SOLID-STATE LIGHTING DEMONSTRATION

Final Report

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Prepared for

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Albany, NY

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NOTICE

Abstract

The primary objective of the ***Solid-State Lighting Demonstration*** was to exhibit the effectiveness of residential LED technologies for achieving energy and cost savings, as well as meeting and exceeding consumer expectations. The project consisted of five whole-house 100% LED lighting demonstration sites using real-time energy monitoring and data collection and analysis to capture the actual effectiveness of LEDs with regards to savings. Additionally, the project included various consumer education and outreach efforts to help to raise consumer awareness of and communicate the potential benefits of LED lighting technology. As result of this comprehensive approach, the following report intends to provide both quantitative and qualitative evidence supporting more widespread use of residential LED technologies and helping to overcome the current barriers hindering further market penetration of LEDs.

Executive Summary

Overview

Solid-state lighting technology, which includes both LED and OLED lighting, has enormous potential for both energy savings and environmental impact. Widely considered to be the future of lighting, LED lighting technology has experienced substantial growth and development since the start of this project. Technological advancements have not only improved efficiency and performance, but expanded product lines and provided innovative lighting solutions and capabilities, changing the way the industry looks at lighting in the residential building sector.

In their *2014 Energy Savings Forecast of Solid-State Lighting*, the US Department of Energy estimated LEDs had the potential to reduce electricity consumption nearly 50% annually by 2030, saving an estimated 4.5 quadrillion Btu's (quads) per year, and over $220 billion in energy costs cumulatively from 2013-2030.[1] In a 2016 update of this report, DOE now estimates annual savings of 5.1 quads by 2035, representing a 75% reduction in energy consumption, and resulting in cumulative savings of over $630 billion in avoided energy costs from 2015-2035.[2]

LEDs market share has also continued to rise, particularly in the residential sector. An industry report from McKinsey & Company, "*McKinsey Global Lighting Market Model*," claims that LED market share in the residential sector has increased from 6% in 2010, to 49% in 2016, and is expected to reach 70% by 2020. The report also claims that the residential sector is the largest general application segment for LED technology, representing over 40% of the general lighting market in 2011.[3]

There are several factors that contribute to the current and expected future growth of LED lighting in the residential market. Advancements in technology and manufacturing have increased light quality, output, controllability, and efficiency. Expanded product lines and increased availability of LED bulbs and fixtures give consumers, builders, and trade contractors more options to choose from that can fit into any home design. And, arguably most importantly, the cost of LEDs has decreased significantly in the past several years. An ENERGY STAR LED bulb, which could have cost north of $40 a few years ago, is now available for under $10.00. However, regardless of these positive trends for the LED industry, there are still several market barriers, both perceived and confirmed, that continue to hinder more widespread market penetration for residential LED technologies.

All of these potential benefits of LED lighting mentioned above have been major reasons for the apparent shift in the lighting market. However, as with most technologies, what is true on paper and in the lab is not always true in real world applications. That is one of the main reasons this project was designed the way it was. Our goal was to reflect real world options by working with real customers, in real homes, built by real builders, and offering real lighting solutions, from real lighting suppliers and manufacturers. None of the products used in these homes were test or sample products and could be purchased online, or from Home Depot, Lowes, or local lighting supplier.

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[1] Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, 2014 Report, US Department of Energy
[2] Energy Savings Forecast of SSL in General Illumination, 2016 Report, US Department of Energy
[3] Lighting the Way: Perspectives on the Global Lighting Market, McKinsey & Company

Quantitative Results- Energy Savings Are Real

In New York State, the residential sector accounts for over 35% of the total electrical consumption and nearly 29% of the state's net energy consumption. Lighting represents approximately 20% of electrical end-use. According to the Pacific Northwest National Laboratory, in 2010 the average household in NY had approximately 54 lamp fixtures, with an average of 40W lamp power, each operating for 1.6 hours per day[4], resulting in an average daily energy consumption of 3.456 kWh. With the average residential utility rate in New York of $0.19, the average annual cost of lighting for a home in the state is approximately $239.67. This is consistent with the findings from our study in which the average annual cost for the five homes was an estimated $217.92.[5]

Each of the project homes was monitored for real-time energy consumption for the lighting load in each home. The monitoring period covered 9 months in order to obtain data from the summer months, winter months, and one shoulder season as indoor lighting use tends to change with the seasons.

The two tables below highlights the total estimated annual energy consumption and energy costs for all homes in the project. These estimates are based on the energy monitoring results for each house and the current electric rates for the areas in which these homes were located.

The tables show estimates for the 100% LED homes in the project and are then compared to other lighting scenarios commonly seen in the field. At the time these homes were built, the New York Energy Code (ECCCNYS) required 50% high efficacy lighting. Therefore, for this project we have two different scenarios for code built homes. The first assumes 50% 13W CFL bulbs and 50% 40W Incandescent. The next assumes the same 13W CFL bulbs but includes 50% 60W Incandescent bulbs. The 40W and 60W Incandescent bulbs are both commonly found in the field, making it important for us to include both scenarios. For the 100% Incandescent scenario, we assume all bulbs are the 60W variety since that is slightly more common than the 40W variety.

	Estimated Annual Consumption (kWh) All Project Homes	Estimated Annual Consumption (kWh) Per Home (5 Homes)	Estimated Annual Consumption Savings (kwH) Per Home
100% LED	3132.60	626.52	
50% 13W + 50% 40W	8030.95	1606.19	979.67
50% 13W + 50% 60W	11061.47	2212.29	1585.77
100% Incandescent	18184.63	3636.93	3010.41

[4] Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates, December 2012, Pacific Northwest National Laboratory, Portland, Oregon

[5] Assumes code built home with 50% 13W CFLs and 50% 60W Incandescent bulbs

On average, the estimated consumption for the lighting in each of the 5 project homes was 626.52 kWh per home. Compared to a "code built" home, using 50% CFL and 50% Incandescent lighting, each LED home would save over 1500 kWh per year.

	Estimated Annual Cost All Project Homes	Estimated Annual Cost Per Home (5 Homes)	Estimated Annual Cost Savings Per Home
100% LED	$302.24	$60.45	
50% 13W + 50% 40W	$791.08	$158.22	$97.77
50% 13W + 50% 60W	$1,089.59	$217.92	$157.47
100% Incandescent	$1,791.11	$358.22	$297.77

The estimated annual cost to light the 5 project homes with the 100% LED lighting systems was only $302.24. That averages to $60.45 in energy costs to light an entire home for 1 year. Compare that to a "code built" home and the estimated savings for each home is $157.47 a year. Again, using the 2012 Census data for number of homes in New York, LED lighting could potentially reduce energy costs by up to $537,229,691.

Qualitative Results- More Options, Better Lighting, More Control

Throughout this project one of the major findings we experienced was the rapid expansion of product lines for LED lighting. This product expansion also allowed us to make use of more creative and efficient lighting designs. At the beginning of the project, when talking through options with lighting designers and suppliers, there were a limited number of LED products available. However, as more options became available, the lighting designs were able to incorporate many different fixtures (integrated fixtures, wall sconces, under cabinet lighting, surface mounts) that delivered better mood and task lighting in all areas of the home.

Regardless of all the benefits, advancements in technology, and decrease in price for LED lighting technologies, what will ultimately determine whether the technology reaches full market potential is consumer perception. It won't matter how efficient or advanced the technology becomes if the end user doesn't like what it provides. For that reason it was important to gauge this consumer perception of LED lighting and the lighting market at large. We conducted multiple surveys and interviews, using various approaches, to help us understand the current opinion of LED lighting.

From these efforts, it became clear that LED lighting is preferred by the vast majority of consumers. In our light box demonstration, where three light sources (Incandescent, CFL, and LED) are compared side by side, 60% of participants indicated they preferred the LED bulb to the other two options. This finding was consistent each time we administered the demonstration survey. Additionally, homeowner and

builder testimonials, and surveys taken at open house events further support the finding that consumers prefer LED lighting to other light sources. Survey participants and testimonials commonly referred to the high quality of light, ability to control the output with improved dimming capabilities, unique design features such as under cabinet lighting, and ability to connect and control the lighting with smart home technologies.

Overall, through the improved energy efficiency, more design options for improved lighting and aesthetics, and positive consumer reaction to LED lighting, this project successfully highlights the many benefits of LED technology in the residential lighting market. There are still barriers to overcome for more widespread adoption, and the industry will continue to evolve to push LEDs to new levels of performance, however the current and future outlook for LED lighting looks very bright.

Technology Transfer

Every home in this project was a newly constructed, ENERGY STAR certified home. With all the homes being new builds, we were able to better incorporate lighting into the initial design phase of the home. This was critical since the builders and electricians involved in the project had little to no experience installing LED lighting. Because the intent of the project was to not only demonstrate the energy and cost savings potential of LEDs, but also the benefits and options LEDs provide with regards to design, being able to integrate the lighting plan from the beginning of the project

was extremely valuable. The LED lighting plans for each home differed slightly from the typical lighting design typically offered by the builders in the project. Components such as under cabinet lighting, wall sconces with integrated LEDs, and surface mount ceiling lights required slightly different wiring and installation techniques.

While there was a short learning curve for some aspects of the lighting design, both the builders and electricians were pleased with the ease of installation. Having no prior experience with LED lighting, several indicated that because of their experience with this project, including design, installation, and ultimately customer satisfaction, they intend to use LED lighting in future projects and would recommend LED lighting to future customers.

Testimonials

"Since this project, I install 100% LED lighting in all my homes."

"The lighting in our home now is so much better than the lighting in our previous home. This was an excellent experience and I will definitely continue to use LEDs in the future."

With regards to the homeowners involved in the project, each of them indicated in their initial survey/interview that they had little to no experience with LED lighting. The lighting in their previous homes was a combination of CFL and Incandescent bulbs, and lighting in general was not something they thought much about. Once the homeowners for the five demonstration homes were identified, we visited each one to discuss with them the project and help educate them on the benefits of LED lighting, discuss their fixture options, and provide a demonstration on the wireless control system (Lutron Caséta Wireless) they would receive with their package.

After 4-8 weeks in their new home and with their LED lighting system, we re-visited each of the homes to perform quality control and interview the homeowners about their opinions on the lighting in their home. Having had no prior experience, and even some skepticism about LED lighting, each homeowner was extremely satisfied with the quality and convenience of their LED lighting. Features such as under cabinet lights, improved dimming, better mood and task lighting, and added convenience of controlling all the lights from their smartphones were among some of the features that were valued Additionally, each of the five homeowners indicated that going forward, they would only be purchasing LED lighting because of their positive experience with them from this project.

Acknowledgements

Newport Ventures would like to thank Daniel Farrell (NYSERDA) for his accessibility and interest in the project and his commitment to advancing energy efficiency in housing.

Newport Ventures would also like to thank other the following partners who contributed to this project.

- Jan Moyer of Jan Moyer Design for her professional input and detail in lighting designs.
- Manny Rodriguez of Lutron Controls for providing Caséta Wireless Control Systems for each home and conducting builder and consumer demonstrations.
- Wendy O'Hearn (Vertex Lighting) and Karl Petersen (Wolberg Electric) for providing lighting options and expertise on bulbs/fixtures.
- Our five builders: Belmonte Builders (Clifton Park, NY), Fedyk Builders (Fairport, NY), Gerber Homes (Rochester, NY), Greenhill Contracting (New Paltz, NY), Saratoga Builders (Saratoga Springs, NY)

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Tables and Figures

Section 1-Project Overview

The primary goal of this project was to assess the benefits of residential LED lighting technologies on both a quantitative (savings) and a qualitative (perception/satisfaction) level and in turn, support the growth of the residential LED market. The demonstration project was designed to not only showcase the energy and cost savings potential of LEDs, but also highlight the wide variety of capabilities and innovative lighting solutions associated with the technology, identify and assess current market barriers hindering more widespread use, and identify consumer perception and attitude towards LED technologies so that any issues might be addressed.

To support the primary goal of this project, objectives include:

- Analyze the impact, both quantitative and qualitative, of a planned whole-house lighting design
- Analyze the impact, both quantitative and qualitative, of smart lighting control systems
- Highlight new innovative design features and expanded LED product lines including integrated LED fixtures
- Demonstrate ease of replacement/installation and compatibility with existing lighting systems
- Identify and assess current market barriers and provide evidence to overcome these barriers
- Raise consumer awareness and education on residential LED technologies to further support market penetration

Five, new construction, ENERGY STAR certified homes across New York State were identified to participate in the demonstration project. Every attempt was made to try and include homes that represented the various regions of New York State. Due to low building activity in several regions, particularly in regards to ENERGY STAR certified homes, as well as project schedule constraints, it was not possible to obtain a home in each region. The demonstration homes identified for the project are listed below and are well representative of the typical ENERGY STAR certified home in New York.

Builder	Location	Demonstration Home Address
Belmonte Builders	Clifton Park, NY	6 Calvin Ct. Stillwater, NY
Gerber Homes	Ontario, NY	Lot 136 Overlook Lane Canadaigua, NY
Greenhill Contracting	New Paltz, NY	20 Cooper St. New Paltz, NY
Fedyk Builders	Rochester, NY	51 Cali Ridge Fairport, NY
Saratoga Builders	Saratoga Springs, NY	1 Corrine Ct. Saratoga, NY

TABLE 1: PARTICIPATING ENERGY STAR BUILDERS

FIGURE 1: MAP OF SITE LOCATIONS

Quantitative Data: Energy Monitoring & Analysis

For each home, a professional lighting designer worked with the builders and homeowners to design a whole-house lighting system using 100% LED bulbs and fixtures. These lighting systems were designed to take advantage of the various benefits associated with LEDs, including integrated designs, under-cabinet lighting, occupancy and sensor controls, and dimming capabilities. A simple wireless smart control system (Lutron Caséta Wireless) was installed in each home.

In each of the five homes, data was collected for energy use, cost, and run time on all of the permanent LED lighting fixtures and some portable lighting fixtures as well (up to 8 fixtures in bedrooms, living rooms, etc.). Each home was equipped with a data acquisition system (DAS), a wireless internet connection, and monitored for a minimum of 6 – 8 months for the model homes, and a full 12 months where possible. Observations/estimates that were either drawn directly or extrapolated from the data include:

- Energy: monthly, seasonal, and annual energy use, including hourly time of use profiles of typical days
- Economic: energy costs, installed costs, savings to investment ratio
- Environmental impact: emissions associated with energy use

See Appendix A for our complete Measurement and Verification Plan providing detailed information for measurement and verification of LED performance, data analysis, and reporting.

Qualitative Data: Surveys & Assessments

In addition to monitoring the energy costs and consumption in the demonstration homes, we conducted surveys and interviews with the builders and homeowners involved in the project, as well as general consumers in order to better understand the general public perception of residential LED lighting. The success of LEDs, particularly in the residential sector, relies just as heavily on how consumers feel about the product as it does its savings potential.

