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Lighting Industry Trends

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Summary

More than 4 billion incandescent light bulbs (sometimes referred to as "lamps") are in use in the United States. The basic technology in these bulbs has not changed substantially in the past 125 years, despite the fact that they convert less than 10% of their energy input into light. Improving light bulb performance can reduce overall U.S. energy use. About 20% of electricity consumed in the United States is used for lighting homes, offices, stores, factories, and outdoor spaces. Lighting represents about 14% of residential electricity use.

The Energy Independence and Security Act of 2007 (EISA, P.L. 110-140) imposed higher efficiency standards for manufacturers and importers of general use, screw-base light bulbs commonly used in residential fixtures, that began January 1, 2012. EISA did not ban incandescent light bulbs. Instead, the law mandated that bulbs manufactured or imported after phase-in dates specified in the bill meet higher efficiency standards—about 25%-30% more efficient on average. The law allows industry to determine which products best meet those requirements. On December 23, 2011, President Barack H. Obama signed the Consolidated Appropriations Act, 2012 (P.L. 112-74). Title III of the law provided FY2012 appropriations for the Department of Energy (DOE), including language barring use of any DOE funds to enforce the lighting standards. That prohibition remains in effect.

Lawmakers have cited several reasons for efforts to delay or repeal the law, including consumer concerns about lack of access to affordable incandescent light bulbs, and reports that companies have shut down incandescent bulb factories because they could not afford to retool to make more efficient products. While DOE predicts that energy-efficient alternatives such as compact fluorescent bulbs (CFLs) and light-emitting diodes (LEDs) will gain a larger U.S. market share after EISA is implemented, it also forecasts that incandescent bulbs will be widely available, and widely used, for years to come. U.S. and foreign manufacturers have developed higher-efficiency halogen incandescent bulbs, available at retailers, that meet the law's minimum standards for 25%-30% electricity savings (compared to 75%-80% savings from CFLs and LEDs) and are competitive in price.

The Obama Administration and major lighting companies oppose efforts to repeal the 2007 law, noting that the industry has invested billions of dollars to prepare for the new standards and develop next-generation lighting. The new light bulb standards are taking effect at a time when the lighting industry, due to advances in LED products that often exceed EISA standards, is undergoing the most sweeping technological changes in decades. The LED industry is producing not just more efficient bulbs, but integrated fixtures that can be specially programmed to emit differing colors and types of light and have other potential applications.

DOE has been funding solid state lighting research projects to bolster the LED industry, which is already the fastest-growing part of the global lighting market. Some analysts project that LEDs will make up at least half the global lighting market by 2020, driven by technical breakthroughs and enhanced demand from energy-efficiency laws in the United States and other nations. Some lighting executives argue that repealing EISA could undercut LED manufacturing efforts, where U.S. companies have a technological edge. The vast majority of the incandescent and CFL light bulbs Americans now use are imported from China and Mexico. China and other countries are investing heavily in LED production.

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Introduction

More than 4 billion incandescent light bulbs (technically referred to as "lamps") are in use in the United States. The basic technology in these bulbs has not changed substantially in the past 125 years, despite the fact that they convert less than 10% of the energy they use into light. Improving light bulb performance can reduce overall U.S. energy use. As much as 20% of the electricity consumed in the United States is used for lighting homes, offices, stores, factories, and outdoor spaces.[1] Lighting represents about 14% of all U.S. residential electricity use.[2]

In the Energy Independence and Security Act of 2007 (EISA, P.L. 110-140), Congress imposed higher efficiency standards for manufacturers and importers of general use, screw-base light bulbs commonly used in residential fixtures, beginning on January 1, 2012.[3] The Department of Energy (DOE) estimates that the federal lighting standards should reduce energy use for lighting per household in 2020 by 33% below the 2009 level.[4] DOE has also estimated that the more energy-efficient bulbs, some of which are estimated to last 10 to 20 times longer than conventional bulbs, could save consumers nearly $6 billion in 2015 alone, when the law is fully phased in—taking into account the initial price of the bulbs, their expected life, and electricity costs.[5]

EISA did not ban incandescent light bulbs. Instead, the law mandated that bulbs manufactured or imported after phase-in dates specified in the bill meet higher efficiency standards—about 25%-30% more efficient on average. The law left it up to the lighting industry to determine what type of product best met those requirements. Energy-efficient alternatives such as compact fluorescent bulbs (CFLs) and light emitting diodes (LEDs) are expected to gain a larger U.S. market share after EISA is implemented, but government estimates project that incandescent bulbs will be widely available, and widely used, for years to come[6] (see **Figure 1**). U.S. and foreign manufacturers have developed higher-efficiency halogen incandescent bulbs, available at many U.S. retailers, which meet the law's minimum standards for electricity savings. The total number

[1] Ines Lima Azevedo, M. Granger Morgan and Fritz Morgan, "The Transition to Solid-State Lighting," *Proceedings of the IEEE*, Vol. 97, No. 3, March 2009, p. 481. The authors estimate that lighting consumes more than 20% of U.S. electricity generated in the United States. Separately, the Energy Information Administration (EIA) estimates that in 2010 lighting in the residential, commercial, and manufacturing sectors accounted for 13.5% of total U.S. electricity use. The manufacturing industry used another 2% of total U.S. electricity production for lighting, based on 2006 EIA figures. EIA, "How Much Electricity is Used for Lighting in the United States?," July 19, 2011, http://www.eia.gov/tools/faqs/faq.cfm?id=99&t=3.

[2] Energy Information Administration, "How Much Electricity is Used for Lighting in the United States?" July 19, 2011, http://www.eia.gov/tools/faqs/faq.cfm?id=99&t=3.

[3] DOE, "New Lighting Standards Began in 2012," http://energy.gov/energysaver/articles/new-lighting-standards-began-2012.

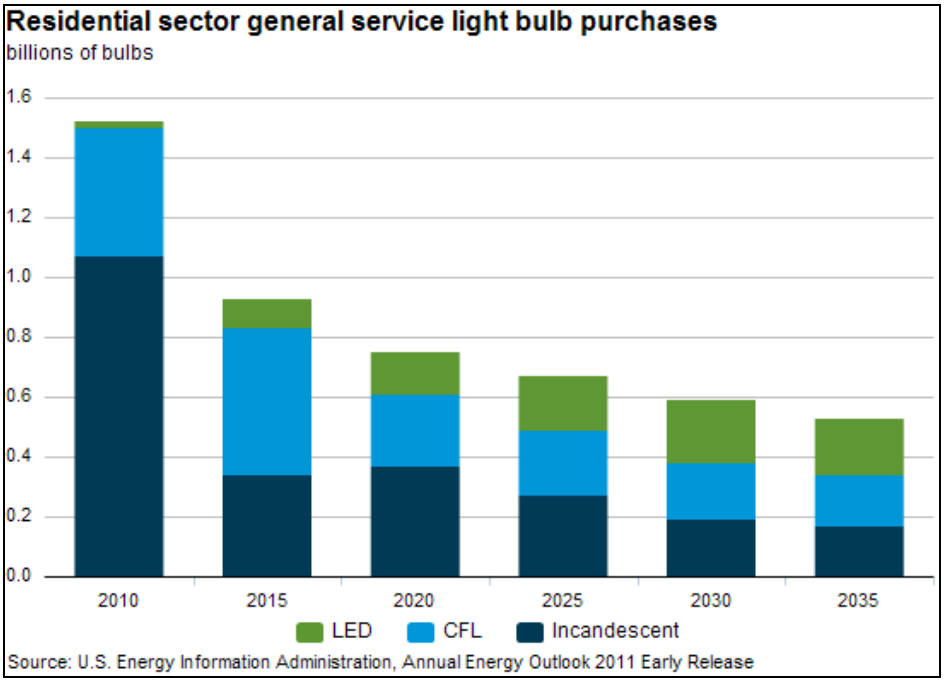
[4] Energy Information Administration, *Annual Energy Outlook 2011*, p. 64 , http://www.eia.gov/forecasts/aeo/pdf/0383(2011).pdf.

