

5-YEAR SSL COMMERCIALIZATION SUPPORT PLAN
FY09 through FY13
May 22, 2009
Final

Plan Summary

This plan sets out a strategic, five year framework for guiding DOE's commercialization support activities for *high-performance solid-state lighting (SSL) products for the U.S. general illumination market*. The commercialization support activities described in this plan, which span federal fiscal years 2009 to 2013, are intended to affect the types of SSL general illumination products adopted by the market, to accelerate commercial adoption of those products, and to support appropriate application of those products to maximize energy savings.

DOE has established aggressive FY13 goals for these activities, including goals for the types of products brought to market, the market adoption of those products, and the energy savings achieved through use of SSL products. These goals are for the combined effect of DOE's SSL commercialization support and R&D investment, as well as the leveraged activities of its partners. Among the goals are inducing the market introduction of SSL luminaires achieving 92 lumens per Watt (lm/W) luminaire efficacy (for warm white products), and 129 lm/W (for cool white products). Other FY13 goals include sales of 2 million high-performance SSL luminaires per year, and achieving annual energy savings of 638 gigawatt hours (GWh).

The plan identifies seven key SSL market needs for DOE commercialization assistance. They are:

- 1) Effective product purchasing and architectural design guidance (to guide buyers and program partners to products that perform well, to provide lighting designers with critical new technology application information, and to help retailers with product selection and merchandising)
- 2) Market visibility for state of the art, commercially available products (to educate the market about the technical potential of the technology in well-designed products)
- 3) Highly visible examples of model SSL general illumination applications (to inform the market about application issues, energy performance and cost effectiveness)
- 4) Market introduction support from energy efficiency program sponsors (to help manufacturers build early sales volume, thereby driving down technology costs)
- 5) Independent performance test results on commercially available products (to help overcome widespread confusion on actual product performance and to encourage manufacturers to use industry standard test procedures as a basis for performance claims)

- 6) Objective, widely available technical information from a credible, respected source (to help fill information gaps and increase understanding of the technology, its attributes, and its limitations)
- 7) Industry standards and test procedures for SSL general illumination products (to enable basic market infrastructure)
- 8) Coordination of local, regional, and federal SSL commercialization activities (to maximize effect of invested public and ratepayer money)
- 9) Independent investigations from credible source of key SSL issues affecting market adoption of SSL
- 10) Coordinated effort among energy efficiency programs to substantially reduce the market risk of introducing very high performance, state-of-the-art, SSL products

Meeting these market needs can collectively help drive down the costs of SSL by creating near-term market opportunities for SSL, which in turn generates revenue for SSL manufacturers to invest in R&D and lower-cost production. Further, meeting these market needs will help build an industry standards/test procedure infrastructure that is widely recognized and used, allowing manufacturers to characterize their products in terms clearly understood by potential buyers. And last, meeting these market needs helps equip lighting industry professionals, facility operators, lighting specifiers, energy efficiency program sponsors, retailers, and consumers with the information they need to make good purchasing decisions, and to properly apply this new technology.

The market needs were used for deciding which types of programs and projects DOE should create, and what general form they should take. Those projects and programs are identified in this plan as the plan's *key strategic elements*. They are:

- 1) Buyer and Specification Guidance**
 - a) ENERGY STAR
 - b) SSL Quality Advocates
 - c) Retailer Outreach
 - d) Lighting Design Guidance
- 2) Design Competitions**
 - a) Lighting for Tomorrow (Residential Fixtures)
 - b) Next Generation Luminaires Design Competition (Commercial Fixtures)
- 3) Gateway Technology Demonstrations and Procurements**
 - a) Demonstrations to Test Field Performance and Market Readiness
 - b) Technology Demonstration Consortia
 - c) Technology Procurements
- 4) CALiPER Testing Program**
- 5) Technical Information**
 - a) Technical Information Development and Dissemination
 - b) Technical Information Network
- 6) Standards and Test Procedures Support**
- 7) Coordination/Leadership**
 - a) Facilitating and Coordinating Local and Regional Efforts
 - b) Federal Government Leadership

- 8) Market Studies and Technology Evaluations**
- 9) Technology Prize Competitions**

The above nine strategy elements represent DOE's comprehensive approach to SSL commercialization support. They depend on active involvement from program partners, ranging from energy efficiency program sponsors, to industry associations, to standards setting bodies. The resources, expertise, and networks these program partners bring to the efforts represented by this plan greatly multiply any market development DOE can achieve on its own, and thus are a critical element to the success of this plan. Among DOE's key program partners are the Next Generation Lighting Industry Alliance, Illuminating Engineering Society of North America, International Association of Lighting Designers, and a large number of electric utilities, retailers, energy efficiency organizations.

Progress toward achieving plan goals with the above strategic elements will be monitored and periodically reported.

Introduction

Purpose

The purpose of this plan is to set out a strategic, five-year framework for guiding DOE's commercialization support activities for *high-performance SSL products for the U.S. general illumination market*. The purpose of the commercialization support activities described in the plan is threefold. DOE plans to create the conditions, specifications, standards, opportunities, and incentives that:

- (1) *affect the types of SSL general illumination products adopted by the market, emphasizing high-performance products likely to reduce energy use and satisfy users;*
- (2) *accelerate commercial adoption of these products;*
- (3) *support appropriate application of these products to maximize energy savings.*

DOE intends the sum of its efforts to shift the commercial adoption curve for high-performance SSL products ahead by five years, yielding large energy and economic savings. DOE estimates that annual energy savings from full implementation of this plan (in combination with its SSL R&D plan) are 638 GWh (site electricity use), or 6.9 terra Btus (primary energy use) by FY13.

DOE Role in SSL Commercialization

In considering the question of whether DOE has a role to play in assisting with the commercialization of SSL, DOE first acknowledges the primary responsibility for commercializing advanced SSL technologies rests with the private sector. SSL system and component manufacturers are best positioned to decide how and when products are brought to market. However, DOE has a commercialization role for SSL, derived from explicit authority given DOE in Sec. 912 of EPLA 2005:

The Secretary [of Energy] shall carry out a Next Generation Lighting Initiative in accordance with this section to support research, development, demonstration, and commercial application activities related to advanced solid-state lighting technologies based on white light emitting diodes.

In addition, SSL commercialization activities are consistent with the 2006 DOE Strategic Plan, which states DOE will,

Work collaboratively with other Federal agencies, private industry, and other countries to accelerate the adoption of technologies capable of substantially reducing global emissions of greenhouse gases and other emissions.

DOE is uniquely positioned to carry out these activities. First, DOE has a large and growing SSL R&D program that provides a strong technical basis from which to develop and implement an SSL commercialization support program (DOE 2009). SSL technology is fundamentally different from conventional lighting technologies. It requires different standards, methods of measurement, product integration, thermal design, optical design, and a range of different approaches for successful lighting application. All this makes a thorough understanding of SSL technology necessary for development and implementation of an appropriate and well-considered commercialization assistance program.

In addition, DOE's experience with a wide range of commercialization methods and programs, especially when coupled with its SSL technical understanding, make DOE the right agency to carry out this program. More specifically, DOE's value in helping commercialize SSL is based, in part, on:

- DOE and the federal government are valued by the public as being providers of unbiased, technically sound information. With the buying public holding a healthy skepticism about vendor product claims, SSL manufacturers value the credibility DOE can bring to this new market.
- DOE's can influence federal purchasing. Many federal agencies look to DOE for assistance and advice on which new energy saving products to investigate and buy. Through FEMP, federal regulations, and a wide range of conferences and technical materials, DOE exerts important influence on what SSL products should be considered for purchase by other federal agencies.
- DOE can provide leadership to the industry, and serve as a focal point to catalyze private activity that competing companies may otherwise be reluctant to engage in. For example, SSL manufacturers now widely credit DOE with having successfully organized the industry into developing a wide ranging set of industry standards and test procedures for SSL application to the general illumination market.
- DOE can facilitate partnerships with a wide range of organizations that can influence the rate at which SSL products are accepted by the market. By working with electric utilities, non-profit organizations, state energy offices, trade associations and others, DOE can rally the assistance of organizations motivated to engage in activities that lead to efficiency improvements and energy savings.
- DOE can use the highly valued and widely recognized ENERGY STAR program to leverage a wide range of activities in support of SSL product commercialization.

DOE's role in SSL commercialization is widely recognized in the lighting industry. DOE entered into a memorandum of understanding with the Next Generation Lighting Industry Alliance (NGLIA) on February 2, 2005, which, among other things, stated NGLIA's intent to cooperate with DOE on developing and implement commercialization support activities such as ENERGY STAR.

DOE's role and value in SSL commercialization was also recognized by the Illuminating Engineering Society of North America (IESNA), with which DOE entered into a

Memorandum of Understanding on July 17, 2006 to enhance, among other things, DOE's SSL commercialization support efforts. The MOA expresses the organizations' plans to work closely together, including an agreement to:

Develop and maintain guides and procedures to assist the lighting community in the photometric measurement of SSL devices and other technologies to support DOE programs (including the development of ENERGY STAR® criteria for solid-state lighting), and to provide consistency and uniformity in photometric reports.

More recently, DOE also entered into a memorandum of understanding with the International Association of Lighting Designers (IALD) on November 10, 2008. That agreement, among other things, states that DOE and IALD will cooperate in:

...developing and disseminating technical information to assist the lighting design community in the assessment and specification of solid state lighting (SSL) and other efficient lighting technologies, to support DOE programs on lighting quality such as ENERGY STAR and SSL Quality Advocates.

