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California Energy Commission

**CONSULTANT REPORT**

# Revised Standardized Regulatory Impact Assessment:

# Computers, Computer Monitors, and Signage Displays

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**California Energy Commission**
Edmund G. Brown Jr., Governor

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# California Energy Commission

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# ABSTRACT

This Standardized Regulatory Impact Assessment (SRIA) analyzes the economic impacts of the California Energy Commission's 2016 proposed efficiency standards for computers, computer monitors, and signage displays. The standards are designed to reduce the use of electricity in notebooks, desktops, small-scale servers, workstations, monitors, and electric signage displays. Based on staff analysis, the standard is expected to save California consumers and businesses approximately 2.3 terawatt hours per year once the existing stock of regulated products has turned over. Valued at projected electricity prices, this translates into approximately $350 million per year in direct net savings.

The analysis also uses the Berkeley Energy and Resources computable general equilibrium model to estimate the macroeconomic impacts of the proposed standard, two regulatory alternatives, and six sensitivity scenarios. The net electricity savings is also expected to have a modest positive impact on gross state product, business output, employment, real household income, and investment.

**Keywords**: Appliance Efficiency Regulations, Standardized Regulatory Impact Assessment, Computer, Monitor, Signage Display

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# EXECUTIVE SUMMARY

This report was prepared by researchers at the University of California, Berkeley, in compliance with the rulemaking requirements for major regulations set forth in Senate Bill 617 (Calderon, Chapter 496, Statutes of 2011). The analysis presented here evaluates the economic impacts of new efficiency standards for computers, computer monitors, and signage displays proposed by the California Energy Commission. The standards would require manufacturers of notebooks, desktops, small-scale servers, workstations, and monitors to comply with minimum product energy efficiency levels.

The direct costs and savings calculations that serve as the inputs to the macroeconomic analysis were prepared in consultation with Energy Commission staff. Staff prepared the engineering and market data based on several rounds of stakeholder engagement. Detailed background information on the proposed regulation, including regulated products and details on market and engineering data sources, is available in the March 30, 2016, *Final Draft Staff Report for Computers, Computer Monitors, and Signage Displays.*[1]

The macroeconomic impacts of the Energy Commission's proposal were evaluated using the Berkeley Energy and Resources computable general equilibrium model. The model is a dynamic forecasting model of the California economy that generates estimates for a wide range of macroeconomic variables, including gross state product, employment, enterprise output, household income, and investment.

Model results show that, relative to a baseline, the Energy Commission's proposed standard would increase the gross state product by 0.014 percent in 2030 and create more than 12,000 jobs from 2018 to 2030. The proposal is also expected to result in modest increases in household income of 0.016 percent to 0.044 percent. Lower-income households that spend a higher proportion of their income on electricity are expected to benefit slightly more than other household groups.

In addition to the proposed standard, this economic analysis evaluated two regulatory alternatives. One alternative was more stringent, providing greater benefits to the proposed standard. The other standard was less stringent, but the lower benefits were provided at a lower cost. Both alternatives were rejected in favor of the proposed standard. In addition to these two alternatives, the analysis also considered three sets of sensitivity analysis (six total scenarios) to explore the impacts of potential uncertainty around key assumptions. None of the sensitivity scenarios suggested major differences in the conclusions of the assessment.

1 Final staff report available at http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN210913_20160330T161602_Final_Draft_Staff_Report_for_Computers_Computer_Monitors_and_Si.pdf.

# CHAPTER 1: Introduction

## Statement of Need for Proposed Regulation

The Warren-Alquist Act establishes the California Energy Commission as California's primary energy policy and planning agency and mandates the Commission to reduce the wasteful and inefficient consumption of energy and water in the state by prescribing standards for the minimum levels of operating efficiency for appliances that consume a significant amount of energy or water statewide.

This Standardized Regulatory Impact Assessment (SRIA) analyzed the economic impact of introducing new efficiency standards for computers, computer monitors, and signage displays. The proposed performance standards would amend the Appliance Efficiency Standards (Title 20, Code of Regulations, Sections 1601-1609). The proposed regulation covers desktops, notebooks, workstations, small-scale servers, thin clients, computer monitors, and signage displays.

The proposed efficiency standards require compliance beginning January 1, 2018. This SRIA assesses the economic impacts of the proposal from 2018 through 2030. Using 2030 as a final year for analysis allows for consistency in comparing the Energy Commission's proposal to other state planning objectives, such as Governor Edmund G. Brown Jr.'s 2030 goals for reducing greenhouse gas emissions through increasing renewable energy, reducing petroleum consumption, and doubling expected savings from energy efficiency. Both compliance costs and benefits of the proposal accrue for the duration of the assessment period.

Results from this SRIA suggest that Energy Commission's proposed regulations are cost-effective and deliver a moderate stimulus to the California economy. Gross state product (GSP) is anticipated to increase by approximately 0.014 percent in 2030 relative to the baseline, and other macro indicators, such as job creation, are also anticipated to increase slightly. The policy is expected to have a moderate positive impact on household income, with slightly greater benefits accruing to lower income households. This is due to the higher expenditure shares towards electricity in lower income households.

The Energy Commission's proposal results in a 0.06 percent reduction in greenhouse gas emissions from the electric power sector in 2030 due to lower demand for regulated products.

## Major Regulation Determination

The proposed regulation is expected to result in electricity savings and incremental product costs to both California consumers and businesses that exceed the $50 million threshold over a 12-month period that requires the completion of a SRIA. Total electricity savings are expected to exceed 2 terawatt hours per year once the existing stock of computers and monitors is replaced, which valued at projected electricity prices results in an aggregate gross savings of over $440 million per year. Gross direct costs to California consumers and businesses are expected to be approximately $100 million per year.

## Baseline Information

Currently, none of the product categories included in the proposed regulation is required to comply with other state or federal energy efficiency standards. However, a percentage of the products covered by the proposal are already compliant with the Energy Commission's proposed standards. The baseline assumes that the current compliance rate for each product category remains fixed at current levels over the 2018 to 2030 analysis period.

California recently committed to increasing the percentage consumption of electricity from renewable resources from 33 percent to 50 percent between 2020 and 2030 (SB 350, DeLeón; Chapter 547, Statutes of 2015). The environmental benefits and electricity expenditure savings expected from the proposed regulation are directly related to the state's electricity portfolio. The baseline scenario for this SRIA assumes that the state's electricity portfolio is compliant with the RPS requirements outlined in SB350, assuming a linear phase-in of additional renewable generation from 2020 to 2030. Uncertainty surrounding the future price of electricity is analyzed in a sensitivity analysis.

## Public Outreach and Input

The Energy Commission requested input from stakeholders and the public on multiple occasions for this rulemaking. The Energy Commission first published a draft staff report and on April 15, 2015, held a public workshop to receive input on the draft proposed regulations. After publishing a revised staff report incorporating stakeholder feedback, the Energy Commission held a second staff workshop on April 26, 2016, to solicit another round of stakeholder and public comments. All documents associated with these staff workshops are available to the public on the Energy Commission's website, under docket number 14-AAER-02.[2]

2 https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=14-AAER-02.

# Chapter 2: Direct Costs and Benefits

The proposed appliance standards are anticipated to deliver considerable electricity savings to individuals and businesses in California. The initial incremental costs of manufacturing compliant computer and monitor products are expected to be considerably less than the anticipated lifetime benefits, resulting in a highly cost-effective energy efficiency proposal.

This section outlines the anticipated direct costs and benefits to Californians from the proposed regulation. Costs and benefits are presented separately for individuals and businesses. Indirect impacts and macroeconomic effects are presented in Section 3.

## Methodology and Assumptions

Both the projected costs and electricity savings are a function of the market trajectory for the regulated products. **Table 1** shows the assumptions for initial product stock levels, initial annual shipments of new products to California consumers, the growth rate of new product purchases, and the expected product life cycle. Market and product assumptions are based on industry data provided to Energy Commission staff during the stakeholder engagement process. It is assumed that the costs and savings of the proposed regulations begin in 2018, consistent with the Energy Commission's target implementation date for the proposed standard.

**Table 1: Assumptions for Regulated Product Market Growth**

| Product Category | Initial Stock (millions) | Shipments (millions) | Growth Rate | Product Life (years) |
|---|---|---|---|---|
| Desktops | 23.40 | 4.62 | -0.7% | 5 |
| Notebooks | 21.00 | 5.30 | 0.6% | 4 |
| Small-Scale Servers | 0.30 | 0.06 | 0.0% | 5 |
| Workstations | 0.53 | 0.11 | 0.0% | 5 |
| Monitors | 21.20 | 3.60 | 0.0% | 6.6 |

Source: Energy Commission staff

Based on these assumptions, a market trajectory was estimated for each regulated product (**Table 2**). As a sensitivity analysis, alternative product growth rate assumptions were analyzed (described in detail below).

**Table 2: Product Stock Forecasts (million units)**

| | Desktops | Notebooks | Small-Scale Servers | Workstations | Monitors |
|---|---|---|---|---|---|
| 2018 | 22.3 | 21.9 | 0.3 | 0.5 | 21.2 |
| 2019 | 22.1 | 22.0 | 0.3 | 0.5 | 21.2 |
| 2020 | 22.0 | 22.2 | 0.3 | 0.5 | 21.2 |
| 2021 | 21.8 | 22.3 | 0.3 | 0.5 | 21.2 |
| 2022 | 21.7 | 22.4 | 0.3 | 0.5 | 21.2 |
| 2023 | 21.5 | 22.6 | 0.3 | 0.5 | 21.2 |
| 2024 | 21.4 | 22.7 | 0.3 | 0.5 | 21.2 |
| 2025 | 21.2 | 22.8 | 0.3 | 0.5 | 21.2 |
| 2026 | 21.1 | 23.0 | 0.3 | 0.5 | 21.2 |
| 2027 | 20.9 | 23.1 | 0.3 | 0.5 | 21.2 |
| 2028 | 20.8 | 23.2 | 0.3 | 0.5 | 21.2 |
| 2029 | 20.6 | 23.4 | 0.3 | 0.5 | 21.2 |
| 2030 | 20.5 | 23.5 | 0.3 | 0.5 | 21.2 |

Source: Energy Commission staff

Electricity savings and incremental costs of compliance for each product category were estimated by Energy Commission staff (**Table 3**). The statewide annual energy savings from the proposed regulation are estimated as the anticipated unit energy savings multiplied by the product stock, adjusting for stock that already complies with the proposed standards (and therefore would not be expected to benefit from any energy savings). Average unit energy consumption was calculated from a large database of computer models. This formed the baseline unit energy consumption. Then the energy consumption was altered for units that did not comply to a level where they would barely comply. For models that already complied, no modifications were made. The resulting average produces the unit energy consumption after the standard. The inclusion of models that comply in the average unit consumption calculation accounts for compliance in existing products even though a specific compliance rate is not used in the calculation.

As an example, consider the average energy usage of desktop computers. Assume that there are 5 models with different levels of baseline energy usage (**Table 3**). Also assume that the regulation requires desktops to meet a 50kWh/year energy standard. Models 1, 2, and 4 are not compliant with the standard and will be required to make adjustments to reduce energy usage to 50 kWh/year. Models 3 and 5 are over-compliant in the baseline and are assumed to maintain their baseline performance after the regulation goes into effect. The difference ("delta") in average baseline energy usage (50.8 kWh/year) and average energy usage after all models comply with, or exceed, the standard (49.4 kWh/year) is then multiplied by the projected desktop shipments (**Table 2**) to provide an estimated average energy savings in a given year.

**Table 3: Example for Energy Usage Calculation**

| Model # | Energy Usage (kWh/year) | |
|---|---|---|
| | Baseline | Regulation |
| 1 | 52 | 50 |
| 2 | 53 | 50 |
| 3 | 48 | 48 |
| 4 | 52 | 50 |
| 5 | 49 | 49 |
| **Average** | **50.8** | **49.4** |

The energy savings is monetized using Energy Commission forecasted electricity rates. Statewide annual costs are the incremental unit costs multiplied by new product purchases. Costs are assumed to pass-through to consumers of the regulated products and manufacturing is expected to occur outside of California. Some aspects of the engineering design process could occur within California for certain companies; however, the incremental costs incurred from the proposed standard are not expected to affect these operations.

