Consumer Understanding of Key Lighting Facts and Implications for Energy Savings[1]

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ABSTRACT

The U.S. lighting market is changing rapidly. The Energy Independence and Security Act of 2007 (EISA) is gradually phasing out popular incandescent bulbs, while the new FTC Lighting Facts label provides consistent information for consumers to make more informed bulb purchasing decisions. These developments are expected to have major effects on the residential lighting market. Consumer reactions and choices to the changing bulb options, and their understanding and use of the Lighting Facts label, will be critical to the ultimate impacts of the legislation and labeling.

In the Fall of 2011, the New York State Energy Research Authority (NYSERDA) surveyed New York consumers and homeowners who had recently purchased light fixtures to gauge their knowledge and understanding of key information on the Lighting Facts label. The results show that New York State consumers are not well prepared to put the information on the Lighting Facts label to full use in choosing bulbs. If consumers who are new to high efficiency bulbs do not understand how to choose an appropriate CFL and cannot put the Lighting Facts label to use as intended, they may turn to less efficient EISA-compliant halogen incandescent bulbs, which look more similar to standard incandescent lamps. Additional energy savings may be possible if consumer education efforts help people better understand lighting metrics including lumens, color rendering, and color appearance. Understanding such terms would help consumers choose light sources that perform similarly to incandescent sources in terms of appearance and light output, but use far less energy.

Introduction

The U.S. lighting market is changing rapidly. On January 1, 2012, The Energy Independence and Security Act of 2007 (EISA) began gradually phasing out popular incandescent bulbs. EISA sets maximum allowable wattage levels by lumen output for most general service, medium screw-base lamps sold in the United States (DOE 2010). On the same date, the Federal Trade Commission (FTC) began requiring manufacturers to carry a new label on the front and back of each package of light bulbs to be sold in the United States. The FTC "Lighting Facts" label provides consumers with information about the bulb's brightness, estimated yearly energy cost, life, light appearance, and wattage (Federal Trade Commission 2011).

The EISA standards go into effect in stages. In the first stage, an eight-year period that began with 100- and 150-watt bulbs in 2012 and will affect 75-watt bulbs in 2013 and 60- and 40-watt bulbs in 2014, general service bulbs are required to use from 20 percent to 30 percent

[1] The views expressed in this paper are those of the authors and do not necessarily reflect the views of the New York State Energy Research and Development Authority (NYSERDA).

less energy than current incandescent bulbs. In the second stage, which begins on January 1, 2020, all general service bulbs are required to meet at least a 45 lumen-per-watt standard (EISA 2007). The first stage allows wattage levels per lumen output that are considerably higher than those for medium, screw-base compact fluorescent lamps (CFLs). Halogen incandescent bulbs that comply with the requirements of the first stage of EISA are already on the market at prices comparable to CFLs (DOE 2010).

As common wattages of general purpose incandescent bulbs are replaced by multiple options, some of which will be unfamiliar to consumers, the decision to buy a light bulb will become a more complicated matter. Consumers wishing to recreate the quality of incandescent lighting with EISA-qualified bulbs will need to understand concepts such as lumens and color rendition. This will be especially true of CFLs or LEDs. EISA-compliant halogen incandescent bulbs are likely to represent an easier choice for consumers seeking to replace general purpose incandescent bulbs, as the light quality from EISA-compliant halogen bulbs is similar to that of standard incandescent bulbs (California Energy Commission, 2012). US consumers may turn more to EISA-compliant halogens than to CFL or LED lamps to replace incandescent lamps phased out under EISA—as happened in Australia after the passage of legislation similar to EISA (IEA 2011), leaving untapped energy savings potential from readily-available alternative residential lighting technologies, i.e., CFLs and LED replacement lamps. Additional residential energy savings from lighting could be realized between now and 2020, when the more stringent standards go into effect, if consumers understand what to expect from their lighting choices and can make sense of the information presented on the new FTC lighting label. Thus many program administrators are likely to look to consumer education as an important part of their residential lighting program strategies in the coming years.

