To: Amy Tong, Secretary, Government Operations Agency
Kevin Day, Acting Executive Director, Building Standards Commission
Lourdes M. Castro Ramírez, Secretary, Business, Consumer Services and Housing Agency
Gustavo Velasquez, Director, California Department of Housing and Community Development

From: Steven S. Cliff, Ph.D., Executive Officer, California Air Resources Board

Date: November 3, 2023

Subject: California Air Resources Board's (CARB) Suggested Changes for Zero-Emission Building Standards in the California Green Building Standards (CALGreen) Code

Thank you for your ongoing collaboration to advance building standards that help California meet its ambitious greenhouse gas (GHG) reduction goals. Building decarbonization must be accelerated in the near term to avoid the worst impacts of climate change. Therefore, the California Air Resources Board (CARB) is recommending mandatory zero-emission residential new construction standards in the 2024 triennial CALGreen code cycle. California's *2022 Scoping Plan* relies on zero-emitting new residential buildings beginning in 2026 to meet the State's climate goals. Eliminating GHG emissions from new residential building end-uses would ensure California's new building stock does not contribute to climate change and would provide co-benefits of reducing indoor and outdoor exposure to air pollutants while improving public health. Mandatory zero-emission building standards for new construction are also an essential part of a broader statewide strategy to reduce building emissions and put California on track to achieve carbon neutrality by mid-century. CARB urges the Department of Housing and Community Development (HCD) and the Building Standards Commission (BSC) to include zero-emission building standards for residential new construction as mandatory provisions in CALGreen in the current triennial code cycle.

Zero-emission new construction is one of the most cost-effective near-term building decarbonization strategies. Since the California Public Utilities Commission (CPUC) ended gas infrastructure extension subsidies for new construction earlier this year, the upfront costs of building homes with fossil gas infrastructure in investor-owned utility service territories, which represent nearly all of residential fossil gas customers in California, are now at least three times greater than the costs for building zero-emission homes. When factoring in energy bill costs, zero-emission buildings can also reduce costs over the lifetime of appliances when compared to fossil-fueled buildings. Zero-emission residential homes have also been shown to be technically feasible. In May 2023, New York became the first state to pass a law prohibiting natural gas hookups and other fossil fuels in most new residential homes. Since zero-emission new construction is cheaper to build than homes with gas

infrastructure, CARB's proposed strategy will help alleviate California's housing affordability crisis. These proposed code changes represent a win-win strategy for all.

There is a wide range of support for this approach from local jurisdictions, state legislators, architects, and environmental groups. Twenty-five local jurisdictions submitted a joint *letter* to Governor Newsom on September 7, 2023, urging the development of mandatory zero-emission new construction requirements in the CALGreen code this code cycle. Several state legislators also submitted a *letter* requesting the state take bolder action to decarbonize buildings and adopt a zero-emission new construction building standard in CALGreen given the climate crisis. Both the American Institute of Architects and RMI submitted their own petitions to BSC for zero-emission new construction measures in this code cycle. CARB staff stand ready to support HCD in engaging with the various interested parties in this code update.

CARB looks forward to working with HCD and BSC to ensure equitable and cost-effective building decarbonization. Thank you in advance for your consideration of CARB's suggested code language in the mandatory provisions of CALGreen during the 2024 triennial code cycle. By adopting these building standards, your agency will support achievement of California's climate and air quality targets.

If you have any questions or need further information, please feel free to contact Jennifer Gress, Chief, Sustainable Transportation and Communities Division at (916) 764-0747 or Jennifer.Gress@arb.ca.gov.

cc:

Kyle Krause, Deputy Director, Codes and Standards, California Department of Housing and Community Development

Liane M. Randolph, Chair, California Air Resources Board

Sydney Vergis, Ph.D, Deputy Executive Officer

Jennifer Gress, Division Chief, Sustainable Transportation and Communities Division (STCD)

Annalisa Schilla, Assistant Division Chief, STCD

INITIAL STATEMENT OF REASONS FOR PROPOSED BUILDING STANDARDS OF THE CALIFORNIA DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT (HCD) REGARDING THE CALIFORNIA GREEN BUILDING STANDARDS CODE CALIFORNIA CODE OF REGULATIONS, TITLE 24, PART 11 (HCD 11/23)

The Administrative Procedure Act (APA) requires that an Initial Statement of Reasons be available to the public upon request when rulemaking action is being undertaken. The following information required by the APA pertains to this particular rulemaking action:

STATEMENT OF SPECIFIC PURPOSE, PROBLEM, RATIONALE AND BENEFITS

Government Code Section 11346.2(b)(1) requires a statement of specific purpose of each adoption, amendment, or repeal; the problem the agency intends to address; and the rationale for the determination by the agency that each adoption, amendment, or repeal is reasonably necessary to carry out the purpose and address the problem for which it is proposed. The statement shall enumerate the benefits anticipated from the regulatory action, including the benefits or goals provided in the authorizing statute.

The specific purpose for each adoption, amendment, or repeal and the problem the agency intends to address and the rationale for the change is summarized below on a section-by-section basis.

Background, Recommended Solutions and Statutory Requirements related to Zero-Emission Buildings

The provisions related to Zero-Emission Buildings proposed by the California Department of Housing and Community Development (HCD), as requested by the California Air Resources Board (CARB), include mandatory green building standards for occupancies within its authority, building upon a framework of measures adopted by HCD in 2008. The intent of the CALGreen Code continues to be: (1) reduce greenhouse gas (GHG) emissions from buildings; (2) promote environmentally responsible, cost-effective, healthier places to live and work; and (3) respond to the directives by the Governor in 2008 to develop a green building code.

HCD's proposed action will support the implementation of Assembly Bill (AB) 32, Senate Bill (SB) 32, and AB 1279 to reduce California's greenhouse gas (GHG) emissions and achieve carbon neutrality. AB 32 set California's first GHG target and called on the state to reduce emissions to 1990 levels by 2020. SB 32 extended the goals of AB 32 and set a 2030 goal of reducing GHG emissions 40 percent from 1990 levels. In 2018, Governor Newsom issued Executive Order B-55-18 establishing a new state goal for California to reach carbon neutrality by 2045 and maintain net negative emissions thereafter; the Legislature codified that goal in AB 1279, with at least 85 percent of actual statewide GHG emissions being reduced below 1990 levels by 2045. These actions keep California on target to achieve the level of reductions scientists say is necessary to meet the Paris Agreement goals to limit global temperature rise and avoid the worst consequences of climate change. Expanding construction of zero-emission buildings is one of several key actions to reduce GHG emissions from buildings (CARB, 2022a). HCD's proposed

amendments to the 2022 CALGreen Code will support California's climate targets.

Statewide application of the proposed building standards will lead to substantial environmental, equity, climate, outdoor/ambient air, and health benefits through reduction in GHG emissions, criteria pollutants, and toxic air contaminants both indoors and outdoors. These benefits lead to improved public health, result in significant cost savings (avoided costs) associated with new construction of residential buildings, and prevent stranded assets and future maintenance costs associated with fossil gas infrastructure. By reducing costs of new construction, the proposed standards will help alleviate California's housing affordability crisis, leading to a win-win situation for all.