Time Frame

This plan addresses the period FY09 – FY13.

Goals

The goals of DOE's SSL commercialization support efforts for the five years covered by this plan are directly related to the purposes of these activities, as described in the above Purpose Section. They are to create and catalyze market conditions, specifications, standards, and market opportunities that, influence products brought to market, accelerate market adoption of SSL products, and achieve energy savings through use of SSL products. Specifically, they are:

(1) **Products Brought to Market:** induce the manufacture and purchase of highly efficient LED luminaires, leading to U.S. market introduction by FY 2013 of *warm white* LED general illumination luminaires achieving at least:

- a. 122 lm/W luminous efficacy¹;
- b. 92 lm/W luminaire efficacy;
- c. 85 CRI (or similar revised color quality metric), and;
- d. at most, 3500 K CCT.

For *cool white* LED general illumination luminaires, at least:

- a. 172 lm/W luminous efficacy;
- b. 129 lm/W luminaire efficacy;
- c. 70 CRI (or similar revised color quality metric), and;

¹ To date, there is no ANSI/IESNA published test procedure for measuring luminous efficacy of LED packages or arrays. Until such test procedures are standardized, DOE will use manufacturer reported values of "typical luminous flux" which are typically measured with LED package temperature at 25° C while power is applied to the device in a brief (milliseconds) pulse.

d. at most, 6500 K CCT.

- (2) **Market Adoption of Products:** accelerate the development of the SSL general illumination market such that high-performance (ENERGY STAR compliant) luminaires achieve sales of 2 million units per year by 2013.
- (3) **Energy Savings:** influence application of SSL luminaires such that electricity savings of at least 638 GWh per year are achieved by FY13.

Desired End State

DOE can be confident that further market support is unnecessary and can justify conclusion of its SSL commercialization support efforts when the U.S. market for high-performance SSL products achieves a state DOE believes will be self sustaining, as defined by the following characteristics:

- (1) **Products Brought to Market:** at least ten 120+ lm/W (luminaire efficacy) *warm white* general illumination luminaires, and at least ten 145+ lm/W *cool white* general illumination luminaires, are offered for sale by major fixture manufacturers (and are available in most major markets through normal lighting equipment sales channels) in each of the following product categories:
Warm White Products: residential recessed downlights, commercial recessed downlights, and commercial office ambient lighting

Cool White Products: pole-mounted roadway luminaires and high-bay luminaires
- (2) **Market Adoption of Products:** high-performance luminaires (ENERGY STAR compliant) comprise 15% of annual sales in the above product categories
- (3) **Energy Savings:** annual U.S. electricity savings of 5 TWh per year²

Market Barriers and Needs Addressed by Plan

Owing to its technical potential for greatly improved performance and greatly reduced costs, the longer-term barriers to market acceptance faced by SSL technology appear modest. Its nearer-term barriers are primarily a consequence of the technology being in its early stages of technical maturation, and its nascent introduction to the market as a general illumination product. As large private and public R&D investments steadily yield large improvements in the technology, SSL is expected by most observers to make its way deeply into the general illumination market. But still at question are how long this market penetration will take, and the extent of resulting energy savings. Accordingly, this plan is focused on near-term market barriers and needs.

² DOE estimates it is technically achievable and economically feasible for SSL to produce U.S. electricity savings of 50 TWh per year by approximately 2015 (DOE 2006).

The primary near-term market barriers faced by SSL general illumination products are:

- High costs relative to competing technologies
- Limited industry standards and test procedures for SSL general illumination products
- Lack of information (for buyers, designers, and lighting fixture manufacturers)

Meeting these market needs can collectively help drive down the costs of SSL by creating near-term market opportunities for SSL, which in turn generates revenue for SSL manufacturers to invest in R&D and lower-cost production. Further, meeting these market needs will help build an industry standards/test procedure infrastructure that is widely recognized and used, allowing manufacturers to characterize their products in terms clearly understood by potential buyers. And last, meeting these market needs helps equip lighting industry professionals, facility operators, lighting specifiers, energy efficiency program sponsors, retailers, and consumers with the information they need to make good purchasing decisions, and to properly apply this new technology.

Market Needs:

- 1) Effective product purchasing and architectural design guidance (to guide buyers and program partners to products that perform well, to provide lighting designers with critical new technology application information, and to help retailers with product selection and merchandising)
- 2) Market visibility for state of the art, commercially available products (to educate the market about the technical potential of the technology in well-designed products)
- 3) Highly visible examples of model SSL general illumination applications (to inform the market about application issues, energy performance and cost effectiveness)
- 4) Market introduction support from energy efficiency program sponsors (to help manufacturers build early sales volume, thereby driving down technology costs)
- 5) Independent performance test results on commercially available products (to help overcome widespread confusion on actual product performance and to encourage manufacturers to use industry standard test procedures as a basis for performance claims)
- 6) Objective, widely available technical information from a credible, respected source (to help fill information gaps and increase understanding of the technology, its attributes, and its limitations)
- 7) Industry standards and test procedures for SSL general illumination products (to enable basic market infrastructure)
- 8) Coordination of local, regional, and federal SSL commercialization activities (to maximize effect of invested public and ratepayer money)
- 9) Independent investigations from credible source of key SSL issues affecting market adoption of SSL
- 10) Coordinated effort among energy efficiency programs to substantially reduce the market risk of introducing very high performance, state-of-the-art, SSL products

Each of the above market needs is used to generate strategy elements for SSL commercialization support, which are discussed in the following section.

Key Strategy Elements

The following key elements collectively are the DOE strategy for SSL commercialization support. They were selected on the basis of:

- Consistency with appropriate federal role
- Expected impact on market development
- Expected impact on potential energy savings
- Expected program costs not exceeding available resources

SSL Commercialization Support 5 Year Plan

Goals: By FY 2013, induce market introduction of general illumination SSL warm white luminaires that achieve 92 lm/W and cool white luminaires that achieve 129 lm/W (luminaire efficacy), facilitate 2 million annual sales of high performance SSL luminaires, and achieve 638 GWh annual energy savings.

Strategy Elements

1) Buyer and Specification Guidance

- a) ENERGY STAR
- b) SSL Quality Advocates
- c) Retailer Outreach
- d) Design Guidance

2) Design Competitions

- a) Lighting for Tomorrow (Residential Fixtures)
- b) Next Generation Luminaires (Commercial Fixtures)

3) Gateway Technology Demonstrations and Procurements

- a) Demonstrations
- b) Technology Demonstration Consortia
- c) Technology Procurements

4) CALiPER Testing Program

5) Technical Information

- a) Technical Information Development and Dissemination
- b) Technical Information Network

6) Standards and Test Procedures Support

7) Coordination/Leadership

- a) Facilitating and Coordinating Local and Regional Efforts
- b) Federal Government Leadership

8) Market Studies and Technology Evaluations

9) Technology Prize Competitions

1) Buyer and Specification Guidance

Market Need: Effective product purchasing and architectural design guidance (to guide buyers and program partners to products that perform well, to provide lighting designers with critical new technology application information, and to help retailers with product selection and merchandising)

a. ENERGY STAR®

www.ssl.energy.gov/energy_star.html

DOE has observed a large number of new SSL general illumination products entering the market in recent years. Based on its knowledge of SSL technology and its own product testing, DOE became concerned that a large number of these products would likely disappoint their buyers due to low energy performance, low color quality, short lives, and other problems. DOE feared a repeat of the early market introduction mistakes that plagued the compact fluorescent lamp market for many years – thus greatly delaying their widespread market acceptance. In addition, DOE recognized that rapid technological progress being made with white, high-power LEDs meant the market could be supplied in the near-term with high performance LEDs capable of providing substantial energy savings, and providing good customer satisfaction. As one of the federal agencies responsible for the ENERGY STAR program, DOE developed ENERGY STAR criteria for SSL general illumination products, with the intent to help steer businesses and consumers to high performance, good quality SSL products. DOE finalized those criteria in September, 2007, and announced they would first take effect on September 30, 2008.

The ENERGY STAR SSL criteria are presently narrow in scope, allowing ENERGY STAR qualification for only a modest number of general illumination applications, such as under-cabinet lighting, task lamps, and recessed downlights. In part, this reflects the limited number of general illumination applications currently appropriate for SSL technology, and in part, reflecting DOE's "go slow" approach to applying ENERGY STAR criteria to general illumination – given the entire lighting industry is in the early stages of learning how best to use this technology for the general illumination market. However, due to the technology's rapid rate of improvement, DOE anticipates quick growth in the number of general illumination applications appropriate for SSL.

Accordingly, DOE has recently updated the original criteria. New technical requirements for an expanded set of lighting applications were finalized in February, 2009, and additional requirements are in various stages of development and adoption as of April 2009. New lighting applications will be added as SSL technology improves.

At some point in the future, approximately three years after finalization of the initial ENERGY STAR SSL criteria, SSL technology will have matured to the point that it will no longer be feasible to base the criteria on individual lighting applications. At that point the technology will be robust enough that specific, application by application criteria are no longer necessary. More general criteria, applying to much broader categories of general illumination products will be substituted to make the criteria more easily managed.