For each of the demonstration homes, each of the homeowners was surveyed or interviewed within the first month of occupancy, and again at the end of the monitoring period. The first set of surveys asked the homeowners to identify such things as past experience and knowledge of LEDs, questions about the lighting in their previous home, what appeals to them most about LED lighting, and their initial impressions of the lighting system in their new home. The second survey, focused primarily on specific aspects of the lighting system including; light quality, aesthetics, task lighting, controllability, and design.

A similar approach was taken with builders involved in the project. Through the fixture selection and design process, we were able to identify what each of these builders typically specifies for their homes in regards to lighting fixtures and design, as well as their familiarity with LED lighting. As a relatively new technology, particularly in the residential sector, for most of the builders and trades involved this was their first experience working with LEDs.

To better gauge the overall consumer perception/attitude towards LED lighting a general survey was administered at various events over the course of the project. These surveys were conducted at various building and home shows, open houses, and other industry events in order to maximize the amount of data collected and provide credible results. Participants were shown a lighting demonstration that compared three different light sources (LED, CFL, and Incandescent) side by side and simply asked to choose which one they preferred and why. Each of the bulbs used in the demonstration were of similar specs with regard to brightness (lumens) and color temperature (degrees kelvin).

A third, more detailed survey, was also administered at the events. The purpose behind this survey was to get a general idea of how the majority of consumers make decisions regarding lighting in their home and gauge how well LED lighting technology is penetrating into the residential lighting market.

Copies of all surveys can be viewed in Appendix B at the end of this report.

Current Market Barriers

Previous lighting technologies have suffered due to roadblocks in market acceptance. Compact Fluorescent Lights (CFLs) were promoted heavily in the 1990's and never experienced the level of market acceptance desired. Today, LED lighting technologies are confronting similar challenges on the path to wide-spread market acceptance. Cost and quality are two of the major market barriers for this lighting technology. Low consumer awareness and poor perceptions of LEDs only adds to the problem.

Finally, code requirements and ENERGY STAR software currently do not reward the use of LED technology in lighting, making the business case more difficult.

Cost and Availability

Even as the price of LEDs decreases (the current rate of cost decline is about 20% per year) the payback period from energy savings does not offset the upfront costs. On average, a traditional incandescent bulb costs $0.50-$1.50 and a CFL costs $3.00-$9.00. Meanwhile, a high quality LED can cost anywhere from $5.00-$60.00; a significant price increase that is hard for many consumers to see past. Cost not only affects consumers, but also retailers and manufacturers. A well-designed, quality LED bulb's useful life is significantly longer than a traditional incandescent or CFL, ultimately resulting in fewer bulbs being purchased. Additionally, because of low energy prices in many areas of the country, consumers may have less incentive to make the switch to LEDs.

Another barrier that we discovered throughout the course of this project was the limited availability of LED products. At the beginning of the project, when discussing options with lighting designers, suppliers, and manufacturers, it became clear that the product line for LED lighting was very small. Basic A-Line lamps, flood and spot lights for recessed cans and outdoor lighting, and some LED strip lighting was pretty much the extent of the lighting options. Through our various outreach efforts we heard similar sentiments from both builders and consumers. They indicated that in many cases there was not an LED solution for certain types of bulbs. Similarly, when discussing integrated LED fixtures with lighting suppliers, most said that these products were not yet being mass produced and to order one it would have to be specially made.

Quality and Performance

LED lighting technology is rapidly evolving and new products are being introduced constantly. Overall however, the technology is still in the early stage of development. Some LEDs fail to match the performance level of more traditional lighting technologies, making the energy-savings and environmental benefits associated with them irrelevant to consumers. Quality and performance issues that have proven to be significant market barriers include problems with dimming, efficacy, and color quality. Advancements in technology and manufacturing have improved many of the performance issues associated with LEDs. However, not all LEDs are created equally, and many low-quality products are still susceptible to these issues. A lack of consistency among LED products and limited labeling standards, have, in the past, made it difficult for consumers to distinguish the difference in quality of LED products. Starting in January 2012, the Federal Trade Commission began mandating a "Lighting Facts" label on light bulb packages. The new labels allow consumers to compare certain specifications on each bulb much like you would with nutrition facts on food packaging.

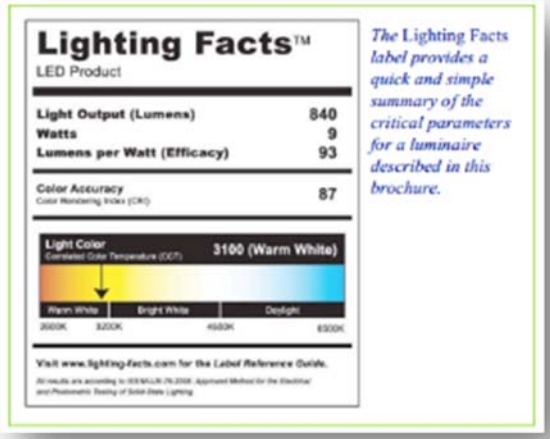

FIGURE 2: LIGHTING FACTS SAMPLE

Solid-State Lighting Demonstration

Consumer Perception and Awareness

How the consumer perceives a product is critical to gaining widespread market acceptance. For LEDs, this has been a serious roadblock. The performance issues associated with some early LEDs and "knock-off" products seem to have hindered more widespread market adoption. Further, the problems and bad experiences with CFLs has made consumers hesitant to accept anything that is labeled as "energy efficient."

As highlighted in a case study on Cree, Inc., the early versions of LEDs have hindered market adoption. "The issue of product standards and accountability became a problem and some product failures slowed adoption."[6] Many LED products have failed to meet manufacturer's performance claims. Poor quality products further complicate the problem. Many consumers are finding out the hard way that a number of the cheaper LED bulbs do not perform up to expected standards. While there have been great strides in LED technology, this initial bad experience is often times enough to leave dissatisfied customers with a negative perception of LED lighting.

The negative perception that many consumers associate with LED lighting is a challenging issue we intend to address in this demonstration. According to Sumit Joshi, head of marketing for Philips Lighting India, "consumer awareness is very low, and most of them think LED lamps are synonymous with cheap Chinese products."[7] As cost continues to decline, it will become less of a market barrier for LEDs. However, without raising consumer awareness about the technological improvements and the benefits of LEDs, and thus changing previous perceptions, the decrease in price will not have as much of an effect on more widespread market adoption as it potentially could or should.

Current State of the LED Industry

In the *2014 Energy Savings Forecast of Solid-State Lighting*, the US Department of Energy (DOE) estimated LEDs had the potential to reduce electricity consumption nearly 50% annually by 2030, saving an estimated 4.5 quadrillion Btus (quads) per year, and over $220 billion in energy costs cumulatively from 2013-2030.[8] In a 2016 update of this report, DOE now estimates annual savings of 5.1 quads by 2035, representing a 75% reduction in energy consumption, and resulting in cumulative savings of over $630 billion in avoided energy costs from 2015-2035.[9]

LEDs have made significant strides integrating into the residential lighting market and all signs lead to this growth continuing for the foreseeable future. According to an industry report from McKinsey & Company, "*McKinsey Global Lighting Market Model*," LED market share in the residential sector has increased from 6% in 2010 to 49% in 2016 and is expected to exceed 70% by 2020. The report also reveals that the residential sector is the largest general application segment for LED technology, representing over 40% of the general lighting market in 2011.[10] According to the 2016 DOE report, LEDs are expected "dominate every general lighting niche" by 2035. The report forecasts that lamps (bulbs)

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[6] Gereffi, Gary; Ahmed, Ghada; Lowe, Marcy: *Case Study: Cree, Inc, Local Markets and Global Competitiveness: A Value Chain Analysis,* 10/22/2010, http://www.cggc.duke.edu/pdfs/CGGC_Cree_CaseStudy_10-22-10.pdf,

[7] *Philips India to focus on quality LED lamps,* 10/30/2013, http://www.thehindubusinessline.com/companies/philips-india-to-focus-on-quality-led-lamps/article5292330.ece

[8] Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, 2014 Report

[9] Energy Savings Forecast of SSL in General Illumination, 2016 Report

[10] Lighting the Way: Perspectives on the Global Lighting Market, McKinsey & Company

and luminaires (fixtures) are "anticipated to hold the majority of lighting installations in each of the niches examined, compromising 86% of installed stock across all categories. By comparison, in 2015 LEDs represented just 6% of the installed stock."

There are several factors that have resulted in the increased market share of LED in the lighting industry. Advancements in technology have improved the quality of LEDs, corrected early performance issues, and rapidly expanded product offerings. Lighting manufacturers have begun to focus solely on LEDs, while phasing out other lighting technologies. This has led to improved manufacturing processes and increased competition, ultimately resulting in a decline in prices. Lighting suppliers and big box stores have also noticed the trend and are stocking their shelves with more LED products while clearing out old technologies. With more products available and increased visibility, LEDs are positioned to become the major player in the lighting industry.

Summary of Key Findings

LEDs Reduce Energy Consumption and Energy Costs

This study provides clear evidence that LED lighting technology has the potential to have a significant impact on the energy consumption and energy costs of residential lighting. Each of the project homes was monitored for real-time energy consumption for the lighting load in each home. The monitoring period covered 9 months in order to obtain data from the summer months, winter months, and one shoulder season as indoor lighting happens tend to change with the seasons.

The table below provides a quick snapshot at the savings potential both for energy consumption as well as cost savings associated with installing LED lighting throughout the home. The savings are estimated values based on real data collected during the monitoring process. The project homes, which all use 100% LED technology, were compared to three of the most common lighting plans seen in the field.[11]

	Estimated Annual Energy Consumption Savings (kWh)	Estimated Annual Energy Cost Savings
100% LED	--	--
Code Home (13W+40W)	979.67	$97.77
Code Home (13W+60W)	1585.77	$157.47
100% Incandescent	3010.41	$297.77

TABLE 2: SUMMARY OF ENERGY AND COST SAVINGS

LED Product Line is Rapidly Expanding

[11] At the time of this study, New York's Energy Code required 50% High Efficacy lighting. For a code home. For the purpose of the study a "code home" uses 50% 13W CFL lighting and 50% Incandescent. The study offers two "code home" scenarios because both 60W and 40W Incandescent bulbs are commonly found throughout homes. It is also not uncommon to find a home using 100% incandescent lighting, particularly in older homes.

Throughout this project one of the major findings we experienced was the rapid expansion of product lines for LED lighting. One of the goals of the project was to make use of lighting technologies that were specific to LEDs. At the beginning of the project, when talking through options with lighting designers and suppliers, there were a limited number of these options available. Most of the LED products that were available were replacement bulbs and basic fixtures using LED lamps. Many of the integrated LED designs either had to be specially ordered or were not yet ready for large scale manufacturing. However, as the project continued we witnessed significant growth in the amount of LED products that became available. Today, there is a viable LED option for just about any style, shape, color, brightness, etc. that the consumer desires.

Consumers Prefer LED's

Regardless of the potential benefits LED lighting provides in terms of lighting design, quality, and efficiency, the consumer perception of the technology will have a profound impact on widespread market adoption of LEDs compared to other light sources. For that reason it was important for us to gauge this consumer perception of LED lighting and the lighting market at large. We conducted several surveys and interviews, using various approaches, to help us understand the current opinion of LED lighting.

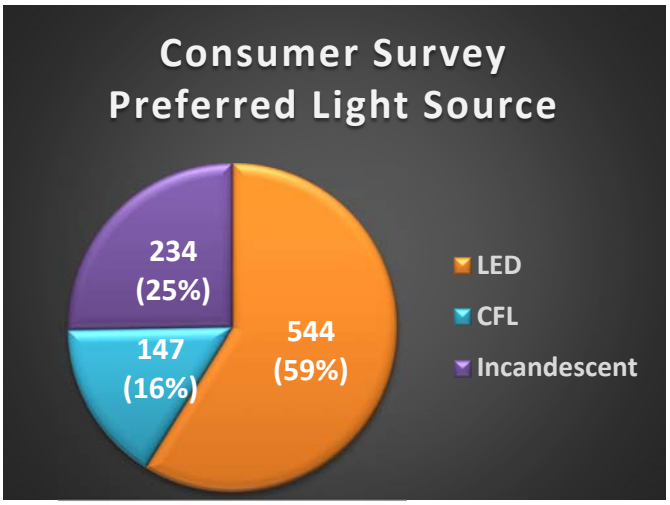


FIGURE 3: SUMMARY OF CONSUMER SURVEY

From these efforts, it became clear that LED lighting is preferred by the vast majority of consumers. In our light box demonstration, where three light sources (Incandescent, CFL, and LED) are compared side by side, using bulbs with matching specifications for brightness (lumens), color (kelvin), and quality (Color Rendering Index). 60% of participants indicated they preferred the LED bulb to the other two options, which was consistent each time we administered the demonstration survey. Additionally, homeowner and builder testimonials, and surveys taken at open house events further support the finding that consumers prefer LED lighting to other light sources.

Section 2- Project Findings

Quantitative Data and Cost Analysis

This project gave a unique opportunity to monitor 5 occupied homes. Newport used a combination of remote and on-site monitoring of all 5 homes. Portable lighting energy use was collected via discrete data loggers read-out during site visits at two month intervals, permanent lighting energy use was recorded remotely through a web-based interface and compiled on an hourly basis. The system used for remote monitoring was the SiteSage system by Powerhouse Dynamics. Cost savings were computed using local utility rates and compared to both typical 2014 construction, and with the use of all incandescent lamps and fixtures.

Energy and Cost Savings

The two tables below highlight the total estimated annual energy consumption and energy costs for all homes in the project. These estimates are based on the energy monitoring results for each house and the current electric rates for the areas in which these homes were located.

	Estimated Annual Consumption (kWh) All Project Homes	Estimated Annual Consumption (kWh) Per Home (5 Homes)	Estimated Annual Consumption Savings (kWh) Per Home
LED	3132.60	626.52	
13+40	8030.95	1606.19	979.67
13+60	11061.47	2212.29	1585.77
Incandescent	18184.63	3636.93	3010.41

TABLE 3: ESTIMATED ANNUAL ENERGY CONSUMPTION AND SAVINGS

On average, the estimated consumption for the lighting in each of the 5 project homes was 626.52 kWh per home. Compared to a "code built" home, using 50% CFL and 50% Incandescent lighting, each LED home would save over 1500 kWh per year. Using the 2012 Census Data of 3,411,632 homes in New York State this could potentially amount to over 5 Billion kWh in energy savings.