[5] Testimony of Kathleen Hogan, Deputy Assistant Secretary for Energy Efficiency, U.S. Department of Energy, Senate Energy and Natural Resources Committee, March 10, 2011, http://energy.senate.gov/public/_files/HoganTestimony03102011.pdf. The DOE analysis assumes light bulbs are on for two hours per day, an electricity rate of $0.11 per kilowatt-hour, and compares a 100-watt incandescent to a 26-watt compact fluorescent bulb. (See also: http://www.eia.gov/todayinenergy/detail.cfm?id=15471, March 19, 2014.)

[6] EIA, "Incandescent Bulbs Still Play a Role in the Future of Lighting," *Annual Energy Outlook 2011 Early Release*, March 23, 2011, http://www.eia.gov/todayinenergy/detail.cfm?id=630.

of light bulbs purchased annually is forecast to decline in future years as technological advances increase the life of the products.

Figure 1. Light Bulb Purchases



Note: LED= Light Emitting Diode; CFL = Compact Fluorescent Light.

The lighting provisions of EISA have created controversy, however. Opponents say the federal government should not mandate the type of light bulbs consumers should buy, or the market should produce.[7] Previous lighting conservation efforts carried out by states and utilities have had limited success, in part, because people have not been satisfied with the quality of light produced by replacement products, mainly compact fluorescent bulbs (CFLs), and have been concerned about the fact that small amounts of mercury are contained in the bulbs.[8] Consumers also have expressed concerns about possible lack of access to affordable light bulbs. The initial cost of CFL or LED bulbs can be substantially higher than conventional incandescent bulbs, even though they are cheaper in the long run due to long life and lower energy consumption. Some companies shut down domestic incandescent bulb factories rather than retool machinery to make more efficient products.[9]

On the state level, Texas Governor Rick Perry in July 2011 signed HB 2510, to allow continued sale, within the state, of incandescent light bulbs produced in Texas even if they did not meet federal standards.[10] South Carolina has been debating similar legislation: a bill was introduced in

[7] Jim Snyder "House Adopts Measure to Halt Light-Bulb Efficiency Law," *Bloomberg News*, June 6, 2012, http://www.businessweek.com/news/2012-06-05/house-adopts-measure-to-halt-light-bulb-efficiency-law.

[8] Pacific Northwest National Laboratory for DOE, *Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market*, June 2006, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/cfl_lessons_learned_web.pdf.

[9] GE, "Driven by Changing Customer Preferences and Legislation, GE Lighting's Incandescent Production Plant in Winchester to Close on September 24," GE Press Statement, September 2010.

[10] Texas HB 2510, http://www.capitol.state.tx.us/BillLookup/Text.aspx?LegSess=82R&Bill=HB2510.

2011 but died in the state Senate.[11] Arizona passed a similar bill in 2010, which was vetoed by Governor Jan Brewer.[12] By comparison in California, which began implementing the EISA standards a year early in January 2011, the California Energy Commission has reported no significant consumer complaints about cost or performance of replacement products.[13] That may be in part because many stores in California still have stocks of traditional incandescent bulbs, purchased before the new standards went into effect.[14]

The House, by voice vote on July 15, 2011, passed an amendment offered by Representative Burgess to the FY2012 Energy and Water Development Appropriations Bill (H.R. 2354, Amendment 29) to prohibit DOE from using funding to implement and enforce the incandescent light bulb standards.[15] On December 23, 2011, President Barack H. Obama signed the Consolidated Appropriations Act, 2012 (P.L. 112-74). Title III provided FY2012 appropriations for DOE, including identical language to the Burgess amendment that bars the use of any FY2012 DOE funds to enforce the standards.[16] Continuing resolutions for FY2013 and FY2014 kept the prohibition intact. For FY2015, the same prohibition was adopted into the House-passed Energy and Water Development Appropriations bill (H.R. 4923).[17]

The DOE enforcement amendment may have only limited impact. The EISA provisions remain in effect. Executives of major lighting companies have said they will comply with the 2007 statute.[18] Further, the funding limitation does not appear to curtail the ability of the FTC or state attorneys general, for example, to enforce provisions of the law.[19]

Major lighting industry executives argue that outright repeal of the lighting provisions of EISA could undercut energy conservation efforts as well as efforts to manufacture next-generation products such as LEDs, where U.S. companies have a technological edge. Indeed, the standards are taking effect at a time when the lighting industry is undergoing another, revolutionary change. Venture capital is flowing into companies in the United States, and abroad, that are developing LED products. LEDs are not only more energy-efficient—most exceeding standards in EISA—but they allow the industry to devise integrated fixtures that can be specially programmed to emit differing colors and types of light for various needs. The technology also has potential for

[11] H. 3795, South Carolina General Assembly, http://www.scstatehouse.gov/sess119_2011-2012/bills/3735.htm.

[12] *Associated Press*, "Brewer vetoes bill picking light-bulb fight," May 11, 2010, http://www.azcentral.com/news/election/azelections/articles/2010/05/11/20100511arizona-light-bulb-bill.html.

[13] Personal communication of Sue Kirchhoff, with staff of California Energy Commission, 2011.

[14] Observation is based in part on spot visits of California retailers by Ecos Consulting, 2011.

[15] In addition, a separate bill, the Better Use of Light Bulbs (BULB) Act of 2011 (H.R. 2417), would have repealed the higher standards for general service incandescent bulbs. The House considered the measure under Suspension of the Rules on July 12, 2011, but did not garner the two-thirds majority needed for passage.

[16] For more information see CRS Congressional Distribution Memorandum, *The Burgess Amendment to H.R. 2354: Potential Impacts on DOE Enforcement and Broader Implementation Aspects of Incandescent Lighting Equipment Efficiency Standards*, by (name redacted), Suzanne Kirchhoff, and (name redacted) (available from (name redacted)).

[17] http://www.congress.gov/cgi-lis/query/R?r113:FLD001:H56069,H56068

[18] National Electrical Manufacturers Association, "NEMA Reiterates that Lightbulb Efficiency Standards Remain, Consumers Retain Diverse Options for Efficient Lightbulbs," December 16, 2011, http://www.nema.org/media/pr/20111216a.cfm.

[19] For more information see CRS Congressional Distribution Memorandum, *The Burgess Amendment to H.R. 2354: Potential Impacts on DOE Enforcement and Broader Implementation Aspects of Incandescent Lighting Equipment Efficiency Standards*, by (name redacted), Suzanne Kirchhoff, and (name redacted) (available from (name redacted)).

communications and other applications.[20] The LED industry already is the fastest-growing part of the global lighting market, propelled by technological breakthroughs and higher demand spurred in part by energy-efficiency laws in the United States and other nations.[21] Some analysts project that LEDs could make up about half the global lighting market by 2020.[22]

The Obama Administration opposed efforts to repeal EISA,[23] noting that the industry has invested to prepare for the new standards and to develop next-generation lighting. Through various research and development, loan, and grant programs, DOE has invested millions of dollars into building the domestic LED manufacturing industry, noting that the U.S. lighting industry has lost "most, if not all, of its incandescent and CFL manufacturing to Asian countries in the last two decades," because it could not match production costs and other incentives offered by foreign governments.[24] With the industry looking past existing technologies such as CFLs and halogen bulbs, LEDs present new U.S. manufacturing possibilities. LED technology already has reached a point where large and small manufacturers have access to investment capital and competition is fierce, but public policy could play an important role by stimulating demand, and providing research and development and startup assistance.[25]

The Energy Independence and Security Act of 2007 (EISA)

EISA imposes higher efficiency standards for manufacturers and importers of screw-base light bulbs. On January 1, 2012, higher standards took effect for 100-watt bulbs. Tighter standards for 75-watt bulbs followed on January 1, 2013, and for 60- and 40-watt bulbs on January 1, 2014 (see **Table 1**).

