Northeast and Mid-Atlantic Residential Lighting Strategy: 2015 Update

December 2015

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Acknowledgements

The Northeast Residential Lighting Strategy was published to address the role of high efficiency lighting products in capturing all cost-effective energy efficiency in the region while also providing broad energy, economic, and environmental benefits. This document provides regional and national updates to the original document finalized in March 2012, the 2012-2013 Update finalized in December 2012, the 2013-2014 Update finalized in October 2013, and the 2014-2015 Update finalized in December, 2014. This report reflects the invaluable contributions of multiple individuals. Claire Miziolek, NEEP's Market Strategies Program Manager, served as the report's project manager and lead author. NMR, led by Chris Russell, contributed the Market Adoption Model analysis.

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About NEEP

NEEP was founded in 1996 as a non-profit whose mission is to serve the Northeast and Mid-Atlantic to accelerate energy efficiency as an essential part of demand-side solutions that enable a sustainable regional energy system. Our vision is that the region will fully embrace next generation energy efficiency as a core strategy to meet energy needs in a carbon-constrained world.

Disclaimer: NEEP verified the data used for this white paper to the best of our ability. This paper reflects the opinion and judgments of the NEEP staff and does not necessarily reflect those of NEEP Board members, NEEP Sponsors, or project participants and funders.

Executive Summary

It has been a long journey working to transform the residential lighting market. NEEP's 2015 Update to the Northeast and Mid-Atlantic Residential Lighting Strategy presents the progress to-date in a market transformation framework and charts a path forward to complete transformation of this market. Using the August 2015 resource *The State of our Sockets* as a launching off point, this update summarizes key research and progress, trends and advances, and includes new analysis of the remaining savings opportunity for this market.

Efficient residential lighting, one of the longest standing efficiency program measures, saw several ground-shifting market developments since last year's analysis. Most notably, the introduction of lower-lifetime LEDs disrupted the market with their significantly lower price points and rocked the residential lighting world in the second half of 2015. Smart lighting products also are coming to market with exciting features and creating new market opportunities. Furthermore, the discussion of market trends has been clarified to speak not only to different technologies, but also to different applications and lamp-types, as not all trends apply to all products.

An update on the state of the market in the Northeast showed gaining socket saturation for LEDs and halogen products. Another layer of influence affecting the market is that of federal standards, EPA's ENERGY STAR program, and California Energy Commission state standards; 2015 was a significant year for activities from all of those agencies. Program Administrators also had a banner year, with a heightened number of programs promoting LEDs and over 13 million efficient lighting products promoted in the region in 2015. Along with the success of programs comes new evaluations and a deeper understanding of the impact program administrators are having on the market.

Looking forward, there are significant quantities of remaining savings in the residential lighting market. Through a Market Adoption Model analysis, we found that in aggregate, with a regional gross annual savings potential in the 2-3 TWh range, the regional savings from a transformed residential lighting market would have the equivalent annual impact of nearly 600 wind turbines installed or taking over half of a coal-fired power plant offline.

Achieving that significant level of regional savings means overcoming market barriers to accelerated adoption of efficient residential lighting. Presented in this update are the barriers that emerged as the greatest challenge for regional stakeholders as well as insight and analysis on each of the following barriers.

- Consumer confusion in selection of lighting products
- High comparative price of efficient alternatives
- Negative consumer perception about high efficiency lighting
- Efficiency program barriers, including misunderstandings across program lighting assumptions, inaccurate delta watt savings assumptions, and regulatory pushback based on limited understanding of EISA legislation

There are also several market opportunities to leverage at this time to transform the market, including:

- LEDs are exciting and desired
- Smart lighting

- ENERGY STAR Luminaire's Specification: new bulb in a box savings opportunity
- Linear Fluorescent: Potential opportunities for improved efficiency
- National efforts moving forward

By working through these barriers and leveraging these opportunities, the region can achieve market transformation. The regional goal NEEP is putting forward is ***to reach a socket saturation of 80-90 percent efficient quality lighting by 2022***. Over the course of the next 5 years, that could add up to over 15 TWh of total savings for the region in the timeframe. Socket saturation was selected as the metric by which to chart progress because it continues to be regularly measured with reliable evaluations and ultimately reflects the final impact on home energy consumption.

Regional Goal:

"Reach a socket saturation of 80-90% efficient quality lighting by 2022. Over the course of the next 7 years, that could add up to over 15TWh of total savings for the region."

Using theory of change methodology, we built a timeline for market transformation on which a series of market interventions can be represented. These are designed to either overcome existing market barriers or leverage emerging market opportunities to accelerate the adoption of efficient residential lighting and effectively transform the long term market in the Northeast and Mid-Atlantic. Market transformation, as established in our goal, is achievable by following the eight recommended strategies:

1. Continued PA support for energy efficient residential lighting
2. PAs transition portfolios in short term towards LEDs and in longer term towards specialty
3. PAs target LEDs in hard-to-reach markets
4. PAs consider including smart lighting in portfolios
5. PAs explore opportunities in residential linear products
6. Regional collaboration on residential lighting research
7. Regional coordination on data collection and sharing
8. Regional discussions on savings calculation inputs to ensure appropriate attribution

NEEP continues to see cost-effective savings from residential lighting products. The residential lighting market is far from transformed, and there is a lot of work to do to ensure customers are selecting the most efficient lighting products over their inefficient counterparts. NEEP's role in the regional market transformation of efficient residential lighting will be to chart progress towards the goal as well as to report on market developments as they come.

Introduction

Welcome to the 2015 Update to the Northeast Residential Lighting Strategy. Take your seats and help us to chart a path to achieve transformation of the residential lighting market from antiquated, inefficient technology to one where efficient lighting dominates. This Update accompanies several previously published reports, starting with the original Residential Lighting Strategy released in 2012. With this third update to that original report, we are making some changes to the format and how information is presented to clearly demonstrate how the market is transforming.

In 2015, we saw many changes to the efficient lighting market. The price point for LEDs dropped significantly, new products such as smart LEDs and lower-lifetime LEDs started to enter the market, and regulators in the Northeast started to push back on program plans to aggressively promote efficient residential lighting as some perceived the market to be "transformed" after decades of promotion. To help address the latter issue, NEEP authored a paper called *The State of our Sockets: a Regional Analysis of the Residential Lighting Market*[1]. This analysis focused on the impact of the Energy Independence and Securities Act (EISA) and what regulators and program administrators should expect from residential lighting in the short and long term. A few of our major findings are as follows:

- Inefficient lighting still fills the majority of sockets in the Northeast.
- Using the best available data, we found that EISA 2020 applies to less than half of the sockets in a home, and is not in place until 2020. Though important, it will not be the panacea for residential lighting market transformation.
- As efforts continue in this space, there is a strong need for better and more consistent data to track progress to allow policy makers and program administrators to make more informed decisions.
- Efficiency programs have an important role to help transform this market in both the short and long term, especially for products not impacted by the EISA legislation.

"EISA 2020 applies to less than half of the sockets in a home, and is not in place until 2020. Though important, it will not be the panacea for residential lighting market transformation."

Given this evidence that the market has not been transformed, the 2015 RLS Update sets out to chart where we are along the residential lighting market transformation curve and provide actionable strategies to continue on our way to transformation. The RLS identifies remaining barriers to be overcome and new opportunities to exploit in order to achieve full market transformation. We developed tools, recommendations, and strategies, and honed our goal for what a transformed market would look like in residential lighting. We also determined the metrics to be tracked and the savings opportunity to be gained through a transformed market.

The information provided in this strategy, along with the previous iterations, can continue to provide value to the residential lighting market and stimulate collaborative relationships to accelerate the transformation of the residential lighting market in the Northeast and Mid-Atlantic.

[1] *The State of our Sockets*, NEEP, August 2015. http://www.neep.org/state-of-our-sockets

Technology and Market Characterization

Technological Trends and Movements Analysis

While the residential lighting market has long been characterized, by NEEP and many others, with this update it seemed necessary to review the available lighting technologies as well as provide some basic updates on standards and test procedures. Table 1 shows the available lighting technologies and residential lighting applications. Represented by arrows in this analysis is the trending information regarding that product's market penetration as either growing (up arrow), staying stable (side arrow), or shrinking (down arrow). Excluded from this analysis is linear fluorescent lighting which makes up about 10%[2] of the market and will be addressed in the *Market Opportunities to Leverage* section. As retail is the primary channel for residential lighting sales, most of the trends described apply to retail sales.

Table 1: Description of Current Trends and Key Factors for Residential Lighting Technologies and Applications[3]

Technology/ Application	Omnidirectional/General Service (approx. 60% of sockets)	Directional (approx. 13% of sockets)	Decorative (approx. 16% of sockets)
Incandescent 	Inefficient[4] ↘ Regulated by EISA (impacted in Phase 1: 2012-2014) Still have significant socket penetration, but mostly off of store shelves except for those exempted by EISA	Inefficient ↘ Regulated by DOE. Not very widespread as halogen is preferred alternative	Inefficient → Not regulated Relatively common and low-cost option
Halogen 	Inefficient ↗ Regulated by EISA (impacted in Phase 2: 2020) Gaining market share and socket penetration. Lowest cost option for customers	Inefficient → Meet regulations Widespread	Inefficient ↘ Not very widespread as incandescents are not regulated and remain the common alternative
Compact Fluorescent Lamps (CFL) 	Efficient → Regulated by EISA (likely not impacted until Phase 3: 2025), currently covered by ENERGY STAR. New DOE Test Procedure underway Northeast socket saturation around 30%, but gains beyond that have been very challenging Common bulb. Relatively low price point. Shrinking but still prominent role in efficiency program portfolios until 2017/2018	Efficient ↘ Technology is not a great fit for directional applications. Many programs moving away from support as LED provides a better alternative	Efficient ↘ Technology is not a great fit for most decorative applications. Many programs moving away from support as LED provides a better alternative

[2] *The State of our Sockets*, NEEP, August 2015. http://www.neep.org/state-of-our-sockets
[3] Images from Natural Resources Defense Council, http://www.nrdc.org/energy/lightbulbs/files/lightbulbguide.pdf
[4] As defined in The State of our Sockets and consistent with EISA, "inefficient" refers to products that are 45lpw or less, with "efficient" referring to products that higher than 45lpw.

