Developing an International Standard Socket Connection for Efficient Residential Lighting

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Abstract

Programmes pursuing efficient residential lighting fixtures (luminaires) have very high potential for energy savings when compared with other residential appliances, but they face numerous challenges. Some of the barriers include: luminaire design and construction; a difficult mix of market players involved in luminaire specification and installation; higher prices for energy-efficient luminaires; limited selection for consumers; and a great number of non-standardized lamps and ballasts, which make replacement of these products difficult for consumers. In particular, the lack of easily replaceable pin-based fluorescent lamps has hindered energy efficiency programmes in the United States.

This paper focuses on the development of a new socket technology that will greatly simplify designing and constructing luminaires as well as locating lamp and ballast replacements by consumers. Recognizing that replacement lamps and ballasts were a barrier to the acceptance of energy-efficient luminaires, a group of energy efficiency advocates and lighting manufacturers gathered at the Lighting Research Center in New York in 2004. They launched a competition to select (and later standardize) a "line voltage socket" design that would hold a pin-based lamp and ballast. According to the rules of the competition, the line voltage socket needed to be non-proprietary and, without any extra wiring, be able to house a removable ballast and replaceable compact fluorescent lamp ranging from 9 to 26 watts, all within the luminaire.

The technology is now reaching the marketplace and is being used by luminaire designers in the United States. Among the benefits highly appreciated by designers are small size and modularity. Energy-efficient lighting programme managers are interested in promoting the standardized technology, because it will allow consumers to replace the ballasts in the luminaires more easily. The U.S. Environmental Protection Agency (US EPA) is working with the lighting industry to develop an ANSI standard in 2006. EPA believes that the new technology has the capacity to do for energy-efficient luminaires what the USB port did for computer hardware peripherals.

Given the rapid state of development of the technology and the potential for minimizing the annoyance of replacing energy-efficient lamps and ballasts, which would simplify energy savings programmes in EU and Asian countries, it is important to begin a cooperative effort toward an international standardization. This paper can serve as the launching point for this important discussion.

Introduction

Programmes promoting energy-efficient lighting in the United States are both popular and growing among states, electric utilities, and government. While savings on the order of 10% can be achieved with major appliances such as refrigerators, lighting technologies can save 66% or more in typical installations. Given this savings potential, and the relative low cost of lighting upgrades when compared with appliances, energy efficiency spending for lighting programs will total $50 million US in 2006.[1] Some of the goals of the ENERGY STAR® programme are to remove market barriers to energy-efficient lighting by encouraging common program specifications and common marketing platforms by retailers, and to drive innovation in new products in order to increase market share for efficient lighting. This paper describes how collaboration among the efficiency community and the lighting industry can result in significant product breakthroughs that have the potential to remove significant barriers to the adoption of efficient lighting in the United States.

Background

Lighting manufacturers are continuously innovating with the type and functionality of the efficient products that they introduce. One of the problems with the current generation of efficient luminaires is that the ballasts were not removable or easily replaceable. This created a maintenance headache for the homeowner over the long term. In the spring of 2004, one manufacturer, Technical Consumer Products, introduced a prototype of a compact, removable ballast to the marketplace. Over the next several months, US EPA programme staff discovered competing models of the same idea, which presented both a challenge and an opportunity. The challenge was that if industry went forward on the projected path, consumers would be faced with a difficult time in finding replacement ballasts, since there were three competing but not interchangeable models. The opportunity was that if industry could be directed, a powerful new technology platform could emerge.

Similarities to Efforts in the Computer Industry

Prior to the release of the universal serial bus (USB) in 1995, a typical personal computer would have different D-connectors for parallel and serial interfaces, mouse, joystick, MIDI connections, sound device jacks, and others. USB technology simplified this tangled web by specifying common mechanical connectors, electrical properties, and a higher-level protocol. However, adoption of the USB standard did not come easily. Adoption of a standard largely comes from its ability to interoperate with other items compatible with the same standard.[2] Even though the USB concept was a better and more desirable technology, it did not guarantee its adoption as a standard until the advent of the original iMac, which accepted only USB ports in significant enough volumes to drive standardization. Driving this standardization process for lighting “connections” was also very much in the interest of the lighting industry and energy efficiency advocates for the same reasons that it benefited the computer industry.