	Estimated Annual Cost All Project Homes	Estimated Annual Cost Per Home (5 Homes)	Estimated Annual Cost Savings Per Home
LED	$302.24	$60.45	
13+40	$791.08	$158.22	$97.77
13+60	$1,089.59	$217.92	$157.47
Incandescent	$1,791.11	$358.22	$297.77

TABLE 4: ESTIMATED ANNUAL ENERGY COSTS AND SAVINGS

The estimated annual cost to light the 5 project homes with the 100% LED lighting systems was only $302.24. That averages to $60.45 in energy costs to light an entire home for 1 year. Compare that to a "code built" home and the estimated savings for each home is $157.47 a year. Again, using the 2012

Census data for number of homes, LED lighting could potentially reduce energy costs by up to $537,229,691.

The table below highlights each of the project homes actual data for both cost and consumption collected over the 9 month monitoring period. Additionally, it provides estimated cost savings over three different potential lighting plans, two homes which are "code built" using 50% CFL bulbs and 50% Incandescent (either 60W or 40W) and another that uses 100% Incandescent bulbs. In our field experience we have found that each of these three lighting plans is prevalent in today's existing housing market.

Builder	Fedyk	Gerber	Greenhill	Saratoga	Belmonte	Totals
100% LED Energy Costs	$49.22	$36.18	$43.35	$37.87	$60.50	**$166.62**
100% LED Consumption (kWh)	984	278	333	291	462	**1886**
Vs. Code Home 13W+40W						
Energy Cost Savings	$69.35	$60.66	$68.61	$60.55	$107.46	**$259.17**
kWh Savings	1387	467	528	466	827	**2848**
Vs. Code Home 13W+60W						
Energy Cost Savings	$114.10	$97.20	$110.86	$97.68	$170.46	**$419.84**
kWh Savings	2282	748	853	751	1313	**4634**
Vs. 100% Incandescent						
Energy Cost Savings ($)	$219.25	$183.08	$210.13	$184.98	$211.77	**$797.43**
kWh Savings (kWh)	4385	942	1616	1424	1629	**8367**

TABLE 5: SUMMARY OF MONITORING RESULTS AND ESTIMATED SAVINGS- PROJECT HOMES

The following charts further highlight the energy savings on for both consumption and costs related to the lighting load for each home. Figure 2 shows the average percentage (estimated for non-LED scenarios) of whole-house electrical consumption attributed to the lighting load for the five project homes. Lighting can have a substantial impact on whole-house electrical consumption making the use of efficient LED bulbs and fixtures an opportunity for significant energy and cost savings.

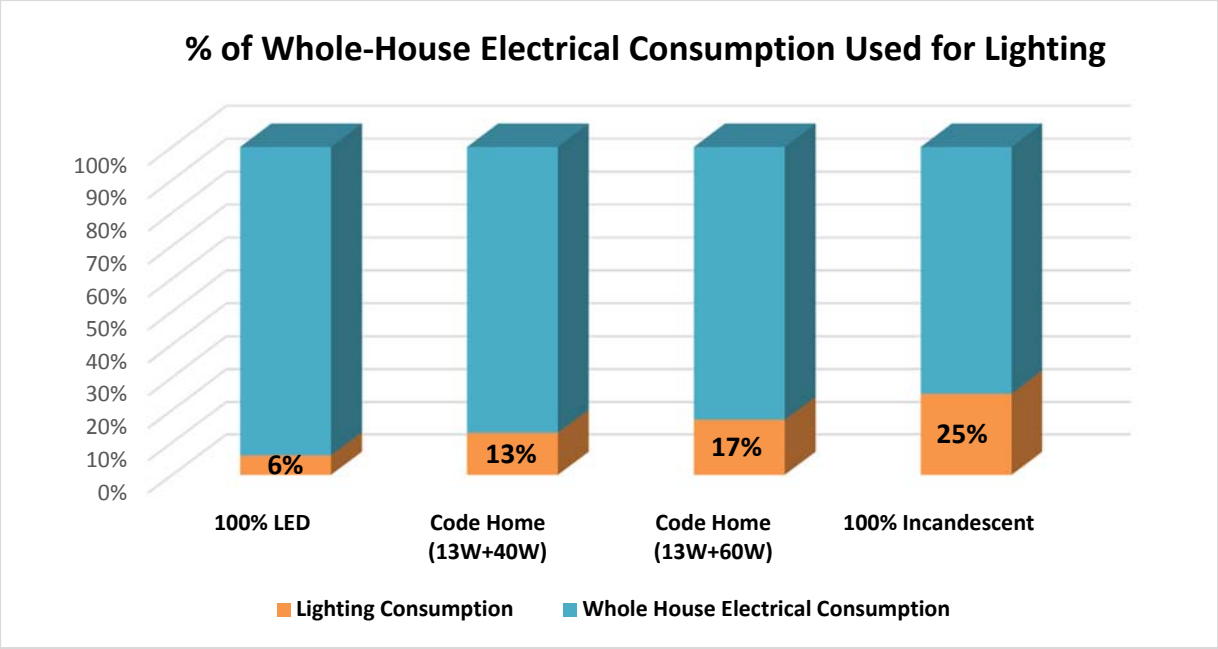


FIGURE 4: WHOLE-HOUSE ELECTRICAL CONSUMPTION VS LIGHTING LOAD

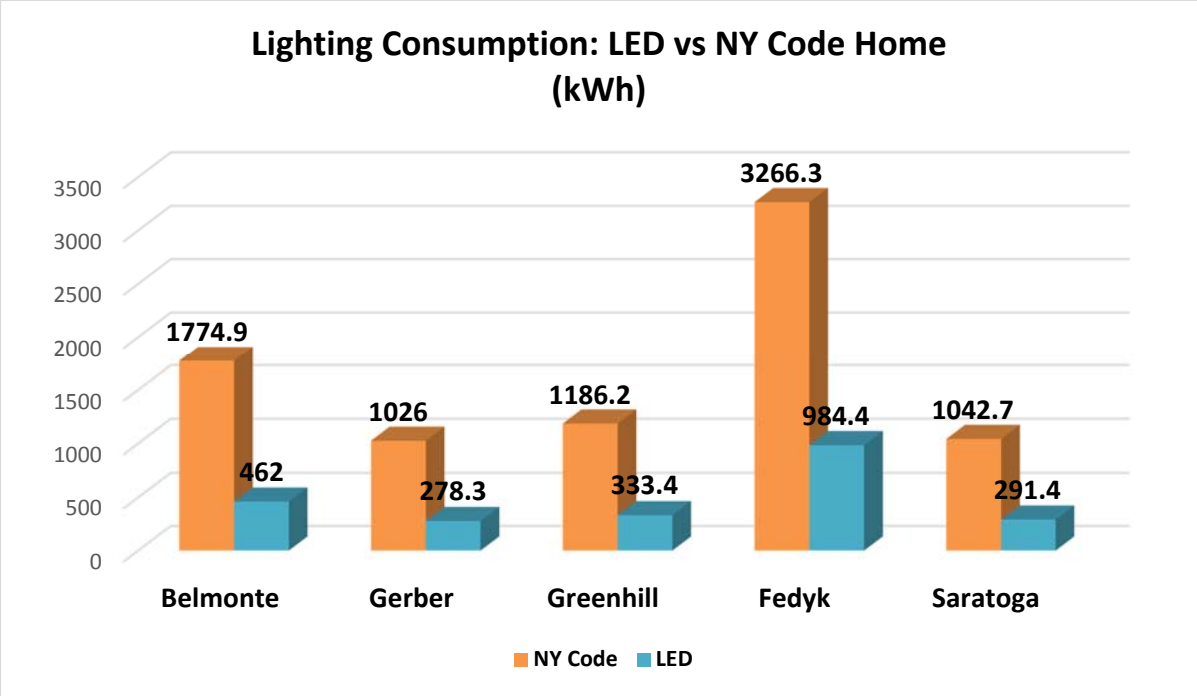


FIGURE 5: COMPARISON OF ELECTRICAL CONSUMPTION FOR LIGHTING LOADS: LED VS. CODE HOME (13W + 60W)

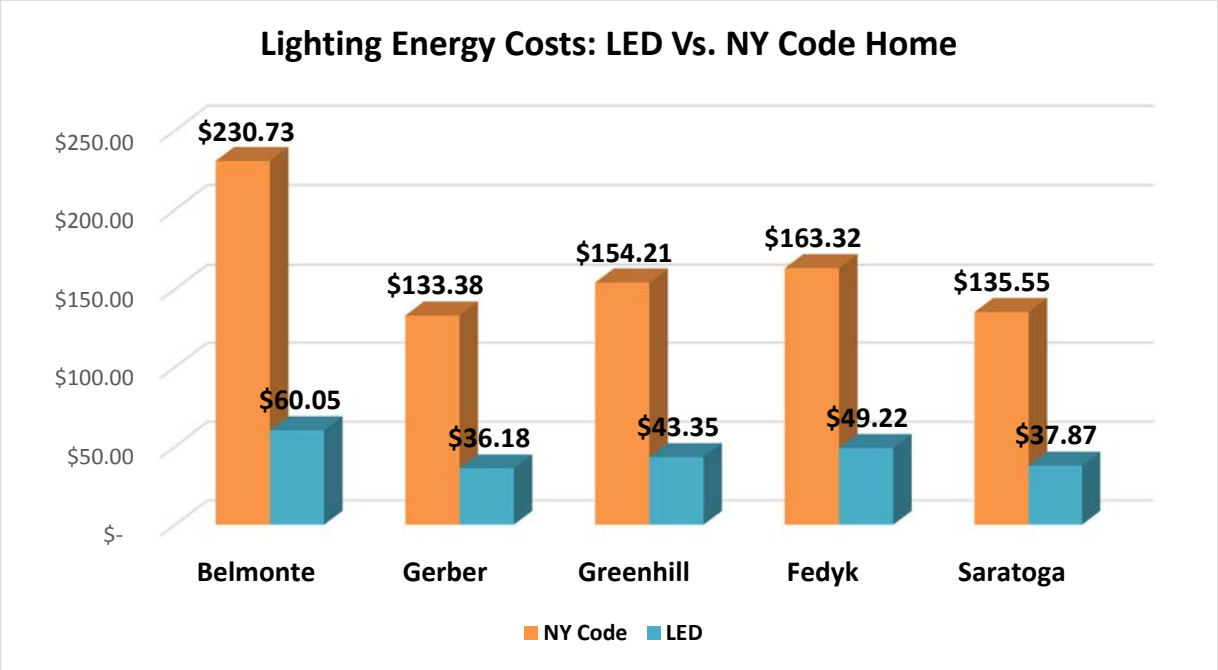


FIGURE 6: COMPARISON OF LIGHTING COSTS: LED VS. CODE HOME (13W + 60W)

Cost of Lighting Systems

For each of the project homes, Newport offered the builders and homeowners an additional $2,500 on top of the typical lighting allowance offered by builders. In some cases, builders offer their homeowners the allowance and allow them to select the fixtures in specific areas of the home. In other cases, the builders estimated the total cost of the typical lighting package they would have installed in the home. These estimates or allowances ranged from $1,000 on the low end, to $2,000 on the high end with most meeting somewhere in the middle.

With their total budget in mind, plus any extra they wanted to spend on upgrading fixtures, homeowners worked with Newport staff, the builder, electricians, and lighting designers to select the fixtures for the home. It is important to note that the goal of this project was not to design the least expensive 100% LED lighting system, but to take advantage of the various benefits that LED lighting design has to offer and provide the homeowner with high-quality and aesthetically pleasing lights and fixtures. Most homeowners opted to spend a small amount over the allotted budget to upgrade a few of the central fixtures in their home.

The table below outlines the approximate cost of the LED lighting system for each of the homes in the study. Additionally, it includes the typical builder allowance or estimate to provide an incremental cost number. It is also important to note that in several situations, where the lighting design was outside the

electrician's typical scope of work, there was an additional cost for wiring included in the total cost for the system. This is included in the total cost (purchase and installation).

Builder	# of Fixtures	# of Bulbs	Cost	Builder Allowance	Added Costs
Belmonte	117	155	$11,500	$1,500	$10,000
Fedyk	63	74	$4,200	$1,400	$2,800
Gerber	46	52	$5,200	$1,000	$4,200
Greenhill	71	97	$4,800	$2,000	$2,800
Saratoga	50	71	$5,100	$1,500	$3,600

TABLE 6: COST OF LIGHTING SYSTEMS FOR PROJECT HOMES

The total cost of a home's lighting system largely depends on two different factors. The size of the home and the number of fixtures and bulbs needed to provide adequate light certainly plays a role. Larger homes with more space to light require more fixtures. The other major factor is consumer preference and budget. Consumers may value high-end fixtures and design for aesthetic purposes and be less concerned with budget. Others may place efficiency first and place less value on the more expensive decorative fixtures. In the case of the Belmonte home, where the cost was double that of the other homes, there were significantly more bulbs and fixtures than in other homes and the homeowner substantially increased their budget to purchase more high-end fixtures.

Qualitative Data Analysis

Energy and cost savings are certainly one of the major benefits of LED lighting technology. There is no argument that LEDs are the most efficient light source available and the results of the monitoring aspect of this study prove the energy and cost savings are real. However, focusing solely on the efficiency of LEDs is selling the technology short. Experience has shown us that energy efficiency, while maybe a driver to some, is not a factor that will result in more widespread adoption of a given technology. More importantly is the experience consumers have with the technology and how it is perceived. For that reason, a big part of this project is based on qualitative data collected from homeowner and builder experience, outreach events, and consumer perception surveys. The following sections highlight these findings.

Homeowner Experience and Testimonials

The homeowners participating in this project all indicated they had little to no familiarity with LED lighting and none had used LED lighting in their previous homes. Several homeowners indicated that lighting was something they had not even thought about when purchasing their new home and selecting from various finishes and materials. However, after being introduced and educated on LED lighting, participating in the fixture selection process, and living with the installed lighting system, each of our homeowners indicated they were very pleased with the LED lighting in their new home. Specifically, they indicated the quality of light was better than that in their previous homes and they enjoyed the added control and convenience from the lighting control system (Lutron Caséta Wireless), highlighting

the smooth dimming range and ability to control the light output from full brightness to off. The homeowners also appreciated the lower electric bills as a result of the LED lighting.

On the lighting in their new home….

"We would not have chosen dimmer switches to start but since we have them now, we really enjoy using them. We enjoy the ability to regulate the light output from bright to dim."- Homeowner

"This has been an incredible experience. My lighting is beautiful, much better than my previous home. I definitely plan on continuing to purchase LEDs in the future."- Homeowner

On the Lutron Caséta Wireless System….

"This system rocks. It was extremely easy to install and program. As for the convenience, life changing. You approach leaving and coming home in a whole new manor. We have scenes set up for both and we never forget to turn a light off, or struggle to find a switch on the way in with our hands full. It will change the way you think about moving from room to room. Great system!"- Homeowner

"We can shut off all the lights in the house when we go to bed. It's nice to be able to shut off lights on the 3rd floor without having to walk up there. We have had a very positive experience with the system. It is low cost, modern, and easy to use."- Homeowner

While much of the focus was centered on the quality of light, efficiency, and design in our surveys and interviews, another main point of emphasis was on the controllability of LED lighting. One of the highly touted benefits of LED technology is its superior controllability and connectivity for smart lighting systems in homes. Homeowner testimonials and surveys taken from open house events show that these features are desired by many consumers to the extent that many of our open house guests inquired about the control system, Lutron Caséta Wireless, in each of the homes after seeing the added comfort and convenience it delivered.

