CALIFORNIA ENERGY COMMISSION

California Energy Commission

Attachment A

Standardized Regulatory Impact Assessment: Efficiency Standards for General Service Linear Fluorescent Lamps Exempt From Federal Regulation

CALIFORNIA ENERGY COMMISSION

EVERGREEN ECONOMICS

Gavin Newsom, Governor

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ABSTRACT

On April 4, 2018, the California Energy Commission (CEC) released an invitation to submit proposals related to efficiency standards, test procedures, and related items for linear fluorescent lighting not already covered by federal efficiency standards for general service fluorescent lamps (GSFLs) because of their shape or length. The CEC reviewed the information received from respondents to the request for proposals and developed draft proposed regulations for linear fluorescent lamps. Specifically, the CEC proposed an addition to the Appliance Efficiency Regulations that outlines specific test methods and performance standards for certain linear fluorescent lamps that are currently exempt from federal standards.

To further analyze the potential impacts of the proposed standards, the CEC is required to complete a Standardized Regulatory Impact Assessment (SRIA) by the California Department of Finance. The SRIA includes a broader statewide economic impact model based on the estimated household savings that would result from the proposed regulatory standards. The SRIA provides further context for impacts on the regional economy in California, highlighting economic output, employment, and labor income resulting from the improved efficiency of the lamps. The SRIA also includes an analysis of the fiscal impacts from the proposed regulations to California state and local governments.

Evergreen Economics and CEC staff analyzed the economic impacts of the proposed and alternative updates to the performance standards for general service fluorescent lamps.

Keywords: Economic impacts, Standardized Regulatory Impact Assessment, appliance efficiency regulations, energy efficiency, linear fluorescent, fluorescent lamp, T12, T8, tube lamp, impact-resistant fluorescent, high-CRI, CRI, color rendering index, lighting, lamps, general service fluorescent lamps

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EXECUTIVE SUMMARY

In March 2020, the California Energy Commission (CEC) engaged Evergreen Economics (Evergreen) to provide economic analysis services to support Standardized Regulatory Impact Assessments (SRIAs). To further analyze the potential impacts of the proposed standards, the CEC is required to complete a SRIA by the California Department of Finance (DOF). The SRIA includes a broader statewide economic impact model based on the estimated household savings that would result from the proposed regulatory standards. The SRIA provides further context for impacts on the regional economy in California, highlighting economic output, employment, and labor income resulting from the improved efficiency of the lamps.

This report presents the results of the economic impact analysis of proposed new efficiency standards for linear fluorescent lamps that are exempt from federal regulation. Evergreen used Impact Analysis for Planning (IMPLAN) modeling software to estimate the economic impacts that the proposed standards will have on California residences and businesses as they transition to more energy efficient T8 and LED lamps, as well as the economic impacts associated with California-based producers of T8 and LED lamps, electrical contractors that will be necessary to update lighting fixtures to support the higher efficiency T8 and LED lamps, and hazardous waste sector treatment and disposal facilities necessary for the proper disposal of magnetic ballasts. CEC staff used a data analysis tool to estimate fiscal and other economic impacts resulted from the proposed regulations.

The analysis also examined the economic benefits of avoided emissions of carbon dioxide (CO_2), nitrogen oxides (NO_X), particulate matter (PM2.5), and sulfur oxides (SO_X) due to lower electricity demand by T8 and LED lamps, relative to linear fluorescent lamps.

For purposes of the economic impact analysis, it was necessary to develop estimates of how the proposed regulation will affect each specific sector. The proposed regulation will impact residential users of the non-compliant lamps much differently than commercial and industrial users because average annual hours of operation are much lower for the residential sector. In addition, residences will react differently to the regulatory change. Specifically, it is assumed that residences will reduce discretionary spending in the short run as they incur the costs associated with converting fixtures to accept the compliant lamps. Residences are then expected to increase discretionary spending in subsequent years as they enjoy lower energy costs associated with the compliant lamps.

For the commercial and industrial sectors, the analysis expects that the initial outlay associated with converting fixtures for the compliant lamps will not impact spending in other aspects of their business operations. Likewise, the analysis does not anticipate that reduced spending on electricity in subsequent years will result in greater spending on other business activities.

This analysis estimates that the proposed regulatory change will have a positive impact on California Gross State Product (GSP) beginning the first year that regulations are in effect, assumed to be 2022 in this report ($158.9 million), and will grow each year through 2028 before declining—but remaining positive—through 2040.

Figure 1 summarizes estimates of the key economic impacts associated with the proposed regulatory change over the projection period from 2022 to 2040.

Figure 1: Summary of Key Economic Impacts

<table>
<tr><th></th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030 - 2040</th></tr>
<tr><td>Net Impacts to Households</td><td colspan="5">Decrease in discretionary income</td><td>Net impact: zero</td><td colspan="3">Increase in discretionary income (ranging from $11.7 to $74.5 million)</td></tr>
<tr><td>Net Impacts to Businesses</td><td colspan="4">Negative impacts as CA businesses convert non-compliant lamps to compliant T8 or LED lamps</td><td colspan="5">Positive impacts (annual savings to businesses of more than $100 million by 2029)</td></tr>
<tr><td>Economic impacts</td><td colspan="9">Estimated annual spending of $115 million each year to replace non-compliant lamps. Most ($100 million) will be paid to firms located in California. Increase in employment of 262 jobs each year, paying on average $78,000 per year.</td></tr>
<tr><td>Annual electricity savings</td><td colspan="9">1,227 GWh between 2022 and 2040 (less than 1/3 the average annual reduction in total system electric generation in California between 2014 and 2019 (avg. reduction of 3,872 GWh per year).</td></tr>
<tr><td>Total annual benefits of avoided emissions</td><td colspan="8">Benefits grown each year as non-compliant (baseline) lamps are replaced at burnout with compliant T8 or LED lamps. Benefits top out in 2030 at $23 million.</td><td>Benefits slowly decline through remainder of projection period.</td></tr>
</table>

CHAPTER 1: Introduction

In March 2020, the California Energy Commission (CEC) engaged Evergreen Economics (Evergreen) to provide economic analysis services to support Standardized Regulatory Impact Assessments (SRIAs). This report presents the results of the economic impact analysis of proposed new efficiency standards for linear fluorescent lamps that are exempt from federal regulation. The authors used Impact Analysis for Planning (IMPLAN) modeling software to estimate the economic impacts that the proposed standards will have on California residences and businesses as they transition to more energy efficient T8 and LED lamps, as well as the economic impacts associated with California-based producers of T8 and LED lamps, electrical contractors that will be necessary to update lighting fixtures to support the higher efficiency T8 and LED lamps, and hazardous waste sector treatment and disposal facilities necessary for the proper disposal of magnetic ballasts.[1]

The analysis also examined the economic benefits of avoided emissions of carbon dioxide (CO_2), nitrogen oxides (NO_X), particulate matter (PM2.5), and sulfur oxides (SO_X) due to lower electricity demand by T8 and LED lamps, relative to linear fluorescent lamps.

Background on Linear Fluorescent Lamp Standards

The Warren-Alquist Act[2] established the CEC as California's primary energy policy and planning agency. The act mandates that the CEC reduce the wasteful and inefficient consumption of energy and water in the state by prescribing statewide standards for minimum levels of operating efficiency for appliances that consume a significant amount of energy or water. On January 19, 2018, the CEC issued an order instituting rulemaking to consider standards, test procedures, labeling requirements, and other efficiency measures to amend the Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601 through Section 1609).[3] In this order, the CEC identified *high color rendering index linear fluorescent lighting*

1 As a conservative assumption, the CEC assumes that all ballasts are magnetic and contain polychlorinated biphenyls (PCBs), which are a toxic material regulated by the U.S. EPA. In fact, many ballasts are electronic and contain no PCBs. Likewise, magnetic ballasts produced after 1979 were also required to contain no PCBs. Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation, 2019 Appliance Efficiency Rulemaking Docket Number 18-AAER-08, Draft Staff Report, California Energy Commission, June 2019, p.36.

2 The Warren-Alquist State Energy Resources Conservation and Development Act, Division 15 of the Public Resources Code, § 25000 et seq., available at https://ww2.energy.ca.gov/2021publications/CEC-140-2021-001/CEC-140-2021-001.pdf.

3 https://efiling.energy.ca.gov/GetDocument.aspx?tn=222253&DocumentContentId=26676.

as a potential energy saving measure.[4] These unregulated lamps are often used in general lighting applications, resulting in wasted energy consumption.[5]

On April 4, 2018, the CEC released an invitation to submit proposals related to efficiency standards, test procedures, and related items for linear fluorescent lighting not already covered by federal efficiency standards for general service fluorescent lamps (GSFLs) because of their shape or length. The CEC reviewed the information received from respondents to the RFP and developed draft proposed regulations for linear fluorescent lamps. Specifically, the CEC proposed an addition to the Appliance Efficiency Regulations that outlines specific test methods and performance standards for certain linear fluorescent lamps that are currently exempt from federal standards.[6]

Lamps Proposed for Regulatory Action

The CEC proposes to include the following impact-resistant fluorescent lamps and fluorescent lamps with a color rendering index of 87 or greater in this proposed regulation:

- 4-foot lamps with medium bipin bases
- 4-foot lamps with standard output and miniature bipin bases
- 4-foot lamps with high output and miniature bipin bases
- 8-foot lamps with standard output and single pin bases
- 8-foot lamps with high output and recessed double contact bases
- 2-foot U-shaped lamps with medium bipin bases

The CEC also proposes to include the following linear lamps in this proposal:

- 2-foot and 3-foot linear lamps with medium bipin or miniature bipin bases

The CEC estimates this proposal will save 2,895 GWh of electricity per year after the existing stock of lamps is turned over (Appendix D).[7]

To further analyze the potential impacts of the proposed standards, the CEC is required under the Administrative Procedure Act to complete a SRIA consistent with the regulations issued by the California Department of Finance (DOF). The SRIA includes a broader statewide economic impact model based on the estimated household and business savings that would result from the proposed regulatory standards. The SRIA provides further context for impacts on the regional economy in California, highlighting economic output, employment, and labor income resulting from the improved efficiency of the lamps. The SRIA also addresses the fiscal

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4 Ibid.

5 Ibid.

6 Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD.

7 Ibid.

impacts of the regulatory proposal on general and special funds of the state and affected local government agencies.

CHAPTER 2:
Economic Impact Analysis

To estimate the direct market-based economic impacts of the proposed update to the performance standards for general service fluorescent lamps (GSFLs), the authors used IMPLAN (Impact Analysis for Planning) v3.1 modeling software. IMPLAN is an input-output model used to estimate the economic effects of proposed policies and projects and is the most commonly used economic impact modeling approach due to its ease of use and extensive detailed information on output, employment, and wages. Please see the appendix section of this report for more information on the economic impact analysis in general and the IMPLAN model in particular.

Throughout this report, all monetary estimates are presented in 2020 dollars. In its November 2020 forecast, the California Department of Finance (DOF) projects that general price inflation (as measured by the California All Urban Consumer Price Index) will average three percent through 2021 and 2022. While this rate is significantly higher than California experienced in 2020 (1.7 percent), it is slightly lower than California experienced from 2016 through 2019.

DOF completed a more current economic forecast in January 2022 with the Governor's Budget for fiscal year 2022-23 and revised upwards its estimates for inflation in the 2021-2025 timeframe. DOF's Finance Bulletin of December 2021 shows national inflation rose 6.9% from November 2020 to November 2021, while California inflation rose 5.6% between October 2022 and October 2021.[8] The Governor's Budget forecast for the category of Fuels and Utilities shows a 2021 inflation rate of 6.9%, but then declines to 2.8% by 2024 which is the estimated effective date of the proposed regulations.[9]

It is noted that the higher rate of inflation between the November 2020 and January 2022 DOF economic forecasts is a negligible difference over the period of impacts expected to result from implementation of proposed standards, which begin in 2024 (i.e., 3.0% versus 2.8%). The sectors categorized as Home Furnishings and Operations, as well as Other Goods and Services show smaller DOF forecasts for inflation compared to Fuels and Utilities. We conclude that consumer utility bill savings will equal or exceed values estimated in this report, given the more current DOF economic forecast for inflation.

8 See Department of Finance Bulletin at https://www.dof.ca.gov/Forecasting/Economics/Economic_and_Revenue_Updates/documents/2021/DEC_2021_FB.pdf

9 See the DOF Governor's Budget 2022-23 inflation forecast at https://www.dof.ca.gov/Forecasting/Economics/Eco_Forecasts_Us_Ca/

Comparative Analysis Between the Baseline and the Proposed Regulatory Change

The economic impact analysis was conducted as a comparative analysis between the "non-compliant" lamps and alternative "compliant" lamps that meet proposed standards by CEC staff. CEC staff proposes minimum energy efficiency standards for state-regulated GSFLs that are aligned with federal standards for GSFLs. For state-regulated linear lamps less than 4-foot, CEC staff proposes a minimum efficiency standard of 115 lumen per watt.

For the economic impact analysis, the baseline is defined as the energy consumed in the absence of the proposed regulation. CEC staff developed the baseline for energy consumption, costs, and other attributes through market analysis of the lamps currently available on the market and the information supplied by the stakeholders through written comments to the CEC. The economic impact analysis estimates the economic effects associated with California residences and businesses moving from the baseline to the alternative. It is an economic comparison between the current baseline where the non-compliant lamps are available for purchase in California and the alternative where the non-compliant lamps are not available for purchase.

The remainder of this section defines the key characteristics of the non-compliant lamps that comprise the baseline and the compliant lamps that comprise the alternative. Following the approach used in the CEC staff report, the analysis segments the non-compliant lamps into six categories based on size and light output (standard versus high). Likewise, the analysis takes as given that the alternative, compliant lamps defined in the CEC staff report do represent the actual alternative lamps that California residences and businesses would use to replace (at burnout) their non-compliant lamps.

Key characteristics of the baseline and alternative lamps include per-lamp purchase price, energy consumption, hours of operation, and design life. The analysis takes as given that the values for the non-compliant and compliant lamps presented in the CEC staff report represent the actual value (or best estimate) of each key characteristic. Differences in the key characteristics between lamps in the baseline and comparison groups have economic implications, which are captured in the analysis to estimate the economic impacts associated with the proposed regulatory change.

Key Assumptions and Inputs for Estimating Economic Impacts Associated with the Proposed Regulatory Change

The proposed update to the performance standard for GSFLs will result in substantial up-front costs for residences and businesses as the non-compliant lamps representing the baseline are replaced with compliant alternatives that are more expensive, require a replacement ballast (when the replacement lamp is a T8), are assumed to require the services of an electrical contractor, and will require the proper disposal of the removed ballast, which CEC staff assumes to contain toxic materials. Table 1 shows CEC estimates of the cost of non-compliant and compliant lamps, the per-lamp cost of replacement ballasts, the per-lamp labor cost of replacing a non-compliant lamp, and the per-lamp cost of disposal of the removed ballasts.

