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that approach is appropriate for mission agencies, it seems less so for basic research agencies.

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Readers Illuminate Issues of Solid-State Lighting

It is refreshing to find proponents of solid-state light sources (SSLs) addressing the all-important issue of cost, as Arpad Bergh, George Craford, Anil Duggal, and Roland Haitz did (Physics Today, December 2001, page 42). It is also gratifying to see the steady progression of reduction in cost per lumen shown in figure 2 of their article. The authors note that white-light SSLs must reach costs of $0.05 per lumen to be economically justified in replacing incandescent light sources for residential use.

For a number of years, I was the director of R&D for a major US lamp company (see Physics Today, February 2001, page 38), and am presently an independent consultant specializing in the science and technology of light sources. I would like to make two points. The lesser one is to ask for a better definition of "cost." There are many possible definitions of the cost of a mass-produced, mass-merchandized item. The direct cost of manufacture is the cost of materials plus the cost of labor plus overhead for the manufacturing process. The total manufacturing cost (TMC) also includes the allocated cost of the facilities and automated manufacturing equipment, including capital expenses. To get the retail cost to the consumer, one must add costs for warehousing, transportation, advertising, and distribution to retailers, and the cost of retailing itself. The retailer of incandescent lamps typically keeps $0.25–$0.30 out of every customer's dollar to cover his costs. The net result is that the retail price to the consumer for such a mass-produced and mass-merchandised item is typically 10 or more times the direct cost of manufacture. To which of these costs does figure 2 refer?

My second, and major, point is that a product presently on the market is the functional equivalent of the incandescent lamp in size, lumen output, color, and color rendering, but triple the efficacy, and it is available for $0.05 per lumen retail cost to the consumer: the compact fluorescent lamp (CFL). Its sales are minuscule. Despite elaborate charts demonstrating payback through energy savings in one year, residential customers don't buy them. The market dynamics are simple: The customer goes to the grocery store to buy supplies, with light bulbs on the list. The choice is stark: $2 for a four-pack of incandescent bulbs and steak for dinner or $30–40 for a four-pack of CFLs and beans for dinner. Why should SSLs be any different?

There is a mechanism for overcoming this obstacle, but its use is very limited. My local electric utility purchases CFLs in bulk and leases them at $0.20 per month to its retail customers. The typical customer saves $0.50 in electricity costs per bulb per month, and so achieves a net savings of $0.30 per bulb per month from day one (assuming replacement of 75-watt incandescent bulbs). Total household monthly savings then, without any up-front investment, are $0.30 times the number of bulbs replaced. The utility reduces its peak demand load by 50 watts per unit, and it only pays wholesale cost (say, $5) for the product, thereby increasing its effective capacity at a cost of $100 per kilowatt, instead of more than $1000 per kilowatt to build new generating plants. This ingenious scheme is actually limited to utilities whose peak load occurs on winter nights, which applies to fewer and fewer utilities today.

Articles elsewhere on the subject of SSLs have suggested that government funds of $50 million per year invested in supporting SSL development could greatly assist in meeting the ambitious goals the SSL community has set for itself.

If the government wants to spend money, it can achieve lighting-energy conservation goals with certainty today, not just possibly in the future; it should spend the $50 million to subsidize the lease program for CFLs, purchasing them at wholesale cost and furnishing them to all utilities to lease at nominal costs to their residential customers. The $50 million would buy 15 million CFLs, each saving 50 watts, or 300 kilowatt hours, over its five-year working life in residential service. The program could be self-supporting by means of a 27% tax on the total lease payments of $180 million generated by the 15 million lamps over their lifetime. Such a self-supporting program, continued over several years, could replace incandescent lamps in many homes with CFLs without requiring the retail customer to bear the burden of the up-front cost. A larger annual expenditure would accelerate the conversion.

Supporting the product that today does everything in replacing residential incandescent lamps that is claimed for SSL lamps in the future, and needing only a way to break through the market constraints, would be a much more effective investment for the government. Even if the SSL community achieves every one of its ambitious technical goals on time, it will still need some similar mechanism to penetrate the marketplace.

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I applaud the authors' efforts to present a tutorial and current status of the field of solid-state lighting. However, I feel compelled to point out two omissions. The first is the attribution of credit to only Nick Holonyak and his coauthor[1] for "the first practical demonstration of LEDs in 1962." The paper by Holonyak and S. F. Bevacqua was on semiconductor lasers and has very little to do with LEDs per se. However, if we allow that paper to be a relevant reference for first LEDs, then we must include reference to three other papers[2] published at very nearly the same time as Holonyak and Bevacqua's, as also being "first" practical demonstrations of LEDs. The article by Bergh and coauthors does not distinguish visible LEDs from infrared LEDs. And to be fair about the history of visible LEDs, we should include Henry Round's publication[3] in 1907 of visible electroluminescence from SiC, the material of choice for blue LEDs before the appearance of GaN-based green and blue LEDs.

The second problem has to do with the data presented in figure 1 of the article. The data there for AlGaAs/GaAs red LEDs start in the early 1980s. In fact, data for "practical" AlGaAs LEDs started with a 1967 paper,[4] which was the first report of practical AlGaAs LEDs in the open literature. This paper also represented the first publication of a practical heterojunction.