Light Emitting Diodes (LEDs) 	Efficient  Regulated by EISA Phase 2/3 but most products are unlikely to be impacted. Can be covered by ENERGY STAR. New DOE Test Procedure underway. Gaining in market share, Northeast socket saturation between 1-10% Bulb is gaining in popularity in retail channels. 2015 saw introduction of several low-cost non-ENERGY STAR LEDs that have disrupted the market.	Efficient  Technology well suited for this application Price points are dropping, but still relatively low market penetration Included in efficiency programs and may be for the longer term	Efficient  Technology well suited for this application New products are coming to market with dropping price points, but still relatively low market penetration Included in efficiency programs and may be for the longer term

As Table 1 demonstrates, this market is very dynamic. Even between technologies and applications, there are fissures in the market. For example, the penetration of LEDs in retail channels varies significantly between lamp types, with directional having the greatest penetration of LEDs at 18%, and decorative bulbs with lower rates of penetration, at 3%[5]. Another example that took hold in 2015 was the lower-lifetime omnidirectional LED (also referred to as the "value," "basic," or "ish" bulbs). This trend gained momentum through the spring and into the summer of 2015, spurred by the release of Philip's 60W equivalent LED rated for 10,000 hours in May at a previously unforeseen price point of 2 bulbs for $4.97[6]. Within a few months, many more familiar LED manufacturers joined this trend by releasing LEDs in the $2.50-$3.50 range without an incentive.[7] Although each of these products is slightly different, they are all aligned in that none of them met ENERGY STAR's Lamps V1.1 requirement for a 25,000 hour rated life. Many of these products have lifetime claims of 10,000 or 15,000 hours. Beyond missing the ENERGY STAR criterial for rated life, some also do not meet the omnidirectional or power factor thresholds. While not a requirement of ENERGY STAR, none of the lower-lifetime LEDs are dimmable. With ENERGY STAR's December release of the Draft Final Specification for the updated Lamps 2.0[8], however, ENERGY STAR is taking a step to adapt the specification that would allow lower-lifetime omnidirectional products to earn certification. This growing trend has been a disrupter in 2015 in the residential lighting market[9], but ENERGY STAR's steps, discussed further in the *Federal and State Standards, Policies, and Voluntary Programs* section, will go a long way to ensure that most LEDs on the market are ENERGY STAR certified, are high quality, and remain eligible for efficiency program rebates.

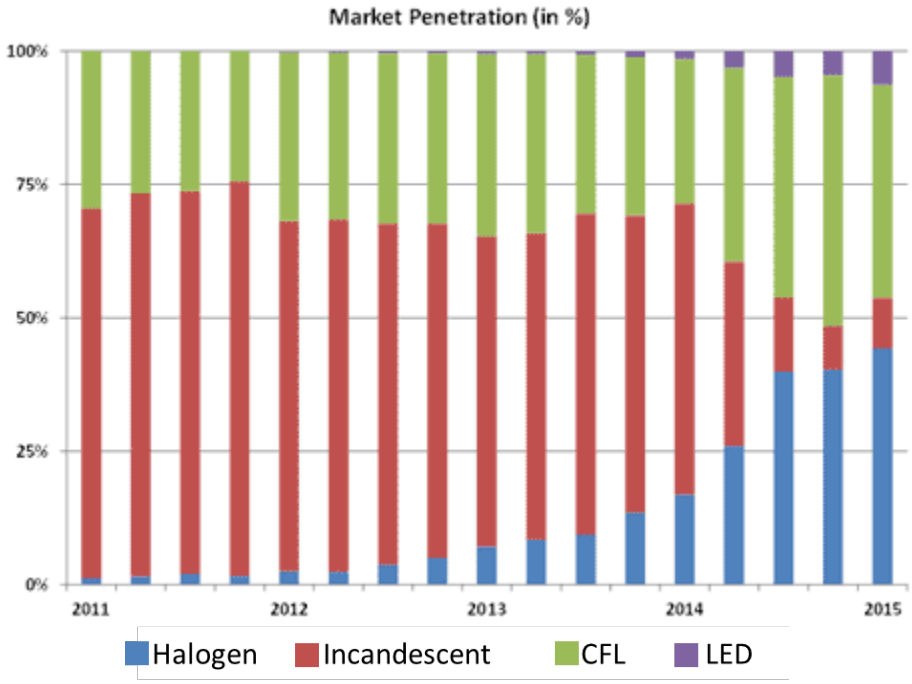
Another trend, which will be explored more in the *Market Opportunities to Leverage* section, is the growth of smart and/or connected lighting. This is an exciting advancement, not only for the residential lighting market, but more broadly as these lights intersect with Home Energy Management Systems and mobile devices.

Between these trends, it is becoming clear that there are at least three classes of LED products that may be available from the same manufacturer such as: smart products equipped with aps and advanced features sitting

[5] From Nov 17 presentation at DOE Market Development workshop, http://energy.gov/sites/prod/files/2015/11/f27/carmichael_ledadoption_portland2015_r.pdf
[6] http://www.wired.com/2015/04/philips-cheap-led-bulbs/
[7] http://switchboard.nrdc.org/blogs/nhorowitz/the_led_lighting_revolution_is_1.html
[8] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2%200%20Draft%20Final%2012-04-2015.pdf
[9] http://www.icfi.com/insights/white-papers/2015/crossroads-of-residential-dsm-lighting-programs

at the highest price point, fully-equipped ENERGY STAR LEDs with great dimming (with potential color tuning features) for a modest price point, and now a class of basic functionality LEDs at lower price points. The latter class of low-cost, basic-functionality LEDS have emerged as a competitor to CFLs and halogen products. With ENERGY STAR's Draft Final Specification for Lamps 2.0, it is hoped that manufacturers will see this as an opportunity to continue engaging with ENERGY STAR, offering omnidirectional LEDs with basic functionality at low price points with quality assurance such that these products could be eligible for efficiency program rebates. Ensuring high quality for all LED lamps is critical for long-term consumer acceptance for the technology. However, depending on the application and the customer, if products within each class are meeting the quality standards set forth in ENERGY STAR, they each have a valuable role in the market.

Figure 1: NEMA Shipping Data Lamp Indices, A-Line[10]



Charting the development of these three classes of LEDs will be a new challenge. Sources such as the National Electrical Manufacturers Association (NEMA's) lamp indices which show quarterly shipping data of NEMA member manufacturers group by technology type. As such, while the LED category continues to grow as seen in Figure 1 with data through the first quarter of 2015, the rate of growth for smart LEDs, or lower-lifetime LEDs is not differentiated.

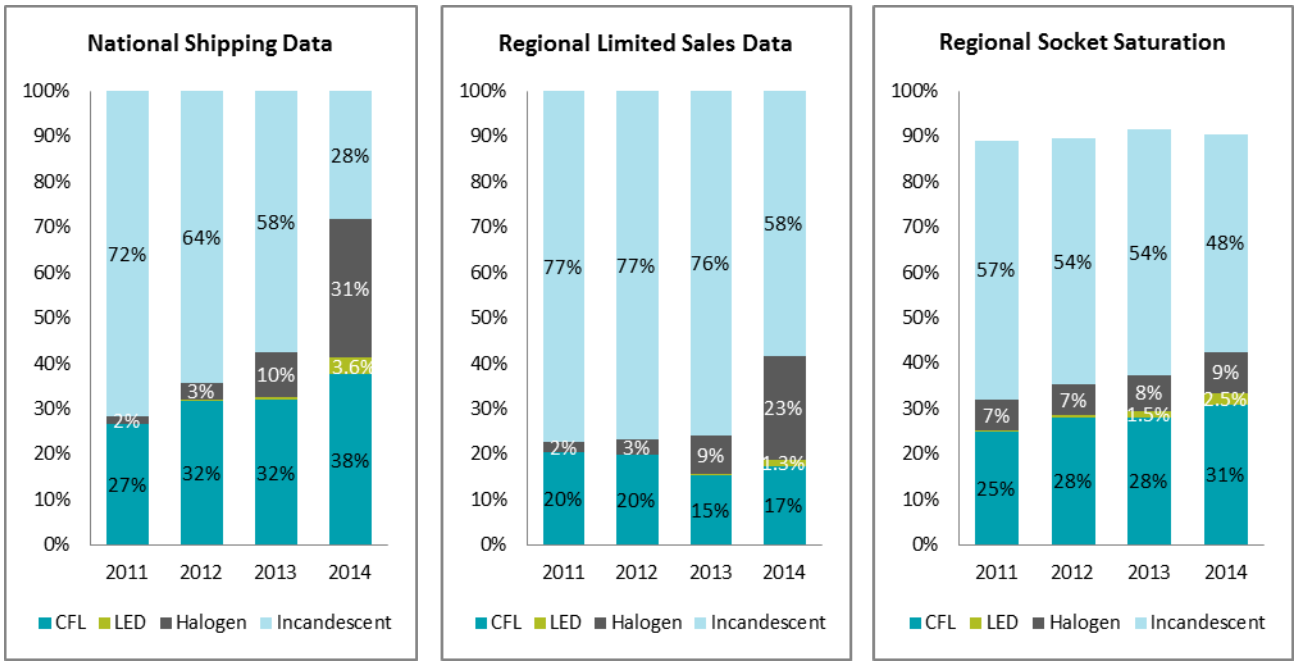
Market Status in the Northeast

As reported in *The State of our Sockets*, the Northeast has long been active in promoting efficient lighting. As such, the market for CFLs and LEDs is quite mature. In Figure 2, we show a snapshot from *The State of our*

[10] http://www.nema.org/news/Pages/First-Quarter-Proves-to-be-a-Mixed-Bag-for-Consumer-Lamp-Indexes.aspx

Sockets of the residential lighting markets from years 2011-2014 for shipping, sales[11], and socket saturation[12]. Each market data source—shipping, sales, and socket saturation—has insights and shortcomings, but many trends can be seen in all three. Most notably, inefficient technologies (halogen and incandescent) are still the dominating technology. In some cases CFLs are growing and in other cases staying stagnant. In all three perspectives, however, LED and halogen are technologies on the rise. While these perspectives are primarily focused on General Service Lighting, many of these trends are observed through all residential lighting applications. As conveyed in *The State of our Sockets*, this snapshot shows that the residential lighting market has not been transformed.

Figure 2: Market Snapshot from *The State of our Sockets*



Federal and State Standards, Policies, and Voluntary Programs

There are several activities underway on the Federal and State level. Six critical efforts to be aware of that had movement in 2015 are as follows:

EISA 2020

As NEEP reported in *The State of our Sockets*, the Energy Independence and Securities Act (EISA) 2020 rulemaking is still underway. In late 2014, DOE released a Preliminary Technical Support Document (PTSD) for the General Service Lighting Standard[13] enacted by EISA in 2007. This PTSD proposed several efficacy levels for

[11] Disclaimer regarding the Regional Limited Sales Data: The information contained herein is based in part on data reported by IRI through its Advantage service for, and as interpreted solely by LightTracker Inc. Any opinions expressed herein reflect the judgment of LightTracker Inc. and are subject to change. IRI disclaims liability of any kind arising from the use of this information

[12] *The State of our Sockets*, NEEP, August 2015. http://www.neep.org/state-of-our-sockets

[13] https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=83

general service lighting products, all of which would be such that currently only LEDs and CFLs would qualify. The Notice of Proposed Rulemaking (NOPR), the last stage in the process, is expected in December of 2015. At this time, a congressional budget rider restricting DOE from enforcing EISA is still in place; whether that will be removed before the standard goes into effect in 2020 is unknown. NEEP, through our Appliance Standards initiative, continues to monitor and provide comments when appropriate to this rulemaking.

DOE LED Test Procedure

In June, 2015, DOE released a Supplemental Notice of Proposed Rulemaking (SNOPR) on a Test Procedure for LED Lamps[14]. This test procedure is important as it will set consistent testing parameters for LEDs as they continue to enter the market. The proposed tests would include lifetime, stress testing, color maintenance, standby mode power, power factor, lumen output, CCT, and CRI. DOE is expected to release the final rule before the end of 2015.

DOE CFL Test Procedure

Hot on the heels of the LED Test Procedure, DOE released a NOPR[15] for a CFL Test procedure in July, 2015. Since a test procedure for CFLs has been in place, this NOPR proposed to expand the scope and include updates to better align with current products and updates to the ENERGY STAR specification. The test procedure covers many of the same parameters as the LED proposed Test Procedure, though the testing methodologies are largely different based on technological differences. DOE is expected to release the final rule before the end of 2015.