DOE also anticipates the lighting industry will learn about a wide range of SSL application issues as experience is gained with SSL in the general illumination market. Some of these issues may need to be addressed through future changes in the ENERGY STAR criteria. For example, early users of commercial ambient lighting systems may find that a large number of products suffer from significant glare problems due to the very high luminous intensity of high-power LEDs. Such a problem many need to be

addressed through glare mitigation requirements in ENERGY STAR criteria. Consistent with its approach emphasizing both energy efficiency and lighting quality, DOE will add to and expand the scope of its criteria as DOE and the lighting industry become more familiar with the particular challenges of using SSL for general illumination.

As described in Section 5 below (Technical Information), DOE plans to develop and disseminate a wide range of information addressing SSL technology and its appropriate application to general illumination. This informational effort will be closely coordinated with ENERGY STAR, providing timely and useful information to ENERGY STAR partners involved in selling or promoting ENERGY STAR SSL products. Further, DOE will continue to facilitate progress in the development and refinement of industry standard test procedures needed to support the effective deployment of energy-efficient SSL technology. These industry standards underpin the ENERGY STAR program, providing credible, comparable performance measurements on the basis of which products are qualified to carry the ENERGY STAR label. As the SSL industry continues to evolve, encompassing more luminaires, lamp replacements, and modular components, additional or revised industry standard test procedures will be needed. DOE's ENERGY STAR SSL program has and will continue to play a critical role in spurring and informing the standards process; please see Section 6 for more on Standards.

b. SSL Quality Advocates

www.ssl.energy.gov/advocates.html

In early 2008, DOE co-hosted a Lighting Designer Roundtable with IALD and IESNA where there was a great deal of discussion about false claims and misinformation from manufacturers, and participants talked about the need for “more standardized reporting of product performance, standardized cut sheets, a quality stamp.” This feedback was instrumental in guiding the development of a new DOE initiative that launched in December 2008, called Solid-State Lighting (SSL) Quality Advocates.

Jointly developed by DOE and the Next Generation Lighting Industry Alliance (NGLIA), SSL Quality Advocates is a voluntary online pledge program (www.lighting-facts.com) to ensure that LED lighting, as it reaches the market, is represented accurately – whether in product labeling, product packaging, product literature, press releases or manufacturer data sheets. The ultimate goal is to facilitate consumer adoption of this energy-saving technology and avoid some of the mis-steps that plagued market adoption of CFLs.

Central to the initiative is a new, standardized Lighting Facts™ label that can be affixed on LED products, packaging, or literature. The label uses the familiar format of the FDA Nutrition Facts label to provide a quick and simple summary of verifiable product performance data as measured by the new industry standard for testing photometric performance, IESNA LM-79-2008. SSL Quality Advocates is open to all those who manufacture, sell or recommend LED lighting.

DOE efforts will focus on:

- recruiting manufacturers, retailers, distributors and utility groups to take the Quality Advocates pledge and make the Lighting Facts label part of their effort to market and sell quality SSL products.
- verification and monitoring products listed in the program, and
- coordination with the Federal Trade Commission's plans to develop a mandatory lighting label program.

c. Retailer Outreach

After hearing from a number of retailers about the challenges they were facing in making sound decisions on what kinds of SSL products to purchase, how to sort through a tangle of technical information on the new technology, how to educate their customers on the technology, and how to link their retail efforts to DOE's efforts to support the market introduction of SSL, DOE launched a pilot program in 2008 to support retailer introduction of SSL. The pilot program is intended to create a sort of market laboratory, in which DOE, in partnership with retailers, could test a number of market introduction ideas.

DOE plans to expand this support in 2009 with a special outreach initiative targeted at major retailers of LED lighting products. DOE will leverage key lessons from the SSL Market Laboratory to prepare retailers entering the solid-state lighting market. In general, retailers are in a prime position to support the introduction of quality products. Their knowledge of customer preferences and demographics drives their product selection process.

DOE will serve as a resource with a focus on product quality and will offer guidance in product selection as a first step to successful promotion. DOE will also provide consumer messaging and merchandising support. DOE will work with them to ensure that whatever marketing hype is used will match the quality of the products they offer.

d. Design/Purchasing Guidance

Most lighting designers are unfamiliar with SSL technology. Its unique characteristics, flexibility, and appropriate application will take time for lighting design professionals to learn. From DOE's perspective, a very important element of this learning process will be how to apply this technology in a manner that meets lighting quality needs yet maximizes potential energy savings.

As the technology evolves, the range of applications to which it can be appropriately applied will grow, though use of conventional lighting technologies will continue to be more efficient for a number of lighting applications for some time. Helping lighting designers and their customers sort through this complicated terrain will increase the likelihood that the U.S. can attain the early energy savings potential of the new technology.

An attractive starting point for DOE efforts to provide purchasing and design guidance is the Federal sector, where DOE has a lead role in providing technical support to federal agency efforts to reduce energy consumption. An Executive Order announced January 24, 2007 directs federal facilities to reduce energy use by 30 percent by end of FY2015, relative to 2003 levels.³ SSL will potentially play an important role in reaching this goal. Initial outreach by DOE to federal agencies has elicited a high level of interest in demonstrating and evaluating SSL technologies. Early federal sector experience in terms of specific product performance, energy savings in specific applications, product costs and procurement issues, and impact on maintenance and lighting service will be captured, synthesized into guidance documents, and shared with the federal sector through the Federal Energy Management Program, the Inter-Agency Energy Task Force, and the Federal Utility Partnership Working Group.

The guidance documents will be organized by application, for example, task lighting for modular offices, recessed downlighting, or parking area lighting. To be useful to those responsible for selecting lighting technologies for federal facilities (i.e., facility managers, consulting lighting designers, lighting contractors, etc.), the following information is necessary: 1) product performance data based on traceable test procedures and in standard IES photometric file format; 2) cost information, including purchase, installation and service costs; 3) information on in-situ performance, such as results of field testing.

As DOE builds a database of performance information on a variety of luminaire types (through CALiPER), and implements demonstrations in various federal and non-federal facilities, DOE will produce a series of LED design and purchasing guidance documents. This information will be of use and interest not only in the federal sector, but also in the wider lighting design community. Information developed for the federal sector will be provided to the International Association of Lighting Designers (IALD) and the Illuminating Engineering Society of North America (IESNA) for potential incorporation into the documents that produce for their members.

DOE's Building Technology program will work closely with the IESNA and the Federal Energy Management Program to develop appropriate design and purchasing guidance for the federal and private sectors.

2) Design Competitions

***Market Need:** Market visibility for state of the art, commercially available products (to educate the market about the technical potential of the technology in well-designed products)*

a. Lighting for Tomorrow (Residential Fixtures)

<http://www.lightingfortomorrow.com/>

³ <http://www.whitehouse.gov/news/releases/2007/01/print/20070124-2.html>

DOE co-developed a residential lighting fixture design competition in 2002 in cooperation with the Consortium for Energy Efficiency and the American Lighting Association. Lighting for Tomorrow (LFT) added SSL fixtures to the competition in 2006. An application focused competition will replace the CFL component of LFT in 2010. SSL technology, as well as control strategies, will be encouraged in this component of the competition. Special emphasis will be placed on designs that take advantage of the unique characteristics of LEDs, and result in significant energy savings relative to conventional lighting technology.

The competition attracts a substantial amount of attention in the lighting industry, primarily through the lighting trade press. Judging by the volume and quality of press covering the LFT in recent years, the program has very successfully raised the profile and awareness of attractive, well-designed energy-efficient residential lighting fixtures.

DOE plans to continue to cooperate in LFT with its partners, focusing its resources on the SSL component of both the fixture design and application focused competitions. Strategic plans for DOE's role in LFT include:

- expanding the categories of the SSL fixture design component to match categories covered by the ENERGY STAR[®] criteria;
- highlighting luminaire efficacy and potential energy savings, and;
- encouraging the appropriate inclusion of SSL products in the application focused competition.

b. Next Generation Luminaires (Commercial Fixtures)

<http://www.ngldc.org/>

The Next Generation Luminaires (NGL) design competition, focused only on SSL luminaires for the commercial specification market, was launched in 2008 in partnership with Illuminating Engineering Society of North America (IESNA) and the International Association of Lighting Designers (IALD). The evaluation of products by a respected, non-biased judging panel and independent testing according to LM-79 are major components to the competition. The NGL marketing materials highlighting the recognized products are an excellent resource for lighting specifiers seeking quality LED products currently ready for specification.

DOE plans to continue to cooperate in NGL with its partners, focusing its resources on meeting the needs of lighting specifiers in the commercial market. Strategic plans for DOE's role in NGL include:

- expanding the categories of the competition to match categories covered by the ENERGY STAR[®] criteria;
- highlighting luminaire efficacy and potential energy savings, and;
- expanding the competition to include an architectural design component.

To the extent possible, DOE will attempt to link winners of the residential and commercial fixture design competitions with other projects, especially within the DOE portfolio. One example of this would be to explore the potential for using winners from the fixture design competitions in the demonstration/procurement projects discussed below.

3) Gateway Technology Demonstrations and Procurements

www.ssl.energy.gov/gatewaydemos.html

Market Needs: 1) Highly visible examples of model SSL general illumination applications (to inform the market about application issues, energy performance and cost effectiveness), and; 2) market introduction support from energy efficiency program sponsors (to help manufacturers build early sales volume, thereby driving down technology costs)

DOE proposes to conduct two general types of technology demonstrations: those that demonstrate market readiness, and those that evaluate field performance.

a. Demonstrations of Field Performance and Market Readiness

These demonstrations will seek to work with products whose technical risks of use are low and whose performance is high, yet face market resistance simply because they are new and unfamiliar. DOE strives to couple these demonstrations with follow-up activities that lead to significant sales of successfully demonstrated products.