Statutory References
AB 1473 (Calderon, Statutes of 2008, Chapter 719) directed HCD to develop green building standards. Health and Safety Code Section 18930.5(b) as amended by AB 341 (Statutes of 2013, Chapter 585) requires HCD and other state agencies that propose building standards to allow for input by state agencies with expertise in green building subject areas. CARB has expertise in and obligations with respect to air quality, climate change, and public health (see, e.g., Health and Safety Code sections 38510, 38560, 39003, 39600, 39601, 39666).

SPECIFIC PROPOSED REGULATORY ACTIONS

Item 1: Chapter 2 DEFINITIONS, Section 202

ZERO-EMISSION BUILDING

Rationale: HCD proposes to adopt the above referenced new definition for residential sections of CALGreen. The new definition clarifies the new term as used within section 4.508.1.

Item 2: Chapter 4 Residential Mandatory Measures, Section(s) 4.508 Zero-Emission Building.

Rationale: HCD proposes this section for adoption, which includes a mandatory provision for all newly constructed residential buildings to be designed and constructed as zero-emission buildings. A zero-emission building would be defined as a newly constructed residential building that emits zero grams of on-site GHGs daily. Hydrofluorocarbons would be excluded from this limit, as those are already separately regulated by CARB and the U.S. Environmental Protection Agency.

HCD is moving forward with the CARB-suggested changes and proposes to include a mandatory provision for zero-emission buildings in new residential buildings. Analysis shows that fuel combustion within buildings emits criteria air pollutants, toxic air contaminants, and GHGs, and therefore deteriorates indoor and outdoor air quality and worsens climate change. Zero-emission buildings can reduce indoor and outdoor air pollution, protect public health, and put California on track to achieve carbon neutrality by 2045. While the term "zero-emission buildings" is broadly defined, one likely compliance

pathway involves the construction of all-electric homes as electric appliances are technically feasible and readily available today. The regulatory analysis and literature sources relied upon in this document investigate the impacts of an all-electric compliance pathway.

Unvented combustion of fossil gas can cause high levels of indoor air pollutants such as nitrogen dioxide (NO_2),[1] carbon monoxide (CO),[2] fine particles (PM2.5, particles with diameters smaller than 2.5 micron), ultrafine particles (UFPs, particles with diameters smaller than 0.1 micron), and formaldehyde, which are harmful to human health and the environment. One study that monitored NO_2 within homes found that those with a conventional gas stove may have NO_2 levels 50 percent to 400 percent higher than those with an electric stove (Seals and Krasner, 2020). Another study estimated that 12 million Californians with conventional gas stoves are exposed routinely to NO_2 levels, exceeding the federal and State ambient air quality standards (Logue et al., 2014). Exposures to air pollutants from conventional gas appliances, such as NO_2, have been linked to both acute and chronic health effects, such as reduced mental development in children and asthma exacerbation (Belanger et al., 2013; Lin et al., 2013; Devon et al., 2018; Morales et al. 2009). A 2013 analysis of multiple studies found that children in a home with a conventional gas stove have increased asthma symptoms, including 42 percent increased risk of current asthma and 24 percent of lifetime asthma (Lin et al., 2013).

Reducing exposure to gas combustion within homes might be more crucial for lower-income households. These households often already have increased exposure levels from local outdoor pollution sources, such as traffic and industry, and they also tend to be exposed to higher levels of indoor air pollution from unvented gas combustion from cooking due to their smaller unit size and higher occupant density (Adamkiewicz et al., 2011). Households in under-resourced communities often also have insufficient ventilation, and residents more often may use gas ovens as heating sources (Seals and Krasner, 2020). A study in new and renovated low-income apartments in California showed that, compared to houses with similar cooking frequency, mean NO_2 levels in these apartments were 165% higher, indicating a higher risk from gas cooking burners in these smaller spaces (Zhao et al., 2021). Three of the sites (apartment complexes) from this research study had buildings that were three stories or less; and the fourth site was a five-story building.

While mechanical ventilation can improve indoor air quality and reduce the impacts of combustion pollutants released indoors, such ventilation only moves these pollutants outdoors; instead, building decarbonization provides a more comprehensive solution. A Healthy, Efficient, New Gas Homes (HENGH) study funded by CEC showed homes built after 2011 that met the mechanical ventilation requirements, when the mechanical ventilation systems were running, had 44 percent lower PM2.5 and formaldehyde indoors than those constructed in 2002-2005 and tested in the California New Homes Study (CNHS) (Singer et al., 2020). However, ventilation alone is insufficient to address health risks of gas combustion in homes, as it only works when people turn the systems on and

[1] NO_2 is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NOx). NO_2 is used as the indicator for the larger group of nitrogen oxides.

[2] Carbon monoxide is a colorless, odorless gas caused by incomplete combustion.

when the systems are functioning well. The HENGH study found ventilation fans were operating in only 26 percent of homes when first visited (Singer et al., 2020). A recent study in California houses and low-income apartments reported that kitchen range hoods were only used for 36% of cooking events in houses and 28 percent in apartments (Zhao et al., 2020). This study in low-income apartments found that, although all 23 studied apartments had mechanical ventilation equipment with specifications that met state requirements, only 8 had on-site performance that operationally met all code requirements; therefore, it was not surprising to find two apartments had weekly NO_2 higher than the California ambient air quality standards for annual average NO_2 of 30 ppb (Zhao et al., 2021). On the other hand, building decarbonization can reduce or eliminate these pollutant exposures without relying on occupant behavior and equipment performance; combined with improved ventilation, it will provide more effective protection and wider coverage for public health.

Combustion of fossil gas in residential buildings emits about 46 tons/day NOx to the ambient air, nearly 3 times the emissions from power plants and about one-half of those from light-duty vehicles (CARB, 2022b). Additionally, fossil gas combustion in residential buildings accounts for nearly 23 million tons of carbon dioxide equivalents annually (CARB, 2022d). For the impact on climate change, about 7 percent of California's GHG emissions come from residential buildings (CARB, 2022c). However, a recent study by Lebel et al. found the contribution from conventional gas stoves on GHG emissions may be far larger than estimated in the current emission inventory. While methane[3] emissions from combustion are part of the inventory, methane leaks during steady-state-off (no combustion) period were not included in the inventory. Steady-state-off leakage could account for over 75% of methane emissions from conventional gas stoves (Lebel et al., 2021). The large contribution of conventional gas combustion appliances to indoor and outdoor air pollution and GHG levels demonstrates the need for near-term action on zero-emission buildings.

HCD proposes to include a mandatory provision for zero-emission buildings in new residential buildings. This change will help improve air quality, reduce GHG emissions, protect public health, and achieve cost savings associated with building construction, operation, and health care:

(1). Cost Savings: Several studies estimate that all-electric new construction is lower cost than building mixed-fuel[4] new homes, primarily due to the avoided costs of gas infrastructure, with cost savings in the range of $2,000 to $10,000 per unit (Mahone, et al., 2019) (Frontier Energy, 2019) (Billimoria, et al., 2018) (TRC, 2018) (TRC, 2016). When factoring in energy costs, all-electric new home construction also reduces costs over the lifetime of appliances when compared to fossil fueled homes (Billimoria, et al., 2018). The benefit would be greater when considering the health costs associated with exposures to air pollution. A recent study by Zhu et al. predicted that if all residential conventional gas appliances in California (in 2018) were replaced with electric ones instantaneously, the emission benefits would result in 354 fewer premature deaths, 596 fewer cases of acute

[3] Methane is one of several greenhouse gases that is considered a short-lived climate pollutant (SLCP); it is a powerful climate forcer with a relatively short atmospheric lifetime.