**Table 4: Savings and Costs from Proposed Performance Standard**

| Product Category | Annual Energy Savings (kWh/unit) | | | Incremental Cost ($/unit) | | |
|---|---|---|---|---|---|---|
| | Proposed | More Stringent | Less Stringent | Proposed | More Stringent | Less Stringent |
| Desktops | 77.4 | 78.6 | 44.1 | $18 | $20 | $6 |
| Notebooks | 3.6 | 3.6 | 3.6 | $1 | $1 | $1 |
| Small-Scale Servers | 24.0 | 24.0 | 24.0 | $13 | $13 | $13 |
| Workstations | 37.4 | 37.4 | 37.4 | $13 | $13 | $13 |
| Monitors | 27.75 | 32.9 | 18.6 | $5 | $10 | $0 |

Source: Energy Commission staff

The total direct costs and savings to Californians are shown in **Table 4**. The proposal is cost effective, with a benefit-cost ratio of 4.2 to 4.5 (total benefits/total costs) once the stock has fully turned over. Benefit-cost ratios are lower in the first few years after the standard is implemented (0.8 to 3.3), due to lower electricity savings from the existing stock of computers and monitors. This benefit-cost ratio excludes any environmental and public health impacts, which are assessed in Chapter 3.

**Table 5: Aggregate Cost and Savings (million 2013$)**

| | Proposed | | More Stringent | | Less Stringent | |
|---|---|---|---|---|---|---|
| Year | Reduced Electricity Cost | Compliance Cost | Reduced Electricity Cost | Compliance Cost | Reduced Electricity Cost | Compliance Cost |
| 2018 | $82 | $105 | $86 | $132 | $50 | $34 |
| 2019 | $167 | $104 | $176 | $131 | $103 | $34 |
| 2020 | $257 | $104 | $270 | $130 | $158 | $34 |
| 2021 | $344 | $103 | $361 | $130 | $211 | $34 |
| 2022 | $428 | $103 | $450 | $129 | $262 | $33 |
| 2023 | $445 | $102 | $471 | $129 | $274 | $33 |
| 2024 | $446 | $102 | $472 | $128 | $274 | $33 |
| 2025 | $447 | $101 | $473 | $128 | $275 | $33 |
| 2026 | $448 | $101 | $474 | $127 | $276 | $33 |
| 2027 | $449 | $100 | $475 | $126 | $276 | $33 |
| 2028 | $450 | $100 | $476 | $126 | $277 | $33 |
| 2029 | $451 | $99 | $477 | $125 | $278 | $32 |
| 2030 | $452 | $99 | $478 | $125 | $278 | $32 |

Source: Energy Commission Staff

## Direct Costs and Benefits to Individuals

Individuals in California are expected to incur both costs and benefits from the proposed efficiency standards. The assumed incremental unit cost to improve the efficiency of each product is assumed to pass through to consumer purchases of these goods. Based on industry data, approximately 40 percent of total computer and monitor purchases are by residential consumers. Based on the total direct cost results presented in **Table 4**, this translates into an approximate cost to residential consumers of $40 million to $43 million per year.

For an individual consumer, the net benefit of the proposed regulation is the difference between additional cost incurred when purchasing a regulated product and the savings on electricity spending over the lifetime of that product. For example, a desktop computer consumer would pay approximately $18 more for the computer upon purchase, and then save approximately 77.4 kWh/year for the life of the product. If the consumer pays 19¢/kWh for electricity (based on the Energy Commission's 2018 projected price for residential consumers), then the consumer would save $14.91 per year. Assuming that the product has a useful life of five years, the consumer saves $73.53 in electricity spending. The net benefit to the consumer over the lifetime of the product is $55.53 ($73.53 to $18), excluding any net present value adjustment. The bulk of the savings comes from reduced electricity consumption from desktops, and a smaller portion of savings come from monitor use. Aggregate savings to consumers are shown in **Table 5**.

**Table 6: Statewide Consumer Savings on Electricity Consumption (million 2013$)**

| | Desktops | Notebooks | Small-Scale Servers | Workstations | Monitors | Total |
|---|---|---|---|---|---|---|
| 2018 | 26 | 1.6 | 0.1 | 0.3 | 7.6 | 36 |
| 2019 | 54 | 3.2 | 0.2 | 0.6 | 15.6 | 74 |
| 2020 | 83 | 4.9 | 0.4 | 1.0 | 23.9 | 113 |
| 2021 | 111 | 6.6 | 0.5 | 1.3 | 32.2 | 152 |
| 2022 | 139 | 6.7 | 0.6 | 1.6 | 40.5 | 189 |
| 2023 | 139 | 6.8 | 0.6 | 1.7 | 48.0 | 196 |
| 2024 | 139 | 6.9 | 0.6 | 1.7 | 48.3 | 197 |
| 2025 | 139 | 7.0 | 0.6 | 1.7 | 48.6 | 197 |
| 2026 | 139 | 7.1 | 0.6 | 1.7 | 49.0 | 197 |
| 2027 | 139 | 7.1 | 0.6 | 1.7 | 49.3 | 198 |
| 2028 | 139 | 7.2 | 0.6 | 1.7 | 49.6 | 198 |
| 2029 | 139 | 7.3 | 0.6 | 1.7 | 50.0 | 199 |
| 2030 | 139 | 7.4 | 0.6 | 1.7 | 50.3 | 199 |

Source: Energy Commission Staff

Distributional economic costs and savings will be addressed in Chapter 3.

## Direct Costs and Benefits to California Businesses

As with individuals, California businesses are also expected to accrue both costs and benefits from the proposed regulation. For businesses that are consumers of the regulated products, costs are expected to be approximately $58 million to $62 million per year (assuming that businesses account for approximately 60 percent of computer and monitor purchases). Expected benefits from reduced electricity consumption are expected to be approximately $280 million to $290 million per year, once the stock has turned over (**Table 6**). As with individuals, the bulk of these savings come from lower energy use in desktops and monitors, with the remainder of savings coming from notebooks, small-scale servers, and workstations.

**Table 7: Statewide Business Savings on Electricity Consumption (million 2013$)**

| | Desktops | Notebooks | Small-Scale Servers | Workstations | Monitors | Total |
|---|---|---|---|---|---|---|
| 2018 | 33 | 1.9 | 0.1 | 0.4 | 9.9 | 46 |
| 2019 | 68 | 4.0 | 0.3 | 0.8 | 20.4 | 94 |
| 2020 | 104 | 6.2 | 0.4 | 1.2 | 31.4 | 144 |
| 2021 | 140 | 8.3 | 0.6 | 1.6 | 42.1 | 192 |
| 2022 | 175 | 8.4 | 0.8 | 2.1 | 53.0 | 239 |
| 2023 | 175 | 8.5 | 0.8 | 2.1 | 62.9 | 249 |
| 2024 | 175 | 8.6 | 0.8 | 2.1 | 63.3 | 250 |
| 2025 | 175 | 8.8 | 0.8 | 2.1 | 63.7 | 250 |
| 2026 | 175 | 8.9 | 0.8 | 2.1 | 64.1 | 251 |
| 2027 | 175 | 9.0 | 0.8 | 2.1 | 64.6 | 251 |
| 2028 | 175 | 9.1 | 0.8 | 2.2 | 65.0 | 252 |
| 2029 | 175 | 9.2 | 0.8 | 2.2 | 65.4 | 252 |
| 2030 | 175 | 9.3 | 0.8 | 2.2 | 65.9 | 253 |

Source: Energy Commission Staff

Some businesses in California are involved in the manufacture and distribution of products covered by the proposal. The performance standards are set in a way that gives the industry compliance flexibility. A number of technically feasible options currently exist for all product categories to achieve the proposed efficiency levels (**Table 7**).[3] It is possible that certain individual businesses may experience higher or lower compliance costs for their products, affecting their competitive position in the market. However, the flexibility in compliance options is designed to avoid this outcome by allowing manufacturers to choose the least-cost compliance pathway.

3 Detailed descriptions of the various compliance options are available in the March 2016, Energy Commission Staff Report, "Revised Analysis of Computers, Computer Monitors, and Signage Displays" (California Energy Commission 2016) http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN210913_20160330T161602_Final_Draft_Staff_Report_for_Computers_Computer_Monitors_and_Si.pdf.

**Table 8: Technically Feasible Compliance Options**

| Product Category | Description | Availability |
|---|---|---|
| Desktops and Notebooks | Improved hard disk subcomponents | Currently available |
| | Improved power supplies | Currently available |
| | Introduction of deeper "C" state | Currently available |
| | Improved optical disk drive power management modes | Currently available |
| | Volatile memory (RAM) | Currently available |
| | Motherboard | Currently available |
| | Improved discrete graphics card | Currently available |
| | Improved software management and organization of system resources | Currently available |
| | Power management enabled | Currently available |
| | More efficient display (for integrated displays) | Currently available |
| Small-scale servers and Workstations | Efficient power supplies | Currently available |
| | Energy Efficient Ethernet | Currently available |
| Monitors | Higher efficiency light-emitting diode (LED) backlights | Currently available |
| | Improved optical film | Currently available |
| | High transmittance screen technologies | Currently available |
| | Efficient power supplies | Currently available |
| | Automatic brightness control | Currently available |
| | Quantum dots technology | Emerging |
| | Organic LEDs that do not require backlight of light filters | Emerging |

Source: Energy Commission staff

Small businesses, like other businesses that use computers and monitors, are expected to benefit from the anticipated electricity savings resulting from the efficiency standards. Like other business enterprises, small businesses will also incur an additional cost when purchasing products covered under the standard. The net effect is expected to be an overall savings in electricity spending. The proposal is not expected to result in savings or costs that disproportionately impact small businesses.

The Energy Commission included an exemption in the proposed regulation for small businesses that manufacture products covered by the proposal. The small business definition in the proposed standard is different than the official California small business definition (California Government Code § 11342.610). The proposed exemption is based on a company's gross revenue and the volume of sales of regulated products, whereas the state definition for manufacturing enterprises is based on number of employees. There is still likely to be some overlap in the two definitions, in which case those businesses would not be subject to any of the costs likely to be incurred by other manufacturers. Small businesses, using the state's definition, that are not covered by the proposed exemption are expected to follow the same manufacturing standards as other businesses enterprises.

# Chapter 3: Economic Impacts

## Methodology for Determining Economic Impact

The economy-wide results of the proposed regulations are assessed using the Berkeley Energy and Resources (BEAR) model. The BEAR model is a dynamic economic forecasting model for evaluating long-term growth prospects for California. The model is an advanced policy simulation tool that models demand, supply, and resource allocation across the California economy, estimating economic outcomes annually over the period 2015 to 2030. This kind of computable general equilibrium (CGE) model is a state-of-the-art economic forecasting tool, using a system of equations and detailed economic data that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also included, with varying degrees of detail, to close the model and account for economy-wide resource allocation, production, and income determination.

BEAR is calibrated to 2013 economic activity data of the California economy and includes highly disaggregated representation of firm, household, employment, government, and trade behavior (see **Table A.2** in Annex A). For this SRIA, the model is aggregated to 60 sectors that are of particular relevance to the economic activities most likely impacted by the proposed regulation (see **Table A.3** in Annex A). The model's 2015 to 2030 baseline is calibrated to California Department of Finance economic and demographic projections.[4]

## Policy Scenarios

This SRIA considers the economic impacts of the proposed regulation, two regulatory alternatives, and three sensitivity scenarios. The two regulatory alternatives include a more stringent alternative with higher benefits and a less stringent alternative with lower benefits. The more stringent alternative includes a slightly higher annual energy savings for desktops (78.6 versus 77.4 kWh/year) and monitors (32.9 versus 27.75 kWh/year). The savings come at a higher incremental cost of $20 versus $18 per unit and $10 versus $5 per unit for desktops and monitors, respectively. This alternative is meant to represent the maximum efficiency possible through existing technologies, whether or not it is cost-effective. The less stringent alternative is similar to the existing ENERGY STAR® standard. The energy savings is lower for desktops and monitors (44.1 kWh/year and 18.6 kWh/year, respectively) but the incremental compliance costs are also expected to be lower ($6/unit and $0/unit, respectively). This alternative is based on efficiency levels proposed by stakeholders in comments following the first Energy Commission staff analysis.

4 A baseline comparison of BEAR and DOF forecasts for key economic variables is available upon request.

The anticipated costs and benefits of the proposed regulation are subject to several areas of uncertainty, which are considered in three sensitivity analyses. First, the anticipated reduction in electricity expenditures is based on the projected price of electricity for residential and commercial users. A high and low electricity price sensitivity is considered. The ranges for electricity prices are taken from the Energy Commission's California Energy Demand 2016-2026, Revised Electricity Forecast, Table 6 (CEC-200-2016-001-V1, p. 35). An electricity price forecast that includes implementation of SB 350 was not available at the time of this assessment. The high and low price scenarios of the Revised Electricity Forecast are used as proxies for sensitivity analysis of electricity rate uncertainty.