DOE will minimize the risk of unsuccessful demonstrations through careful selection of candidate products and suitable applications, limiting participation to only those situations offering high potential for success. Prior to field installation, DOE will subject candidate products to a range of laboratory tests and technical (e.g., lighting simulation) reviews. Only after receiving acceptable results from these evaluations and tests will DOE proceed with field installations. For selected products, long-term laboratory testing for lumen depreciation will continue in parallel with field tests.

In general for these projects, DOE will:

- identify target products/applications/host sites for demonstrations;
- issue invitations to or accept invitations from suitable candidate participants;
- evaluate proposed products to assess their quality and performance, including verification through laboratory testing;
- conduct laboratory lumen maintenance testing that will run concurrently with field testing;
- identify candidate project hosts who would be highly motivated to follow up a successful demonstration project with significant direct purchases or product promotion;
- install products in host facilities;

- measure and evaluate field performance;
- prepare and issue a project report, and finally;
- use the demonstration to leverage significant follow-up sales and product promotion.

Via the strong linkage with follow-up promotion and sales activity and careful selection of projects with potential for high visibility and impact, DOE intends to achieve more direct market impacts with this type of demonstration project than might be otherwise achieved.

In recognition of the speed with which SSL technology is improving and the resulting short cycles for SSL product improvements, DOE structures its demonstration projects to be as dynamic as possible. Results have a limited shelf life due to rapid obsolescence of performance-related information and thus are needed quickly. Also, to accommodate the widest possible range of projects, the specific details and procedures must be flexible. Each project tends to be slightly different in one or more respects from all others that have preceded it.

b. Technology Demonstration Consortia

For key SSL market segments, DOE plans to establish consortia of demonstration project partners for the purpose of more systematically and regularly guiding, evaluating, and promoting technology demonstrations within target market segments. In general, these consortia will be made up of members with high levels of interest in investigating the field performance of new-to-the-market SSL products. Anticipated activities for these consortia include:

- development of technical specifications for products to be considered for demonstration/promotion;
- joint and individual sponsorship of technology demonstrations;
- sharing of demonstration results among members, including joint evaluations, both prior to and after demonstrations;
- communications to SSL manufacturers
- development of application guidance for SSL products in a market segment
- invited presentations from manufacturers and SSL experts
- development of demonstration project protocols for this market segment

The first such consortium will be established for the large retailers, focusing on a range of lighting products of high interest to that sector. DOE is also considering the creation of consortia to serve public outdoor and roadway lighting. DOE will invite participation from government agencies (local, regional, and state) with high interest in investigating the performance of SSL public outdoor and roadway lighting.

4) Commercial Product Testing (CALiPER Program)

www.ssl.energy.gov/caliper.html

Market Need: *Independent performance test results on commercially available products (to help overcome widespread confusion on actual product performance and to encourage manufacturers to use industry standard test procedures as basis for performance claims)*

DOE conducts a SSL commercial product testing program to serve three purposes: (1) to provide market feedback data to its SSL R&D program, (2) to collect information useful for developing, evaluating and improving standardized test procedures for SSL equipment, and (3) to provide accurate, objective product performance information to SSL buyers.

DOE launched the SSL commercial product testing program in the first quarter of FY07. The program broadly monitors SSL general illumination products available in the market, and identifies products that are high priority targets for testing, weighing a number of factors intended to serve the three purposes of the program described above. Products are purchased and then tested by one of several contractors arranged to assist this program. Tests include a number of electrical, photometric, and colorimetric measurements. Manufacturers of tested products are given an opportunity to comment on test results prior to their finalization. Testing results, summaries, and interpretations are distributed in both hard copy and via the DOE SSL website.

The testing conducted to date has already revealed important technical issues, including power consumption by LED luminaires in the off state, and the need for better definition and standardized procedures for rating the performance of individual LED packages. Issues identified through the testing program will feed into the standards development process and the ENERGY STAR program. As SSL product performance improves, becomes more clearly competitive with traditional technologies, and the industry understanding of SSL testing and performance matures, the CALiPER program will evolve to meet changing needs.

This program will be continued and expanded in the following ways:

- The number of products tested per four month period will be from 20 to 30, subject to budget constraints, product availability, and program needs.
- The program will continue to provide support and/or coordinate testing for other DOE SSL programs (ENERGY STAR, LFT, NGL, Gateway, L-Prize...)
- The program supports linkages with stakeholder groups for understanding testing best practices, credibility, new developments, improvements (independent testing arena, manufacturers, NVLAP and accreditation community, FTC/NEMA/IES, European and International testing arena, purchasing, acquisitions, and distributors, retailers and specifiers, EEPS and utilities...)
- CALiPER monitors, facilitates and provides expert support for pathways to introducing new testing paradigms (new testing techniques, new scopes, extended scopes of SSL product testing...).

- Information developed in the program will be marketed through promotional efforts, wider distribution of program materials, conference exhibits, and linkages with related lighting and energy efficiency programs.
- Reports based on analysis of accumulated test results will be periodically prepared to identify important trends and issues needing consideration by DOE and other entities interested in monitoring the performance of commercial SSL products.
- The CALiPER Guidance Committee representing energy efficiency program sponsors (EEPS), utilities, lighting designers and key industry experts will continue to convene and transition as needed with the SSL market maturation and ENERGY STAR headway.
- As SSL technology and implementations evolve, the focus of CALiPER testing should evolve to encompass new issues such as componentization, substitutability, process control, and OLEDs.

5) Technical Information

www.ssl.energy.gov/technetwork.html

***Market Need:** Objective, widely available technical information from a credible, respected source (to help fill information gaps and increase understanding of the technology, its attributes, and its limitations)*

a. Technical Information Development and Dissemination

DOE will continue to implement a multi-faceted technical information effort whose purpose is to inject high-quality, objective, impactful information into the emerging SSL market such that buyers can make better SSL purchasing decisions. Information materials developed for this effort are primarily oriented toward potential buyers of SSL systems and to the organizations that develop technical information and purchasing guidance for those buyers, such as electric utilities. These materials do not target general consumers. Instead, they are developed for facility managers, energy managers, lighting professionals (such as designers and specifiers), and organizations that develop technical materials for residential and commercial buyers, such as electric utilities.

Included among the technical information to be developed and distributed by DOE will be:

- Fact sheets on key technical issues
- Explanations of SSL technology (technology primers)
- Lighting applications issues unique to SSL systems
- Buying guidance
- Lighting application/design guidance
- Technology demonstration reports
- Selected experience/knowledge base for SSL installations
- Peer-reviewed journal articles
- Trade press articles
- Conference papers and presentations

DOE's technical information is posted on the commercialization support section of DOE's SSL Website. These materials serve participants in the Technical Information Network for Solid State Lighting (TINSSL) and others. Materials posted on the Website are regularly updated and expanded, creating a rich, highly useful collection of technical information. Given the pace of SSL technology development, DOE plans to leverage the Website for "rapid response" to emerging technical, application, and marketplace issues. This would be accomplished through regularly-updated features (e.g., "hot topics," "quick facts," etc.), coupled with Web syndication functionality (e.g., RSS, Atom).

In addition to content pages on the Website, DOE will produce a range of printed technical materials, primarily in the form of two-page fact sheets and other short printed formats that can be downloaded for use by Website visitors, and be distributed at conferences and meetings. A SSL Program booth, under development in FY09, will be used to showcase and share DOE SSL technical information and market introduction support activities (CALiPER, Gateway Demonstrations, Next Generation Luminaires, etc.)

b. Technical Information Network for Solid-State Lighting

To maximize the effectiveness of this effort, DOE relies heavily upon the Technical Information Network for Solid State Lighting (TINSSL), established in FY07 to leverage existing outreach programs in key lighting markets. Creation of the network is based upon the idea that is far more cost-effective and impactful to leverage existing, well-established information channels than to create new ones. Organizations and companies participating in this network include electric utilities, regional market transformation organizations, state energy offices, and other operators of energy efficiency programs.

The network educates participants about SSL technology and key issues in its effective application, serves as a forum for information sharing by SSL program innovators, and helps identify SSL market and technical issues that require DOE's attention. This is a critical step in development of the market in a way that maximizes energy efficiency and quality. TINSSL members meet once per month via conference call and periodically at events such as DOE SSL Market Introduction Workshops, and conferences sponsored by TINSSL members. Members provide feedback to DOE on current and new Technical Information materials and help identify topics for National DOE-sponsored SSL Educational events, which TINSSL sponsors four or more times per year.

Activities to be conducted by TINSSL include:

- Monthly telephone conferences among participants to plan DOE activities, share information on SSL activities among participants, and to review technical information materials developed for participant use;
- Webcasts on selected SSL technical topics, presented by DOE or outside subject matter experts;

- Maintenance and operation of an on-line SSL technical discussion forum, open to TINSSL members, electric utilities, government agencies, energy efficiency consultants, and large buyers;
- Development of technical educational material that can be branded by TINSSL participants and used throughout their own technical information distribution networks;
- TINSSL information resources library, including reports, fact sheets, photos and web links to other relevant information;
- Fact sheet development;
- Development and maintenance of technical information on the DOE SSL website, and;
- Provision of direct technical assistance to TINSSL members, such as review and comment on the technical content of proposed SSL energy efficiency programs

6) Standards and Test Procedures Support

www.ssl.energy.gov/standards.html

Market Need: Industry standards and test procedures for SSL general illumination products (to enable basic market infrastructure)

When DOE initiated its SSL commercialization support efforts in FY06, there were no industry standards or test procedures for SSL general illumination products. Knowing the importance of standards and test procedures for the successful commercialization of the technology, an intensive effort was initiated to organize and support the organizations with responsibilities for developing these standards and test procedures. Much progress has been made since the March 1, 2006 launch of these efforts. As of April, 2009, several key test procedures standards were complete: LM-79 (photometric testing), LM-80 (lumen depreciation testing), C78.377 (chromaticity standard), and RP-16 a (SSL definitions). Several other high priority standards and test procedures are still in development. Additional, next-tier standards and test procedures need to be developed as soon as the initial set of high priority ones are complete.

