Response to comments made at CEC Title 24 pre-workshop (held Nov 3, 2014)

Jim Gaines, Philips Lighting

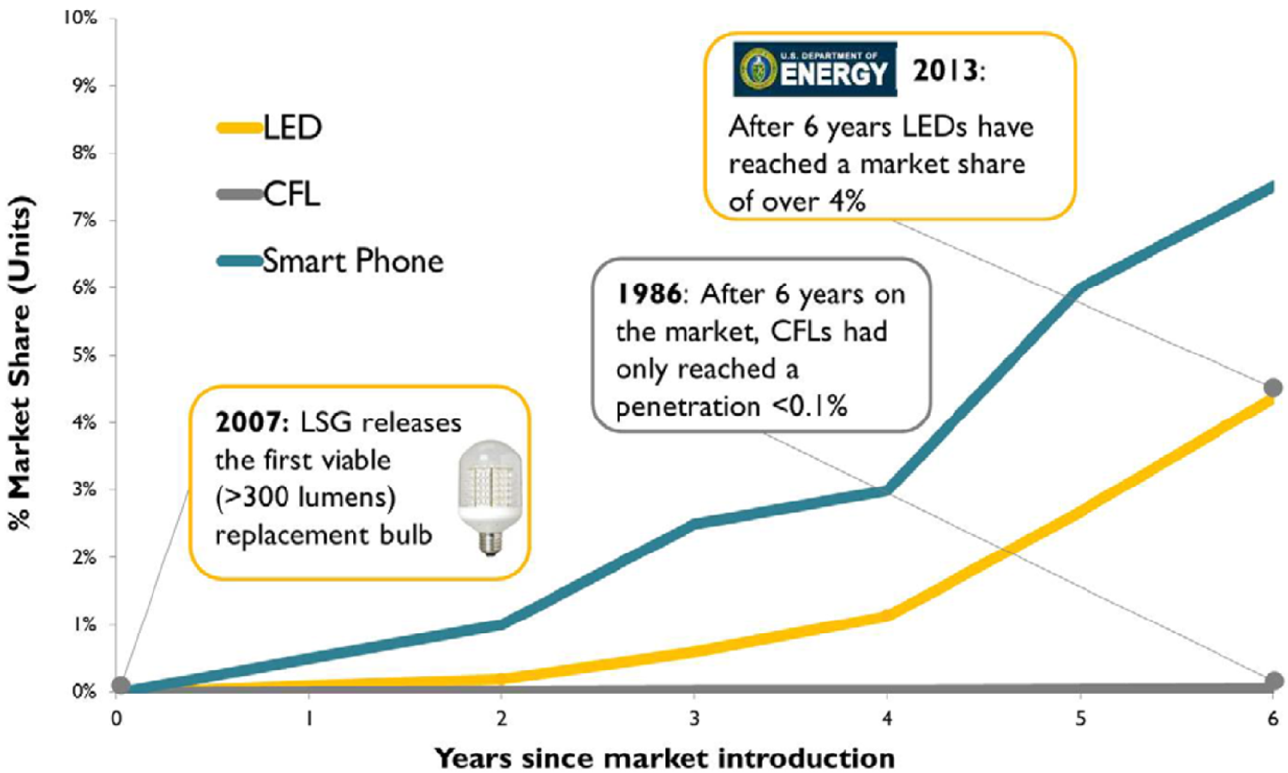
I made this statement (approximately) at the pre-workshop on 3 November:

> "I'm afraid that the 10 points from Lorne Whitehead oversimplify the point of those people who are not in favor of CRI 90. We believe that there is a place for CRI 90, in certain applications. Certainly there is no fundamental technical difficulty to make CRI 90 products. Philips has produced many CRI 90 products. We do not believe that it makes any sense as a MINIMUM spec. There are plenty of applications that do not require CRI 90. There is not a "HUGE" efficacy hit, but there is an efficacy hit (or you can trade this off for reliability), there is not a "HUGE" cost hit, but there is a cost hit. Higher cost is a major aspect that influences adoption rates. Another point, well shown by DOE, is that SSL is being adopted radically faster than CFL ever was. "

I would like to respond to comments that were made at the CEC workshop on 3 November, 2014, in response to Philips' inputs.

