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## On Federally Exempted Linear Fluorescent Lamps

Comments from Appliance Standards Awareness Project (ASAP), the American Council for an Energy-Efficient Economy (ACEEE)s, The Natural Resources Defense Council, and the Northeast Energy Efficiency Partnerships

*Additional submitted attachment is included below.*

**Appliance Standards Awareness Project**
**American Council for an Energy-Efficient Economy**
**Natural Resources Defense Council**
**Northeast Energy Efficiency Partnerships**

Commissioner Andrew McAllister
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814-5512

May 24, 2018

Dear Commissioner McAllister,

Please consider the following response by the Appliance Standards Awareness Project (ASAP), the American Council for an Energy-Efficient Economy (ACEEE), The Natural Resources Defense Council, and the Northeast Energy Efficiency Partnerships to the California Energy Commission's Notice of Invitation to Comment on Federally Exempted Linear Fluorescent Lamps. We applaud the CEC for circulating this invitation, and encourage the CEC to set California state energy efficiency standards for such lamps.

## Summary

The linear fluorescent lamp is the dominant lighting technology used in commercial and industrial buildings in California and nationwide, and also holds a significant share of the residential sector lighting market. Current US Department of Energy (DOE) minimum energy performance standards (MEPS) for general service fluorescent lamps (GSFL) prohibit the manufacture or importation of non-compliant lamps. The most recent update to these federal GSFL MEPS came into effect on January 26, 2018. The US MEPS apply to both four and eight foot long linear fluorescent lamps and cover T12, T8, T5 and other diameter products comprising the vast majority of the market.

ASAP's examination of market data strongly suggests that the expected benefits of the federal GSFL MEPS have been significantly undercut by a loophole in the standard. To address this problem, ASAP and cosigners propose that the CEC establish California state energy efficiency standards for linear fluorescent lamps with color rendering index of 87 or higher. We also recommend that the CEC give serious consideration to the more ambitious proposal included in the Codes and Standards Enhancement (CASE) Initiative Analysis of Standards Proposal for Federally Exempted Linear Fluorescent Lamps, prepared by the California investor owned utilities. Establishing this new California state energy efficiency standard will generate large benefits for Californians, and also help to close the loophole in the federal GSFL MEPS.

## Background

Fluorescent lighting systems based on T12 (3.81 cm diameter) lamp technology were the dominant US fluorescent lighting technology starting with the broad implementation of fluorescent lighting in the US during World War II. During the post-War economic expansion, T12 lighting systems were installed in the vast majority of commercial buildings in the US. Linear fluorescent lamps based on T8 (2.54 cm) and later T5 (1.59 cm) technologies were introduced in the '70s and '90s respectively, and T8s started outselling T12s in the 2000's. Substitutes for linear fluorescent lamps based on light emitting diode technology (TLEDs) entered the market in 2012 and accounted for over 23% of shipments of all linear fluorescent lamp type products by the end of 2017.[1]

In its 2015 Lighting Market Characterization Report, the DOE estimated that there were nearly 2.4 billion linear fluorescent lamps (and TLEDs) in use in the US. Linear fluorescent lamps also accounted for 10% of the electric lamps used in US homes.[2] This Report also estimated that the total electricity consumed by linear fluorescent

lighting annually in the US in 2015 was 212 Terawatt-hours (TWh), of which 121 TWh (41%) was consumed by T12 lamp systems of all types. MEPS-compliant alternatives to T12 lighting systems are able to save about 45% of the energy they consume to produce the same amount of useful light.

The Energy Policy Act of 1992 established the first MEPS for linear fluorescent lamps in the US. When DOE held a rulemaking to update the federal MEPS in 2009, both DOE and industry acknowledged that T12 lamp technology was not capable of meeting the new efficiency requirements. Those federal standards for GSFLs came into effect in 2012, and were upgraded again in 2015 with a compliance date of 2018. Amendments to the US fluorescent ballast MEPS also effectively required electronic technology starting in 2005[3] and the federal ballast MEPs was updated again in 2011 with a 2014 compliance date. This is relevant because while the same luminaire can physically accept either T12 or T8 lamps, the two lamp types usually require different ballasts to operate properly.

