A New Socket for a New Generation of Energy Efficient Lighting

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ABSTRACT

In the past couple years, a few manufacturers started selling film-canister size fluorescent ballasts that are easily replaceable by simply "twisting and locking" into specially designed line voltage sockets. This technology is significantly increasing the adoption rate of residential energy efficient lighting and addresses a number of market barriers that are of concern for energy efficiency program sponsors.

ENERGY STAR® realized the potential benefits for this type of socket and replaceable ballast, so the Environmental Protection Agency (EPA) encouraged future development and standardization of this socket and base type by working with component suppliers. Manufacturers adopted a voluntary standard for the line voltage socket, now known as the GU-24[1], and American National Standards Institute (ANSI) is pursuing a standard. Numerous fixture manufacturers, the American Lighting Association and other market actors have realized the benefits of the GU-24 and are actively promoting the technology. One major benefit is that the consumer can change out lamps/ballasts of varying wattage and lumen output to meet their specific lighting needs – this is as easy as screwing in a light bulb but without the risk of snapback associated with screw-base CFLs.

This paper covers the technical parameters, status of market adoption, and advances that are currently being researched. Details on how this technology helps overcome technical and market place barriers are presented, along with the benefits to consumers, utilities, fixture manufacturers, and retailers. The GU-24 base is currently used with compact fluorescent lamps and ballasts, but was developed with the intention that LED lamps and drivers can also fit into the GU-24 socket.

Introduction

Fixtures (luminiares) using compact fluorescent lamps are increasing in use, but functional limitations have slowed their widespread adoption. Early energy-efficient compact fluorescent fixtures employed lamps, ballasts, and sockets traditionally used for commercial fixtures. The ballasts were able to fit easily in typical down lights, troffers, and other commercial fixtures. They were designed with a socket that accepted only one type of dedicated wattage (and lumen output) lamp in order to correctly match the lamp with the ballast used in the fixture. The ballasts and lamps were relatively large, which was fine for commercial fixtures because they have accommodating space. The ballasts are also replaceable to "commercial standards," meaning that in most open plenums the ballast can be replaced by an electrician or facility manager with the proper tools. However, these components are not optimized for residential fixtures.

[1] GU is standard industry nomenclature for the base type, and 24 is the center to center distance of the pins.

Residential fixtures have tighter space constraints and need to meet a wide range of consumer illuminance (light level) requirements. In addition, the lamps and ballasts need to be easily accessible and replaceable. Fixtures designed with one type of lamp, and thus lumen output, are fine for commercial applications because generally the lighting in each space is designed for one light level. However, in residential applications users want flexibility. The consumer needs to be able to easily switch out the lamp to a higher or lower lumen lamp depending on their changing needs and as rooms become darker or brighter with new paint and furnishings. With compact fluorescent lamps, this generally means the ballast needs to be changed as well. Typical commercial style ballasts were not designed with this functionality in mind because there was no need. Furthermore, because each existing compact fluorescent lamp had to be matched with a specific ballast, each socket was designed to fit a specific wattage lamp.

The several different socket types for the various wattage and lumen output lamps have led to consumer confusion and stocking issues for the retailers. In addition, the hard-to-reach ballasts are very difficult for consumers to change and consumers are generally not comfortable with disconnecting wires inside the fixture.

These issues are not new or recently discovered. They have been well known in the lighting industry and were documented in a report to EPA in 2003 (Ecos Consulting 2003).

A standard line-voltage socket for residential fixtures that can accept multiple lamp/ballast types and easily replaceable ballasts will address these issues. A standard line-voltage socket will help overcome the barrier of ballast interchangeability, increase consumer acceptance of energy efficient products, and help retailers manage inventory/stocking of replaceable lamps and ballasts.

The Potential

There is significant opportunity for a standardized line-voltage socket to work with an easy to replace ballast/lamp. A ballast that can easily twist and unlock will be beneficial for maintenance needs, but also provides flexibility for the fixture to accept different wattage lamps. Because a twist and lock mechanism is easy to understand, consumers and fixture manufacturers will both benefit.

Furthermore, a smaller sized ballast that is designed to fit in the residential fixtures (as opposed to using larger commercial ballasts in residential fixtures) will again benefit the manufacturer and consumer. This smaller ballast is more applicable for decorative residential fixtures and opens up entire fixture families to energy-efficient options.