A second sensitivity analysis considers possible variation in anticipated compliance costs, which include high and low value assumptions for the incremental cost of manufacturing desktops and monitors that comply with the proposed performance standards. The high cost scenario reflects concern amongst several industry stakeholders that the Energy Commission has underestimated the cost of producing compliant products. The low cost scenario reflects the possibility that technological improvements will decrease the compliance costs over time.

A third sensitivity analysis considers alternative market growth rates for the regulated products. Since both savings and costs are a function of market stock and new product purchases, these alternate market growth scenarios are likely to affect both the cost and the electricity savings of the proposed regulation.

Additional details on the assumptions used for each sensitivity analysis are available in Annex B.

# Inputs of the Assessment

For the macroeconomic assessment, the direct cost and electricity savings data presented in **Table 4** are used as an input into the BEAR model. Electricity savings is apportioned to households and businesses separately based on the total savings shown in **Table 5** and **6**. This induces expenditure shifting away from direct electricity consumption towards other activities.

Total costs of compliance, shown in **Table 4**, are allocated to the two impacted sectors in the BEAR model. The costs for desktops, notebooks, small-scale servers, and workstations are attributed to the model's dedicated computer and related products sector, while additional monitor costs are attributed to the model's dedicated monitor sector.

# Assumptions and Limitations of the Model

The following assumptions were made for the macroeconomic analysis:

- The baseline economy grows at the long-term rate projected by the California Department of Finance. The labor force is also projected to change according to the Department of Finance's demographic forecast.

- The energy efficiency of regulated products is fixed at current levels in the baseline. There is some evidence that energy efficiency improves over time even without regulatory standards. Exogenous improvements in baseline efficiency would reduce the benefits from lower electricity consumption in the proposal. However, in this case, it is also likely that the assumed compliance costs would be overstated.

- An average compliance cost across a wide range of technically feasible compliance options was assumed. Actual compliance costs for individual manufacturers could be higher or lower.

- Additional compliance costs are assumed to pass through to consumers of regulated computer and monitor products.

- The analysis assumes that users do not change the power management setting on regulated products. Actual energy savings may be different if users change the default power management settings.

- The compliance rate is assumed to be 100 percent for the purpose of this economic analysis. Other appliance regulations typically have a 60 to 90 percent compliance rate.

# Results of the Assessment

Results from the macroeconomic assessment are shown below. In compliance with the SRIA requirements, results from the BEAR model are presented for GSP, employment, business impacts, statewide investment, household income, and environmental impacts. Qualitative discussions on incentives for innovation and competitive advantages and disadvantages are also presented.

## Impacts on Gross State Product

**Table 8** shows the impact of the proposed standards and various sensitivity scenarios on GSP. The standard has an overall positive effect on economic activity in the state once the current stock has fully turned over. The lower energy savings in the first few years of the standards results in a very slight decline in GSP. Both effects are small and expected due to the size of the economic stimulus. Because the electricity savings accumulate over time at a faster rate than the incremental costs, the growth effects expand in later years of the analysis period. The increasing rate of growth over time, relative to the baseline, is also due to the multiplier effects that begin accruing as soon as the policy begins. The positive impact of expenditure shifting due to lower electricity spending is compounded over time.

None of the sensitivities have a dramatic effect on statewide economic activity. As would be expected, scenarios that increase savings relative to costs have a slightly larger positive impact on GSP than scenarios that have increased costs relative to savings. The former include higher projected electricity prices, lower expected compliance costs, and higher expected market growth rates.

**Table 9: Change in Gross State Product from Baseline (2013 $M and %)**

| | | 2020 | | 2025 | | 2030 | |
|---|---|---|---|---|---|---|---|
| **Proposal** | | **-87** | **-0.003%** | **374** | **0.011%** | **636** | **0.014%** |
| **Sensitivity: Electricity Price** | High | -79 | -0.003% | 398 | 0.011% | 674 | 0.015% |
| | Low | -98 | -0.003% | 347 | 0.010% | 596 | 0.014% |
| **Sensitivity: Compliance Cost** | High | -99 | -0.004% | 347 | 0.010% | 592 | 0.013% |
| | Low | -84 | -0.003% | 394 | 0.011% | 685 | 0.016% |
| **Sensitivity: Market Growth** | High | -84 | -0.003% | 386 | 0.011% | 655 | 0.015% |
| | Low | -90 | -0.003% | 362 | 0.010% | 619 | 0.014% |

Source: BEAR model

## California Employment Impacts

The proposed efficiency standards are expected to have a moderate positive impact on overall job creation (**Table 9**). Approximately 5,500 additional jobs (FTE annual) are expected to be created relative to the baseline in 2030. The cumulative change over the analysis period, 2018-2030, is expected to be slightly greater than 12,000 jobs created. Most of the jobs are created towards the end of the analysis period due to the fact that there is a lag of several years in enterprise expansion as consumers spend their additional electricity bill savings on alternative goods and services, and because there is a phase-in period for more efficient products to replace existing stock.

The proposal is not expected to result in the elimination of jobs in the economy. Expenditure shifting by households may result in some short-term employment adjustments, although the aggregate effect, as measured by the model, is positive across sectors. The short-term adjustments are not captured in the general equilibrium model. Employment *growth* in the electricity sector may be slighter lower than in the baseline due to lower electricity demand.

Variation based on the sensitivity scenarios is small. The largest increase in jobs relative to the proposal comes from the high electricity price scenario (~6.4 percent increase). The low electricity price scenario creates the fewest additional jobs (~6.6 percent decline) as a result of the lower savings levels for individuals and businesses.

**Table 10: Change in Employment from Baseline (FTE annual jobs)**

| | | 2030 | Cumulative Change (2018-2030) |
|---|---|---|---|
| **Proposal** | | **5,525** | **12,158** |
| **Sensitivity: Electricity Price** | High | 5,878 | 12,471 |
| | Low | 5,162 | 11,833 |
| **Sensitivity: Compliance Cost** | High | 5,325 | 12,011 |
| | Low | 5,769 | 12,401 |
| **Sensitivity: Market Growth** | High | 5,812 | 12,430 |
| | Low | 5,272 | 11,919 |

Source: BEAR model

## California Business Impacts

In addition to the direct net benefits that energy efficiency standards have for California businesses, the proposal also improves overall business activity in the state (**Table 10**). The net savings are redistributed as a general stimulus throughout the economy. The results suggest that the policy will have very modest positive impact on aggregate business creation.

**Table 11: Change in Real Enterprise Output from Baseline (2013 $M and %)**

| | | 2020 | | 2025 | | 2030 | |
|---|---|---|---|---|---|---|---|
| **Proposal** | | **-20** | **0.000%** | **750** | **0.013%** | **1,189** | **0.017%** |
| **Sensitivity: Electricity Price** | High | -13 | 0.000% | 773 | 0.013% | 1,227 | 0.017% |
| | Low | -28 | -0.001% | 726 | 0.013% | 1,148 | 0.016% |
| **Sensitivity: Compliance Cost** | High | -42 | -0.001% | 705 | 0.012% | 1,118 | 0.016% |
| | Low | -14 | 0.000% | 786 | 0.014% | 1,273 | 0.018% |
| **Sensitivity: Market Growth** | High | -21 | 0.000% | 753 | 0.013% | 1,195 | 0.017% |
| | Low | -13 | 0.000% | 773 | 0.013% | 1,227 | 0.017% |

Source: BEAR model

Lower electricity expenditures resulting from the efficiency standards are expected to have a modest adverse impact on the electricity sector. Sectoral results confirm this (**Table 11**), showing a less than 2 percent reduction in electric power sector output in 2030, relative to the baseline. This result would be expected with any large-scale energy efficiency policy affecting the electric power sector. The slower growth in the electric power sector is partially muted by an overall increase in economic activity resulting from the policy; however, the net sectoral impact is still slightly negative. Nonetheless, there is no expectation that this would eliminate businesses in California.

**Table 12: Percent Change in Sector Output from Baseline in 2030**

| | | Electric Power | Refined Petroleum | Manufacturing | Services | Other |
|---|---|---|---|---|---|---|
| **Proposal** | | **-1.7%** | **0.031%** | **0.06%** | **0.033%** | **-0.05%** |
| **Sensitivity: Electricity Price** | High | -2.0% | 0.032% | 0.06% | 0.034% | -0.05% |
| | Low | -1.5% | 0.030% | 0.06% | 0.031% | -0.05% |
| **Sensitivity: Compliance Cost** | High | -1.7% | 0.031% | 0.05% | 0.032% | -0.05% |
| | Low | -1.7% | 0.030% | 0.06% | 0.033% | -0.05% |
| **Sensitivity: Market Growth** | High | -2.0% | 0.032% | 0.06% | 0.033% | -0.05% |
| | Low | -1.5% | 0.030% | 0.06% | 0.032% | -0.05% |

Source: BEAR model

## Impacts on Investments in California

The BEAR model predicts a modest increase in investment as a result of the proposed regulation (**Table 12**). This result is consistent with the expected increase in economic activity resulting from the large electricity savings. Investment impact decreases over time as the incremental net savings from the proposed standard level off. This is different than GSP and employment, which grows over time relative to the baseline, due to economy-wide multiplier effects.

**Table 13: Change in Real Investment from Baseline (2013 $M and %)**

| | | 2020 | | 2025 | | 2030 | |
|---|---|---|---|---|---|---|---|
| **Proposal** | | **175** | **0.038%** | **170** | **0.029%** | **124** | **0.017%** |
| **Sensitivity: Electricity Price** | High | 179 | 0.039% | 180 | 0.031% | 137 | 0.019% |
| | Low | 170 | 0.037% | 159 | 0.027% | 111 | 0.016% |
| **Sensitivity: Compliance Cost** | High | 167 | 0.036% | 160 | 0.028% | 113 | 0.016% |
| | Low | 177 | 0.039% | 180 | 0.031% | 141 | 0.020% |
| **Sensitivity: Market Growth** | High | 176 | 0.038% | 176 | 0.030% | 132 | 0.018% |
| | Low | 174 | 0.038% | 165 | 0.028% | 117 | 0.016% |

Source: BEAR model

## Impacts on Individuals in California

The Energy Commission staff proposal is expected to provide electricity savings to all California consumers of regulated computer and monitor products. However, results suggest that electricity savings are distributed differently across household income deciles (**Table 13**). Model results suggest that households at the very low and high ends of the income spectrum will benefit disproportionately from lower electricity bills. For low-income households, electricity is a necessary good which consumes a larger percentage of total household expenditures, so reducing the electricity spending provides a greater benefit. Higher income households consume a larger fraction of energy intensive products and are therefore also expected to benefit more than other income deciles. It should be noted that these disproportionate impacts for high and low income households are very modest.

The sensitivity scenarios have a negligible impact on the results. Results vary by less than one basis point (a hundredth of a percentage point) across the scenarios, and the same distributive theme emerges. Household income increases for all income deciles, and low and high income households continue to have a modestly higher benefit from the proposal.

**Table 14: Change in Household Relative Real Income by Decile in 2030 (% change from baseline)**

| Household Decile (HH1=low) | Proposal | Sensitivity Analysis | | | | | |
|---|---|---|---|---|---|---|---|
| | | Electricity Price | | Compliance Cost | | Market Growth | |
| | | High | Low | High | Low | High | Low |
| **HH1** | **0.044%** | 0.045% | 0.043% | 0.044% | 0.044% | 0.044% | 0.044% |
| **HH2** | **0.044%** | 0.045% | 0.044% | 0.044% | 0.044% | 0.045% | 0.044% |
| **HH3** | **0.028%** | 0.029% | 0.026% | 0.027% | 0.029% | 0.029% | 0.027% |
| **HH4** | **0.027%** | 0.028% | 0.025% | 0.026% | 0.028% | 0.028% | 0.025% |
| **HH5** | **0.018%** | 0.020% | 0.016% | 0.017% | 0.020% | 0.020% | 0.017% |
| **HH6** | **0.018%** | 0.020% | 0.016% | 0.017% | 0.020% | 0.019% | 0.017% |
| **HH7** | **0.026%** | 0.028% | 0.024% | 0.024% | 0.028% | 0.027% | 0.025% |
| **HH8** | **0.016%** | 0.018% | 0.013% | 0.014% | 0.018% | 0.017% | 0.014% |
| **HH9** | **0.036%** | 0.038% | 0.034% | 0.034% | 0.038% | 0.037% | 0.035% |
| **HH10** | **0.030%** | 0.032% | 0.028% | 0.028% | 0.032% | 0.031% | 0.029% |

Source: BEAR model

## Incentives for Innovation

The proposed efficiency standard is by design meant to promote innovation for the regulated product categories. While a number of technically feasible compliance options are currently available, the standard is also likely to incentivize manufacturers to consider other lower cost options for delivering energy efficiency benefits.