As part of a broad study of the New York residential lighting market[2] (NYSERDA 2012), in 2011 NYSERDA sought to measure New Yorkers' familiarity with different types of energy efficient bulbs, their knowledge of the relative energy use of each type, and their current understanding of key lighting terms that appear on the new lighting label. Among the purposes of this research was to set baselines for these measurements, with an eye to the possibility of using them as indicators of progress should NYSERDA choose to focus on consumer education about lighting facts as a substantial element of its residential lighting program efforts in future. The results of this study should be of use to program administrators who make consumer education a focus of their residential lighting program approaches.

Background and Research Approach

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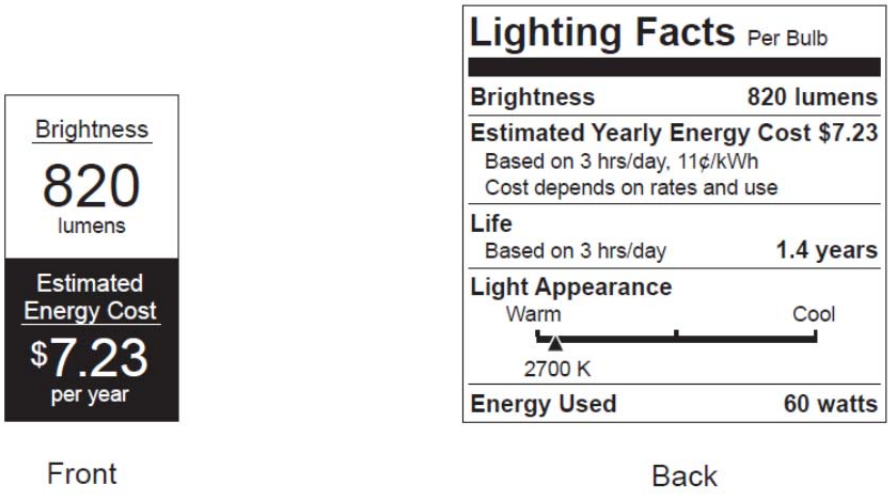
[2] Excluding Long Island.

Figure 1 shows, the Lighting Facts label provides consumers with information about brightness, expressed in terms of lumens; light appearance, expressed in terms of Kelvin (absolute temperature scale, denoted K) and a visual scale indicating how warm or cool the light appears; and wattage. An estimate of annual energy cost is provided, based on assumed average hours of use and electricity rates.

Figure 1. The FTC Lighting Facts Label



Source: Federal Trade Commission. 2011. Accessed March 5, 2012 from http://www.ftc.gov/os/2010/06/100618lightbulbs.pdf.

For this research, NYSERDA conducted telephone surveys of two populations of New York State residents: 510 consumers from the general population of New York as well as 140 homeowners who had installed at least one fixture in the twelve months prior to the survey. The surveys were fielded from September to November, 2011 and households were selected via random-digit dial. Survey samples were selected proportionately by county. The results were weighted to adjust for patterns of non-response that might have biased the results. Further weights were also developed to adjust for demographic differences between the sample and the region, including home ownership, head of household age, education, number of adults in household, and number of people in the household.

While the sample of consumers also included people who owned their own homes, references in this paper to "homeowners" are specifically to those homeowners who had installed at least one light fixture in the previous 12 months.