The California Energy Commission's LED State Standards

California has been working to establish a state standard for General Services LED Lamps and Small Diameter Directional Lamps.[16] In October, the California Energy Commission (CEC) released a staff report analysis of the efficiency opportunities, and proposed several metrics for the state standard, to take effect in 2017. These included a minimum 10,000 hour lifetime, efficacy minimums tied to the CRI of the product, as well as other metrics. The proposed standard will limit the LEDs allowed to be sold within California significantly and may have impacts on LEDs produced for the rest of the country.

ENERGY STAR Luminaires Specification Update

Version 2.0 of the ENERGY STAR Luminaires Specification[17] was finalized in May 2015 and will be effective in June of 2016. This updated specification included efficacy increases across the board. Another significant change was allowing ENERGY STAR Certified Luminaires to ship with an ENERGY STAR Certified Lamp which would not have to be integrated or pin-based as discussed further within the *Market Opportunities to Leverage* section. This shift is based off the logic that ENERGY STAR Lamps have consumer appreciation enough that a consumer can be expected to keep the lamp the product was shipped with and not replace it with an inefficient alternative. The Luminaires specification also included opportunities for connected luminaires to gain

[14] http://www.regulations.gov/#!docketDetail;D=EERE-2011-BT-TP-0071
[15] http://www.regulations.gov/#!documentDetail;D=EERE-2015-BT-TP-0014-0001
[16] http://www.energy.ca.gov/appliances/2015-AAER-06/rulemaking/
[17] https://www.energystar.gov/products/spec/luminaires_specification_version_2_0_pd

recognition even if they use a small amount of energy in standby power. This opens up the opportunities for luminaires to better integrate with other smart home technologies and home energy management systems.

ENERGY STAR Lamp Specification Update

In February, 2015, ENERGY STAR released the first draft of the Lamp Specification Version 2.0[18]. Since then, this specification has gone through several iterations as the needs of stakeholders and the state of the market have changed considerably in 2015. In November, ENERGY STAR released a proposed revisions document[19] in lieu of a draft 4 specification. EPA scheduled several stakeholder calls to have targeted discussions on issues of efficacy, power factor, omnidirectionality, and LED lifetime. The need for such continued discussion largely came out of the lower-lifetime LEDs and their disruption of the omnidirectional LED market. In December, ENERGY STAR released the Final Draft Specification for Lamps 2.0, which had significant changes from the original draft. One significant change was lowering the lifetime requirement for omnidirectional LEDs to 15,000 hours (from 25,000 hours), which greatly opens up the pool of products that might seek ENERGY STAR certification, while still offering a consumer a lightbulb that will last them over a decade[20]. The specification also significantly increased the efficacy requirements for all lamps from the 1.1 specification; an analysis of the current qualified products list[21] found no CFLs in any category qualifying to the new specification, which is proposed to go into effect in January, 2017. This will have a significant impact on program promotions, in 2017 and beyond, however ENERGY STAR will host an archived list of CFLs that had qualified to the 1.1 specification which programs could potentially use to reference for continued promotion of CFLs. The changes to the specification include allowing connected products to qualify, as well as slight adjustments in omnidirectionality requirements; these were made "to allow greater product design flexibility for cost reductions"[22]. EPA ran an experiment to assess the consumer experience of omnidirectionality and found no discernable different between the propose Draft Final Specification omnidirectionality requirements and the version 1.1 requirements[23]. The specification is expected to be finalized and allow products to start certifying to it in early January, 2016, though given testing requirements, it is not expected that lower-lifetime LEDs would quality to the ENERGY STAR Specification until mid-2016 at the earliest.

> *"lowering the lifetime requirements… opens up the pool of products that might seek ENERGY STAR certification, while still offering a consumer a lightbulb that will last them over a decade"*

Regional Program Administrator Activity

Efficiency programs across the region have a long history of being very active in promoting efficient lighting. Program administrators (PAs) have successfully worked through federal and voluntary standards to promote ENERGY STAR certified Lamps and Luminaires while accounting for the impact of EISA in their savings baselines. This year in particular has been dynamic for efficient lighting programs. We have seen several programs move

[18] https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd
[19] https://www.energystar.gov/sites/default/files/ESLamps2%200InterimProposal_0.pdf
[20] 15,000 hours of lamp lifetime equates to 13.7 years based on 3 hours of use per day
[21] Qualified product list downloaded from energystar.gov on December 4th, 2015
[22] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2%200%20Draft%20Final%2012-04-2015.pdf
[23] Report available at http://www.energystar.gov/sites/default/files/EPA%20LED%20Light%20Distribution%20Study_Final.pdf

away from support of specialty CFLs over the course of the year (including New Hampshire, Connecticut, the District of Columbia, and Vermont), as well as all programs making a move towards greater adoption of LEDs. On another front, the largest state in our region, New York, undertook a significant change through their *Reforming the Energy Vision (REV)* proceeding. One immediate impact of the REV was that NYSERDA stopped offering incentives on residential lighting products altogether. Throughout the rest of the region however, we have seen significant uptake in program activity and decreases in incentives as the cost of LEDs continues to go down. In Table 2, you can see a state-by-state comparison of the 2015 planned program promotion for retail residential lighting programs (note Massachusetts's numbers represent a year to date sales through October).

Table 2: Planned 2015 Program Promotion of Retail Residential Lighting Program, By State

State	# Standard CFLs	# Specialty CFLs/ Fixtures	# Standard LEDs	# Specialty LEDs/ Fixtures	Total	# Households	Bulbs/ Household
CT	1,179,199	225,383	780,987	631,359	2,816,928	1,392,677	2.0
DC	221,000	15,000	100,000	20,000	356,000	257,220	1.4
MA (Year to Date)	*2,164,920*	*279,460*	*1,297,772*	*1,081,302*	*4,823,454*	*1,998,335*	*2.4*[24]
NH	123,537	0	152,144	26,241	301,922	707,856	0.4
NY (PSEG LI)	1,000,000	450,000	470,340	548,730	2,469,070	999,172	2.5
RI	705,802	241,970	225,000	128,500	1,301,272	425,083	3.1
VT	405,300	101,132	287,000	185,350	978,782	309,019	3.2

In addition to their 2015 plans, besides NYSERDA, all NEEP sponsor programs expect to continue robust promotion of residential lighting in 2016. In fact, in 2015, both Massachusetts and Connecticut filed three year plans for 2016-2018 that included strong support for residential lighting, especially pushing programs to transition from CFL to LED in the next three years. More details on the filed plans for residential lighting can be found in *Appendix B: List of Residential Lighting Details in Program Plans*.

Table 3: Planned 2015 Retail Residential Lighting Percentages of CFL, LED, and Specialty Bulbs

State	Percentage CFL (all)	Percentage LED (all)	Percentage Specialty (Both LED and CFL Specialty)
CT	50%	50%	30%
DC	66%	34%	10%
MA (Year to Date)	*51%*	*49%*	*28%*
NH	41%	59%	9%
NY (LI)	59%	41%	40%
RI	73%	27%	28%
VT	52%	48%	29%

[24] The numbers presented here for Massachusetts are year to date through October, 2015. For comparison, a rate of 2.4 bulbs/household from January-October would extrapolate out to 2.9 bulbs/household by the end of 2015.

As a further point of comparison, Table 3 shows the level of planned promotion of CFLs, LEDs, and all specialty products. Most programs are getting closer to a one-third to one-half level of LED promotion. The percentage of specialty products promoted, including fixtures, varies considerably between states. Moving forward, the specialty product promotion will be a larger focus for remaining savings.

Regional Evaluation and Research

In 2015, many research and evaluation reports were published focused on residential lighting in the Northeast. By focusing analysis on some of the lingering questions pertaining to residential lighting, program administrators through the region have a better understanding of their impact on the residential lighting market.

- Lighting Market Assessment and Saturation Stagnation Overall Report[25]: This Massachusetts report summarizes results from three studies (2014 Market Assessment Study, 2015 Market Assessment Study, and 2014 Saturation Stagnation Study) which explored market reactions to interventions within the MA Residential Lighting Program. The interventions were providing incentives for participating in the program, and program support for general service Light Emitting Diode (LEDs) bulbs and expanding program activity in retail channels and with specific "hard-to-reach" (HTR) consumers.
- Multistage Lighting Net-to-Gross Assessment: Overall Report[26]: The purpose of this Massachusetts report is to describe approaches that estimated net-to-gross (NTG) or net-of-free ridership and to explain the consensus building process undertaken to develop and finalize the NTG estimates, both retrospectively for 2014, and prospectively for 2016-2018.
- Massachusetts Upstream Lighting Program Net-to-Gross Ratio Estimates Using Supplier Self-Report Methodology[27]: This report presents the Residential Evaluation Team's estimates of net-to-gross (NTG) ratios for CFL and LED bulbs sold through the Massachusetts ENERGY STAR upstream lighting program in 2013 using the supplier self-report methodology.
- Efficient Bulb Saturation Comparison of Massachusetts, California, and New York[28]: This report compares estimates for efficient lighting saturation with an eye on the circumstances and strategies that may have been most effective in boosting California's saturation while Massachusetts and New York saw a plateau.
- Supplier and Retailer Perspectives on the Massachusetts Residential Lighting Market Final Report[29]: This report summarizes findings from retailer and supplier interviews conducted in 2014 to support the comprehensive assessment and monitoring of recent trends, new opportunities, and lingering barriers in the Massachusetts residential lighting market and the Massachusetts ENERGY STAR Lighting Program.

[25] http://ma-eeac.org/wordpress/wp-content/uploads/Lighting-Market-Assessment-and-Saturation-Stagnation-Overall-Report.pdf
[26] http://ma-eeac.org/wordpress/wp-content/uploads/Multistage-Lighting-Net-to-Gross-Assessment-Overall-Report.pdf
[27] http://ma-eeac.org/wordpress/wp-content/uploads/Upstream-Lighting-Net-to-Gross-Estimates-Using-Supplier-Self-Report-Methodology.pdf
[28] http://www.neep.org/sites/default/files/resources/Efficient-Bulb-Saturation-Comparison-of-Massachusetts-California-and-New-York-Final-Report1.pdf
[29] http://ma-eeac.org/wordpress/wp-content/uploads/Supplier-Retailer-Perspectives-on-Residential-Lighting-Market-Summary-of-Year-2014-Interviews-Final-Report-.pdf

- Results of the Massachusetts On-site Lighting Inventory 2014[30]: This report includes the results of on-site lighting socket inventories performed from May through August of 2014 conducted to understand the market for energy-efficient light bulbs in Massachusetts.
- Final Draft Report of Massachusetts LED Market Effects: Baseline Characterization[31]: This study aimed to provide a market baseline for LED saturation, market share, availability, price, awareness, and customer attitudes in Massachusetts to inform future studies about the state of the LED market.
- Massachusetts Point of Sale Modeling[32]: This report summarizes the findings of the Massachusetts Point-of-Sale (POS) modeling research to inform the Saturation Stagnation investigation and the Multistage Lighting Net-to-Gross (NTG) research.
- Residential Lighting Interactive Effects Memo[33]: This Connecticut study reports the effects of upgrading to more efficient lighting on heating and cooling system usage. The results of the study showed a significant impact to heating system interaction with efficient lighting.