Due to the state's large market share of regulated products, there is the possibility that the Energy Commission's proposed standards would compel manufacturers to incorporate the higher efficiency technologies into similar products sold outside of the state. It is also possible that the state's proposal could serve as a template for federal computer efficiency standards, especially because it is not expected that the Energy Commission's proposal will be preempted by the federal government with an equal or less stringent appliance efficiency standard.

## Competitive Advantage or Disadvantage

The regulation would apply to all businesses manufacturing the regulated products inside and outside of the state, and selling computers and monitors to California customers. It is therefore not anticipated that the regulation will have an adverse effect on the competitiveness of California businesses. In fact, the BEAR model results suggest that the macroeconomic stimulus effect from the proposal will induce a modest increase in the state's aggregate export volume.

## Other Benefits and Impacts of the Regulations

The BEAR model predicts levels of greenhouse gas emissions and criteria air pollutants resulting from the proposed efficiency standards. These estimates are based on emissions factors linked to sectoral output from polluting sectors. Base year emissions levels are calibrated to the California Air Resources Board emissions inventory.

Benefits from reduced GHG emissions in the electric power sector are shown in **Table 14**. Under the proposed standard and all six sensitivity scenarios, emissions decline in the electric power sector due to the decreased demand for electricity from computers, monitors, and displays. Emissions reductions are greater in later years, relative to the baseline, as the stock of products turns over and cumulative energy savings are realized. For example, expected emissions reductions in 2030 are approximately 2.5 times larger than in 2020. The high electricity price and high market growth sensitivities yielded the greatest emissions reductions of the six sensitivities. Model results suggest that alternative compliance cost scenarios are unlikely to affect the emissions outcome.

The emission reduction benefits are monetized using estimates from the U.S. EPA for global damages due to GHG emissions.[5] Using a low range estimate of \$13/mt$CO_2$e and a high range of \$47/mt$CO_2$e, the proposed standard would result in avoided damages of \$11.4 million to \$41.1 million from 2018 to 2030.

**Table 15: Change in Electric Power Sector GHG Emissions (million t$CO_2$e, difference from baseline)**

| | | 2020 | 2025 | 2030 |
|---|---|---|---|---|
| **Proposal** | | -0.0376 | -0.0810 | -0.0938 |
| **Sensitivity: Electricity Price** | High | -0.0421 | -0.0933 | -0.1122 |
| | Low | -0.0322 | -0.0677 | -0.0752 |
| **Sensitivity: Compliance Cost** | High | -0.0368 | -0.0808 | -0.0944 |
| | Low | -0.0380 | -0.0818 | -0.0944 |
| **Sensitivity: Market Growth** | High | -0.0405 | -0.0927 | -0.1144 |
| | Low | -0.0348 | -0.0703 | -0.0757 |

Source: BEAR Model

The BEAR model also reports emissions from other sectors of the economy. The model results suggest that the economic stimulus created by the proposed standard could potentially increase emissions outside of the electric power sector (**Table 15**). This would be due to consumption shifting away from electricity towards other GHG-intensive activities, such as transportation and manufacturing. This possibility of increases in indirect and induced emissions highlights the importance of an economy-wide approach to GHG mitigation.

5 For social cost of carbon, see http://www.epa.gov/climatechange/EPAactivities/economics/scc.html.

**Table 16: Change in Sector GHG Emissions (million $tCO_2e$, difference from baseline)**

| Sector | 2020 | 2025 | 2030 |
|---|---|---|---|
| Electricity | -0.038 | -0.081 | -0.094 |
| Refined Petroleum | 0.061 | 0.096 | 0.119 |
| Manufacturing | 0.079 | 0.122 | 0.147 |
| Services | -0.017 | -0.006 | 0.003 |
| Other | -0.047 | -0.066 | -0.074 |

Source: BEAR model

The reduction in electricity demand due to the proposed standard is also expected to reduce the amount of other air pollutants. Model results for five common pollutants known to have adverse human health impacts are shown in **Table 16.** These emissions reductions were monetized using the COBRA model, developed by the US Environmental Protection Agency.[6] The COBRA model results, which report a low and high range for health impacts, suggest a cumulative health benefit from 2018-2030 of $4.7 million to $10.6 million.[7] This valuation result is driven almost entirely by reductions in premature adult mortality.

**Table 17: Cumulative Change (2018-2030) in Electric Power Sector Criteria Pollutants (thousand metric tons, difference from baseline)**

| | | CO | NOx | SOx | $PM_{2.5}$ | VOC |
|---|---|---|---|---|---|---|
| **Proposal** | | **-0.298** | **-0.152** | **-0.024** | **-0.030** | **-0.018** |
| **Sensitivity: Electricity Price** | High | -0.346 | -0.176 | -0.028 | -0.035 | -0.021 |
| | Low | -0.248 | -0.126 | -0.020 | -0.025 | -0.015 |
| **Sensitivity: Compliance Cost** | High | -0.297 | -0.152 | -0.024 | -0.030 | -0.018 |
| | Low | -0.301 | -0.154 | -0.025 | -0.030 | -0.018 |
| **Sensitivity: Market Growth** | High | -0.343 | -0.175 | -0.028 | -0.035 | -0.021 |
| | Low | -0.257 | -0.012 | -0.021 | -0.026 | -0.015 |

Source: BEAR Model

# Summary and Interpretation of the Results of the Economic Impact Assessment

The Energy Commission's computer and monitor efficiency proposal is expected to provide substantial energy savings to California consumers. Net direct savings to individuals and businesses in the state are expected to be approximately $3.5 billion cumulatively from 2018 to 2030, or $350 million per year once the product stock has fully turned over.

6 The COBRA Model is available at https://www.epa.gov/statelocalclimate/co-benefits-risk-assessment-cobra-screening-model.

7 The COBRA model does not consider the health impact of lower carbon monoxide emissions. The other four pollutants are included in the model.

The macroeconomic impact results show that, relative to the baseline, economic growth, employment, enterprise output, and investment all increase due to the electricity savings associated with the proposed efficiency standards. Employment and enterprise output increase at a slightly faster rate than GSP due to the fact that expenditure shifting occurs from relatively low employment electricity sectors to higher employment service sectors. All macroeconomic effects are modest, relative to the size of the California economy, which is consistent with the magnitude of the stimulus generated by the standards. The proposed standards are also expected to modestly reduce greenhouse gas and criteria air pollutant emissions in the electric power sector.

Based on three sets of sensitivity analyses, the direction and magnitude of the results are not significantly affected by reasonable variation in future electricity price projections, compliance costs, or assumed product market growth rates. These results suggest that the intended benefits of proposal are likely to be delivered under a range of relevant economic and policy conditions.

Two regulatory alternatives were evaluated, including a higher stringency alternative that delivered greater energy savings and a less stringent standard that delivered lower energy savings but at a lower compliance cost. Each of these alternatives was rejected by the Energy Commission. The higher stringency alternative delivered only modest additional direct gross savings but at a significantly higher compliance cost, yielding a significantly lower benefit to the consumer. The lower stringency option did not deliver energy savings that were consistent with the Energy Commission's objectives to set cost-effective and technically feasible standards that maximize reduction of the wasteful consumption of energy from appliances that consume a significant amount of energy statewide.

# Chapter 4: ALTERNATIVES

The SRIA requires the consideration of two regulatory alternatives to the proposed regulation. One alternative would deliver greater benefits ("more stringent") and the other ("less stringent") would deliver fewer benefits but at a lower compliance cost. A description of each alternative, its economic impact, and the reason for rejection is outlined below.

The primary difference between the alternatives and the proposal are the aggregate costs and savings assumptions. The timing and distribution of these costs and savings is not expected to deviate from the proposed regulation.

## Alternative 1: High Stringency

The first alternative considers a more stringent efficiency standard that requires greater energy savings from desktops and monitors (higher efficiency requirements for the other product categories were considered to be technically infeasible). The electricity savings by product category and assumed costs are reported in **Table 3** in Chapter 2.

### Economic Impacts

Based on the assumed direct costs and electricity savings presented in **Table 4**, the more stringent alternative has a considerably lower benefit-cost ratio than the proposed standard. The benefit-cost ratio for the more stringent alternative ranges from 4.3 to 4.9, whereas the benefit cost-ratio for the proposal ranges from 5.3 to 6.0. This is due primarily to a doubling in the incremental compliance costs for regulated monitors that would in turn deliver only a modest level of electricity savings. The additional savings for desktops from the higher stringency standard is also very modest, although the incremental cost for desktops is also small ($2/unit).

The macroeconomic results, shown in **Tables 17** and **18**, also suggest that the more stringent alternative delivers lower economy-wide benefits than the proposed standard. However, it is worth noting that this alternative still provides net direct and economy-wide benefits relative to the baseline.

**Table 18: Economic Impact Summary, More Stringent Alternative**

| | | 2020 | 2025 | 2030 |
|---|---|---|---|---|
| **Gross State Product (2013 M$)** | **Proposal** | -87.4 | 373.6 | 636.0 |
| | **More Stringent** | -94.2 | 359.8 | 610.5 |
| | **Percent Difference** | 7.8% | -3.7% | -4.0% |
| **Real Investment (2013 M$)** | **Proposal** | 175 | 170 | 124 |
| | **More Stringent** | 170 | 166 | 119 |
| | **Percent Difference** | -2.9% | -2.6% | -4.5% |

Source: BEAR Model

**Table 19: Employment Impacts, More Stringent Alternative**

| | 2030 | Cumulative Change (2018-2030) |
|---|---|---|
| **Proposal** | 5,525 | 12,158 |
| **More Stringent** | 5,490 | 12,149 |
| **Percent Difference** | -0.64% | -0.07% |

Source: BEAR Model

### Reason for Rejection

The higher stringency alternative was rejected because of its significantly lower cost-effectiveness. The additional energy savings from a stricter standard would have been very modest, but the costs incurred, especially for monitor compliance, are much higher, resulting in fewer savings to consumers and a lesser economic benefit to the state.

## Alternative 2: Low Stringency

The second alternative considers an efficiency standard that provides considerably lower energy savings for desktops and monitors. The incremental cost for these two product categories is also substantially lower.

### Economic Impacts

The benefit-cost ratio of the low stringency alternative (8.4-9.5) is substantially higher than the proposal. However, the aggregate net benefits are much smaller. The macroeconomic impacts of the less stringent proposal suggest that this regulatory option would generate considerably less aggregate economic activity than the proposed regulatory standard (**Table 19**). The cumulative impact on jobs is a negligible increase over the analysis period (**Table 20**).

**Table 20: Economic Impact Summary, Less Stringent Alternative**

| | | 2020 | 2025 | 2030 |
|---|---|---|---|---|
| **Gross State Product (2013 M$)** | **Proposal** | -87.4 | 373.6 | 636.0 |
| | **Less Stringent** | -94.4 | 357.8 | 633.9 |
| | **Percent Difference** | 7.9% | -4.2% | -0.3% |
| **Real Investment (2013 M$)** | **Proposal** | 175 | 170 | 124 |
| | **Less Stringent** | 175 | 160 | 116 |
| | **Percent Difference** | 0.1% | -6.2% | -6.8% |

Source: BEAR Model

**Table 21: Employment Impacts, Less Stringent Alternative**

| | 2030 | Cumulative Change (2018-2030) |
|---|---|---|
| **Proposal** | 5,525 | 12,158 |
| **More Stringent** | 5,490 | 12,149 |
| **Percent Difference** | -0.64% | -0.07% |

Source: BEAR Model

## Reason for Rejection

The lower stringency alternative was rejected because the energy savings are unacceptably low given the Energy Commission's mandate to reduce the wasteful consumption of energy statewide through cost-effective and technically feasible standards. Even though the benefit-cost ratio was higher than the proposed standard, the Energy Commission's objectives of significantly reducing energy consumption would not have been met.

# Chapter 5: FISCAL IMPACTS

The California state government is a large consumer of computers and monitors. The proposed regulation is expected to affect state agencies in much the same way as individuals and businesses. Based on procurement data from the Department of General Services (DGS), the state purchased an average of approximately 31,000 desktops, 15,000 notebooks, and 41,500 monitors in 2014/2015. This data was used to quantify the impact of the proposed regulation on the state government. This approach excludes procurement of regulated products from a number of other state institutions, such as the University of California system, and local governments. Therefore, this estimate should be considered a lower bound for the statewide fiscal impact.

It is assumed that the State electricity rate is similar to other commercial users. The proposed regulation is expected to provide $592,000 to $3,361,000 in reduced electricity costs at an additional cost to procuring compliant products of $771,000 to $728,000 (**Table 21**). In all years, except the first year of implementation, the proposed standard is expected to result in a benefit-cost ratio greater than 1.