1. Adoption Rate of CFL vs. SSL

I find it remarkable that CA is able to so freely dismiss the DOE data comparing the market adoption of LED (which is not unlike the adoption of smart phones, incidentally) to CFL. The plot I referred to in my comments is below. I hope that the CEC and utilities have seen it before.



DOE report: "Solid-State Lighting: Early Lessons Learned on the Way to the Market" Published January 2014
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_lessons-learned_2014.pdf

Comments made at the workshop were likely referring to later years of CFLs, when there *was* a rise in CFL adoption, following about 25 years of the CFL market share piddling its way up to ~5%, and fueled by a media/rebate blitz. (See figure below.)

To conclude that the LED market is likely to make an abrupt turn downwards or level off at a low adoption rate, after the behavior above, is quite a stretch of the imagination. And then, building from that stretch, to conclude that CA needs to set strict performance standards that exceed those of Energy Star (CRI 90+, 4 SDCM, PF 0.9[1], deeper dimming, etc), to pre-emptively prevent the feared hypothetical imminent demise of LED, is a much larger stretch of the imagination.

The plot above says that adoption of SSL is going very well, and we don't need to mess with it. We find it difficult to believe, given the reception by customers, the rapidly falling prices and the removal of incandescents from the market, that adoption will suddenly dive. CA is more likely to slow adoption than facilitate it with overly strict performance requirements, because they will force the price to be unnecessarily high. In fact, the Home Depot data previously supplied shows CA does lag the rest of the country in adoption of energy saving lamps.

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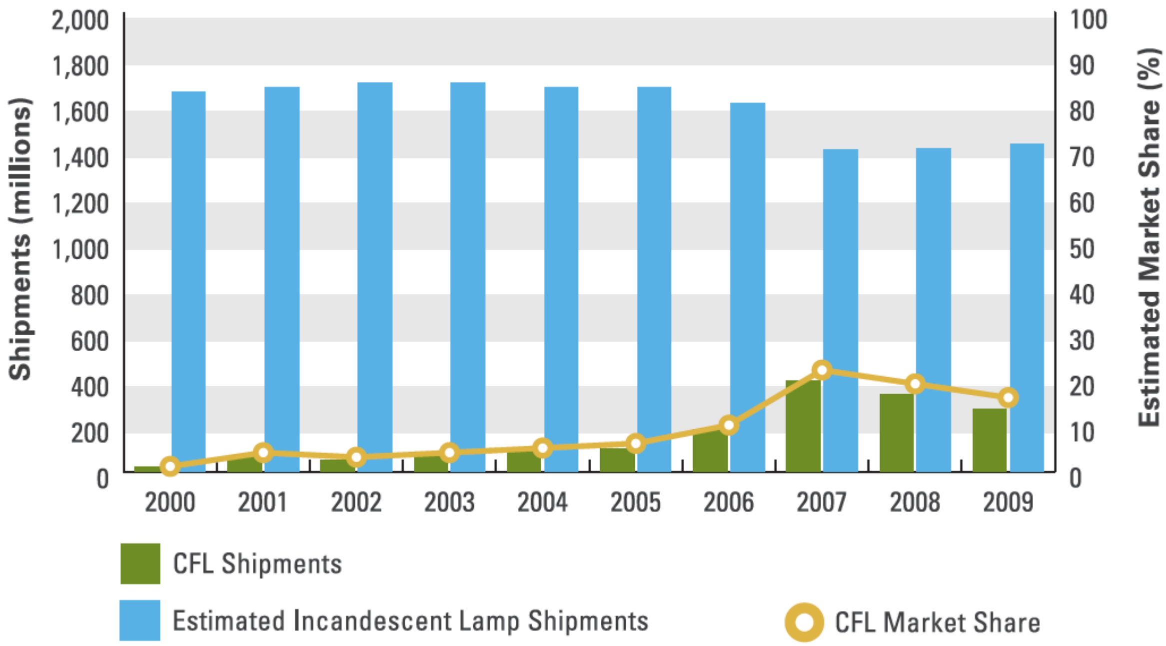
[1] As if power factor had anything at all to do with consumer acceptance.