Table 1. Energy Independence Act Light Bulb Performance Standards

Electricity Use in Current Bulbs (Watts)	Future Performance Standard (Watts)	Light Output Range (Lumens)	Effective Date
100	72	1,490-2,600	1/1/2012
75	53	1,050-1,489	1/1/ 2013
60	43	750-1,049	1/1/ 2014
40	29	310-749	1/1/ 2014

[20] Susan Walsh Sanderson, Kenneth L. Simons, Judith L. Walls, and Yin-Yi Lai, *Lighting Industry: Structure and Technology in the Transition to Solid State*, Alfred P. Sloan Foundation, Industry Studies, May 2008, http://web.mit.edu/is08/pdf/Lighting%20to%20distribute%2010Apr2008.pdf.

[21] Lighting Science Group, "Lighting Science Group's CEO Asks Congress Not to Roll Back Light Bulb Energy Efficiency Standards," Press Release, July 11, 2011, http://files.shareholder.com/downloads/LSGP/1338555355x0x481602/6f01794e-aa30-4645-9eef-5a3ea1471c6b/LSCG_News_2011_7_11_General_Releases.pdf.

[22] Camcord Genuity, "Update to the Third Cycle, Revised Forecasts of the LED Lighting Market and Global Supply-Demand Analysis," August 8, 2011.

[23] Office of Management and Budget, "Statement of Administration Policy, H.R. 2417 – Better Use of Light Bulbs Act," July 11, 2011, http://www.whitehouse.gov/sites/default/files/omb/legislative/sap/112/saphr2417h_20110711.pdf.

[24] DOE, "Keeping Manufacturing in the United States," Summary of 2010 SSL Manufacturing R&D Conference in San Jose, CA, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_whitepaper_july2010.pdf.

[25] Susan Walsh Sanderson, Kenneth L. Simons, Judith L. Walls, and Yin-Yi Lai, *Lighting Industry: Structure and Technology in the Transition to Solid State*, Alfred P. Sloan Foundation, Industry Studies, May 2008, http://web.mit.edu/is08/pdf/Lighting%20to%20distribute%2010Apr2008.pdf.

Note: A lumen is a unit used to measure the amount of light passing through a given area per second.

While the law requires firms to cease producing or importing bulbs that do not meet the higher standards on the effective dates, it does not preclude manufacturers or retailers from selling existing inventory.

EISA also set standards for bulbs used in candelabra and so-called intermediate base bulbs (such as refrigerator and oven bulbs). At the request of industry, DOE announced a delay enforcing higher standards for those products by one year, to January 1, 2013.[26] Another 22 types of bulbs are exempt from higher standards, including three-way light bulbs and black lights.[27] Consumers could use some of these exempt bulbs as replacements for traditional incandescent bulbs (see **Appendix**). In addition, DOE in 2009 issued higher efficiency standards for fluorescent tube lighting, commonly used in retail and industrial establishments, and incandescent reflector bulbs, which took effect in July 2012.[28]

EISA directed DOE to initiate a rulemaking by January 1, 2014, to review and determine whether more stringent standards should be set for general service, screw-in light bulbs, which would take effect in 2020.[29] The law requires DOE to consider using a minimum efficiency level of 45 lumens per watt, which could require general service bulbs to be at least 70% more efficient than existing incandescent bulbs.[30] Most CFLs and LEDs already meet that standard.

The lighting industry has geared up to meet the first-tier standards, which began nationally in January 2012. Many of the higher efficiency screw-in bulbs available to consumers generally carry higher retail prices than conventional incandescent bulbs, though there is considerable variability among products. Consumers could save significant money over the life of many higher efficiency bulbs, however, because they use less electricity than incandescent bulbs and could last far longer than the bulbs they will replace. Nevertheless, high initial cost remains a concern for many consumers.

Several existing technologies would meet the EISA standards:

- Halogen incandescent bulbs. A more efficient version of the standard bulb, this bulb contains a tungsten filament like a standard incandescent, but also a halogen gas capsule that allows it to emit more light with less energy. Halogen incandescent bulbs are about 25% more energy-efficient than traditional

[26] "DOE Guidance Concerning Enforcement of EISA Standards for Candelabra Base and Intermediate Base Lamps," July 1, 2011.

[27] The Energy Independence and Security Act requires DOE to monitor sales of these exempted bulbs. If any one of these exempted bulbs doubles in sales, DOE will be required to establish an energy savings standard for the product. This provision is designed to prevent exempted bulbs from taking market share from bulbs affected by the efficiency standards.

[28] DOE, 10 CFR Part 430, Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule, *Federal Register*, July 14, 2009, http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf.

[29] EISA, Section 321(a)(3)(A)(ii). P.L. 110-140, 121 STAT 1579. As of August 20, 2014, DOE had not initiated a proposed rulemaking to address this requirement.

[30] John Lippert, Energy Enterprise Solutions – EERE Contractor, *A Bright Idea: New Efficiency Standards for Incandescent and Fluorescent Lights*, http://www.eereblogs.energy.gov/energysavers/post/A-Bright-Idea-New-Efficiency-Standards-for-Incandescent-and-Fluorescent-Lights.aspx.

incandescent bulbs, according to DOE.[31] The bulbs retail on average for about $1.50 each, compared to about 50 cents for an existing incandescent bulb. While the bulbs are more efficient, and some can last three times as long as traditional incandescents, others last only about as long as standard incandescent bulbs.[32] According to one analysis, the total cost of halogen incandescent bulbs may be equivalent to that of regular incandescent bulbs over the total life of the product.[33] Other analyses predict a small savings if retail prices for the bulbs decline.

- Compact fluorescent bulbs work by exciting electrons that strike phosphorus coatings. CFLs are about 75% more energy-efficient than traditional incandescent bulbs and burn an estimated 10 times as long.[34] The CFLs have been around for decades, but have had difficulty gaining consumer acceptance because of complaints they emitted a harsh light, did not last as long as advertised, and were bulkier than incandescent bulbs.[35] The bulbs contain traces of mercury, making disposal more difficult, though a number of retailers such as Home Depot recycle the product. The industry has improved CFLs, giving them a more traditional shape and warmer color of light, and has made some that are compatible with dimmable fixtures. CFLs can cost from $0.50 each in a multipack in a big box store to $9.99 in a single pack in an office supply store.[36] Given their lower cost of operation and longer life, consumers could see a payback on the multipack CFL purchase price in less than a year and save $50 over a 10,000-hour life of a bulb.
- Light-emitting diodes, or solid-state lights, produce light when a current is passed through a semiconductor material. Viewed as a major breakthrough in lighting technology, LEDs are estimated to produce 75%-80% energy savings compared to traditional incandescent bulbs. LEDs can have an estimated lifetime of 50,000 hours or more, though durability varies depending on room placement, ambient temperature and other factors.[37] Some LED products such as under-cabinet and Christmas tree lights are readily available in lighting and hardware stores. But LEDs have not yet made major inroads as replacements for incandescent screw-in bulbs due to their higher cost and a dearth of higher-wattage products. LEDs

[31] DOE, "Lighting Choices to Save You Money," http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=11975.

[32] Ibid.

[33] D & R International for DOE, *Lighting Facts, Product Snapshot: LED Replacement Lamps*, May 2011, p. 14, http://www.lightingfacts.com/downloads/LF_Product_Snapshot_May_2011.PDF.

[34] DOE, "Lighting Choices to Save You Money," http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=11975.

[35] Pacific Northwest National Laboratory for DOE, *Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market*, June 2006, p. 2.1, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/cfl_lessons_learned_web.pdf.