Another benefit of the standard line-voltage socket is that fixture manufacturers are able to work with what they understand – wires and a socket. The ballast and lamp simply twist and lock into the line-voltage socket, and if needed, they can be easily replaced. The fixture manufacturer no longer needs to worry about how to design fixtures to hold and hide a large ballast while also making the ballast accessible for replacement.

Overcoming these barriers helps the manufacturers and will increase the availability of energy-efficient fixtures, including decorative families, which are common for new construction housing developments. The increase in number of products and easy replacement for consumers is expected to significantly increase market penetration of energy-efficient fixtures.

Evolution of the GU-24 Socket

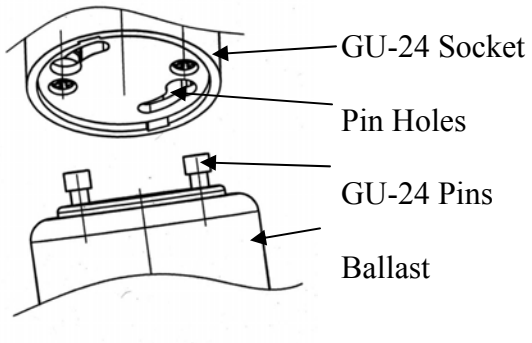
In 2003, equipment suppliers recognized the need for line-voltage sockets with small replaceable ballasts and started making their own versions. With this development, the emerging need to standardize the line-voltage socket quickly became apparent. If several versions were available from different manufacturers, the outcome would be an increase in the number of different lamp and ballast bases. This would lead to more consumer confusion and frustration for retailers.

Understanding this need, EPA tasked the Lighting Research Center (LRC) to work with industry to develop a standard design for the line voltage socket. In June 2004, the LRC collaborated with the American Lighting Association (ALA) and held a roundtable of fixture and ballast manufacturers to discuss options and determine a course of action for a standard, pin-based, line-voltage socket (Lighting Research Center, 2005).

The result was a design competition where manufacturers provided line-voltage socket designs for lamps of 26 watts or less that could be used in floor and table lamps, wall fixtures, chandeliers, and ceiling fans. The winning design was required to maintain an open protocol and be available to the public after the competition without any royalties. Entries were reviewed by an evaluation panel of luminaire, lamp and ballast manufacturers, energy efficiency organizations, the ALA, and the LRC. The winner was selected in October 2004. The drawings and release letter for the open protocol are available at: http://www.lrc.rpi.edu/programs/lightingTransformation/lineVoltage/index.asp.

The new socket, called the GU-24, uses a twist and lock configuration, which is easy for an average consumer to twist about a quarter turn and remove from the socket (see Figure 1). EPA stated its intent to adopt the GU-24 design into the ENERGY STAR® specification and eventually require all compact fluorescent fixtures with a line-voltage socket to use the GU-24 standard design. Several manufacturers – Maxlite, Rhine, Technical Consumer Products, Viva – quickly stated their intent to voluntarily adopt the GU-24 standard design.

Figure 1. GU-24 Socket with GU-24 Pin-based Ballast



In addition, the ANSI and Underwriters Laboratory (UL) began reviewing the GU-24 to determine manufacturing and use and safety standards for the GU-24. A proposed GU-24 ANSI standard is currently in review by the C81 ANSI Committee. The standard includes clauses that mention: 1) the GU-24 configuration is NOT to be used with incandescent systems, and 2) the base is limited to 50watts (Galluccio, 2005).