In addition to the completed studies, there are several important residential lighting studies and pieces of research that are near-completion.

- Currently in draft form, the *Connecticut LED Lighting Study Report (R154)* is expected to be released in late 2015. While not yet final, the draft released in November showed significant increases in LED socket saturation. Another part of this analysis was to look at the different products within a home and break out which products are decorative, directional, linear, impacted by EISA, or EISA Exempt. This will be a great next step to the analysis presented in *The State of our Sockets* which was put together based largely on shelf stocking surveys.
- A forthcoming *Vermont Single Family Housing Baseline Study* will include lighting measures to better understand how lighting is used in Vermont homes.
- Another forthcoming report is the *Vermont Smart Lighting/Home Energy Management Systems Interaction study*, report expected late 2015. This study looked at the interaction between smart lighting, HEMS, and smart plugs in 15 Vermont homes in 2015.
- Forthcoming from Massachusetts is an *LED Incremental Cost analysis*, which should help explore and clarify recent developments in the costs of LEDs.
- Finally, a forthcoming White Paper from CLEAResult focuses on the lower-lifetime LEDs is expected by the end of 2015. This white paper is expected to be an important contribution to the understanding of the impact these products are having on the efficient lighting market.

Potential for Energy Savings

Understanding the savings opportunity for residential lighting is critical when justifying continued investment in this product category. Since residential lighting offers a prominent amount of savings for efficiency programs, we analyzed the amount of remaining potential savings available to all states in the Northeast and Mid-Atlantic region as programs continue to re-shape the residential lighting market. For general service lighting, which

[30] http://ma-eeac.org/wordpress/wp-content/uploads/On-Site-Lighting-Inventory-Final-Results.pdf
[31] http://ma-eeac.org/wordpress/wp-content/uploads/LED-Market-Effects-Baseline-Characterization-Final-Draft.pdf
[32] http://ma-eeac.org/wordpress/wp-content/uploads/Residential-Point-of-Sale-Modeling-Final-Report.pdf
[33] http://www.energizect.com/sites/default/files/Residential Lighting Interactive Effects %28R67%29 Final Report%2C 12-20-14.pdf

reflects just a portion of the market, we ran a Market Adoption Model analysis given various market conditions and found the following ranges of gross annual savings as seen in Figure 3 and Figure 4. The first scenario was anticipating a ramp down in CFL support between now and 2018 with robust LED support until 2020. The second scenario took into account the lower-lifetime LEDs entering the market and assumed 50% of all LEDs sold in the market would not be ENERGY STAR and therefore programs would not be able to claim savings for their sale. We included all states in the region[34] to show the entire potential that a transformed residential lighting market could have.

Figure 3: Regional Potential Program Savings from General Service Lighting, All LEDs in Program Scenario (in GWh)

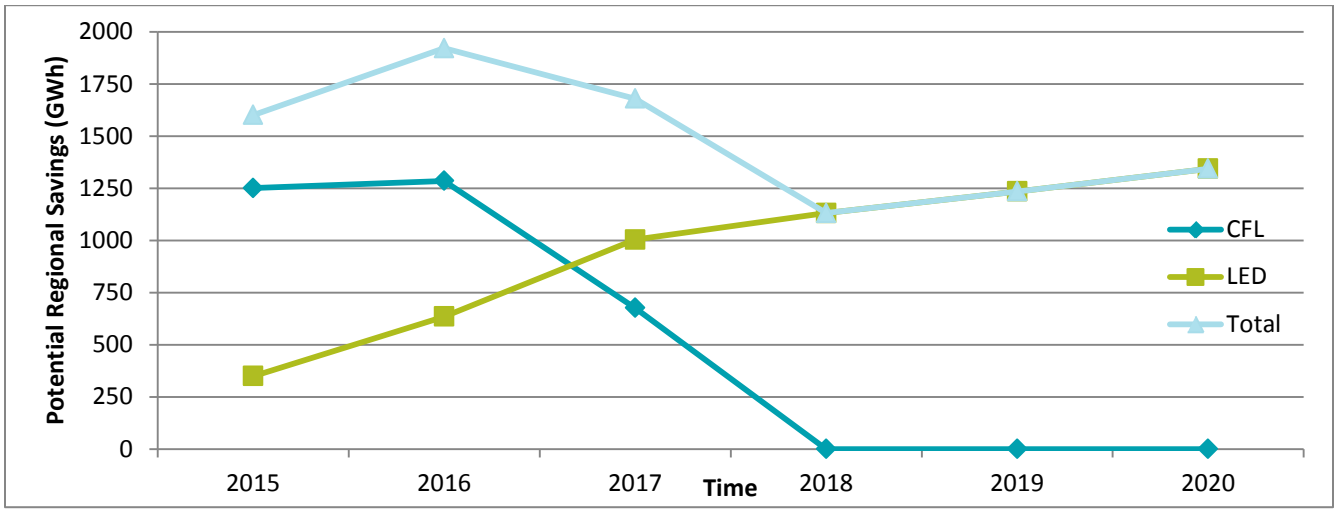
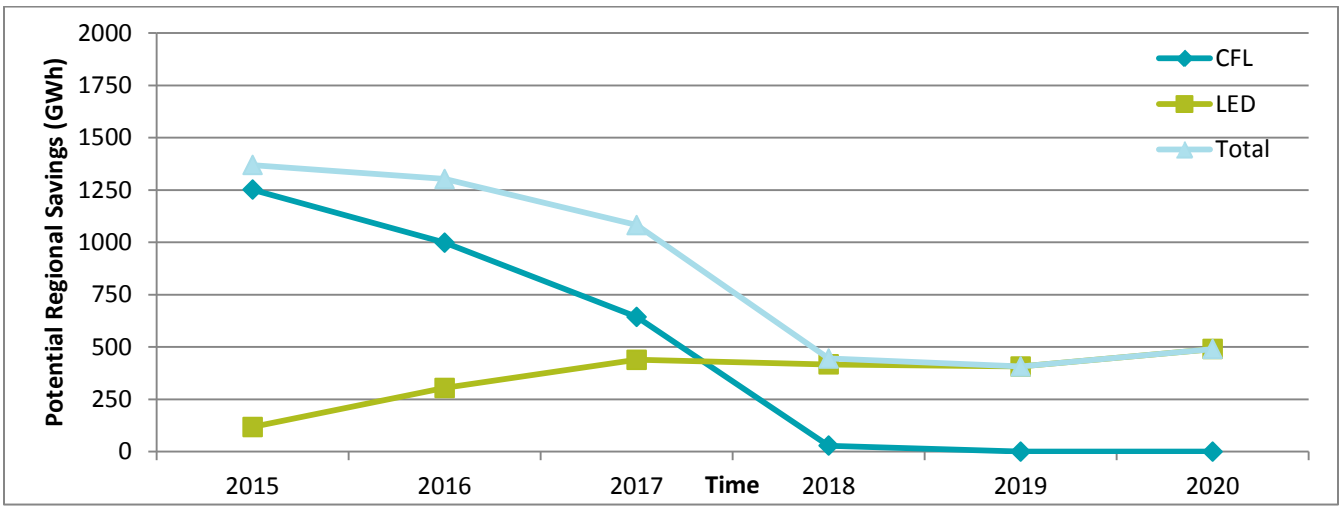


Figure 4: Regional Potential Program Savings for General Service Lighting, 50% of LEDs Attributed to Programs Scenario (in GWh)



[34] Including: DC, MD, DE, NJ, NY, PA, RI, CT, MA, VT, NH, and ME.

Between the two scenarios presented, there is a significant decrease in potential savings if many LEDs purchased in the market are not included in programs. With the Draft Final version of ENERGY STAR's Lamps 2.0 Specification lowering omnidirectional lifetime requirements, it is expected that many of the LEDs currently in the market that do not meet ENERGY STAR will earn certification with minimal engineering changes in 2016. Manufacturers would be motivated by program incentives to earn the ENERGY STAR certification, and customers will reap the benefits of more quality assurance in their lighting choices. Even so, the full impact of lower-lifetime LEDs on the market and programs is yet to be appreciated.

We also ran these analyses looking at two different rates of program activity to represent the range of programs within the Northeast and Mid-Atlantic. What we found noteworthy was that the programs with the lower (though still significant) activity levels had larger opportunities for savings, as the higher program promotion caused baselines to rise such that each additional bulb results in fewer kWh savings. While this is consistent with how most programs are currently evaluated, it suggests the opportunity for new EM&V methodology that could recognize and reward programs for their market transformation impacts, rather than penalizing future savings based on successful promotion today. Using the same modeling tool, we ran an analysis for specific states, listed in Table 4, assuming the majority of LEDs in the market went through efficiency programs and assuming an annual rate of purchase of 2.7 total lightbulbs/person. We ran this scenario for the medium level of program activity and adjusted for each state's population. It is clear that significant savings remain available in residential lighting.

"higher program promotion caused baselines to rise such that each additional bulb results in fewer kWh savings. While this is consistent with how most programs are currently evaluated, it suggests the opportunity for new EM&V methodology that could recognize and reward programs for their market transformation impacts, rather than penalizing future savings based on successful promotion today"

Table 4: Gross Annual Potential State Savings for General Service Lamps (in GWh)

State	2016 Potential Savings (in GWh)	2017 Potential Savings (in GWh)	2018 Potential Savings (in GWh)
CT	108	95	64
DC	20	17	12
MA	203	178	120
NH	40	35	24
NY (ALL)	595	521	351
Long Island (only)	30	26	18
RI	32	28	19
VT	19	17	11

Most publically available data on residential lighting reports one of two things; the relative share of the different technologies (but not differentiating between decorative, directional, etc.), or details on the general service lamp category. For decorative and directional lighting products, which have long be referred to as "specialty" products by efficiency programs, reliable market share data is not publically available. It is therefore very

challenging to accurately project the savings potential for these product categories without an accurate baseline of what is currently installed into decorative and directional sockets in homes. That being said, in *The State of our Sockets* analysis, we found that about 16% of sockets were decorative and about 13% of sockets were directional. A recent MA evaluation[35] provided some evidence to support this, showing that in 2014, 65% of specialty bulbs were either incandescent or halogen showing a large amount of remaining savings available in this category. Determining an accurate saving differential between efficient and inefficient is very complex as both the decorative and directional product categories have a large diversity of product types and wattages for different applications; however, within the market, is it likely that an LED directional lamp is replacing a halogen alternative, whereas an LED decorative lamp is likely replacing an incandescent. To determine potential savings from specialty LEDs, we selected the same starting socket saturation and LED delta watt baselines for decorative and directional as we had for general service lighting; this is quite conservative considering CFLs are widespread in the general service lighting baseline but not as common in directional and decorative. We also continued this analysis beyond 2020, as specialty products are not impacted by the 2020 EISA legislation. Given these assumptions, we would expect to see savings approximately as shown in Figure 5.