The primary responsibility for developing these standards and test procedures rests with the industry standards organizations, such as ANSI, IESNA, and UL with input from NEMA, CIE and others, but DOE will offer support for the purpose of speeding standards development and enhancing its technical strength and applicability, and will focus on those standards and test procedures needed to achieve SSL's energy saving potential. DOE plans to continue to support these efforts with national meetings, coordination assistance, technical assistance, Procedure development and review, and laboratory testing.

7) Coordination/Leadership

Market Need: *Coordination of local, regional, and federal SSL commercialization activities (to maximize effect of invested public and ratepayer money)*

a. Facilitating and Coordinating Local and Regional Efforts

A large number of electric utilities, state energy offices, state RD&D organizations, and regional energy efficiency programs operate programs to promote the deployment of emerging energy-efficient technologies. The cumulative program resources available to these organizations greatly exceed those of DOE. However, most of these organizations have not yet developed programs that address SSL. DOE could help catalyze activity among these organizations, first by providing much needed technical information on the technology (which is proposed as part of the SSL Technical Information Network), but also by proposing joint projects, providing opportunities for collaboration, and by convening meetings and conferences.

One of the means through which DOE will achieve this coordination is through annual SSL technology commercialization workshops, conducted in cooperation with local and regional organizations. To date, DOE has held three such workshops, with the first being in Pasadena, CA (in cooperation with Southern California Edison), Boston, MA (in cooperation with the Northeast Energy Efficiency Partnership), and Portland, OR (in cooperation with the Energy Trust of Oregon, Northwest Energy Efficiency Alliance, Bonneville Power Administration, and Puget Sound Energy). DOE plans to continue annual workshops, each time coordinating with local organizations implementing SSL programs.

b. Federal Government Leadership

A key means by which DOE can provide leadership and catalyze activity in other government funded programs is to stimulate SSL adoption within the federal sector. The Buildings Technology (BT) Program needs to work closely with the Federal Energy Management Program for this element. Joint BT/FEMP activities could include collaboration on demonstration projects, educational seminars, presentations at FEMP meetings and conferences, development and distribution of technical materials designed specifically for the federal sector, technical assistance for model projects, and others.

8) Market Studies and Technology Evaluations

www.ssl.energy.gov/publications.html

Market Need: *Independent investigations from credible source of key SSL issues affecting market adoption of SSL*

To support the above strategies, DOE will complete a series of market studies and technology evaluations. These studies will help guide and shape DOE's strategic decisions, and will help inform individual activities. The first study done for this purpose

was, “Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market.” (DOE, 2006b) That study sought to identify lessons learned from the market introduction experience of CFLs, hoping those lessons would be helpful in shaping the market introduction of SSL products. DOE also recently updated its report entitled, “Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications,” which presents research findings for twelve niche markets where LEDs are competing or are poised to compete with traditional light sources, such as incandescent, halogen, fluorescent, neon, and high-intensity discharge (DOE, 2009b). DOE will identify needed studies and evaluations during the course of its program activities. Near-term needs identified thus far include:

- a study to identify the highest value early general illumination applications for organic LEDs (OLEDs), including identification of key market needs for OLED market introduction;
- an study of alternative approaches for incorporating SSL into the LEED certification program operated by the U.S. Green Building Council;
- a forecast of potential U.S. energy savings from SSL used in general illumination applications;
- a life cycle analysis of SSL technology as compared to competing lighting technologies, with particular attention to environmental releases of toxic substances (such as mercury) during product manufacture and final consumer product disposal, and;
- a study of the cost-effectiveness of SSL for specific lighting applications, relative to competing lighting technologies.

9) Technology Prize Competitions

<http://www.lightingprize.org/requirements.stm>

Market Need: Coordinated effort among energy efficiency programs to substantially reduce the market risk of introducing very high performance, state-of-the-art, SSL products.

The Bright Tomorrow Lighting Prize (L Prize™) was established by Congress in the Energy Independence and Security Act of 2007. The legislation directs the Department of Energy (DOE) to award a total of \$20 million in prize money to the first manufacturers able to produce solid state lighting products with the following general characteristics:

60-Watt Incandescent Replacement Lamp

- More than 90 lm/W luminous efficacy
- Less than 10 Watts
- More than 900 lumens

PAR-38 Halogen Replacement Lamp

- More than 123 lm/W luminous efficacy
- Less than 11 Watts
- More than 1,350 lumens

21st Century Lamp

- More than 150 lm/W luminous efficacy
- More than 1,200 lumens

All products are required to have minimum color rendering index (CRI) of 90 and 25,000 hour life. Additional technical requirements will be specified.

Continued rapid advancement in LED technology for general lighting presents the potential for significant electric demand reduction and energy savings, beyond what is possible using today's available consumer lighting products. Currently available compact fluorescent lamps (CFLs) have quadrupled the luminous efficacy (lumens of light per watt of power, lm/W) of incandescent lamps. Yet, for a variety of reasons, CFLs have achieved only about 20% of the general lighting service (GLS) lamp market nationwide. Although fluorescent and high-intensity discharge (HID) are the dominant light sources in commercial settings, incandescent lamps remain common in hotels, restaurants, small businesses, and institutional/government buildings; as well as in applications such as display lighting, portables, and downlights. Incandescent remains the workhorse of residential lighting, valued for its low purchase price, high light output, good color quality, dimmability, reliability, and variety of wattages, sizes, and beam characteristics. The proliferation of downlights in new residential construction has also created a new growth area for incandescent lamps.

Within the next several years, white light LED products are expected to double CFL efficacy. LEDs will address some drawbacks of CFLs, such as slow run-up time and lack of dimming capability, but will have their own limitations and challenges associated with emerging technologies; price is likely to be a major one in the near term.

The L Prize contest was announced in May 2008, following a nine-month program development process led by DOE with intensive collaboration and input from four California-based utilities with extensive lighting energy efficiency program experience and expertise. The resulting program design places energy efficiency front and center, without sacrificing lighting quality or consumer satisfaction. Large volume sales through federal procurement and utility programs are contingent on meeting aggressive energy performance requirements. This places an explicit value on the potential energy savings of LED technology, which may otherwise be undervalued in a market that typically places more value on other lighting attributes. The initial program announcement includes the first two lamp categories identified in the EISA 2007 legislation: the 60W incandescent replacement lamp and the PAR38 halogen replacement lamp. A separate future announcement will include the 21st Century Lamp category.

The L Prize strategy encompasses several key elements:

- Aggressive performance targets for participating products, ensuring that winning products will save energy and meet user expectations for lighting quality.
- Nationwide partnerships with utilities and energy efficiency programs representing tens of millions of consumers and hundreds of millions of program incentive and promotion dollars.

- Partnership with the key federal agencies responsible for lighting procurement for federal facilities nationwide and internationally, including the General Services Administration and the Defense Logistics Agency, as well as the Federal Energy Management Program.
- Extensive product performance evaluation including independently-verified photometric measurement, statistically-valid long term lumen maintenance testing under elevated temperature conditions, stress testing to identify failure modes under a range of extreme conditions, and field assessments conducted by L Prize Partners nationwide to evaluate installed performance and build familiarity with the products.
- Active publicity and communications efforts for the duration of the program, to ensure interest and motivation by lighting manufacturers, success in recruiting new energy efficiency partners, lasting commitment and engagement by partners, extensive recognition for winning products and their manufacturers, and a high level of interest and demand for winning products by consumers and large volume lighting users.

Since the May 2008 program launch, DOE has recruited 20 additional utility partners nationwide (for a total now of 25 partners), and more are expected to join the effort. At least one and possibly two L Prize entries are expected in calendar year 2009. The rigorous testing and evaluation process will take most of a year to complete, but products that pass are likely to enjoy widespread support by energy efficiency programs and demand by large-volume purchasers, including the federal government. The program design stipulates that the first product in each lamp category to successfully complete all testing and evaluation will be deemed the winner of the cash prize in that category. However, up to two additional products in each category may be recognized and promoted through partner programs and large volume procurements.

Future modifications and expansions to the L Prize program may include additional product categories, development of new test procedures, additional program partners, and demonstration and showcase projects.

Task Areas and Their Interrelationships

Each of the strategic elements of the plan described above comprises a task area. Those task areas and their relationships to each other are described here. The task areas are organized to exploit three primary market interfaces, each providing a distinct approach for working with manufacturers, interacting with buyers, and ultimately accelerating movement of high-efficiency products into the market place. These three pathways – Buyer and Specification Guidance (e.g., ENERGY STAR, SSL Quality Advocates, and Retailer Outreach), Design Competitions (e.g., Lighting for Tomorrow), and Gateway Technology Demonstrations/Procurements – are complementary, and collectively provide a comprehensive approach to commercialization support. They are supported by a set of crosscutting task areas that provide a range of important services to the pathways.