**Table 22: Direct Impact on State Agencies (million $)**

| | Reduced Electricity Cost | Increased Procurement Cost |
|---|---|---|
| **2018** | 0.592 | 0.771 |
| **2019** | 1.211 | 0.768 |
| **2020** | 1.858 | 0.764 |
| **2021** | 2.488 | 0.760 |
| **2022** | 3.115 | 0.756 |
| **2023** | 3.304 | 0.753 |
| **2024** | 3.312 | 0.749 |
| **2025** | 3.320 | 0.746 |
| **2026** | 3.328 | 0.742 |
| **2027** | 3.336 | 0.739 |
| **2028** | 3.344 | 0.735 |
| **2029** | 3.353 | 0.732 |
| **2030** | 3.361 | 0.728 |

The proposed regulation is not expected to incur an enforcement or compliance cost for the state government. Enforcement of appliance efficiency standards is self-funded through fines levied against entities that violate the standards, pursuant to Public Resources Code Section 25402.11. <u>The additional cost to enforce compliance is estimated to be negligible since enforcement resources for other products are expected to be shifted to computers</u>.

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# Appendix A: Technical Summary of the BEAR Model

The Berkeley Energy and Resources (BEAR) model is a constellation of research tools designed to elucidate linkages across the California economy. The schematics in **Figures A.1** and **A.2** describe the four generic components of the modeling facility and their interactions. This section provides a brief summary of the formal structure of the BEAR model. For the purposes of this report, the 2013 California Social Accounting Matrix (SAM) was aggregated along certain dimensions. The current version of the model includes 195 activity sectors, 22 occupations, and ten households aggregated from the original California SAM. The equations of the model are completely documented elsewhere (Roland-Holst 2008), and for the present we only review its salient structural components.

## Structure of the CGE Model

Technically, a CGE model is a system of simultaneous equations that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economy-wide resource allocation, production, and income determination.

The role of markets is to mediate exchange, usually with a flexible system of prices, the most important endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system is solved for prices that correspond to equilibrium in markets and satisfy the accounting identities governing economic behavior. If such a system is precisely specified, equilibrium always exists and such a consistent model can be calibrated to a base period data set. The resulting calibrated general equilibrium model is then used to simulate the economy-wide (and regional) effects of alternative policies or external events.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed-form specification of all activities in the economic system under study. This can be contrasted with more traditional partial equilibrium analysis, where linkages to other domestic markets and agents are deliberately excluded from consideration. A large and growing body of evidence suggests that indirect effects (e.g., upstream and downstream production linkages) arising from policy changes are not only substantial, but may in some cases even outweigh direct effects. Only a model that consistently specifies economy-wide interactions can fully assess the implications of economic policies or business strategies. In a multi-regional model like the one used in this study, indirect effects include the trade linkages between countries and regions which themselves can have policy implications.

The model we use for this work has been constructed according to generally accepted specification standards, implemented in the GAMS programming language, and calibrated to the new California SAM estimated for the year 2013. The result is a single economy model calibrated over the thirty-five year time path from 2015 to 2050. Using the very detailed accounts of the California SAM, we include the following assumptions in the present model.

# Production

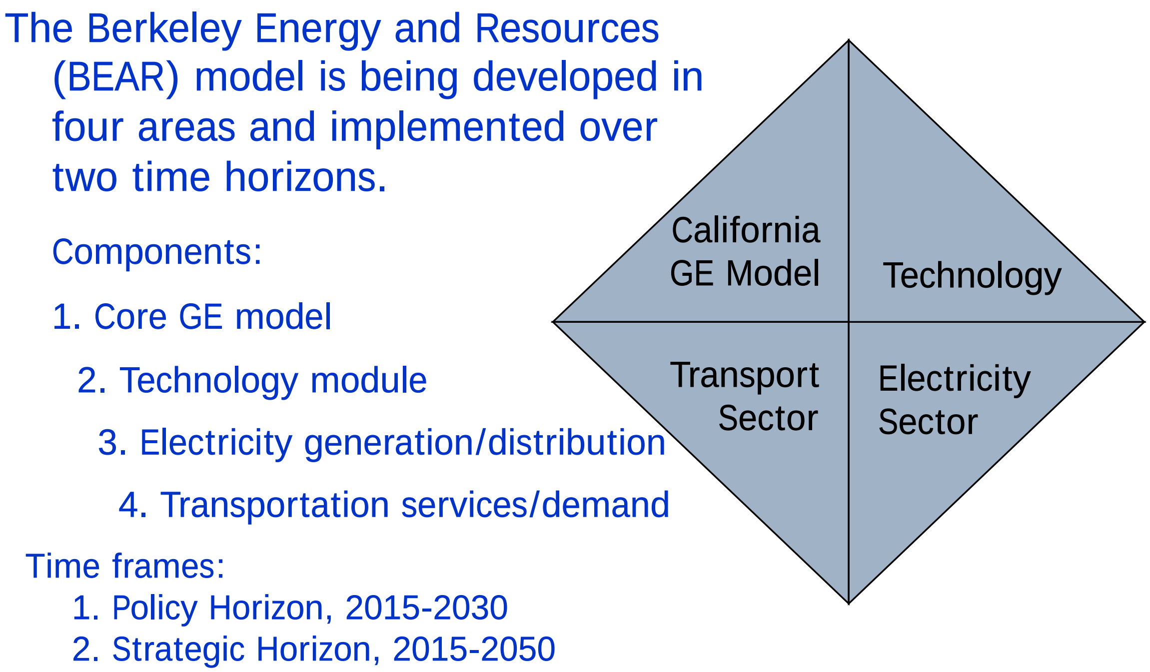
All sectors are assumed to operate under constant returns to scale and cost optimization. Production technology is modeled by a nested constant-elasticity-of-substitution (CES) function.

In each period, the supply of primary factors—capital, land, and labor—is usually predetermined.[8] The model includes adjustment rigidities. An important feature is the distinction between old and new capital goods. In addition, capital is assumed to be partially mobile, reflecting differences in the marketability of capital goods across sectors.[9] Once the optimal combination of inputs is determined, sectoral output prices are calculated assuming competitive supply conditions in all markets.

8 Capital supply is to some extent influenced by the current period's level of investment.

9 For simplicity, it is assumed that old capital goods supplied in second-hand markets and new capital goods are homogeneous. This formulation makes it possible to introduce downward rigidities in the adjustment of capital without increasing excessively the number of equilibrium prices to be determined by the model.

**Figure A.1: Component Structure of the Modeling Facility**




## Consumption and Closure Rule

All income generated by economic activity is assumed to be distributed to consumers. Each representative consumer allocates optimally his/her disposable income among the different commodities and saving. The consumption/saving decision is completely static: saving is treated as a "good" and its amount is determined simultaneously with the demand for the other commodities, the price of saving being set arbitrarily equal to the average price of consumer goods.

The government collects income taxes and indirect taxes on intermediate inputs, outputs, and consumer expenditures. The default closure of the model assumes that the government deficit/saving is exogenously specified.[10] The indirect tax schedule will shift to accommodate any changes in the balance between government revenues and government expenditures.

The current account surplus (deficit) is fixed in nominal terms. The counterpart of this imbalance is a net outflow (inflow) of capital, which is subtracted (added to) the domestic flow of saving. In each period, the model equates gross investment to net saving (equal to the sum of saving by households, the net budget position of the government and foreign capital inflows). This particular closure rule implies that investment is driven by saving.

10 In the reference simulation, the real government fiscal balance converges (linearly) towards 0 by the final period of the simulation.

## Trade

Goods are assumed to be differentiated by region of origin. In other words, goods classified in the same sector are different according to whether they are produced domestically or imported. This assumption is frequently known as the *Armington* assumption. The degree of substitutability, as well as the import penetration shares are allowed to vary across commodities. The model assumes a single Armington agent. This strong assumption implies that the propensity to import and the degree of substitutability between domestic and imported goods is uniform across economic agents. This assumption reduces tremendously the dimensionality of the model. In many cases this assumption is imposed by the data. A symmetric assumption is made on the export side where domestic producers are assumed to differentiate the domestic market and the export market. This is modeled using a *Constant-Elasticity-of-Transformation* (CET) function.

## Dynamic Features and Calibration

The current version of the model has a simple recursive dynamic structure as agents are assumed to be myopic and to base their decisions on static expectations about prices and quantities. Dynamics in the model originate in three sources: i) accumulation of productive capital and labor growth; ii) shifts in production technology; and iii) the putty/semi-putty specification of technology.

## Capital Accumulation

In the aggregate, the basic capital accumulation function equates the current capital stock to the depreciated stock inherited from the previous period plus gross investment. However, at the sectoral level, the specific accumulation functions may differ because the demand for (old and new) capital can be less than the depreciated stock of old capital. In this case, the sector contracts over time by releasing old capital goods. Consequently, in each period, the new capital vintage available to expanding industries is equal to the sum of disinvested capital in contracting industries plus total saving generated by the economy, consistent with the closure rule of the model.

## The Putty/Semi-Putty Specification

The substitution possibilities among production factors are assumed to be higher with the new than the old capital vintages — technology has a putty/semi-putty specification. Hence, when a shock to relative prices occurs (e.g., the imposition of an emissions fee), the demands for production factors adjust gradually to the long-run optimum because the substitution effects are delayed over time. The adjustment path depends on the values of the short-run elasticities of substitution and the replacement rate of capital. As the latter determines the pace at which new vintages are installed, the larger is the volume of new investment, the greater the possibility to achieve the long-run total amount of substitution among production factors.

## Profits, Adjustment Costs, and Expectations

Firms' output and investment decisions are modeled in accordance with the innovative approach of Goulder and co-authors (see Goulder, Hafstead, and Dworsky 2010 for technical details). In particular, we allow for the possibility that firms reap windfall profits from events such as free permit distribution. Absent more detailed information on ownership patterns, we assume that these profits accrue to U.S. and foreign residents in proportion to equity shares of publically traded U.S. corporations (16 percent in 2009, Swartz and Tillman, 2010). Between California and other U.S. residents, the shares are assumed to be proportional to GSP in gross domestic product (GDP) (11 percent in 2009).

## Dynamic Calibration

The model is calibrated on exogenous growth rates of population, labor force, and GDP. In the baseline scenario, the dynamics are calibrated in each region by imposing the assumption of a balanced growth path. This implies that the ratio between labor and capital (in efficiency units) is held constant over time.[11] When alternative scenarios around the baseline are simulated, the technical efficiency parameter is held constant, and the growth of capital is endogenously determined by the saving/investment relation.

## Modelling Emissions

The BEAR model captures emissions from production activities in agriculture, industry, and services, as well as in final demand and use of final goods (e.g. appliances and autos). This is done by calibrating emission functions to each of these activities that vary depending upon the emission intensity of the inputs used for the activity in question. We model both $CO_2$ and the other primary greenhouse gases, which are converted to $CO_2$ equivalents. Following standards set in the research literature, emissions in production are modeled as factors inputs. The base version of the model does not have a full representation of emissions reduction or abatement. Emissions abatement occurs by substituting additional labor or capital for emissions when an emissions tax is applied. This is an accepted modeling practice, although in specific instances it may either understate or overstate actual emissions reduction potential.[12] In this framework, emission levels have an underlying monotonic relationship with production levels, but can be reduced by increasing use of other productive factors such as capital and labor. The latter represent investments in lower intensity technologies, process cleaning activities, etc. An overall calibration procedure fits observed intensity levels to baseline activity and other factor/resource use levels. The BEAR model has the capacity to track 13 categories of individual pollutants and consolidated emission indexes, each of which is listed in **Table A.1**. For more detail, please consult the full model documentation.

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11 This involves computing in each period a measure of Harrod-neutral technical progress in the capital-labor bundle as a residual. This is a standard calibration procedure in dynamic CGE modeling.
12 See e.g. Babiker et al. (2001) for details on a standard implementation of this approach.

An essential characteristic of the BEAR approach to emissions modeling is endogeneity. Contrary to assertions made elsewhere (Stavins 2008), the BEAR model permits emission rates by sector and input to be exogenous or endogenous, and in either case the level of emissions from the sector in question is endogenous unless a cap is imposed. This feature is essential to capture structural adjustments arising from market-based climate policies, as well as the effects of technological change.