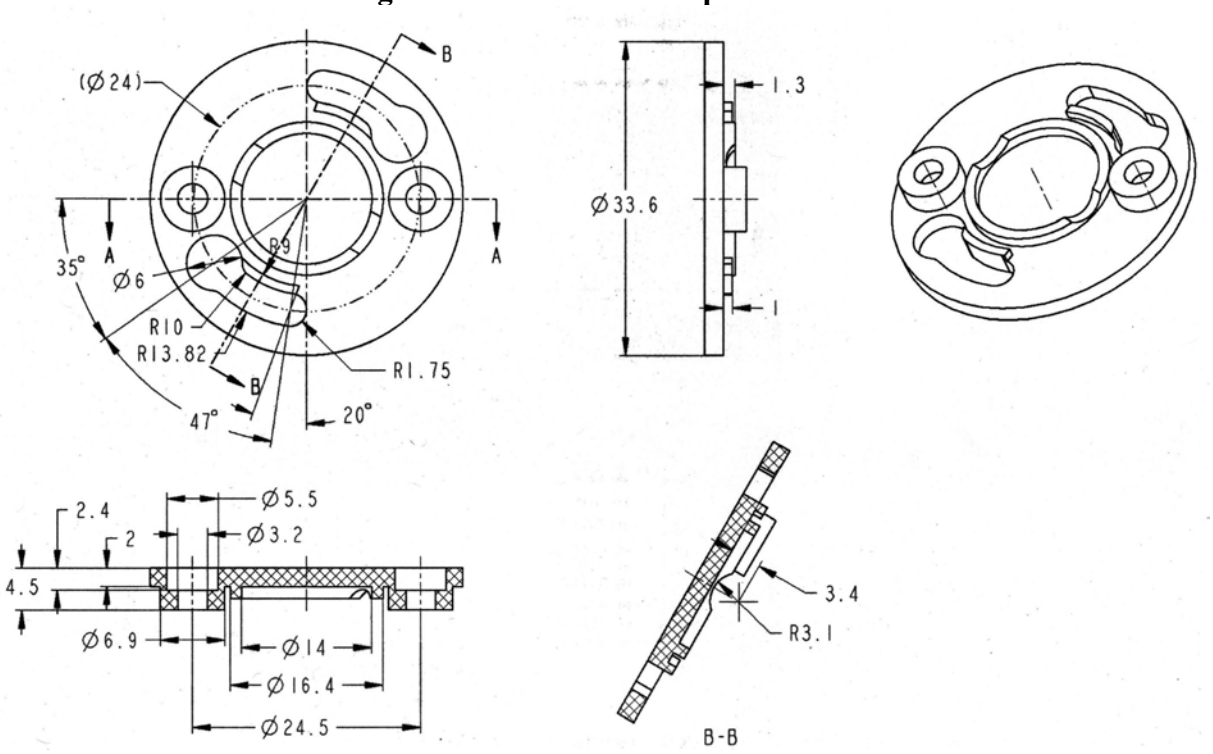
Furthermore, UL has already made changes to UL Listing (Guide) Cards stating that GU-24 socket is only to be used for ballasted devices. The Listing Cards are technical guides used by UL inspectors when approving products.

ANSI and UL are working to classify the GU-24 socket as a device to be used by energy-efficient technologies. These efforts will help prevent the development of incandescent conversion kits or GU-24 use with incandescent technology.

The Technology

The GU-24 socket pin spacing is 24 millimeters and overall diameter is approximately 30 millimeters (see Figure 2). Given the diameter of a standard medium Edison screw base of approximately 28mm, the 30mm diameter of the GU-24 can easily be used by residential fixture manufacturers without the need to retool existing fixture components such as fixture arms and glass openings for different size sockets and lamps.

Figure 2. GU-24 Socket Specifications



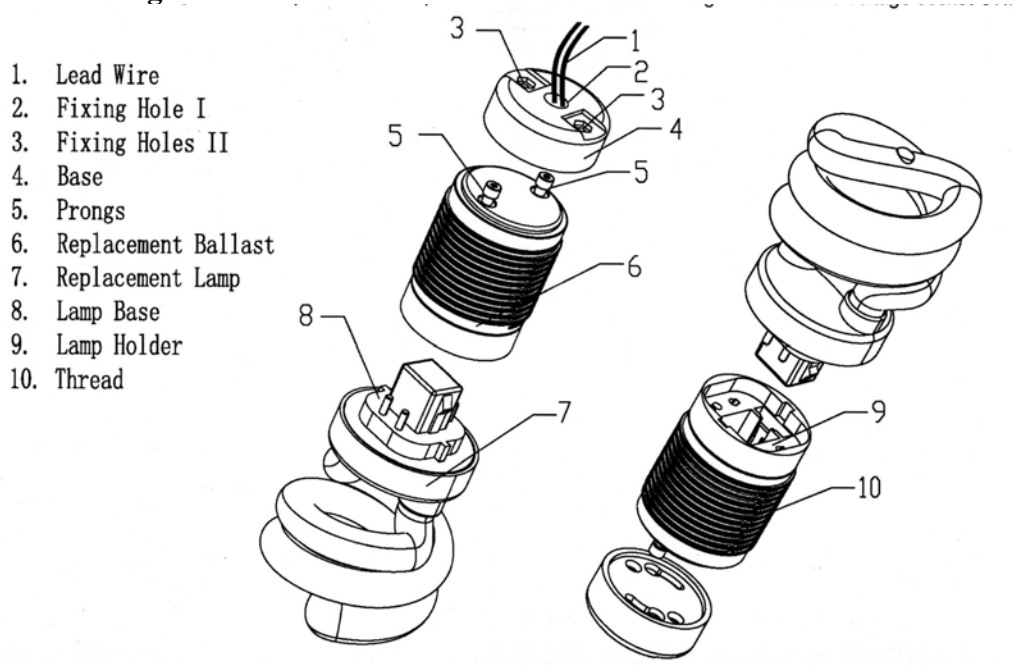
As shown earlier in Figure 1, the GU-24 pins are wider at the bottom. This allows the pins to securely "lock" into the socket. The typical ballast with a GU-24 base is generally the size of a film canister. Currently, most GU-24-based ballasts come with a detachable lamp (see Figure 3). The lamp base and corresponding socket in the ballast are an ANSI standard for the given wattage lamp. However, integrated, one-piece lamp/ballast units with GU-24 bases (to fit into the line voltage socket) are quickly becoming available. Fixture manufacturers stated they like the one-piece for its smaller size and lower price (ENERGY STAR Partners, 2006).