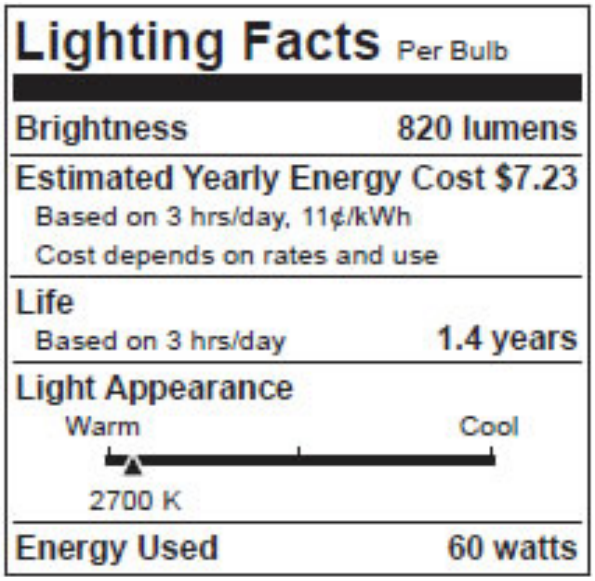
[36] D & R International for DOE, *Lighting Facts, Product Snapshot: LED Replacement Lamps*, May 2011, p. 14, http://www.lightingfacts.com/downloads/LF_Product_Snapshot_May_2011.PDF.

[37] John W. Curran, "LED Lighting: A Class of Cultures, Presentation at National Building Museum," September 8, 2011, http://www.ledtransformations.com/nbm. LEDs tested at a 55 degree Celsius ambient temperature lasted nearly twice as long as those tested at an 85 degree temperature. Further, LEDs, unlike incandescent bulbs do not simply cease producing light at a certain point. Rather they produce less light over time, with the lifetime of an LED defined as the point at which it produces 70 percent of the original value of the light emitted.

designed to replace conventional light bulbs can cost up to $20 per bulb, though prices are falling rapidly. In the summer of 2014, Home Depot carried a $20 screw-in LED that is the equivalent of a 100-watt bulb.[38] Similarly, 60-watt equivalent bulbs were selling for $16 and 40-watt equivalent bulbs were selling for $14.[39] In terms of reduced cost of operation, LEDs would have to fall to near $5 per bulb for consumers to see a payback in less than a year.[40]

Retailers and DOE are providing consumer information about the replacement bulbs, as are the media.[41] EISA directed the Federal Trade Commission to examine the effectiveness of light bulb labeling. In response, the FTC crafted a new packaging label for light bulbs.[42] The label, which resembles the nutrition label on food, includes information on brightness, the estimated yearly cost of using the bulbs, the expected life of the product, the color of light produced and the mercury content, if any. The labels, as well as second-tier standards to be issued in 2020, focus on lumens—a measure of brightness—rather than wattage, which is a measure of energy use (see **Figure 2**).

Figure 2. Federal Trade Commission Label



Source: Federal Trade Commission.

Some analysts note that the FTC label does not readily help consumers compare wattage on new products to former products, which would allow them to more easily buy an efficient bulb that is equivalent to an incandescent 60-watt bulb. Current bulbs can also emit a dimmer light than the

[38] Purchased in Hyattsville, MD, July 2014; and in Oxnard, CA, August 2014.

[39] "Cree LED Bulb with Industry's Best Color Quality Now Available Nationwide," Press Release, May 6, 2014, http://www.creebulb.com/News/Release_2014_05_06.

[40] D & R International for DOE, *Energy Star CFL Market Profile: Data Trends and Market Insights*, September 2010, p. 14, http://www.drintl.com/Data/Sites/1/downloads/publications/2010_cfl_market_profile.pdf. LEDs can degrade faster than advertised in higher-heat applications.

[41] Bob Tedeschi, "Almost Time to Change the Bulb," *New York Times*, August 11, 2011.

[42] Federal Trade Commission, 16 C.F.R. Part 305, Appliance Labeling Rule*, Federal Register,* Vol. 75, No. 137, July 19, 2010, http://www.ftc.gov/os/2010/06/100719appliancelabelingrule.pdf.

bulbs they are replacing because of the lumens range allowed in the regulations.[43] Some analysts worry that consumers will trade up to a higher wattage-equivalent bulb to increase brightness, undercutting potential energy savings of the law.[44]

U.S. Lighting Industry

The Energy Information Administration estimates that, in 2010, residential and commercial consumers used about 507 billion kilowatt-hours (kWh) of electricity for lighting—about 13.5% of total U.S. electricity consumption. Residential lighting consumed about 207 billion kWh, or about 14% of all residential electricity use. Commercial users, which include commercial and institutional buildings and public street and highway lighting, accounted for nearly 300 billion kWh, or about 22% of commercial electricity consumption. In addition, EIA's most recent data indicate that manufacturing lighting was about 2% of total U.S. electricity use in 2006.[45]

Incandescent bulbs have traditionally been used for about 85% of household lighting.[46] In the office, commercial, and industrial sector, however, the majority of light is provided by fluorescents—mainly the long tubes found in ceiling fixtures.[47] Overall, in 2009 conventional incandescent bulbs provided about 12% of the total light delivered in the United States.[48]

The $11 billion U.S. lighting industry[49] includes companies that produce light bulbs, component parts, and light fixtures for residential, commercial, and industrial use. Major international companies manufacturing lighting or lighting components in the United States include Philips Lighting, GE, and Osram Sylvania. (For information on LED manufacturing see "Next-Generation LEDs.") Prominent lighting fixture and equipment manufacturing companies[50] include Hubbell Lighting,[51] Cooper Lighting,[52] Juno Lighting Group,[53] and Acuity Brands.[54]

[43] Chris Cawell, Ecos, "Lighting Portfolio Planning and Efficiency Programs: Advanced Session," Power Point Presentation, 2010.

[44] Conservation with Ecos Consulting, September 20, 2011.

[45] Energy Information Administration, "How Much Electricity is Used for Lighting in the United States?" July 19, 2011, http://www.eia.gov/tools/faqs/faq.cfm?id=99&t=3.

[46] DOE, Incandescent Lighting, http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12120.

[47] Navigant Consulting for DOE, *Solid-State Lighting Research and Development*, March 2009, p. 39, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2009_web.pdf.

[48] Ibid.

[49] Census and BLS data on shipments for 2010. The data do not include LEDs which are categorized in U.S. economic data as semiconductors rather than light bulbs.

[50] Vrinda Bhandarkar, Strategies Unlimited, *World Status of SSL Manufacturing*, Power Point Presentation, DOE Manufacturing Workshop, San Jose, California, April 21, 2010,

http://www.scribd.com/doc/33881071/LED-Lighting-Analysis-from-Duke-Center-on-Globalization-Governance-and-Competitiveness.

[51] Hubbell Lighting Inc., http://www.hubbelllighting.com/.

[52] Cooper Lighting, http://www.cooperindustries.com/content/public/en/lighting.html.

[53] Juno Lighting Group, http://www.junolightinggroup.com/.

[54] Acuity Brands, http://www.acuitybrands.com/Home.aspx.

The National Electrical Manufacturers Association (NEMA) in 2010 estimated there were 12,000-14,000 U.S. jobs in light bulb manufacturing, marketing, and research and development.[55] The U.S. lighting industry—including light bulb, component, and fixture production—has shrunk, both in output and employment, during the past several decades due to heightened competition from abroad, including lower-cost production in China and Mexico (see **Table 2**).