Manufacturers shipped more than 100 million T12 GSFLs in the US in 2012. After the 2012 GSFL MEPS came into effect, a customer with a burnt out T12 lamp should no longer have been able to replace it with a complying T12 lamp and would likely have replaced it with either a more efficient T8 lamp or a linear LED lamp, or "TLED". Replacing the T12 with a T8 lamp would also necessitate replacing the T12 ballast with a more efficient T8 ballast. Replacing the T12 with a TLED might involve disconnecting the ballast altogether, depending upon the type of TLED. Either way, the federal GSFL and fluorescent ballast MEPS should have started to substantially reduce the installed stock of T12 lamps and ballasts in the U.S. starting in the end of 2014 (allowing for the sell-through of inventory as permitted by the GSFL MEPS).[4] DOE subsequently issued several waivers to manufacturers that extended their ability to sell non-complying GSFLs through 2014, but sales of new T12 lamps should have ended by 2016 at the latest.

DOE expected that by accelerating the replacement of inefficient T12 lighting technology that the GSFL MEPS would yield the most energy savings of any federal energy efficiency standard issued up to that point. DOE estimated that the 2012 update would save about 410 Terawatt-hours (TWh) of electricity from 2012 - 2030 and avoid the emissions of about 190 million metric tonnes of $CO_2$,[5] and that the 2018 update would yield an additional 260 TWh in savings from products sold from 2018 – 2047, and an additional 160 million metric tonnes of avoided $CO_2$ emissions.[6]

However, in 2017, five years after the 2012 GSFL MEPS came into effect, both 4- and 8-foot T12 lamps continue to be widely available in the US.[7] The National Electrical Manufacturers Association (NEMA) reports that in Q4 of 2017, T12 linear fluorescent lamps still made up over 11% of all linear fluorescent lamps shipped in the US, representing more than 30 million units. It is even possible to buy new T12 luminaires, despite the federal MEPS for both GSFLs and fluorescent ballasts. As a result, T12 lighting technology clearly is not being replaced as rapidly as expected, and the estimated energy savings are not being achieved.

Inefficient T12 fluorescent technology persists in the market because the DOE's legal definition of GSFL exempts eight categories of linear fluorescent lamps:

(i) Fluorescent lamps designed to promote plant growth.

(ii) Fluorescent lamps specifically designed for cold temperature installations.

(iii) Colored fluorescent lamps.

(iv) Impact-resistant fluorescent lamps.

(v) Reflectorized or aperture lamps.

(vi) Fluorescent lamps designed for use in reprographic equipment.

(vii) Lamps primarily designed to produce radiation in the ultra-violet region of the spectrum.

(viii) Lamps with a color rendering index of 87 or greater.

All of the currently available T12 lamps ASAP has identified over the past year have had a color rendering index (CRI) of 87 or greater, excluding them from coverage by the federal GSFL MEPS. When DOE issued the current federal MEPS in 2009, high CRI linear fluorescent lamps were expensive and accounted for only a small share of the total linear fluorescent lamp market. By 2017 Philips, Sylvania, GE and other manufacturers offered

entire lines of high CRI, low efficiency, low priced, T12 lamps and today it appears that nearly all of the millions of 4 and 8 foot T12 lamps still being sold take advantage of the loophole in the federal GSFL MEPS.

## Lighting Technology Comparison

T8, T5 and TLED lighting systems are all more energy efficient than T12 luminaires, and TLED systems are generally more efficient than the fluorescent systems. Replacing a magnetically ballasted T12 luminaire with a new T8 or TLED lighting system[8] provides large energy savings (see Table 1).