Figure 1 illustrates the relationship of the proposed task areas to the SSL program, SSL MYPP goals, market, and each other. As seen, the three market interfaces are the central elements of the commercialization effort. They are positioned at the critical juncture between manufacturers and buyers, leveraging DOE's unique identity, reputation for objectivity, and resources to accelerate the rate at which the market demands high performance SSL devices and the rate at which manufacturers commercialize these products. Positioning DOE's efforts in this manner allows DOE to offer valuable assistance to both manufacturers and buyers, as indicated in the value streams. Likewise, it allows DOE to obtain valuable information and collaboration from buyers and manufacturers. Supported by the crosscutting task areas at the bottom of the figure, the three market interfaces are the primary channels through which the SSL program seeks to influence what manufacturers produce, and what buyers purchase. The distinguishing characteristics of these three market channels are:

Buyer and Specification Guidance (e.g., ENERGY STAR, SSL Quality Advocates, Retailer Outreach) – mass market oriented; unique brand; used to guide buyers to higher performing, energy-efficient products; strong emphasis placed on working with retailers, distributors and energy efficiency program sponsors

Design Competitions (e.g., Lighting for Tomorrow) – industry oriented; unique brands; primarily used to support new product introductions; strong emphasis on aesthetic design to make products attractive to buyers; strong emphasis on collaborating with lighting retailers, fixture manufacturers and lighting professionals

Gateway Technology Demonstrations and Procurements – target market oriented; no branding; supports new product introductions; strong emphasis on collaborating with high volume buyers and energy efficiency program sponsors

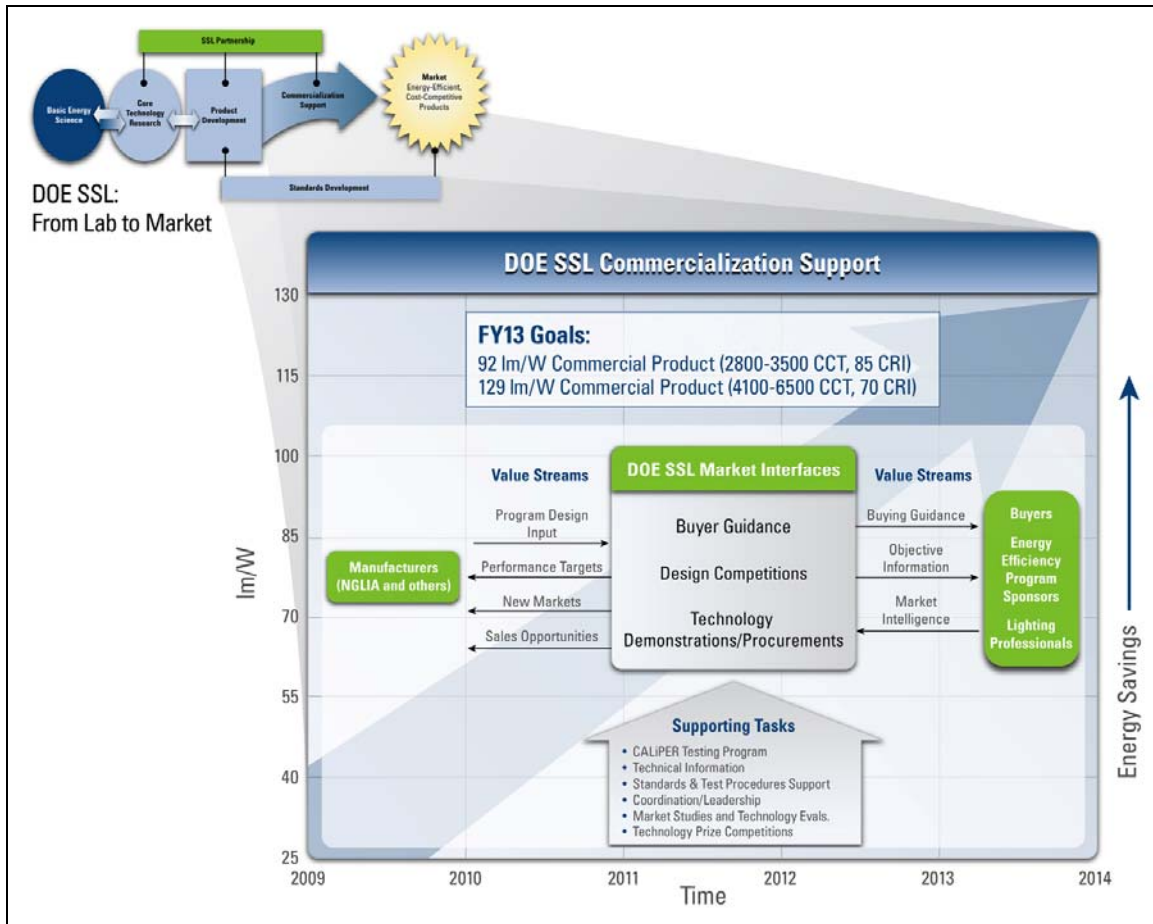


Figure 1. Relationship of task areas to SSL Program, SSL MYPP goals, market, and each other.

The supporting task areas provide valuable services to the above market interfaces, in multiple and interrelated ways:

CALiPER – needed to verify product performance claims, provide consumers with reliable third-party product information, and inform test procedures and standards; supports:

- Buyer and Specification Guidance by providing performance information directly to buyers and those who work with buyers
- Design Competitions by helping judges evaluate products submitted in competitions
- Gateway Technology Demonstrations by providing useful laboratory performance information on products to be tested in field demonstrations

Technical Information – delivers important information into the hands of buyers – and those who influence them – to help them make better purchase decision; supports:

- Buyer and Specification Guidance by providing a range of technical information primarily of use to energy efficiency program sponsors (who use them to develop program designs and materials for their customers) and large facility managers

- Gateway Technology Demonstrations/Procurements by helping large volume buyers in those projects better understand SSL technology

Standards and Test Procedures Support – accelerates development of standards and test procedures that support application of SSL to the general illumination market; supports:

- Buyer and Specification Guidance by helping develop the test procedures and standards that are necessary for ENERGY STAR specifications and design/purchasing guidelines
- Design Competitions and Gateway Technology Demonstrations/Procurements by making possible the standards and test procedures needed to properly evaluate product performance

Coordination/Leadership – helps organize and leverage the substantial resources of the federal government and energy efficiency program sponsors; supports:

- Buyer and Specification Guidance by improving the effectiveness with which energy efficiency program sponsors can use ENERGY STAR
- Design Competitions by expanding involvement in and awareness of design competition results
- Gateway Technology Demonstrations/Procurements by helping identify potential partners for projects and by expanding involvement in and awareness of projects

Market Studies and Technology Evaluation – develops important market and technical information needed for program design, management, and public information materials; supports:

- Buyer and Specification Guidance by helping program managers design their programs and information materials in a manner that reflects the latest market and technology information
- Design Competitions by providing information that needs to be considered each year during the program redesign cycle, such as which lighting applications to include in the competitions
- Gateway Technology Demonstrations/Procurements by helping target the demonstrations at newly emerging lighting applications, and by identifying technical issues that need to be investigated in field settings

Technology Prizes – speeds commercial introduction of advanced, high-performance products; supports:

- Buyer and Specification Guidance by providing additional product options for buyers and specifiers, and by advancing the state of the art in commercially available products
- Design Competitions by “raising the bar,” i.e., by inducing companies to develop better designed and higher performing products for the competitions in a competitive response to the performance thresholds achieved in technology competitions
- Gateway Technology Demonstrations/Procurements by providing additional product options for project partners to consider

Key Issues to be Addressed in Project Development

The preceding section described the key elements of DOE's SSL commercialization support strategy. These elements will be used to guide development of projects that flow from the plan, some of which will be short-term, others may last the entire five year life of this plan. This section identifies a number of high priority issues DOE plans to consider when developing these projects.

1. *Early, low- performing SSL products are likely to cause substantial and lasting market damage. (First impressions are important.)*

As occurred with compact fluorescent lamps and described in the report, *Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market*, early generation, new technology lighting products can cause long-term market damage (DOE, 2006c). Disappointed buyers of those early products are reluctant to try the new technology again, even if it has been improved, and share their disappointment with other potential buyers, both of which can lead to long-term market damage.

2. *High costs*

High quality, high brightness LEDs currently sell at a substantial price premium over fluorescent lighting when measured on a per kilolumen basis. DOE projects this difference will continue to decline rapidly, but will remain higher than conventional cost lighting for many years to come. Lighting equipment buyers, however, don't purchase light sources by comparing per kilolumen costs. They use such measures as simple payback and lifecycle costing. Careful analysis of the economics of using SSL for individual general illumination applications will be necessary to help guide program planning and project designs.

3. *Low color quality/high color correlated color temperature (CCT)*

An oft heard complaint of early generation CFLs was they didn't produce warm light and they made skin color look unnatural. This widely held view didn't die out when warm color, high color quality CFLs became available. Reporters and consumers continue to refer to "harsh, cold fluorescent lighting" as if the technology hasn't changed and by definition, fluorescent means poor quality lighting. A 2006 Wall Street Journal article on CFLs described the persistence of this view, and how it continues to hinder sales of CFLs long after CFLs with good color quality became available in the market.⁴

Similarly, many early versions of LEDs being introduced as general illumination products use high-CCT, low-CRI LEDs because they are more efficacious than their warm white counterparts. These products may be defining LED products to the market for a whole generation of potential users, creating the possibility that like fluorescent

⁴ "Philips Pushes Energy Saving Bulbs: Why this Bright Idea is a Hard Sell," Wall Street Journal, Dec. 5, 2006.

lamps, LEDs will mean cold, unattractive light for a significant number of potential buyers.