CEC staff estimated the power consumption, costs, and other attributes of compliant lamps through market analysis of the lamps that meet the proposed standards and are currently available on the market, as well as the information supplied by the stakeholders through written comments.

Table 1: Estimated Costs for Non-Compliant (Baseline) and Compliant Lamps, Replacement Ballasts, Labor for Electrical Contractor, and Ballast Disposal

Lamp Types	Non-Compliant Lamp	Compliant T8 Lamp	Compliant LED Lamp	New Ballast	Labor Cost per Lamp	Ballast Disposal Cost per Lamp
4-foot T12	$2.36	$1.80	$9.00	$4.30	$30.15	$1.25
8-foot Stand. Out T12	$4.40	$9.70	$24.20	$8.15	$35.38	$2.50
8-foot High Out T12	$5.90	$8.80	NA	$28.45	$35.38	$5.00
Less than 4-foot T12	$4.40	NA	$8.70	NA	$30.15	$1.25
Less than 4-foot T8	$2.10	NA	$8.70	NA	$30.15	$1.25
Less than 4-foot T5	$3.10	NA	$8.70	NA	$30.15	$1.25

The analysis in the CEC staff report[10] used an average annual energy use per non-compliant and compliant lamp in order to develop per-lamp estimates of expected annual energy savings associated with converting (on burn-out) non-compliant lamps to compliant lamps. Table 2 shows the estimates of average annual energy use per lamp for non-compliant and compliant lamps, and the per-lamp savings associated with the regulatory change.

There is substantial variability in the design life among the non-compliant lamps that comprise the baseline and compliant lamps (see Table 3).[11] For example, the CEC staff report states that the design life of a non-compliant 4-foot standard output T12 lamp is 8 years, while the design life of compliant fluorescent and LED replacement lamps are 12 years and 19 years, respectively. As Table 3 shows, the design life of all compliant LED lamps is 19 years. This economic impact analysis is based on the maximum design life of the replacement lamps (19 years).

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10 Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD.

11 Ibid.

Table 2: Average Annual Energy Use and Average Annual Energy Savings Per Lamp

Non-Compliant (Baseline) Lamp Types	Baseline Energy Use (kWh/year)	Compliant T8 Energy Use (kWh/year)	Compliant LED Energy Use (kWh/year)	Compliant T8 Energy Savings (kWh/year)	Compliant LED Energy Savings (kWh/year)
4-foot T12	121.8	76.4	38.9	45.4	82.9
8-foot Stand. Out T12	224.2	141.2	93.3	83.0	130.9
8-foot High Out T12	333.0	207.3	NA	125.7	NA
Less than 4-foot T12	72.6	NA	23.3	NA	49.3
Less than 4-foot T8	42.8	NA	23.3	NA	19.5
Less than 4-foot T5	44.1	NA	23.3	NA	20.8

Source: Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD. Table A-2

Table 3: Estimated Design Life of Non-Compliant and Compliant Lamps, in Years

Non-Compliant (Baseline) Lamp Types	Design Life of Non-Compliant Lamps	Compliant T8 Design Life	Compliant LED Design Life
4-foot T12	8	12	19
8-foot Stand. Out T12	5	9	18
8-foot High Out T12	5	8	NA
Less than 4-foot T12	3	NA	19
Less than 4-foot T8	10	NA	19
Less than 4-foot T5	11	NA	19

Source: Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD. Table A-2.

The economic impact analysis assumes that the proposed regulatory change would become effective January 1, 2022, and that non-compliant lamps comprising the baseline will no longer be available to California residences and businesses. However, CEC staff recognizes there will be a delay in the expected adoption date for proposed regulations, which is now projected to be in late 2022. The minimum timeframe to be covered in this report is the period between 2022 and 2024 (one year after the full implementation date). This delay in the adoption date is not expected to have a significant impact on results of the economic and fiscal impact analyses of the proposed regulations. Authors have no new information on changes in fluorescent lamp manufacturing costs, but expect there could be an increase in costs consistent with the national inflation rate for goods and services, resulting in higher initial incremental costs to consumers. Authors recognize that average annual electricity rates across all sectors in California has also risen over the last two years. Authors expect the value of energy saved will be equal to or higher than the increase in manufacturing costs, which leads to the same payback period or better for purchases of the higher efficiency GSFLs by businesses and individuals. Therefore, the expected impact of recent changes in the rate of inflation does not change the conclusions of this report.

This analysis assumes that all non-compliant lamps would be replaced on burnout with an alternative compliant lamp, which is assumed to occur evenly over the design life of each lamp.[12] The analysis therefore assumes that within 11 years, all six types of non-compliant lamps comprising the baseline installed in residences and businesses will have been replaced with compliant lamps.

Table 4 shows the stock of the six non-compliant lamps estimated by the CEC to be installed in California residences and businesses. To estimate the stock of 4-foot and 8-foot T12 lamps, CEC staff used the estimated inventory of lamps from 2010 and 2015 U.S. Department of Energy (DOE) Lighting Market Characterization (LMC) reports. CEC used the lamps' average lifetimes to extrapolate the stock and annual sales growth rates and project the national stock levels and annual sales of the 4-foot and 8-foot T12 lamps. To estimate California's stock levels and shipments, a simple scaling of 12.09 percent was used. This scaling percentage reflects the ratio of California's population over the entire United States population and was applied to the estimated national stock levels and shipments. CEC assumed that 85 percent of 8-foot lamps are standard output and 15 percent are high output.

An approach similar to the one used for state-regulated GSFLs was applied to estimate California's statewide stock and annual sales for the less than 4-foot T12, T8, and T5 linear fluorescent lamps. Because the DOE LMC reports the inventory of T5 lamps as an aggregate for all lamp lengths, CEC staff analyzed available T5 retail models and assumed that the number of available models for a particular lamp's length correlates with its market share. Using that approach, CEC estimates that about half of T5 lamps are less than 4-foot.

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12 For example, for a non-compliant 4-foot T12, one-eighth (12.5%) of the lamps will fail each year.

Table 4: Projected Stock of Non-Compliant (Baseline) Lamps in California in Thousands

Year	4-foot T12	8-foot Stand. Out T12	8-foot High Out T12	Less than 4-foot T12	Less than 4-foot T8	Less than 4-foot T5
2021	41,887	1,793	316	64	3,227	10,259
2022	38,970	1,476	260	47	3,348	10,580
2023	36,256	1,215	214	35	3,473	10,910
2024	33,372	1,000	176	26	3,603	11,251
2025	31,382	823	145	19	3,737	11,603
2026	29,197	677	120	14	3,877	11,965
2027	27,164	557	98	10	4,022	12,339
2028	25,272	459	81	8	4,172	12,724
2029	23,512	378	67	6	4,328	13,122
2030	21,875	311	55	4	4,490	13,532
2031	20,351	256	45	3	4,658	13,955

As shown in Table 4, the CEC assumes that, even without the proposed regulatory change, the stock of four of the six lamp types will decline over the next 10 years (e.g., 4-foot T12s), while for the other two lamp types, the stock is projected to increase.

While the CEC staff report included estimates of the number of each of the six GSFLs currently installed in California and projected the number of installed lamps each year through 2031, it did not indicate where the lamps are installed. To allocate those lamps by sector—residential, commercial, and industrial—this analysis relied on the 2015 U.S. DOE LMC report published by the U.S. Department of Energy.[13] This lighting characterization study provides estimates of the installed stock and energy use of all general illumination lighting products operating in the U.S.[14]

Table 5 shows the distribution of each of the six GSFLs by sector, which, though based on national data, they are assumed to also be representative for California. CEC staff could not

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13 U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. 2017. *2015 U.S. Lighting Market Characterization*. https://www.energy.gov/eere/ssl/2015-us-lighting-market-characterization.

14 Ibid.

find sources of information on the concentrations or numbers of impacted GSFLs sold annually within each of these three broad sectors of the California economy. However, the CEC does not expect any differential impacts to specific categories of individuals or businesses. The only categories of businesses that will have a relatively small impact is electrical contractors and hazardous waste disposal for replacement of certain types of lamp fixtures (see Chapter 3).

Table 5: Distribution of the Six GSFLs by Sector*

Sector	4-foot T12	8-foot T12 Stand. Out	8-foot T12 High Out	Less than 4-foot T12	Less than 4-foot T8	Less than 4-foot T5
Residential	48%	38%	38%	51%	5%	13%
Commercial	50%	44%	44%	47%	93%	66%
Industrial	2%	18%	18%	2%	2%	22%

*Total may not sum to 100% due to rounding

Table 6 shows the cost of electricity per kWh assumed by the CEC, which was also used in the economic impact analysis.[15] Residential and commercial electricity rates have increased in California since completion of the CEC 2019 staff analysis. The U.S. Energy Information Administration (EIA) estimated that California average residential electricity rates increased 10.7% between September 2020 and 2021. Commercial aver[16] These EIA figures for rising electricity costs are consistent with the Pacific Gas and Electric Company (PG&E) recent general rate[17] The recent increases in electricity rates appear to be equal or exceeding inflation rates for GSFLs impacted by proposed standards, therefore, the economic impacts described in this report are conservative lower bounds on the cost-effectiveness of proposed energy efficiency standards.

15 Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD.

16 See the U.S. Energy Information Administration at https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

17 See PG&E 2023 general rate case application of June 30, 2021 at https://www.pge.com/pge_global/common/pdfs/about-pge/company-information/regulation/general-rate-case/PGE-GRC-Application-2023.pdf

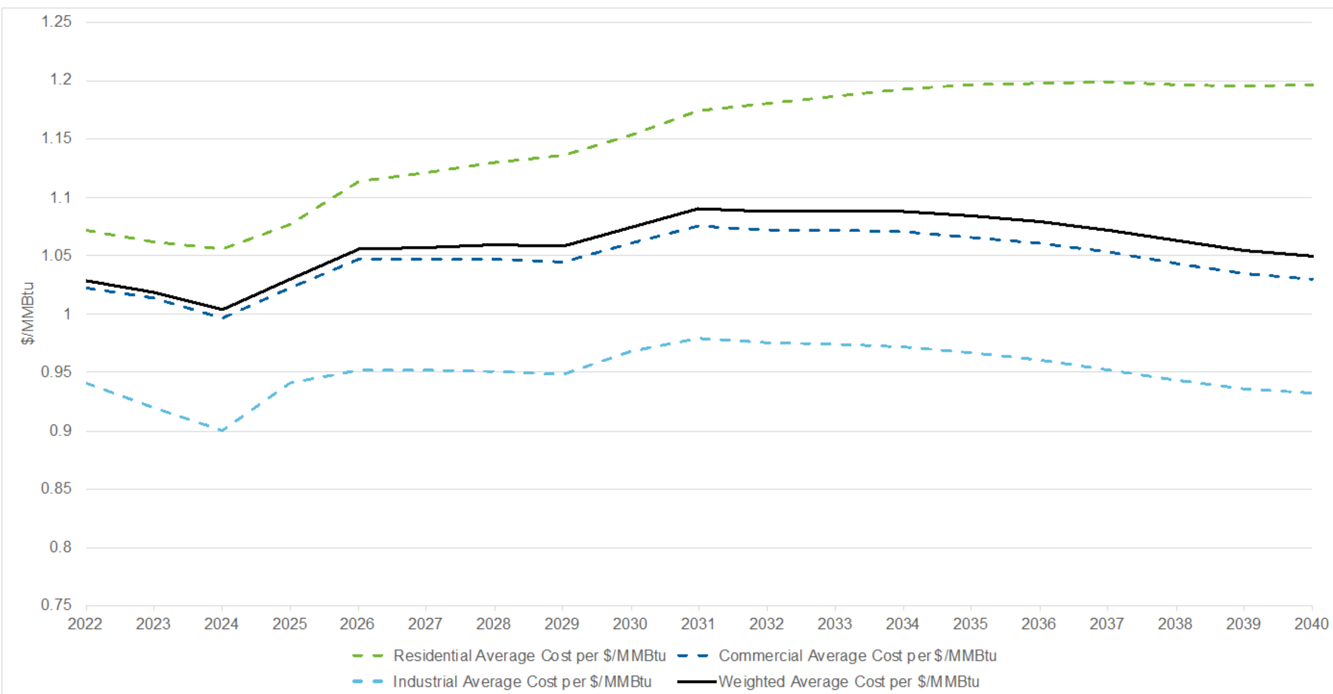
Table 6: Average Cost Per kWh Assumed in CEC Analysis, 2020 Dollars

Description	Assumed Value
Average Residential Electricity Rate in California per kWh (not discounted)	$0.1832
Average Commercial Electricity Rate in California per kWh (not discounted)	$0.1490
Average Industrial Electricity Rate in California per kWh (not discounted)	$0.1143

Source: Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD. Table A-3.

Figure 2 shows the projected average cost of electricity per million metric British thermal units (MMBtu)[18] for the residential, commercial, and industrial sectors for the years 2022 through 2040 for the Pacific region.[19] Using this data, the weighted average cost per MMBtu that would be saved through the proposed regulatory change can be estimated (also shown in Figure 2).

Figure 2: Forecasted Electricity Rates - 2022 through 2040



Source: U.S. Energy Information Administration (Oct 2020). https://www.eia.gov/outlooks/aeo/

18 1 MMBtu is equal to approximately 293 kWh.

19 U.S. Energy Information Administration (Oct 2020). https://www.eia.gov/outlooks/aeo/.

The overall change in price each year for electricity is trivial, and material impacts on the economic impacts estimated in this analysis on the proposed regulation are not expected.

The purpose of the IMPLAN model is to represent a specific economic area, such as a county, group of counties, or a state. The IMPLAN model for this analysis represents the state of California and accounts for average household expenditures, the value of goods and services that flow between industrial sectors, the value of goods and services produced “domestically” (i.e., within California), and the value of goods and services “imported” into California. Based on the IMPLAN model’s representation of the California economy, the analysis assumes the following:

- 93.1 percent of expenditures for residential electrical services will be met by California-based electrical contractors.[20]
- 93.2 percent of expenditures for commercial and industrial electrical services will be met by California-based electrical contractors.[21]
- 99.9 percent of expenditures for disposing of replaced ballasts will be met by California-based hazardous waste disposal services.[22]
- 26.6 percent of expenditures for compliant lamps will be met by California-based manufacturers.[23]

20 IMPLAN v3.1 modeling software, state-level local purchasing percentage for California. The analysis in this report took this value as given and conducted no additional investigation or sensitivity analysis. www.implan.com.