[4] Mixed-fuel refers to a building that typically uses natural gas or propane and electricity.

bronchitis and 304 fewer cases of chronic bronchitis. These health benefits are equivalent to approximately $3.5 billion in monetized savings over the course of one year (Zhu et al., 2020). This study demonstrated the relative magnitude of health benefits for zero-emission residential buildings.

(2). Climate Benefits: Near-term action to decarbonize buildings is essential to put California on track for climate neutrality by 2045 (CARB, 2022a) (Mahone, et al., 2020).

(3). Outdoor Air Quality: Zero-emission new construction of residential buildings will cut the emissions of GHGs to help meet California's climate targets as well as criteria air pollutants such as NO_2, CO, and PM2.5 released from fuel combustion and vented into the ambient air.

(4). Indoor Air Quality: Construction of new zero-emission residential buildings will eliminate air pollutant emissions from fuel combustion and greatly improve air quality in indoor environments where on average Californians spend over 87 percent of time. As studies have shown, replacing an emissive gas stove with a non-emitting one, such as an electric stove, can decrease NO_2 concentrations by 42 to 51% in a home (Seals and Krasner, 2020). Additionally, benzene emissions from gas burners and ovens are 10 to 25 times higher than from electric alternatives (Kashtan et al., 2023).

TECHNICAL, THEORETICAL, AND EMPIRICAL STUDY, REPORT, OR SIMILAR DOCUMENTS

Government Code Section 11346.2(b)(3) requires an identification of each technical, theoretical, and empirical study, report, or similar document, if any, upon which the agency relies in proposing the regulation(s).

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STATEMENT OF JUSTIFICATION FOR PRESCRIPTIVE STANDARDS

Government Code Section 11346.2(b)(1) requires a statement of the reasons why an agency believes any mandates for specific technologies or equipment or otherwise

prescriptive standards are required. This proposal for a mandatory zero-emission requirement for newly constructed residential buildings is not a prescriptive standard. It does not mandate specific technologies or equipment but rather establishes a requirement for new residential buildings to emit no GHGs in their normal course of functioning; the building developer or owner must determine how to best ensure that requirement is met (e.g., by electrifying, by using emission capture and control technologies, etc.).

Even if this proposal were a prescriptive standard, it would be necessary and preferable to a performance standard. HCD is statutorily required to adopt by reference model building codes for other parts of the California Building Standards Code which contain prescriptive standards. Although CALGreen is not based on a model code, prescriptive standards provide the following: explicit guidance for certain mandated requirements; consistent application and enforcement of building standards while also establishing clear design parameters; and assurance of compliance with minimum health, safety, and welfare standards for owners, occupants, and guests.

CONSIDERATION OF REASONABLE ALTERNATIVES

Government Code Section 11346.2(b)(4)(A) requires a description of reasonable alternatives to the regulation and the agency's reasons for rejecting those alternatives. In the case of a regulation that would mandate the use of specific technologies or equipment or prescribe specific action or procedures, the imposition of performance standards shall be considered as an alternate. Agencies need not artificially construct alternatives or describe unreasonable alternatives.

HCD's proposals during this triennial code cycle are intended to add mandatory provisions in CALGreen to meet climate targets as set forth by AB 32, SB 32, and AB 1279 to reduce California's GHG emissions to at least 85 percent below 1990 levels and achieve carbon neutrality by 2045. Two alternatives were considered. The first alternative considered was less burdensome and would apply to new low-rise single family home buildings and townhomes (2-4 unit multifamily housing) only. The second alternative considered was to adopt a mandatory requirement for zero-emission buildings for newly constructed residential buildings and alterations to existing residential buildings. Alternative 2 assumes a certain percentage of existing buildings would undergo alterations annually based on remodel rates found in the California Residential Remodeling/Renovation Market Study (Primen, 2001). The first alternative was rejected at this time because it results in notably less GHG emission reductions and thus is insufficient to achieve the State's long-term climate goal to achieve carbon neutrality by mid-century and protect public health. The second alternative was rejected because it is over 40 times more costly to implement.

REASONABLE ALTERNATIVES THE AGENCY HAS IDENTIFIED THAT WOULD LESSEN ANY ADVERSE IMPACT ON SMALL BUSINESS

Government Code Section 11346.2(b)(4)(B) requires a description of any reasonable alternatives that have been identified or brought to the attention of the agency that would lessen any adverse impact on small business.

Small businesses would not be impacted by this proposal. No alternatives were identified to lessen the adverse impact on small business.

FACTS, EVIDENCE, DOCUMENTS, TESTIMONY, OR OTHER EVIDENCE OF NO SIGNIFICANT ADVERSE IMPACT ON BUSINESS

Government Code Section 11346.2(b)(5)(A) requires the facts, evidence, documents, testimony, or other evidence on which the agency relies to support an initial determination that the action will not have a significant adverse economic impact on business.

HCD has determined that this regulatory action would increase costs marginally to California business enterprises representing less than 0.18 percent of the total new construction costs of residential buildings with significant benefits to Californians due to improved air quality and reduced impacts of climate change.

ASSESSMENT OF EFFECT OF REGULATIONS UPON JOBS AND BUSINESS EXPANSION, ELIMINATION OR CREATION

Government Code Section 11346.3(b)(1) requires agencies to assess the extent this proposal will affect the following:

A. **The creation or elimination of jobs within the State of California**.
   Some jobs may be created for installation, maintenance, and manufacturing of zero-emission appliances. Some jobs for gas pipefitters may be eliminated.
B. **The creation of new businesses or the elimination of existing businesses within the State of California.**
   Some special trade construction businesses may be created. No business is expected to be eliminated.
C. **The expansion of businesses currently doing business within the State of California.**
   The proposal is likely to promote the expansion of businesses currently involved in zero-emission appliance manufacturing, installation, maintenance, use and technology development.
D. **The benefits of the regulation to the health and welfare of California residents, worker safety, and the state's environment.**
   The proposal will increase the sustainability of California's natural resources and promote public health by reducing GHG emissions, criteria pollutants, and toxic air contaminants.

ESTIMATED COST OF COMPLIANCE, ESTIMATED POTENTIAL BENEFITS, AND RELATED ASSUMPTIONS USED FOR BUILDING STANDARDS

Government Code Section 11346.2(b)(5)(B)(i) states if a proposed regulation is a building standard, the initial statement of reasons shall include the estimated cost of compliance, the estimated potential benefits, and the related assumptions used to determine the estimates.