Some companies, such as GE, have closed U.S. factories that made incandescent bulbs due to global competition, changing federal and state energy standards, and other factors that rendered the plants obsolete.[56] The consolidation has been occurring for some time. GE announced in 2007 that it would close a number of plants in the United States and Brazil.[57] The company noted in its announcement that demand for traditional incandescent bulbs had been falling for years: "The market for traditional household incandescent light bulbs has declined by half over the past five or so years, according to data from the National Electrical Manufacturers Association. This has created considerable overcapacity, rising costs and inefficiencies across our manufacturing system."[58]

At the same time large lighting manufacturers are closing facilities, some are opening or refitting others to manufacture more competitive products. Osram Sylvania, which has U.S. facilities in New Hampshire, Illinois, Pennsylvania, and Kentucky, has refitted a factory in St. Marys, PA, to make halogen incandescent bulbs. GE closed plants in North Carolina and Virginia, but has invested $60 million to expand a facility in Ohio, including increasing fluorescent lighting production.[59] GE and Philips are making some components for halogen incandescent bulbs in the United States. It is not possible from publicly available data to determine all the factors contributing to manufacturers' decisions to close certain production facilities, but lighting standards appear to be only one issue.

[55] Information from NEMA.

[56] GE, "Driven by Changing Customer Preferences and Legislation, GE Lighting Incandescent Production Plant in Winchester to Close on September 24," Corporate Press Statement, September 2010.

[57] *Bloomberg News*, GE to Cut About 1,400 Lighting Jobs in U.S., Brazil, October 4, 2007.

[58] Ibid. One of the last U.S. independent, incandescent U.S. light bulb producers is American Light Bulb Manufacturing of Mullins, SC, which employs 14 people. Company officials say they cannot afford to retool to meet the new federal standards, and have been searching for grant money to make the transition to more energy-efficient products. There are other U.S. firms producing specialty incandescent products, such as rough service bulbs or heat lamps, that are exempt from the new standards.

[59] GE, "GE Lighting Invests More Than $60 Million to Expand Manufacturing of Energy-Efficient Lighting Products in Bucyrus, Ohio," Press Release, October 1, 2010, http://www.genewscenter.com/Press-Releases/GE-Lighting-Invests-More-Than-60-Million-to-Expand-Manufacturing-of-Energy-Efficient-Lighting-Products-in-Bucyrus-Ohio-2b5b.aspx.

Table 2. U.S. Lighting Industry

Figures Include Light Bulbs and Fixtures

Year	Employment	Gap Between U.S. Lighting Exports and Imports
1990	80,800	-$1.1 Billion
2001	84,800	-$4.2 Billion
2010	45,700	-$6.1 Billion

Source: Bureau of Labor Statistics, Census Bureau, International Trade Administration.

Notes: Out of the overall lighting industry employment total, the number of U.S. workers making light bulbs and light bulb components declined from 18,000 in 2001 to about 9,000 in 2010. The light bulb category includes general use bulbs for home fixtures, as well as Christmas tree lights, specialty lighting, and commercial and manufacturing lights.

Most of the incandescent and CFL bulbs used in the United States are imported. Light bulb imports, as a share of U.S. consumption, more than doubled from 1989 to the mid-2000s, according to one analysis.[60] The United States in 2010 imported $6 billion more in lighting products than it exported,[61] with China accounting for 65% of imports, while Mexico was second with 13%.[62]

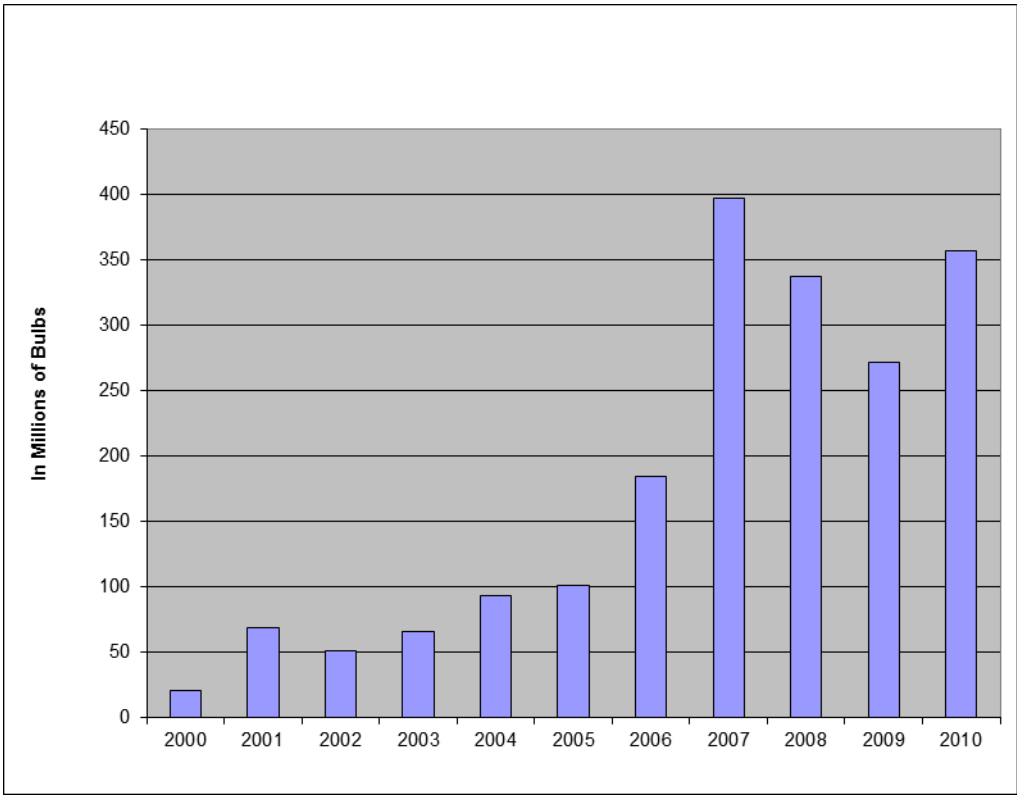
[60] Susan Walsh Sanderson, Kenneth L. Simons, Judith L. Walls, and Yin-Yi Lai, *Lighting Industry: Structure and Technology in the Transition to Solid State*, Alfred P. Sloan Foundation, Industry Studies, May 2008, p. 5, http://web.mit.edu/is08/pdf/Lighting%20to%20distribute%2010Apr2008.pdf.

[61] International Trade Administration data.

[62] International Trade Administration data.

Figure 3. U.S. Compact Fluorescent Bulb Imports

Millions of Bulbs



Source: Global Trade Atlas, Ecos Consulting.

Between 1996 and 2007, Chinese production of CFLs rose 30-fold, making it the world leader in production and exports.[63] China's rapid expansion has led to questions about quality, with U.S. Agency for International Development working with China on product and safety quality controls such as more stringent oversight, heightened control of hazardous substances such as mercury, and better supervision of product distribution.[64]

Separately, there is a significant public-private partnership underway to encourage U.S. LED manufacturing (see "Next-Generation LEDs").

EISA was intended to both improve energy efficiency and rationalize manufacturing by setting uniform, national light bulb standards. The NEMA, which represents 95% of U.S. lighting manufacturers, in 2007 testimony to the Senate Energy and Natural Resources Committee,[65]

[63] USAID/Asia, *Quality Control and Market Supervision of Compact Fluorescent Lamps in China*, 2010, p. 1, http://usaid.eco-asia.org/programs/cdcp/reports/quality-supervision-cfl-china.pdf.

[64] Though most CFLs are imported, linear fluorescent bulbs (long tubes common in ceiling fixtures in stores and offices) are made domestically, in part because they are prone to breakage during shipping.