4. Incomplete standards, test procedures

One of DOE's first efforts in helping commercialize SSL products was offering its assistance to the SSL industry for developing a number of industry standards and test procedures. As of January, 2009, four key standards and test procedures were complete. The specific procedures selected were identified by DOE and the SSL industry as having the highest priority for early completion. However, a number of other standards and test procedures are still needed, and until they are complete, the industry will continue to encounter problems that limit growth of the SSL industry. Among those still needed are those addressing interconnections between system components, LED device and LED array efficacy, and perhaps test procedures for low-cost methods to measure luminous flux from residential SSL luminaires.

5. Will SSL lead to profligate use of lighting?

LEDs' small form factor, low-voltage circuits, and high durability, as well as high potential to become much less expensive and much more efficient combine to create the possibility of a future in which new applications for lighting become so numerous, and LED lighting so ubiquitous, that SSL technology could in the long run lead to more lighting energy use rather than less.

6. Quick obsolescence

The speed of technology improvement for LEDs creates special challenges for their market introduction. Similar to computer hardware during the 1990s, technological improvements for LEDs are being introduced so quickly that systems become obsolete long before the end of their physical lives. So how important is it for LED systems to have physical lives in the tens of thousands of hours when products being introduced to the market one year or 18 months later may be twice as efficient? Should LED systems have easily replaceable parts knowing that in most cases, users will be better off replacing the entire LED system upon component failure? Should product specifications and standards require physical lives longer than economic lives?

7. Retrofit products

Many of LED general illumination products being introduced to the market are designed to imitate the function of incandescent lamps, and thus could be retrofit into lighting fixtures designed for incandescent lamp use. A large fraction of these products are poorly designed, from both a thermal management and optical perspective. In short, the limitations of current technology present very substantial challenges for designing LED products intended for retrofit into existing fixtures.

But that is likely to change as technology improves. Manufacturers steadily introduce products with much higher maximum operating temperatures than previous LED generations. Products designed with these LEDs face far less challenging thermal management design difficulties, potentially enabling future LED retrofit products that won't need to use the fixture as part of the thermal management system. In addition, the unrelenting pace of efficacy improvement means that LED retrofit products will eventually be so efficient that significant light losses within the fixture may still leave an LED-retrofitted fixture a more efficient option than a fluorescent-retrofitted fixture.

In addition, a lesson learned from the many years of utilities promoting CFL fixtures is also applicable here: While a fixture specifically designed for using CFLs is typically more efficient than an incandescent fixture retrofit with a CFL, consumers have overwhelmingly chosen to retrofit CFLs into existing fixtures rather than buy CFL-dedicated fixtures. Among the reasons consumers choose screw in CFLs over CFL fixtures is they cost less, they like their existing fixtures, and they like the flexibility of being able to revert back to another light source if they don't like the CFL. Many existing fixtures are an important aesthetic part of a living space, and consequently, consumers don't easily part with them. We can expect a similar reaction to new LED fixtures. When faced with the choice of buying a dedicated-LED fixture of high efficiency or retrofitting an LED system into an existing fixture of modest efficiency, we can expect a large fraction of consumers to choose the latter.

9. Commercial vs. residential luminaire emphasis

As indicated in the Purpose, Goals, and End State sections above, DOE plans to strongly emphasize those SSL applications likely to produce significant energy savings. This raises the question of whether to focus efforts on the residential or commercial sector. While commercial lighting dominates U.S. lighting energy use, and thereby represents a much larger potential energy savings target, residential lighting nonetheless represents a significant energy saving opportunity for SSL because:

- incandescent lighting is the dominant light source in the sector, a very inefficient source relative to fluorescent and SSL technology;
- required levels of luminous flux from fixtures is modest due to generally lower ceilings and smaller spaces (which is consistent with the lower flux capabilities of SSL's near-term state of technical development), and;
- SSL's dimming capabilities compete well with fluorescent lighting, the primary energy-efficient alternative to SSL. (Compact fluorescent dimming products tend to be difficult to find in retail stores, are significantly more expensive than non-dimming products, and often don't perform well enough to meet consumer expectations.)

However, the commercial market remains the leading candidate for SSL products because:

- electricity costs are generally higher than in the residential sector, and lighting hours of operation are much longer, making the economics of SSL more compelling;

- commercial customers tend to be more sophisticated lighting buyers, and pay more attention to cost-effective lighting investments;
- labor costs for replacement and maintenance are often monetized, making LED durability and long life more attractive, and;
- commercial customers are generally more receptive to lighting products with higher first costs than other alternatives.

DOE will closely monitor changing economics for both commercial and residential applications, as well as changes in the technology affecting SSL's suitability for various applications. Resources will be focused on lighting applications and projects most likely to maximize potential U.S. energy savings.

10. LED Glare

One of the key advantages of LEDs is the inherently directional nature of their light emissions. Well designed fixtures using LEDs can often avoid or limit the use of secondary optics that contribute to light losses within fixtures, resulting in high luminaire efficacy relative to fixtures that use diffuse light sources. However, fixtures for some lighting applications that take full advantage of this attribute could also cause significant glare problems. If LED luminaires gain a reputation as unacceptably glary, their market acceptance could be greatly slowed.

At present there is no widely recognized method of glare measurement, leaving glare to be subjectively evaluated by lighting professionals. In the development of its projects and work plans, DOE will be mindful of potential glare issues resulting from poor luminaire designed. In addition, it will work with the lighting industry to improve understanding of glare measurement, and possibly support development of objective glare measurements that help LED luminaires steer clear of gaining a reputation for causing glare problems.

Program Communications

DOE's SSL communications goal is to improve marketplace knowledge and awareness of SSL. More specifically, DOE seeks to increase knowledge about the technology's characteristics, appropriate application, and energy and economic performance in order to maximize national energy savings. The target audiences are described below.

- **Supply Side of Market:** R&D technology developers (research institutions, universities, national laboratories); manufacturers; marketers; retailers and distributors
- **Demand Side of Market:** Lighting designers/professionals; big buyers (GSA, DLA, HUD, Army, Navy, hotels, large chains, etc.); end-users (business owners, commercial, property owners/managers, consumers)
- **Partners/Major Enablers:** NGLIA, IES, IALD, utilities, energy efficiency programs, professional trade associations, standards organizations, state energy offices, ENERGY STAR partner networks, municipalities, investors

- **Channels:** Trade press and editors; industry analysts; financial, business, and mainstream press; trade conference organizers

DOE's communications strategies for **Partnerships** and **Education and Outreach** are designed to provide cross-cutting support for the strategic elements outlined in this Plan. Implementation of DOE's communications strategies requires extensive coordination with DOE partners and the DOE SSL team, including DOE Headquarters, the National Energy Technology Laboratory, Pacific Northwest National Laboratory, D&R International, Radcliffe Advisors, Navigant Consulting, and others.

Partnerships

Strategy: Cultivate market transformation partners who share DOE's interest in the energy efficiency benefits of SSL and are willing to invest their resources in education and outreach, demonstrations, incentive programs, and other market introduction efforts.

- **NGLIA:** Provides input to shape research priorities and planning for DOE commercialization support activities.
- **IES:** Collaborates on development of appropriate standards and guides to assist the lighting community.
- **IALD:** Collaborates on DOE commercialization support efforts to improve lighting quality and energy efficiency, with a focus on specifiability.
- **TINSSL:** Increases awareness of SSL technology, performance, and appropriate applications.
- **Demonstration partners:** Showcase high-performance LED products, promote results
- **Utility partners:** Develop programs and incentives to accelerate market introduction of high-quality, energy-efficient, cost-effective LED products.

Education and Outreach

Strategy: Increase awareness of SSL technology status and appropriate applications to foster the emerging market for high-performance SSL products.

- Position DOE as *the* source for credible information to aid market transformation.
- Equip lighting buyers and specifiers with the information needed to choose and apply SSL products successfully.

Strategy: Increase recognition of DOE programs and DOE's role in moving the market toward high efficiency solutions.

- Convene meetings, workshops, and roundtables for targeted audiences to solicit input to guide DOE planning, and to increase awareness of DOE activities and opportunities to participate.
- Increase visibility of DOE in key lighting conferences, industry publications, trade and national press.
- Publicize R&D program goals and successes in order to attract strong, high-quality responses to solicitations.

- Publicize results and analysis from DOE CALiPER testing, GATEWAY demonstrations, design competitions, and other DOE commercialization support activities.
- Create events around demonstrations, awards, new initiatives, major milestones.