When accounting for the avoided construction costs of installing gas infrastructure, an estimated $1.20 billion could be saved over a 25-year lifetime of this regulation. Statewide costs are estimated to total $502 million over a 25-year lifetime of this regulation. Five residential end-uses were analyzed: space heating, water heating, cooking, clothes drying, and pool heating. Staff estimates cumulative GHG emissions reductions of 22.4 million metric tons CO_2 equivalents over a 25-year lifetime of this regulation. Greenhouse gas reductions were estimated as the net impact from four categories: reduced emissions from avoided gas combustion, reduced emissions from avoided behind-the-meter gas leakage,

increased emissions from refrigerants used in zero-emission appliances, and increased upstream emissions for electricity generation.

DUPLICATION OR CONFLICTS WITH FEDERAL REGULATIONS

Government Code Section 11346.2(b)(6) requires a department, board, or commission within the Environmental Protection Agency, the Resources Agency, or the Office of the State Fire Marshal to describe its efforts, in connection with a proposed rulemaking action, to avoid unnecessary duplication or conflicts with federal regulations contained in the Code of Federal Regulations addressing the same issues.

Staff have analyzed both this proposal and relevant law and concluded that these regulations do not duplicate or conflict with federal law or regulations.

Draft Dated November 3, 2023

INITIAL EXPRESS TERMS FOR PROPOSED BUILDING STANDARDS OF THE CALIFORNIA DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT REGARDING THE CALIFORNIA GREEN BUILDING STANDARDS CODE, CALIFORNIA CODE OF REGULATIONS, TITLE 24, PART 11 (HCD 11/23)

The State agency shall draft the regulations in plain, straightforward language, avoiding technical terms as much as possible and using a coherent and easily readable style. The agency shall draft the regulation in plain English. A notation shall follow the express terms of each regulation listing the specific statutes authorizing the adoption and listing specific statutes being implemented, interpreted, or made specific (Government Code Section 11346.2(a)(1)).

If using assistive technology, please adjust your settings to recognize underline, strikeout and ellipsis.

LEGEND for EXPRESS TERMS (California only codes - Parts 1, 6, 8, 11, 12)

- Existing California amendments appear upright
- Amended or new California amendments appear <u>underlined</u>
- Repealed California language appears ~~upright and in strikeout~~
- Ellipsis (...) indicate existing text remains unchanged

INITIAL EXPRESS TERMS

Item 1: HCD proposes to bring forward amendments in Chapter 2 – Definitions for adoption into the 2025 CALGreen.

CHAPTER 2
DEFINITIONS

Section 202 Definitions

<u>ZERO-EMISSION BUILDING</u> <u>– A building that emits no more than 0 grams daily of on-site greenhouse gases (GHG), as defined in Health and Safety Code section 38505(g), to protect public health and safety by reducing exposure to pollutants that impact outdoor air quality and contribute to climate change. This limit does not include HFCs, as those are regulated separately (see California Code of Regulations, title 17, sections 95371-95398; California Health and Safety Code sections 39735-39736; Code of Federal Regulations, title 40, part 84).</u>

Item 2: Chapter 4 Residential Mandatory Measures,

Section 4.502.1 Definition

The following terms are defined in Chapter 2.

<u>ZERO-EMISSION BUILDING</u>

Section 4.508 OUTDOOR AIR QUALITY

ZERO-EMISSION BUILDING

4.508.1 Zero-Emission Building. All newly constructed residential buildings, as defined in Title 24, Part 11, Chapter 2, including but not limited to one- and two-family dwellings, townhouses, and multifamily dwellings shall be designed and constructed as Zero-Emission Buildings.

Economic and Fiscal Impact Statement (Form 399) Attachment Amend the 2022 California Green Building Standards Code, CCR, Title 24, Part 11

This proposed amendment to the 2022 California Green Building Standards Code, CCR, Title 24, Part 11 would add a mandatory provision for all newly constructed residential buildings to be designed and constructed as zero-emission buildings, or buildings that emit no greenhouse gases (excluding hydrofluorocarbons, which are controlled separately). The proposed building standard would result in the development of zero-emission buildings for all residential new construction. This provision would facilitate greenhouse gas, criteria pollutant, and toxic air contaminant emission reductions from residential buildings. It would require builders to procure and install zero-emission end uses, such as for water heating, space conditioning, cooking, and clothes drying, in newly constructed residences. While the term "zero-emission buildings" is broadly defined, one likely compliance pathway involves the construction of all-electric homes as electric appliances are technically feasible and readily available today. The regulatory analysis and literature sources relied upon in this document investigate the impacts of an all-electric compliance pathway. Individuals purchasing or renting dwelling units or residences subject to this regulation would be required to use and pay for related utility expenses for these appliances. Government entities permitting new construction would need to review building designs to ensure they are compliant with this regulation as part of their standard review process.

The costs for this proposed amendment are evaluated on 3-year and 25-year time horizons. The 3-year time horizon is in keeping with the update cycle for the CALGreen building code (in this case January 1, 2026, through December 31, 2028). The 25-year time horizon is aligned with California's climate planning (in this case January 1, 2026, through December 31, 2050).

I. Economic Impact Statement

A. Estimated Private Sector Impacts

A-3. Total Number of Businesses Impacted

None. It is expected that any business funding the development of newly constructed residential housing will likely pass changes in upfront costs on to individuals.

B. Estimated Costs

B-1. Estimated Statewide Dollar Costs for Individuals

Staff estimate the statewide dollar costs to individuals in incremental terms (the cost of proposed end uses vs. business-as-usual or baseline). Staff surveyed several cost studies to create a database of upfront capital costs to install typical gas (baseline) and zero-emission (proposed) equipment and appliances. Table 1 summarizes the distribution of upfront costs for baseline and proposed end uses.

Table 1: Upfront End Use Cost Summary[1] - New Construction Equipment Costs

End Use	Baseline Equipment Costs	Proposed Equipment Costs	Incremental Equipment Cost
Space Conditioning	A. Gas Furnace:[2] $1,248 B. Gas Furnace (see A) and Air Conditioner:[3] $3,950	(A and B) Air Source Heat Pump:[4] $4,970	A. $3,723 B. -$228
Water Heating	A. Gas-Fired Instantaneous Water Heater:[5] $1,378 B. Gas Storage Water Heater:[6] $1,155	(A and B) Heat Pump Water Heater:[7] $1,498	A. $120 B. $343

[1] *Energy Information Administration (EIA) "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies."* Accessed 9/29/2023.

Where "typical" and "high" costs are denoted in the table above, staff assume 75% of housing units experience typical costs, and 25% experience high costs, unless otherwise noted.

[2] EIA (2023, p. 12), "Residential Gas-Fired Furnaces (Rest of Country). Where "typical" and "high" costs are provided, staff assume that 75% of housing units experience typical costs, and 25% experience high costs. For example, this cost estimate of $1247.50 is derived from a reported "typical" cost of $1,200 and "high" cost of $1,390.

[3] EIA (2023, p. 28-29), "Residential Air Conditioners North and South."

[4] EIA (2023, p. 40), "Residential Air-Source Heat Pumps." Like gas furnaces, the weighted average of air source heat pump costs ($4,380 typical and $6,740 high) yields an estimated cost of $4,970 per unit.

[5] EIA (2023, p. 72), "Residential Gas-Fired Instantaneous Water Heaters." Based on $1,360 "typical" and $1,430 "high" costs.

[6] EIA (2023, p. 57), "Residential Gas-Fired Storage Water Heaters." Based on $990 "typical" and $1,650 "high" costs.