[65] National Electrical Manufacturers Association, Testimony to the Senate Committee on Energy and Natural Resources, September 12, 2007, http://www.nema.org/gov/energy/positions/upload/NEMA%209-12-07%20Testimony1.pdf#xml=http://search.nema.org/texis/search/pdfhi.txt?query=light+bulbs&pr=nema.org&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&rdepth=0&sufs=0&order=r&cq=&id=4b4d834a2b. The Lamp Section of NEMA represents 15 companies that sell over 95 percent of light bulbs, known in (continued...)

endorsed the light bulb proposals, saying that federal standards were needed to keep the industry competitive and to limit uncertainty as states and foreign governments moved to impose higher efficiency standards. The group pointed out that Connecticut, Rhode Island, California, and Nevada were among states that at that time were considering laws or regulations to impose more stringent, and possibly conflicting, lighting energy-efficiency standards. California in 2007 passed AB 1109, which requires a 50% increase in efficiency for residential general service lighting by 2018. In addition to state activity, Australia, the European Union, and Canada are among countries and regions that have upgraded lighting standards,[66] another factor shifting world production toward more efficient products. NEMA reaffirmed its support for the federal law in March 2011 testimony to the Senate Natural Resources and Energy Committee.[67] While some other industry officials voiced support for the light bulb standards at that hearing, a longtime lighting designer opposed the standards, saying the energy savings would not be as high as forecast, consumer costs could rise, and the law took away consumers' freedom of choice.[68]

Energy Savings and Consumer Acceptance

DOE predicts that the lighting provisions of EISA will reduce energy use and provide cost savings to consumers. U.S. primary energy consumption could fall by 21 quadrillion British Thermal Units (BTU) and greenhouse gas emissions could decline by 330 million metric tons over the next 30 years.[69]

Those forecasts depend on factors including consumer choice of bulb, which in turn depends on variables like purchase price and product satisfaction. Other considerations in terms of total energy savings include whether more efficient bulbs are placed in high usage areas of a home, and whether the bulb actually meets forecasts for efficiency and longevity.

Experience shows that it can be difficult to get consumers to embrace new lighting products. Significant energy savings can be realized only when there is widespread acceptance of energy-saving technology. That has been the case with CFLs, which have been on the U.S. market since the 1970s. States and utilities have promoted CFLs as part of programs to reduce energy use. Some utilities gave CFLs to customers at no cost, while others provided millions of dollars in subsidies for purchase of the products. American consumers increased purchases of CFLs, as shown by import and usage data (**Figure 1** and **Figure 2**), but still used incandescent bulbs for

(...continued)

the industry as lamps, that are used in the United States.

[66] Michael Petras, President and CEO, GE Lighting, "An Industry Undergoing Transformation—Global Lighting Industry Moving from Iconic Edison Incandescent Bulb to Energy-Efficient Light Sources," *NEMA electroindustry*, February 2011, p. 14, http://www.nema.org/media/ei/upload/EI_February11.pdf#xml=http://search.nema.org/texis/search/pdfhi.txt?query=light+bulbs&pr=nema.org&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&rdepth=0&sufs=0&order=r&cq=&id=4d83d6861.

[67] Statement of Kyle Pitsor, Vice President Government Relations for the National Electrical Manufacturers Assn., Senate Energy and Natural Resources Committee, March 10, 2011, http://energy.senate.gov/public/_files/PitsorTestimony03102011.pdf.

[68] Testimony of Howard M. Brandston, Senate Energy and Natural Resources Committee, March 10, 2011, http://energy.senate.gov/public/_files/BrandstonTestimony03102011.pdf.

[69] Testimony of Kathleen Hogan, Deputy Assistant Secretary for Energy Efficiency, U.S. Department of Energy, Senate Energy and Natural Resources Committee, March 11, 2011.

most of their lighting, citing factors including the higher price for the CFLs and concerns about light quality and mercury contained in the products.[70]

CFL sales declined in 2009 to 272 million units, from 397 million units in 2007.[71] The recent decline may be due to a number of factors. Sales figures may have been affected by the recession, which made consumers less likely to switch to bulbs with a higher up-front cost. Shipments may also be affected by the fact that CFLs last longer, meaning consumers do not buy as many bulbs.[72] Also, some subsidy and promotion programs ended.[73]

The lighting industry appears to have responded to consumer concerns by producing a range of replacement options for traditional incandescent bulbs. U.S. and foreign manufacturers have developed higher-efficiency halogen incandescent bulbs, available at many retailers, that meet the requirements for 25%-30% energy savings and may overcome some consumer reluctance to embrace energy-saving lighting technologies such as CFLs. Indeed, energy savings under EISA could be near the low end of DOE projections if halogen incandescent bulbs, which sell for a price near that of conventional incandescent bulbs, turn out to be consumers' main replacement choice. In addition, EISA exempts a number of commonly used incandescent bulbs from efficiency standards. Some of the exempted bulbs can also be used as replacements for standard incandescent products, which would negate some potential energy savings from more efficient technologies (see **Appendix**).

Next-Generation LEDs

The lighting sector is going through another potentially historic transformation with advances in LED technology. LED efficiency depends both on the light source and the fixture in which it is placed. Depending on the package, some LEDs can be about 10 times as efficient as incandescent bulbs and as much as twice as efficient as CFLs.[74] Solid-state lighting, a semiconductor-based technology that coverts electrical energy into light, is already the fastest-growing part of the global lighting industry and is expected by some analysts to make up one-third of the U.S. lighting market, on a unit basis, and three-fourths of the market, on a revenue basis, by 2015.[75] Solid-state lighting has been adopted by industry, commercial businesses, and municipalities, with the main applications currently in electronics such as TVs, computers and smart phones, traffic lights and auto tail lights.[76] LEDs are starting to move into the residential market. While 40-watt and 60-watt equivalent replacement bulbs appeared in the marketplace during 2013,

[70] Pacific Northwest National Laboratory for DOE, *Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market*, June 2006, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/cfl_lessons_learned_web.pdf.

[71] The decline may also have been partly due to the end of a successful program by Walmart to promote sales.

[72] Chris Cawell, Ecos, "Lighting Portfolio Planning and Efficiency Programs: Advanced Session," Power Point Presentation, 2010.

[73] D & R International for DOE, *Energy Star CFL Market Profile: Data Trends and Market Insights*, September 2010, p. 12, http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile.pdf. Recent trade data indicate that CFL imports to the United States rose in 2010, a sign that sales may have been rebounding.

[74] DOE, LED Basics, http://www1.eere.energy.gov/buildings/ssl/sslbasics_ledbasics.html#how_efficient.

[75] Ross Young, IMS Research, "Global Manufacturing Trends: What Can We Learn from the HB LED Market Explosion?" DOE Solid-State Lighting Manufacturing R&D Workshop, Boston, MA, April 12–13, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/young_trends_boston2011.pdf.

[76] Ibid.

products at higher 75-watt and 100-watt equivalent levels just began to appear during the spring and summer of 2014.[77]

Retail prices of LEDs are still much higher than for traditional incandescent bulbs, but are falling. Since the late 1960s, LED light output has increased by a factor of 20 each decade, while the cost per lumen has fallen by a factor of 10.[78] The industry projects similar or faster cost reductions going forward. With technology advancing, some analysts project that general use LED bulbs could fall to a price of $5 within 10 years.[79] However, because LED prices are still significantly more than for other replacements for incandescent lamps, consumer adoption initially could be limited.

The development of LED technology and markets is a global pursuit.[80] Major companies investing in the LED arena include Philips Lighting, GE, and Osram Sylvania. Among U.S. companies are Cree of North Carolina;[81] the Lighting Science Group in Florida;[82] Feit Electric of California;[83] Switch of California;[84] Vu 1 lighting in New York;[85] and Bridgelux in California.[86] The firms are competing with start-up companies and established manufacturers like Toshiba[87] and other foreign firms. U.S.-based manufacturers Cree and Philips Lumileds together have about 11.5% of worldwide LED production.[88]

The North American LED bulb market is expected to grow from $3.6 billion in 2010 to more than $11 billion in 2015, partly due to stricter lighting efficiency standards that are being introduced in the United States, Canada, and Mexico, according to analysts.[89] In 2010, global LED production

[77] DOE publishes regular updates—Snapshot Reports—with new LED lighting facts. For example, see "April 2014 Snapshot: Indoor LED Luminaires," April 2014, http://www.lightingfacts.com/Library/Content/Snapshot/Archive/April2014.