Results

Awareness of Energy Efficient Light Bulbs

In order to assess New Yorkers' familiarity with energy-efficient light bulbs, consumers and homeowners who had installed fixture(s) were asked whether they had ever heard of CFLs, LEDs, and "high efficiency halogen" bulbs.[3] EISA-compliant halogen bulbs are quite new to consumers. The term "high efficiency halogen"[4] was used for these bulbs in the survey in order to differentiate them from the types of halogen bulbs historically associated with torchieres, and because these bulbs are often positioned as "green" (with names such as "EcoVantage®" [Philips],"SuperSaver®" [Osram Sylvania], or "EcoHalogen" [Bulbrite®]). For each bulb type,

[3] "High efficiency halogen bulbs" refers to EISA-complaint halogen bulbs.
[4] EISA-compliant halogen bulbs are not high efficiency compared to standard halogen lamps.

respondents who said that they had heard of it were read a description of the bulb type and then asked "Is this the kind of light bulb you have heard about?"

Table 1 shows that the majority of consumers had heard of each bulb type, with two-thirds having heard of CFLs, nearly six out of ten (59%) having heard of LEDs, and slightly more than one-half (55%) reporting that they had heard of "high efficiency halogen" bulbs. As might be expected, the homeowners who had recently installed fixtures, and thus recently had been shopping for lighting, were somewhat more familiar with energy-efficient bulbs, with more than three-quarters of these respondents reporting having heard of each bulb type.

Table 1. Familiarity with Energy-Efficient Bulb Types

Bulb Type		Consumers (n=510)	Homeowners Who Installed Fixture(s) (n=140)
CFLs	Yes	66%	76%
	No	32%	23%
	DK/refused	3%	1%
LEDs	Yes	59%	78%
	No	38%	21%
	DK/refused	3%	1%
"High Efficiency" Halogen Bulbs	Yes	55%	76%
	No	38%	24%
	DK/refused	7%	<1%

While EISA-compliant incandescent halogen bulbs are more efficient than the general use incandescent bulbs being phased out, they are considerably less efficient than existing CFLs (U.S. Department of Energy, 2012). Consumers were asked to identify which type of bulb—a CFL or a "high efficiency" halogen bulb—uses less energy to produce light (Table 2). Only 30% of respondents correctly identified CFLs as using less energy than "high efficiency" halogens. It is possible that referring to EISA-compliant bulbs as "high efficiency" halogen in the survey may have encouraged respondents to over-rate the energy efficiency of these bulbs. As consumers become more familiar with these bulbs, program administrators wishing to assess consumer education needs and measure progress in consumer understanding of the relative energy use of each bulb type may want to explore other ways to refer to EISA-compliant halogen bulbs in surveys.

Table 2. Consumer Judgments about Relative Energy Use of CFLs and "High Efficiency" Halogen Bulbs

Which Bulb Uses Less Energy	Consumers (n=510)
CFLs	30%
"High efficiency" halogen bulbs	19%
About the same	17%
Don't know/refused	34%

Lighting Knowledge Among Consumers and Homeowners

Consumers and homeowners who had recently installed fixture(s) were asked a series of open-ended questions about whether they had heard of various key lighting terms that appear on

the Lighting Facts label, and if so, what the term meant to them. These and all other responses to open-ended survey questions were recorded verbatim and back coded after all surveys had been administered.

Understanding of lumens. Lumens are an empirical measure of the quantity of light emitted from a source (EIA 2012*)*. Less than one-half (43%) of the consumers affirmed that they had seen or heard of this term. Homeowners who had recently installed fixture(s) were more familiar with the term than were the consumers. Nearly six out of ten homeowners (59%) had heard of the term. It is possible that this difference could be due to the more involved nature of fixture shopping than bulb shopping.

Respondents who reported having seen or heard the term were asked to describe what the word "lumens" meant to them. Multiple answers were allowed. As Table 3 shows, about eight out of ten respondents who had heard of lumens (81% consumers, 82% homeowners) correctly identified lumens as light output or brightness. This translates into 35% of all consumers and 48% of all homeowners demonstrating a correct understanding of lumens.[5] Although the homeowners who recently installed fixture(s) were more likely than the consumers to have heard of lumens and were equally likely to give a correct understanding of the term, homeowners were also more likely to confuse lumens with watts (14% of the homeowners versus only 4% of the consumers).