21 Ibid.

22 Ibid.

23 Ibid.

CHAPTER 3: Key Findings

The CEC conducted its analysis of the cost effectiveness, technical feasibility, and statewide energy savings associated with the proposed regulatory change based on *average* usage of the six general service fluorescent lamp (GSFL) types across residential, commercial, and industrial applications. While hours of lighting operation vary considerably between the three sectors, aggregating all users (regardless of sector) is sufficient for understanding the overall energy and fiscal impacts of the proposed regulation, which was the purpose of the CEC analysis.

For purposes of the economic impact analysis, it was necessary to develop sector-specific estimates of how the proposed regulation will affect each sector. The proposed regulation will impact residential users of the non-compliant lamps much differently than commercial and industrial users because average annual hours of operation are much lower for the residential sector. In addition, residences will react differently to the regulatory change. Specifically, the analysis assumes that residences will reduce discretionary spending in the short run as they incur the costs associated with converting fixtures to accept the compliant lamps. Residences are expected to increase discretionary spending in subsequent years as they enjoy lower energy costs associated with the compliant lamps.

For the commercial and industrial sectors, the authors do not expect that the initial outlay associated with converting fixtures for the compliant lamps will impact spending in other aspects of their business operations. Likewise, the authors do not anticipate that reduced spending on electricity in subsequent years will result in greater spending on other business activities. Manufacturers of the lamps are assumed to pass all of the higher incremental cost of producing compliant products along to consumers. These incremental costs are identified in Table 1 in Chapter 2. It is recognized the vast majority of manufacturers of GSFLs are in other states or other countries. Assuming full cost pass through to consumers in California is the most conservative approach to assessing the cost-effectiveness of the proposed regulations. Note that the higher initial cost to businesses that use these state-regulated GSFLs in their buildings are expected to be retained within those businesses, as they will recoup those initial incremental costs through lower electricity bills.

The proposed regulations do not require special markings beyond general marking requirements that includes the manufacturer's name, product model number, and date of manufacture. Since linear fluorescent lamps typically contain these general markings, there is no new change in behavior of manufacturers related to marking content requirements. The proposed regulations require the use of federal test procedures for covered products. While lamp types covered in the scope of the proposed regulations may have had no testing by manufacturers, the new cost of testing requirements for them is expected to be insignificant, as manufacturers are required to only test a few samples of each basic model of lamp per test procedure. Recognizing that manufacturers produce a very large number of each basic model type, the incremental cost of testing per lamp is de minimis.

The analysis estimated the direct impact of the proposed regulation separately for residences, commercial businesses, and industrial businesses. As mentioned above, it is assumed that the proposed regulation will have negative short-term and positive longer-term impacts on discretionary spending by residences but will not impact spending or investment decisions by commercial or industrial businesses. In effect, for businesses, the cost of compliance is expected to be regarded as a cost of operations and maintenance and will not affect spending in other areas in a positive or negative way.

The analysis estimated the economic impacts associated with the proposed regulatory change that will affect the following sectors:

- California Residences
- Residential/Commercial/Industrial Electrical Contractors
- Hazardous Waste Treatment and Disposal Facilities
- Lamp and Ballast Manufacturing

The analysis begins with a summary of state-level impacts on Gross State Product (GSP), employment, and expectations regarding potential impacts on business creation or elimination in California. Then the results for residences, electrical contractors, hazardous waste treatment and disposal facilities, and lamp and ballast manufacturers located in California that would be affected by the rule change are provided separately.

Total Statewide Impacts

California Gross State Product

The proposed regulatory change will result in California residences and businesses converting non-compliant lamps on burnout to compliant T8s and LEDs. Doing so will require purchasing compliant lamps and potentially ballasts if the compliant lamp is fluorescent, hiring electrical contractors to convert fixtures to accept the compliant lamps, and properly disposing of removed ballasts.[24] All these activities involve market activities that will have stimulative impacts on the California economy.

Installation of the compliant lamps will result in substantial reductions in electricity use by California residences and businesses. For California households, the analysis assumes the cost of switching lighting fixtures to accommodate the compliant lamps will result in reduced discretionary spending at the onset and then money saved from lower electric bills will result in increased discretionary spending on goods and services. For California businesses, it is not anticipated that the costs of switching lighting fixtures to accommodate compliant lamps will

24 For simplicity, the CEC assumes all ballasts removed from non-compliant lamps contain mercury that requires special handling and disposal.

reduce spending in other areas. Likewise, it is not anticipated that money saved through lower utility costs for lighting will result in increased spending.

Most of the direct and indirect spending associated with the proposed regulatory change will occur locally in California, but some will be for goods and services purchased from out of state. Local spending will result in a relatively small increase in economic activity in California, which is measured in the value of economic activity generated (as measured by GSP), jobs created, and wages paid.

Table 7 shows the estimates of the impacts that the proposed regulatory change will have on California's GSP over the 19-year period beginning in 2022. The overall impact to GSP is positive beginning in 2022 ($158.9 million) and will grow each year through 2028 before declining—but remaining positive—through 2040. For California residents, changes in discretionary income associated with switching to the compliant lamps will result in reduced economic activity (as measured by GSP) through 2026, but will become positive in the following year and will grow rapidly as the cumulative benefits of the higher efficiency lamps grow and all non-compliant lamps are replaced. Based on market analysis of current lamps on the market and the data received from stakeholders' written comments, the CEC assumes that the majority of non-compliant lamps will burnout within eight years and be replaced but some non-compliant lamps can last up to eleven years.

Table 7: Estimated Impacts on California GSP from Proposed Change in Performance Standards of Linear Fluorescent Lighting, 2020 Dollars

Year	GSP Impacts from Change in Discretionary Spending by Residents	GSP Impacts from Increased Spending on Electrical Contractors	GSP Impacts from Increased Spending on Hazardous Waste Disposal	GSP Impacts from Increased Demand for Lamps and Ballasts	Total GSP Impacts Associated with Proposed Regulation
2022	($49,768,350)	$194,966,279	$8,656,754	$5,052,780	$158,907,463
2023	($45,244,226)	$210,326,646	$9,501,191	$7,554,628	$182,138,239
2024	($30,133,749)	$204,171,531	$9,375,871	$8,468,416	$191,882,069
2025	($38,453,145)	$255,246,723	$11,720,770	$13,391,893	$241,906,242
2026	($11,259,773)	$233,596,758	$10,319,043	$11,421,938	$244,077,966
2027	$1,141,461	$243,610,059	$10,825,705	$13,234,920	$268,812,145
2028	$17,413,799	$246,864,080	$10,788,175	$13,892,042	$288,958,095
2029	$90,976,170	$112,974,128	$4,957,017	$3,307,014	$212,214,329
2030	$93,035,461	$119,598,777	$5,245,533	$4,283,092	$222,162,862
2031	$111,164,562	$66,766,526	$2,944,589	($161,757)	$180,713,920
2032	$102,950,992	$49,638,543	$2,187,645	($1,626,863)	$153,150,317
2033	$101,463,757	$0	$0	($6,229,011)	$95,234,746
2034	$93,182,295	$0	$0	($6,096,570)	$87,085,725
2035	$85,526,583	$0	$0	($5,985,702)	$79,540,881
2036	$78,449,385	$0	$0	($5,894,847)	$72,554,538
2037	$71,907,575	$0	$0	($5,822,638)	$66,084,937
2038	$65,861,706	$0	$0	($5,767,869)	$60,093,837
2039	$60,275,642	$0	$0	($5,729,479)	$54,546,163
2040	$55,116,228	$0	$0	($5,706,532)	$49,409,696

California Employment

Table 8 shows estimated statewide impacts on employment from the proposed regulatory change. As with GSP, the impact on jobs is immediately positive and grows each year. When considering the estimated changes in employment, it is important to remember that the additional economic activity will occur statewide and, therefore, the impacts will be spread across many businesses. The effect on the vast majority of businesses will be small and will result in little or no adjustment in employment levels. However, some businesses will need to adjust hours worked for some employees, and other businesses may find it necessary to hire additional workers. The California economy is enormous and, even with the impact of the COVID-19 pandemic, there were more than 16.5 million people employed in California as of August 2020. The estimated job impacts from this analysis—even once all the job impacts are realized—represent an infinitesimal portion of the state's employment.

Table 8: Estimated Impacts on California Employment from Proposed Change in Performance Standards of Linear Fluorescent Lighting

Year	Job Impacts Due to Change in Discretionary Spending by Residents	Job Impacts Due to Increased Spending on Electrical Contractors	Job Impacts Due to Increased Spending on Hazardous Waste Disposal	Job Impacts Due to Increased Demand for Lamps and Ballasts	Total Job Impacts Associated with Proposed Regulation
2022	(300)	1,108	42	21	871
2023	(273)	1,195	47	31	1,000
2024	(182)	1,160	46	35	1,059
2025	(232)	1,450	57	55	1,330
2026	(68)	1,327	51	47	1,357
2027	7	1,384	53	54	1,498
2028	105	1,402	53	57	1,617
2029	549	642	24	14	1,229
2030	561	680	26	18	1,285
2031	671	380	14	(1)	1,064
2032	621	282	11	(7)	907
2033	612	0	0	(25)	587
2034	562	0	0	(25)	537
2035	516	0	0	(24)	492

2036	473	0	0	(24)	449
2037	434	0	0	(24)	410
2038	397	0	0	(24)	373
2039	364	0	0	(23)	341
2040	332	0	0	(23)	309

Source: Analysis by Evergreen of data from the CEC and other sources.

Increased Investment by California Businesses

The proposed regulatory change affecting the identified linear lamps will likely result in a modest change in investment by California businesses in capital stock expansion.[25] The IMPLAN model does not provide estimates of business investment; instead, it analyzed data from the Bureau of Economic Analysis (BEA) on net private domestic investment (hereafter referred to as "net capital investment"), which is a measure of the total amount of investment in capital by businesses that is actually used to expand capital stock. This analysis analyzed data on net investment over the seven-year period from 2013 through 2019 (data for 2020 are not yet available), which was compared to U.S. gross domestic product (GDP) over that same period. It found that net capital investment as a percentage of GDP ranged from a low of 2.5 percent to a high of 3.3 percent, and the average over the period was 3.0 percent. In other words, on average, about 3.0 percent of GDP is invested in capital stock to expand production. The analysis assumed this rate was the same for California businesses and that it would remain at this level over the next 19 years. Table 9 shows estimates of annual change in capital investment.

[25] For purposes of estimating the impacts that the proposed regulatory change would have on investment by California businesses, the analysis focuses on investment that expands capital stock and exclude investment by businesses to maintain or replace existing capital stock.

Table 9: Estimated Impacts on Net Capital Investment by California Businesses Due to Proposed Regulatory Change Affecting Linear Fluorescent Lighting, 2020 Dollars

Year	Business Investment Due to Change in Discretionary Spending by Residents	Business Investment Due to Increased Spending on Electrical Contractors	Business Investment Due to Increased Spending on Hazardous Waste Disposal	Business Investment Due to Increased Demand for Lamps and Ballasts	Estimated Business Investment Due to Proposed Regulation
2022	($1,493,051)	$5,848,988	$259,703	$151,583	$4,767,224
2023	($1,357,327)	$6,309,799	$285,036	$226,639	$5,464,147
2024	($904,012)	$6,125,146	$281,276	$254,052	$5,756,462
2025	($1,153,594)	$7,657,402	$351,623	$401,757	$7,257,187
2026	($337,793)	$7,007,903	$309,571	$342,658	$7,322,339
2027	$34,244	$7,308,302	$324,771	$397,048	$8,064,364
2028	$522,414	$7,405,922	$323,645	$416,761	$8,668,743
2029	$2,729,285	$3,389,224	$148,711	$99,210	$6,366,430
2030	$2,791,064	$3,587,963	$157,366	$128,493	$6,664,886
2031	$3,334,937	$2,002,996	$88,338	$0	$5,426,270
2032	$3,088,530	$1,489,156	$65,629	$0	$4,643,315
2033	$3,043,913	$0	$0	$0	$3,043,913
2034	$2,795,469	$0	$0	$0	$2,795,469
2035	$2,565,797	$0	$0	$0	$2,565,797
2036	$2,353,482	$0	$0	$0	$2,353,482
2037	$2,157,227	$0	$0	$0	$2,157,227
2038	$1,975,851	$0	$0	$0	$1,975,851
2039	$1,808,269	$0	$0	$0	$1,808,269
2040	$1,653,487	$0	$0	$0	$1,653,487

Source: Analysis by Evergreen of data from the CEC and other sources.

Businesses that do experience increased economic activity due to the proposed regulatory change and respond by investing in capital stock expansion will likely do so in a single year or incrementally over multiple years. To more clearly show the magnitude of net capital investment projected to occur over the 19-year period, the present value of future investment is computed (shown in Table 9) using a 3 percent real rate of return. For context, we also computed the present value of the annual GSP forecast.

It is estimated that the proposed regulatory change will lead to an increase in GSP and net capital investment in California of $2.8 billion and $84.8 million, respectively, in 2020 dollars (see Table 10). This level of net capital investment—which will occur over many years—represents only 0.0027 percent of the value of California's GSP for 2019.

Table 10: Present Value of Future Impacts in California GSP and Net Capital Investment by California Businesses

Description	Results
Present value (in 2020 dollars) of changes in California GSP for years 2022 through 2040, discounted by a real rate of return of 3 percent.	$2.8 billion
Ratio of present value of change in GSP to California's GSP for 2019. *	0.0900%
Present value (in 2020 dollars) of net capital investment by California businesses, discounted by a real rate of return of 3 percent.	$84.8 million
Ratio of present value of net capital investment to California's GSP for 2019. *	0.0027%

*According to data published by the U.S. Bureau of Economic Analysis, California's GSP in 2019 was $3.14 trillion

Creation of New Businesses or Elimination of Existing Businesses Within the State

The authors do not foresee any new businesses being created, nor will any be eliminated due to the proposed regulation. This is especially given most of the lighting products subject to the proposed standards are not manufactured in California.

Costs and Benefits to Residents in California from Reduced Spending on Electricity

The increase in the energy efficiency of compliant lamps purchased by California residents will lead to lower electric bills and provide a de facto increase in their discretionary income.[26] Evergreen and CEC Staff examined how money saved by California residents due to the regulatory change will likely result in additional economic activity in California through increased household spending. In conducting this analysis and to simplify, it is assumed that residents within each household income category will purchase, on average, the distribution of

[26] Household discretionary income is the income remaining after taxes, Social Security and other deductions, and mandatory expenses, which realistically includes some minimal amounts of spending on energy, available to be saved or spent on goods and services.

goods and services developed by IMPLAN based on data from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS) Consumer Expenditure (CE) Survey.[27]

Households were segmented into nine income categories to account for income-based differences in household consumption patterns,[28] including differences in the proportion of goods and services purchased in California versus from outside the state. Overall, about 84 percent of household purchases are local (in California), with the remainder consisting of online, subscription, or other purchases from sources outside California, as well as travel outside the state.