***Table 1: T12 and Alternative Lighting System Energy Use Comparison***

| Lighting System | Ballast Type[4] | Lumen Output | Nominal Watts | Lumens/ Watt | Ann. kWh Savings[5] |
|---|---|---|---|---|---|
| T12 (2 F40 lamps)[1] | Magnetic, 60 Hz | 4,650 | 88 | 53 | NA |
| T8 (2 F28 lamps)[2] | Electronic, high frequency | 5,200 | 60 | 87 | 137 |
| TLED (2 14 W units)[3] | none (Type B TLED) | 3,600 | 28 | 129 | 308 |

1. Philips F40T12/DX ALTO T12 lamp with rapid start magnetic ballast
2. Philips F32T8/VEA841/EW/ALTO 28W T8 lamp with programmed start, high frequency electronic ballast.
3. ESPEN L48T8/850/14G-ID TLED Type B “bypass” lamp with internal driver.
4. Assumes reference ballasts with 1.0 ballast factors. Magnetic ballast energy consumption 4 W per lamp, high frequency electronic ballast energy consumption 2 W per lamp.
5. Assumes 4,051 annual hours of operation for 4-ft lamp in residential, commercial and industrial applications.

Table 1 compares the common 4 ft, 2 lamp luminaire application with T12 lamps and a magnetic ballast to the same luminaire with T8 lamps and an electronic ballast, and a Type B TLED designed to operate on 120 V current. The lower lumen output of the TLED provides equivalent illumination to the fluorescent options due to the directionality of the LED light source.

## Market Failures Slow the Transition

Superior lifecycle economics for T8 and TLED options are moving customers away from T12 lighting. However, not all sectors of the market are taking advantage of the benefits. Many of the remaining T12 lighting systems in the US can be found in small commercial applications. A market study in Colorado in 2016[9] found that while larger commercial buildings in the study area had converted to T8 lighting, T12 technology still provided the majority of fluorescent lighting in commercial buildings of less than 10,000 square feet. The Colorado study also found that “the individual saturations of T12, T8, T5, and T8 premium lighting in percentage of square footage served by that technology did not shift a statistically significant amount between 2005 and 2015.” Other studies in Ohio[10] and New York City[11] suggest a similar persistence of T12 lighting in smaller commercial buildings. Conversely, lighting inventory studies from Massachusetts[12] and the Pacific Northwest[13] suggest that T12 lighting has declined, possibly because large, active commercial sector energy efficiency programs in those regions provide financial incentives to businesses for the replacement T12 luminaires.

Businesses tend to have long operating hours which make the savings from conversion to T8, T5 or LED lighting add up quickly. Larger business have the ability to perform technology lifecycle analyses and will commonly replace T12 with more efficient options instead of a scheduled relamping. Small businesses (and residential customers) tend to look at up-front costs only and consider changing lighting technology when a luminaire stops working or as part of a renovation, not for purely economic reasons. This means that for many current T12 users, opportunities for transitioning away to more efficient lighting happen infrequently. Magnetic fluorescent lamp ballasts are obsolete and inefficient, but they last a long time with rated lives typically around 75,000 hours. This means that T12 luminaires may stay in service for as long as the most frequently replaced component, the T12 lamp, is still available.

This continued persistence of T12 technology is consistent with what we would expect when the range of lighting consumers make decisions about technology in the absence of an effective federal GSFL MEPS. One function of a MEPS is to correct market failures and prevent economically inefficient delays in the removal and replacement of energy inefficient technology. Without an effective federal GSFL MEPS, small businesses and residential customers are disadvantaged by failures in the linear fluorescent lamp market.

## Savings From Closing the GSFL MEPS Loophole

Figure 1 shows ASAP projections of US 4- and 8-foot linear fluorescent lamp shipments assuming that the high CRI loophole in the U.S. GSFL MEPS persists into the future.[14] Although market forces are reducing sales of all linear fluorescent lamps the high CRI loophole will allow tens of millions of inefficient T12 lamps be shipped annually in the U.S. for many years.

