



California Energy Commission

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RE: Docket No. 15-BSTD-01

Adoption of 15-Day Language for the 2016 Building Energy Efficiency Standards

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The California Energy Commission,

I write on behalf of my Company Once Innovations about the proposed Codes and Standards Enhancement Initiative (CASE) Residential Lighting (hereinafter the CASE Report) and the suggested “flicker” requirements on LED lighting technologies discussed on pg. 13 and Reference Joint Index JA10 pgs. 15-23. Once Innovations is a small company based out of Minnesota that sells LED lighting products. Once sells lights into the agricultural lighting market including into California. We are dedicated to making a more humane indoor lighting product for chicken, turkeys and swine with our patented spectrum based lighting. We also license our patented AC based LED technology for residential and commercial lighting including technology sold in California.

Implementing the standards on so called “flicker” provided in the CASE Report will eliminate choice for consumers of a less expensive LED lighting technology in the marketplace that has been widely accepted and adopted by consumers as an acceptable technology, resulting in the slowing in adoption of a much needed energy efficient technology. This will only act to increase problems associated with global warming. In opposite to the suggestions by the CASE Report, 100 and 120 Hz modulated LED lighting technology has never been shown in any study to cause any negative health results, including simple eye strain, and instead has been seen as acceptable in real-world situations. Any design requirement in addition to requiring 100 Hz modulation is unnecessary and will only act to increase product costs and thus decrease adoption of energy efficient LED technologies.<sup>1</sup> To this end Once requests California change the language of its proposed rules to present a requirement that LED technologies operate at or above 100 Hz or 120 Hz and additional modulation information be reported by manufacturers similar to that required by Energy Star or The European LED Quality Charter.

As background regarding LED lighting technologies, there are two main ways in the marketplace to operate a LED lighting device, the first is the traditional technology in the industry, which is to use an AC to DC converter (DC based). The second newer and typically less expensive technology is to modify AC without a DC converter (AC based). Companies that manufacture or sell these AC based lighting

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<sup>1</sup> The proposed additional requirements appear based upon current IEEE 1789 recommendations. Once has requested the IEEE Board investigate procedural flaws and the lack of AC LED representatives as balloting members for the recommendations that restrain trade against AC based lighting technologies and favor DC based lighting technologies.

products include Feit Electric, Seoul Semiconductor, Texas Instruments, Hubbell Lighting, Acuity Brand Lighting, Microchip, Exar, Edison Opto, American Bright, etc<sup>2</sup>. Based on the properties of these technologies, DC based LED lighting typically produces light without a frequency/modulation (0 Hz). AC based LED lighting in the marketplace produces light with a frequency/modulation of 100 Hz or 120 Hz.

While I understand that science can be mundane, tedious and legislatures would likely rather leave this to others, this decision has the potential to economically harm AC LED manufacturers and sellers based out of California and impede the adoption of energy efficient lighting that will cause harm to the environment. As a quick lesson in the properties of light, light has multiple properties including wavelength (measured in nanometers - nm), frequency/modulation (measured in Hertz - Hz), intensity (measured in lux), etc. Depending on these properties, different chemical reactions occur in humans. For example, light at a wavelength of 200nm will cause the chemical reaction of blindness, at 400 nm will cause the chemical reactions of causing a human to produce vitamin D and tan and at 600 nm will cause the chemical reaction of appearing orange. Similarly studies have shown for frequency/modulation at 30 Hz (full strobing light) in a portion of the population seizures will occur, at 70 Hz (more traditional flicker where some dark is detected) a portion of the population experiences headaches and at 120 Hz (existence of modulation typically not detected/perceivable in any form unless special condition present) and higher the evidence suggests with LED lighting no negative health effects and people find the lighting acceptable.

In the 1980s and 1990s fluorescent tube lighting existed that was shown to cause headaches among a small percentage of the population. Studies also showed reduced reading speed under fluorescent lighting, negative effects on cats, etc. Fluorescent lighting utilized a magnetic ballast that produced significant EMI (electromagnetic interference) and an unforgettable audible hum. It also operated at 100 Hz and 120 Hz frequencies. At the time some scientist concluded the 100 Hz and 120 Hz lighting frequencies were causing the negative health effects. However, since that time many tests have shown that EMI and audible noise such as that produced by the fluorescent tube lighting both cause headaches and can be responsible for the effects noted.

When AC LED lighting began being used in the marketplace at 120 Hz interest in these previous fluorescent lighting studies renewed. Additional testing has occurred. In 2013 Veitch, who had previously performed the test on 60 Hz fluorescent lighting that showed reduced reading speed released preliminary results of her study entitled Flicker Effects on Brain Activity. In this study frequencies of 0 Hz (DC), 100Hz and 500Hz were analyzed to determine the effect on sentence reading and Stroop tasks. In

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<sup>2</sup> This letter/comments by Once are solely provided by Once and the opinions and concerns outlined in this letter are in no way affiliated with or associated with the companies listed and Once is unaware of these companies' positions or opinions on the subject matter discussed. Listing them in no way should be seen as an endorsement, support or otherwise of Once's positions, instead this is merely a statement based on Once's knowledge of the marketplace.

the early results it showed “[T]he speed of reading sentences was the same regardless of the flicker condition.”