Builder Experience and Testimonials

Each of the five builders indicated they primarily used some combination of incandescent and CFL bulbs throughout their homes. However, after participating in this project, several of the builders indicated they intend to either solely use LEDs in all future construction or offer their future clients an LED lighting package as an upgrade to their standard package. Additionally, because of the high satisfaction rate with the Lutron Caséta Wireless system, many builders indicated they plan to offer this system to both their new and existing clients.

"Since this project, I install 100% LED lighting in all my homes." –Builder

"The LED lights in the home exceeded all of our expectations. The whole process, from design to installation was very smooth and the lights really make the home look beautiful. The Lutron Caséta control system is awesome and so easy to install. We are so impressed with the system we are now offering it to our other homeowners."-Builder

Consumer Perception Surveys

Regardless of the potential benefits LED lighting provides in terms of lighting design, quality, and efficiency, the consumer perception of the technology will have a profound impact on widespread market adoption of LEDs compared to other light sources. To help us better understand the general public awareness and perception of LEDs, Newport participated in several outreach events across New York State, conducting lighting demonstrations, surveys and interviews with attendees.

Below is a list of the major highlights from the consumer outreach events. These highlights include both quantitative and qualitative findings from the events. While conducting the demonstrations and administering the surveys, we were able to talk with over 1,000 people about their lighting preferences. This allowed us to get a sense of the common perceptions consumers hold in regards to lighting their homes. With the number of people reached, and the general consistency of the messages overheard, we feel the qualitative findings are just as credible as any quantitative findings we analyzed. A full report of our first two consumer perception surveys is attached as Appendix C.

FIGURE 7: NEWPORT VENTURES LIGHT BOX DEMONSTRATION

Major findings include:

- The LED bulb was the clear favorite of the three bulbs. Most felt it was the brightness that drew them to the light. Overall, 59% of participants chose the LED bulb.
- There is a willingness to pay more for a high performing bulb particularly if the bulb is ENERGY STAR certified and has a long life expectancy.
- Economic considerations such as energy savings, cost, and life expectancy tend to be more important than physical characteristics of the bulbs.
- Brand recognition is not important to consumers when choosing light bulbs. There seems to be no clear leader in the light bulb market from a consumer's perspective.
- Most people are aware the incandescent bulbs are being phased out and are beginning to make the switch to more energy efficient lighting.
- Many people currently have CFLs in their homes however; there was a good majority that seemed unhappy with them. Participants indicated they are planning to or would switch to LEDs if the price was more comparable to CFLs.
- The $12 price of the LED was a surprise to many, however most felt that it was still too high. According to the written survey the "sweet spot" for a price point should fall between $5-$15.
- Many people are unaware of the new capabilities and advancements in LED lighting and seem to have a bad taste for energy efficient lighting, mostly due to bad experience with CFLs.

The following charts further highlight some of the major findings from the data collected at the outreach events.

Light Box Demonstration Survey

925 Responses

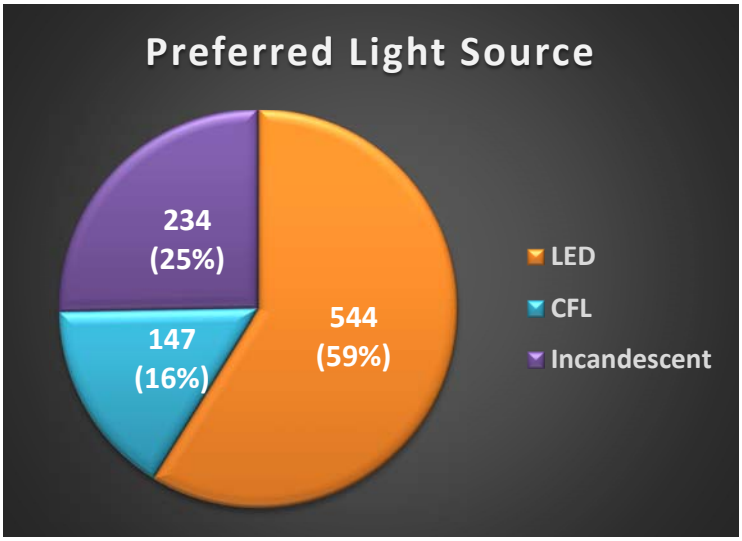


FIGURE 8: PREFERRED LIGHT SOURCE- LIGHT BOX DEMONSTRATION SURVEY

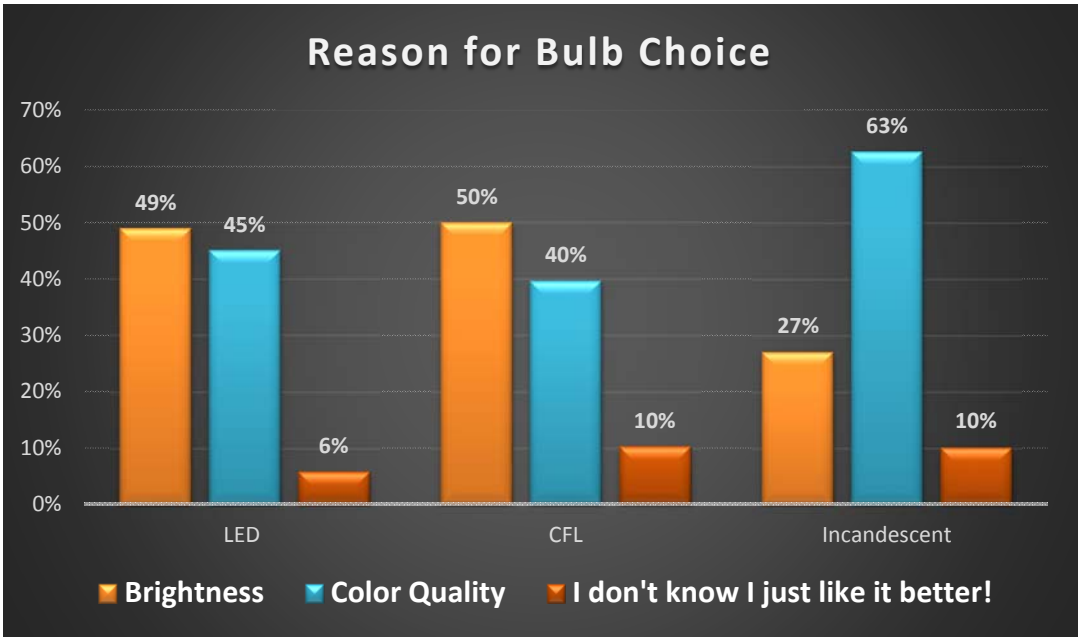


FIGURE 9: REASON FOR PREFERRED LIGHT SOURCE- LIGHT BOX DEMONSTRATION SURVEY

Consumer Survey

289 Responses

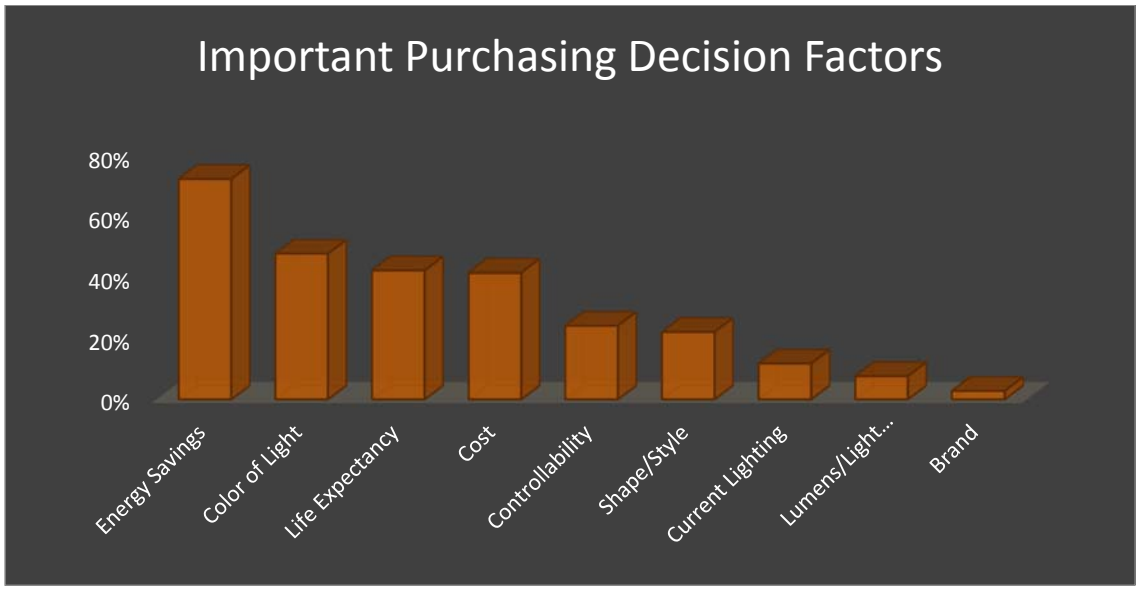


FIGURE 10: IMPORTANT PURCHASING DECISION FACTORS- CONSUMER SURVEY

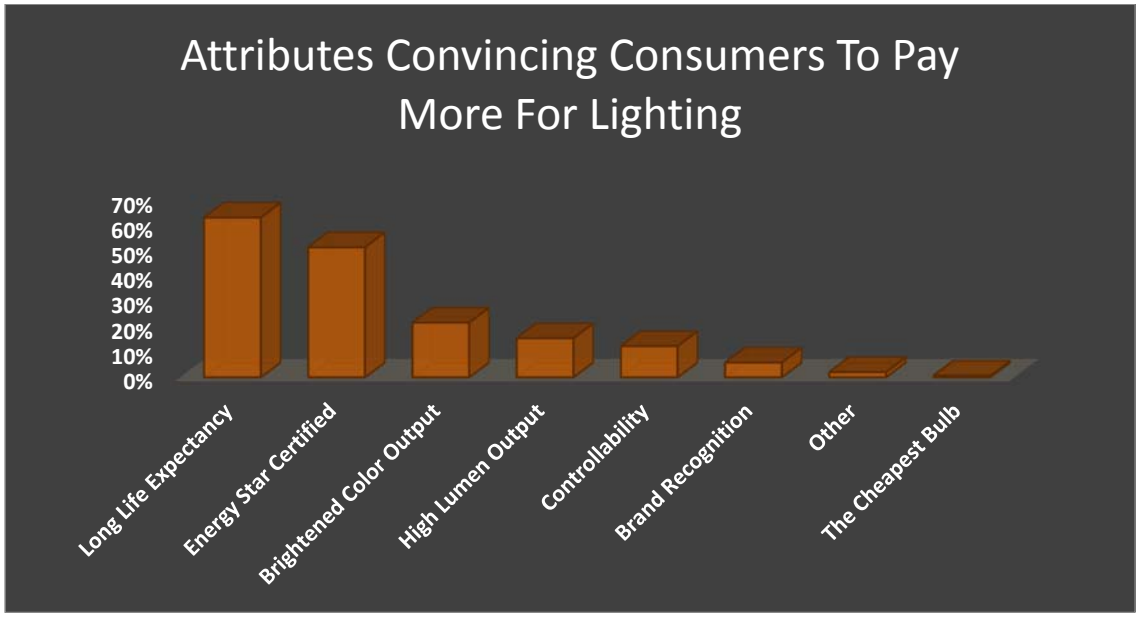


FIGURE 11: ATTRIBUTES CONVINCING CONSUMERS TO PAY MORE- CONSUMER SURVEY

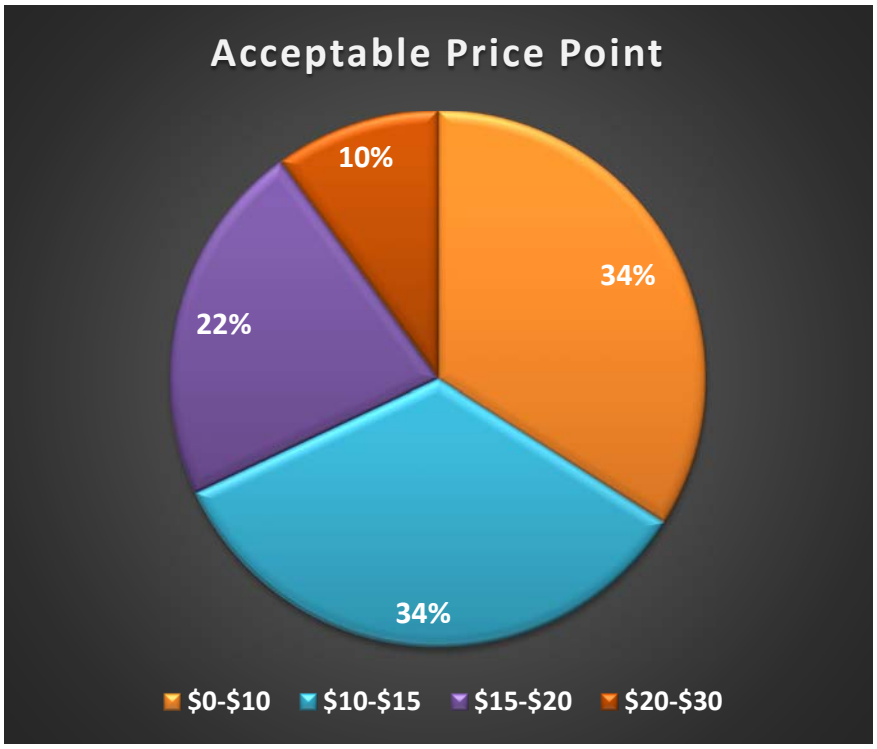


FIGURE 12: ACCEPTABLE PRICE POINT FOR HIGH PERFORMANCE BULBS- CONSUMER SURVEY

Section 3- Technology Transfer

Advancements in the LED Market

In a presentation at the 2015 LEDucation conference in New York City, Joseph Rey-Barreau, Education Director for the American Lighting Association, compared LED lighting technology to that of the cell phone. In the early cell phone days you could make phone calls and send brief text messages. What else did you need? Why would anyone want to take a picture with their phone? Now, think about your cell phone today. Every day it seems as though we find out how we can do more and more with our phones. It's essentially a computer, camera, television, radio, and of course…phone in the palm of your hand.

LED lighting is experiencing much of the same rapid product growth. Today's LEDs not only deliver high quality and efficient light, but they also have introduced innovative solutions and design opportunities that are changing the way we think about lighting as a whole. LED technologies have opened up new possibilities such as the ability to change colors, integrate more seamlessly and more effectively with smart home controls, provide health benefits for occupants, and allow us significantly more flexibility in lighting design. In short, like the cell phone, technological advancements in LEDs allow us to do more with our lighting.