Consumers' and homeowners' understanding of lumens was further assessed by asking those who had heard the term to estimate the number of lumens produced by a 60-watt incandescent bulb.

A 60-watt incandescent bulb is rated at approximately 800 lumens (ENERGY STAR 2012, Architectural Lighting 2011). Overall, respondents showed a poor understanding of the relationship between watts and lumens in the context of incandescent lighting. Among the consumers, estimates ranged from one to 2,300, but the most common value given was 60, indicating that despite the fact that 81% of those who had heard of the term understood that lumens refer to brightness, many respondents believed watts and lumens were the same thing. Nearly six out of ten said they did not know the number of lumens produced by a 60-watt bulb. Only 3% of respondents provided an answer within 200 lumens of the correct value, and only three respondents said 800 lumens (Table 4).

Table 3. Understanding of the Term "Lumens"
(Base: Respondents who have heard of the term "lumens")

Description of Lumens[6]	Consumers (n=270)	Homeowners Who Installed Fixtures (n=78)
Light output/brightness	81%	82%
The same as watts	4%	14%
Light (general)	2%	3%
Light color	1%	0%
Other	3%	<1%
Don't know/refused	12%	12%

[5] Calculated for consumers as (43% heard of term)*(81% correctly identified as brightness); for homeowners, as (59% heard of term)*(82% correctly identified as brightness).

[6] Columns sum to more than 100% because some respondents provided more than one response.

Similarly, among the homeowners who had recently installed fixtures, over one-half of respondents who were asked this question provided an estimate of between 1 and 199 lumens; eleven of these respondents estimated that a 60-watt bulb produced sixty lumens. These results indicate that despite their greater awareness of high efficiency bulbs and familiarity with the term lumens, homeowners who recently installed light fixtures also confuse lumens with watts at high rates. Nearly four out of ten (38%) said that they did not know the number of lumens produced by a 60-watt bulb. Only 5% of respondents provided an answer within 200 lumens of the correct value, and only two respondents said 800 lumens.

Table 4. Respondents' Estimates of Number of Lumens Produced by 60-watt Incandescent Bulb (Base: Respondents who have heard of the term "lumens")

Ranges of estimates	Consumers (n=270)	Homeowners Who Installed Fixtures (n=78)
Range	1-2300	1-900
Mode	60	60
1-199	35%	54%
200-399	0%	2%
400-599	0%	1%
600-799	2%	3%
800-999	1%	2%
1000 and up	4%	0%
Don't know/refused	59%	38%

Understanding of color rendering. Next, respondents to both surveys were asked if they had seen or heard the term "color rendering" used in relation to lighting. Color rendering is a quantitative measure of the ability of a light source to reproduce the colors of various objects faithfully in comparison with a reference light source. The Color Rendering Index (CRI) is expressed on a scale of one to 100, where a value of 100 indicates no color shift compared to the reference source; incandescent sources and a specifically-defined spectrum similar to daylight are valued at 100 (IESNA 2000). Less than one-fifth (17%) of the consumers and just over one-fifth of the homeowners (22%) had seen or heard of the term color rendering.

Respondents who indicated they had seen or heard of the term color rendering were asked to describe what the term meant to them; multiple responses were allowed. As Table 5 shows, among consumers who had heard of the term, almost one-fifth (18%) stated that color rendering refers to the naturalness of light or its likeness to daylight, which is partially correct. The 25% that said it refers to the effect of light on the color of its surroundings were very close to the correct definition.

The results are very similar for the homeowners who had installed fixtures, with 18% who had heard the term indicating that the term means the naturalness of light and 29% expressing that it means the effect of light on the color of its surroundings. Some common misconceptions among respondents in both surveys were that color rendering is the color of the light itself, the brightness of the light, or the color of the bulb.