[7] EIA (2023, p. 66), "Residential Heat Pump Water Heaters." Although EIA estimates that future costs will decline, we conservatively use the higher 2022 estimate for all cost years. Based on $1,440 "typical" and $1,670 "high" costs.

End Use	Baseline Equipment Costs	Proposed Equipment Costs	Incremental Equipment Cost
Cooking[8]	A. Gas Range (60% of units): $850 B. Gas Cooktop and Oven (40% of units): $1,140	A. Electric Range: $900 B. Electric Cooktop and Oven: $1,540	A. $50 B. $400
Clothes Drying[9]	Gas Clothes Dryer: $670	Electric Heat Pump Clothes Dryer: $980	$310
Pool Heating	Gas Pool Heater:[10] $2,598	Electric Pool Heater:[11] $2,277	-$322

[8] EIA (2023, pp.89, 94). Electric cost estimate includes both electric resistance and induction units, so while "typical" and "high" costs were provided by EIA, we use the "high" value, since we assume induction technology adoption in the emissions modeling, and induction cooking appliance costs are usually higher than electric resistance.

[9] EIA (2023, pp. 98-99). "Residential Clothes Dryers (Electric)", "Residential Clothes Dryers (Gas)". Since EIA electric cost estimates include both vented and ventless (heat pump) units, staff assume "high" costs apply.

[10] Forbes Home, "

Best Natural Gas Pool Heaters Of September 2023 – Forbes Home

. The value provided in the table is an average of the units listed in this article.

[11] *Forbes Home, "Best Electric Pool Heaters of September 2023"* The value provided in the table is an average of the units listed in this article and includes units using heat pump technology.

Table 2 Developer Costs for New Gas Infrastructure

Gas Infrastructure	Cost Description	Baseline	Proposed
Service Extension	A. For New Greenfield Subdivision/Development B. For Existing Subdivision/Development[12]	A. $1,300 to $1,850 B. $6,750 to $9,200	$0
Gas Meter	A. Residential Single Family B. Residential Multi-family	A. $300 B. $300 + $300 per manifold outlet	$0
In-House Infrastructure	A. Single-family B. Multi-family	A. $800 B. $600 per unit	$0

Staff estimates the number of end uses in newly constructed residences that would, in the absence of regulatory intervention, be fueled by gas. Staff estimate the incremental capital costs (equipment costs for new construction, and installation and equipment costs for retrofits in Alternative 2) and assume that these costs are all immediately accrued (not amortized over the appliance lifetime). Staff estimate the cost of avoided gas consumption and additional electricity consumption under each alternative.

Staff also estimate the costs of installing gas infrastructure in new buildings. To estimate the net present value of costs associated with this regulation, staff discount costs accrued in future years using a 10 percent discount rate. However, the estimated average cost to households is provided in real, undiscounted, 2023 dollars.

The 3-year discounted statewide cost of this regulation is $188.9 million, and the 25-year statewide discounted cost of this regulation is $502 million. The 3-year discounted benefit of this regulation is $422 million, and the 25-year statewide discounted benefit is $1.20 billion.

[12] *PG&E advice letter 4386-G*. Since the existing/new greenfield status of new construction projects was not estimated, this analysis used the conservative estimate that all new construction would be occurring in greenfield contexts. Each new building would accrue service extension costs, and each new unit would accrue meter and in-house infrastructure costs. Since the exact number of new multifamily buildings constructed is unknown, we estimate one new line extension per 4 units built in the 3-4 unit building category, and one new extension per 25 units built in the 5+ unit category.

a) Costs to Small Business
None. It is assumed that any added upfront costs would be passed on to individuals.

b) Costs to Typical Business
None. It is assumed that any added upfront costs would be passed on to individuals.

c) Initial Cost for Individuals

a. In the context of this proposed amendment, costs to individuals are described in terms of costs to households – defined as those sharing a dwelling unit and associated end uses impacted by this regulation. Costs to households are estimated in terms of the newly constructed housing units impacted by this policy. If upfront costs are passed on to individuals purchasing or renting new homes, households would experience an average of $741 in additional appliance costs, and $150 in additional energy costs (for more detail on energy cost calculations, see "b. Annual ongoing costs" below). Households would also experience an average cost savings of $1,607 from avoiding the construction of additional gas infrastructure. This amounts to a first-year net benefit of $741 across all impacted housing units. Table 3 further summarizes first-year upfront and ongoing cost impacts by housing type.

$$Average\ Net\ Household\ Benefit_{year}:$$
$$= \frac{\sum ApplianceCost_{proposed} - ApplinaceCost_{baseline}}{Housing\ Units}$$
$$+ \frac{\sum EnergyCost_{proposed} - EnergyCost_{baseline}}{Housing\ Units}$$
$$+ \frac{\sum InfrastructureCost_{proposed} - InfrastructureCost_{baseline}}{Housing\ Units}$$

Table 3: Average incremental upfront (first-year) costs to households

Housing Type (percent of new housing units)	Equipment	Energy	Avoided Gas Infrastructure	Net Benefit
Single-Family Detached (68%)	$830	$177	- $2,675	$1,668
Single-Family Attached (7.4%)	$864	$121	- $2,675	$1,690
Multi-Family (3-4 units) (5.9%)	$522	$96	- $710	$92
Multi-Family (5+ units) (18%)	$412	$87	- $368	- $131
All housing units (100%) [13]	$741	$150	-$1,607	$716

Between 2026-2050, an estimated 71,000 new single-family and 30,000 new multifamily housing units are expected to be impacted by the regulation annually.[14] According to the 2019 Residential Appliance Saturation Survey,[15] about 80% of homes installed gas equipment for water heating, 40% installed gas appliances for clothes drying, 70% installed gas cooking, and 70% installed gas equipment for space heating. The remaining share of new home construction typically installs electric equipment/appliances for these end uses. More recent data suggests nearly half of new single-family homes and about 80% of multi-family homes install heat pumps for space heating, while nearly 20% of single-family homes and 35% of multi-family homes install heat pumps for water heating.[16] The number of units installing gas infrastructure was inferred from the count of gas-fueled cooking appliances since more newly constructed homes are expected to install gas cooking than any other appliance in the absence of the proposed CALGreen code changes. The total statewide costs for zero-emission new construction are based on an estimated annual average of 67,900 new housing units installing zero-emission equipment/appliances that would have otherwise installed gas equipment/appliances.

[13] Overall average weighted by relative share of housing units statewide.
[14] CEC. 2022. *"California Energy Demand Forecast, 2021-2035 Baseline Forecast - Mid Demand Case."*
[15] Palmgren, C., M. Goldberg, B. Ramirez, and C. Williamson. 2021. *"2019 California Residential Appliance Saturation Survey (RASS)."* *California Energy Commission*. Publication Number: CEC-200-2021-005.
[16] Data received from CEC. Heat pump installation based on CalCERTs reported data in 2021.