Improved Performance, Product Expansion, and Cost Decline

There are a variety of reasons that LED lighting has experienced significant growth in recent years and is projected to continue that trend for the foreseeable future. Advancements in technology, manufacturing, and design have also continued to improve performance metrics such as efficiency, light quality, output, and durability. Today, LEDs are better, more reliable, and offer more control to the end-user than they did just a couple of months ago, and will continue to improve rapidly.

According to a report from the US Energy Information Administrations, the *Annual Energy Outlook 2014*, the average efficacy (lumens/watt) for a typical LED bulb was just under 50 lumens/watt. In 2014, there were several ENERGY STAR bulbs were available that exceeded 100 L/W. Future projects predict that the efficacy for LED bulbs will surpass 150 L/W by 2020 and 200 L/W by 2030.[12]

While the improved performance is critical to the future success of LEDs, another important development is that these advancements have opened the door for a substantial increase in product offerings. Today, almost any type of light (bulb or fixture) can be replaced with an LED equivalent and because of their manufacturing design, LEDs can be designed in virtually any shape and size, to fit any application or space. This design flexibility has changed the way we think about lighting as a whole. LEDs have moved lighting from an afterthought into a sophisticated design element of the modern home. Now, every aspect of lighting -- placement, function, control, style – can be designed to provide precisely what is needed in a particular room and for particular tasks, offering further opportunity for energy savings, convenience and homeowner comfort.

[12] US Energy Information Administration, *Annual Energy Outlook 2014*, April 2014

This product expansion is something that we witnessed firsthand throughout the project. For example, in our very first home, the homeowner owned a vintage light fixture that was intended to be equipped with Edison filament light bulbs for aesthetic effect. At the time the project began there was no good option for an LED replacement, eventually resulting in the installation of a different fixture. Fast forward just a year later and there are a plethora of lighting manufacturers whose main product line is LED bulbs that look like an Edison filament.

More available products, improvements in the manufacturing process, as well as an increase in competition with more lighting manufacturers focusing on marketing their LED products has also resulted in a drastic decrease in the price of LED bulbs. What was a $40 ENERGY STAR bulb a couple of years ago can now be purchased for as little as $5.00-$10.00. The US EIA report mentioned above also highlights this drastic decline in price for LED lighting. In 2010, a typical LED bulb had a price point of nearly $70.00. In just six years, that price has fallen nearly 85% to around $10.00. Future projections indicate that the price of LED bulbs will continue to decline, although not as rapidly. By 2020 and beyond, the average price of an LED bulb is estimated to be around $2.00-$3.00.[13]

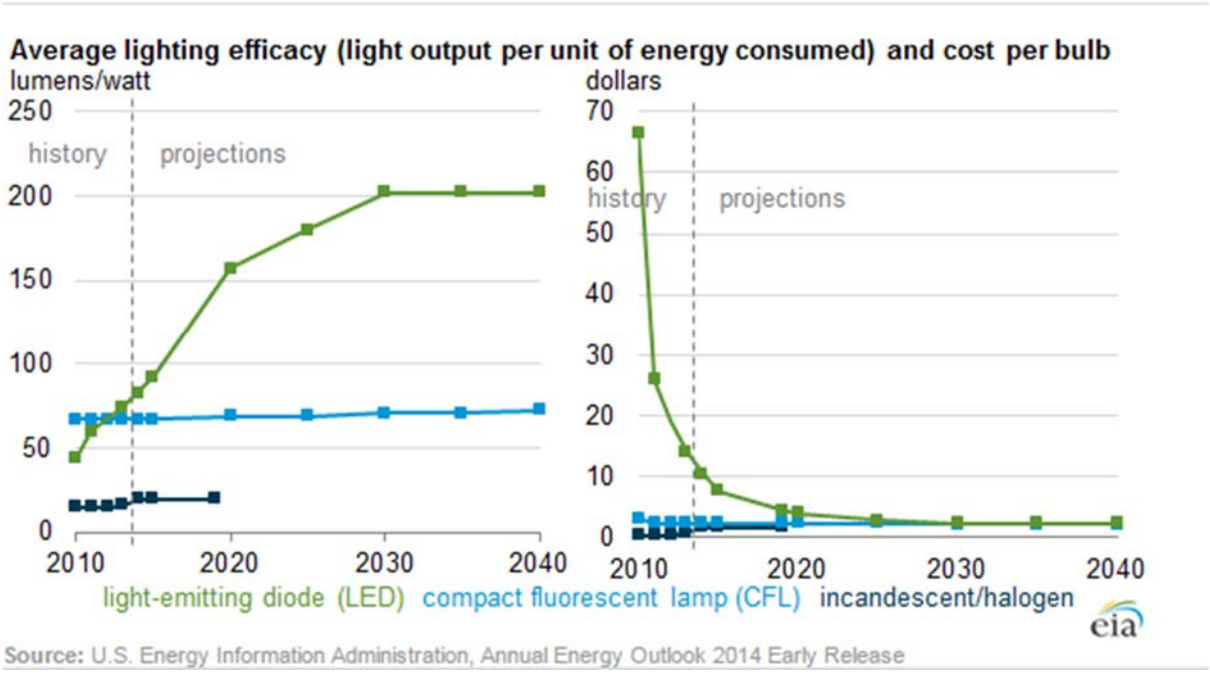


FIGURE 13: ESTIMATED PROJECTIONS FOR EFFICACY AND COST OF LED LIGHTING

Laws, Codes and Standards, Industry Trends

[13] US Energy Information Administration, *Annual Energy Outlook 2014*, April 2014

As building technologies, systems, and practices are updated to improve home performance so too are building codes and product standards. Related to lighting, there are several laws, codes and standards, and industry trends that are helping to push LEDs further into the lighting market while phasing out other lighting technologies. The Energy Independence and Security Act of 2007, has effectively phased out the manufacturing of incandescent bulbs in the US.[14] This gradual phase-out began with the 100-Watt bulb in 2012, continued with the 75-Watt bulbs in 2013, and finished with the phase-out of the 40 and 60-Watt bulbs on January 1, 2014.

Building codes and standards continue to be updated to improve efficiency and performance of today's homes. For example, at the start of this project, the New York State Energy Code was based on the 2009 International Energy Conservation Code which required 50% of the lighting in all new construction be "high efficacy." However, as of October of 2016, the state Energy Code has been updated to be based on the 2015 IECC, which now requires 75% "high efficacy" bulbs or fixtures. Further, both the US Department of Energy and ENERGY STAR have both proposed updates to both the International Energy Conservation Code and the required ENERGY STAR specifications respectively, which would essentially phase-out CFLs and heavily favor LED technology.

As these forces push the industry more and more towards LED technology, major manufacturers are preparing for the future. General Electric has announced they will stop production of CFL bulbs to focus primarily on LED products, and big box stores such as Sam's Club and WalMart are clearing their shelves of other lighting products to make room for LEDs. [15] In 2016, Ikea converted its full lighting range to 100% LED, selling only LED bulbs and LED lamps in all of its stores.[16] With more availability and expanded product lines, LEDs will certainly continue to further integrate into the residential lighting market.

Education and Awareness

Through our various outreach efforts there were two things that became obvious when speaking with consumers. The first was that their knowledge of LED lighting was very limited. The majority of consumers associated LED lighting with "Energy Efficiency" and that was about the extent of their knowledge. Further, that association with "Energy Efficiency" was not always a positive one. After dealing with the various problems and poor light quality of CFLs, many consumers have a bad perception of energy efficient lighting.

However, the second finding was a positive one. After seeing the lighting demonstrations, touring open houses with 100% LED lighting, and learning about some of the further benefits of LED lighting, the vast majority of consumers whom we came into contact with left with a positive perception of LEDs. At open houses visitors were surprised to find out that the home was illuminated with all LED lighting. At home shows, visitors thoroughly enjoyed the lighting demonstration and were again surprised when they selected the LED light bulb as their first choice. Getting a chance to speak with thousands of consumers across the state and show them firsthand the quality, efficiency, control, and innovative design solutions, we were able to effectively highlight the benefits of LED lighting.

[14] https://www.gpo.gov/fdsys/pkg/PLAW-110publ140/html/PLAW-110publ140.htm
[15] http://www.nytimes.com/2016/02/02/business/energy-environment/ge-to-phase-out-cfl-light-bulbs.html?_r=0
[16] http://www.csrwire.com/press_releases/34685-IKEA-To-Sell-Only-LED-Lighting-By-2016

Additionally, the project allowed us to connect with various builders across the state and introduce them to the various benefits of LED lighting. As stated previously, the builders involved in the project admittedly were fairly unfamiliar with LED technology. As is often the case in the building industry, new technologies and practices are first met with some resistance. In particular with this project, educating both builders and electricians on LED lighting and introducing to them new options for lighting design in the home was very effective.

In many cases our initial lighting design was met with resistance from both builders and electricians because it was significantly different from what they typical install for a lighting system in the home. Rather than installing central overhead fixtures to light an entire room, the LED lighting designs often called for a combination of recessed overhead lighting, wall sconces, and other innovative lighting products that improved both task lighting and ambiance. After working through some early issues regarding wiring and fixture selection, both builders and electricians were surprised at how easy the LED lighting designs were to install, as well as the setup of the control system. After seeing the final product and the overwhelming positive reviews from their homeowners, both builders and electricians were able to see tremendous value in LED lighting.

The table below highlights Newport's outreach efforts during this project.

Event	Date	Location	Estimated Reach
2014 Capital Region Parade of Homes	5/31/1-6/1/14	Saratoga, NY	500
2014 Rochester Home-A-Rama	6/12/14-6/13/14	Rochester, NY	700
Efficiency Revolution Series	2/3/15, 2/9/15	Latham, NY/ Tarrytown, NY	200
Times Union Home Expo	2/6/15-2/7/15	Albany, NY	500-700
Rochester Home and Garden Show	3/21/15-3/22/15	Rochester, NY	500-700
Fedyk Open House	3/28/15, 4/12/15	Fairport, NY	100
Gerber Open House	4/18/15	Canandaigua, NY	50
Greenhill Open House	10/24/14	New Paltz, NY	25
Belmonte Open House/ Parade of Homes	2/6/16	Saratoga, NY	100
DOE Lighting Webinar	5/21/2015	Online	63
LED Discussion in Code and Building Science Trainings	Continuous	New York State	2000+

TABLE 7: PROJECT OUTREACH EVENTS SUMMARY

Conclusion

There is clear evidence that the lighting industry is rapidly changing and that LED technology is at the forefront of this movement. While LEDs and the lighting industry at large will continue to evolve and develop, introducing new ideas and solutions, to look back at how far it has come in recent years is incredible. Especially, when you consider the lack of innovation in lighting technologies for nearly a century after Thomas Edison patented the incandescent bulb in 1879. While there were certainly improvements and upgrades to Edison's original bulb, it was still the primary lighting technology until CFLs became a viable option in the 1990s. With increased focus on energy efficiency and improved science, the development of LED lighting technologies has improved lighting efficiency and performance, allowed for added control and connectivity with smart lighting solutions, and opened up new possibilities in lighting design that has changed the way we approach lighting in general.

This purpose of this project was to demonstrate the benefits of LED lighting technologies in the residential sector. It was not to find the cheapest LED lighting solutions or to solely focus on energy and cost savings. While the savings and monitoring of energy use was an important aspect of the study, it was just one of the benefits of LED lighting that was intended to be highlighted with this project. The project was also designed to show how LED lighting through its innovative design solutions, quality and performance, controllability, and improved connectivity meets and exceeds consumer expectations. Additionally, the project aimed to introduce LED lighting technologies to New York State builders and trades, and increase education and awareness of LED products to consumers throughout the state through various outreach efforts.

Overall, the findings from the project clearly demonstrate the numerous benefits of LED lighting technology and support the notion that LEDs are the future of the lighting industry. The real-time energy monitoring of the project homes highlight the obvious energy and cost savings potential of LED lighting. The positive experience of the homeowners and builders involved in the project provides further evidence that LED lighting is not only efficient, but it provides high quality light that meets and exceeds consumer expectations. Further, the various outreach efforts proved that consumers prefer LED lighting over other options and was effective in providing education and raising awareness to the various benefits and advancements in LED lighting.

These project findings, coupled with the current state of the market and future projections for the lighting industry as a whole are solid indicators that the future for LED lighting is very bright.

Appendix A- Measurement and Verification Plan

NYSERDA Solid State Lighting Demonstration
Draft Monitoring Verification and Data Collection Plan

Introduction

Through extensive data collection, analysis and reporting, Newport Ventures (Newport) will quantify and communicate the energy, economic, and environmental benefits of LEDs which are expected to increase market acceptance of the technology. Within five LED homes, Newport will collect energy use, cost, and run time data on all of the permanent LED lighting fixtures and some portable lighting fixtures as well (up to 8 fixtures in bedrooms, living rooms, etc.). Each LED home will be equipped with a data acquisition system (DAS), a wireless internet connection, and monitored for a minimum of 6 – 8 months for the model homes, and a full 12 months where possible. Observations/estimates that will be either drawn directly or extrapolated from the data include:

- Energy: monthly, seasonal, and annual energy use, including hourly time of use profiles of typical days
- Economic: energy costs, installed costs, savings to investment ratio
- Environmental impact: emissions associated with energy use

This plan provides detailed information for measurement and verification of LED performance, data analysis, and reporting.

Test Home Configuration and Participant Cooperation

Prior to any data collection efforts, Newport will communicate and verify the following requirements with the homeowner and builder/electrician:

- Homeowner responsibilities include:
    - Provide a wireless internet connection over the period of the study and to install the router within 30' of the electric panel.
    - Sign a utility release agreement authorizing Newport/NYSERDA access to the home's utility bills during the monitoring period.
    - Provide access to Newport at mutually agreed upon times throughout the project to install DAS equipment, retrieve data, and remove DAS equipment.
    - Be responsive to communications and surveys.
- Builder/electrician responsibilities include:
    - Permanent lighting will only be installed on dedicated circuits in distinct zones.
    - Four distinct zones shall be used for lighting circuits: 1st floor, 2nd floor, garage/basement, and exterior.
    - Multiple circuits may be used in each zone, but no lighting circuits may cross zones (e.g., individual circuits will not cover lighting on both the 1st and 2nd floor, etc.).

Data Collection

To verify the performance of the LED system, data will be collected during the design phase, site visits, and remote monitoring via a data acquisition system (DAS).

Design Phase

During the design phase, a plan review, conversations with the builder/homeowner, and communication with the lighting designer will be used to document key characteristics of the home and lighting design.