Figure 5: Approximated Potential Regional Program Savings from Specialty LED Support (GWh)

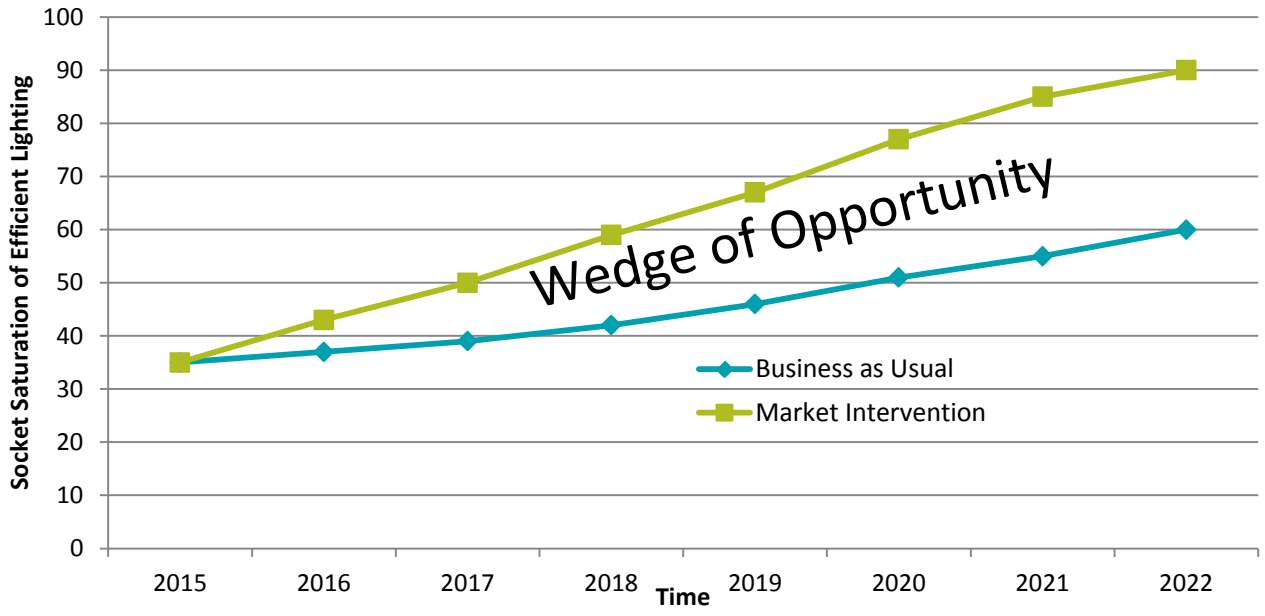
In aggregate, with a **regional gross annual savings potential in the 2-3 TWh range**, the regional savings from a transformed residential lighting market would have the equivalent annual impact of nearly 600 wind turbines installed or taking over half of a coal-fired power plant offline[36]. In Figure 6, we see that without program intervention, the residential efficient lighting market would grow, but at a much slower pace than with program intervention. While Figure 3 through 5 demonstrate the potential savings for efficiency programs, translating that to socket saturation with or without program intervention provides a different perspective. Especially as

[35] From table 59 of "Results of the Massachusetts On-Site Lighting Inventory 2014 FINAL", published March 2015, http://ma-eeac.org/wordpress/wp-content/uploads/On-Site-Lighting-Inventory-Final-Results.pdf

[36] http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator

the first price of LEDs is still significantly higher than halogens (even for the new lower-lifetime LEDs), program intervention is necessary to accelerate market transformation.

Figure 6: Residential Lighting Socket Saturation with or without Program Intervention



Key Market Barriers

While a great amount of activity has taken place in the residential lighting market, there are still some remaining barriers that obstruct the regional from accelerating adoption of efficient residential Lighting transforming this market. We are going to focus on the barriers that emerged as the greatest challenge for regional stakeholders and provide some insight and analysis for each one.

Consumer Confusion in Selection of Lighting products

While education and awareness has been the cornerstone of all residential lighting efficiency programs, consumers continue to see lighting as a low-investment, commodity product. In a recent exercise as part of the 2015 Northeast Residential Lighting Workshop, participants reported that consumer education and awareness was the largest barrier to market transformation (tied with price, described below). As we break down the residential lighting market further, we find several lingering points of confusion:

- Not all sockets within a home can even take the same lightbulbs; while most general service lamps are medium screw based, several decorative products use candelabra screw bases, and then some products are pin based, such as linear fluorescent, MR-16, or any fixtures with a GU-Base.
- Lighting products include complex details from CCT to CRI to providing the lumen output to including the equivalent wattage as well as the actual wattage.
- Will this new lightbulb be compatible with the current dimmer? Can it be used in an enclosed fixture? In most cases, LEDs are not fully compatible with legacy dimmers designed for incandescent lamps, though many ENERGY STAR certified LEDs are dimmable and work with specified dimmers. Furthermore, finding

the small print to determine enclosed fixture compatibility can be a significant challenge for the average consumer.

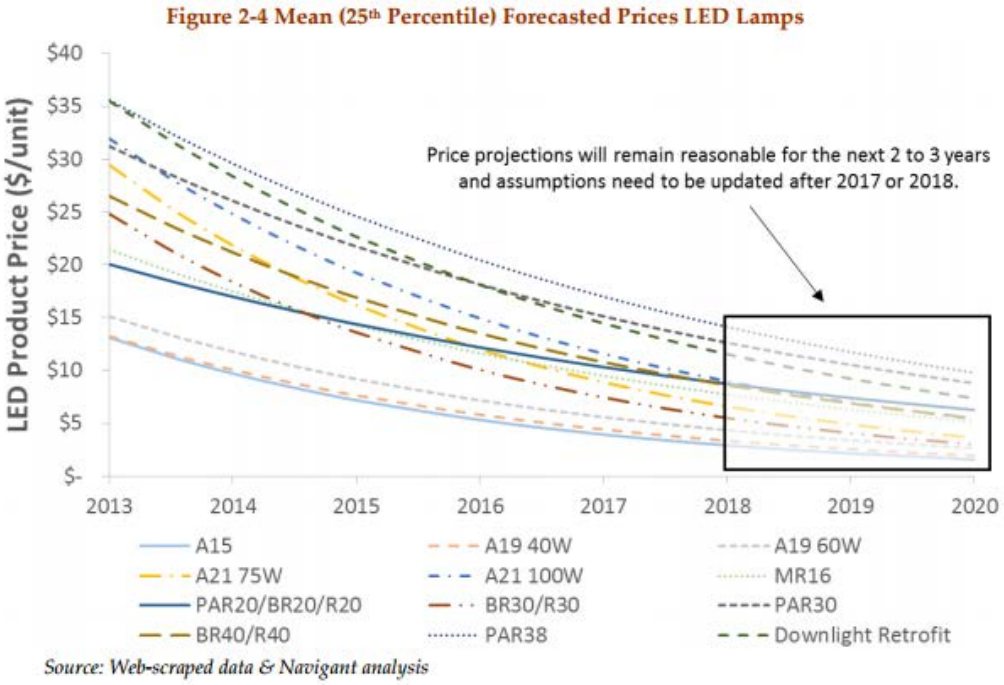
- Even for those who want to think things through, labeling information such as “2700K” and “9W=60W” are counter intuitive (“Why are these products getting so hot? How can 9 be equal to 60?”).

Education and clear marketing can help overcome consumer confusion points to some extent, but the market is still very complex. In addition to the dozens of lamp shapes and four possible technologies, even for consumers who want to be efficient, it can be hard to select the correct product.

High Comparative Price of Efficient Alternatives

While prices for all LEDs have gone down, they have not done so evenly. Several products, most notably the decorative and directional, are still very expensive for consumers. While the standard LED price has gone down dramatically, especially for 60W and 40W equivalent, it is still significantly more expensive than the halogen alternative. CFL prices have stayed level for several years and are close to halogen, however without an incentive, the CFL is still typically a more expensive product than the halogen. As detailed in Navigant’s recent analysis of the *LED Lighting Trends in California*[37], prices for all LEDs have decreased. However, as much attention has been paid to the general service lighting products, the reduction in prices has not been even across product categories. As show in Figure 7 from the Navigant report, the slopes for the A-bulbs are general the steepest, with flatter curves being seen for the directional products researched.

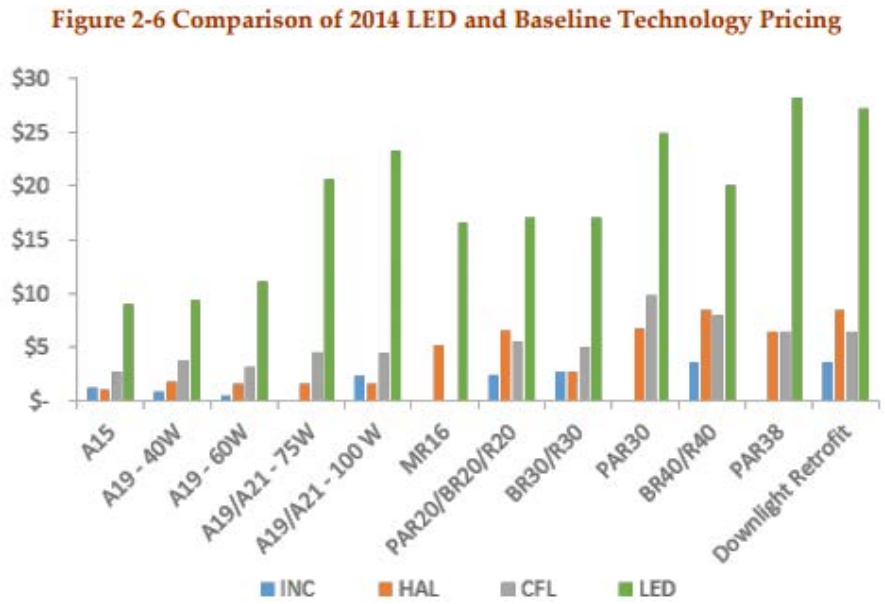
Figure 7: Forecasted LED Lamp Prices from Navigant



[37] http://www.calmac.org/publications/LED_Study_Report_FINAL_201510029.pdf

Even as these prices are decreasing, they are still comparatively higher than their inefficient alternative as seen in Figure 8. These price differentials continue to demonstrate the need for efficiency program incentives as well as a challenge to getting quality, affordable, efficient lighting into the hands of consumers.

Figure 8: Price Comparison of Different Technologies and Lamp Types from Navigant



Negative Consumer Perception about High Efficiency Lighting

While the consumer experience with CFL products has rebounded from its early negative impressions that resulted from low-quality, unreliable products, the reputation of efficient lighting is still damaged for some. In some situations, a lingering stigma about efficient lighting based on poor experience with early CFLs has transferred to all efficient technologies, though the performance of LEDs and the improved quality assurance through the ENERGY STAR program have helped ensure an early positive experience with LEDs. These are not new barriers, as the early and existing challenges of CFLs were chronicled in DOE's 2006 report *Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market*[38]. For LEDs, however, as many customers are just having their first experiences with this technology, it is critical that their experiences with LED products are positive (as detailed in the 2014 DOE report follow up: *Solid-State Lighting: Early Lessons Learned on the Way to Market*[39]). The ENERGY STAR program is critical to maintaining LED product quality; as the market is evolving with lower-lifetimes and new products, ENERGY STAR to is evolving to qualify the products that will yield the best customer experience and are worthy of efficiency program promotion. Now, perhaps more than ever, it is critical to rely on the ENERGY STAR brand for promotion of residential lighting.

