AC 2011-1582: GREEN HABITATS: PARTNERS IN SUSTAINABLE LIGHTING EDUCATION

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1.0 abstract

Residential building activity for LEED certification continues to grow, including energy efficient Habitat for Humanity homes that have reached the Platinum level. Green lighting design practices contribute to this highest level of LEED achievement however homeowners are not always knowledgeable about how to sustain energy efficiency through lighting. The LEED for Homes Rating System provides minimal description for achieving lighting credits toward certification and little supplemental information about lighting to educate the homeowner or other lay person. As a result, homeowners are left to rely on their own consumer information with regard to maintaining an energy efficient lighting system and over time can become less satisfied with the aesthetic and functional results.

This paper reviews and examines an educational experience across interior design and architectural technology disciplines to learn about energy efficient lighting and apply it in a consumer education effort. Specifically, it describes the pedagogy of a design project where students apply concepts and technologies of current lighting trends in energy efficiency to the practice of implementing and maintaining successful lighting systems. The project focuses on:

1. Identifying current LEED Platinum certification for Homes,
2. Correlating LEED standards to appropriate lighting design strategies,
3. Designing an energy efficient lighting system for new Habitat for Humanity construction, and
4. Creating and delivering consumer education for homeowners to successfully maintain their lighting system.

The pedagogical discussion focuses on the appropriate combination of the art and science of lighting so that students design functionally effective lighting systems that are also aesthetically pleasing to homeowners. Through this approach, homeowners are more likely to continue maintaining their system when it is one that provides pleasing, effective, and energy efficient lighting. Students then educate homeowners in the effective selection of lamps, considering cost and characteristics, as well as maintenance strategies to keep lighting optimally functional. Students apply a foundation of lighting education to ever-changing lighting technology and how it can effectively apply to the consumer. Literature reviews of consumer education efforts in new lighting technologies combined with student research of LEED standards in Habitat for Humanity construction address the need for consumer-friendly lighting education.

With upcoming U.S. legislation for increased efficiency of incandescent lighting, students learn how to address public education efforts to realize energy savings. Their contributions to environmental sustainability are measured by homeowner response to education and maintenance strategies that students create. Through this interdisciplinary approach, students of interior design and architectural technology build upon the strengths of each discipline to engage in a viable design and teaching opportunity that realizes measurable impact in sustainable practices.

2.0 background

Consumer information about aesthetically effective and energy efficient lighting products is not standardized and can be unclear as well as uninformative. While many residential consumers prefer to implement the most energy efficient lighting solutions in their homes, they are not presented with appropriate and easy to understand package labeling to make educated decisions. As a result, consumers are left to base decisions almost exclusively on lamp wattage. This approach results in associating standard lamp solutions in terms of their wattage without regard to the amount or quality of light they emit. For example, consumers learn to associate a certain brightness level with each standard wattage option – 60 watts, 100 watts, etc. Manufacturers of compact fluorescent substitutes have therefore developed packaging that compares wattage levels to a comparable incandescent lamp, resulting on an increasing dependence on wattage as the selection factor. While this is one factor toward an energy efficient solution, other factors must weigh in the decision process for the most effective solution.

Consumers are left to guess about the most effective lamp selections, and students enter lighting education with a similar perspective. At first, students are reluctant to consider lamp solutions other than incandescent for residential project proposals. They quickly learn the aesthetic and functional benefits of considering alternate solutions such as fluorescent and LED products. Through lighting education they learn how to search for and specify effective lamp solutions to achieve their project design goals.

Energy efficiency becomes an increasingly important component for students to incorporate as builders and owners strive for project certification through sustainable building programs such as the Leadership in Energy and Environmental Design (LEED) Green Building Rating System developed by the U.S. Green Building Council (USGBC). Since the first homes were LEED certified in 2006, more than 9,000 homes have achieved one of four levels of LEED certification[11]. Of these, approximately 650 are certified throughout the U.S. and Canada at the highest LEED standard, the Platinum level[11]. Beginning in 2011, a pilot program will accept international residential building projects for certification. Through the LEED for Homes program, building projects must achieve a minimum of 20-30% energy savings of the national energy code through such means as improved insulation, HVAC, and lighting systems[11].