Total incremental upfront real capital costs were calculated by multiplying the average incremental costs for each end use by the total number of new electric equipment/appliances installed in new residential housing. Initial costs for individuals were calculated by taking the total incremental upfront real capital costs and dividing it by the number of housing units impacted by the regulation.

b. Annual ongoing costs: annual ongoing costs were estimated in terms of changes to the volume and cost of gas or electricity consumed by each end-use. For each modeled geographic area (69 total), end-use energy consumption is assigned to a probable gas and electric utility rate (see Figure 2). These costs are then summed for each year and divided by that year's cumulative count of impacted housing units. Annual ongoing utility costs are estimated to total an added $150 per housing unit on average. Figure 2 includes a summary of the projected change in energy rates for fossil gas and electricity. Ongoing costs are very sensitive to the relative cost of gas and electricity.

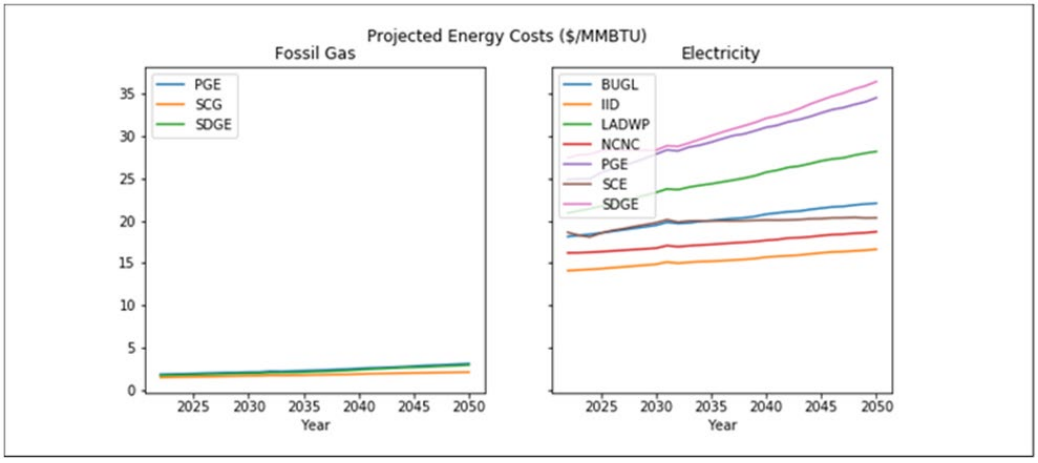

Figure 1 Projected energy costs for electricity compared to fossil gas by Electricity Planning Area and Gas Utility (PGE: Pacific Gas & Electric; SCE: Southern California Electric; SCG: Southern California Gas; SDGE: San Diego Gas and Electric; BUGL: Burbank/Glendale; IID: Imperial Irrigation District; NCNC: Northern California Non-California ISO) Rates from the CEC 2020 IEPR Forecast <https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2020-integrated-energy-policy-report-update-0>

B-5. Explain the need for State regulation given the existence or absence of Federal regulations:

Currently, there are no federal regulations requiring new residential buildings to be zero-emission. SB 32[17] requires CARB to reduce statewide greenhouse gas emissions to at least 40 percent below 1990 levels by the end of 2030, and AB 1279[18] established a goal of reducing statewide anthropogenic greenhouse gas emissions to at least 85 percent below 1990 levels by 2045. These limits cannot be achieved without controlling greenhouse gas emissions from buildings. Buildings are a major source of GHG emissions and air pollution. Residential buildings contribute approximately 7% of California's total GHG emissions.[19] Combustion of gas for space and water heating, cooking, clothes drying, and other residential end uses accounts for 46 tons per day, or about 4% of statewide oxides of nitrogen (NOx) emissions.[20] This is equivalent to nearly 3 times the NOx emissions from power plants and about one-half of those from light-duty vehicles. Decarbonization of California's buildings must be accelerated to achieve mid-century climate targets and avoid the worst impacts of climate change, improve air quality, and provide important public health benefits.[21]

Builders in California already express a clear preference for zero-emission new construction. A recent survey found that builders prefer zero-emission (electric) end uses to gas ones across all end-uses (+54 percentage points for clothes drying, +36 for space cooling, +31 for water heating +20 for space heating, and +8 percentage points for cooking). Moreover, in the context of many disparate local policies, builders also report a desire for more statewide regulatory consistency to ease decision-making.[22]I

1. Estimated Benefits

C-1. Explain the estimated benefits to be derived from this proposal:

The benefits of this regulation include:

a. Reducing greenhouse gas (GHG) emissions: This regulation would reduce cumulative GHG emissions by an estimated 0.6 million metric tons of carbon dioxide equivalent (MMT CO_2e) in the first three years. Over a 25-year life of the regulation, this regulation is estimated to reduce approximately 22.4. MMT

[17] D. Cortese, H. Stern. 2020. *"Senate Bill No. 32"*

[18] A. Murasutchi. 2022. *"Assembly Bill No. 1279".*

[19] CARB. 2022. *"California Greenhouse Gas Emissions for 2000 to 2020 Trends of Emissions and Other Indicators."*

[20] CARB**.** 2022. *"CARB Criteria Emission Inventory CEPAM 2022 v1.01 - Standard Emission Tool."* CARB (2021).

[21] Mahone, A., Z. Subin, G. Mantegna, R. Loken, C. Kolster, and N. Lintmeijer. 2020. *"Achieving Carbon Neutrality in California: PATHWAYS Scenarios Developed for the California Air Resources Board." Energy and Environmental Economics, Inc.*

[22] Pacific Consulting Group. 2023."California Zero-Emission Appliance Awareness Study."

CO_2e. Emission estimates were generated by analyzing the effects of installing zero-emission appliances in place of gas appliances in residential buildings. Five residential end-uses were analyzed: space heating, water heating, cooking, clothes drying, and pool heating. Greenhouse gas reductions were estimated as the net impact from four main categories: reduced emissions from avoided gas combustion, reduced emissions from avoided behind-the-meter gas leakage, increased emissions from hydrofluorocarbons (HFCs) used as refrigerants in electric heat pumps, and increased upstream emissions for electricity generation used to serve new electric demand. CARB staff utilized housing and gas demand forecasts from the California Energy Commission to estimate emission impacts. Even though residential buildings represent a significant (7%) portion of statewide GHG emissions, a recent study found the contribution from gas stoves on GHG emissions may be far larger than estimated in the current emission inventory. Methane leakage during the steady-state-off (no combustion) period, which could account for over 75% of methane emissions from gas stoves, was not included in the inventory.[23]

b. Reducing outdoor air pollutants: In California, 40 out of 58 counties suffer poor ambient air quality and do not meet federal air quality standards for health-protective levels of fine particle pollution (PM2.5) and ozone.[24] Gas appliances release nitrogen oxide (NOx) emissions to outdoor air, which are precursors to ozone and PM2.5. Zero-emission building standards for new construction can help California reduce NOx emissions and ensure California can meet federal air quality standards.

   The regulation is estimated to reduce 587 tons of NOx and 66 tons of PM2.5 cumulatively during the first three years of implementation. Over a 25-year life of the regulation, this regulation is estimated to reduce approximately 16,801 tons of NOx and 2,086 tons of PM2.5. Both the 3-year and 25-year emission reductions are significant and will support California in meeting the federal air quality standards.