Efficiency Program Barriers

As has been concluded in previous RLS reports, efficiency programs offer a great line of defense to transform the residential lighting market. Administering efficiency programs, however, can come with its own set of barriers.

[38] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/cfl_lessons_learned_web.pdf
[39] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_lessons-learned_2014.pdf

Barrier: Misunderstandings across Program Lighting Assumptions

There are over a dozen variables that go into the calculation of efficiency program savings; as such, a program supporting the same lightbulb in one state will not claim the same savings as another state. Some of the differences between state program savings assumptions are inherent: what is true in northern New England may not hold true in the Mid-Atlantic. However, some of these differences are unexplained and may be leaving savings on the table for programs. To analyze this issue, NEEP's EM&V Forum has teamed up with NEEP's Residential Lighting Initiative to provide an analysis from the Regional Energy Efficiency Database (REED) of similarities and differences in residential lighting evaluation assumptions across the region. The analysis focuses the key assumptions that go into determining savings from retail residential lighting programs, and focuses on standard CFLs and LEDs as they presently provide the majority of savings in residential lighting portfolios – and on decorative and directional LEDs which are growing in importance to program portfolios. This forthcoming research examines residential lighting input assumptions from the following states in the Northeast and Mid-Atlantic: Connecticut, District of Columbia, Maryland, Massachusetts, Rhode Island and Vermont.

The full analysis, to be published by NEEP in late 2015, will dive deeply into the following program assumptions in TRMs: gross savings formulas and inputs, hours of use, delta watt values, measure life values, and net savings formulas. One of the assumptions of potential difference that may benefit from better alignment is that of delta watt. As seen in Table 5, in some cases delta watt values are presented as an average, and in some cases there is a formula involved to establish the delta watt for each product sold through a program. The range of values, however, can have a significant difference in how much savings is attributed to the program with comparable volumes of sales. When programs are promoting millions of lightbulbs a year, savings assumption differences of 5-10 watts per bulb can make for a very significant difference in attributable savings. Assumptions on values such as delta watt should be closely compared between states to ensure accuracy.

Table 5: Delta Watt Values in 2015 TRMs by State for Retail Residential Lighting Programs

	MD	DC	VT	MA	CT	RI
Standard CFL Bulb	Calculated based on wattage of efficient lamp using halogen baseline	32.7	32.7	49	Calculated ratio: *.75 x Watt pre* / *Watt post* Or 3.0 if pre wattage unknown	44
Standard LED Bulb	Calculated based on wattage of efficient lamp using halogen baselines If unknown assume 14.5W	< 15W = 34.9 >=15W = 53.5	< 15W = 26.2 >=15W = 40.2	37	Calculated ratio: *.75 x Watt pre* / *Watt post* Or 3.4 if pre wattage unknown	33
Decorative LED Bulb	I f actual LED lumens is known, find the equivalent baseline wattage from TRM table If unknown assume 14.5W	<15W = 50.2 15<=W<25 = 61.4 >=25W = 85.0	<15W = 29.3 15<=W<25 = 27.0 >=25W = 39.4	46	4.0 wattage ratio	44
Directional LED Bulb	If actual LED lumens is known, find the equivalent baseline wattage from TRM table If unknown assume 14.5W	<20W = 51.9 >=20W = 116.5	<20W = 39.0 >=20W = 87.5	46	5.0 wattage ratio	44

Barrier: Inaccurate Delta Watt Savings Assumptions

Given the differences in delta watt assumptions, as well as the moving market, NEEP commissioned a Market Adoption Model analysis of appropriate baselines for efficiency programs given several sets of scenarios. It is worth noting that for this analysis, CFLs were included in the baseline for LEDs, thus making the delta watt savings to be claimed by LEDs lower than that claimed by CFLs. This is standard practice in the Northeast, however many states around the nation do not take this approach. As the prices for CFLs and LEDs come closer and closer together, the need for separate baseline methodologies may not be necessary. By comparison, in the Illinois Technical Reference Manual,[40] a higher delta watt is claimed by LEDs as their efficient wattage is less than that of CFLs. As the analysis moves through time and fewer and fewer CFLs are included in the program, the delta watt values for LEDs are more similar to that of CFLs.

In Table 6, we show the delta watt results for standard CFLs and LEDs from the Market Adoption Model analysis. While we ran this analysis using multiple scenarios for the upcoming EISA legislation, we did not see a difference in baseline whether EISA was strongly enforced in 2020 or if it was repealed. It is expected that programs would stop support for CFLs in or around 2018, and therefore we did not show baseline results beyond that year. Both the gross and net delta watt are represented.

Table 6: Delta Watt Table, both Gross and Net for Standard CFLs and LEDs

Year	CFL Gross Delta Watt	LED Gross Delta Watt	CFL Net Delta Watt	LED Net Delta Watt
2014	45	34	31	33
2015	43	32	29	29
2016	38	29	28	25
2017	34	29	38	21
2018	33	33	62	21
2019		35		20
2020		35		18

We also ran this analysis considering the impact of lower-lifetime LEDs that might be sold outside of programs. While that scenario had a major impact on the potential savings attributable to programs (see *Potential for Energy Savings* section), that market change did not impact delta watt numbers. The Market Adoption Model is a powerful tool taking many market factors into effect and provides a best guess at the appropriate baseline to be used by efficiency programs in this region. NEEP has presented this model at the regional level, but individual states and circumstances may necessitate different assumptions. As such, NEEP is committed to working with program administrators to help determine appropriate delta watt assumptions moving forward.

Barrier: Regulatory Pushback Based on Limited Understanding of EISA Legislation

As noted in *The State of our Sockets*, several regulators in the Northeast and beyond have started to question the continued need for efficiency program support of residential lighting measures given the long history of

[40] Illinois TRM effective June, 2015: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf

program activity. Residential lighting, however, is a unique product category, and while the second phase of EISA (2020) is set to transform the market for general service lighting products making only efficient options available for sale, there are several real challenges ahead:

- There are 4 full years during which consumers can potentially purchase inefficient products before the 2020 regulation would kick in.
- DOE currently does not have the authority to enforce EISA, making full compliance in 2020 unlikely and some halogens still available for sale a real possibility.
- There are several products that are exempted from coverage by EISA that could be exploited as loopholes around the law.

While all of those caveats help support the argument for continued program promotion of residential lighting up until 2020, they omit the fact that most decorative and directional products are not covered by EISA legislation. That means upwards of 30% of the sockets in a home could still be filled with inefficient halogen or incandescent technology. LEDs offer great replacements for decorative and directional applications, but much of the diminishing cost of LED R&D has been focused on the largest product category, the general service illumination (as demonstrated in Figure 8). As such, decorative and direction LEDs are still much more expensive than their inefficient counterparts and efficiency programs have a major role to play to transform those sockets up until and potentially beyond 2020.

"DOE currently does not have the authority to enforce EISA, making full compliance in 2020 unlikely and some halogens still available for sale a real possibility."

Market Opportunities to Leverage

While there are several remaining barriers to overcome, there are also new market developments that are key opportunities to leverage at this time to transform the market.

LEDs are Exciting and Desired

Also coming out of the 2015 Northeast Residential Lighting Workshop exercise, participants reported that excitement about LED products now available was the largest opportunity for market transformation. In general, consumers and the efficiency community alike are finding that LED technology achieves energy savings without sacrifice of utility or performance. Furthermore, LED prices are coming down while their features are increasing. There is positive momentum for LEDs which creates a great opportunity to ride the LED wave towards market transformation. Below in Table 7 (recreated from the 2014-2015 RLS Update), we see that for several key measures, LEDs are the leading technology.

Moving forward, there is an exciting opportunity to harness the lower-cost LEDs to help fill more sockets with efficient technology. As ENERGY STAR's Draft Final Lamps 2.0 Specification reflects, it is anticipated that some LEDs will begin to qualify to the ENERGY STAR specification and reach a price point much closer to what consumers currently pay for halogens or non-incented CFLs. Coupled with a modest incentive, the basic LED could become the go-to lightbulb for an average consumer who may have heard about the new, exciting technology, but never had a price point where they were willing to try it.

Table 7: Ranking of Lighting Technologies by Various Measures/Features

Measure	Advantage	Description
Efficacy	LEDs	While halogens are more efficient than incandescent, their efficacy is much lower than CFLs or LEDs. Many ENERGY STAR LEDs already far exceed the efficacy of the best CFLs. LED efficacy continues to improve while the CFL and halogen efficacy potential has been reached
Lifetime	LEDs	ENERGY STAR requires a lifetime of 10,000 hours for CFLS and 15-25,000 hours for LEDs. Halogen lifetimes are typically around 2500 hours.
Dimmability	Tie: LEDs (with compatible dimmer) and halogen	Due to technological challenges, most dimmable CFLs dim to only 10-30% of their light output, while many dimmable LEDs on the market dim to 5-15% of their light output. Halogens are able to dim comparably to incandescents
Aesthetics	LEDs for variety, LEDs tie halogen if goal to mimic incandescents	As a fluorescent technology, CFLs are not a point source and produce a "blob" of light. They are unable to produce "sparkle", a desirable feature with some consumers, especially with decorative luminaires where the bulb is visible. As a small, directional source, LEDs are able to better mimic the "sparkle" of incandescent bulbs. The form factor of halogens is similar to incandescents.
Beam control	Tie: LEDs and halogen	Because CFLs are not a point source, CFLs cannot precisely control the direction of light. LEDs can be designed with precise optics to precisely control the direction of light in the same way that incandescents or halogens can.
Durability/ cold weather	LED	CFLs perform poorly in cold weather. Halogens are not much more durable than incandescents. LEDs are durable and perform well in cold weather.

Smart Lighting

In 2015, the dream of the connected home became a lot more achievable. While there are hundreds of smart products available, connected LED lightbulbs are some of the most affordable and compelling products on the market. At this point, there are no inefficient smart lamps available, with the vast majority of smart options being LED, an inherently efficient light source. With smart lighting, there is the potential for dimming on every lamp and use optimized to the consumers' needs, so there is the opportunity for these products to provide incremental savings over their "less-evolved" LED counterparts. On the flip side, however, many of these products require a hub to work, which adds a load to the home, in addition to adding a small standby power consumption even when the light is not used. Furthermore, with the opportunity for remote control, consumers may end up using these lights *more* than standard alternatives because of the novelty. In an effort to better understand how consumers are actually using and interacting with smart light bulbs, Efficiency Vermont organized a small pilot to demonstrate the use of these products within the home (results of study pending).

Smart lighting offers several benefits to efficiency, particularly to efficiency programs, including:

- Potentially providing self-reporting data on metrics such as hours of use, confirming installation, and ultimately reporting actual energy usage for better M&V
- Potential energy savings with optimized usage and dimming
- Through smart lighting, programs might find a path to help customers move towards a more comprehensive home energy management system
- Potential health and consumer engagement non-energy benefits, such as safety and security

There are many products available on the market, with many advanced features, including:

- Geofencing to turn lights on or off based on users proximity to home

- Color Tuning (CCT/White light tuning, RGB/Color tuning, or Dim to warm)
- Dimming
- Schedule programing and mood or scene setting
- Remote control

See Appendix A: Smart Lighting Product Details for a more comprehensive chart on connected lighting products.