[78] Ines Lima Azevedo, M. Granger Morgan and Fritz Morgan, "The Transition to Solid-State Lighting," *Proceedings of the IEEE*, Vol. 97, No. 3, March 2009, p. 507; Roland Haitz, Fred Kish; Jeff Tsao and Jeff Nelson, *The Case For a National Research Program on Semiconductor Lighting*, presented at the 1999 Optoelectronics Industry Development Forum, Washington, DC, October 6, 1999. http://lighting.sandia.gov/lightingdocs/hpsnl_long.pdf. The paper details what has become known and Haitz's Law on LED efficiencies and pricing.

[79] D & R International for DOE , Product Snapshot: LED Replacement Lamps, " May 2011, p. 14, http://www.lightingfacts.com/downloads/LF_Product_Snapshot_May_2011.PDF. Bulb prices are just one cost factor, however, with other materials costs that make up LED fixtures not falling as rapidly.

[80] For more about the global context, see McKinsey and Company, *Lighting the Way: Perspectives on the Global Lighting Market (second edition)*, 2012, http://www.led-professional.com/business/reports/lighting-the-way-perspectives-on-the-global-lighting-market-second-edition-2012-executive-summary-mckinsey.

[81] Cree, http://www.cree.com/.

[82] Lighting Science Group, "Lighting Science Group's CEO Asks Congress Not to Roll Back Light Bulb Energy Efficiency Standards," Press Release, July 11, 2011, http://files.shareholder.com/downloads/LSGP/1338555355x0x481602/6f01794e-aa30-4645-9eef-5a3ea1471c6b/LSCG_News_2011_7_11_General_Releases.pdf.

[83] Feit, http://www.feit.com/index.html.

[84] "Market for More Efficient Light Bulbs Moves On as House Vote Fizzles," *New York Times*, July 13, 2011.

[85] Vu1, http://www.vu1corporation.com/.

[86] Bridgelux, http://bridgelux.com/.

[87] Darian Unger, "Modern innovation management theory and the evolving US lighting industry," Howard University School of Business, *Journal of Management History,* Vol. 17 No. 1, 2011, p. 9-26.

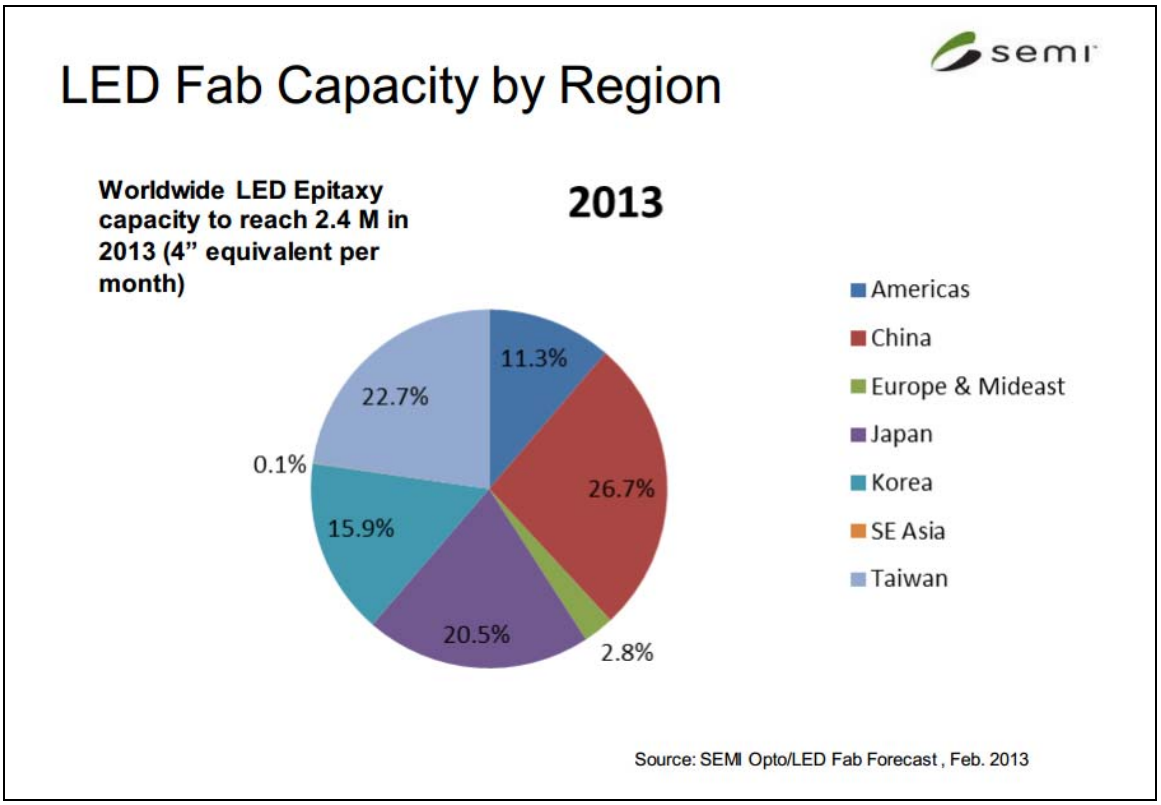
[88] DOE, "U.S. Manufacturing Strength Growing: Cautious Optimism" Paper summarizing 2011 DOE Solid-State Lighting Manufacturing Workshop in Boston, MA, April 12-13, 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/whitepaper_ssl-strength_2011.pdf.

[89] Ibid.

had a projected value of $9.9 billion. Global value could reach $18 billion by 2015.[90] Major LED manufacturing nations are shown in **Figure 4**.

Figure 4. World LED Fabrication Capacity, 2013

LED Production Capacity, by Region



Source: SEMI, U.S. Department of Energy; http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/morrow-mfgoutlook_boston2013.pdf.

LEDs magazine, which produces an annual guide to solid state lighting industry suppliers, lists hundreds of affiliated makers and suppliers in the United States. The companies run the gamut from semiconductor producers to specialty firms that make hospital and other lighting. Another lighting technology under development is organic light-emitting diodes, or OLEDs, where light is produced by a chemical reaction. The OLED technology is used in commercial electrical appliances such as color display screens.[91]

While the lighting market has been divided between companies producing light bulbs and companies producing fixtures, the two sectors will become more integrated if LED usage expands as forecast. According to DOE:

[90] Ibid.

[91] Alex Boesenberg, "Reading at Night by Firefly Light, Leveraging Bioluminescence and Other Research to Create Organic Light Sources for the Future," *NEMA electroindustry*, February 2011, p. 12, http://www.nema.org/media/ei/upload/EI_February11.pdf#xml=http://search.nema.org/texis/search/pdfhi.txt?query=light+bulbs&pr=nema.org&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&rdepth=0&sufs=0&order=r&cq=&id=4d83d6861.