The GU-24 was originally envisioned to have two pin holes for the hot and neutral connections. A third hole can be incorporated to facilitate dimmability, and has been discussed

among manufacturers, as well as ALA, ANSI, and other stakeholders. The stakeholders agreed that the ANSI standard should require the socket to have three holes, including one hole for third-wire dimmability if needed. In the event that the unit is not dimmable, or does not require the third wire, the third hole and third pin will be "dead." Currently manufacturers are investigating this concept and at least one is developing dimmable GU-24 lamps. (Maxlite, 2005)

Figure 3 shows the GU-24 socket with a film canister-size ballast and a CFL lamp with a standard ANSI pin-base. The drawing shows the typical ballast that would twist and lock into the GU-24 socket. Another option is a ballast with an additional locking mechanism on the side of the ballast to secure it into the socket. Although the ballast securely fits into the GU-24 socket, this locking mechanism adds additional security for the ballast, but does require another step to remove the ballast. One manufacturer, Rhine, has such locking arms that are on the side of the ballast and simply push down and click into the GU-24 socket. The slots to accept the locking mechanism are optional on the GU-24 socket. However, the standard design of the GU-24 requires that it accept ballasts with and without locking arms, even if the arms can not be engaged.

Figure 3. GU-24 Socket and Ballast with Pin-Based CFL



Benefits of the GU-24 Socket and Replaceable Ballast

The GU-24 socket and replacement ballasts have numerous benefits for manufacturers, retailers, consumers, and energy efficiency advocates, including the following:

Small Size Is Easy to Incorporate into the Fixture and for Luminaire Designers to Understand

The use of a standard line-voltage socket is easy for residential fixture manufacturers to understand because they have been working with standard Edison base sockets and wires for a century. Residential fixture manufacturers were, and in many cases still are, not accustomed to working with ballasts or any type of control gear inside the fixture. Most decorative residential fixtures are not styled to accommodate typical ballasts – there is no room to place the ballast inside the fixture *and* make it easily accessible for replacement. The GU-24 socket with a film canister-size replaceable ballast overcomes this challenge. Fixture manufacturers can now get back to focusing on designing stylish decorative fixtures with a standard socket and not have to worry about ballasts. Thus, the GU-24 socket would help make more decorative ENERGY STAR qualified fixtures available for energy efficiency programs, retailers, and consumers.

Consumers and Retailers Can Easily Replace the Ballast

The twist and lock ballast can be easily replaced upon failure or to switch to a lamp/ballast with higher or lower lumen output.

The Twist and Lock Ballast Is Easier for Consumers and Retailers to Understand

Consumers and retailers can sell various wattage lamps that all have the same GU-24 base – this is similar to how consumers currently shop for incandescent and linear fluorescent fixtures. This system is easier for the retail sales associates to understand.

Fixtures Are more Cost Effective

Fixture manufacturers are able to easily manufacture fixtures with a GU-24 socket at the same price point as standard Edison socket fixtures, if the GU-24 lamp is purchased separately from the fixture. (ENERGY STAR Residential Fixture Manufacturer Partners, 2006)

Fixture Manufacturers Are Able to Choose from Several Suppliers of Ballast and Lamps

Fixture manufacturers can easily source ballasts and lamps from several suppliers without any changes to the fixture. They are not committed to one ballast that was originally specified to fit inside the fixture housing.