Through its Initiative for Affordable Housing, LEED recognizes and certifies sustainable building practices that achieve affordable efficiencies through the LEED for Homes rating system. Since 2008, over 260 homes have achieved the highest, Platinum, level of LEED certification through the Affordable Housing program[11]. Of this number, over 160 residential building projects achieved the Platinum level in 2010 alone[11]. It is through this program, that organizations such as Habitat for Humanity, Global Green USA, and other regional and local groups and builders can receive assistance to fund fees associated with LEED certification. Students can assist these groups by designing energy efficient lighting systems to meet LEED requirements and by designing solutions that offer functional and pleasing lighting solutions for eventual homeowners.

As practicing designers, students must learn how to educate all clients about benefits of lamp solutions that are more energy efficient than standard incandescent products. Following the international community, imminent legislation in the U.S. will mandate more energy efficient

lighting products than those currently on the market. Initial efforts by Cuba and subsequently, Australia, New Zealand, several Caribbean countries, and Venezuela worked toward converting incandescent to fluorescent lighting, and other countries including the UK and Canada have since adopted a phase-out of inefficient incandescent lighting[14]. This global issue was addressed at the 2007 IESNA/Cooper Teachers of Lighting Workshop by an international cohort of lighting educators. This consortium considered methods of incorporating energy efficient lighting methodology into relevant coursework, transforming traditional lighting design education. As these legislative directives are recent and continually evolving, architectural and interior design curricula must stay abreast of developments to reflect emerging issues in lighting technology.

It is pertinent for students to understand current lighting legislation as it applies to their field of study and eventually, to their design practice. Gaining approval of effective project proposals is the first step toward achieving successful lighting solutions; eventually they must educate their clients on maintaining effective, energy efficient lighting solutions. Students in this project will partner with the local Habitat for Humanity organization to work with its contractors in design of lighting systems and will educate its homeowners to maintain energy efficiency. Long-lasting energy efficient solutions that are maintainable by homeowners will be the most cost-effective strategies for successful residential lighting.

3.0 methodology

3.1 experimentation and research

In this project students examine lighting technology options – the point in their degree program where they have a working knowledge of the art and science of lighting, having completed at least two lighting designs. Toward energy efficiency and aesthetic goals in their designs, they explore properties of various standard incandescent, halogen incandescent, linear and compact fluorescent, and LED lamps. They look for differences in color appearance of light and they experiment with creating a cohesive combination of similar color temperatures. Students compare light sources for their color rendering indices and examine objects under them to determine threshold levels. As well, they experiment with differences in pattern distribution among incandescent, fluorescent, and LED sources.

Simultaneously with experimentation of lighting effects, students examine lamp packaging for labeling information helpful to consumers. They look for lumen output, color temperature, and color rendering index (CRI) toward design aesthetics and they consider lamp life and wattage consumption toward energy efficiency. Students explore various retail locations to seek acceptable light sources that have informative packaging. Life-cycle cost is considered to combine initial product cost with cost of operation over life of the lamp. With a consideration of consumer education, students specify light sources with the best combination of performance characteristics and informative labeling.

Students research various paths of current and proposed legislative programs as they apply to the field of lighting. Since programs and regulations continually evolve, this is an important practice in which they should become familiar and comfortable. Students explore a variety of resources including public legislation and regulations, professional organizations, and local sources.

Students find through research that current labeling practices vary and are currently voluntary efforts by manufacturers. There has not yet been a consistent labeling practice for lamp packaging, except for the U.S. Department of Energy's (DOE) Lighting Facts program for solid-state lighting products developed with the Next Generation Lighting Industry Alliance (NGLIA) in 2008. This voluntary program for solid-state product manufacturers provides consistent product information either directly on packaging or in a web-accessible format as shown in the example in Figure 1. Students learn that this program summarizes verifiable product information as measured by IES LM-79-2008, the industry standard for testing photometric performance[10]. While the program does not specifically endorse products, since June, 2010 it requires testing by the program of at least one product for a manufacturer to be listed with the program.

Students can currently locate information from 194 manufacturers for 1,911 solid-state lighting products from www.lightingfacts.com[6]. They find information on complete LED luminaires helpful when specifying solutions for design proposals, although they can also find information on self-contained replacement lamps through the Lighting Facts program. Both luminaires and replacement lamp information include lumen output, consumed wattage, efficacy (lumens/watt), CRI, and correlated color temperature. This is important for design proposals that include multiple LED products so that they are compatible with each other, and compatible with incandescent and fluorescent solutions included in a project.