Similarly a 120Hz fluorescent lighting study had been conducted on cats and noted phase-locked firing of LGN neurons in cats under the fluorescent lighting. Once manufactures lighting for poultry, animals with a significantly more complex and advanced visual system than humans or cats. In a study from the University of Delaware that has since published Once’s 120Hz lights compared to CFL and a DC LED showed a Heterophils to lymphocyte (H:L) ratio was superior to that of CFL and DC LED lighting, indicating less stress on the bird. Not only does this show no health issues existed contradicting the previous fluorescent lighting study on cats, but the lights actually were beneficial and reduced stress, enhancing health and providing a more humane light source.

In Effects of Flicker Characteristics from Solid-State Lighting on Detection, Acceptability and Comfort, Bullough et. al Feb. 2011 multiple LEDs having multiple flicker index were provided to subjects at varying frequencies from 50 Hz to 300 Hz. Of the 9 different conditions in the trial 6 were done with 100Hz or 120Hz LED lighting devices.

Under each condition subjects indicated whether they could detect flicker in the following situations 1. When using a computer; 2. When looking at the luminaire; 3. When looking at point A (approximately 40° from the luminaire) 4. When shifting their gaze between point A and B in the room (separated by a visual angle of approximately 54°); 5. When waving their hand underneath the luminaire. In all with 10 test subjects, 6 conditions of 100Hz and 120Hz lighting and 5 different scenarios, 300 different modulation situations were considered. Then, if the subjects could detect a stroboscopic effect they were asked to provide the acceptability of the effect with -2 being very uncomfortable, -1 somewhat unacceptable, 0 neither acceptable or unacceptable, +1 somewhat acceptable and +2 very acceptable. Id. The end result, for each situation 1-5 for frequencies 100 Hz and above, in the few cases where modulation could actually be perceived the acceptability rating was over 1, or somewhat to very acceptable to subjects. In other words, 100% of participants in all 300 situations, real life or otherwise, showed no negative health issues and generally found lighting acceptable.

From the Bullough et. al. studies an additional paper was published - Detection and Acceptability of Stroboscopic Effects from Flicker. While this paper itself is not currently available to Once, Assist Recommends put out by the Lighting Research Center provided a paper entitled Flicker Parameters for Reducing Stroboscopic Effects from Solid-State Lighting Systems Volume 11, Issue 1 May 2012 providing additional analysis from the data presented in the second Bullough paper. In particular, an additional experiment was conducted where subjects provided acceptability ratings of detectable flicker on the same acceptability scale -2 – 2 when a light-colored rod was waved against a dark background. In this one situation in the 100 Hz to approximately 160 Hz range for percent flickers well above 25% and typically above 54% some ratings in the 0 to -1 acceptability range were provided.

Still, as indicated by the Assist paper:

Because the study that assessed stroboscopic effects (Bullough et al. in press) used a light-colored, rapidly moving object viewed against a dark background, it comprises a near-worst-case condition for perception of stroboscopic effects. Slower movements, objects with lower contrast, and the presence of non-flickering light sources such as daylight would all be expected to reduce the likelihood of detecting, and to increase the acceptability of, stroboscopic effects from a flickering light source.

Thus, in nearly the worst conditions possible, with the worst performing lights, subjects found the flicker or stroboscopic effects of 100Hz and higher lighting to be somewhere between neither acceptable nor unacceptable to somewhat unacceptable. Basically some individuals were slightly annoyed with the extreme non-real world light colored wand waving.

Other studies on LED lighting operating at 100 Hz and higher typically involve some sort of special condition and whether under such special condition modulation can be perceived. However, no study reviewed shows that perception of modulating light from a LED device during a special condition results in a negative health condition such as a headache or even eye strain. In the only test where subjects were asked if the perceived modulation was acceptable in all real world situations the answer was yes. In sum, based on all studies on actual LED lighting devices operating at 100Hz and above show no health risks exist. In addition the tests on actual LED lighting devices further show in real world settings individuals find the light sources acceptable.

More significant to point out than the studies is that if actual health problems existed as a result of 120Hz LED lighting devices, this would be well documented by the public and industry. A significant portion of the LED lighting technology is now AC LED. Arguably around 20% of residential LED lighting devices are now AC LED and growing. Enough 120Hz AC lighting devices have been sold over the years that in the day and age of internet webpages, facebook pages, company webpages all dedicated to consumers voicing compliments or complaints that if a persistent health issue existed or even unacceptability, it would be well known in the field and adoption of AC technologies would not be increasing. Consumers have spoken and AC LEDs at 100Hz or greater are extremely acceptable in the marketplace with basically no health or headache issues being reported and instead AC LED products appear to be very acceptable to consumers just as the Bullough study indicates.