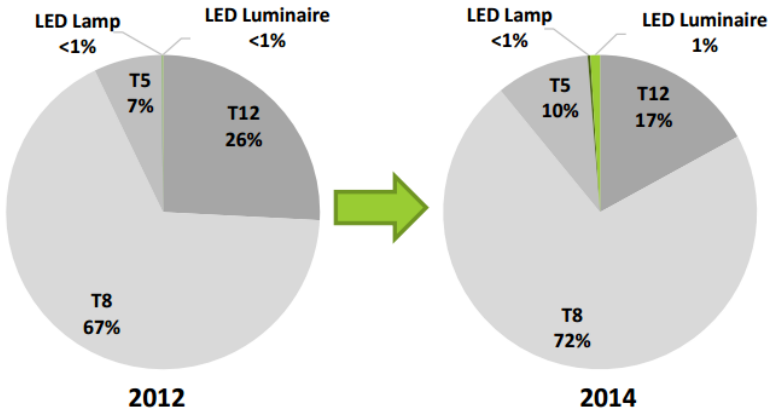
ENERGY STAR Luminaire's Specification: New Bulb in a Box Savings Opportunity

One significant change to the ENERGY STAR Luminaire's specification was to allow luminaires to ship with ENERGY STAR certified lightbulbs. This change opens up the opportunity to offer promotions and claim savings for fixtures shipping with ENERGY STAR bulbs in a much more straightforward way, could result in greater savings for program administrators. This change also allows customers more opportunities in their fixture selection process.

Linear Fluorescent: Potential Opportunities for Improved Efficiency

As continuously confirmed by new socket saturation surveys, approximately 10% of residential sockets are filled with linear fluorescent tubes. While these are general considered to be efficient, many of these sockets are filled with T12 or T8 tubes that are less efficient than T5 or TLED (LED tubes) that could be used in their place. This has not been a focus for residential efficiency programs, but as many of the other high usage sockets are transforming to efficient options, it may be a great opportunity to focus on improving the efficiency of that remaining 10%. Some programs are beginning to consider this as the next area to tackle for residential lighting programs.[41] This T12 or T8 transformation has been an area of focus for commercial lighting programs given the linear tube popularity in commercial settings, and much of the program model for residential could be modeled off of commercial lighting best practices regarding product selection, with retail as the target channel for customers. At present, the total market share for most efficient products (linear LEDs and T5) is relatively low as shown in Figure 6, suggesting an opportunity for program interventions to make an impact.

Figure 9: Information on Linear Fixture Technology Market Share, for both Residential and Commercial[42]



[41] Recommendation in the August 2015 Lighting Market Assessment and Saturation Stagnation Overall Report prepared for the MA PAs, http://ma-eeac.org/wordpress/wp-content/uploads/Lighting-Market-Assessment-and-Saturation-Stagnation-Overall-Report.pdf

[42] From November 17 presentation at DOE Market Development Workshop, http://energy.gov/sites/prod/files/2015/11/f27/yamada_ledadoption_portland2015.pdf

National Efforts Moving Forward

As the federal standards and voluntary specifications for residential lighting products are coming along, there is a great opportunity to get involved and push for higher efficacy across the board to help transform this market. The efficiency community has the opportunity to influence key pieces, especially for CFL and LED test procedures (as described in Existing Efforts to Promote High Efficiency Options), to ensure quality, efficiency products are available in the market and supported by other market transformation efforts.

Regional Strategy to Achieve Market Transformation

Long-term Market Transformation Goal

Given the dynamic state of the residential lighting market, we are working towards the regional goal to reach ***a socket saturation of 80-90% efficient quality lighting by 2022***. Over the course of the next 7 years, that could add up to over 15TWh of total savings for the region.

NEEP has decided to chart the transformation of the residential lighting market by **socket saturation**, or the percentage of sockets in a home that are filled with efficient lighting vs. inefficient light sources. The reason for this is (1) there is currently more available data on socket saturation than many of the other market metrics such as sales or shipping data; and (2) socket saturation tells the story of what is actually installed and drawing energy, which is what residential lighting programs are trying to influence. Socket saturation is not the only or even necessarily the best way to track the impact of programs; however without additional data available, especially sales data, we feel that socket saturation is the best metric to reflect progress at this time.

Regional Goal:

"Reach a socket saturation of 80-90% efficient quality lighting by 2022. Over the course of the next 7 years, that could add up to over 15TWh of total savings for the region."

Theory of Change

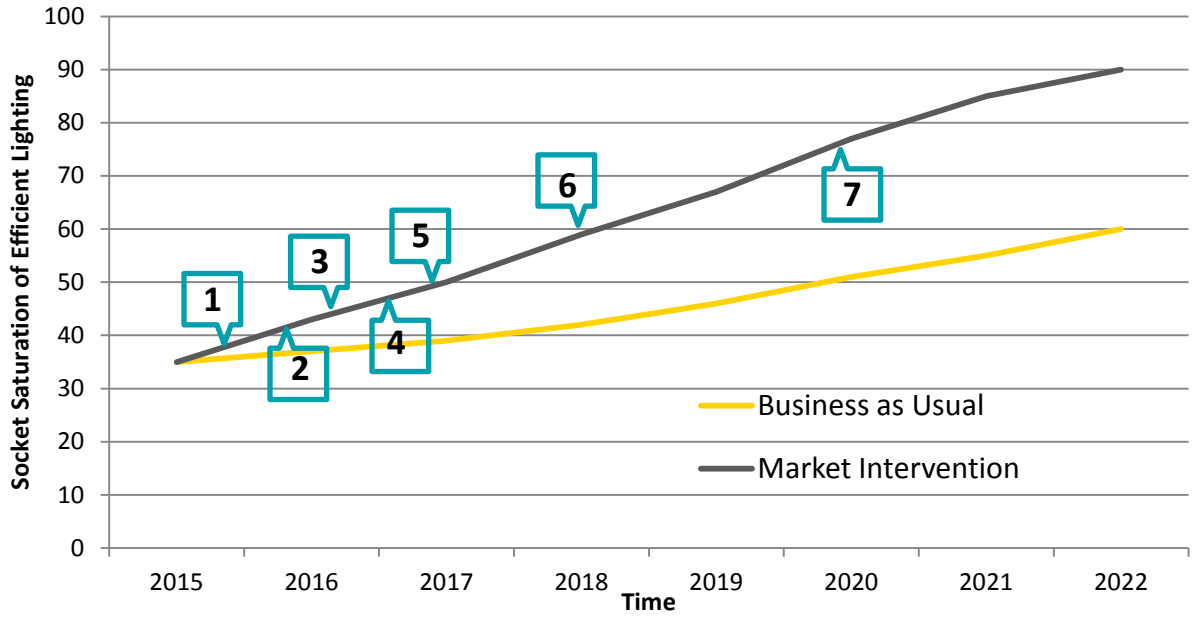
The findings from this analysis and previous RLS reports provide NEEP and regional stakeholders a foundation from which a series of market interventions can be developed. These are designed to either overcome existing market barriers or leverage emerging market opportunities to accelerate the adoption of efficient residential lighting and effectively transform the Northeast and Mid-Atlantic market in the long-term.

Some of the key market interventions are detailed here and can be seen in Figure 10:

1. In 2015 and for as long as the price differential necessitates, PAs drive down the cost of GSL LEDs to be competitive with inefficient alternatives.
2. In 2016, PAs only include specialty products that are LED. LEDs are well suited for specialty applications and are expected to have high rates of uptake and consumer satisfaction.
3. Also in 2016, PAs also start to leverage the growing popularity of smart bulbs through incentives, education, and product quality requirements. Incentives should be appropriately set as to make the products more affordable but not to make competitive with inefficient alternatives. This could include pointed Point of Purchase as well as connecting to other Home Energy Management Systems promotions.
4. In 2017, PAs shift program strategy to ramp up resources towards specialty LEDs and focus on those applications for market transformation, as we expect the sales of specialty LEDs to lag behind that of general service lamps.
5. In 2017, PAs starts to tackle the linear fluorescent product category through coordination with Commercial Lighting counterparts.

6. In 2018, ENERGY STAR is expected to revise the Lamps and Luminaires specifications; the ceiling efficiency level can be pushed up even higher because of last 3 years of market activity.
7. In 2020, EISA Phase 2 is expected to go into effect. This applies just to general service lamps and has some limitations. For laggards who have not yet adopted efficient lighting, this standard will force their transition in efficient general service lighting.

Figure 10: Residential Lighting Theory of Change for Market Interventions to Transform the Market



Coordination with Other Regional and National Efforts

Throughout the nation, efficiency programs continue to grapple with many of the same barriers and challenges described in this report. In California, their standards process and LED quality specification make for a different marketplace, though many of the recommendations we make in the Northeast and Mid-Atlantic can be applied more broadly to the rest of the country. The EISA legislation affecting general service lamps is expected to impact the entire country in the same way. NEEP intends to communicate our findings more broadly and encourage regional and national alignment on key strategies where possible.

Tracking Market Transformation Progress

A number of different metrics could be used to track the transformation of the residential lighting market, including market share, socket saturation, sales, shipments, and retail shelf stocking. All of these metrics are related, but the reliability and availability of this information is variable. A few of the common indicators are compared in Table 8. NEEP has chosen Socket Saturation as the key metric to track progress for reasons detailed in the Long-term Market Transformation Goal section, however we will continue to look at all available data to gain insights into this dynamic market. In 2016, NEEP is committed to presenting market analyses twice a year that tracking the change and progress made towards market transformation.

Table 8: Comparison of Residential Lighting Market Tracking Metrics

Metric	Touch point	Pros	Cons
Socket Saturation	Consumer 	• Assessed regularly by PAs throughout the country • Directly reflects installed base	• Range of data collection techniques and quality of data • Does not tell the whole story (stock piling, consumer preferences, etc.) • Research can be expensive
Retail Sales Data	Retailer 	• Accurately represents customers' investments • Can show true influence of a program on customer decisions	• Very limited data available • Data that are available for purchase do not represent the entire market
Shipment	Manufacturer 	• Data are relatively available from NEMA • Demonstrates early trends in the market	• Several steps removed from end-user • Retailers may store products for long periods so it does not necessarily reflect what is sold • National level-data • Publicly available data source does not include all manufacturers

Strategy Implementation Plan and Recommendations

Program Administrator Strategies

The strategies developed to help the region achieve the goal of market transformation are divided into strategies for an efficiency program to implement, and those for other regional players to push forward. These strategies are critically important to the transformation of this market.

Strategy #1: Continued PA support for residential lighting

First, programs should continue support for cost-effective efficient residential lighting products. Given the lower-lifetime, low-cost LEDs that entered the market in 2015, and the changes in the ENERGY STAR Lamps Specification, it is expected that LED products will be more cost effective moving forward. This can be accomplished starting immediately and should include the following key components:

- Programs should promote only ENERGY STAR certified products that will meet consumer expectations.
- Programs should to support only LEDs in specialty applications.