**Table A.1: BEAR Emissions Categories**

| Variable Description | Variable Name |
|---|---|
| **Greenhouse Gas Emissions** | |
| Carbon Dioxide | CO2 |
| Methane | CH4 |
| Nitrous Oxide | N2O |
| **Air Pollutants** | |
| Suspended Particulates | PART |
| Sulfur Dioxide | SO2 |
| Nitrogen Dioxide | NO2 |
| Volatile organic compounds | VOC |
| Carbon monoxide | CO |
| Toxic air index | TOXAIR |
| Biological air index | BIOAIR |
| **Water Pollutants** | |
| Biochemical oxygen demand | BOD |
| Total suspended solids | TSS |
| Toxic water index | TOXWAT |
| Biological water index | BIOWAT |
| **Land Pollutants** | |
| Toxic land index | TOXSOL |
| Biological land index | BIOSOL |

**Figure A.2: Schematic Linkage Between Model Components**

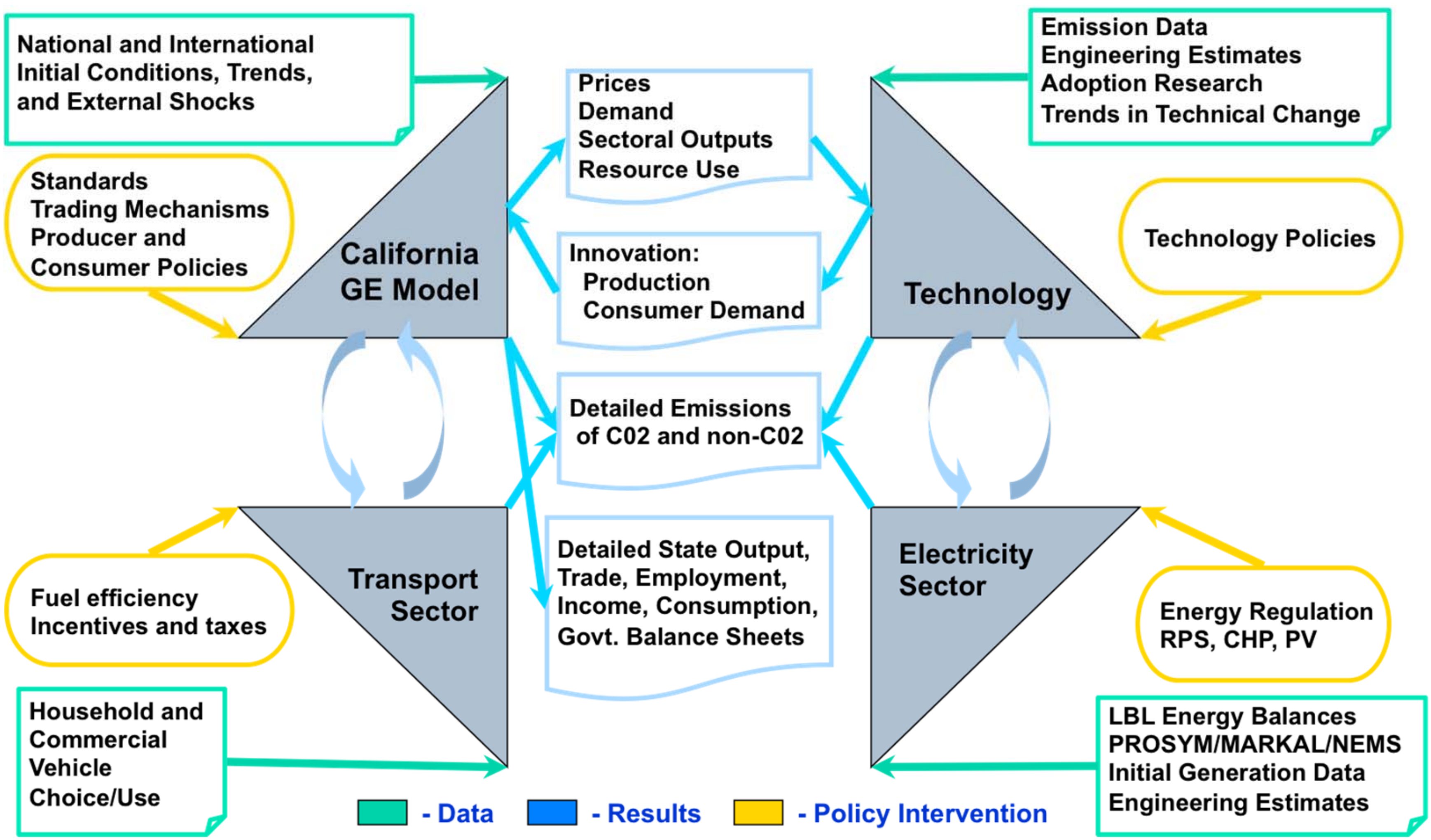

**Table A2: California SAM for 2013 - Structural Characteristics**

| SAM Category |
|---|
| 195 commodities (includes trade and transport margins) |
| 24 factors of production |
| 22 labor categories |
| Capital |
| Land |
| 10 Household types, defined by income tax bracket |
| Enterprises |
| Federal Government (7 fiscal accounts) |
| State Government (27 fiscal accounts) |
| Local Government (11 fiscal accounts) |
| Consolidated capital account |
| External Trade Account |

The 60 production sectors and commodity groups used in this analysis are shown in **Table A.3**. This aggregates based on the original 195 sectors in the BEAR model.

**Table A.3: Aggregate Accounts for CEC California CGE Model**

| Label | Description | Label | Description |
|---|---|---|---|
| A01Agric | Agriculture | A31Aluminm | Aluminum |
| A02Cattle | Cattle and Feedlots | A32Machnry | General Machinery |
| A03Dairy | Dairy Cattle and Milk Production | A33MfgMon | Monitor and Displays Manufacturing |
| A04Forest | Forestry, Fishery, Mining, Quarrying | A34MfgComp | Computer Manufacturing |
| A05OilGas | Oil and Gas Extraction | A35SemiCon | Semi-Conductor Manufacturing |
| A06OthPrim | Other Primary Products | A36ElecApp | Electrical Appliances |
| A07EleHyd | Electricity Generation- Hydro | A37Autos | Automobiles and Light Trucks |
| A08EleFF | Electricity Generation-Fossil Fuels | A38OthVeh | Other Vehicle Manufacturing |
| A09EleNuc | Electricity Generation-Nuclear | A39AeroMfg | Aeroplane and Aerospace Manufacturing |
| A10EleSol | Electricity Generation-Solar | A40OthInd | Other Industry |
| A11EleWind | Electricity Generation-Wind | A41WhlTrad | Wholesale Trade |
| A12EleGeo | Electricity Generation-Geothermal | A42RetVeh | Retail Vehicle Sales and Service |
| A13EleBio | Electricity Generation- Biomass | A43AirTrns | Air Transport Services |
| A14EleOth | Electricity Generation-Other | A44GndTrns | Ground Transport Services |
| A15DistElec | Electricity Distribution | A45WatTrns | Water Transport Services |
| A16DistGas | Natural Gas Distribution | A46TrkTrns | Truck Transport Services |
| A17DistOth | Water, Sewage, Steam | A47PubTrns | Public Transport Services |
| A18ConRes | Residential Construction | A48RetAppl | Retail - Electronics and Appliances |
| A19ConNRes | Non-Residential Construction | A49RetGen | Retail- General Merchandise |
| A20ConPow | Power Sector Construction | A50InfCom | Information and Communication Services |
| A21ConRd | Other Infrastructure Construction | A51FinServ | Financial Services |
| A22FoodPrc | Food Processing | A52OthProf | Other Professional Services |
| A23TxtAprl | Textiles and Apparel | A53BusServ | Business Services |
| A24WoodPlp | Wood, Pulp, and Paper | A54WstServ | Landfill Services |
| A25PapPrnt | Printing and Publishing | A55Educatn | Educational Services |
| A26OilRef | Oil Refining | A56Medicin | Medical Services |
| A27Chemicl | Chemicals | A57Recratn | Recreation Services |
| A28Pharma | Pharmaceutical Manufacturing | A58HotRest | Hotel and Restaurant Services |
| A29Cement | Cement | A59OthPrSv | Other Private Services |
| A30Metal | Metal Manufacture and Fabrication | A60GovtSv | Government Services |

These data enable us to trace the effects of responses to climate change and other policies at unprecedented levels of detail, tracing linkages across the economy and clearly indicating the indirect benefits and tradeoffs that might result from comprehensive policies, pollution taxes, or trading systems. The effects of climate policy can be quite complex. In particular, cumulative indirect effects may outweigh direct consequences, and affected groups are often far from the policy target group.

It should be noted that the SAM used with BEAR departs in a few substantive respects from the original 2013 California SAM. The two main differences have to do with the structure of production, as reflected in the input-output accounts, and with consumption good aggregation. To specify production technology in the BEAR model, we rely on both activity and commodity accounting, while the original SAM has consolidated activity accounts. We chose to maintain separate activity and commodity accounts to maintain transparency in the technology of emissions and patterns of tax incidence. The difference is non-trivial and considerable additional effort was needed to reconcile use and make tables separately. This also facilitated the second SAM extension, however, where we maintained final demand at the full 119 commodity level of aggregation, rather than adopting six aggregate commodities like the original SAM.

## Emissions Data

Emissions data were obtained from California's own detailed emissions inventory. In most of the primary pollution databases like this, measured emissions are directly associated with the volume of output. This has several consequences. First, from a behavioral perspective, the only way to reduce emissions, with a given technology, is to reduce output. This obviously biases results by exaggerating the abatement-growth tradeoff.

Second, output-based pollution modeling imperfectly captures the observed pattern of abatement behavior. Generally, firms respond to abatement incentives and penalties in much more complex and sophisticated ways by varying internal conditions of production. These responses include varying the sources, quality, and composition of inputs, choice of technology, etc.

The third shortcoming of the output approach is that it does not provide guidance about other important pollution sources outside the production process, especially pollution in use of final goods. The most important example of this category is household consumption. BEAR estimates emissions from both intermediate and (in-state) final demand.

Emissions impacts were evaluated using the U.S. EPA Co-Benefits Risk Assessment (COBRA) Model. The U.S. EPA developed the COBRA Model to help state and local governments assess the health and economic impacts of policies that affect criteria air pollutant levels. The COBRA Model provides a high and low estimate of avoided public health impacts due to reductions in criteria emissions. It also provides estimates of economic impacts resulting from changes in criteria air pollutant emissions.

The COBRA Model uses U.S. EPA emissions estimates for criteria air pollutants in the year 2017 as a baseline. Users specify a discount rate and scenarios for emissions levels at different geographic scales. The COBRA Model employs a reduced form air quality model, the Source-Receptor Matrix, for assessing changes in ambient particulate matter. The model then uses concentration response functions to link the changes in particulate matter to health and economic impacts, based on data from epidemiological studies. Outputs are expressed with multiple metrics such as willingness-to-pay, value of a statistical life and direct medical costs for economic impacts, and incidences of mortality, hospital admissions, and work loss days for health impacts.[13]

[13] The COBRA Model is available at https://www.epa.gov/statelocalclimate/co-benefits-risk-assessment-cobra-screening-model. Prior SRIAs on LED lights and appliance efficiency have used the COBRA model.

# Appendix B: Sensitivity Analysis Assumptions

## Electricity Price

Projected electricity price assumptions for the proposed standards, as well as the high and low electricity price sensitivity scenarios are shown in **Table B.1**. Prices were averaged across the various planning areas reported in the Energy Commission forecast. Residential rates are used for calculating individual consumer savings and the commercial rates are used for the calculated business savings.

**Table B.1: Electricity Price Assumptions (2013 cents/kWh)**

| | Baseline | | Low Price Forecast | | High Price Forecast | |
|---|---|---|---|---|---|---|
| **Year** | **Residential** | **Commercial** | **Residential** | **Commercial** | **Residential** | **Commercial** |
| 2013 | 16.91 | 14.77 | 16.91 | 14.77 | 16.91 | 14.77 |
| 2014 | 17.23 | 15.05 | 16.95 | 14.81 | 17.78 | 15.53 |
| 2015 | 17.54 | 15.32 | 16.99 | 14.85 | 18.64 | 16.28 |
| 2016 | 18.03 | 15.75 | 17.18 | 15.02 | 19.25 | 16.81 |
| 2017 | 18.52 | 16.17 | 17.38 | 15.19 | 19.86 | 17.34 |
| 2018 | 19.00 | 16.60 | 17.57 | 15.35 | 20.46 | 17.87 |
| 2019 | 19.49 | 17.02 | 17.76 | 15.52 | 21.07 | 18.40 |
| 2020 | 19.98 | 17.45 | 17.96 | 15.69 | 21.67 | 18.93 |
| 2021 | 20.12 | 17.57 | 18.01 | 15.74 | 21.92 | 19.14 |
| 2022 | 20.25 | 17.69 | 18.07 | 15.79 | 22.17 | 19.36 |
| 2023 | 20.39 | 17.81 | 18.12 | 15.84 | 22.42 | 19.58 |
| 2024 | 20.53 | 17.93 | 18.18 | 15.89 | 22.67 | 19.79 |
| 2025 | 20.67 | 18.05 | 18.23 | 15.94 | 22.92 | 20.01 |
| 2026 | 20.81 | 18.17 | 18.29 | 15.98 | 23.17 | 20.23 |
| 2027 | 20.95 | 18.29 | 18.35 | 16.03 | 23.42 | 20.45 |
| 2028 | 21.09 | 18.41 | 18.40 | 16.08 | 23.68 | 20.67 |
| 2029 | 21.23 | 18.54 | 18.46 | 16.13 | 23.94 | 20.90 |
| 2030 | 21.38 | 18.66 | 18.51 | 16.18 | 24.20 | 21.12 |

Source: Energy Commission's California Energy Demand 2016-2026, Revised Electricity Forecast, Table 6 (CEC-200-2016-001-V1, p. 35)

## Compliance Cost

The compliance cost sensitivity analysis considers a high and low incremental cost to manufacturers of regulated products. The high compliance cost scenario assumes the same incremental cost as the more stringent alternative (**Table 3**). The low compliance cost scenario assumes that the incremental cost declines by 5 percent per year from the assumed proposal cost in 2018.