Table 11 shows expected savings to California residents associated with the proposed regulatory change. In the first year (2022), the net impact on households is a decrease in discretionary income of $33.4 million ($0.82 per California resident), and the net impact each year through 2026 is also negative. In 2027, the net impact is effectively zero, but in each subsequent year there is a positive increase in discretionary income ranging from a low of $11.7 million to a high of $74.5 million.

[27] In reality, it is likely that additional household expenditures would look different than average household spending. In addition, households may save some of the money, but this analysis does not speculate on savings rates, and instead assume the additional money is spent.

[28] This analysis do not foresee any impact on household income per se. Rather, households will enjoy net savings from this update to the performance standard that can be used for other purchases.

Table 11: Estimated Annual Change in Discretionary Income for California Residents, 2020 Dollars*

a.	b.	c.	d.	e.
Year	Value of Electricity Savings	Cost of Lamp Replacement	Net Change in Discretionary Income (b – c)	Net Change in Discretionary Income per Resident**
2022	$7,871,691	$41,227,935	($33,356,244)	($0.82)
2023	$16,916,273	$47,240,313	($30,324,040)	($0.74)
2024	$25,806,972	$46,003,516	($20,196,544)	($0.49)
2025	$38,275,953	$64,048,407	($25,772,454)	($0.63)
2026	$49,767,294	$57,313,932	($7,546,638)	($0.18)
2027	$62,232,288	$61,467,246	$765,041	$0.02
2028	$74,976,468	$63,305,216	$11,671,251	$0.28
2029	$78,392,045	$17,417,082	$60,974,964	$1.45
2030	$82,461,725	$20,106,562	$62,355,162	$1.48
2031	$76,320,164	$1,814,333	$74,505,831	$1.75
2032	$70,425,730	$1,424,881	$69,000,849	$1.62
2033	$64,869,142	($3,134,918)	$68,004,060	$1.59
2034	$59,486,137	($2,967,438)	$62,453,575	$1.45
2035	$54,507,593	($2,814,894)	$57,322,487	$1.33
2036	$49,903,087	($2,676,048)	$52,579,136	$1.21
2037	$45,644,817	($2,549,801)	$48,194,618	$1.11
2038	$41,707,329	($2,435,166)	$44,142,495	$1.01
2039	$38,067,287	($2,331,259)	$40,398,547	$0.92
2040	$34,703,265	($2,237,288)	$36,940,553	$0.84

Source: Analysis by Evergreen of data from the CEC and other sources.

*Positive represents benefit; negative represents cost.

**Computed as column *d* divided by the population forecast from the California Dept. of Finance, January 2020, http://www.dof.ca.gov/Forecasting/Demographics/projections/

Table 12 shows the estimates of the economic impacts likely to occur in California as households spend the money saved through reduced spending on electricity for lighting. The economic impacts shown in Table 12 account for the incremental cost of switching to the compliant lamps, which will reduce discretionary income, as well as the benefits associated with reduced spending on electricity for lighting. It is assumed that the annual net change (either negative or positive) will directly impact spending on other goods and services. Approximately 84 percent of this spending will occur in California, and it is only this local spending that is considered in the analysis.

Table 12: Estimated Economic Impacts to California from Additional Household Spending by California Residents, 2020 Dollars

Year*	Spending by CA Households	Changes in Employment**	Changes in Labor Income	Changes in Economic Output
2022	($33,356,244)	(300)	($17,112,954)	($49,768,350)
2023	($30,324,040)	(273)	($15,557,324)	($45,244,226)
2024	($20,196,544)	(182)	($10,361,554)	($30,133,749)
2025	($25,772,454)	(232)	($13,222,197)	($38,453,145)
2026	($7,546,638)	(68)	($3,871,697)	($11,259,773)
2027	$765,041	7	$392,494	$1,141,461
2028	$11,671,251	105	$5,987,772	$17,413,799
2029	$60,974,964	549	$31,282,352	$90,976,170
2030	$62,355,162	561	$31,990,443	$93,035,461
2031	$74,505,831	671	$38,224,173	$111,164,562
2032	$69,000,849	621	$35,399,920	$102,950,992
2033	$68,004,060	612	$34,888,531	$101,463,757
2034	$62,453,575	562	$32,040,932	$93,182,295
2035	$57,322,487	516	$29,408,499	$85,526,583
2036	$52,579,136	473	$26,974,990	$78,449,385
2037	$48,194,618	434	$24,725,574	$71,907,575
2038	$44,142,495	397	$22,646,689	$65,861,706
2039	$40,398,547	364	$20,725,909	$60,275,642
2040	$36,940,553	332	$18,951,833	$55,116,228

Source: Analysis by Evergreen of data from the CEC and other sources.

*Assumes full year impacts

**The additional spending will occur statewide, and its effects will be modest. Most businesses will manage by increasing (or decreasing) hours of work for existing employees.

Costs and Benefits to California Businesses from Reduced Spending on Electricity

The increase in energy efficiency of the GSFLs will also lead to reduced spending on electricity for California businesses. The CEC estimated the number of each of the six types of GSFLs currently installed in California and projected the number of installed lamps each year through 2031 (see Appendix-D). To allocate these lamps by sector—residential, commercial, and industrial—this analysis relied on the 2015 U.S. Lighting Market Characterization report published by the U.S. Department of Energy.[29] The lighting characterization study provides estimates of the installed stock and energy use of all general illumination lighting products operating in the U.S.[30] Table 13 shows the distribution of each of the six types of GSFLs by sector based on national data, which is assumed to also be representative for California.

Table 13: Distribution of the Six Types of GSFLs by Sector*

Sector	4-foot T12	8-foot T12 Stand. Out	8-foot T12 High Out	Less than 4-foot T12	Less than 4-foot T8	Less than 4-foot T5
Residential	48%	38%	38%	51%	5%	13%
Commercial	50%	44%	44%	47%	93%	66%
Industrial	2%	18%	18%	2%	2%	22%

*Total may not sum to 100% due to rounding.

Table 14 shows estimated annual savings on electricity for lighting and costs for lamps and fixture replacements for California commercial and industrial businesses. In the first four years (2022 through 2025), the analysis estimates the proposed regulatory change will have net negative impacts as California businesses convert their non-compliant lamps to compliant T8 or LED lamps. However, by year five (2026), the net impact of replacing the non-compliant lamps will be positive for California businesses as the value of electricity savings will more than cover the cost of replacing non-compliant lamps. By 2029, net annual savings to businesses of replacing the non-compliant lamps will exceed $100 million.

Even though this analysis estimates that the proposed regulatory change will result in annual impacts of tens of millions of dollars (either positive or negative), it is not expected these impacts will affect business spending. Therefore, it is assumed there will be no additional

[29] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. 2017. *2015 U.S. Lighting Market Characterization*. https://www.energy.gov/eere/ssl/2015-us-lighting-market-characterization.

[30] Ibid.

economic impacts associated with annual net changes in spending by businesses on electricity for lighting and converting to compliant lamps.

Table 14: Estimated Annual Savings on Electricity for Lighting and Costs for Lamp Replacement, California Commercial and Industrial Businesses, 2020 Dollars

a.	b.	c.	d.
Year*	Benefit of Electricity Savings	Cost of Lamp Replacement**	Net Impact of Lamp Replacement (b - c)***
2022	$19,649,268	$81,621,655	($61,972,386)
2023	$42,042,258	$88,932,075	($46,889,817)
2024	$64,503,026	$88,221,538	($23,718,512)
2025	$94,351,885	$108,419,232	($14,067,347)
2026	$121,238,594	$98,907,382	$22,331,212
2027	$150,273,691	$103,724,650	$46,549,041
2028	$178,707,939	$104,800,769	$73,907,170
2029	$188,909,512	$54,579,323	$134,330,188
2030	$200,537,865	$57,416,593	$143,121,272
2031	$191,726,670	$37,327,377	$154,399,293
2032	$182,537,794	$25,085,535	$157,452,259
2033	$173,688,520	($7,487,706)	$181,176,225
2034	$164,296,214	($7,429,329)	$171,725,542
2035	$155,796,785	($7,392,804)	$163,189,589
2036	$148,123,767	($7,376,711)	$155,500,478
2037	$141,217,355	($7,379,816)	$148,597,170
2038	$135,023,622	($7,401,051)	$142,424,673
2039	$129,493,852	($7,439,490)	$136,933,342
2040	$124,583,957	($7,494,328)	$132,078,285

Source: Analysis by Evergreen of data from the CEC and other sources.

*Assumes full year impacts.

**Negative values represent savings to businesses due to longer design life of T8 and LED lamps.

***Negative values represent net cost to business.

Impact on Power Plant Construction from Reduced Spending on Electricity

Between 2014 and 2019 (the last year for which full-year data are available), California's economy grew in real terms by 3.9 percent per year on average.[31] Over this same period, total system electric generation in California—the sum of all utility-scale in-state generation plus net electricity imports—decreased an average of 1.3 percent per year (see Table 15). Clearly, economic growth in California has become less energy dependent due to a number of factors, including economic transitions toward industries that are less energy intensive, investments in energy efficiency, and growth in distributed solar resources.

Table 15: Total System Electric Generation in California, GWh*

Year	Total System Electric Generation, CA*	Annual Change	Annual Percent Change
2014	297,062		
2015	295,405	297,062	-0.6%
2016	290,567	295,405	-1.6%
2017	292,037	290,567	0.5%
2018	285,488	292,037	-2.2%
2019	277,704	285,488	-2.7%
	Average Annual Change	-3,872	-1.3%

Source: California Energy Commission. 2021. "California Electricity Data." https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data

*Total system electric generation is the sum of all utility-scale in-state generation plus net electricity imports

Based on the analysis of the CEC staff report regarding the proposed efficiency standards for linear fluorescent lamps exempt from federal regulation,[32] an average annual electricity savings of 1,227 GWh between 2022 and 2040 is estimated, which is less than one-third the average annual reduction in total system electric generation in California between 2014 and 2019 (average reduction of 3,872 GWh per year). Therefore, the proposed regulatory change will have a negligible impact on the already decreasing demand for electricity in California and the derived demand for power plant construction.

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[31] Real total gross domestic product for California, Federal Reserve of St. Louis, Economic Research, https://fred.stlouisfed.org/series/CARGSP.

[32] Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD.

Statewide Economic Impacts from Additional Revenue Received by California Electrical Contractors, Hazardous Disposal Services, and Linear Fluorescent Lamp Manufacturers

Spending by residences and businesses as they replace non-compliant lamps results in economic impacts for California businesses. Shifting to compliant lamps includes the cost of the lamps, the cost of disposal for the removed ballasts (assumed to be hazardous), and the cost for electrical contractors to replace the non-compliant lamps.[33] Of these, the labor cost for electrical contractors is by far the greatest expense associated with replacing the non-compliant lamps.

Most but not all of the spending to replace non-compliant lamps will go to businesses located in California. Based on the IMPLAN model's representation of the California economy, it is assumed that just over 93 percent of spending on electrical contractors and nearly 100 percent of spending on hazardous disposal services for replaced ballasts will go to businesses in California. However, only about 27 percent of spending on new lamps and ballasts (for compliant T8s) will go to California-based lamp manufacturers, while the remainder will go to manufacturers located outside of California (including outside the U.S.)

Compliant lamps already exist in the marketplace, and it is not expected that the proposed regulatory change will have any material impact on manufacturers in California or elsewhere meeting the increased demand by California residences and businesses. Likewise, the proposed regulatory change is not expected to have any material impact on hazardous disposal services. The proposed regulatory change will likely have the greatest impact on electrical contractors as demand for their services will increase, especially through 2030, as most of the non-compliant lamps comprising the baseline are replaced at burnout. The analysis estimates that at the peak in 2025, upwards of 1,250 person-years of electrical contractor services will be demanded to replace the non-compliant lamps.[34]

In varying degrees, this analysis expects increased investment in labor and to a lesser degree capital stock by manufacturers, electrical contractors, and hazardous disposal services, as well as their suppliers both inside and outside California, to meet the demand for compliant lamps. This additional investment is embedded within the economic impacts described below.

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[33] See Table 1 for lamp, labor, and ballast disposal costs.

[34] About 5.2 million non-compliant lamps are estimated tol be replaced at burnout in 2025. While it is not known exactly how many minutes are required to convert a light fixture for a compliant T8 or LED lamp, it is assumed that with travel time, a typical two-lamp fixture can be replaced in one hour. Finally, it is assumed that the typical electrical contractor works 2,080 hours per year (52 weeks x 40 hours = 2,080 hours). Therefore, the analysis arrives at 1,250 person-years through the following calculation: 5.2 million lamps ÷ (52 weeks × 40 hours × two lamps converted) = 1,250. Note that this is just an estimate, and the actual number of person-years of electrical contractor services may be greater or less.
In 2019, there were approximately 113,000 electrical contractors in California. Employment Development Department, State of California, "Quarterly Census of Employment & Wages" (Data Search Tool). https://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry.

In this analysis, only the portion of incremental spending that goes to businesses located in California are considered. The remainder of incremental spending will go to firms located outside the state. The authors do not foresee any competitive advantages or disadvantages for any firms currently impacted by the proposed regulation, nor will the proposed regulation affect the ability of California businesses to compete with businesses in other states.

In total, this analysis estimates that residences and businesses will spend on average about $115 million each year to replace non-compliant lamps. Most of this spending, $100 million, will be paid to firms located in California (see Table 16).

Table 16: Average Annual Estimated Incremental Spending by California Residences and Businesses to Replace the Six Identified Non-Compliant GSFLs, 2020 Dollars

Metric	Residences	Commercial Businesses	Industrial Businesses	Total
Total Spending to Replace Non-Compliant Lamps	$38,306,311	$67,623,097	$9,562,006	$115,491,414
Spending Received by California Businesses*	$33,475,050	$58,165,034	$8,112,142	$99,752,226
Percent of Spending Received by California Businesses*	87%	86%	85%	86%

Source: Analysis by Evergreen of data from the CEC and other sources.

*All non-compliant lamps would be replaced by 2032.