While CRI is not shown on the Lighting Facts label, color rendering is an important characteristic of bulbs that can set the stage for satisfaction—or disappointment—with a particular bulb. To gauge the rate at which NY consumers understand what is meant by color rendering, we created a new variable representing level of understanding of color rendering and

assigned a level of understanding to each respondent based on their open-ended responses to the understanding question.[7] Among the 17% of consumers who had heard the term color rendering, 41% demonstrated a correct understanding of color rendition. Thus, only 7% of the total sample of consumers have a good understanding of color rendition.[8]

Table 5. Understanding of the Term "Color Rendering"
(Base: Respondents who have heard of the term "color rendering")

Description of Color Rendering[1]	Consumers (n=81)	Homeowners Who Installed Fixture(s) (n=33)
Color/tone of light	27%	46%
Effect of light on color of surroundings	25%	29%
Naturalness of light/likeness to daylight	18%	17%
Refers to light spectrum	13%	8%
Light/color temperature	13%	5%
Softness of light	8%	4%
Brightness of light	7%	7%
Quality/purity of light	7%	0%
Color of bulb	5%	3%
Other/unclear	9%	6%
Don't know/refused	2%	7%

Understanding of color temperature. Consumers and homeowners who had installed fixture(s) were also asked if they had seen or heard the term "color temperature" used in relation to lighting. Color temperature refers to the color appearance of a light source, stated in terms of the thermal unit Kelvin (K). This measurement can also be described as the "warmth" or "coolness" of a light source, with temperatures over 4,000K referred to as "cool colors" that show a bluish white light, and temperatures below 3,200K referred to as "warm colors" that show yellowish through reddish white light (Architectural Lighting 2011).

Less than one-fifth of both samples had seen or heard of the term color temperature (17% of the consumers and 19% of the homeowners who had recently installed fixtures).

Respondents who claimed to have seen or heard the term color temperature were asked to define what the term meant to them. As Table 6 shows, among the consumers, less than half (44%) stated correctly that color temperature refers to warm (reddish) or cool (bluish) light. A small percentage overall correctly identified color temperature as referring to harsh or soft light (5%) and Kelvin temperatures (3%). Some definitions given, including "daylight/white light," "brightness," and "similar to color rendering," suggest that some respondents confuse color temperature with lumens or color rendering.

[7] Respondents whose responses included the following were considered to have a correct understanding of color rendering: "naturalness of light/similarity to daylight" or "effect of light on color of surroundings."

[8] Calculated as 17% (awareness of the term among consumers)*41% (correct understanding of the term). The variable was not created for respondents to the survey of homeowners who had purchased a fixture.

Table 6. Understanding of the Term "Color Temperature"
(Base: Respondents who have heard of the term "color temperature")

Description of Color Temperature[9]	Consumers (n=77)	Homeowners Who Installed Fixtures (n=30)
Warm (redish) or cool (bluish) light	44%	19%
Color of light	20%	35%
Brightness	10%	20%
Temperature of bulb	9%	8%
Temperature of light	7%	10%
Daylight/white light	7%	5%
Harsh or soft light	5%	15%
Related to TV image	5%	--
Ambience of light	4%	--
Refers to Kelvin temperatures	3%	--
Same as color rendering	2%	--
Energy of light	--	1%
Other	6%	5%
Don't know/refused	8%	13%

Among the thirty homeowners who had purchased fixture(s) and were familiar with the term "color temperature," about one out of three (35%) indicated that it had to do with the color of the light. Two out of ten respondents who were familiar with the term incorrectly said that color temperature meant the brightness of light, while somewhat fewer (15%) mentioned the subjective quality of warm versus cool lighting by referring to the "softness" versus "harshness" of light. More than one out of ten respondents who had heard the term (13%) said they did not know what it meant.