*Figure 1: US Annual GSFL Shipments – Base Case*

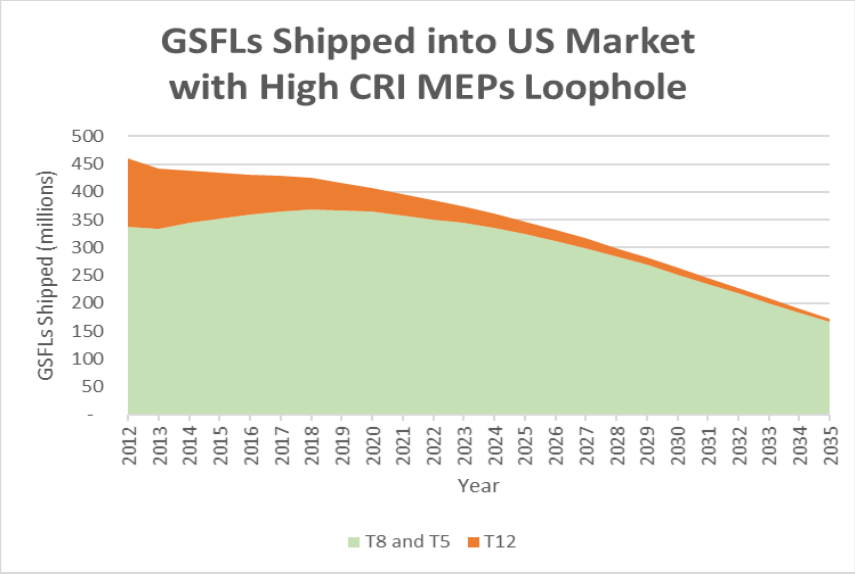


*Figure 2: US Annual GSFL Shipments - ASAP State Standards Case*

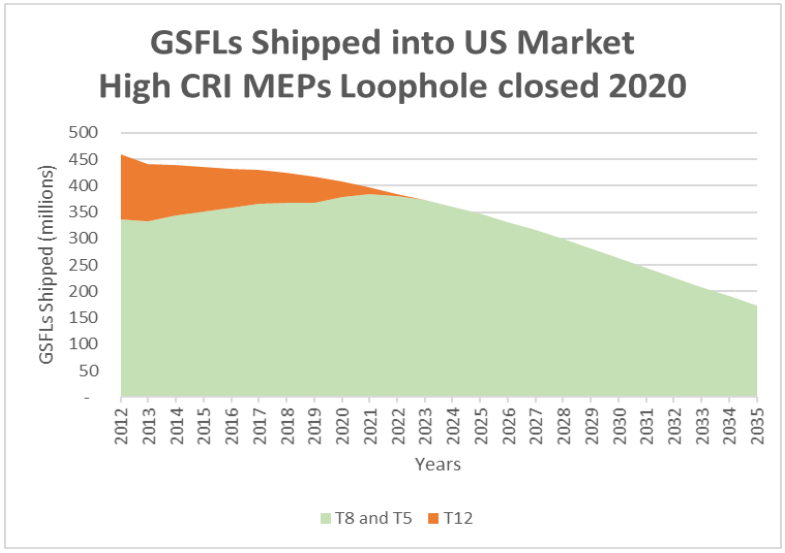


Figure 2 shows the relative impact on national shipments of three types of linear fluorescent lamps if the T12 lamp loophole is closed in 2020.

ASAP's analysis is based on information obtained primarily from DOE and NEMA[15] with impacts for California scaled from national estimates. ASAP estimates that eliminating T12 4- and 8-foot lamps from the California

market by 2020 will result in 1,228 gigaWatt hours (GWH) of annual electricity savings by 2025, dropping to 409 (GWH) annually by 2035 as sales of all types of fluorescent lamps are replaced by sales of LED-based lighting products. Closing the T12 lamp loophole by 2020 will be worth over $219 million annually to Californians in the form of reduced electricity bills by 2025, and will also avoid the emission of 235,000 metric tons of $CO^2$.