Table 17 shows the average annual economic impacts in California from spending by residences and businesses to replace non-compliant lamps. The increase in employment over the projected period (2022-2040) is estimated to be 1,069 jobs and will pay on average about $64,000.[35]

35 Computed by dividing labor income by employment.

Table 17: Annual Estimated Economic Impacts in California from Increased Spending to Replace Non-Compliant GSFLs, 2020 Dollars

Metric	Residences	Commercial Businesses	Industrial Businesses	Total
Spending Received by California Businesses*	$92,309,589	$4,187,417	$3,255,219	$99,752,226
Change in Employment	1,001	39	29	1,069
Change in Labor Income	$63,725,821	$2,642,432	$2,033,669	$68,401,922
Change in Economic Output	$176,160,005	$7,865,663	$7,165,282	$191,190,950

Source: Analysis by Evergreen of data from the CEC and other sources.

*All non-compliant lamps would be replaced by 2032.

Impacts on Business Investment in California

This analysis anticipates the proposed regulatory change will result in modest increases in investment by lamp manufacturers and other businesses in California. It estimates the present value of future (net) capital investment by all businesses will be $58 million in 2020 dollars. This analysis did not consider any change in investments in power plants or electrical distribution. The change in demand for electricity associated with the proposed regulation is trivial compared to California’s economy as a whole. Likewise, in comparison to the demands by California officials and regulators to transition toward renewable energy, the impacts on electricity generators is likely nonconsequential.

Incentives for Innovation

The proposed change in performance standards is intended to promote innovation for the regulated product category.[36] Due to California's large market share among the states and its reputation for innovation, there is the possibility that the proposed change in performance standards would lead manufacturers to incorporate the higher efficiency technologies into lamps sold outside of the state.

Competitive Advantage or Disadvantage for California Businesses

The regulation would apply to all lighting manufacturers inside and outside of the state producing lamps sold to California customers.[37] It is therefore not anticipated that the regulation will have an adverse effect on the competitiveness of California businesses.

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36 Gov. Code, § 11346.3(c)(1)(E); 1 CCR § 2003(a)(3)(E).

37 Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

Benefits of Avoided Emissions from Energy Conservation

In addition to the market-based economic impacts associated with the regulatory change, there are also societal benefits that can be quantified. Increased energy efficiency of GSFLs will reduce electricity demand and in turn lead to avoided emissions associated with combustion-based electricity generation. On average, about 40 percent of electricity consumed in California is generated by natural gas-fired power plants, which emit pollutants harmful to human health.[38]

In addition, California purchases electricity generated from coal from the Intermountain Power Plant in Delta, Utah (1,900-megawatt capacity) and the Four Corners Generating Station in San Juan County, New Mexico (1,540-megawatt capacity). These facilities generate relatively little of the electricity consumed in California today, and it is assumed their contribution to California's electricity supply will continue to decline through 2025.[39] On a per kWh basis, these facilities produce more sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and particulate matter with a diameter of 2.5 microns or less ($PM_{2.5}$) than natural gas-fired power plants. Therefore, as California's electricity generation becomes "cleaner," the avoided emissions due to the energy conservation associated with the proposed regulation will decrease over time.

AVERT (the AVoided Emissions and geneRation Tool) was used to analyze avoided emissions associated with the new standard for GSFLs. AVERT is a free, publicly accessible tool to estimate emissions impacts of energy efficiency and renewable energy policies and programs. AVERT estimates generation that will not take place because energy efficiency and/or renewable energy programs are meeting consumers' energy needs.[40] The tool quantifies the displaced emissions of SO_2, NO_x, CO_2, and $PM_{2.5}$. AVERT combines historical data on electricity generation and emissions reported by fossil fuel-fired electric generating units (EGUs) with load reduction profiles for energy efficiency and renewable energy resources. AVERT allows one to estimate the impacts that policies affecting energy efficiency and renewable energy resources have on emissions from EGUs.[41] AVERT can be used to predict energy efficiency and

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38 California Energy Commission. "California Electrical Energy Generation." 2020. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/california-electrical-energy-generation.

39 Los Angeles Times. "Boiling Point: The coal industry comes tumbling down in the American West." December 24, 2020. https://www.latimes.com/environment/newsletter/2020-12-24/coal-industry-comes-tumbling-down-in-the-american-west-boiling-point.

40 AVoided Emissions and geneRation Tool (AVERT), User Manual Version 2.0, May 2018, p.1.

41 Historical generation, heat input, and emissions data used by AVERT come from three Environmental Protection Agency programs:

Clean Air Markets Division (CAMD). https://www.epa.gov/airmarkets renewable energy-related emissions for near-future years, although it is based on historical behavior rather than predicted economic behaviors.[42]

AVERT has three main components:

- **Main Module** – The Excel-based Main Module allows users to estimate displaced emissions that are likely to result from energy efficiency and renewable energy policies and programs. The Main Module uses data files generated by the Statistical Module to analyze energy efficiency and renewable energy scenarios. This can be done for either a historical base year or a future year.
- **Statistical Module** – The Statistical Module performs analysis on historical generation, heat input, and emissions data, which are collected in the EPA Clean Air Markets Division's Air Markets Program Data, to produce data files that are then used by AVERT's Main Module.
- **Future Year Scenario Template** – The Excel-based Future Year Scenario Template allows users to modify base year emissions data. Users can retire and add EGUs as well as change emission rates.[43]

This analysis used AVERT to project avoided emissions over a 19-year period beginning in 2022. In this scenario, it is assumed that the amount of electricity provided by the only coal powered EGU that services the California region, the Intermountain Power Plant, would decrease in each year of the projection period. By assuming that electricity supplied by the Intermountain Power Plant will decrease each year—irrespective of energy savings associated with the new efficiency standards for GSFLs—this analysis accounts for likely emissions reductions associated with changes to California's electricity generation portfolio. Table 18 shows the projection of avoided emissions from reduced electricity demand associated with installation of the compliant GSFLs in residential, business, and industrial facilities.

Acid Rain Program (ARP). https://www.epa.gov/acidrain/acid-rain-program

Air Markets Program Data (AMPD). https://ampd.epa.gov/ampd

AVERT models California as a single region

Load reduction profiles identify the time of day, week, or year that (a) energy efficiency measures reduce energy usage, or (b) renewable energy generation reduces fossil fuel-based electricity generation.

42 Ibid, 4.

43 AVoided Emissions and geneRation Tool (AVERT), User Manual Version 2.0, May 2018, p. 10.

Table 18: Projected Reductions in Emissions Associated with Electricity Savings*

Year	Savings (GWh/Yr)	SO2 (lbs.)	NOx (lbs.)	CO2 (tons)	PM2.5 (lbs.)
2022	178	7,201	36,020	92,698	6,731
2023	382	10,613	59,389	196,192	13,430
2024	586	11,450	73,161	298,163	19,572
2025	860	12,192	90,302	435,044	27,744
2026	1,108	4,640	75,410	553,920	33,410
2027	1,375	5,760	93,590	687,310	41,440
2028	1,639	6,860	111,580	819,110	49,380
2029	1,728	7,230	117,630	863,500	52,050
2030	1,830	7,660	124,610	914,690	55,130
2031	1,738	7,270	118,310	868,410	52,350
2032	1,643	6,870	111,890	821,400	49,520
2033	1,554	6,500	105,770	776,490	46,810
2034	1,461	6,110	99,420	729,970	44,010
2035	1,376	5,760	93,640	687,660	41,460
2036	1,299	5,440	88,400	649,220	39,150
2037	1,229	5,140	83,660	614,430	37,060
2038	1,166	4,880	79,370	582,930	35,150
2039	1,109	4,640	75,490	554,500	33,440
2040	1,057	4,430	72,020	528,950	31,890

Source: Analysis by Evergreen of data from the CEC and other sources.
*Estimated by Evergreen using U.S. EPA AVERT model;
tons are measured as short tons (2,000lbs).

Economic Value of Avoided Emissions

The estimates of reduced emissions shown in Table 18 are meaningful only to the extent that they show that the proposed change in the performance standard of GSFLs will reduce the amount of these pollutants emitted into the atmosphere. To provide a more meaningful context for policymakers and regulators, the reduced emission volumes shown in Table 18 are converted into the dollar value of avoided emissions based on published estimates of the benefits to human mortality and morbidity of avoided emissions.[44] Table 19 shows estimates of the per-ton benefits of avoided emissions for each of the primary pollutants associated with fossil fuel-based electricity generation in 2020 dollars. For SO_2, NO_x, and $PM_{2.5}$, the two reported estimates of benefits were averaged. This analysis relied on a single estimate of the benefit of avoided CO_2, which is based on California carbon markets but low relative to many studies about the social cost of carbon.[45]

Table 19: Estimated Per-Ton Benefits of Avoided Emissions, 2020 Dollars

Pollutant	Estimate 1	Estimate 2	Average
SO2 *	$43,444	$99,921	$71,683
NOx *	$6,517	$15,205	$10,861
CO2 **	$17.71		$17.71
PM2.5 *	$152,054	$358,413	$255,233

Source: Analysis by Evergreen of data from the CEC and other sources.
*Dollar values of avoided SO_2, NO_X, and $PM_{2.5}$ from U.S. Environmental Protection Agency. 2018. *Technical Support Document: Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors*, Table 31, p.45. https://www.epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf;
** California Air Resources Board. 2021. *California Cap-and-Trade Program, and Quebec Cap-and-Trade System Summary Results Report*. https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/auction/feb-2021/summary_results_report.pdf.

Using the per-ton estimates of avoided emissions in the "Average" column of Table 19, the total annual benefits of avoided emissions associated with the proposed regulatory change are computed. These are shown in Table 20. The benefits grow each year as the non-compliant

44 Dollar values of avoided SO_2, NO_x, and $PM_{2.5}$ from U.S. Environmental Protection Agency. 2018. *Technical Support Document: Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors*, Table 31, p.45. https://www.epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf; California Air Resources Board. 2021. *California Cap-and-Trade Program, and Quebec Cap-and-Trade System Summary Results Report.* https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/auction/feb-2021/summary_results_report.pdf.

45 Succeeding this analysis, the White House announced it is reinstating social cost of carbon. The cost of carbon at a 3-percent discount rate is $56 per metric ton in 2025 and increasing to $85 per metric ton by 2050. 2021. *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990*. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

(baseline) lamps are replaced at burnout with compliant T8 or LED lamps. The benefits top out in 2030 at $23 million before slowly declining through the remainder of the projection period.

Table 20: Economic Value of Avoided Emissions from Reduced Electricity Use, 2020 Dollars

Year	SO2	NOx	CO2	PM2.5	Total
2022	$234,138	$177,451	$1,641,682	$779,261	$2,832,532
2023	$345,078	$292,578	$3,474,560	$1,554,818	$5,667,034
2024	$372,293	$360,425	$5,280,467	$2,265,889	$8,279,074
2025	$396,419	$444,870	$7,704,629	$3,211,978	$11,757,896
2026	$150,868	$371,505	$9,809,923	$3,867,942	$14,200,238
2027	$187,285	$461,068	$12,172,260	$4,797,591	$17,618,203
2028	$223,051	$549,695	$14,506,438	$5,716,820	$20,996,004
2029	$235,081	$579,500	$15,292,585	$6,025,931	$22,133,098
2030	$249,062	$613,887	$16,199,160	$6,382,509	$23,444,619
2031	$236,382	$582,850	$15,379,541	$6,060,663	$22,259,436
2032	$223,376	$551,222	$14,546,994	$5,733,028	$21,054,621
2033	$211,345	$521,072	$13,751,638	$5,419,286	$19,903,342
2034	$198,665	$489,789	$12,927,769	$5,095,125	$18,711,347
2035	$187,285	$461,314	$12,178,459	$4,799,906	$17,626,964
2036	$176,880	$435,500	$11,497,686	$4,532,473	$16,642,539
2037	$167,125	$412,148	$10,881,555	$4,290,509	$15,751,338
2038	$158,672	$391,014	$10,323,690	$4,069,385	$14,942,761
2039	$150,868	$371,899	$9,820,195	$3,871,415	$14,214,377
2040	$144,040	$354,804	$9,367,705	$3,691,968	$13,558,517

Source: Estimated by Evergreen using U.S. EPA AVERT model; Dollar values of avoided SO_2, NO_X, and $PM_{2.5}$ from U.S. Environmental Protection Agency. 2018. *Technical Support Document: Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors*, Table 31, p.45. https://www.epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf; ** California Air Resources Board. 2021. *California Cap-and-Trade Program, and Quebec Cap-and-Trade System Summary Results Report*. https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/auction/feb-2021/summary_results_report.pdf.

CHAPTER 4: Alternatives

The proposed update analyzed in this report is one of three alternative updates developed by CEC staff. The three alternative updates to the performance standards are as follows: [46]

Alternative 1: No Minimum Efficiency Standards for Less than 4-foot Linear Lamps and Federal Minimum Efficiency Standards for "Loophole" Lamps.

Alternative 2: More Stringent Minimum Efficiency Standards for State-Regulated GSFLs.

Alternative 3, Proposed Regulation: Federal Minimum Efficiency Standards for Loophole Lamps and LED Efficiency Levels for Less than 4-foot Linear Lamps. Alternative 3 is selected for the proposed regulations for the reasons that are discussed later in this chapter and hereafter will be referenced as "proposed regulation".

Table 21a shows the estimates of the impacts for the two alternatives and the proposed regulation on the reduced spending on electricity by California residences and businesses over the 19-year period beginning in 2022. The overall impact on spending is positive beginning in 2022 for both alternatives and the proposed regulation, peaking in year 2030 and decreasing each year after that. Alternative 2 far exceeds the impacts estimated for Alternative 1 and are only negligibly different from the impacts of the proposed regulation.

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46 For details on the alternatives, see Appendix B. Pasha, Soheila. 2021. *Alternatives to Proposed GSFLs Standards*.