Core Tools for Cross-Cutting Communications

- **DOE SSL Website.** Delivers over 300 pages of relevant, up-to-date content on DOE R&D, product testing, demonstrations, and other key activities. DOE plans to expand the website in 2009 to include a new content area with simple, easy-to-digest information on the status of SSL technology, market trends and issues, hot topics, etc. DOE also plans to introduce new web tools for “rapid response” (e.g., an on-line discussion forum) and develop more and different reciprocal links on partner sites (e.g., video, widgets).
- **SSL Updates, Postings.** E-mail based communications from DOE provide ongoing updates on program progress, plus in-depth insights on program developments and market trends. In 2009 DOE plans to utilize more e-mail-based tools such as electronic newsletters for L Prize, TINSSL, etc., providing cross-cutting “nuggets” of information in short, simple, easy-to-digest formats.
- **Meetings, Workshops, Roundtables.** DOE convenes meetings, workshops, and roundtables to provide a forum for education and information exchange on the rapidly evolving SSL market. In addition to the annual R&D and Market Introduction Workshops, DOE plans to host 3 Manufacturing Workshops in 2009. Additional workshops may be planned to convene key audiences for targeted purposes (e.g., regional gatherings of municipalities).
- **DOE Visibility at Other Conferences.** DOE presentations, exhibits, and presence at non-DOE workshops serve to broaden DOE’s reach, educating a wider audience on DOE program activities, market trends, and opportunities to partner and participate. In 2009 DOE plans to increase its visibility at key conferences with a new DOE SSL booth (for Lightfair, GovEnergy, and other key conferences), and acceptance of more (and more varied) speaking invitations (by DOE and DOE representatives).
- **Events.** DOE develops special events as needed, to publicize major program announcements (e.g., L Prize launch), promote high-profile demonstrations, or other major news.
- **Publications/Media Outreach.** DOE’s strategy for publications/media outreach is designed to establish ongoing relationships with target publications and media outlets, to pitch articles and topics for placement, and to respond to requests for articles or information. In 2009 DOE will focus on expanding the target publications and outlets to include more end-user publications and mainstream media.
- **Webcasts.** DOE webcasts provide another vehicle for sharing updates on DOE SSL program developments, industry trends, etc. with a wider audience. DOE webcast plans for 2009 include at least six webcasts on varied topics.
- **Print.** DOE print materials (e.g., R&D Portfolio, Illuminating Ideas, program 1-pagers, technology fact sheets, analysis reports, CALiPER reports, GATEWAY

- **Video.** In 2009, DOE will develop a set of short videos with high-level messages for use at DOE workshops and on the DOE and partner websites.

Performance Measurement

Progress towards the goals of this plan will be assessed using a set of quantitative and qualitative metrics. Measurements will be made on an annual basis. Results from these measurements will be used to update and modify the plan, improving the quality and effectiveness of its activities. These measures will also be used to facilitate early identification of problems so that timely corrections can be made while any issues are still minor.

DOE will seek commitments from its SSL Commercialization Support partners and contractors to work toward the goals of this plan and take responsibility for ensuring satisfactory progress. At a minimum, DOE will pursue commitments from:

- Next Generation Lighting Industry Alliance
- Pacific Northwest National Laboratory
- Akoya, Inc.
- D&R International
- Radcliffe Advisors
- Navigant Consulting

The performance metrics and underlying information for each include:

- 1) Identification and documentation of top-performing general illumination commercialized SSL products
 - Device efficacy (luminous efficacy), luminaire efficacy, CCT and CRI if available from manufacturer; verify with independent laboratory testing
 - Description of intended lighting applications
 - Description of market availability (e.g., where offered for sale, through what channels, evidence of installations, references in lighting media, etc.)
 - Data collected via active monitoring of trade media, manufacturers communications, conference proceedings, laboratory testing, and survey instruments
- 2) Annual sales of ENERGY STAR compliant SSL products
 - ENERGY STAR compliance representing the baseline of high-performance products
 - Voluntary sales reporting from ENERGY STAR manufacturer partners

- Identification of intended lighting application by sales category; these numbers will be compared to sales of conventional light sources for these lighting applications to estimate fraction of sales due to SSL products.

3) Annual energy savings achieved

- Annual energy savings calculated as the difference between energy savings due to a “natural rate” of SSL market adoption and energy savings due to an accelerated rate of market adoption.⁵

Schedule

A schedule of key outcomes, by task, by fiscal year is attached as Attachment A.

Partnerships

DOE has identified the following key partners whose cooperation will be important to successful implementation of this plan. The resources, expertise, and networks these program partners bring to the efforts represented by this plan greatly multiply any market development DOE can achieve on its own.

This plan will be shared with them, and to the extent possible, DOE will seek agreements solidifying their cooperation in helping implement elements of this plan. In addition to many special purpose meetings that will be held with these partners, DOE plans to hold an annual SSL Commercialization Support Workshop whose primary purpose will be to solicit involvement and guidance on projects carried out under this plan, as well as the plan itself. The first of such workshops was held April 23 and 24, 2007 in Southern California. They now occur on an annual basis. In addition to the annual Commercialization Support Workshop, DOE organizes special purpose workshops for targeted interaction with partners, such as the lighting designer roundtable held in collaboration with IALD in Chicago in March of 2008.

Key Partners (not listed in order of priority)

⁵ The “natural rate” of SSL market adoption would occur in the absence of a DOE SSL program. It is not directly measurable, or easily estimated because DOE has already made five years of substantial investments in SSL technology, thus already affecting the rate at which SSL general illumination products are being developed and sold.

Based on findings from a National Research Council evaluation of DOE energy research, DOE is estimating its investment in SSL is accelerating the market adoption of the technology by five years. The natural and accelerated market adoption curves are parallel, but offset by five years. The accelerated rate market adoption curve is deemed to be that curve estimated in a recent DOE energy savings estimate (DOE, 2006). The natural rate adoption curve is deemed to be the accelerated curve, plus five years. DOE will collect market data to support annual updates of its SSL energy savings estimate, using the same methodology used for its 2006 energy savings estimate.

- 1) Federal Energy Management Program
- 2) Energy Efficiency Program Sponsors, especially those which have partnered with the ENERGY STAR program (utilities, energy efficiency organizations, and state agencies)
- 3) Building America
- 4) DOE/BT Market Sector Energy Alliances
- 5) U.S. Green Building Council
- 6) Next Generation Lighting Industry Alliance
- 7) Illuminating Engineering Society of North America
- 8) American Lighting Association
- 9) International Association of Lighting Designers
- 10) National Association of Lighting Distributors
- 11) National Electric Manufacturers Association
- 12) American National Standards Institute
- 13) Underwriters, Inc. Laboratories (U.L.)
- 14) Federal Trade Commission
- 15) National Institute of Standards and Technology
- 16) Commission Internationale de l'Eclairage (CIE)
- 17) L Prize Partners (a growing list of utilities and efficiency programs supporting the L Prize Program (<http://www.lightingprize.org/partners.stm>))
- 18) SSL Quality Advocates Partners (a growing list of manufacturers, retailers and others who pledge use of program principles (<http://lighting-facts.com/default.aspx?cp=partners>))

Attachment A

KEY OUTCOMES BY FY						
		09	10	11	12	13
	Market Interfaces					
	Buying and Specification Guidance					
1.1	Energy Star Criteria	Ver. 1.1, Ver. 1.2	Ver 1.3, Ver. 1.4	Ver. 2.0	Ver. 2.1	Ver. 2.2
1.2	SSL Quality Advocates	100 partners/products	150 products	200 products	Update	Update
1.3	Retailer Outreach	2 Natl Retailers	3 More Natl Retail.	3 More Natl Retail.	N/A	N/A
1.4	Lighting Design Guidance	New Guidance	Update	Update	Update	Update
	Design Competitions					
2.1	Lighting for Tomorrow	09 Comp Winners	10 Comp Winners	11 Comp Winners	12 Comp Winners	13 Comp Winners
2.2	Next Generation Luminaires	09 Comp Winners	10 Comp Winners	11 Comp Winners	12 Comp Winners	13 Comp Winners
	Demonstration/Procurements					
3.1	Technology Demonstrations	10-12 Demos	10-12 Demos	10-12 Demos	10-12 Demos	10-12 Demos
	Demonstration Consortia	1 Consortium	2 Consortia	3 Consortia	3 Consortia	3 Consortia
	Supporting Task Areas					
	CALiPER Testing Program					
4.1	Product Tests	70-80 Tests	80-100 Tests	Self-supt spin-off	-	-
	Special Investigations	4 Investigations	4 Investigations	4 Investigations	6 Investigations	6 Investigations
	Technical Information					
5.1	Technical Information Dev. & Dissemination	Dev/Dissm 15 Prod	Dev/Dissm 15 Prod	Dev/Dissm 15 Prod	Dev/Dissm 15 Prod	Dev/Dissm 15 Prod
5.2	Technical Information Network Mtgs/Coord	Monthly Meetings	Monthly Meetings	Monthly Meetings	Monthly Meetings	Monthly Meetings
	Standards and Test Procedures Support					
6.1	Standards and Test Procedures Support	2 new std/2 update	1 new std/2 update	1 new std/2 update	1 new std/1 update	1 new std/1 update
	Coordination/Leadership					
7.1	Local and Regional	2 joint projects	2 joint projects	2 joint projects	2 joint projects	2 joint projects
7.2	Federal Government	1 major fed action	1 major fed action	1 major fed action	1 major fed action	1 major fed action
	Annual Commercialization Workshops	1 Workshop	1 Workshop	1 Workshop	1 Workshop	1 Workshop
	Market Studies and Technology Evaluations					
8.1	Reports	2 Each	3 Each	3 Each	3 Each	3 Each
	Technology Prize Competition					
9.1	L-Prize		Announce 1st Win.	Announce 2nd/3rd	Sales Target TBD	Sales Target TBD
	Project Management					
10.1	Management	meet proj goals	meet proj goals	meet proj goals	meet proj goals	meet proj goals
10.2	Project Analysis and Planning	as assigned	as assigned	as assigned	as assigned	as assigned
10.3	Progress Measurements	annual report	annual report	annual report	annual report	annual report

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