Round Table Process at the Lighting Research Center

In response to the increasing number of new products that were penetrating the US market, the US EPA and the American Lighting Association (ALA) combined forces to make it easier for consumers to use energy-efficient residential luminaires, especially those incorporating replaceable electronic ballasts. This new technology was, without any doubt, a simple way to increase the selection of ENERGY STAR residential luminaires. ENERGY STAR is a government-based program helping businesses and individuals protect the environment by using energy-efficient products. However, it was important to ensure that the use of this new technology was not going to introduce a new complication for consumers, i.e., ballast replacement. At the time, there was no design standard for the line-voltage sockets (i.e. what the replaceable ballast plugs into). The lack of a standard line-voltage socket, and thus a lack of a standard pin base on the replaceable ballasts, could have become a barrier to ballast interchangeability.

With that in mind, the US EPA asked the Lighting Research Center (LRC) to host a round table, bringing together luminaire and ballast manufacturers to discuss and determine a standard pin-base configuration and to identify next steps. On June 24, 2004 the LRC held the round table. The participants agreed to organize a design competition to select one standard line-voltage socket and ballast base that would accept replaceable ballasts from different manufacturers within a category of luminaires.

In August 2004, all of the ENERGY STAR partner manufacturers were invited to compete with innovative line-voltage socket designs suitable for residential luminaires of 26 watts or less, including floor and table lamps, wall fixtures, chandeliers, and ceiling fans. The standardization effort did not focus on the ballast itself, its components, or its manufacturer. Rather, the standardization effort was for the "socket"—the base of the ballast where it connects to the 120V supply. As a condition of entry, the winning socket design had to maintain an open protocol and be made available to the public after the competition without royalties. Four manufacturers tendered intent to submit letters. The competition submission period closed at the end of September, and three manufacturers submitted design specifications and product samples. One manufacturer dropped out of the competition.

Line Voltage Socket Design Competition Outcome

In October, 2004, the evaluation committee members and a representative from US EPA undertook a process to evaluate competing versions of the product design. Evaluation committee members rated each of the technical requirements from 1 to 5 (1 = not acceptable; 2 = acceptable; 3 = good; 4 = very good; 5 = excellent). The ratings given by each committee member were compiled and tallied by the Evaluation Committee Chair. The design receiving the highest overall ratings was selected as the winner of the competition. The overall ratings for the three entries are shown in Table 1.

Table 1: Outcome of design competition

Company	Score (points)
Technical Consumer Products	120
Viva Lighting	172
Rhine	157

The best line-voltage socket and ballast holder design for compact fluorescent lamp (CFL) fixtures was selected and drawings of the winning design were made available at the LRC's Web site. Once the line-voltage socket (GU-24) base design was selected, the competition evaluation committee submitted its recommended design to ALA and US EPA (Figures 1 and 2). As a follow up, the US EPA recommended that the winning entry be the design standard for CFL line-voltage sockets used in ENERGY STAR qualified luminaires, making it easier for consumers to purchase replacement ballasts for their home lighting. The US EPA has recently built the selected socket into the ENERGY STAR residential light fixtures specification, Version 4.0, as a program requirement for luminaires which use removable ballasts that are 26 watts or less.