Figure 2 | CFL and Incandescent Lamp Shipments Plus CFL Market Share, by Year



The figure above is taken from:
http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf

We were surprised to hear it stated at the workshop that CFL adoption has reached a level of 30-40%! We thought the percentage was in the 20s, at best, according to most. By most people's standards, 30-40% would be pretty high adoption. If the adoption rate is 30-40% why does CA treat CFL as an abject failure, and all of its parameters are to be avoided at all costs?

2. Cost decreasing faster for high CRI

It was also stated at the workshop that the cost of high CRI SSL products is decreasing faster than CRI 80 products, based on a survey of market prices. To conclude that prices will therefore reach price parity is another remarkable leap of logic. The CRI 90 SSL products are at an earlier stage in the market, by and large, and starting from a higher price than CRI 80 lamps, so it is no surprise that they decrease in price more quickly. To conclude on the basis of market prices that the price of CRI 90 will reach equality (or "negligible" difference) with CRI 80 is absurd and ignores all the underlying technical basis. On a more practical and immediate level, if a person in CA just compares the lamps in his/her own local CA Home Depot, he/she will see that both price and efficacy of the CREE CRI 90 lamp shown at the pre-workshop are considerably less favorable than the CRI 80 version. Noah Horowitz demonstrated this at the Title 20 workshop a few weeks ago, along with some other bulbs:

There are good reasons that CRI 90 is, and is likely to remain, more expensive than CRI 80. See Appendix.

It is quite amazing that the people involved in the CEC specification can overlook the much poorer Lumens/dollar of the CRI 90 product in the figure above.

3. Power Factor

It was also asserted at the workshop that the increase in cost of power factor 0.9 is negligible. Power factor has no influence on consumer adoption. There is no evidence that high power factor is needed for these low power lamps. Utilities tend to *believe* that higher power factor requirements on lighting is “good”, but they have not *shown* that CFLs or other low-power factor equipment are causing disturbances in the grid. In fact, a review of many studies done by USAID (E. Page, M. Ton, Power Factor: Policy Implications for the scale-up of CFL programs, USAID | ASIA, December 2010) shows that CFLs (with their much higher THD and lower PF (0.5)) have *not* caused increased disturbance to the grid.

> “Prior research has not proved that HPF CFLs are needed or even beneficial: One thing that can be concluded with relative certainty is that the totality of the research to date, and especially field research, has not proved that HPF CFLs are needed or even beneficial. “

As anyone from the utilities should know, the aggregate effect of the entire household/business/equipment connected to the grid is the important factor to the grid. CFLs, with their capacitive nature, actually compensate for the inductive load of motors and other equipment connected to the grid. LEDs will do the same. The extra electronics required to attain 0.9 power factor increases overall size and complexity of the electronics making it more difficult and expensive to fit the electronics within small lamp outlines. It also decreases overall efficiency of the lamp, in most executions. There are complicated trade-offs with other performance factors, such as flicker and dimmer compatibility. We see no reason to set the PF specification so tight.

Finally, those who support CRI 90 and other high performance specifications should take time to truly understand the reasoning and the perspective of manufacturers, and not immediately reject their statements and attempt to shoot them down with half-truths and straw men. I suggest that you also consider carefully the lighting experience that companies like Philips, GE and Osram bring to the discussion. None of these companies support CRI 90 as a minimum specification. Why do CRI 90 supporters think that manufacturers do not support CRI 90? Maybe, due to decades of market experience, these companies know what is needed to meet the expectations of the consumer while maintaining quality products, which is so important to their brand reputation. Those companies that do support CRI 90 are new to the lighting field. Could their apparent desire for “higher quality” lighting be driven by a motivation for a protected market for their products?

