focus' freezer case lighting product line) compared to commonly used technology include:

- Better food—the lack of infrared radiation in the beam allows food to stay fresh longer.
- Less compressor load—it lights products in the case without adding as much heat as conventional lights.
- Better light—EFO systems provide full brightness even in the most frigid temperatures while fluorescent lamps lose up to half of their intensity when chilled.
- Easier maintenance—one lamp replaces three to five fluorescent lamps; there is easy access for lamp changes, only one ballast for every three doors, and no tools needed; fixtures have no electricity, eliminating lamp socket destruction during case cleaning; and, they contain no glass so there is never a possibility of shattering a lamp inside the case.

SBIR Impacts

Realized Benefits of EFO Lighting vs. 50W MR-16 Halogen Lighting: 2004 to 2008[1]

Energy[2]	Energy savings (EFO vs. MR-16 bulbs)	EFO-44: 83%, EFO-33: 77%
	Energy savings over entire MR-16 accent lighting market (both EFO-44 and EFO-33)	0.06 quads
Economic[3]	Reduced energy cost (based on EFO-44 and EFO-33 units sold)	$3 million
	Average bulb life (EFO/MR-16)	15,000/5000 hours
	Ratio of bulbs needed (EFO-44:MR-16; EFO-33: MR-16)	1:8, 1:6
	Reduced annual O&M costs (both EFO-44 and EFO-33 systems)	75%
Environmental[4]	Reduction of SO_X emissions (over total EFO-44 and EFO-33 bulb life)	39,000 lbs
	Reduction of NO_X emissions (over total EFO-44 and EFO-33 bulb life)	103,000 lbs
	Reduction of CO_2 emissions (over total EFO-44 and EFO-33 bulb life)	26 million lbs

Innovation

The EFO Lighting System meets the two main requirements for more energy- and environmentally-friendly lighting—quality and cost—and has many added benefits, including:

- Elimination of nearly 100% of IR and UV. This reduces the emission of heat at the fixture, reducing air conditioning needs (one Watt of HVAC is saved on average for every three Watts of lighting).
- Cheaper to install—because they use fiber, they require far fewer electrical service connection points than traditional systems, reducing installation costs for new construction and energy retrofits.
- Reduced mercury by up to 75% compared to fluorescent lighting technologies.

Company Success

SBIR funding enabled Energy Focus, Inc. to refine an efficient fiber optic lighting system for use in commercial applications, allowing Energy Focus to enter additional lighting markets. As the company's website asks, "What do Victoria's Secret, the Magna Carta, U.S. naval vessels, and the fresh fish display at Whole Foods have in common? Each has been illuminated by Energy Focus lighting solutions." By adding an instant-on capability to fiber optic accent lighting designed for applications such as swimming pools, EFO has been able to compete with incandescent and other commonly used accent lighting methods. Additionally, their SBIR projects allowed Energy Focus to work on improving manufacturing processes in order to lower costs.

EFO product sales had grown to $10.9 million for the twelve months ended December 31, 2008, compared to $7.1 million for the same period of the prior year — a 55% increase. Total revenue for the company in 2008 was $23.0 million with EFO lighting systems accounting for 47.4% of total sales.

EFO now generates more revenue than any other Energy Focus product line. In 2007, Energy Focus was awarded a DARPATech SBIR Award for Excellence for their advanced naval lighting.

1 Equivalent benefits are expected to continue for systems currently in place but will not increase because the EFO-44 and EFO-33 are no longer being marketed.
2 Energy savings were calculated based on EFO and MR-16 lighting configurations and sales data from Energy Focus (www.energyfocusinc.com).
3 Economic benefits based on actual sales and performance data.
4 Emissions reduction calculated based on bulb performance data and typical emissions reported for electricity generation.

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