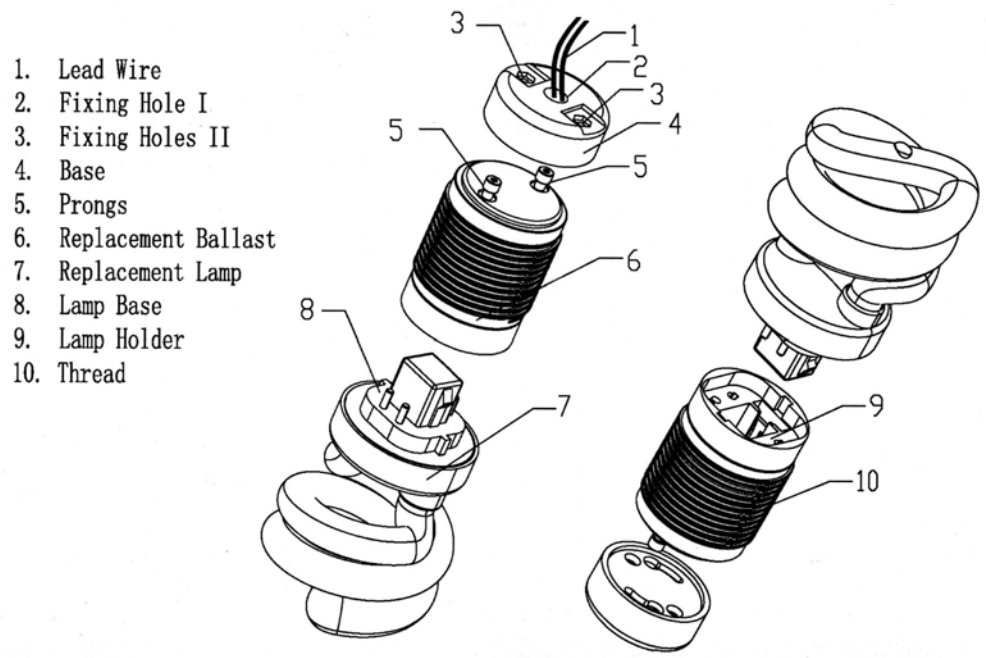

Figure 1: Design competition winning submission

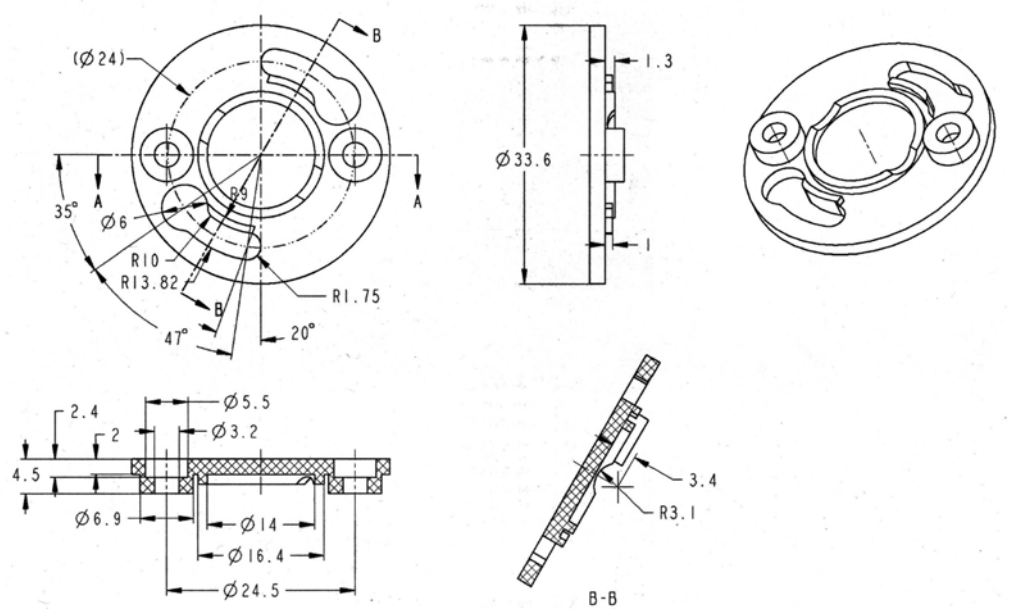

Figure 2: GU -24 Drawings Submitted to ANSI for Standardization

The US EPA and the LRC are working with the ALA, market transformation groups, retailers, trade associations, and socket and ballast manufacturers to encourage universal acceptance of the recommended design. Following the completion of the round table process several manufacturers began to modify their existing products in order to meet the new consensus design. In spring 2005, Technical Consumer Products (TCP) began producing prototypes of single piece units with integrated ballasts in one of their Chinese factories. TCP took a new approach by creating a single piece unit, which had several advantages. Table 2 summarizes the advantages and disadvantages of single piece GU-24 lamp/ballast.