ASAP's analysis is extremely conservative because the exemption for high CRI lamps in the federal GSFL MEPS is not limited to T12 products. For example, high CRI, low efficiency, loophole T8 lamps are also available on the market (see Table 3). NEMA does not publish linear fluorescent shipments by CRI which makes it difficult to estimate the percentage of T8 shipments represented by products that are exempt from the federal GSFL MEPS. Anecdotal information from a New England lighting distributor in late 2017 suggested that loophole T8 lamps were widely available in that region.[16] The market conditions for loophole T8 lamps are less attractive than for a loophole T12 lamps. Loophole T8s must compete against many models of MEPS-compliant T8 GSFLs which all operate on the same ballasts, not to mention TLEDs. As of Q4 2017, 11.4% of the US linear fluorescent lamp market was claimed by T12 lamps, presumably all loophole lamps. T8 lamps accounted for more than 50% of that market, so even if only a quarter of the T8 market is taken by T8 loophole lamps, more T8 loophole lamps would be shipped than loophole T12 lamps.

***Table 3: Availability and Pricing of Exempt 4' T8 Linear Fluorescent Lamps (internet 3/2/2018)***

| Brand | SKU | CCT | CRI | Watts | Lumens | lpw | Price | notes |
|---|---|---|---|---|---|---|---|---|
| Philips | 479634 | 5000 | 90 | 32 | 2600 | **81.3** | $2.49 | (ea, 30/case) |
| Philips | 479642 | 6500 | 90 | 32 | 2600 | **81.3** | $2.74 | (ea, 30/case) |
| Philips | 479626 | 4100 | 90 | 32 | 2600 | **81.3** | $2.49 | (ea, 30/case) |
| Philips | 479600 | 3500 | 90 | 32 | 2625 | **82.0** | $2.49 | (ea, 30/case) |
| Philips | 209056 | 5000 | 98 | 32 | 2000 | **62.5** | $9.49 | (ea, 25/case) |
| Sylvania | 22438 | 4100 | 90 | 32 | 2450 | **76.6** | $2.49 | (ea, 30/case) |
| Sylvania | 22437 | 3500 | 90 | 32 | 2450 | **76.6** | $2.09 | (ea, 30/case) |
| Sylvania | 22438 | 4100 | 90 | 32 | 2450 | **76.6** | $2.49 | (ea, 30/case) |
| Sylvania | 22439 | 5000 | 90 | 32 | 2450 | **76.6** | $2.09 | (ea, 30/case) |
| Sylvania | 22440 | 6500 | 90 | 32 | 2400 | **75.0** | $2.09 | (ea, 30/case) |
| Sylvania | 22441 | 6500 | 90 | 32 | 2400 | **75.0** | $2.07 | (ea, 30/case) |

The prices for the lamps in Table 3 are comparable to prices for standards compliant GSFLs. None of the 4 foot T8 lamps listed in Table 3 meet the efficiency requirements in the federal GSFL MEPS. All of the lamps have CRI above 87 and are therefore exempt from the MEPS and legal to sell. There are high CRI fluorescent lamps (offered by other manufacturers) that meet the efficiency requirements in the MEPS, but they tend to be more expensive.

Other linear fluorescent lamps that are exempt from the federal GSFL MEPS may also pose current, or future loophole risks. We are particularly concerned about lamps specifically designed for cold temperature installations and impact-resistant fluorescent lamps because both types can be manufactured at relatively low prices in both T12 and T8 versions.