## Market Growth

Market growth rates for new products are subject to a great deal of uncertainty based on consumer preferences, changing technologies, and macroeconomic conditions. We assess the possibility that growth rates might deviate from the base assumption for the proposed regulation. A high and low growth rate adder of +/- 0.75 percentage points is applied for new purchases in each product category.

# Appendix C: Annual Macro Results

The following tables show variables reported as differences from the baseline scenario.

**Table C.1 Gross State Product at Factor Cost (2013 M$, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -326 | -207 | -87 | 25 | 139 | 226 | 303 | 374 | 636 |
| Sensitivity: Electricity Price | High | -324 | -201 | -79 | 38 | 156 | 246 | 325 | 398 | 674 |
| | Low | -328 | -212 | -98 | 11 | 120 | 204 | 279 | 347 | 596 |
| Sensitivity: Compliance Cost | High | -333 | -216 | -99 | 10 | 121 | 205 | 279 | 347 | 592 |
| | Low | -326 | -205 | -84 | 31 | 147 | 238 | 318 | 394 | 685 |
| Sensitivity: Market Growth | High | -326 | -205 | -84 | 30 | 146 | 236 | 314 | 386 | 655 |
| | Low | -326 | -208 | -90 | 21 | 132 | 217 | 292 | 362 | 619 |
| More Stringent Alternative | | -331 | -213 | -94 | 18 | 130 | 217 | 291 | 360 | 611 |
| Less Stringent Alternative | | -320 | -207 | -94 | 11 | 117 | 205 | 284 | 358 | 634 |

Source: BEAR Model

Table C.2 Employment (FTE Jobs, difference from baseline)

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -6633 | -4926 | -3261 | -1769 | -273 | 776 | 1662 | 2478 | 5525 |
| Sensitivity: Electricity Price | High | -6593 | -4842 | -3127 | -1582 | -32 | 1039 | 1939 | 2769 | 5878 |
| | Low | -6672 | -5019 | -3420 | -1985 | -547 | 481 | 1357 | 2163 | 5162 |
| Sensitivity: Compliance Cost | High | -6686 | -4994 | -3342 | -1863 | -380 | 655 | 1529 | 2333 | 5325 |
| | Low | -6633 | -4915 | -3237 | -1729 | -215 | 852 | 1760 | 2598 | 5769 |
| Sensitivity: Market Growth | High | -6619 | -4886 | -3190 | -1664 | -131 | 966 | 1868 | 2699 | 5812 |
| | Low | -6646 | -4965 | -3329 | -1868 | -407 | 599 | 1473 | 2278 | 5272 |
| More Stringent Alternative | | -6660 | -4940 | -3261 | -1755 | -247 | 807 | 1684 | 2489 | 5490 |
| Less Stringent Alternative | | -6684 | -5142 | -3644 | -2309 | -969 | 77 | 991 | 1834 | 4998 |

Source: BEAR Model

**Table C.3 Real Output (2013 M$, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -398 | -207 | -20 | 159 | 334 | 486 | 624 | 750 | 1189 |
| Sensitivity: Electricity Price | High | -396 | -203 | -13 | 169 | 347 | 502 | 643 | 773 | 1227 |
| | Low | -400 | -212 | -28 | 148 | 318 | 467 | 603 | 726 | 1148 |
| Sensitivity: Compliance Cost | High | -411 | -224 | -42 | 133 | 303 | 450 | 583 | 705 | 1118 |
| | Low | -398 | -204 | -14 | 170 | 349 | 508 | 652 | 786 | 1273 |
| Sensitivity: Market Growth | High | -400 | -208 | -21 | 159 | 334 | 488 | 626 | 753 | 1195 |
| | Low | -397 | -206 | -19 | 159 | 333 | 484 | 622 | 748 | 1184 |
| More Stringent Alternative | | -410 | -221 | -37 | 139 | 310 | 460 | 594 | 717 | 1138 |
| Less Stringent Alternative | | -372 | -179 | 8 | 188 | 362 | 518 | 661 | 792 | 1254 |

Source: BEAR Model

**Table C.4 Real Investment (2013 M$, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | 161 | 167 | 175 | 185 | 192 | 187 | 179 | 170 | 124 |
| Sensitivity: Electricity Price | High | 162 | 170 | 179 | 191 | 200 | 196 | 188 | 180 | 137 |
| | Low | 159 | 165 | 170 | 178 | 183 | 177 | 168 | 159 | 111 |
| Sensitivity: Compliance Cost | High | 154 | 160 | 167 | 177 | 183 | 178 | 169 | 160 | 113 |
| | Low | 161 | 169 | 177 | 189 | 197 | 194 | 187 | 180 | 141 |
| Sensitivity: Market Growth | High | 160 | 168 | 176 | 187 | 195 | 192 | 184 | 176 | 132 |
| | Low | 161 | 167 | 174 | 183 | 189 | 182 | 174 | 165 | 117 |
| More Stringent Alternative | | 155 | 162 | 170 | 180 | 188 | 183 | 175 | 166 | 119 |
| Less Stringent Alternative | | 171 | 173 | 175 | 180 | 181 | 175 | 168 | 160 | 116 |

Source: BEAR Model

Table C.5 Household Relative Real Income (2013 M$, difference from baseline)

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -367 | -209 | -56 | 87 | 225 | 317 | 391 | 457 | 652 |
| Sensitivity: Electricity Price | High | -363 | -201 | -42 | 106 | 250 | 345 | 422 | 489 | 697 |
| | Low | -371 | -218 | -71 | 65 | 196 | 286 | 358 | 422 | 606 |
| Sensitivity: Compliance Cost | High | -378 | -223 | -71 | 70 | 205 | 296 | 368 | 431 | 616 |
| | Low | -367 | -207 | -51 | 95 | 236 | 332 | 410 | 479 | 699 |
| Sensitivity: Market Growth | High | -367 | -207 | -50 | 95 | 237 | 334 | 410 | 478 | 683 |
| | Low | -367 | -211 | -60 | 79 | 213 | 301 | 374 | 438 | 625 |
| More Stringent Alternative | | -376 | -218 | -63 | 81 | 219 | 312 | 385 | 449 | 637 |
| Less Stringent Alternative | | -354 | -212 | -74 | 53 | 174 | 265 | 341 | 408 | 613 |

Source: BEAR Model

**Table C.6 Electric Power Sector GHG Emissions (million tCO2e, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -0.0066 | -0.0210 | -0.0376 | -0.0552 | -0.0739 | -0.0785 | -0.0796 | -0.0810 | -0.0938 |
| Sensitivity: Electricity Price | High | -0.0078 | -0.0237 | -0.0421 | -0.0619 | -0.0831 | -0.0889 | -0.0909 | -0.0933 | -0.1122 |
| | Low | -0.0054 | -0.0180 | -0.0322 | -0.0474 | -0.0635 | -0.0669 | -0.0672 | -0.0677 | -0.0752 |
| Sensitivity: Compliance Cost | High | -0.0056 | -0.0201 | -0.0368 | -0.0545 | -0.0734 | -0.0782 | -0.0793 | -0.0808 | -0.0944 |
| | Low | -0.0066 | -0.0212 | -0.0380 | -0.0557 | -0.0746 | -0.0793 | -0.0804 | -0.0818 | -0.0944 |
| Sensitivity: Market Growth | High | -0.0071 | -0.0225 | -0.0405 | -0.0597 | -0.0804 | -0.0876 | -0.0899 | -0.0927 | -0.1144 |
| | Low | -0.0060 | -0.0194 | -0.0348 | -0.0509 | -0.0679 | -0.0702 | -0.0701 | -0.0703 | -0.0757 |
| More Stringent Alternative | | -0.0064 | -0.0218 | -0.0396 | -0.0584 | -0.0785 | -0.0841 | -0.0856 | -0.0873 | -0.1025 |
| Less Stringent Alternative | | -0.0033 | -0.0105 | -0.0192 | -0.0283 | -0.0379 | -0.0395 | -0.0386 | -0.0380 | -0.0392 |

Source: BEAR Model

**Table C.7: Electric Power Sector SOx Emissions (thousand metric tons, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -0.0002 | -0.0006 | -0.0010 | -0.0015 | -0.0021 | -0.0022 | -0.0022 | -0.0023 | -0.0026 |
| Sensitivity: Electricity Price | High | -0.0002 | -0.0007 | -0.0012 | -0.0017 | -0.0023 | -0.0025 | -0.0025 | -0.0026 | -0.0031 |
| | Low | -0.0001 | -0.0005 | -0.0009 | -0.0013 | -0.0018 | -0.0019 | -0.0019 | -0.0019 | -0.0021 |
| Sensitivity: Compliance Cost | High | -0.0001 | -0.0006 | -0.0010 | -0.0015 | -0.0020 | -0.0022 | -0.0022 | -0.0022 | -0.0026 |
| | Low | -0.0002 | -0.0006 | -0.0011 | -0.0015 | -0.0021 | -0.0022 | -0.0022 | -0.0023 | -0.0026 |
| Sensitivity: Market Growth | High | -0.0002 | -0.0006 | -0.0011 | -0.0017 | -0.0022 | -0.0024 | -0.0025 | -0.0026 | -0.0032 |
| | Low | -0.0002 | -0.0005 | -0.0010 | -0.0014 | -0.0019 | -0.0020 | -0.0019 | -0.0020 | -0.0021 |
| More Stringent Alternative | | -0.0002 | -0.0006 | -0.0011 | -0.0016 | -0.0022 | -0.0023 | -0.0024 | -0.0024 | -0.0029 |
| Less Stringent Alternative | | -0.0001 | -0.0003 | -0.0005 | -0.0008 | -0.0010 | -0.0011 | -0.0011 | -0.0010 | -0.0011 |

Source: BEAR Model

**Table C.8: Electric Power Sector NOx Emissions (thousand metric tons, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -0.0011 | -0.0036 | -0.0065 | -0.0096 | -0.0129 | -0.0137 | -0.0139 | -0.0141 | -0.0164 |
| Sensitivity: Electricity Price | High | -0.0013 | -0.0041 | -0.0073 | -0.0108 | -0.0145 | -0.0155 | -0.0159 | -0.0163 | -0.0196 |
| | Low | -0.0009 | -0.0031 | -0.0056 | -0.0082 | -0.0111 | -0.0117 | -0.0117 | -0.0118 | -0.0131 |
| Sensitivity: Compliance Cost | High | -0.0009 | -0.0035 | -0.0064 | -0.0095 | -0.0128 | -0.0136 | -0.0138 | -0.0141 | -0.0165 |
| | Low | -0.0011 | -0.0037 | -0.0066 | -0.0097 | -0.0130 | -0.0138 | -0.0140 | -0.0143 | -0.0165 |
| Sensitivity: Market Growth | High | -0.0012 | -0.0039 | -0.0070 | -0.0104 | -0.0140 | -0.0153 | -0.0157 | -0.0162 | -0.0200 |
| | Low | -0.0010 | -0.0034 | -0.0060 | -0.0089 | -0.0118 | -0.0122 | -0.0122 | -0.0122 | -0.0132 |
| More Stringent Alternative | | -0.0011 | -0.0038 | -0.0069 | -0.0102 | -0.0137 | -0.0147 | -0.0149 | -0.0152 | -0.0179 |
| Less Stringent Alternative | | -0.0005 | -0.0018 | -0.0033 | -0.0049 | -0.0066 | -0.0068 | -0.0067 | -0.0066 | -0.0067 |