Table 21a: Total Reduced Spending on Electricity by California Residences and Businesses from Proposed Change in Performance Standards of Linear Fluorescent Lighting: Comparison of Proposed Regulation to Alternatives 1 and 2, 2020 Dollars

a.	b.	c.	d.	e.	f.
Year*	Proposed Regulation	Alternative #1	Alternative #2	Difference** Alternative #1 c. – b.	Difference: Alternative #2 d. – b.
2022	$27,520,959	$22,511,700	$27,862,591	($5,009,259)	$341,632
2023	$58,958,531	$48,863,308	$59,645,507	($10,095,223)	$686,976
2024	$90,309,998	$75,139,094	$91,343,915	($15,170,905)	$1,033,916
2025	$132,627,838	$112,325,969	$134,012,028	($20,301,869)	$1,384,190
2026	$171,005,888	$145,591,104	$172,741,738	($25,414,784)	$1,735,850
2027	$212,505,979	$181,920,745	$214,597,128	($30,585,234)	$2,091,148
2028	$253,684,406	$217,866,405	$256,134,511	($35,818,001)	$2,450,105
2029	$267,301,557	$226,195,134	$270,114,442	($41,106,423)	$2,812,885
2030	$282,999,590	$236,552,035	$286,178,881	($46,447,555)	$3,179,291
2031	$268,046,834	$216,662,574	$271,562,989	($51,384,260)	$3,516,155
2032	$252,963,524	$197,958,706	$256,727,970	($55,004,819)	$3,764,446
2033	$238,557,662	$180,339,661	$242,540,904	($58,218,000)	$3,983,242
2034	$223,782,351	$163,661,531	$227,896,234	($60,120,820)	$4,113,884
2035	$210,304,378	$148,217,043	$214,553,249	($62,087,336)	$4,248,871
2036	$198,026,854	$133,907,441	$202,415,195	($64,119,413)	$4,388,341
2037	$186,862,171	$120,643,128	$191,394,609	($66,219,044)	$4,532,437
2038	$176,730,951	$108,342,617	$181,412,262	($68,388,335)	$4,681,311
2039	$167,561,140	$96,931,640	$172,396,257	($70,629,499)	$4,835,118
2040	$159,287,222	$86,342,372	$164,281,242	($72,944,851)	$4,994,020
Avg. Annual	$188,370,412	$143,156,432	$191,463,771	($45,213,980)	$3,093,359

Source: Analysis by Evergreen of data from the CEC and other sources.

*Assumes full year impacts.

**Negative values represent lower savings to California residences and businesses.

Table 21b shows the annual incremental costs for the proposed regulation and Alternative 1 and Alternative 2. Annual average incremental costs are lowest for Alternative 1 ($87.8 million) and greatest for Alternative 2 ($117.5 million).

Table 21b: Total Incremental Costs for Compliant GSFLs Paid by California Residences and Businesses from Proposed Change in Performance Standards of Linear Fluorescent Lighting: Comparison of Proposed Regulation to Alternatives 1 and 2, 2020 Dollars

a.	b.	c.	d.
Year*	Proposed Regulation	Alternative #1	Alternative #2
2022	$122,849,590	$76,169,980	$124,499,757
2023	$136,172,388	$89,314,433	$137,829,105
2024	$134,225,055	$87,775,085	$135,872,044
2025	$172,467,639	$126,067,507	$174,116,825
2026	$156,221,314	$110,088,984	$157,865,804
2027	$165,191,897	$119,189,550	$166,836,387
2028	$168,105,985	$122,240,705	$169,750,476
2029	$71,996,405	$26,939,238	$73,640,895
2030	$77,523,156	$31,974,473	$79,167,646
2031	$41,504,727		$42,974,939
2032	$29,973,948		$30,237,845
2033			
2034			
2035			
2036			
2037			
2038			
2039			
2040			
Avg. Annual	**$116,021,100**	**$87,751,106**	**$117,526,520**

Source: Analysis by Evergreen of data from the CEC andother sources.
*Assumes full year impacts.

Table 22 and Table 23 show the estimates of the impacts of the two alternatives and the proposed regulations on California's Gross State Product (GSP) and employment over the 19-year period beginning in 2022. The overall impact on GSP is positive beginning in 2022 for all three alternatives.

The three alternatives have similar relative impacts on employment. The analysis in this report estimates that all three alternatives have an immediate impact on employment in 2022, though for Alternative 2, the impact is greater than Alternative 1 and consistent with the proposed regulation. All three alternatives see a growth in employment until 2028, with those numbers decreasing each year after. Given the size of California's economy, the impacts of the three alternatives are not materially different.

Although Alternative 2 has the greatest impacts on reduced spending on electricity, GSP, and employment, the CEC staff analysis of the 2-foot and 3-foot linear LED lamps result in a benefit-cost ratio that is lower than the benefit-cost ratio for linear LED lamps with the minimum efficiency of 115 lumen per watt.[47] Therefore, Alternative 2 was not chosen. Instead, CEC staff proposes the alternative of federal minimum efficiency standards for loophole lamps and LED efficiency levels for less than 4-foot linear lamps because it saves significant energy, is technically feasible, is cost effective, and closes the loopholes in federal regulations that exempt products from general service fluorescent lamp (GSFL) minimum efficiency standards. Additionally, the alternative creates consistency with the federal efficiency standards for GSFLs and the efficiency standards in other states for high-CRI lamps.

47 For details on the alternatives, see Appendix B. Pasha, Soheila. 2021. *Alternatives to Proposed GSFLs Standards*.

Table 22: Total Estimated Change in California GSP from Proposed Change in Performance Standards of Linear Fluorescent Lighting: Comparison of Proposed Regulation to Alternatives 1 and 2, 2020 Dollars

a.	b.	c.	d.	e.	f.
Year*	Proposed Regulation	Alternative #1	Alternative #2	Difference** Alternative #1 c. – b.	Difference** Alternative #2 d. – b.
2022	$158,907,463	$91,569,709	$159,649,737	($67,337,754)	$742,274
2023	$182,138,239	$114,093,450	$182,919,125	($68,044,788)	$780,886
2024	$191,882,069	$123,528,920	$192,704,242	($68,353,149)	$822,173
2025	$241,906,242	$172,969,934	$242,767,590	($68,936,307)	$861,348
2026	$244,077,966	$174,735,422	$244,979,566	($69,342,544)	$901,600
2027	$268,812,145	$198,947,921	$269,753,566	($69,864,224)	$941,421
2028	$288,958,095	$218,561,351	$289,939,883	($70,396,745)	$981,787
2029	$212,214,329	$141,281,120	$213,236,892	($70,933,209)	$1,022,564
2030	$222,162,862	$150,689,552	$223,226,584	($71,473,311)	$1,063,722
2031	$180,713,920	$108,709,378	$181,818,120	($72,004,542)	$1,104,200
2032	$153,150,317	$99,454,110	$154,063,214	($53,696,207)	$912,897
2033	$95,234,746	$90,715,926	$95,689,463	($4,518,820)	$454,717
2034	$87,085,725	$82,427,903	$87,554,811	($4,657,822)	$469,086
2035	$79,540,881	$74,739,262	$80,024,805	($4,801,619)	$483,924
2036	$72,554,538	$67,604,298	$73,053,780	($4,950,239)	$499,243
2037	$66,084,937	$60,981,192	$66,599,992	($5,103,745)	$515,056
2038	$60,093,837	$54,831,617	$60,625,213	($5,262,220)	$531,376

Source: Analysis by Evergreen of data from the CEC and other sources.

*Assumes full year impacts

**Negative values represent lower savings to California residences and businesses.

Table 23: Total Estimated Change in California Employment from Proposed Change in Performance Standards of Linear Fluorescent Lighting: Comparison of Proposed Regulation to Alternatives 1 and 2

a.	b.	c.	d.	e.	f.
Year*	**Proposed Regulation**	**Alternative #1**	**Alternative #2**	**Difference** Alternative #1 c. – b.**	**Difference: Alternative #2 d. – b.**
2022	871	502	875	(369)	4.1
2023	1,000	626	1,004	(374)	4.3
2024	1,059	682	1,064	(377)	4.5
2025	1,330	951	1,335	(379)	4.7
2026	1,357	971	1,362	(386)	5.0
2027	1,498	1,109	1,503	(389)	5.2
2028	1,617	1,223	1,622	(394)	5.5
2029	1,229	818	1,235	(411)	5.9
2030	1,285	872	1,291	(413)	6.2
2031	1,064	640	1,071	(424)	6.5
2032	907	589	912	(318)	5.4
2033	587	559	590	(28)	2.8
2034	537	508	540	(29)	2.9
2035	492	462	495	(30)	3.0
2036	449	418	452	(31)	3.1
2037	410	378	413	(32)	3.2
2038	373	340	376	(33)	3.3
2039	341	307	344	(34)	3.4
2040	309	274	313	(35)	3.5
Avg. Annual	**880**	**644**	**884**	**(236)**	**4.3**

Source: Analysis by Evergreen of data from the CEC and other sources.

*Assumes full year impacts.

**Negative values represent lower jobs to California residences and businesses.

APPENDIX A: Economic Modeling – Methods and Assumptions

A regional economic impact model is a tool for estimating how policy actions will affect a regional economy. There are two standard approaches to conducting economic impact analysis: input-output models and computable general equilibrium (CGE) models. Input-output models rely on detailed information regarding household spending on goods and services and similarly detailed matrices of interdependencies between industry sectors that produce those goods and services. Input-output models are especially useful in analyzing how small (relative to the overall regional economy) changes in household spending or business or government investment may affect output, employment, and employee wages in each sector of a regional economy.

The CGE modeling approach also accounts for interrelationships between households and industry sectors, but generally not in as great of detail as an input-output model. However, CGE models are more sophisticated and account for optimizing behaviors by households and businesses (e.g., utility or profit maximization); adjustments over time in the economy, demand, supply, and price; and forecasting of economic activities in future years. This greater sophistication is warranted when considering a policy change or action that is expected to have significant impacts on a region's economy. For a policy or event that is expected to have relatively small impacts on a regional economy—such as changes in efficiency standards for appliances—the greater investment in time and cost associated with developing a CGE model and the added complexity associated with the CGE approach is generally not warranted and would likely produce similar results as the input-output approach.

The input-output modeling approach provides estimates of the economic impacts that spending associated with a capital investment, event, government policy, or other action has on a region's economic output, employment, and labor income. There are three widely used input-output models for conducting economic impact analysis:

- RIMS-II (Regional Input-Output Modeling System)
- REMI (Regional Economic Models, Inc.)
- IMPLAN (Impact Analysis for Planning)

Underlying each of these models are matrices quantifying the value of goods and services that flow between industrial sectors. The matrices account for the value of goods and services produced "domestically" (i.e., within the geography of interest) and the value of "imported" (i.e., produced outside the geography of interest) goods and services brought into the geography of interest.[48] IMPLAN is the most used economic impact model due to its ease of use; extensive detailed information on output, employment, and wages at the sub-industry

48 The geography of interest for this analysis is the state of California but could be an individual or collection of zip codes, counties, or states.

level;[49] availability of information at the state, county, and zip code level; and the frequency at which data are updated.

RIMS-II

The RIMS-II model is essentially a set of multipliers that the analyst applies to develop estimates of economic impacts, which are economy wide with limited or no detail by industry sector. The tables of multipliers are developed by the U.S. Bureau of Economic Analysis (BEA) and cannot be modified by the analyst, nor does RIMS-II allow for the introduction of new industries into a region. The RIMS-II model is a static representation of a region's economy at a point in time. While a limiting characteristic, the static nature of the model is only a shortcoming when the policy change being considered is likely to have a substantial impact on consumer purchasing decisions and/or the economic structure of the region.

REMI

REMI is the most complex of the three models. It combines the input-output modeling capabilities of IMPLAN and RIMS-II with a dynamic general equilibrium model that allows for economic adjustments and forecasting. This additional capability comes at a cost in that REMI provides less sectorial detail than IMPLAN (about 100 sectors for REMI compared to 536 for IMPLAN), and REMI is far more expensive than IMPLAN. For most economic impact analyses, the additional capabilities that REMI provides are not necessary, and its greater complexity may make the modeling process and results seem less transparent.

IMPLAN

IMPLAN, like RIMS-II, reflects the impacts on the regional economy as it exists at a point in time. In this way, IMPLAN assumes that the technology employed by each industrial sector remains static, the local share of each industry's economic activity is assumed to be fixed into the future, and supply constraints are perfectly elastic—meaning there is no capacity limit to an industry's ability to respond to an economic event.[50] IMPLAN also assumes that changes in household income will impact household demand based on average expenditure patterns. However, economists typically assume that a change in income will impact household expenditure at the *margin*, resulting in increased demand for some goods and services and lower or unchanged demand for others.

It is necessary to consider these limitations when determining if IMPLAN is an appropriate modeling approach for conducting an economic analysis of the impact of a regulatory change that is expected to affect California households or businesses, which requires completion of a Standardized Regulatory Impact Assessment (SRIA). The flow chart shown in Figure 3 is a

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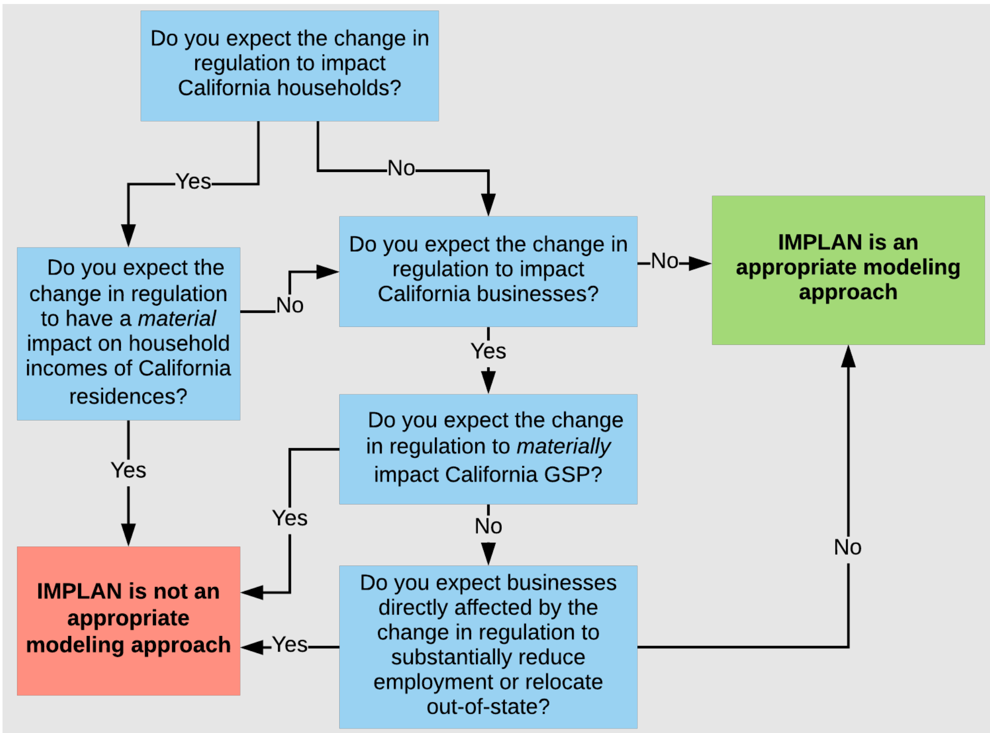
49 IMPLAN organizes industry data into 536 sectors. While these sectors are not exactly aligned to the North American Industrial Classification System (NAICS), IMPLAN sectors can be linked to corresponding NAICS sectors.

50 In addition, the IMPLAN and RIMS-II models do not account for "welfare effects," which consider how changes in resource allocation may affect the wellbeing of society.

simple guide for judging whether IMPLAN is an appropriate modeling approach for conducting the economic impact analysis required for an SRIA.