Appendix

Why can't CRI 90 be as inexpensive and efficient as CRI 80?

It is possible to make lamps that provide CRI 90. It has been done in many products (many of which have subsequently been discontinued). Lamps with CRI 90 are presently receiving rebates according to the CEC Quality LED Lamp Specification. However, there are major challenges to widespread creation and adoption of such lamps.

CRI 90 is obtainable in three distinct ways:

1. The simplest way (and the way used in most white CRI 80 LED products today) is to use a blue LED to excite a yellow phosphor. Some of the blue light from the LED is mixed with the light emitted by the phosphor to produce white light of the desired correlated color temperature (CCT). The phosphor formulation must be modified to produce light with CRI 90. In order to obtain 90 CRI, phosphor that produces more red light must be used. This approach inevitably results in lower LED efficacy, because more energy is lost in converting a blue photon to a red photon, than to a green or yellow photon. Also, some of the broad band emission from the red phosphor is in the infrared spectral region. Because LED efficacy is lower, in order for a lamp to produce the same amount of light, more power is needed. Typically, the extra power required is about 15-20%. This means more LEDs are needed, the electronics must provide more power, and the heatsinking must dissipate more power. Depending on the exact lamp design and LED selection/configuration, the optics may also need to be larger. This approach results in higher cost, both for initial lamp purchase and for the ongoing electricity use to power the lamp. There are research efforts to produce narrow band red phosphors, which will reduce the amount of light lost in the infrared, but will still lose energy relative to typical CRI 80 LEDs, because more photons must still be converted from blue to red.
2. The second way is to use two (or more) colors of LEDs (e.g. phosphor-converted white + red). The advantage of this approach is that the extra red light is generated directly by a red LED, so efficacy is higher than with approach 1. (It is no longer necessary to generate red light by converting a blue photon to a red photon.) The difficulty with this approach is that color consistency is more difficult to maintain with two LED colors. Both colors must be controlled separately, requiring two channels in the driving electronics. Because of the inevitable different temperature dependence of the two colors of LEDs, if fixed currents are provided to the two colors, then color will change as the lamp warms up, and color will vary at different ambient temperatures. The other difficulty, even if two channels are used, is that the two colors of LEDs, which are built from different materials systems, degrade differently over time. Inevitably, color will drift much more over time than with approach 1, and can lead to unsatisfying color performance. There are ways to avoid this differential degradation:
    a. Add more complicated (and expensive) electronics that perform both optical and thermal feedback to maintain constant color.
    b. Use the approach used in the L Prize lamps. In this case, the LEDs are substantially underdriven to reduce degradation. However, this requires many more LEDs to reach the necessary light output, and therefore much higher cost.

Approach 2 may yield efficacy for CRI 90 products that is nearly equal to that of CRI 80 products. However, much more complicated electronics, sensing, and different optics are also required. Initial cost will inevitably be higher.

3. The third way is to filter out some of the non-red light from phosphor-converted LEDs so that the remaining light meets the CRI and R9 specifications. This is the least efficient approach, because it starts with a CRI 80 LED and completely discards a portion of the light. At least one CA-qualified lamp uses this method. The 80 CRI version of that lamp uses 9.5W, in its 60W incandescent equivalent. The 90 CRI version uses 13.5W, or 42% more energy than the 80 CRI version! Approach 3 results in the poorest lamp efficacy of the three approaches.

It is to be expected that the cost of CRI 90 products will go down, and the efficacy will go up. However, a distinct difference between CRI 90 and CRI 80 products will remain, because CRI 80 products will also improve. In fact, because CRI 80 products are being well-accepted in the rest of the world, and CRI 90 is not an attractive feature, the difference is more likely to worsen the argument for CRI 90 as time goes by, and greater effort is dedicated to higher-volume CRI80 products.