Source: BEAR Model

**Table C.9: Electric Power Sector VOC Emissions (thousand metric tons, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -0.0001 | -0.0004 | -0.0008 | -0.0011 | -0.0015 | -0.0016 | -0.0016 | -0.0017 | -0.0019 |
| Sensitivity: Electricity Price | High | -0.0002 | -0.0005 | -0.0009 | -0.0013 | -0.0017 | -0.0018 | -0.0019 | -0.0019 | -0.0023 |
| | Low | -0.0001 | -0.0004 | -0.0007 | -0.0010 | -0.0013 | -0.0014 | -0.0014 | -0.0014 | -0.0015 |
| Sensitivity: Compliance Cost | High | -0.0001 | -0.0004 | -0.0008 | -0.0011 | -0.0015 | -0.0016 | -0.0016 | -0.0017 | -0.0019 |
| | Low | -0.0001 | -0.0004 | -0.0008 | -0.0011 | -0.0015 | -0.0016 | -0.0017 | -0.0017 | -0.0019 |
| Sensitivity: Market Growth | High | -0.0001 | -0.0005 | -0.0008 | -0.0012 | -0.0017 | -0.0018 | -0.0018 | -0.0019 | -0.0024 |
| | Low | -0.0001 | -0.0004 | -0.0007 | -0.0010 | -0.0014 | -0.0014 | -0.0014 | -0.0014 | -0.0016 |
| More Stringent Alternative | | -0.0001 | -0.0004 | -0.0008 | -0.0012 | -0.0016 | -0.0017 | -0.0018 | -0.0018 | -0.0021 |
| Less Stringent Alternative | | -0.0001 | -0.0002 | -0.0004 | -0.0006 | -0.0008 | -0.0008 | -0.0008 | -0.0008 | -0.0008 |

Source: BEAR Model

**Table C.10: Electric Power Sector CO Emissions (thousand metric tons, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -0.0022 | -0.0071 | -0.0128 | -0.0188 | -0.0253 | -0.0268 | -0.0272 | -0.0276 | -0.0320 |
| Sensitivity: Electricity Price | High | -0.0026 | -0.0080 | -0.0143 | -0.0211 | -0.0284 | -0.0304 | -0.0311 | -0.0319 | -0.0384 |
| | Low | -0.0018 | -0.0061 | -0.0109 | -0.0161 | -0.0217 | -0.0228 | -0.0229 | -0.0231 | -0.0256 |
| Sensitivity: Compliance Cost | High | -0.0018 | -0.0068 | -0.0125 | -0.0186 | -0.0251 | -0.0267 | -0.0271 | -0.0276 | -0.0322 |
| | Low | -0.0022 | -0.0072 | -0.0129 | -0.0190 | -0.0255 | -0.0271 | -0.0275 | -0.0279 | -0.0323 |
| Sensitivity: Market Growth | High | -0.0024 | -0.0076 | -0.0138 | -0.0203 | -0.0275 | -0.0299 | -0.0307 | -0.0317 | -0.0392 |
| | Low | -0.0020 | -0.0066 | -0.0118 | -0.0173 | -0.0232 | -0.0239 | -0.0239 | -0.0240 | -0.0258 |
| More Stringent Alternative | | -0.0021 | -0.0074 | -0.0135 | -0.0199 | -0.0268 | -0.0287 | -0.0292 | -0.0298 | -0.0350 |
| Less Stringent Alternative | | -0.0011 | -0.0035 | -0.0065 | -0.0096 | -0.0129 | -0.0134 | -0.0131 | -0.0128 | -0.0132 |

Source: BEAR Model

**Table C.11: Electric Power Sector PM 2.5 Emissions (thousand metric tons, difference from baseline)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal | | -0.0002 | -0.0007 | -0.0013 | -0.0019 | -0.0026 | -0.0027 | -0.0027 | -0.0028 | -0.0032 |
| Sensitivity: Electricity Price | High | -0.0003 | -0.0008 | -0.0014 | -0.0021 | -0.0029 | -0.0031 | -0.0031 | -0.0032 | -0.0039 |
| | Low | -0.0002 | -0.0006 | -0.0011 | -0.0016 | -0.0022 | -0.0023 | -0.0023 | -0.0023 | -0.0026 |
| Sensitivity: Compliance Cost | High | -0.0002 | -0.0007 | -0.0013 | -0.0019 | -0.0025 | -0.0027 | -0.0027 | -0.0028 | -0.0033 |
| | Low | -0.0002 | -0.0007 | -0.0013 | -0.0019 | -0.0026 | -0.0027 | -0.0028 | -0.0028 | -0.0033 |
| Sensitivity: Market Growth | High | -0.0002 | -0.0008 | -0.0014 | -0.0021 | -0.0028 | -0.0030 | -0.0031 | -0.0032 | -0.0040 |
| | Low | -0.0002 | -0.0007 | -0.0012 | -0.0018 | -0.0023 | -0.0024 | -0.0024 | -0.0024 | -0.0026 |
| More Stringent Alternative | | -0.0002 | -0.0007 | -0.0014 | -0.0020 | -0.0027 | -0.0029 | -0.0030 | -0.0030 | -0.0035 |
| Less Stringent Alternative | | -0.0001 | -0.0004 | -0.0007 | -0.0010 | -0.0013 | -0.0014 | -0.0013 | -0.0013 | -0.0013 |

Source: BEAR Model

The following tables show levels of the baseline, proposal and alternate scenarios.

**Table C.12: Real GDP at Factor Cost (2013 M$)**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | | 2,590,770 | 2,707,691 | 2,829,537 | 2,956,866 | 3,089,925 | 3,228,972 | 3,374,276 | 3,526,118 | 4,394,185 |
| Proposal | | 2,590,444 | 2,707,484 | 2,829,450 | 2,956,892 | 3,090,064 | 3,229,198 | 3,374,578 | 3,526,492 | 4,394,821 |
| Sensitivity: Electricity Price | High | 2,590,446 | 2,707,490 | 2,829,458 | 2,956,904 | 3,090,081 | 3,229,217 | 3,374,600 | 3,526,516 | 4,394,858 |
| | Low | 2,590,441 | 2,707,479 | 2,829,439 | 2,956,877 | 3,090,045 | 3,229,176 | 3,374,554 | 3,526,465 | 4,394,781 |
| Sensitivity: Compliance Cost | High | 2,590,437 | 2,707,475 | 2,829,438 | 2,956,877 | 3,090,046 | 3,229,177 | 3,374,555 | 3,526,465 | 4,394,777 |
| | Low | 2,590,444 | 2,707,486 | 2,829,453 | 2,956,897 | 3,090,072 | 3,229,210 | 3,374,594 | 3,526,512 | 4,394,870 |
| Sensitivity: Market Growth | High | 2,590,444 | 2,707,486 | 2,829,453 | 2,956,896 | 3,090,071 | 3,229,208 | 3,374,590 | 3,526,504 | 4,394,840 |
| | Low | 2,590,443 | 2,707,483 | 2,829,447 | 2,956,887 | 3,090,057 | 3,229,189 | 3,374,568 | 3,526,480 | 4,394,803 |
| More Stringent Alternative | | 2,590,438 | 2,707,478 | 2,829,443 | 2,956,884 | 3,090,056 | 3,229,189 | 3,374,567 | 3,526,478 | 4,394,795 |
| Less Stringent Alternative<br>_ | | 2,590,449 | 2,707,484 | 2,829,443 | 2,956,878 | 3,090,042 | 3,229,177 | 3,374,560 | 3,526,476 | 4,394,818 |

Source: BEAR Model

Table C.13: Employment (FTE Jobs)

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | | 18,818,315 | 19,312,734 | 19,822,601 | 20,348,181 | 20,889,318 | 21,445,663 | 22,016,876 | 22,602,616 | 25,738,625 |
| Proposal | | 18,811,683 | 19,307,807 | 19,819,339 | 20,346,412 | 20,889,045 | 21,446,439 | 22,018,538 | 22,605,095 | 25,744,150 |
| Sensitivity: Electricity Price | High | 18,811,723 | 19,307,892 | 19,819,473 | 20,346,599 | 20,889,286 | 21,446,702 | 22,018,815 | 22,605,385 | 25,744,504 |
| | Low | 18,811,644 | 19,307,715 | 19,819,181 | 20,346,195 | 20,888,770 | 21,446,144 | 22,018,233 | 22,604,780 | 25,743,787 |
| Sensitivity: Compliance Cost | High | 18,811,629 | 19,307,740 | 19,819,258 | 20,346,318 | 20,888,937 | 21,446,318 | 22,018,405 | 22,604,950 | 25,743,950 |
| | Low | 18,811,683 | 19,307,818 | 19,819,364 | 20,346,452 | 20,889,102 | 21,446,515 | 22,018,636 | 22,605,214 | 25,744,394 |
| Sensitivity: Market Growth | High | 18,811,697 | 19,307,847 | 19,819,410 | 20,346,516 | 20,889,187 | 21,446,630 | 22,018,744 | 22,605,315 | 25,744,437 |
| | Low | 18,811,669 | 19,307,769 | 19,819,272 | 20,346,313 | 20,888,911 | 21,446,262 | 22,018,349 | 22,604,894 | 25,743,898 |
| More Stringent Alternative | | 18,811,656 | 19,307,794 | 19,819,340 | 20,346,425 | 20,889,071 | 21,446,471 | 22,018,560 | 22,605,106 | 25,744,115 |
| Less Stringent Alternative | | 18,811,632 | 19,307,592 | 19,818,957 | 20,345,871 | 20,888,348 | 21,445,741 | 22,017,867 | 22,604,450 | 25,743,623 |

Source: BEAR Model

**Table C.14: Real GDP at Factor Cost (2013 M$) - Level Change from pervious year**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | | _ | 116,921 | 121,846 | 127,329 | 133,059 | 139,047 | 145,304 | 151,842 | 173,613 |
| Proposal | | _ | 117,041 | 121,965 | 127,442 | 133,172 | 139,134 | 145,380 | 151,913 | 173,666 |
| Sensitivity: Electricity Price | High | _ | 117,044 | 121,969 | 127,446 | 133,177 | 139,137 | 145,383 | 151,916 | 173,669 |
| | Low | _ | 117,037 | 121,961 | 127,438 | 133,168 | 139,131 | 145,378 | 151,911 | 173,663 |
| Sensitivity: Compliance Cost | High | _ | 117,038 | 121,963 | 127,439 | 133,170 | 139,131 | 145,377 | 151,910 | 173,662 |
| | Low | _ | 117,042 | 121,967 | 127,444 | 133,175 | 139,137 | 145,384 | 151,918 | 173,672 |
| Sensitivity: Market Growth | High | _ | 117,042 | 121,967 | 127,444 | 133,175 | 139,137 | 145,382 | 151,915 | 173,667 |
| | Low | _ | 117,040 | 121,964 | 127,440 | 133,170 | 139,131 | 145,379 | 151,912 | 173,665 |
| More Stringent Alternative | | _ | 117,040 | 121,965 | 127,441 | 133,172 | 139,133 | 145,378 | 151,911 | 173,663 |
| Less Stringent Alternative | | _ | 117,035 | 121,959 | 127,435 | 133,165 | 139,135 | 145,383 | 151,916 | 173,669 |

Source: BEAR Model

**Table C.15: Employment (FTE Jobs) - Change in total employment from previous year**

| _ | _ | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | | _ | 494,418 | 509,867 | 525,580 | 541,137 | 556,346 | 571,213 | 585,741 | 627,202 |
| Proposal | | _ | 496,125 | 511,532 | 527,073 | 542,633 | 557,394 | 572,100 | 586,557 | 627,811 |
| Sensitivity: Electricity Price | High | _ | 496,169 | 511,581 | 527,125 | 542,688 | 557,416 | 572,113 | 586,570 | 627,824 |
| | Low | _ | 496,071 | 511,466 | 527,015 | 542,575 | 557,374 | 572,089 | 586,546 | 627,801 |
| Sensitivity: Compliance Cost | High | _ | 496,111 | 511,518 | 527,059 | 542,620 | 557,381 | 572,087 | 586,544 | 627,800 |
| | Low | _ | 496,136 | 511,545 | 527,088 | 542,650 | 557,413 | 572,120 | 586,579 | 627,836 |
| Sensitivity: Market Growth | High | _ | 496,151 | 511,563 | 527,106 | 542,670 | 557,443 | 572,115 | 586,571 | 627,824 |
| | Low | _ | 496,100 | 511,503 | 527,041 | 542,598 | 557,351 | 572,087 | 586,545 | 627,801 |
| More Stringent Alternative | | _ | 496,138 | 511,546 | 527,085 | 542,646 | 557,400 | 572,089 | 586,546 | 627,802 |
| Less Stringent Alternative | | _ | 495,961 | 511,365 | 526,915 | 542,477 | 557,392 | 572,127 | 586,583 | 627,834 |

Source: BEAR Model