Figure 3: Is IMPLAN an Appropriate Modeling Approach?



Source: Evergreen

There is not a set rule for concluding that IMPLAN is or is not a suitable modeling approach; however, the guide shown in Figure 3 provides a framework for making this determination. If the regulatory change is expected to materially impact household incomes of California residences—either positively or negatively—this would suggest the regulatory change will affect household demand for goods and services, which would require adjustments to the regional economy to accommodate.[51] In this case, since IMPLAN is a static model and does not consider potential structural changes in the economy, one would likely conclude it is not a suitable modeling approach. Likewise, if the regulatory change is expected to affect California businesses in such a way as to materially impact Gross State Product (GSP)—either positively or negatively—or lead California businesses to reduce employment and/or relocate out-of-state, one would likely conclude IMPLAN is not a suitable modeling approach.

The IMPLAN input-output model developed estimates of the economic impacts associated with the proposed regulatory change affecting the six identified GSFLs. The IMPLAN model is a widely used modeling approach for conducting economic analysis. More than 2,000 public and

51 Deciding what is a "material" impact to household income is to some degree arbitrary. A possible rule of thumb to consider would be an annual change of 1 percent or more in median household income, which was $63,783 in California in 2016 for a four-person household https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml.

private institutions have used IMPLAN to conduct economic impact analysis, including the Federal Reserve Bank, the U.S. Forest Service, and Ernst & Young.[52]

The IMPLAN model relies on user-specified inputs (e.g., a change in household discretionary income) to generate estimates of economic impacts to the region, including changes in Gross State Product (GSP), employment, and wages. Three types of economic effects are estimated in the analysis and aggregated in this report:

- *Direct effects* are the first level of economic impact and represent expenditures by consumers or producers as a result of a project, policy, or other activity.
- *Indirect effects* occur in response to a change in demand for factor inputs by producers.
- *Induced effects* represent changes in spending by workers and households (generally) as a result of a change in labor income. The term "induced" refers to the fact that these effects reflect impacts on industries that were not directly involved with the program or in supplying a program's factor inputs.

Economic impacts were estimated for a 19-year period beginning in 2022 and extending through 2040. The 19-year analysis period was used to match the estimated useful life (EUL) for compliant LED lamps reported by CEC staff.[53] Key inputs and assumptions are as follows:

- All of the money saved by California residences through replacement of existing non-compliant lamps with compliant lamps will be spent on additional consumer goods and services. [Evergreen assumption]
- Approximately 79 percent of the additional household spending will be local (in California), with the remainder consisting of online, subscription, or other purchases from sources outside California, as well as travel outside the state. [IMPLAN assumption]
- Increased spending by California residents for goods produced and services provided in California will result in a small increase in expansive capital investment. [Evergreen assumption based on IMPLAN and Federal Reserve data]
- Money saved by businesses and government facilities through replacement of existing non-compliant lamps with compliant lamps will not be used for other economic purposes. [Evergreen assumption]
- Approximately 27 percent of spending in California on compliant lamps will be for units manufactured in California. The remaining demand will be met by domestic and foreign imports. [IMPLAN assumption]
- Approximately 93 percent of spending by California residences and businesses on labor to upgrade fixtures for compliant lamps will be for electrical contractors in California.

52 See references at www.implan.com.

53 Pasha, Soheila. 2019. *Analysis of Proposed Efficiency Standards for Linear Fluorescent Lamps Exempt from Federal Regulation*. California Energy Commission, Publication Number: CEC-400-2019-009-SD.

The remaining demand will be met by electrical contractors located outside California (e.g., Nevada). [IMPLAN assumption]

- Approximately 99 percent of spending by California residences and businesses on disposal of ballasts removed from non-compliant light fixtures will paid to hazardous waste disposal facilities located in California [IMPLAN assumption]
- Increased demand for compliant lamps will not have a significant impact on manufacturers in California but will lead to modest expansive capital investment by manufacturers. [Evergreen assumption based on IMPLAN and Federal Reserve data]

APPENDIX B: Alternatives to Proposed GSFLs Standards

California Energy Commission (CEC) staff considered two alternatives to proposed general service fluorescent lamp (GSFL) standards: (1) Proposing no state standards for less than 4-foot linear lamps and federal minimum efficiency standards for "loophole" lamps; and (2) a more stringent minimum efficiency standard with LED efficiency levels for "loophole" lamps and less than 4-foot linear lamps.

Alternative 1: No Minimum Efficiency Standards for Less than 4-Foot Linear Lamps and Federal Minimum Efficiency Standards for "Loophole" Lamps

As the first alternative, CEC staff considered setting minimum energy efficiency standards with levels consistent with the federal standards for high-CRI and impact-resistant linear fluorescent lamps, and not setting any standards for 2-foot and 3-foot linear lamps.

Table 24: Average Power Use per Unit for Non-Compliant Lamps

Lamp Type	Number of lamps per fixture	Lamp Power (W)	Fixture Power (W)
4-foot T12	2	40	94
8-foot Standard Output T12	2	73	173
8-foot High Output T12	2	110	257

Table 25: Average Power Use per Unit for Compliant Lamps

Lamp Type	Number of lamps per fixture	Lamp Power (W)	Fixture Power (W)
4-foot T8	2	32	59
4-foot LED	2	15	30
8-foot Standard Output T8	2	50	109
8-foot Standard Output LED	2	36	72
8-foot High Output T8	2	86	160

Table 26: Average Energy Use per Unit

Lamp Type	Energy Use Baseline (kWh/year/unit)	Energy Use Compliant T8 (kWh/year/ unit)	Energy Use Compliant LED (kWh/year/unit)	Energy Savings (kWh/ year/unit)
4-foot T12	121.8	76.4	38.9	T8: 45.4 LED: 82.9
8-foot Standard Output T12	224.2	141.2	93.3	T8: 83.0 LED: 130.9
8-foot High Output T12	333.0	207.3	-	125.7

Table 27: Overall Energy Savings from Annual Sales

Lamp Type	Annual Sales in 2021 (Thousands)	Replacement: Compliant T8	Replacement: Compliant LED	Energy Savings from Annual Sales (GWh/year)
4-foot Standard Output T12	4,012	62%	38%	239.7
8-foot Standard Output T12	234	62%	38%	23.7
8-foot High Output T12	41	100%	-	5.2

Source: CEC Staff

Lamp Type	Design Life Baseline (years)	Design Life Compliant (years)	Life-Cycle Energy Savings (kWh/unit)	Lifecycle Cost Savings ($/unit)	Incrementa l Costs ($/unit)	Benefit-Cost Ratio (Benefits/ Costs)
4-foot Standard Output T12	8	T8: 12 LED: 19	T8: 544.8 LED: 1,575.1	T8: $83.19 LED: $238.75	T8: $35.58 LED: $38.69	T8: 2.3 LED: 6.2
8-foot Standard Output T12	5	T8: 9 LED: 19	T8: 747 LED: 2,487.1	T8: $153.01 LED: $497.21	T8: $52.31 LED: $59.12	T8: 2.9 LED: 8.4
8-foot High Output T12	5	8	1005.6	$144.49	$74.00	1.9

Table 29: First Year and Stock Net Energy and Cost Savings

Lamp Type	Unit Stock (Thousands)	First year Energy Savings (GWh/year)	Stock Energy Savings (GWh/year)*	Weighted Average Electricity Rates ($/kWh)	First year Monetary Savings ($M/year)	Annual Monetary Savings ($M/year) *
4-foot T12	41,887	239.7	1,870.4	0.149	$35.7	$278.7
8-foot Standard Output	1,793	23.7	91.9	0.137	$3.2	$12.6
8-foot High Output	316	5.2	18.3	0.137	$0.7	$2.5

* After stock turn over

Table 30: List of Cost Estimates

Lamp Types	Non-Compliant Lamp Cost ($)	Compliant T8 Cost ($)	Compliant LED Cost ($)	New Ballast Cost ($)	Labor Cost per Lamp ($)	Ballast Disposal Cost per Lamp ($)[51]
4-foot	2.36	1.80	9.00	4.30	30.15	1.25
8-foot SO	4.40	9.70	24.20	8.15	35.38	2.5
8-foot HO	5.90	8.80	-	28.45	35.38	5

Source: CEC Staff

Year	Weighted Average Electricity Rates in State ($/kWh)	Lifetime Electricity Savings per unit (T8) (kWh/unit)	Lifetime Electricity Savings per unit (LED) (kWh/unit)	Lifetime Cost Savings per Unit (T8) ($/unit)	Lifetime Cost Savings per Unit (LED) ($/unit)
4-foot	0.149	544.8	1,575.1	$83.19	$238.75
8-foot SO	0.137	1,044.9	3,481.2	$153.01	$497.21
8-foot HO	0.137	1,005.5	-	$144.49	-

Source: CEC Staff

Staff evaluated the effect of not setting an efficiency standard for less than 4-foot linear fluorescent lamps. As the energy and cost analysis shows, the proposed standards for less than 4-foot linear fluorescent lamps are extremely cost effective and forgoing new efficiency standards means the loss of significant energy savings and monetary benefits to California consumers and businesses from having those standards. As a result, this alternative was not chosen.

Alternative 2: More Stringent Minimum Efficiency Standard for State-Regulated GSFLs

As the second alternative, CEC staff considered energy efficiency standards with levels consistent with the federal standards for high-CRI and impact-resistant linear fluorescent lamps, and a minimum efficiency level of 140 lumens per watt for 2-foot and 3-foot linear lamps.

Table 32: Average Power Use per Unit for Compliant Lamps

Lamp Type	Number of lamps per fixture	Lamp Power (W)	Fixture Power (W)
4-foot T8	2	32	59
4-foot LED	2	15	30
8-foot Standard Output T8	2	50	109
8-foot Standard Output LED	2	36	72
8-foot High Output T8	2	86	160
Less than 4-foot LED	2	8.46	16.92

Table 33: Average Energy Use per Unit

Lamp Type	Energy Use Baseline (kWh/year/unit)	Energy Use Compliant T8 (kWh/year/unit)	Energy Use Compliant LED (kWh/year/unit)	Energy Savings (kWh/year/unit)
4-foot T12	121.8	76.4	38.9	T8: 45.4 LED: 82.9
8-foot Standard Output T12	224.2	141.2	93.3	T8: 83.0 LED: 130.9
8-foot High Output T12	333.0	207.3	-	125.7
Less than 4-foot T12	72.6	-	21.9	50.7
Less than 4-foot T8	42.8	-	21.9	20.9
Less than 4-foot T5	44.1	-	21.9	22.2

Source: CEC Staff

Table 34: Overall Energy Savings from Annual Sales

Lamp Type	Annual Sales in 2021 (Thousands)	Replacement: Compliant T8	Replacement: Compliant LED	Energy Saving from Annual Sales (GWh/year)
4-foot Standard Output T12	4,012	62%	38%	239.7
8-foot Standard Output T12	234	62%	38%	23.7
8-foot High Output T12	41	100%	-	5.2
Less than 4-foot T12	10	-	100%	0.5
Less than 4-foot T8	852	-	100%	17.7
Less than 4-foot T5	2,684	-	100%	59.4
Total	**7,833**	-	-	**346.2**

Source: CEC Staff

Lamp Type	Design Life Baseline (years)	Design Life Compliant (years)	Life-Cycle Energy Savings (kWh/unit)	Lifecycle Cost Savings ($/unit)	Incremental Costs ($/unit)	Benefit-Cost Ratio (Benefits/ Costs)
4-foot Standard Output T12	8	T8: 12 LED: 19	T8: 544.8 LED: 1,575.1	T8: $83.19 LED: $238.75	T8: $35.58 LED: $38.69	T8: 2.3 LED: 6.2
8-foot Standard Output T12	5	T8: 9 LED: 19	T8: 747 LED: 2,487.1	T8: $153.01 LED: $497.21	T8: $52.31 LED: $59.12	T8: 2.9 LED: 8.4
8-foot High Output T12	5	8	1005.6	$144.49	$74.00	1.9
Less than 4-foot T12	3	19	963.3	$165.64	$37.41	4.43
Less than 4-foot T8	10	19	397.1	$56.46	$39.88	1.42
Less than 4-foot T5	11	19	421.8	$61.15	$38.81	1.58

Table 36: First Year and Stock Net Energy and Cost Savings

Lamp Type	Unit Stock (Thousands)	First year Energy Savings (GWh/year)	Stock Energy Savings (GWh/year) *	Weighted Average Electricity Rates ($/kWh)	First year Monetary Savings ($M/year)	Annual Monetary Savings ($M/year) *
4-foot T12	41,887	239.7	1,870.4	0.149	$35.7	$278.7
8-foot Standard Output	1,793	23.7	91.9	0.137	$3.2	$12.6
8-foot High Output	316	5.2	18.3	0.137	$0.7	$2.5
Less than 4-foot T12	64	0.5	1.1	0.147	$0.07	$0.2
Less than 4-foot T8	3,227	17.7	210.5	0.147	$2.6	$30.1
Less than 4-foot T5	10,259	59.4	765.8	0.147	$8.7	$112.6
Total	**57,546**	**346.2**	**2,958**	-	**$50.97**	**$436.7**

* After stock turn over

Table 37: List of Cost Estimates

Lamp Types	Non-Compliant Lamp Cost ($)	Compliant T8 Cost ($)	Compliant LED Cost ($)	New Ballast Cost ($)	Labor Cost per Lamp ($)	Ballast Disposal Cost per Lamp ($)[52]
4-foot	2.36	1.80	9.00	4.30	30.15	1.25
8-foot SO	4.40	9.70	24.20	8.15	35.38	2.5
8-foot HO	5.90	8.80	-	28.45	35.38	5
Less than 4-foot	4.40 (T12) 2.10 (T8) 3.10 (T5)	-	10.01	-	30.15	1.25

Source: CEC Staff

Table 38: Lifetime Energy and Cost Savings per Unit for 4-Foot Lamps

Year	Weighted Average Electricity Rates in State ($/kWh)	Lifetime Electricity Savings per unit (T8) (kWh/unit)	Lifetime Electricity Savings per unit (LED) (kWh/unit)	Lifetime Cost Savings per Unit (T8) ($/unit)	Lifetime Cost Savings per Unit (LED) ($/unit)
4-foot	0.149	544.8	1,575.1	$83.19	$238.75
8-foot SO	0.137	1,044.9	3,481.2	$153.01	$497.21
8-foot HO	0.137	1,005.5	-	$144.49	-
Less than 4-foot T12	0.147	-	962.12	-	$169.6
Less than 4-foot T8	0.147	-	395.88	-	$60.37
Less than 4-foot T5	0.147	-	420.50	-	$65.06

Source: CEC Staff

CEC staff market analysis of the 2-foot and 3-foot linear LED lamps showed that the average price of linear LED lamps with an energy efficiency of 140 lumens per watt or more is about 15 percent higher than linear LED lamps with a minimum efficiency of 115 lumens per watt, while these lamps use about 6 percent less power. As a result, the benefit-cost ratio is lower than the benefit-cost ratio for linear LED lamps with the minimum efficiency of 115 lumen per watt. Therefore, this alternative was not chosen.