   Criteria pollutant reductions were estimated from avoided gas combustion expected from the proposed regulation. Using CARB's CEPAM tool as a starting point, these reductions were calculated as the percent of gas avoided for each end-use multiplied by the corresponding annual statewide emissions in CEPAM.[25]

c. Improving indoor air quality: Californians spend an average of 87 percent of their time indoors. Due to the potential for high pollution concentrations

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[23] Lebel, E. D., C. J. Finnegan, Z. Ouyang, and R. B. Jackson. 2021. *"Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes." Environmental Science & Technology, p. 11*.

[24] US EPA. 2023. *"Current Nonattainment Counties for All Criteria Pollutants."*

[25] CARB**.** 2022. *"CARB Criteria Emission Inventory CEPAM 2022 v1.01 - Standard Emission Tool."*

generated from indoor sources, people can be exposed to serious health risks indoors. Cooking with gas stoves and ovens, when the emissions are not adequately vented outside, is a major source of air pollutants indoors. Zero-emission buildings can greatly reduce air pollutants emitted indoors. For example, replacing a gas stove with an electric stove can decrease nitrogen dioxide (NO_2) concentrations by 42% to 51% in a home.[26] Toxic air contaminants, such as benzene from cooking with gas, can also be reduced through zero-emission buildings.[27]

d. Enhancing environmental equity for under-resourced communities: Of the 101,000 new housing units constructed annually, the California Housing Partnership[28] estimates that around 80 percent of new homes are targeted to be affordable housing units. While California has not yet met this target and only about 16 percent of targeted affordable homes were constructed, there is great potential for how new construction in coming years may impact low-income households.

   Low-income households have increased exposure to local outdoor pollution sources such as traffic and industry and may also be exposed to higher levels of air pollution from gas combustion such as gas stoves, due to their smaller unit size, higher occupant density, and insufficient ventilation. A study on new and renovated low-income apartments in California showed that, compared to houses with similar cooking frequency, mean NO_2 levels in these apartments were 165% higher.[29] When adopted by low-income housing providers, zero-emission buildings can help advance health equity by mitigating the health risks from gas stove pollution exposures for low-income households.

   Zero-emission buildings can also benefit low-income households by improving climate resilience. More frequent extreme weather events from climate change often hit vulnerable and disadvantaged communities hardest and first.[30] More than half (55%) of vulnerable communities in Southern California—those with the lowest levels of air conditioning penetration and affluence—are expected to

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[26] Seals, B., A. Kasner, R. Golden, B. Gottlieb, and B. Nilles. 2020. *"Health Effects from Gas Stove Pollution." Rocky Mountain Institute,*

[27] Yannai S. Kashtan, M. Nicholson, C. Finnegan, Z. Ouyang, E. Lebel, D. Michanowicz, S. Shonkoff, and R. Jackson. "Gas and Propane Combustion from Stoves Emits Benzene and Increases Indoor Air Pollution". *Environmental Science & Technology.* 2023 57 (26), 9653-9663 DOI: 10.1021/acs.est.2c09289

[28] California Housing Partnership Preservation Database. 2022. "*California's Roadmap Home 2030*."

[29] Zhao, H, Chan, WR, Cohn, S, Delp, WW, Walker, IS, Singer, BC. 2021. "*Indoor Air Quality in New and Renovated Low-income Apartments with Mechanical Ventilation and Natural Gas Cooking in California*." *Indoor Air*. 31: 717– 729.

[30] *Greenlining Institute. 2021. "Climate Resilience."*

experience more extreme heat days by the end of the century.[31] Installation of electric heat pump space conditioning systems, which provide both efficient heating and cooling, is particularly valuable in frontline communities to improve occupant comfort and increase resilience to heat waves because they are more likely to lack access to air conditioning.[32]

e. Sustaining California's natural resources by reducing energy usage: Newer zero-emission appliances, such as heat pumps or induction cooktops, are much more efficient than traditional appliances and therefore use less energy. Specifically, heat pumps are three to five times more efficient than traditional gas units and 50% more than electric resistance heating such as furnaces and baseboard heaters.[33] [34] Similarly, induction cooktops are about three times more efficient than gas ones and up to 10% more efficient than electric resistance units.[35]

f. Improving public health: There are well-documented respiratory health risks from exposure to gas combustion pollution. Reducing NOx emissions both to outdoor air and indoor air provides important public health benefits.

   A UCLA study estimated that if, in 2018, 100 percent of residential gas appliances in California were replaced by electric appliances and powered by clean energy, the reduction of ambient PM2.5 within this year would result in 354 fewer premature deaths, 596 fewer cases of acute bronchitis and 304 fewer cases of chronic bronchitis, which is equivalent to approximately $3.5 billion every year.[36] While this study demonstrates how air pollution reduction from the replacement of gas appliances could lead to great public health benefits, it is based on the scenario that all existing residential buildings are converted to zero-emission in one year. The current proposed regulation is focused on constructing zero-emission new residential buildings which would occur year by year in different locations across the state. Therefore, additional analysis to quantify the possible health and economic benefits of zero-emission new home construction would be needed.

   From an indoor air quality perspective, children are particularly at risk of respiratory illnesses associated with gas stove pollution. A meta-analysis study

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[31] Chen, M., G. A. Ban-Weiss, and K. T. Sanders. 2020. "*Utilizing Smart-Meter Data to Project Impacts of Urban Warming on Residential Electricity Use for Vulnerable Populations in Southern California*." *Environmental Research Letters.*15(6).

[32] RMI. 2021. "*Heat Pumps are the Answer to Heat Waves*.".

[33] International Energy Agency, Accessed on 23 October 2023. "*Heat Pumps*."

[34] U.S. DOE. Accessed on 11 January 2022. *"Heat Pump Systems." Energy Saver.*

[35] U.S. DOE. 2023. Accessed on 23 October 2023. "*Making the Switch to Induction Stoves or Cooktops*."

[36] Zhu, Y., R. Connolly, T. Mathews, and Z. Wang. 2020. "*Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California.*" *UCLA Fielding School of Public Health Department of Environmental Health Sciences*.

conducted by Lin et al. (2013) reported a 42% and 24% increased risk of current asthma and lifetime asthma, respectively, for children living in a house with gas stove cooking.[37] For children living in multifamily housing, exposure to emissions from gas stoves increased likelihood of wheezing, shortness of breath, and chest tightness, even though the indoor NO_2 levels were well below the federal ambient air quality standard.[38] In December 2019, the Massachusetts Medical Society recognized that the use of a gas stove increases household air pollution and the risk of childhood asthma and asthma severity.[39] Additionally, benzene emissions from gas burners and ovens have been found to be 10 to 25 times higher than from electric alternatives.[40] Zero-emission new construction would reduce health risks by reducing residential criteria pollutants and toxic air contaminants indoors and outdoors.

g. Cost savings for new construction: As of July 2023, builders in investor-owned utility service territories will no longer receive subsidies for gas line extensions. Several studies estimate that the costs of constructing zero-emission homes are lower than constructing mixed-fuel[41] new homes, primarily due to the avoided costs of gas infrastructure at the building site, with cost savings in the range of $2,000 to $10,000 per unit.[42] [43] [44] [45] [46] Additionally, zero-emission new construction will prevent future maintenance costs and avoid stranded assets associated with fossil gas infrastructure.