Strategy #2: PAs transition portfolios in short and medium term

Next, as these programs continue over time, we see two main strategies:

- Over the course of the next 1-3 years, programs should shift all residential lighting promotions to all-LED. When the ENERGY STAR Lamps 2.0 specification is fully in effect in January 2017, it is unlikely that any CFLs will remain on the qualified products list. While ENERGY STAR will archive a list of 1.1 products for programs to reference, the time to move program promotion from CFL to LED is increasingly imminent.
- In 2-4 years, programs should lay the foundation for a shift away from omnidirectional and towards specialty products that may continue to provide savings past 2020. While program promotion of omnidirectional LEDs will still be cost effective in 2018 and likely 2019, starting in 2017, program are recommended to start planning and budgeting to promote only specialty LEDs in 2019 and beyond. Specifically, some of the assumptions and savings calculation inputs for specialty LEDs are currently quite sparse; it would be advantageous to ensure a robust attribution system is set up well in advance of 2019 for specialty LEDs.

Strategy #3: PAs target LEDs in hard-to-reach markets

In the next 0-2 years, programs should take advantage of momentum with lower-cost LEDs earning ENERGY STAR certification and work with Hard-to-Reach retailers to include LEDs in those offerings. It is especially important to begin introducing efficient LEDs into these market segments now to ensure a smooth transition to an all-LED program in coming years.

Strategy #4: PAs consider including smart lighting in portfolios

Programs should consider promotion of ENERGY STAR smart lighting products, especially when coupled with other HEMS/smart home initiatives. While the net savings opportunity of these bulbs is yet to be established, the smart bulbs are LED and therefore offer a significant efficiency boost over baseline products. One potential approach would be to add a “normal” LED incentive to a smart bulb, but couple it with POP to promote more

general smart home activities. While the incentive would not be huge, a small incentive coupled with educational material could influence consumers who had thought about smart lighting, but had not yet taken the plunge.

- Example: EnergizeCT is helping raise your homes' smarts with these Smart Lightbulbs, now only $15.99 (from $19.99).

Strategy #5: PAs explore opportunities in residential linear products

A new area of exploration for efficiency programs in residential lighting is the potential opportunity offered by linear products. Approximately 10% of sockets within a home are filled with these products, but beyond that is it hard to know what level of savings might be achievable. Discussions with commercial lighting program managers to understand the products and market of linear tube lighting would be a great first step for residential programs to take.

Regional Strategies beyond Programs

Beyond just what PAs should do, regional actors including state agencies, EPA, manufacturers, and retailers should collaborate on the following strategies.

Strategy #6: Regional collaboration on residential lighting research

The region should consider collaboration on key research projects. Leveraging resources from multiple stakeholders to produce joint research allows all budgets to stretch further. Some potential research projects could be:

- Research on consumer perspectives for performance metrics like lifetime, CRI, omnidirectionality, etc.
- Market characterization of residential linear market, evaluate savings opportunity
- Further research on smart lighting potential savings

Strategy #7: Regional coordination on data collection and sharing

Additionally, the region should continue to collect and share data to inform regional progress and program evolution. Through processes such as NEEP's Residential Lighting initiative, as well as regional working groups and efforts, is it important activities are coordinated. Data sharing, especially for sales and other indicators of market change, is incredibly important to understand the changes in the market and inform future activity. Furthermore, for evaluations such as socket saturation, alignment in methodology is critical to ensure the information collected is consistent.

Strategy #8: Regional discussions on savings calculation inputs to ensure appropriate attribution

State-to-state differences in savings calculation inputs should be evaluated to ensure appropriate attribution by all programs. This included analyzing the assumptions behind some of the inputs, including assessing whether CFLs belong in the baseline of LED products. While NEEP did an initial analysis of TRM differences, further alignment and efforts are necessary to ensure the savings left on the table is realized. A few inputs to potentially analyze include:

- Including baseline assumptions, delta watt, NTG, HOU, measure life, etc.

Conclusion

Through the tireless efforts of efficiency programs, federal agencies, manufacturers, retailers, and other stakeholder, the residential lighting market continues to chart a path towards transformation, and yet there still is a long way to go before reaching the regional goal of 80-90% socket saturation of high quality efficient lighting by 2022. Program administrators have a unique and important role to play to help customers make efficient lighting decisions, but all parties have a part in this effort. While LEDs offer a great opportunity, and the potential that new lower-cost LEDs will be able to earn ENERGY STAR certification is a leg-up, many of the lingering market barriers still make transformation challenging.

There is exciting potential for cost-effective, impactful program promotion of residential lighting products across the Northeast and Mid-Atlantic. To reach that potential, we anticipate that residential lighting programs will be changing every year for the foreseeable future. While standard LEDs and CFLs are important products to continue promoting in the short term, current CFLs will not be eligible for ENERGY STAR certification past 2017, and the EISA standard will impact all general service lighting in 2020, eroding the necessity for efficiency program support of these general service products. EISA, however, does not apply to most products currently designated as “specialty” by efficiency programs, nor to fixtures or linear products, and those applications leave open the opportunity for continued market transformation activities.

NEEP intends to continue tracking the transformation of this market and providing updates on regional and national trends when appropriate. As a collective of stakeholders working together to push the efficiency of this market, we can transform the residential lighting market.

Appendix A: Smart Lighting Product Details

The first table presents detailed information on several bulbs from several manufacturers. The second table provides more general information on products available in the smart lighting category as adopted from the 2015 NEEP Home Energy Management Systems report.[43]

Company/ Product	Needs hub to operate?	Cost of Bulb	Cost of hub	Features	Wattage of bulb	Standby Power of bulb	Compatible with Home Energy Management Systems/ Protocol?
GE Lighting A19	Yes	$14.97		800 lumens, 2700K, 25,000 hr, 80 CRI, dimmable with Wink App	12	<.5W	ZigBee HA 1.2
GE Lighting BR30	Yes	$19.97		650 lumens, 2700K, 25,000 hr, 80 CRI, dimmable with Wink App	10	<.5W	ZigBee HA 1.2
GE Lighting PAR38	Yes	$24.97		900 lumens, 3,000K, 25,000 hr, 80 CRI, dimmable with Wink App	13	<.5W	ZigBee HA 1.2
GE Lighting Wink Hub			$49.99				
GE Lighting Link Hub			not sold individually, $49.97 for 2 A19's and a Link Hub				
OSRAM SYLVANIA LIGHTIFY Gateway Hub			$29.99 MSRP	Local and remote control of lighting devices			WiFi/ZigBee, Nest Learning Thermostat
OSRAM SYLVANIA LIGHTIFY Tunable White A19	Yes	$29.99 MSRP		Dimmable, Tunable White 2700-6500	9.5W	<1W	Zigbee HA 1.2 Light Source, Wemo, SmartThings, Wink
OSRAM SYLVANIA LIGHTIFY Tunable White BR30	Yes	$34.99 MSRP		Dimmable, Tunable White 2700-6500	10W	<1W	Zigbee HA 1.2 Light Source, Wemo, SmartThings, Wink

[43] NEEP, August 2015, Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programs, http://neep.org/opportunities-home-energy-management-systems-hems-advancing-residential-energy-efficiency-programs.

OSRAM SYLVANIA LIGHTIFY Tunable White RT 56	Yes	$39.99 MSRP		Dimmable, Tunable White 2700-6500	10W	<1W	Zigbee HA 1.2 Light Source, Wemo, SmartThings, Wink
OSRAM SYLVANIA LIGHTIFY RGBW Flex	Yes	$64.99 MSRP		Dimmable, Tunable White 2700-6500 and RGB	2.2W /2 ft	<1W	Zigbee HA 1.2 Light Source, Wemo, SmartThings, Wink
OSRAM SYLVANIA LIGHTIFY RGB Gardenspot Mini	Yes	$79.99 MSRP		Dimmable, RGB	7.5+ W	<1W	Zigbee HA 1.2 Light Source, Wemo, SmartThings, Wink
Philips Hue A19 Color	Yes	$60	3 bulb starter kit - $199	800 lumen, White light, RGB, Scenes, 3rd Party Apps, IFTTT	10W	<.5W	Zigbee
Philips Hue A19 White	Yes	$20	3 bulb starter kit - $80	800 lumen, White light, Scenes, 3rd Party Apps, IFTTT	9.5W	<.5W	Zigbee
Philips Hue BR30 Color	Yes	$60	3 bulb starter kit - $199	630 lumen White light, RGB, Scenes, 3rd Party Apps IFTTT	8W	<.5W	Zigbee
Philips Hue GU10 Color	Yes	$60	3 bulb starter kit - $199	300 lumen, White light, RGB, Scenes, 3rd Party Apps, IFTTT	6.5W	<.5W	Zigbee
Philips Hue PAR16 Color	Yes	$60	3 bulb starter kit - $199	300 lumen, White light, RGB, Scenes, 3rd Party Apps, IFTTT	6.5W	<.5W	Zigbee

Company	Product	Description	Cost
Aeon Labs Aeotec	Z-Wave LED Light Bulb, Gen5	Smart LED lightbulb with 16 million different color shades	$50
Bayit Home Automation	Bayit Wireless LED lighting kit	Color Changing wi-fi enabled LED bulbs	$80
Belkin	WeMo LED Lighting	Smart LED bulbs connected to the WeMo Link	
Centralite	JetStream	Wireless lighting LED Bulb and wireless switch	$80 per switch
Flux	Smart LED lightbulb	Smart LED, bluetooth enabled bulb	$35
Lutron	Homeworks QS	Whole home interactive lighting control	
STACK	Alba	A lightbulb that is smarter than you	$60 per bulb +$150 starter kit

Appendix B: List of Residential Lighting Details in Program Plans

Connecticut 2016-18 Plans (page 246)

- http://www.energizect.com/sites/default/files/2016_2018 C%26LM PLAN 10-01-15.FINAL_.pdf

District of Columbia Sustainable Energy Utility 2014 Annual report

- https://www.dcseu.com/docs/DCSEU-AnnualReport14-FinalWeb.pdf

Maine 2014-16 Triennial Plan (page 64)

- http://www.efficiencymaine.com/docs/TriPlan2-11-26-2012.pdf

Maryland 2015-17 (BGE Plan)- (pg 27/21)

- http://www.psc.state.md.us/wp-content/uploads/2015-EmPOWER-Maryland-Energy-Efficiency-Act-Standard-Report.pdf

Massachusetts 2016-18 Plans- (page 91)

- http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-1-Gas-and-Electric-PAs-Plan-2016-2018-with-App-except-App-U.pdf

New Hampshire 2015-16 CORE plans- (page 40)

- http://www.puc.nh.gov/Regulatory/Docketbk/2014/14-216/LETTERS-MEMOS-TARIFFS/14-216 2014-09-12 PSNH 2015-2016 NH STATEWIDE CORE EE PLAN.PDF

New Jersey Clean Energy Program (AEG- Winning program administration proposal)- (pg 17-19)

- http://www.njcleanenergy.com/files/file/Section 5 FINAL.pdf

NYSERDA Clean Energy Fund- (113)

- http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b91A4D238-6896-472E-A33D-F2234AFE8921%7d

NY National Grid ETIP (pg 55/51)

- http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b2B19CBEA-A19C-4270-9677-F3FE739FEA46%7d

Pennsylvania Act 129 Plans- Plans Pending December 1

Rhode Island 2016 Program Plan (pg 66)

- http://www.ripuc.org/eventsactions/docket/4580-NGrid-2016-EEPP(10-15-15).pdf

Vermont 2015-17 Triennial Plan- pg 15/20

- https://www.efficiencyvermont.com/docs/about_efficiency_vermont/annual_plans/evt-triennial-plan-2015-2017.pdf