> The ultimate value of SSL [solid state lighting], including its energy efficiency potential, is not in the production of replacements for incandescents or CFLS, but in the development of integrated luminaires that serve a particular function. Fixtures and even replacement lamps must be specifically designed to accommodate light-emitting diode (LED) light sources properly; failure to do so will result in poorly performing, unreliable products.[92]

Barriers and Concerns

As with the introduction of CFLs, there are potential barriers to consumer acceptance of LEDs. Testing by DOE and others has found variations in product performance.[93] For example, a recent article notes that China's manufacturing capacity—which now accounts for more than 30% of world LED production capacity—puts out products that often have problems with light quality and short lifetimes.[94]

The outlook for U.S. manufacturing is unclear. China and other countries are offering tax breaks and other incentives to lure existing companies. China is also expanding production of its domestic industry.[95] The rapidly changing nature of products and technology is another factor affecting profitability. LED firm Cree in its 2011 Annual Report noted that the industry is "in the early stages of adoption and is characterized by constant and rapid technological change, rapid product obsolescence and price erosion, evolving standards, short product life-cycles and fluctuations in product supply and demand."[96]

China has not only invested heavily in LED production, but is a chief supplier of rare earth minerals needed to produce LEDs.[97] The cost and availability of materials used for fluorescent and LED bulbs, including phosphorus and gallium, is a potential issue going forward.[98]

Federal R&D Efforts for LEDs

DOE has been working with private industry to foster U.S. LED manufacturing. The Energy Policy Act of 2005 (P.L. 109-58) created the Next Generation Lighting Initiative to support research, development, and commercial application of LED technology. DOE has used its

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[92] DOE, "Keeping Manufacturing in the United States," Summary of 2010 SSL Manufacturing R&D Conference in San Jose, CA, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_whitepaper_july2010.pdf.

[93] DOE, CALiPER Benchmark Report, *Performance of Incandescent A-Type and Decorative Lamps and LED Replacements*, November 2008, p. 14, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/a-type_benchmark_11-08.pdf. Additional reports on LED products are available at DOE's Solid-State Lighting, http://www1.eere.energy.gov/buildings/ssl/benchmark.html.

[94] *New York Times*, "As LED Industry Evolves, China Elbows Ahead," June 17, 2014, http://www.nytimes.com/2014/06/18/business/as-led-industry-evolves-china-elbows-its-way-to-the-fore.html.

[95] *LEDs Magazine*, "Counting down to SIL China part 3: China leads the world in investment in the LED industry," April 19, 2011, http://www.ledsmagazine.com/news/8/4/12.

[96] Cree, *2011 Annual Report*, p. 12, http://files.shareholder.com/downloads/CREE/1403526609x0x497270/28743D97-17AA-461C-824A-AE5E5156EC34/CREE_AR_9.6.11.pdf.

[97] Keith Bradsher, "Chasing Rare Earths, Foreign Companies Expand in China, *New York Times*, August 25, 2011, http://www.nytimes.com/2011/08/25/business/global/chasing-rare-earths-foreign-companies-expand-in-china.html?scp=2&sq=rare%20earth&st=cse.

[98] CRS Report R41347, *Rare Earth Elements: The Global Supply Chain*, by (name redacted).

authority under the 2005 law to develop a commercialization plan and is funding eight LED manufacturing projects designed to reduce costs and improve products.

EISA directed DOE to have the National Academy of Sciences prepare a report on the status of advanced solid state lighting (SSL) technology. Published in 2013, the report made a wide range of technological and policy findings.[99] The technology findings include: LED and organic LED (OLED) efficiency and performance are limited by materials issues; the development of robust OLEDs requires R&D on degradation resistance and materials to extend the operational lifetimes; and technological and manufacturing breakthroughs are needed to make LED-based luminaires and lamps with high efficacies with prices lower than those for fluorescent fixtures. The policy findings include: DOE's SSL program should be increased (if possible); DOE should seek 50% cost sharing for manufacturing projects; and DOE should lead a study that evaluates the effectiveness of lighting efficiency incentives.

DOE also used funds from the American Recovery and Reinvestment Act of 2009 for LED manufacturing research and development, with the goals of improving domestic efficiency and avoiding "the loss of technological expertise, intellectual property and manufacturing jobs to other countries."[100] Other efforts include improving the consistency and quality of LEDs through DOE's Commercially Available LED Product Evaluation and Reporting program, known as CALiPER.

Another federal law that helped spur energy-efficient lighting was the Commercial Building Tax Deduction Program. It provided incentives through 2013 for energy-efficiency measures including lighting equipment.[101] The program covered new construction and upgrades to existing buildings. So-called green building is the fastest-growing part of the construction industry,[102] including Leadership in Energy and Environmental Design (LEED) building criteria that focus on site, water, energy, materials, and indoor environment.[103]

Looking Forward

The lighting industry has spent billions of dollars to meet the requirements of EISA and to advance LED research and development. The rapid technological pace of change in an industry that largely relied on incandescent technology for more than 100 years has created some unease among businesses, lawmakers, and consumers about product availability and cost; possible job loss; and more broadly about the role of government in mandating consumer product choices.

Congress has a long-established record in the energy-efficiency area. The recent lighting standards are one in a series of home appliance and commercial equipment standards mandated by Congress to reduce overall energy use.[104] The EISA lighting provisions, in concert with tighter

[99] National Academies Press, *Assessment of Advanced Solid State Lighting*, 2013, http://www.nap.edu/catalog.php?record_id=18279.

[100] DOE, Solid State Lighting Program, *Keeping Manufacturing in the United States*, 2010 conference.

[101] A brief history of the tax deduction is available at http://energy.gov/savings/energy-efficient-commercial-buildings-tax-deduction.

[102] CRS Report R41806, *The Construction Sector in the U.S. Economy*, by (name redacted).

[103] CRS Report R40147, *Issues in Green Building and the Federal Response: An Introduction*, by (name redacted).

[104] CRS Report RL33831, *Energy Efficiency and Renewable Energy Legislation in the 110th Congress*, by (name redacted), (continued...)

standards in other countries, are helping to spark increased demand for new, more efficient products worldwide. Industry analysts add, however, that many changes now underway in the U.S. lighting industry would have occurred without EISA because of existing requirements in other countries and the pace of LED technology developments.

Early indications are that the lighting industry has developed a range of products, including halogen incandescent bulbs, that meet the EISA efficiency standards and are widely available at a price point close to that of conventional incandescent bulbs. Consumers will have more and possibly confusing choices about purchasing replacement light bulbs, some of which are likely to perform better than others.[105]

Going forward, one major question is how much LED manufacturing will stay in the United States. U.S. manufacturers have been moving operations overseas for decades to capture lower production costs and secure necessary materials. Long-term manufacturing trends are unclear given major efforts in China and other Asian countries to increase production (see **Figure 4**). Industry officials have called for an expanded federal-business effort to build LED fabrication facilities and increase domestic capacity and have warned that delaying the EISA implementation could reduce energy savings and delay the transition to next-generation lighting products.

(...continued)

(name redacted), and (name redacted).

[105] *Consumer Reports*, "Lightbulbs: LEDs and CFLs Offer More Choices and Savings," Complimentary Ratings for Facebook, 2011.

Appendix. Lamp Types Exempted from EISA

EISA exempts 22 types of traditional incandescent bulbs, or lamps, from the energy-efficiency standards. DOE will monitor sales of these exempted products as the legislation is implemented. If any one of the exempted lamp types doubles in sales, EISA requires DOE to establish an energy conservation standard for the particular bulb type. The provision is designed to ensure that none of the exempted products take market share from bulbs affected by the new efficiency standards.

- Appliance lamp
- Black light lamp
- Bug lamp
- Colored lamp
- Infrared lamp
- Left-hand thread lamp
- Marine lamp
- Marine's signal service lamp
- Mine service lamp
- Plant light lamp
- Reflector lamp
- Rough service lamp
- Shatter-resistant lamp (including shatter-proof & shatter-protected)
- Sign service lamp
- Silver bowl lamp
- Showcase lamp
- 3-way incandescent lamp
- Traffic signal lamp
- Vibration service lamp
- G shape lamp (as defined in ANSI C78.20-2003 and C79.1-2002) with a diameter of 5" or more
- T shape lamp (as defined in ANSI C78.20-2003 and C79.1-2002) and that uses no more than 40W or has a length of more than 10"

B, BA, CA, F, G16-1/2, G-25, G-30, S, or M-14 lamp (as defined in ANSI C78.20-2003 and C79.1-2002) of 40W or less.

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