## ASAP Proposal for California Standards on Federally Exempt Linear Fluorescent Lamps

States may adopt state MEPS for the eight categories of linear fluorescent lamps that are excluded from the federal GSFL MEPS, and are therefore not preempted for state level MEPS. ASAP's current model state legislation includes an energy efficiency standard for high CRI linear fluorescent lamps that requires them to meet the efficacy requirements for GSFLs under the current federal MEPS. On May 21, 2018 Vermont's Governor Phil Scott signed H.410[17] which was based on the ASAP model bill and includes a state MEPS for high CRI linear fluorescent lamps. The bill also includes a ban on the sale of luminaires designed and marketed to use T12 lamps added by the Vermont Senate Committee on Natural Resources and Energy. The new Vermont state MEPS prohibits the sale of non-complying lamps starting July 1, 2020 and non-complying luminaires starting July 1, 2019. ASAP is working actively with similar legislation in Massachusetts and Rhode Island. New York's Governor Cuomo has also made new energy efficiency standards a priority. ASAP and cosigners propose

that California also adopt the current efficiency requirements in the federal GSFL MEPS for high CRI versions of lamps covered by the federal MEPS. If California adopt MEPS for high CRI linear fluorescent lamps it will realize a double benefit – significant savings for its citizens, and support for closing an important loophole in the federal GSFL MEPS. The shortest path to closing the loophole in the federal GSFL MEPS is for enough states to adopt MEPS for high CRI lamps that manufacturers no longer see an attractive business opportunity for exploitation.

The experience with the loophole in the federal GSFL MEPS underlines the potential for new technology to undermine the effectiveness of standards. ASAP believes that there are benefits to the lighting industry if California follows Vermont's lead and helps to establish a consistent MEPS for high CRI linear fluorescent lamps. However, we have reviewed the draft proposal being prepare by the California investor owned utilities which includes both a more stringent energy efficiency requirement and a broader scope, and we also support the IOU's proposal. The ASAP model bill was designed for consideration by state legislatures, processes which cannot always accommodate the level of technical review possible in a CEC rulemaking. A broader and more ambitious standard for federally exempt linear fluorescent lamps may better protect against future loopholes, and could serve as a basis for future standards in other states.

Thank you for the invitation to comment. We commend the CEC and participants on this collaborative process and look forward to a conclusion by the end of 2018.

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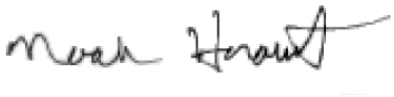

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## End Notes

[1] National Electrical Manufacturers Association. *Linear Fluorescent Lamp Indexes Continue Year-Over-Year Decline in Fourth Quarter 2017 while T-LED Market Penetration Increases*. http://www.nema.org/Intelligence/Indices/Pages/Linear-Fluorescent-Lamp-Indexes-Continue-Year-Over-Year-Decline-in-Fourth-Quarter-2017-while-T-LED-Market-Penetration-Incre.aspx

[2] DOE. *2015 US Lighting Market Characterization*. November 2017. Table 4.1, pg 47.

[3] https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=3

[4] DOE. *Preliminary Technical Document for GSFLs and IRLs, Chapter 9: Shipments Analysis, 2011*. "While new production of T12 lamps appears unlikely under the 2012 lamp efficiency standards, because of their relatively long lifetimes and their large historical market share, they still constitute a significant fraction of the existing lighting stock."

[5] Appliance Standards Awareness Project. *Appliance Standards Questions and Answers: Progress Toward 3 Billion MT $CO_2$ Reduction*, June 2016. https://appliance-standards.org/sites/default/files/Progress_toward_3_billion_CO2_reduction_June_2016_0.pdf

[6] DOE. *Final Rule Technical Support Document Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: General Service Fluorescent Lamps and Incandescent Reflector Lamps. Chapter 14, Emissions Impact Analysis*. December 2014.

[7] NEMA lamp index *(see [1])* http://www.nema.org/Intelligence/Indices/Pages/Linear-Fluorescent-Lamp-Indexes-Continue-Year-Over-Year-Decline-in-Fourth-Quarter-2017-while-T-LED-Market-Penetration-Incre.aspx

[8] Assumes that a new T8 lighting system using Fourth and Fifth Generation T8 lamps (as classified by the Consortium for Energy Efficiency. Such lamps are typically rated at 25-28 watts, and are rated at CRI from 82 to 86, up to 30,000 hours of life, and from 2,285 to 2,650 mean lumens. https://library.cee1.org/sites/default/files/.../Commercial_Lighting_Initiative_0708.pdf).