As with color rendering, for consumers we created a new variable representing level of understanding of color temperature and assigned a value to each respondent based on their open-ended responses to the understanding question[10]. Of the 17% of consumers who had heard of the term, 57% demonstrated a reasonable understanding of color temperature. Thus 10% of the total sample of NY consumers have some understanding of color temperature.[11]

[9] Columns sum to more than 100% because some respondents provided more than one response.

[10] Respondents who included any of the following in their responses were considered to have a correct understanding of color temperature: "warm/reddish or cool/bluish light," "harsh or soft light," "color/shade of light," and "refers to Kelvin temperatures."

[11] Calculated as 17% (awareness of the term among consumers)*57% (correct understanding of the term).

Table 7. Understanding of the Terms "Warm White" and "Cool White" (Base: Respondents who have heard of the term "warm white" and "cool white")

Description of Warm White/Cool White[12]	Consumers (n=77)	Homeowners Who Installed Fixtures (n=88)
Cool is brighter/more intense	23%	--
Warm is more yellow/red/orange/pink, cool more blue	22%	18%
Warm is softer/mellow	13%	14%
Warm emits more heat	9%	9%
Warm is brighter/more intense	5%	15%
Cool is harsher/more stark/ hard on eyes	5%	7%
Coating of bulb	3%	4%
Cool is clearer	3%	--
Cool is more like daylight	3%	--
Cool has more glare	2%	--
Warm is associated with incandescent	2%	--
Cool is associated with fluorescent light	1%	2%
Warm is more like daylight	1%	2%
Refers to brightness (not further specified)	--	9%
Cool is brigher/more intense	--	8%
Cool white looks artificial	--	1%
Warm uses more energy	--	1%
Other/unclear	30%	12%
Don't know/refused	7%	18%

Finally, all respondents were asked if they had seen or heard of the terms "warm white" and "cool white." These terms are connected to color temperature. Cool white tends to have a bluish hue and is described as giving the light a cold feeling; warm white tends to have a yellowish or reddish hue and is similar to light given off by an incandescent light bulb (Architectural Lighting 2011). European and North American consumers tend to prefer bulbs that produce warmer light (Kanellos 2011). Given this, it stands to reason that U.S. consumers are more likely to be satisfied with CFL and LED bulbs—and thus be more likely to make repeat purchases of them—if they are aware that the color temperature of light from CFL and LED bulbs can vary, and they learn to take color temperature into account in selecting among bulbs. Compared to other terms that appear on the Lighting Facts label, the situation is more positive for the terms "warm white" and "cool white." Nearly two-thirds (62%) of the consumers and more than two thirds (69%) of the homeowners who had recently installed fixtures said they had seen or heard the terms "warm white" and "cool white."

Respondents who reported having heard of warm white and cool white were asked to explain what the terms meant to them. As shown in Table 7 above, over one-fifth (22%) of the consumers and just under one-fifth (18%) of the homeowners who had heard the term correctly identified warm white as having more yellow, red, orange, or pink, and cool white as having

[12] Columns sum to more than 100% because some respondents provided more than one response.

more blue. Extrapolating from the rate of understanding of these terms in the consumer sample, the results suggest that 14% of NYS consumers understand the meaning of warm white and cool white.[13] Many of the other responses describe subjective attributes of the light, such as that warm white is brighter or more intense, that warm white is softer, and that cool white is "harsher" or harder on the eyes.

Conclusions

It is clear from these results that New York State consumers are not well prepared to put the information on the Lighting Facts label to full use in choosing bulbs. While the findings described above cannot be generalized beyond New York State,[14] it seems reasonable to assume that the rates of awareness and understanding of information on the Lighting Facts label may be similar for states in which there has been no concerted effort to educate consumers about this information. Given this, it seems likely that without effective communications to inform consumers about the information on the Lighting Facts label, a large percentage of consumers who are new to high efficiency bulbs will not understand how to choose a CFL or LED bulb that is most likely to satisfy their preferences and will not be capable of putting the Lighting Facts label to use as intended. In frustration, these consumers may instead turn to less efficient EISA-compliant halogen incandescent bulbs.