The Lighting Facts program also educates students about identifying authentic Lighting Facts labels and misuse of unauthorized labeling. In students' design proposals they are required to use products from the Lighting Facts program for any solid-state products specified and to include the product label in their construction documentation.

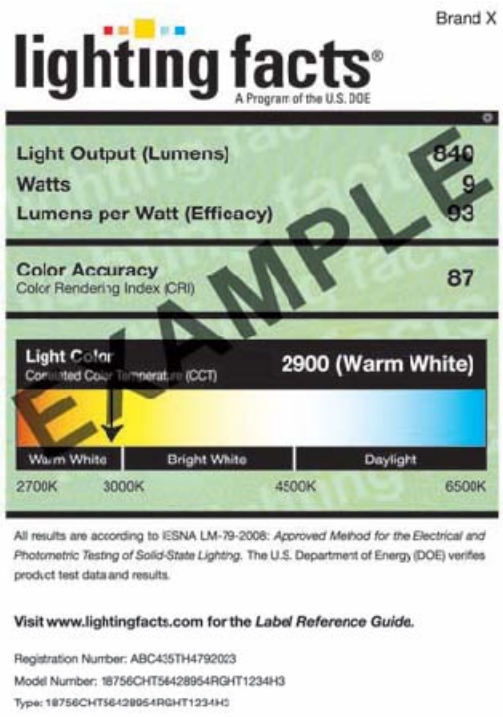

Figure 1: Example DOE Lighting Facts Label[6]

Student research compares the Lighting Facts program to the DOE's Energy Star program developed jointly with the U.S. Environmental Protection Agency (EPA). They find that some products may qualify to meet the minimum performance requirements of Energy Star, but this program does not provide light characteristic information such as that included on the Lighting Facts label[1]. Therefore students are not able to use Energy Star to evaluate their design criteria, nor to direct their clients to it for specific lighting criteria of replacement lamps.

Student research also compares the DOE's Lighting Facts label to the Federal Trade Commission's (FTC) Lighting Facts label. Distinguishing information about these two similar programs is important for students to incorporate in their design criteria as well as in creating educational information for their clients. Students learn that the FTC's labeling program is required for medium-screw base lamps beginning in July, 2011 but that manufacturers may begin to incorporate the labels before that date[2]. Some manufacturers have also requested an extension to meet the labeling deadline, so complete implementation may be delayed beyond July, 2011.

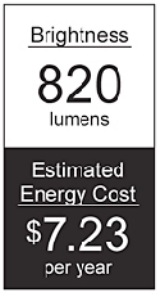

Figure 2: Example FTC Lighting Facts Label – Front of Package[7]

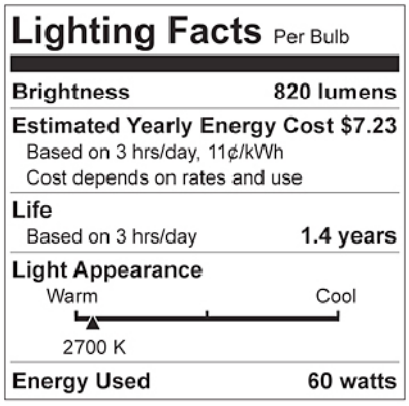

Figure 3: Example FTC Lighting Facts Label – Back of Package[7]

As shown in the example front and back packaging labels in Figures 2 and 3, students find that similar information is contained in both the DOE and the FTC Lighting Facts labels, except that CRI is not included in the FTC label. Without this important information, students will determine lamp products with acceptable CRI from manufacturers catalog data and recommend these products for their homeowner clients to maintain proper lighting. Students also find that lamp life is included in the FTC label and that lumen output is labeled 'Brightness', a term that students learn to associate with luminance rather than directly attributable to a light source.

Students' thorough understanding of these labeling similarities and differences will help their clients navigate successful purchases of replacement lamps.