GU-24 Products Offer Sustainability for Energy Efficiency Programs

The GU-24 lamp and screw-base CFLs have many similarities, but there are two distinct advantages to the GU-24. First, a one-piece integrated GU-24 lamp has a shorter base than an

Edison screw-base CFL. This means that the GU-24 lamp has more room for the ballast. This allows for more air circulation and heat dissipation, which theoretically could lead to longer life. Secondly, GU-24 lamps offer sustainable energy savings for utilities because consumers must replace them with GU-24 based products, as opposed to screw-base CFLs that can be replaced by incandescent products.

Heat Limitations

As with all electronics, ballasts are sensitive to heat and should only be used in temperatures that will allow them to live as long as their rated life. The fixture application with the greatest heat impact on the ballast is recessed down lights, especially airtight down lights rated for contact with insulation.

EPA understands these limitations and that the GU-24 socket with replaceable ballasts would locate the ballast directly above the lamp in the hottest part of the fixture. EPA is currently developing tests at the Lighting Research Center that simulate high heat conditions for these products.

Progress and Market Adoption

Since the design competition in 2004, the adoption of the GU-24 socket and corresponding ballasts has been impressive. Component suppliers and fixture manufacturers are aggressively adopting the socket, and ALA is supporting the design for a standard socket to reduce consumer and retailer confusion.

At the time of writing this paper, there are five component suppliers actively marketing sockets and GU-24-based ballasts – Maxlite, Philips, Rhine, TCP, and Viva – and more manufacturers are considering GU-24 products. At least two of these manufacturers offer integrated one-piece lamp/ballast designs with the GU-24 base in addition to separable ballasts and lamps as shown in Figure 3.

The GU-24 has significantly impacted the development of ENERGY STAR decorative fixtures – from chandeliers to flush mounts. As of March 2006, nine ENERGY STAR manufacturing partners including American Fluorescent, Brownlee, Cordelia, Dolan Designs, Good Earth, Hubbardton Forge, Lithonia, Progress and Sea Gull Lighting have adopted the GU-24 socket. In addition, ENERGY STAR continues to receive an ever increasing number of applications with the GU-24. Based on the 2006 applicants, ENERGY STAR estimates 30 percent of new fixture submittals are using the GU-24 (ENERGY STAR Qualified Product Data, 2006).

Furthermore, at the January 2006 Dallas Lighting and Accessories [Buyers] Market several more manufacturers, including Minka and Maxim, were selling fixtures with the GU-24 socket even though they have not yet qualified the fixtures for ENERGY STAR. They stated their main attraction to the socket is its simplicity and price. It appears the GU-24 has become the socket of choice for decorative ENERGY STAR residential light fixtures. See Figure 4 for an example of a decorative wall sconce with GU-24 socket, ballast, and lamp.

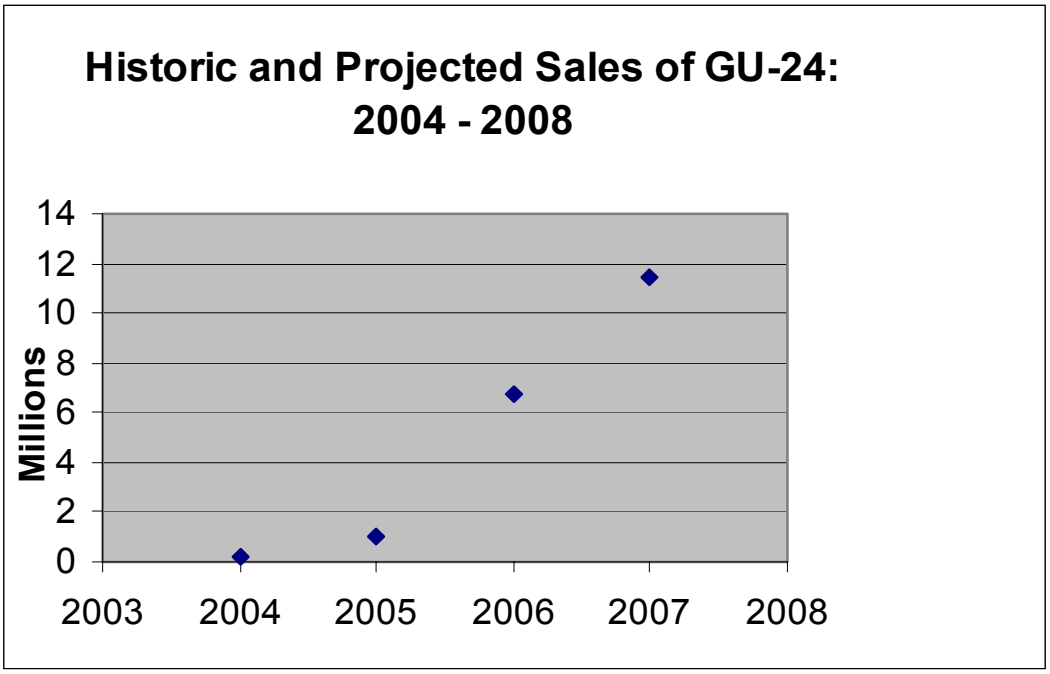
Figure 4. Decorative Wall Sconce with GU-24 Socket, Ballast and Lamp
(photo courtesy of Sea Gull Lighting)