The survey results described above can help in prioritizing areas of focus for consumer education about the information on the Lighting Facts label. The number of lumens now appears prominently on the front of bulb packages as part of the Lighting Facts label. Awareness and understanding of the term "lumens" among the sample was admittedly higher than the authors expected to find: more than four out of ten (43%) consumers and six out of ten homeowners (59%) had heard of the term lumens. Thirty-five percent of all consumers and 48% of all homeowners demonstrated a correct understanding of the concept. However, when it came to quantifying lumens, there is ample room for improvement: only 3% to 5% of respondents provided an answer within 200 lumens of the correct value of 800 lumens in a 60-watt incandescent bulb.

There is no scale associated with the lumens information on the label. Without context, it is questionable whether consumers will know how to interpret the lumens data when they see it on the label. Given this, it would seem that increasing understanding of the term "lumens" is probably the highest priority for consumer education about information on the Lighting Facts label. Perhaps the single most important lighting consumer education service that energy efficiency programs could play in the next few years is to help consumers transition from thinking about bulb brightness in terms of 40, 60 and 75 watts to thinking about it in terms of 450, 800, and 1,100 lumens.[15]

Light appearance is another high priority area for consumer education with plenty of room for improvement. It is addressed on the Lighting Facts label by a scale with "warm" and "cool" as endpoints and color temperature in Kelvin. Nearly two-thirds (62%) of the consumers and more than two thirds (69%) of the homeowners surveyed said they had seen or heard the terms "warm white" and "cool white." However, only 14% of consumers demonstrated

[13] Calculated as 62% (awareness of the term among the consumers in the General Population survey)*22% (understanding of the term among consumers in the General Population survey).
[14] Specifically, New York State excluding Long Island.
[15] The corresponding minimum lumens for these wattages, according to ENERGY STAR (ENERGY STAR 2012).

understanding the meaning of warm white and cool white, and just 10% demonstrated understanding of color temperature.

While the color rendering index, or CRI, is not shown on the Lighting Facts label, color rendering is part of light appearance and is an important characteristic of bulbs that can set the stage for satisfaction—or disappointment—with a particular bulb. CRI appears on the packaging of many CFLs, and more sophisticated lighting consumers can use this information to help in purchasing bulbs appropriate for particular areas of the home or for particular uses. The data showed that awareness and especially understanding of color rendering were both low. Less than one-fifth (17%) of the consumers and just over one-fifth of the homeowners (22%) had seen or heard of the term color rendering. Among consumers, only 7% of the total sample of consumers demonstrated a good understanding of color rendering. Given that CRI does not appear on the Lighting Facts label, increasing consumer understanding of the meanings of the terms that appear on the label is probably more important in the near term than increasing consumer understanding of color rendering or encouraging them to look for CRI on packaging.

The research results suggest another high priority area of focus for consumer education: informing consumers about the substantial difference in efficiency between CFLs and LEDs versus EISA-compliant halogen incandescent bulbs. While the fact that the survey referred to these bulbs as "high efficiency" halogen may have contributed to respondents over-rating the efficiency of this type of bulb, these bulbs are often positioned as "green" and may continue to be positioned this way as EISA standards take effect. Thus consumers may continue to over-rate the efficiency of this bulb type going forward. As consumers become more familiar with EISA-compliant halogen incandescent bulbs, NYSERDA and other program administrators wishing to measure progress in consumer understanding of the relative energy use of each bulb type may wish to find another way to refer to these bulbs in surveys.

Finally, program administrators who choose to pursue a path of educating consumers about lighting facts may find it useful to replicate the questions used in this study. Their initial measurements can serve as baselines of key indicators of consumer lighting knowledge in their jurisdictions, and periodic measurements over time can help in assessing market progress and the effectiveness of consumer education campaigns.

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