The FTC Lighting Facts label is designed to work in conjunction with minimum efficiency and lifetime requirements of general service incandescent lamps under the U.S. Energy Independence and Security Act (EISA) of 2007. These requirements to be implemented in 2012, and in California in 2011, have been misleadingly referred to as a 'phase-out' or 'ban' of incandescent lamps. Students' research examines the energy limits and lifetime requirements of the legislation that lamp manufacturers have begun designing into new lamp products. For example, they find that a general service incandescent lamp manufactured with lumen output of 1490-2600 lumens can consume no more than 72 watts and must have a rated life of 1,000 hours beginning January 1, 2012[9]. This lamp compares to a current standard incandescent lamp that consumes 100 watts and frequently has a 750-hour rated life. Since wattage requirements for specific lumen output of incandescent lamps will be reduced, students and their clients can no longer rely upon familiar lamp products. New consumer labeling will provide necessary information for lamp selection and students will create educational information to assist their client homeowners.

Student research is recently impacted by the EISA 2007 provisions for lighting energy efficiency that are in jeopardy of repeal through House of Representatives Bill 91 (H.R.91.IH) introduced January 5, 2011 and related Senate Bill 395 introduced February 17, 2011[8]. These recent bills contain the 'Better Use of Light Bulbs Act (BULB)'. It addresses concerns of domestic employment opportunity in the lamp industry, and mercury content and safety concerns in compact fluorescent lamps[5]. Students will follow this legislation as it applies to their design proposals and client education.

3.2 Green Habitats project

The Green Habitats project described in this paper builds upon student research and experimentation with light sources, their properties and effects. The pilot for this project is development of an energy-efficient lighting lab for students to experiment with lighting quality and effects. The lighting lab is created with a variety of qualifying light sources such as halogen, compact fluorescent, and LED, and a variety of bulb types and shapes. Traditional incandescent sources are also included for comparison, along with a selection of effects such as dimming, tri-level switching, and lamp shade materials. Students consider lamp properties while experimenting with effects, specifying their recommended light sources in a residential lighting solution. Results of this pilot led to modifications in the lighting lab components, an instructional strategy for team experimentation in the lab, and standardization of lamp specification format. These components are included in the full implementation of Green Habitats.

Current issues in the lighting industry are key components of the Green Habitats project. One focus area is building sustainable homes that are energy efficient. Both the USGBC and Habitat for Humanity focus on this type of building construction; Habitat for Humanity builds green homes and USGBC certifies them. Habitat advocates for healthy homes that are economical to live in and maintain, and many of these homes earn LEED certification by the USGBC. In fact, since 2008 when the first Habitat home earned the highest – Platinum – LEED certification[11], many local Habitat affiliates have adopted LEED certification goals. Already one Habitat home

in the local community has been built to LEED Platinum standards and others are likely to follow. With this momentum, undergraduate design students are able to contribute toward Habitat's goals of building and maintaining sustainable, energy efficient homes.

The Green Habitats team project focuses on designing an energy efficient lighting system for a Habitat home that is aesthetically pleasing for its occupants and easily maintainable by the homeowner. In a team scenario, the project replicates professional design practice where team members focus on individual areas of research and current design guidelines. With a combination of team members in the Interior Design and Architectural Technology programs, each discipline receives its industry's focus in the project: Interior Design students create programming and design goals, Architectural Technology students focus on sustainable building practices through Habitat for Humanity projects, and all team members work toward meeting prescribed goals through their solutions. Using LEED Platinum-level certification as a goal, students research LEED requirements with regard to lighting contribution. At the Platinum level a minimum of 90 LEED for Homes points are required[13]. Within the Lighting component (EA8) of the Energy & Atmosphere category, a minimum of four Energy Star labeled light fixtures or compact fluorescent lamps (CFLs) must be installed in high-use rooms to achieve the lowest level of LEED certification. Additional credits can be earned for increased use of Energy Star fixtures and lamps, including ceiling fans, up to a maximum of 3 additional points. Exemplary performance earns an additional Innovation & Design Process point for using 90% Energy Star fixtures and 100% Energy Star ceiling fans[12]. These requirements support Habitat's green building practices for lighting that recommend compact fluorescent lamps and Energy Star-approved fixtures[4].

Students are directed in this project to design lighting for the maximum LEED credit possible, earning a total of 4 points toward the EA8 Lighting component. This requires researching manufacturers of Energy Star labeled fixtures and lamps for a cohesive specification meeting design goals as well as LEED requirements.