- Plan review
  - Square footage of home
  - Ceiling heights in different areas of home
  - Square footage of glazing on each exterior wall as well as any skylights, light tubes, etc.
  - Window overhangs
- Conversation with builder/homeowner
  - Specific builder/homeowner requests regarding lighting package
  - Occupancy characteristics
    - Number of occupants and ages
    - Use of bedrooms [e.g., unused, shared, use for office]
    - Specific portable lighting loads anticipated: aquariums, grow lamps, home office equipment, other
    - Behaviors that could impact lighting use [e.g., typical occupancy schedules, stay at home parent, working from home; use of window coverings; etc.]
- Communication with lighting designer, manufacturer, and manufacturer rep:
  - Collect information on interior and exterior fixtures and lamps for the LED home as related to:
    - Style
    - Type
    - Placement
    - Lumens
    - Watts
    - CRI
    - Color temperature
    - Controls
    - Cost
  - Construct the baseline model. Review the LED lighting plan with the lighting designer, and from this plan, identify a comparative standard lighting package for the baseline home, aggregated by room and zone, and including the same metrics as detailed in the LED plan. For example, a bathroom sink in the LED home may use two one-socket side-lights where the baseline home would perhaps use a 4-socket vanity. For each fixture, document the fixture type, number of lamps, and the associated wattage, assuming 100% incandescent lamps are used. This assumption will be adjusted later, as detailed in the Data Analysis section for the baseline home, but is necessary to make at this stage to estimate the lumens per fixture. Exceptions may exist for special lighting that is

typically installed, such as halogen track lighting. Initial wattage values that will be proposed for lamps are based on fixture type as follows:

- Vanities: 60 W
- Wall sconce: TBD
- Lensed ceiling: TBD
- Recessed: 65 W
- Track: TBD
- Other lighting types: TBD

Site Visits

Three types of site visits will occur for each home: installation, data retrieval, and final equipment removal.

Installation

As soon as possible after the home has received its CO, a site visit will be conducted for each demonstration home to document characteristics of the home that might impact lighting performance as well as install the DAS. Newport will schedule the builder's electrician to be on site during the visit to assist with installation of electrical DAS equipment and wattage measurements in the electric panel. The site visit is expected to take one day. During the visit, the following information will be recorded:

- House conditions
  - Wall/ceiling color
  - Cardinal direction that home faces
  - Window coverings [confirm frequency of use/schedule with homeowner]
- Verification of installed lighting package versus specified lighting package (cross reference and confirm lighting spec style, type, placement, lumens and lumens per watt, CRI, and controls)
- Create a matrix that maps installed lighting package to circuits
- Power measurements
  - Turn every light on and leave on for the duration of the visit (both portable and permanent; lighting will need to be turned off when installing DAS monitoring equipment, but should be turned back on immediately following installation). Using a watt meter, record the max lighting power consumption for each lighting circuit at the electric panel. Power measurements will be compared to average energy use over the course of an hour to verify that the DAS values correlate to the site measurements.
- Data acquisition system installation
  - At least six weeks prior to the home's completion, Newport will order the home's DAS components, including the SiteSage 14-4 and any additional Kill-A-Watts needed (up to 8; check the Ventures stockpile of data logging equipment before ordering). Appendix A list specifications for both types of monitoring equipment.
  - Electrician will install CTs on the designated lighting-only breakers as well as the homes main phases to record whole house electrical consumption
  - After the CTs are installed, Newport will finish the DAS install and verify that the monitoring equipment is communicating with the web portal. If needed, PowerWise Systems provides phone support for trouble shooting.

- Newport will install up to 8 Kill-A-Watts around the home where portable fixtures with the potential for highest usage are located (bedrooms, living rooms, etc). Units will be zeroed out so that only new readings are recorded.
- Newport will record placement of all DAS equipment, including the following:
  - Kill-A-Watt locations and serial numbers along with a description of the device they are plugged into (type of portable fixture, max watts, lumens, etc.)
  - Room and location of room
  - Map/matrix of circuits; their name, serial number, and any other ID as registered in the DAS; and associated rooms, floors, and fixtures
- By confirming the lighting loads and associated energy use with a portable watt meter and the SiteSage system, Newport will ensure that the system is operating properly prior to leaving the site.
- During the week following the site visit, Newport will check the web based monitoring system to identify any anomalies in the data that would suggest equipment error.

Data Retrieval

Site visits to tally the portable lighting energy use recorded by Kill-A-Watt meters will be conducted every other month, over a data monitoring period of 6-8 months. See Appendix A for more information on Kill-A-Watt specifications. For remote sites with competent homeowners, Newport will explore the opportunity to work with the homeowners to provide these data every other month. Time of use data will not be available for discrete data loggers.

Final Equipment Removal

At the completion of the monitoring period, visit the home to remove the equipment.

Remote Monitoring

While portable lighting energy use will be collected via discrete data loggers that are read-out during site visits at two month intervals, permanent lighting energy use will be recorded remotely through a web-based interface and compiled on an hourly basis. The DAS used for remote monitoring is the SiteSage system by Powerhouse Dynamics. This system uses CTs that monitor circuits at the electrical panel with an accuracy of +/- 2% at 10%-130% of the full load. CTs are available in 20A and 50A sizes. Newport will investigate opportunities to improve the accuracy of the equipment through specification of CTs that are more closely matched to the low loads that are anticipated with LEDs. For example, Continental Control Systems supplies a 5A CT with 0.75% accuracy when the load is 1% to 100% of the rated load.

Early in the monitoring period for each LED demonstration home, remotely collected data will be reviewed every few days to flag and address any apparent abnormalities with the targeted data's collection, transfer, and storage. Lighting power measurements taken during the site visit will be used to verify the accuracy of the DAS during full load conditions. Thereafter, hourly and daily data will be exported to an Excel file on a weekly basis and carefully reviewed so that any issues may be resolved in a timely manner. Remote data monitoring will continue for a period of 6-8 months.

Data Analysis

Daily energy use of permanent fixtures will be compiled on a monthly basis. The monthly data will be organized according to electric panel circuit, e.g., location at the residence, and summed for the house as a whole. Observations with respect to areas of highest/lowest use will be noted. Total permanent lighting energy consumption will be compared across different months in order that any significant discrepancies can be investigated promptly. For permanent lighting, a representative day consisting of 24 average hourly blocks of energy use will be developed for each season. With data in hand for a portion of the portable lighting in each home as well, we will also calculate percentages of total consumption for each.

At the end of the monitoring period, a final rollup and calculations will be made. The following metrics will be reported:

- Daily whole house electrical consumption, kWh
- Hourly and daily permanent LED lighting energy consumption – 1st floor, 2nd floor, basement and garage, exterior, kWh
- Seasonal portable LED energy consumption for 8 table/floor lamps by location, kWh
- Total annualized permanent lighting energy consumption
- Annualized portable lighting energy consumption for lamps monitored
- Total seasonal lighting energy consumption
- Areas of highest/lowest use
- Observations regarding permanent lighting time of use
- Total annualized LED lighting energy costs using local electric utility rates

Data analysis for determining lighting energy use and costs will comply with the following methodology.

Quantifying the Lighting Energy Use of the LED Home

- Overview: Lighting energy use of the LED home will be recorded over a period of 6-8 months via a DAS, as detailed in the Data Collection section. Using industry protocol, annual energy use will be estimated from data collected over the 6-8 month monitoring period.
- Measure and record the maximum lighting power consumed per circuit in the LED home during the site visit as detailed in the data collection section of this document. Aggregate for each zone.
- Aggregate lighting energy use as follows
    - Discrete data loggers (i.e., Kill-A-Watt meters) for portable lighting energy
        - Portable lighting energy use will be collected in roughly two month intervals. Monthly energy use for each logger will be estimated by calculating the average daily consumption over the period and then multiplying by the number of days in the month. Annual energy use will be estimated using the following equation:

$$PtAE = \frac{\sum_{i=1}^{n} PtME_i}{\sum_{i=1}^{n} MP_i}$$

where
PtAE = estimated LED portable lighting annual energy use
n = number of months of monitoring of the LED home

$PtME_i$ = LED lighting portable monthly energy use in the i^{th} month of monitoring of the LED home

MP_i = estimated percent of annual portable lighting energy use consumed in the i^{th} month of monitoring of the LED home, based on Table 17 of the Building America House Simulation Protocols (BAHSP)[17] as shown below.

Table 17. Monthly Multipliers for Hard-Wired Lighting

Month	Multiplier	Month	Multiplier
January	0.116	July	0.058
February	0.092	August	0.065
March	0.086	September	0.076
April	0.068	October	0.094
May	0.061	November	0.108
June	0.055	December	0.120

- Estimate the missing monthly portable lighting energy use (i.e., those months in a 12 month period where lighting energy use is not recorded based on a planned 6-8 month monitoring period) by multiplying the corresponding BAHSP monthly multipliers by the estimated portable lighting annual energy use.
- Aggregate estimated monthly energy use into estimated seasonal lighting energy use (winter, spring, summer, and fall).
- Aggregate seasonal energy use into estimated annual lighting energy use.

o Internet-accessed data loggers (i.e., SiteSage) for total lighting energy and permanent lighting energy

- Permanent lighting energy use will be collected in real time, summed, and stored in hourly intervals. Monthly permanent lighting energy use will be aggregated from hourly data. Annual permanent lighting energy use will be estimated using the following equation:

$$PmAE = \frac{\sum_{i=1}^{n} PmME_i}{\sum_{i=1}^{n} MP_i}$$

where

PmAE = estimated LED permanent lighting annual energy use

n = number of months of monitoring of the LED home

$PmME_i$ = LED permanent lighting monthly energy use in the i^{th} month of monitoring of the LED home

MP_i = estimated percent of annual permanent lighting energy use consumed in the i^{th} month of monitoring of the LED home, based on Table 17 of BAHSP.

- Estimate the missing monthly permanent lighting energy use (i.e., those months in a 12 month period where lighting energy use is not recorded based on a minimum 6-8 month monitoring period) by multiplying the corresponding BAHSP monthly multipliers by the estimated permanent lighting annual energy use.
- Aggregate estimated monthly permanent lighting energy use into estimated seasonal lighting energy use (winter, spring, summer, and fall).

[17] Wilson, E; Engebrecht Metzger, C; Horowitz, S; and Hendron, R. 2014 Building America House Simulation Protocols. National Renewable Energy Laboratory. NREL/TP-5500-60988. http://www.nrel.gov/docs/fy14osti/60988.pdf.

        - Aggregate seasonal lighting energy use into estimated annual lighting energy use.
        - Total monthly, seasonal, and annual lighting energy use will be calculated as the sum of permanent lighting energy use and portable lighting energy use.
- Divide the hourly permanent lighting energy use per zone by the permanent power per zone to calculate the equivalent run time at full power. Aggregate to develop the permanent equivalent monthly run time at full power. This variable will be used to estimate the permanent lighting energy use of the baseline home.

Estimating Lighting Energy Use of the Baseline Home

- Overview: For each LED-fitted home in the study, a corresponding baseline home will be developed. The baseline home's lighting specification will be selected to enable energy use and savings comparisons between the LED homes and a standard, code-compliant counterpart.
- Assumptions and calculations:
    - Estimate the fixtures' power draw using the following procedure:
        - Using the baseline home lighting specification developed under the Data Collection – Design Phase section, record the total lumens for each permanent fixture. If the lumens are unknown, calculate the lumens for each fixture based on the number of lamps and assuming incandescent bulbs are used for each lamp. Lumens will be estimated based on wattage using the default efficacy provided in Table 18 of the 2014 BAHSP (i.e., 15 lm/W for incandescents); see below. The wattage to be assumed for each lamp will be estimated as follows, with final assumed values to be determined through consultation with the lighting designer under the Data Collection – Design Phase section:
            - Vanities: 60 W
            - Wall sconce: TBD
            - Lensed ceiling: TBD
            - Recessed: 65 W
            - Track: TBD
            - Other lighting types: TBD

Table 18. Default Efficacy by Lamp Type

Lamp Type	Default Efficacy (lm/W)	Efficacy Ratio (ER)
Incandescent	**15**	**1.00**
Linear fluorescent, T5	104	0.14
Linear fluorescent, T8 (default)	**88**	**0.17**
Linear fluorescent, T12	82	0.18
Compact fluorescent (CFL)	**55**	**0.27**
Miscellaneousfluorescent	85	0.18
High pressure sodium	90	0.17
Metal halide	75	0.20
Light-emitting diode (LED)	**50**	**0.30**

Bold values indicate default values for use in Equations 10–12.

        - Where the wattage for permanent fixtures with representative lamps (i.e., not maximum rated wattage) is unknown, convert the total lumens for each permanent fixture to a representative watt value assuming 50% of these lumens

are provided by high efficacy lamps (i.e., CFLs) and 50% are provided by standard efficacy lamps (i.e., incandescents). This assumption is intended to be aligned with the minimum ECCCNYS 2010 requirement. In converting between lumens and watts, use the default efficacy provided in Table 18 of the 2014 BAHSP (i.e., 15 lm/W for incandescents and 55 lm/W for CFLs).

- Estimate the total wattage for each portable fixture by assuming 60 W per socket (final value to be determined through consultation with lighting designer). Portable lighting for the baseline home is assumed to be 100% incandescent because its efficacy is not regulated by the building code.
- Example: A permanent vanity fixture is assumed to be used in a bathroom. The light has three screw-based sockets. The total lumens for the fixture are calculated as: 3lamps*60W*15lm/W = 2700 lm. Half of these lumens are assumed to be standard efficacy, corresponding to 90 W (2700lm/2/15lm/W = 90 W). The other half of the lumens are assumed to be high efficacy CFL, corresponding to 19.5 W (2700lm/2/55lm/W = 25 W). The total power draw of the fixture is calculated as 90+25 = 115 W.

- Estimate annual total lighting energy use for the baseline home
  - Calculate the maximum total lighting power (i.e., the sum of portable and permanent) for each zone in the baseline home (i.e., 1st floor, 2nd floor, garage/basement, outdoor).
  - Develop estimates for the monthly, seasonal, and annual total, permanent, and portable lighting energy use in the baseline home.
    - Estimate the monthly permanent lighting energy use for the baseline home by multiplying each zone's maximum lighting power by its estimated monthly run time at full power, as calculated for each corresponding LED home over the monitored months (see "Quantifying the Lighting Energy Use of the LED Home" within this document for more info).
      - Aggregate baseline estimated monthly permanent lighting energy use into estimated seasonal permanent lighting energy use (winter, spring, summer, and fall).
      - Aggregate baseline seasonal permanent lighting energy use into estimated annual permanent lighting energy use.
    - Estimate the monthly portable lighting energy use for the baseline home by multiplying each fixture's baseline lighting power by its estimated monthly run time at full power, as calculated for each corresponding LED home over the monitored months (see "Quantifying the Lighting Energy Use of the LED Home" for more info).
    - Estimate the baseline homes' total lighting energy use by adding the portable fixture lighting energy use to the permanent lighting energy use.
    - Aggregate estimated monthly lighting energy use into estimated seasonal lighting energy use (winter, spring, summer, and fall).