The 2005 Lighting for Tomorrow competition also saw a significant number of fixtures with the GU-24. In 2006, the competition required manufacturers to submit families of fixtures – not just one fixture design. The easy application of the GU-24 socket made it easy for manufacturers to design families. Lithonia's first place winner used the GU-24 socket in their family and two-thirds of the submittals used the GU-24 socket (Foster, 2006).

At Dallas Market Sea Gull Lighting, Dolan Designs and other manufacturers indicated that lighting showroom buyers appear to like fixtures with the GU-24. The fixture aesthetics attract the buyers, but the simple functionality of the GU-24 socket and corresponding lamp/ballast impresses the buyers. The simple functionality of being able to twist and unlock the ballast is a plus with showrooms. ENERGY STAR is also working with mass retailers to educate them on the benefits of fixtures with GU-24 sockets and the stocking of self-ballasted lamps with GU-24 bases.

Based on current manufacturer adoption and pending wide-spread retailer adoption, GU-24 sales are projected on an exponential growth curve. Figure 5 shows the historical and project sales based on this information and other proprietary industry estimates.

Figure 5. GU-24 Sales



(Banwell, 2006. Authors estimates based on manufacturer supplied information.)

The (Not So Far Off) Future

Since its introduction in late 2004, the GU-24 socket has realized impressive market penetration. The future also holds the promise of further adoption of the GU-24 socket and development of GU-24-based ballast and lamps.

Although relatively new to the market, fixture manufacturers are already mentioning cost savings per fixture because it is easier to design fixtures with the GU-24 compared to traditional ballast/lamp platforms. It is highly unlikely that GU-24 fluorescent fixtures will ever be at the same price as incandescent fixtures when pricing in the lamp and ballast. However, as market demand and penetration grows, it is likely the cost per fixture will continue to decrease, thus making GU-24 fixtures a cost-effective choice for energy efficiency programs to lock-in sustainable savings.

Manufacturers have already started making GU-24-based dimmable CFLs and they should be available in Spring/Summer 2006. These products use an integrated lamp/ballast that is two-wire dimmable, meaning they can work on standard wall dimmers. They are expected to dim to twenty percent of full light output.

Another major advantage of the line-voltage GU-24 socket is that other light sources, such as LEDs, could replace the CFLs. Manufacturers can market GU-24-based LED lamps, where the LEDs and driver are integrated into a GU-24-based product. This means that as the next generation of energy-efficient products becomes available they can fit into today's energy-efficient fixtures. Actually, this generation is emerging right now and at least one manufacturer is introducing GU-24 based LED lamps (Lynch, 2006). In addition, if standards establish that the GU-24 socket cannot be used with incandescent lamps, then once consumers begin to install CFLs the GU-24 socket will make sure that they continue to use energy efficient CFLs or LEDs.

EPA also intends that future versions of the ENERGY STAR specification will require the use of the standard design GU-24 socket. The current ENERGY STAR Specification Version 4.0 indicates EPA's intent and encourages manufacturers to be proactive and adopt the GU-24. It appears that many manufacturers are adopting the GU-24 and realizing the various benefits.

Conclusion

This paper describes the genesis of a relatively basic technology that is bringing rapid positive change to energy-efficient residential lighting. The design simplicity, cost advantage, and ease of replacement are attracting fixture manufacturers that have never made efficient fixtures before. With further development of testing requirements, design standards, and the introduction of dimmable models, this new socket has the potential to bring dramatic change to consumer's choices in the lighting market. What is critical now is that the market transformation community recognizes this huge opportunity and works with the lighting industry and EPA to provide proper incentives and program support to ensure that the potential is realized.

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