As part of Habitat's sustainability goals, homes should not only be sustainably built but also maintainable to support long-term energy efficiency. Students' Green Habitats projects include an educational component for which students create a maintenance schedule for all luminaires specified in the project proposal. This includes replacement lamp products, and their manufacturers, along with possible retail sources and product cost, as well as life-cycle cost. Clients are educated in the long-term payoff of operating energy efficient lighting vs. the cost of operating standard incandescent sources. The maintenance schedule also considers lamp life and a timeline schedule of lamp replacement so that students learn the practical meaning of 'rated lamp life'. To support Habitat's sustainability goals, luminaire maintenance is achievable by the homeowner without assistance of an electrical contractor.

Recycling options for fluorescent lamps are also addressed in consumer education. Student research of LEED requirements indicates that this educational component contributes to the LEED prerequisite for 'Guidance on occupant activities and choices, including….lighting selection'[13]. This is part of the documentation included in an operations and maintenance manual provided to the homeowner(s) satisfying the LEED Education of the Homeowner or Tenant

(AE1) category. In the Education of Building Manager (AE2) category for multifamily buildings, this documentation activity is not required and can earn an additional LEED credit.

The LEED AE1 category for homeowner education includes additional earned credit for providing enhanced training and/or public awareness. These are activities that will be developed into succeeding projects for service learning. Additional planned activities suggested by the LEED for Homes Rating System address lighting in the following[13]:

1. A walkthrough or training held in another home with similar green measures.
2. A builder-sponsored meeting of potential homebuyers about LEED features.
3. A group homebuyer training to discuss the homeowner's operations and maintenance manual.
4. A homebuyer DVD with operations and maintenance information.

The first three items listed above can be included in future courses when meeting times and construction schedules coincide with course schedules. In the event that scheduling does not permit these activities, students can create an instructional DVD as suggested in the last item. These activities should also address energy cost savings and payback time for purchasing compact fluorescent lamps instead of the incandescent counterpart. Grosslight (2007) suggests residential strategies specific to the client for calculating light source savings, as well as a quick calculation method of $30 in savings per compact fluorescent source over lamp life[3].

Public awareness is the last category where additional LEED points may be earned. Service learning opportunities where students can participate or lead these efforts include the following recommendations in the LEED for Homes Rating System[13]:

1. Hold a public open house or green building exhibition or tour.
2. Publish a website about features and benefits of LEED homes.
3. Generate a newspaper article on the LEED for Homes project.

By conducting three or more of these types of activities an additional LEED credit may be earned toward project certification. All of these activities can be planned instructionally within student teams so that many of these deliverables can assist the Habitat project in its LEED certification effort without additional cost.

4.0 assessment

Evaluation of student projects is based on pedagogical criteria that assess achievement of learning objectives – (a) objective lighting criteria and (b) subjective achievement of both design goals and consumer education. Data is obtained in two phases: preliminary data from the lighting lab pilot and succeeding data from the Habitat for Humanity design component. Data in both phases includes student feedback and evaluation by the instructor, as well as student achievement data.

Pilot project data has dual value:

1. for evaluation to design improvements to light source experimentation in the lighting lab, and
2. to assess student achievement based on use of the lab.

Pilot results from student feedback indicated a need for additional light sources to be included in the lighting lab. For example, students needed to see not only a variety of color temperatures between fluorescent and LED sources, but to experiment with various bulb shapes to understand retail availability of lamp types for homeowners. Extended student time in the lab should also be scheduled into studio class meetings. Objective data from pilot results will compare student exam achievement as well as design project results from two sections of the course – one that included the lighting lab learning component and one that instead relied upon traditional lecture and demonstration methods. It is expected that objective data will evidence higher levels of achievement in the lighting lab section. Results from this pilot phase of Green Habitats will support refinement of the Habitat for Humanity phase of the project, including its homeowner education component.

Since meeting the highest level of LEED credit toward lighting components is a goal of the Green Habitats project, this is a primary assessment objective of design proposals for the Habitat for Humanity home. Therefore, fixtures and lamps should be Energy Star-labeled, primarily including halogen, fluorescent and LED light sources. While standard incandescent sources may be included, current energy efficiency direction necessitates a need for justification of these sources rather than a practice that includes them as a primary solution. These are conditions that students will increasingly find in practice and this work will prepare them in their employment searches.