- Aggregate seasonal lighting energy use into estimated annual lighting energy use.
- Develop estimates for the monthly, seasonal, and annual permanent and portable lighting energy costs in the baseline home by multiplying estimated lighting energy use by estimated electricity costs ($/kWh). Electricity costs will be determined from local utility bills.

Reporting

The following metrics for the LED Demonstration homes will be available in the final report:

- Total permanent LED lighting, total portable LED lighting, and outdoor LED lighting energy consumption and electric cost in each home by season, kWh and $
- LED lighting energy consumption in each home as a percentage of whole house electrical energy consumption, kWh
- Estimated annual total lighting energy consumption in the baseline home for permanent and portable lighting
- Estimated annual energy savings afforded by the LED lighting package vs. the estimated energy use of the baseline package
- Savings to investment ratio afforded by the LED lighting package vs. baseline package, taking life expectancy of each into account, based on industry and manufacturer data
- Environmental benefits (tons CO_2, SO_2, NO emissions removed/avoided). These will be calculated by applying emissions factors for the state of NY (as determined by EPA's eGRID database) to the energy savings associated with the LED package.

About SiteSage (previously e-monitor)

SiteSage provides real-time electricity monitoring for the home. The equipment records data about the current flow in each circuit every second, and sends it to the secure web-based dashboard every minute.

System Specifications

SiteSage Base (inside panel)

- **Connections**
  - 14 CT sensor ports (pre-packaged, 6-20 amp circuits, 6-50 amp circuits, 2 main phases)
  - Six Pin SiteSage expansion module (xPod) connector (up to 3)
  - Each xPod: 10 CT sensor ports
  - Modular Power Connector (120V AC)

- Connects to 120V/15A breaker
- **Communication Protocols**
  - eLink Wireless 2.4GHz connection to SiteSage Gateway
  - RS485 link protocol to pin SiteSage expansion module (xPod)

Gateway (outside panel)

- **Connections**
  - 1 x10/100 RJ-45 Ethernet port
  - 1 x High Speed RJ-14 serial port
  - 3 Analog inputs – wire pair +/-2V; 3 digital input/outputs
  - USNAP 2.0 modular connector
- **Communication Protocols**
  - TCP-IP via Ethernet (802.3) 10/100base-T
  - Wi-Fi/802.11/b/g/n (Wireless 2.4GHz connection to Base Unit)
  - Local via High Speed Serial Port
  - ZigBee (802.15) mesh networking (optional USNAP module)

Accuracy

Split-core CTs are accurate to within +/-2% when the load is between 10% and 130% of the CT's rated load.

Cost

SiteSage Energy Monitor $754.00

- SiteSage 4-14 (Monitor up to 12 circuits plus 2 mains)
- Includes 2 years of data service and registration.
- Purchase Ethernet cable connected Gateway
- 3-5 business days for delivery

Purchase and support contact for the SiteSage

Christian Gilbert,
Business Development PowerWise Systems
www.powerwisesystems.com
Phone: 207-266-4922
christian@powerwisesystems.com

About Kill-A-Watts

The Kill-A-Watt EZ P4460 Meter ***(do not purchase the Kill-A-Watt 4440 no memory retention)*** – Capabilities- Readout for Watts, Volts, Current, Frequency, Power Factor, and VA, and keeps a running total of kWh (energy consumption) and the total time operation plus program in the price you pay for electricity so it can keep a running total of cost as well as kWh, and provide projected costs per hour, day, week, month and year. The other advantage of the EZ is that it doesn't lose its cumulative totals when it's unplugged or there's a power cut ***(you have to physically hold the reset button to reset the totals).***

Accuracy

0.2% of reading

Cost

Kill-A-Watt P4460 EZ

- $24.67 on Amazon ($28.97 Home Depot)

Appendix B- Consumer and Homeowner Surveys

Homeowner Survey
Pre-LED Home Occupancy

How much knowledge of LED lighting did you have prior to participating in this project?

None Very Little Knowledge Somewhat Knowledgeable Extremely Knowledgeable

The primary bulb type for the lighting in your previous home was….

CFLs Incandescent/Halogen LED

Prior to this project, what type of lighting controls did you plan on putting in your new home? (Check all that apply)

Toggle Switches (On/Off) Dimmer Switches Timer Switches Motion Detectors

Occupancy Sensors "Smart" lighting controls

Prior to knowing about this project how interested were you in LEDs for your new home? What about "smart" lighting controls?

What features of LED lighting appeal to you the most? Why?

Describe your experience with regards to designing and specifying the lighting plan in your new home. Did you find it difficult to understand the terminology used to specify LEDs? (lumens, kelvin, CRI, etc.)

Describe your experience with the Lutron system in regards to ease of installation, programming, and overall convenience.

Homeowner Survey
Post-LED Home Occupancy

General

How many people live in your new home?

On a scale of 1-5 (5 being the best) rate the effectiveness of the lighting in your home for the following:

Quality of light	1	2	3	4	5
Aesthetics	1	2	3	4	5
Task Lighting	1	2	3	4	5
Controllability	1	2	3	4	5
Design/Layout	1	2	3	4	5

LEDs

What did you like best about the lighting in your home? Was there anything you did not like?

Did you experience any failures or malfunctions with your LED lighting?

Will you continue to purchase LED lights in the future?

Dimming

How often did you use the dimming capabilities of your light fixtures?

Which lights did you dim the most?

Did you experience any issues dimming any of the lights in the home? Please explain.

Controls

How often did you use the Lutron controls?

What feature of the control system did you use the most?

Was there anything you did not like about the system?

Would you purchase a control system in the future after your experience with this system?

Appendix C- Case Studies

Belmonte Builders

Belmonte Builders is located in Clifton Park, their mission is to provide customers with fine quality homes that meet their individual needs.

Belmonte achieves this by paying close attention to detail, using innovative high quality products, and attaining and keeping experienced staff who strive for excellence. They are proud of their reputation as in industry innovator. They are constantly trying to improve themselves and have been a perfect fit for the SSL project.

Belmonte is an ENERGY STAR builder. Most of the homes they build are between 1,800 and 4,000 square feet and has won numerous awards throughout the years for both their designs and construction quality.

The home used for the SSL project was typical customized home with the owner's being very energy efficiency minded – making them a perfect fit for the SSL project. The overall Home Energy Rating System (HERS) Index for this home is a 43.

Contact Information

Builder	Peter Belmonte	518-371-1000	peter@belmontebuilders.com

Lighting Design and Specification

Belmonte Builder's typically gives homeowners an allowance of $1500 to cover indoor/outdoor lighting for the home. Any cost above that the homeowners are responsible for. Due to the additional cost of choosing LED fixtures Newport contributed $2500 to the homeowners for selecting LED lighting throughout their home. The total lighting cost for this home was approximately $11,500.

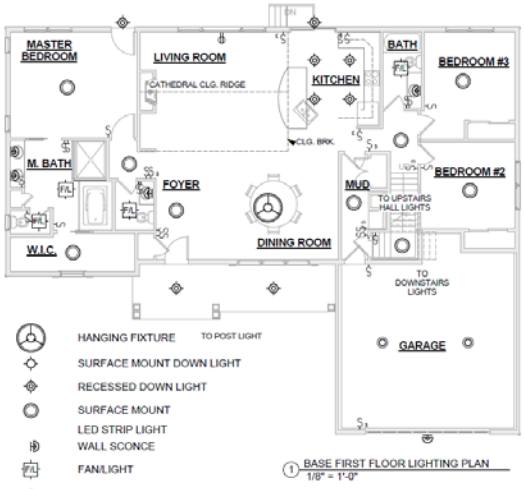
The Belmonte built home averaged 9.5 watts per light fixture with a 65 lumen per watt output. Many of the homes 117 permanently installed fixtures are integrated LED's while the remaining fixtures received screw in LED bulbs. The floor lamps and table lamps in the home all received screw in LED bulbs with 4 of the most frequently used lamps getting plugged into Kill-A-Watt meters to record daily electrical consumption during the course of the nine-month monitoring period.

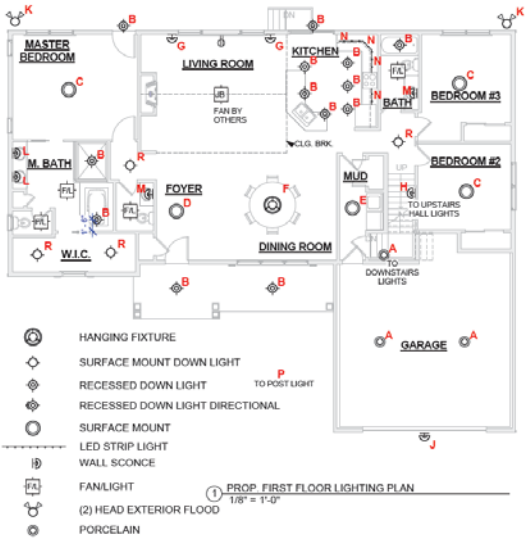
The homeowner's in this case were an interesting mix. The wife is very sensitive to different types of light and was extremely concerned about her comfort in using LED's. The husband is actually an efficiency expert and was very excited to build a home with 100% LED's. Design and style was of utmost concern with this lighting package and the majority of the decorative fixtures in this home were of

traditional lighting, non-integrated LED's, using simple bulb replacements. Where the integrated LED's did shine were in locations such as the under cabinet lighting and the addition of the internal closet lighting as well as all of the exterior fixtures.

A complete list of bulbs and fixtures is available upon request.

Floor Plans





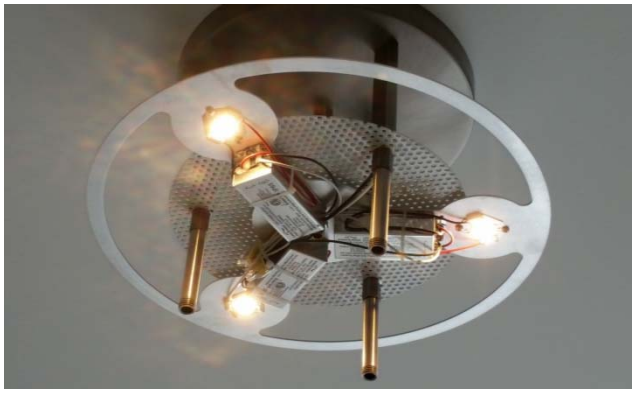
Summary of data collection for Belmonte Home

Light Source	Avg. Monthly Cost ($0.13 kWh)	Yearly Cost (estimated)	Year One Savings (estimated)
100% LED	$6.67	$80.07	----------
13W/60W (50% high efficacy)	$25.64	$307.64	$227.57
100% Incand.	$42.14	$505.71	$425.64

Fedyk Builders

Fedyk Builders is a luxury custom home builder founded in 1980 when the family owned business built their own house. Since then they have built over 400 homes in the Rochester, NY area. In 2003 they joined the ENERGY STAR program and have completed 54 ENERGY STAR homes and counting.

The home chosen for the project was already under construction but at an early enough stage that lighting design and a site visit made by all interested parties to layout the lighting plan and what fixtures should go where. Some of the fixtures that the homeowner wanted to keep came with pin based halogen bulbs but those were easily swapped out for pin based LED's.



The home was an ideal pick as it was already being built as an ENERGY STAR home. The building shell consists of R-21 fiberglass batts in the wall spaced at 16" on center, the ceiling received R-38 fiberglass batt insulation. With a HERS index of 53 the home was rated 47% better than a comparison home.

Contact Information

Builder	Oksana Fedyk	585-729-5061	ofedyk@aol.com

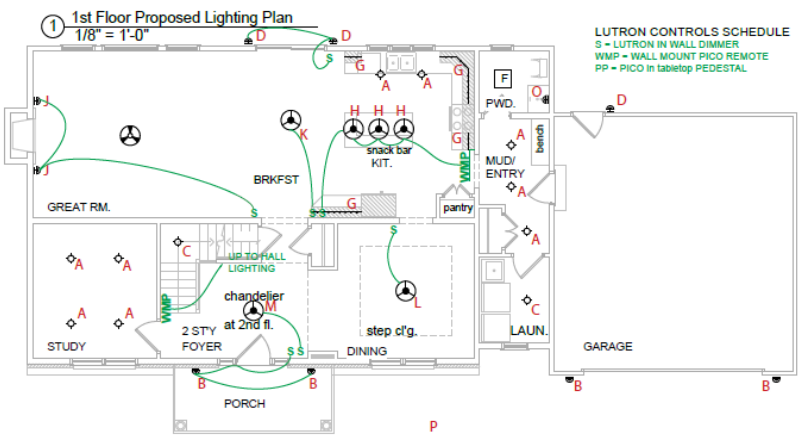
Lighting Design and Specification

Fedyk Builders typically gives homeowners an allowance of $1400 to cover indoor/outdoor lighting for the home. Any cost above that the homeowners are responsible for. Due to the additional cost of choosing LED fixtures Newport contributed $2500 to the homeowners for selecting LED lighting throughout their home. The total lighting cost for this home was approximately $4,200.

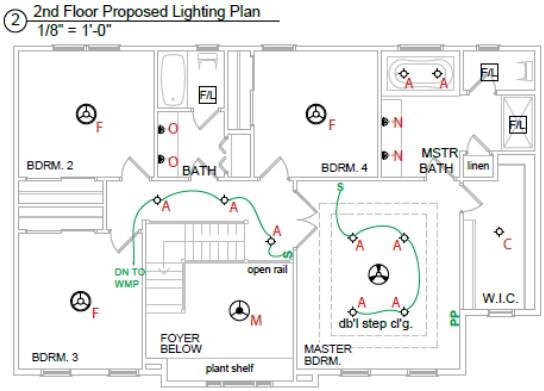
The Fedyk built home averaged 11.0 watts per light fixture with an 85 lumen per watt output. Many of the homes 63 permanently installed fixtures are integrated LED's while the remaining fixtures received screw in LED bulbs. The floor lamps and table lamps in the home all received screw in LED bulbs with 4 of the most frequently used lamps getting plugged into Kill-A-Watt meters to record daily electrical consumption during the course of the nine-month monitoring period.

A complete list of bulbs and fixtures is available upon request.

Floor Plans



FIRST FLOOR LIGHTING PLAN – PROPOSED



SECOND FLOOR LIGHTING PLAN – PROPOSED

Summary of Data Collection for Fedyk Home

Light Source	Avg. Monthly Cost ($0.05 kWh)	Yearly Cost (estimated)	Year One Savings (estimated)
100% LED	$5.47	$65.62	----------
13W/60W (50% high efficacy)	$18.15	$217.76	$152.13
100% Incand.	$29.83	$357.95	$292.33

Gerber Homes

Gerber Homes, Inc., a family owned and operated home building business, has been building and renovating homes in the Greater Rochester area for more than 50 years. Having built over 2,000 homes, with at least 344 of those rated as ENERGY STAR, Gerber Homes prides itself on being on the cutting edge of energy efficiency.