Most of the recommendations from the CASE Report appear to flow from IEEE 1789 committee recommendations. Once's CEO/CTO Zdenko Grajcar is a nuclear physicist who has extensively studied the effect on LED lighting on living organisms, including humans, avian, swine, and plants and has filed and received an abundance of patents in these areas including U.S. Pat. Nos. 8,651,691, 8,876,313 and 8,858,005 all entitled Light Sources Adapted to the Spectral Sensitivity of Diurnal Avians and Humans and has similar filings directed toward swine lighting, aquaculture lighting and horticulture lighting. Mr. Grajcar was a working group member for IEEE 1789 and recognized and complained of the bias within the working group and balloting members against manufacturers of AC LED technologies vs. DC LED technologies. The exclusion of AC LED manufacturer representatives in the balloting group

underscores the procedural flaws that occurred during the IEEE 1789 standard making process. At this time Once is attempting to work with IEEE to determine why these procedural flaws occurred.

In reviewing the 2016 CASE Report, numerous errors exist regarding support for the proposed flicker requirements that appears to come from the IEEE 1789 committee. At page 17 last paragraph states “Flicker can be related headaches and eyestrain even when the light source is not perceived to flicker (Wikins et al. 1989). Wilkins compared the number of headaches . . . under two types of fluorescent lamp . . .” As indicated above, fluorescent lamps produced both EMI and audible noise that have been linked to headaches. No study exists on LED lighting where headaches were shown to increase or be caused from 100 Hz or 120 Hz lighting.

The first full paragraph of page 18 indicates in 1995 Veitch found visual performance was reduced under 60Hz AC fluorescent lamps compared to 20-60kHz lamps. As indicated above Veitch repeated this same test using 100 Hz LED lamps compared to 0 Hz LED lamps and the speed of reading sentences was seen as the same.

In the second full paragraph on page 18 indicates in the study by the Light Research Center and concludes “This region of frequencies and amplitude modulation is detectable by at least 80% of the population and the stroboscopic effects are considered very unacceptable.” In Once’s opinion this is just a complete misrepresentation. We believe this statement directed toward the Light Research Center are regarding the Bullough tests and Assist paper. Once is sending paper copies of these papers to be part of this record. Please read the Bullough test and the Assist paper on the second and decide for yourselves the accuracy of the suggestion that 80% of the population detected and found stroboscopic effects very unacceptable for 100 Hz and above LED lighting. 5 of 5 real-world situations at 100Hz and above all graded in the acceptable range even in the rare case when the stroboscopic effect was perceivable. The only situation where 100Hz or above was not “acceptable” and ranked between neither acceptable nor unacceptable to somewhat unacceptable was essentially the worst possible condition and a complete non-real world condition. Again, please read the actual papers and decide for yourselves the merits of this statement in the CASE Report.

Thus, of the three main studies the CASE Report uses to support the need for additional requirements above a minimum frequency of 100 Hz or 120 Hz the first is unsupported in relation to LED lighting devices, the second is contradicted by studies on LED lighting devices and the third is plainly misrepresentative of the LED light study that instead shows lighting at and above 100 Hz in real life situations is more than acceptable.

The most telling statistics from the CASE Report indicate that 15 out of 25 (60%) LED lighting devices tested failed the flicker test with 12% of the samples being lamps having less than 200Hz and amplitude modulation of 100%. The CASE Report suggests the market is not self-policing. The CASE Report seems to be missing the obvious – consumers are adopting devices in mass that fail these excessive requirements because the excessive requirements are completely unwarranted. The reason

to police flicker is to ensure lamps that are unacceptable to consumers are not placed into the marketplace giving a bad name to all of LED lighting and reducing adoption. The problem here is that the lamps in the marketplace are acceptable to consumers as the Bullough test actually shows despite its inaccurate characterization by the CASE Report. As a result, the only thing the proposed flicker requirement will accomplish is forcing completely unneeded design changes on perfectly acceptable LED lighting devices thus unnecessarily increasing costs. Without question these increased costs will be seen as unacceptable to multiple consumers and thus reduce adoption of LED lighting technologies in favor of cheaper, less energy efficient lighting products. This undoubtedly will result in negative effects on the environment and economic harm to multiple California companies that sell AC LED products. Thus we request California adopt the same standard on flicker/modulation as Energy Star or The European LED Quality Charter and put an end to the “flicker” boogiemans.

Sincerely

Joe

Joe Hoffmann

General Counsel  
Once Innovations, Inc.