Table 2: Advantages and disadvantages of single piece GU-24 lamp/ballast

Advantages	Disadvantages
Lower production cost than a two-piece unit	More likely to attract "lower quality" manufacturers of CFLs due to simplified design
Fewer components for light fixture designers	Disposal issues – increased waste caused by shorter ballast life
Smaller overall size	—

In addition to the innovation on the manufacturing side, luminaire designers have also been active in integrating the GU-24 into their products. Compliance with ENERGY STAR has become more difficult as both the lamp and ballast requirements are becoming more restrictive. Because the most recent version of the specification (Version 4.0) requires manufacturers to use the selected GU-24 base for any fixture models that have removable ballasts, the manufacturers of the GU-24 lamps and ballasts now have a rapidly growing market. Luminaire manufacturers are enthusiastic about the standardization that is taking place; they now have the choice of several manufacturers for lamps and ballasts where in years past they were forced into permanent alliances with particular lamp and ballast suppliers. Today, if a luminaire manufacturer is unsatisfied with its current supplier of GU-24 products, they can simply switch to a new supplier. Several manufacturers are adopting the GU-24, because it solves multiple problems for them, including being easily understood by the consumer.[3] At one of the premier lighting industry events in the US, Dallas Market, numerous luminaire manufacturers indicated their intention of adopting the GU-24 for integration with their efficient lighting models.[4] Table 3 shows the growth in adoption of the product. Manufacturers currently using GU-24 bases include Seagull, Progress, Lithonia, Maxim, Minka, Dolan Designs, Good Earth Lighting, Brownlee Lighting, and Hubbarton Forge.

Table 3: Growth in adoption: Percent of partners and luminaires using GU-24 Base[5]

	2004	2005
Partners	0%	20%
Products	0%	4%

Development of Formal Standards

Another important step toward the adoption of the winning design was to work with members of the American National Standards Institute (ANSI) toward the standardization of the selected line-voltage socket design. The US EPA and the LRC contacted members of the ANSI base and holder committee, asking them to put forward the winning design as a standard. The first step in the ANSI process was to make a technical standardization proposal to the ANSI Subcommittee/Working Group. A technical coordinator/leader, responsible for preparing the detailed proposal, was appointed to move the project forward. The technical coordinator/leader prepared an initial Committee Draft for Comment (CDC) in December 2005. The draft is currently being circulated for comments and will be followed by a voting process. Assuming the vote passes, the document will proceed after any negative votes are resolved. Based on comments received to date, the votes are expected to be positive. Once the voting process is finalized, the final standard will be edited and adopted, and a publication will be issued. The expectation is to have the final publication during the first semester of 2006. Once the ANSI standard is approved, it will be necessary to pursue the International Electrotechnical Commission (IEC) standardization of the line voltage socket. It is to everyone's benefit that the socket be adopted internationally.

Future Market Projections

For the numerous reasons stated previously, luminaire manufacturers have begun purchasing the GU-24 products in large numbers. While the product is not appropriate for all applications (under-cabinet lighting, for example) there are numerous luminaires in the marketplace which are already being designed with the GU-24. Figure 3 shows the historic and projected sales of the GU-24 product based on industry projections. While these sales still account for just a fraction of US lighting sales (less than 1%), the trend is very positive. Part of this trend follows the progress of the ENERGY STAR residential light fixtures program, which has begun to see more and more submissions of luminaires which utilize multiple "light sources" such as decorative hanging luminaires. These luminaires may have between three and nine individual light sources (Figure 4), making them a perfect candidate for the modular relatively low wattage GU-24 design. The alternative is for a luminaire manufacturer to use multiple lamps and ballasts, which are larger, more expensive, and more difficult to design and manufacture.