While not contributing to a project grade because of timing considerations, a valuable reflection of achievement is contribution of LEED credits toward project certification. This is valuable not only toward student learning, but of aiding Habitat projects to be recognized for their sustainable building efforts and maintainability. Cost toward this effort is minimized for Habitat through the USGBC's Initiative for Affordable Housing as well as student contribution of LEED credit both in building components and homeowner education initiatives. Students will stay apprised of the Habitat home's certification process after completion of their design proposals.

It is anticipated that complete assessment data will indicate higher levels of student learning in both phases of the project, from the lighting lab pilot through the Habitat design proposal and homeowner education effort. Assessment data will be used to implement experimentation methods in the studio lighting design course as well as its prerequisite lighting fundamentals course. With lighting technology advances, as well as changes in legislative and certification efforts, instructional methodology will be adapted based on assessment of the initial, and subsequent, Green Habitat projects.

5.0 reflection

As a service project, Green Habitats provides benefits to those it serves – Habitat for Humanity homeowners. Families benefit from sustainable building practices that result in healthy homes as well as energy efficient homes that result in lower energy costs. Through education and awareness efforts, homeowners can successfully maintain their homes and their efficiencies in addition to enjoying aesthetically pleasing environments. With increased attention to energy efficient lighting solutions, consumers will benefit from improved product awareness when purchasing lamps and fixtures, resulting in pleasant living environments that cost less to operate.

Students benefit from not only learning about successful energy efficient lighting but by creating education efforts for their clients. They learn the practicality of locating appropriate retail sources that meet a variety of criteria: regulatory, design guidelines, and maintainability. By focusing their education efforts on real project scenarios that affect homeowners, students engage in their learning environment by putting forth best efforts in a collaborate team approach. They learn to work with team members of another discipline, relying on the strengths of each. They conclude the Green Habitats project with a successful lighting proposal that meets design goals, sustainable and energy efficient building practices, and a contribution of service to deserving homeowners. This is a story that students can relate to future employers and carry with them into their professional practice.

Bibliography

[1] Energy Star. (n.d.). How a product earns the Energy Star label. Retrieved from http://www.energystar.gov/index.cfm?c=products.pr_how_earn.

[2] Federal Trade Commission. (2010, July 19). Appliance labeling rule. *Federal Register, 75*(137). Retrieved from http://www.ftc.gov/os/2010/06/100719appliancelabelingrule.pdf.

[3] Grosslight, J. (2007). *Energy-efficient daylighting & electric lighting techniques*. Tallahassee, FL: Durwood Publishers.

[4] Habitat for Humanity International. (2011). Green build checklist. Retrieved from http://www.habitat.org/youthprograms/greenbuild/check_list.aspx.

[5] House Energy and Commerce Committee. (n.d.). Barton, Burgess and Blackburn introduce bill to repeal light bulb ban. Retrieved from http://energycommerce.house.gov/News/PRArticle.aspx?NewsID=8038&IID=8.

[6] Lighting Facts. (2011). Anatomy of the label. Retrieved from http://www.lightingfacts.com/default.aspx?cp=content/label.

[7] Lighting Facts. (2011). Overview of FTC guidelines on new consumer label. Retrieved from http://www.lightingfacts.com/default.aspx?cp=content/ftclabel.

[8] Thomas (Library of Congress). (n.d.). Bill text: 112th Congress (2011-2012): H.R.91.IH. Retrieved from http://thomas.loc.gov/cgi-bin/query/z?c112:H.R.91: .

[9] U.S. Department of Energy. (n.d.). Fact sheet: General service incandescent lamp provisions contained in EISA 2007. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/dec2010_lighting_factsheet.pdf.

[10] U.S. Department of Energy. (2010). Energy efficiency and renewable energy: Building technologies program. Retrieved from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/dec2010_lighting_factsheet.pdf.

[11] U.S. Green Building Council. (2010). LEED for homes certified projects by project type. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=2719.

[12] U.S. Green Building Council. (2010). LEED for homes project checklist. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=3658.

[13] U.S. Green Building Council. (2010). LEED for homes rating system. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=3638.

[14] Waide, P. (2007, October 22). Global efforts to phase-out incandescent lamps. *International Energy Agency OPEN Technology Bulletin, 45*. Retrieved from http://www.iea.org/impagr/cip/archived_bulletins/issue_no45.htm.