Gerber's interest in advancing energy efficiency to the next level fit well with the SSL project. Most of the homes they build are ranch style and between 1,400 and 3,500 square feet.

Gerber Homes immediately had a ranch home made available for the project. They identified this home as an opportunity to learn more about high efficacy lighting and the associated costs to offer a 100% LED package for future homes.

The home selected for the project is located in Canadaigua, NY just south of Rochester. Newport Ventures provided the lighting design services along with the ENERGY STAR rating for the home.

The house was built as a model home but was soon purchased by a retired couple looking to down size from their previous Gerber built home. The building shell consists of R-19 fiberglass batts in the wall spaced at 24" on center, the ceiling received R-44 blown in cellulose insulation. With a HERS index of 50 the home was rated 50% better than a comparison home.

Contact Information

Builder	John Graziose	585-509-0994	John@gerberhomes.com

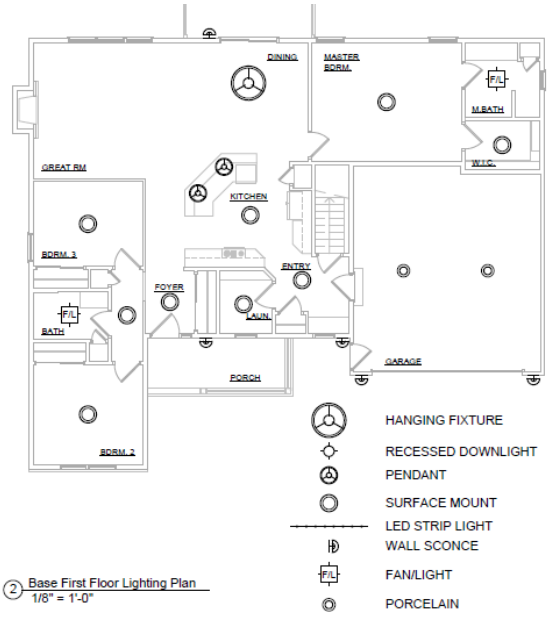
Lighting Design and Specification

Gerber Homes typically gives homeowners an allowance of $1000 to cover indoor/outdoor lighting for the home. Any cost above that the homeowners are responsible for. Due to the additional cost of choosing LED fixtures Newport contributed $2500 to the homeowners for selecting LED lighting throughout their home. The total lighting cost for this home was approximately $5,200.

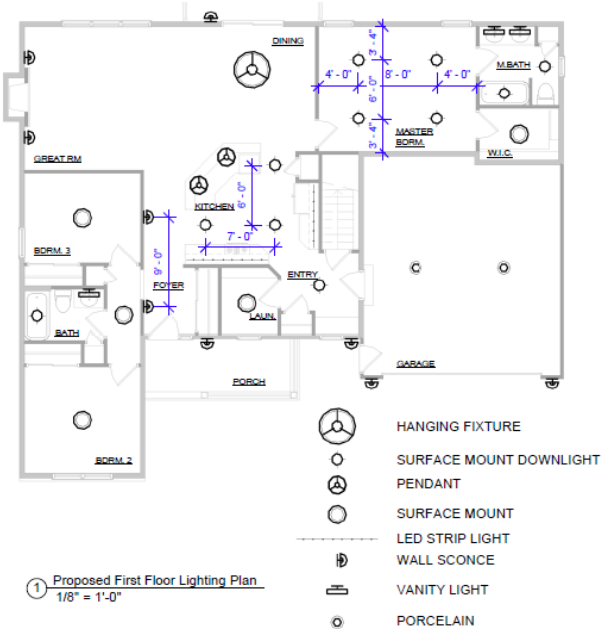
A mixture of integrated LED's, were installed along with screw in LED bulbs for the homes 46 permanently installed fixtures. The Gerber home averaged 9.9 watts per light fixture with a 62 lumen per watt output. The floor lamps and table lamps in the home all received screw in LED bulbs with 4 of the most frequently used lamps getting plugged into Kill-A-Watt meters to record daily electrical consumption during the course of the nine-month monitoring period.

A complete list of bulbs and fixtures is available upon request.

Floor Plans



2 Base First Floor Lighting Plan
1/8" = 1'-0"



1 Proposed First Floor Lighting Plan
1/8" = 1'-0"

Summary of Data Collection for Gerber Home

Light Source	Avg. Monthly Cost ($0.13 kWh)	Yearly Cost (estimated)	Year One Savings (estimated)
100% LED	$4.02	$48.24	----------
13W/60W (50% high efficacy)	$14.82	$177.84	$129.60
100% Incand.	$24.36	$292.34	$244.10

Greenhill Contracting

Greenhill Contracting is located in Kingston, NY their mission is to provide customers with the highest energy efficiency homes while meeting many green building standards in the process.

Greenhill builds each home to comply with the ENERGY STAR, EPA Indoor airPLUS, USGBC LEED for Homes, and DOE Zero Energy Ready Homes certification. The homes are built with R-22 ICF walls, R-20 closed cell foam under the basement slab, R-63 foam roof insulation and ground source heat pumps.

Greenhill Contracting homes sizes average around 2,000-4,500 square feet. Greenhill was recognized by NYSERDA as the lowest HERS Index Builder in the state for 2012-2013.

The home used for the SSL project was typical of the builders current housing stock. The owners were greatly interested in the project and asked for their home to be used even though much of the construction was already complete and Greenhill was moving on to the finishing stages of the home. The overall Home Energy Rating System (HERS) Index for this home is a -3 achieved by the addition of solar panels on the roof.

Contact Information

Builder	Anthony Aebi	845-384-6188	Greenhillcontracting@yahoo.com

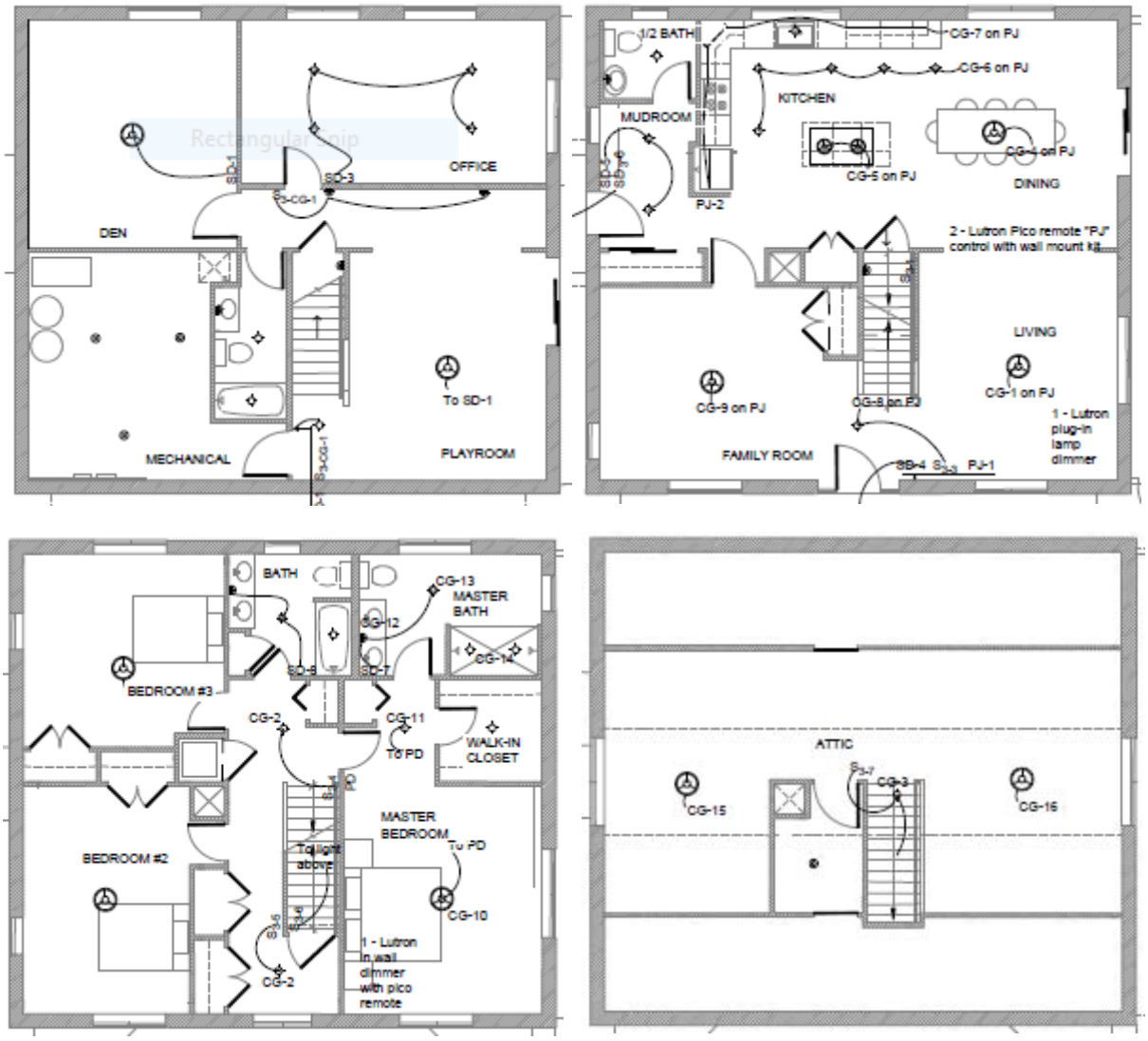
Lighting Design and Specification

Greenhill Contracting typically gives homeowners a lighting allowance of $2000 which typically consists of 24 recessed lights for use anywhere in the house. Any cost above that the homeowners are responsible for. Due to the additional cost of choosing LED fixtures Newport contributed $2500 to the homeowners for selecting LED lighting throughout their home. The total lighting cost for this home was approximately $4800.

The Greenhill home averaged 10.3 watts per light fixture with a 74 lumen per watt output. Many of the homes 71 permanently installed fixtures are integrated LED's while the remaining fixtures received screw in LED bulbs. The floor lamps and table lamps in the home all received screw in LED bulbs with 4 of the most frequently used lamps getting plugged into Kill-A-Watt meters to record daily electrical consumption during the course of the nine-month monitoring period.

A complete list of bulbs and fixtures is available upon request.

Floor Plans



Summary of Data Collection for Greenhill Home

Light Source	Avg. Monthly Cost ($0.13 kWh)	Yearly Cost (estimated)	Year One Savings (estimated)
100% LED	$4.82	$57.80	----------
13W/60W (50% high efficacy)	$17.13	$205.61	$147.81
100% Incand.	$28.16	$337.97	$280.17

Saratoga Builders, LLC

Saratoga Builders, LLC is located in Saratoga Springs, they are an award-winning builder specializing in building homes with energy efficiency in mind. Saratoga Builders has been building custom homes in and around Saratoga Springs since 2004. Since that time they have built over 50 homes with over 30 of them receiving ENERGY STAR certifications.

Saratoga's interest in advancing energy efficiency to the next level fit well with the Solid State Lighting project. Most of the homes they build are between 1,700 and 3,500 square feet.

The home used for the SSL project was the winner of 6 awards including, Realtor's Choice, Best Master Bedroom Suite, Best Curb Appeal, Best Craftsmanship, Best Architectural Design and Best Kitchen during the 2015 Parade of Homes. Saratoga's 2,020 square foot SSL home contained three bedrooms and an attached garage. The overall Home Energy Rating System (HERS) Index for this home is a 50.

Contact Information

Builder	Sam Palazzole	518-587-2666	SamPalazzole@aol.com

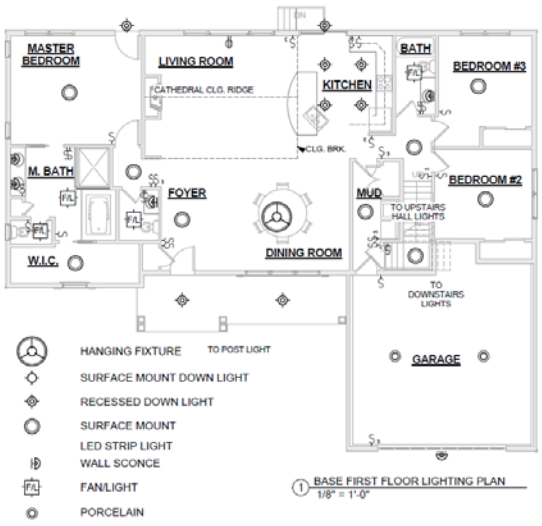
Lighting Design and Specification

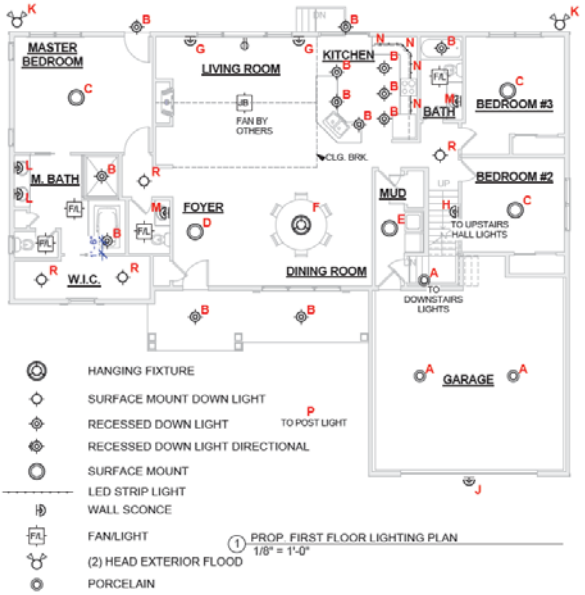
Saratoga Builder's typically gives homeowners an allowance of $1500 to cover indoor/outdoor lighting for the home. Any cost above that the homeowners are responsible for. Due to the additional cost of choosing LED fixtures Newport contributed $2500 to the homeowners for selecting LED lighting throughout their home. The total lighting cost for this home was $5100.

78% of the homes 50 permanently installed fixtures are integrated LED's while the remaining 22% received screw in LED bulbs. The average wattage per fixture was 10.2 with a lumen per watt output of 82. The floor lamps and table lamps in the home all received screw in LED bulbs with 4 of the most frequently used lamps getting plugged into Kill-A-Watt meters to record daily electrical consumption during the course of the nine-month monitoring period.

A complete list of bulbs and fixtures is available upon request.

Floor Plans





Summary of Data Collection for Saratoga Home

Light Source	Avg. Monthly Cost ($0.13 kWh)	Yearly Cost (estimated)	Year One Savings (estimated)
100% LED	$4.21	$50.49	----------
13W/60W (50% high efficacy)	$15.06	$180.74	$130.24
100% Incand.	$24.76	$297.13	$246.63