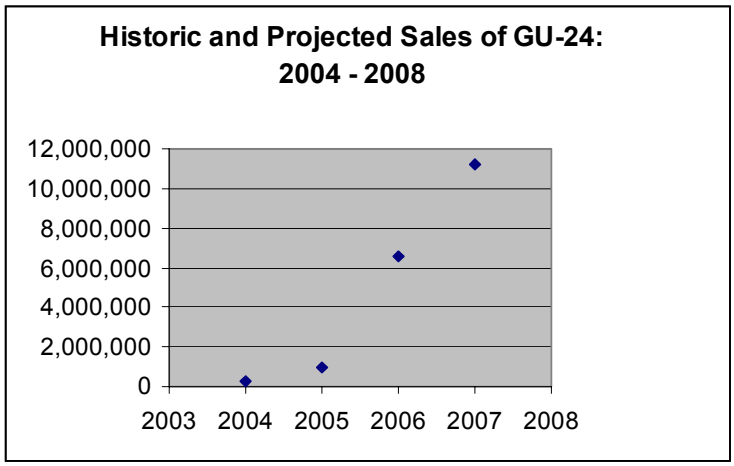

Figure 3: Market Success, Sales of GU-24 Products
Source: EPA estimates based on industry projections (2006)

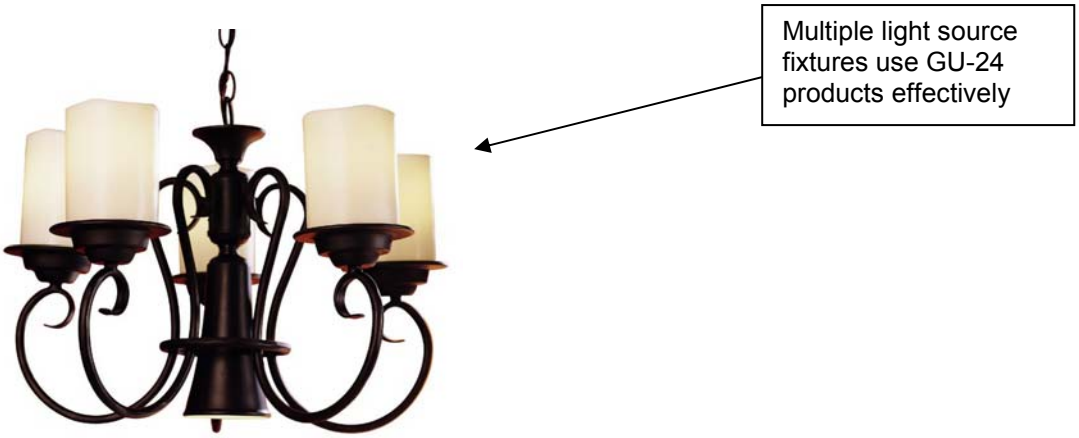

Figure 4: Example of New Luminaire Utilizing the GU-24
Source: American Fluorescent

Conclusions

In this paper we have shown how a combination of technology development, industry market forces, and standardization efforts have created a breakthrough in lighting technology. While the technology itself is relatively simple when compared with similar standardization breakthrough in other industries such as the USB port for computers, it offers significant benefits to users which are driving its popularity. Components for residential lighting were previously niche products made in low numbers and the GU-24 has radically changed that by building a bridge to the global CFL production infrastructure. The benefits to this bridge include: rapid product development, mass manufacturing capacities, smaller and smaller sizes, competition among manufacturers, much lower prices, and faster qualification of products for the ENERGY STAR program. ANSI standardization in 2006 will formalize the process started at the Lighting Research Center by the US EPA in 2004 and next steps for global acceptance include proposals to IEC. International efficiency program sponsors and luminaire manufacturers are invited to join in this effort to globalize the product by taking steps to incorporate the GU-24 into their countries' respective efficiency programs.

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