[9] Cadmus Consulting. *Colorado Lighting Market Study*. for Xcel Energy, January 14, 2016 "As the overwhelming majority of business customers cite cost and lack of capital as significant barriers to making energy-efficiency upgrades, the EISA loophole that allows certain T12 technologies to continue to be sold has limited the changeover to T8s and will likely continue to limit it in the near future."

[10] Cadmus Consulting. *2014 Evaluation, Measurement, and Verification Report*. for Dayton Power and Light, May 12, 2015. Cadmus interviewed 70 businesses across a range of industries and facility sizes who had not participated in a Dayton Power and Light commercial energy efficiency programme to determine the saturation of T12 light fixtures. "When asked what percentage of their fluorescent lighting T12 lamps made up, one-third said almost all lighting and nearly one-half said at least 71%. Twenty-six percent of overall respondents said none of their fluorescent lamps were T12s." (pg 98)

[11] Leigh, Richard et. al. *Benchmarking and Audit Data Inform Building Science*. Proceedings of the 2016 ACEEE Summer Study on Energy Efficiency in Buildings. "The multifamily sector has the largest opportunity to save energy through lighting improvements, with 40 percent of the sector lit by low-efficiency T-12 fluorescent lamps and incandescents. These low-efficiency lamps serve more than half the area of low-rise multifamily buildings." (pg 6)

[12] DNV GL. *T12 Phaseout Market Research Final Report, and Massachusetts C&I Market Characterization On-Site Assessments and Market Share and Sales Trends Study*, October 2014 and November 2016 respectively. Available at http://ma-eeac.org/studies/commercial-and-industrial-studies/. The MA C&I Market Characterization study found that T12 lamps made up 12% of linear technologies in Massachusetts businesses, and were still present in 54% of businesses in 2014, T12 lamp purchases from 2009-2015 represent less than 1% of recent linear lamp purchases.

[13] Northwest Energy Efficiency Alliance. *Annual Lighting Survey of Northwest Electrical Distributors 2015*, September 2016. "LFLs (linear fluorescent lamps) remain the dominant commercial lighting technology, but 2015 continued a steady decline in LFL sales. LFL categories with low efficacies, such as 700 series T8s and four-foot T12s, showed the sharpest decline….".(pg 5)

[14] For details of ASAP analysis, please see “Impacts of a Loophole in the US Fluorescent Lamp Efficiency Standards” by Chris Granda and Joanna Mauer, presented at the 2017 Energy Efficiency in Domestic Appliances conference.

[15] Based on DOE, *2014 National Impacts Analysis and Shipments Analysis for DOE’s Final Rule Analysis for GSFL and IRL (Final Rule)* (Washington, DC: DOE, 2014). www.regulations.gov/document?D=EERE-2011-BT-STD-0006-0062.

DOE, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: General Service Fluorescent Lamps and Incandescent Reflector Lamps* (Washington, DC: DOE, 2014). www.regulations.gov/document?D=EERE-2011-BT-STD-0006-0066.

NEMA, “Linear Fluorescent Lamp Indexes Continue to Decline in the Third Quarter of 2016” (Rosslyn, VA: NEMA, 2017). www.nema.org/news/Pages/Linear-Fluorescent-Lamp-Indexes-Continue-to-Decline-in-the-Third-Quarter-of-2016.aspx.

Xcel Energy, *Lighting Efficiency Input Wattage Guide* (Minneapolis: Xcel Energy, 2004). www.xcelenergy.com/staticfiles/xe/Marketing/Lighting-Wattage-Guide.pdf.

[16] Private communication with Stephen Beard

[17] http://legislature.vermont.gov/bill/status/2018/H.410