APPENDIX C: Fiscal Impacts

California Energy Commission (CEC) staff calculated fiscal impacts to state and local agencies based on the procurement data for the linear fluorescent lamps from the Department of General Services (DGS). It is assumed that state and local agencies do not purchase or use high CRI and shatter resistant linear fluorescent lamps because no specific applications for these kinds of lamps could be identified. Therefore, only state-regulated less than 4-foot linear lamps are considered for the fiscal impact analysis.

Fiscal Impacts for State Agencies

To estimate state's annual procurement of less than 4-foot linear fluorescent lamps, staff used the proportional values between less than 4-foot and 4-foot linear fluorescent lamps from the US DOE's data for the inventory of lamps in the commercial buildings[54] and applied it to the annual lighting procurement data from the DGS. Based on this information, it is estimated that state agencies purchase an average of 1,923 less than 4-foot linear fluorescent lamps annually.

It is assumed that the state electricity rate is similar to other commercial consumers' rate which is an average rate of $0.1490 per kWh. Therefore, the proposed regulations are expected to annually save about $5,600 and acquire an additional cost of approximately $74,000 to procure compliant products.

The CEC's Office of Compliance Assistance and Enforcement is responsible for the investigation and enforcement of appliance efficiency and flexible demand technology standards. According to staff in this unit, the potential number of infractions with proposed GSFL standards is too uncertain to estimate. Specifically with these proposed GSFL standards, the CEC will absorb any increase in staff time to investigate and enforce those standards.

Fiscal Impacts for Local Agencies

The estimated annual procurements of less than 4-foot lamps are used for estimating the annual cost impacts of the proposed regulations to California's local government agencies. It is assumed that the number of lamps used in office buildings are directly proportional to the number of their employees. To extrapolate the annual procurements of less than 4-foot lamps for local governmental agencies, staff scaled the annual procurement of less than 4-foot lamps for the state based on the ratio of the number of employees that work for local agencies over the number of state employees.

54 2015 US Lighting Market Characterization: https://www.energy.gov/sites/prod/files/2017/12/f46/lmc2015_nov17.pdf.

The total number of local government employees is 2,016,334 using the State Controller's Government Compensation data.[55] Local government employment is 7.78 times greater than those employed by the State of California. Therefore, local state agencies are expected to procure about 15,000 lamps annually. As a result, local government agencies will save about $44,000 annually for their reduced electricity use and will acquire about $575,000 annually in additional cost to procure compliant lamps.

The additional initial costs for the compliant lamps will be fully paid off by the cost of the electricity saved in about 12 years which is less than the life of the compliant lamps (19 years).

The proposed regulations do not impose any enforcement or compliance costs on local governments and therefore this analysis finds that no potential exists for a cost reimbursement to local governments.

55 The State Controller's Government Compensation in California: https://publicpay.ca.gov/.

APPENDIX D: Energy Savings and Cost Analysis

This appendix explains the approach CEC staff used for estimating the energy savings, incremental costs, and consumer utility bill savings. The proposed energy efficiency standards for the linear fluorescent lamps exempted from federal standards and for less than 4-foot linear lamps would significantly reduce energy consumption in the state. CEC staff analyzed the cost effectiveness of the proposed efficiency standards for linear fluorescent lamps and for less than 4-foot linear lamps, to ensure that the energy saving benefits over the lifetime of a compliant lamp would exceed the increased incremental cost or price of the lamp and other relevant incremental costs such as installation and ballast disposal. In addition to the cost analysis, this appendix includes the estimated statewide electricity savings for both the first year the proposed standards are in effect and after all existing stock of noncompliant lamps are replaced with the more efficient compliant lamps.

Stocks and Sales

CEC staff estimated the stock of 4-foot and 8-foot T12 lamps using an inventory of lamps from 2010 and 2015 in U.S. Department of Energy (DOE) LMC reports. CEC staff used the lamps' average lifetimes to extrapolate the stock and annual sales growth rates and project the national stock levels and annual sales of the 4-foot and 8-foot T12 lamps. California's stock levels and shipments were estimated using a simple scaling of 12.09 percent. This scaling percentage reflects the ratio of California's population to the United States population, and it is applied to the estimated national stock levels and shipments. It is assumed that 85 percent of 8-foot lamps are standard output and 15 percent are high output.

Table 39: Projected Stocks and Shipments of Linear Fluorescent Lamps in 2021 (in thousands)

	4-foot T12	8-foot SO T12	8-foot HO T12	Less than 4-foot, T12	Less than 4-foot, T8	Less than 4-foot, T5
National Stock	346,363	14,827	2,617	526.42	26,683	84,830
California Stock	41,887	1,793	316	63.66	3,227	10,259
National Shipment	33,174	1,935	341	79.32	7,042	2,684
California Shipment	4,012	234	41	9.59	852	22,196

Source: CEC high output lamps which are assumed to be replaced by T8 fluorescent type lamps.

Although LED lamps have higher initial cost than fluorescent lamps, they offer higher energy savings and are overall more cost effective due to their higher levels of energy efficiency and their longer lifetimes.

To calculate the annual energy consumption of each light fixture, the power consumption for the fixture is multiplied by its average hours of operation per year. The light fixture's annual energy consumption is then divided by the number of lamps in each light fixture to obtain the average annual energy consumption for each lamp.

Table 40 shows the average power consumption of the non-compliant lamps that are used as the baseline.[56] **Table 41** lists the power consumption for the replacement lamps that are compliant with the proposed standards. For less than 4-foot linear lamps, the power consumption of 2-foot lamps is used.

The annual average hours of operations is 2,591.5 and this figure is obtained from the weighted average daily operating hours by end-use sector in DOE's 2015 LMC report.[57]

Table 40: Average Power Use per Unit for Non-Compliant Lamps

Lamp Type	Number of lamps per fixture	Lamp's Power (W)	Fixture's Power (W)
4-foot T12	2	40	94
8-foot Standard Output T12	2	73	173
8-foot High Output T12	2	110	257
Less than 4-foot T12	2	20	56
Less than 4-foot T8	2	17	33
Less than 4-foot T5	2	14	34

Source: CEC staff

56 Default fixture wattage reference table from Commonwealth Edison Electric Company: https://webtools.dnvgl.com/projects62/Portals/3/TA_Files/PY7_FixtureWattage_Table_v08.pdf.

57 2015 U.S. Lighting Market Characterization: https://www.energy.gov/sites/prod/files/2017/12/f46/lmc2015_nov17.pdf.

Table 41: Average Power Use per Unit for Compliant Lamps

Lamp Type	Number of Lamps per Fixture	Lamp's Power (W)	Fixture's Power (W)
4-foot T8	2	32	59
4-foot LED	2	15	30
8-foot Standard Output T8	2	50	109
8-foot Standard Output LED	2	36	72
8-foot High Output T8	2	86	160
Less than 4-foot LED	2	9	18

Source: CEC, when a non-compliant lamp is replaced with a compliant fluorescent or LED lamp individually.

CEC staff evaluated the overall energy savings when all non-compliant lamps are replaced by using estimates of the portion of lamps replaced with fluorescent and LED lamps. Staff used the shipment trend of linear lamps from the lamp indices published by NEMA and the linear projection methodology recommended by the California Investor Owned Utilities' (IOUs) Codes and Standards Enhancement (CASE) Team to extrapolate the share of each replacement lamp technology from 2021 to 2031.[58]

Table 42: Average Energy Use per Unit

Lamp Type	Energy Use - Baseline (KWh/yr/unit)	Energy Use – Compliant T8 (KWh/year/unit)	Energy Use – Compliant LED (KWh/yr/unit)	Energy Savings (KWh/yr/unit)
4-foot T12	121.8	76.4	38.9	T8: 45.4 LED: 82.9
8-foot Standard Output T12	224.2	141.2	93.3	T8: 83.0 LED: 130.9
8-foot High Output T12	333.0	207.3	-	125.7
Less than 4-foot T12	72.6	-	23.3	49.3
Less than 4-foot T8	42.8	-	23.3	19.5
Less than 4-foot T5	44.1	-	23.3	20.8

Source: CEC staff

58California Investor-Owned Utilities Comments and Analysis of Standards Proposal for Federally Exempted Linear Fluorescent Lamps https://efiling.energy.ca.gov/GetDocument.aspx?tn=223575&DocumentContentId=53663.

Table 43: Overall Energy Savings from Annual Sales

Lamp Type	Annual Sales in 2021 (Thousands)	Replacement: Compliant T8	Replacement: Compliant LED	Energy Saving from Annual Sale (GWh/yr)
4-foot Standard Output T12	4,012	62%	38%	239.7
8-foot Standard Output T12	234	62%	38%	23.7
8-foot High Output T12	41	100%	-	5.2
Less than 4-foot T12	10	-	100%	0.5
Less than 4-foot T8	852	-	100%	16.6
Less than 4-foot T5	2,684	-	100%	55.7
Total	7,833	-	-	341.4

Source: CEC staff

Lifecycle Energy Savings and Cost Savings

For the state-regulated GSFLs, CEC staff assumed that none of the T12 linear fluorescent lamps that are currently on the market would be able to comply with the proposed standards. Moreover, staff assumed that none of the linear fluorescent lamps on the market comply with the proposed efficiency levels.

The energy savings for the linear fluorescent lamps are determined by the difference in the energy efficiency of linear fluorescent lamps that are on the market today and the energy efficiency of the lamps replacing them that are compliant with the proposed regulations. Lifecycle energy savings is estimated using each unit's energy savings throughout the expected life of the replaced lamp.

Incremental costs are the initial additional costs that consumers pay for installing a compliant product in place of a non-compliant product. The cost of the compliant lamps in this analysis includes the cost for the parts, installation, sales tax, and disposal of the removed ballasts. In this report, all disposed ballasts are assumed to be magnetic. This assumption leads to more conservative cost estimates because pre-1979 magnetic ballasts may contain polychlorinated biphenyls (PCBs), which are toxic materials regulated by the U.S. Environmental Protection Agency (USEPA). The USEPA requires fluorescent light ballasts not stamped with "No PCBs" to be considered as containing PCB.[59] Hence, magnetic ballasts have a higher average disposal cost than electronic ballasts.

Table 44 shows the per-unit lifecycle cost savings and the incremental costs for the various lamp replacements. The proposed standards are very cost effective with the benefit-to-cost ratio ranging from 1.5 to 8.4, and results in a relatively short time period for the savings to compensate for the initial incremental cost.

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59 EPA, Storage and Disposal: Ballasts https://www3.epa.gov/region9/pcbs/ballast.html.

Table 44: Costs and Benefits per Unit

Lamp Type	Design Life Baseline (years)	Design Life Compliant (years)	Life-Cycle Energy Saving (KWh/unit)	Lifecycle Cost Saving ($/unit)	Incremental Cost ($/unit)	Net Benefit Ratio (Benefit/Cost)
4-foot Standard Output T12	8	T8: 12 LED: 19	T8: 544.8 LED: 1,575.1	T8: $83.19 LED: $238.75	T8: $35.58 LED: $38.69	T8: 2.3 LED: 6.2
8-foot Standard Output T12	5	T8: 9 LED: 19	T8: 747 LED: 2,487.1	T8: $153.01 LED: $497.21	T8: $52.31 LED: $59.12	T8: 2.9 LED: 8.4
8-foot High Output T12	5	8	1005.6	$144.49	$74.00	1.9
Less than 4-foot T12	3	19	934.8	$165.64	$36.01	4.6
Less than 4-foot T8	10	19	369.4	$56.46	$38.48	1.5
Less than 4-foot T5	11	19	393.9	$61.15	$37.41	1.6

Source: CEC staff

Table 45 shows the overall estimated energy and cost savings for the first year after the proposed standards are effective and after the entire stock has turned over. The proposed standards save an estimated 2,895 GWh of electricity per year after the stock is turned over. That translates to more than $428 million in electricity cost savings per year, through reduced utility bills, after the entire stock is turned over.

This analysis also indicates that the proposed standards will save a significant amount of energy, in addition to being cost effective and technically feasible.

Table 45: First Year and Stock Net Energy and Cost Savings

Lamp Type	Unit Stock (thousands)	First Year Energy Savings (GWh/yr)	Stock Energy Savings (GWh/yr)*	Weighted Average Electricity Rates ($/KWh)	First Year Monetary Savings ($M/yr)	Annual Monetary Savings ($M/yr)*
4-foot T12	41,887	239.7	1,870.4	0.149	$35.7	$278.7
8-foot Standard Output	1,793	23.7	91.9	0.137	$3.2	$12.6
8-foot High Output	316	5.2	18.3	0.137	$0.7	$2.5
Less than 4-foot T12	64	0.5	1.1	0.147	$0.07	$0.2
Less than 4-foot T8	3,227	16.6	196.4	0.147	$2.4	$28.9
Less than 4-foot T5	10,259	55.7	717.3	0.147	$8.2	$105.4
Total	**57,546**	**341.4**	**2,895**	**-**	**$50.27**	**$428.3**

* After stock turn over

Source: CEC staff

APPENDIX E: List of Acronyms

Original Term	Acronym/Abbreviation
AVoided Emissions and geneRation Tool	AVERT
Bureau of Economic Analysis	BEA
Bureau of Labor Statistics	BLS
California Energy Commission	CEC
Carbon Dioxide	CO_2
Color Rendering Index	CRI
Computable General Equilibrium	CGE
Consumer Expenditure	CE
Department of Energy	DOE
Department of Finance	DOF
Electric Generating Unit	EGU
Energy Information Administration	EIA
Estimated Useful Life	EUL
General Service Fluorescent Lamp	GSFL
Gigawatt hours	GWh
Greenhouse Gas	GHG
Gross Domestic Product	GDP
Gross State Product	GSP
Impact Analysis for Planning	IMPLAN
kilowatt/kilowatt-hours	kW/kWh
Lighting Market Characterization	LMC
Million British thermal units	MMBtu
Nitrogen Oxides	NO_x
Pacific Gas and Electric	PG&E
Particulate Matter	$PM_{2.5}$
Regional Economic Models, Inc	REMI
Regional Input-Output Modeling Systems	RIMS-II
Standardized Regulatory Impact Assessment	SRIA
Sulfur Dioxide	SO_2

APPENDIX F: References

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