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[37] Lin, W., B. Brunekreef, and U. Gehring. 2013. "*Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children*." I*nternational Journal of Epidemiology.* 42(6): pp. 1724-1737.

[38] Belanger, K., J. F. Gent, E. W. Triche, M.B. Bracken, and B. P. Leaderer. 2006. "*Association of Indoor Nitrogen Dioxide Exposure with Respiratory Symptoms in Children with Asthma*." *American Journal of Respiratory and Critical Care Medicine.* 173(3): 297-303.

[39] The Massachusetts Medical Society. 2019. "*Informing Physicians, Health Care Providers, and the Public That Cooking with a Gas Stove Increases Household Air Pollution and the Risk of Childhood Asthma*." Resolution I-19 A-102.

[40] Kashtan, Y., Nicholson, M., Finnegan, C., Ouyang, Z. Lebel, E., Michanowicz, D., Shonkoff, S., and Jackson, R. 2023. "*Gas and Propane Combustion from Stoves Emits Benzene and Increases Indoor Air Pollution*." *Environmental Science & Technology,* 57(4): 9653-9663.

[41] Mixed-fuel refers to a building that typically uses gas or propane and electricity.

[42] Mahone, A., C. Li, Z. Subin, M. Sontag, G. Mantegna, A. Karolides, A. German, and P. Morris. 2019. "*Residential Building Electrification in California: Consumer Economics, Greenhouse Gases, and Grid Impacts*." *Energy and Environmental Economics, Inc*.

[43] Billimoria, S., L. Guccione, M. Henchen, L. Louise-Prescott. 2018. "*The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings*." *RMI.*

[44] TRC. 2016."*Palo Alto Electrification Final Report*." *City of Palo Alto*.

[45] Frontier Energy. 2019. "*2019 Cost-effectiveness Study: Low-Rise Residential New Construction*". *California Energy Codes and Standards: A Statewide Utility Program*.

[46] TRC. 2018. "*City of Palo Alto 2019 Title 24 Energy Reach Code Cost Effectiveness Analysis DRAFT*" *City of Palo Alto*.

C-3. What are the total statewide benefits (avoided costs) from this regulation over its lifetime?

a. Health benefits: As new homes constructed after 2020 will present about 35 percent of the State's total housing stock by mid-century,[47] the health benefits due to air pollutant reductions from the implementation of a requirement for zero-emission residential buildings would be substantial. Although the recent study by Zhu et al. (2020) demonstrated the relative magnitude of health benefits for all-electric residential buildings, additional analysis to quantify possible health and economic benefits for zero-emission new home construction would be needed. Therefore, monetized health benefits are not accounted for in the total statewide benefit assessment.

b. Avoided construction costs: Based on several studies, all-electric new home construction can save between $2,000 to $10,000 per unit primarily due to the avoided cost of gas infrastructure.[48] [49] [50] [51] [52] Based on single-family and multi-family infrastructure costs reported by PG&E,[53] $141 million, or $1,607 per new housing unit could be saved annually with the implementation of a zero-emission requirement for new residential construction. Overall, $422 million (discounted) could be saved over a three-year period of this regulation, and $1.20 billion (discounted) could be saved over a 25-year life of the proposed regulation when accounting for avoided gas construction costs.

c. Social Cost of Carbon: The Social Cost of Carbon (SC-CO2) is the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to

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[47] *CARB, 2022, "2022 Scoping Plan: Appendix F – Building Decarbonization*".

[48] Mahone, A., C. Li, Z. Subin, M. Sontag, G. Mantegna, A. Karolides, A. German, and P. Morris. 2019. "*Residential Building Electrification in California: Consumer Economics, Greenhouse Gases, and Grid Impacts*." *Energy and Environmental Economics, Inc*.

[49] Billimoria, S., L. Guccione, M. Henchen, L. Louise-Prescott. 2018. "*The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings*." *RMI.*

[50] TRC. 2016. "*Palo Alto Electrification Final Report*." *City of Palo Alto*.

[51] Frontier Energy. 2019. "2019 Cost-effectiveness Study: Low-Rise Residential New Construction". *California Energy Codes and Standards: A Statewide Utility Program*.

[52] TRC. 2018. "*City of Palo Alto 2019 Title 24 Energy Reach Code Cost Effectiveness Analysis DRAFT*" *City of Palo Alto*.

[53] Pacific Gas & Electric. 2018. Advice Letter 4386-G.

climate change.[54] By avoiding the social costs of carbon emissions, there is an additional $12.5 to $59.5 million global benefit expected over a three-year period of this regulation, and a $658 million to $2.62 billion global benefit expected over the 25-year lifetime of the regulation (values estimated based on 5% and 2.5% discount rates, adjusted to 2021 dollars).

[54] *Interagency Working Group. 2016. Technical Support Document for Social Cost of Carbon*. Reported in 2007 dollars and adjusted to 2021 using California's CPI-U.

2. Alternatives to the Regulation

Table 4: Summary of Statewide Costs and Cost-Effectiveness (25-year values)

Proposals	Emission Reductions	Costs	Cost-Effectiveness	Benefits
Main Proposal *All new residential construction*	22.4 MMT CO2e (25-year cumulative)	$502 million (25 year)	$22/MT CO2e	Avoided Infrastructure Costs (25 year): $1.2 billion Global Benefits (25 year): $658 million to $2.62 billion
Alternative 1 *Low-rise new residential construction*	20.2 MMT CO2e (25-year cumulative)	$446 million (25 year)	$22/MT CO2e	Avoided Infrastructure Costs (25 year): $1.15 billion Global Benefits: $594 million to $2.36 billion
Alternative 2 *New residential construction and alterations*	114.5 MMT CO2e (25-year cumulative)	$21.4 billion (25 year)	$187/MT CO2e	Avoided Infrastructure Costs (25 year): $1.2 billion Global Benefits: $3.34 billion to $13.3 billion

Alternative 1: Zero-emission buildings in new low-rise single-family home buildings and townhomes (2-4 unit multifamily housing) only.

A statewide discounted cost of $446 million was estimated for implementation over a 25-year life of Alternative 1 to the regulation or $169 million over a 3-year life of the regulation from January 1, 2026, to December 31, 2028. An estimated upfront cost of $811 per new housing unit may be passed on to individuals.

An estimated $136 million could be saved annually in avoided gas construction costs for Alternative 1. The overall statewide benefit for Alternative 1 was estimated to total $136 million annually, $408 million (discounted) over a three-year lifetime, and $1.15 billion (discounted) over a 25-year lifetime.

Social Cost of Carbon: Accounting for the social cost of carbon, an estimated $11 to $55 million benefit over a three-year lifetime of this regulation, or a $594 million to $2.36 billion benefit over the 25-year lifetime of the regulation is expected (estimate range based on 5% and 2.5% discount rates adjusted to 2021 dollars).[55]

[55] Interagency Working Group. 2016. Technical Support Document for Social Cost of Carbon.

Alternative 2: Zero-emission buildings for all newly constructed residential buildings and alterations to existing residential buildings.

According to remodel rates found in the California Residential Remodeling/Renovation Market Study,[56] an estimated 3.3% of existing buildings make structural changes to the basic living area. It was assumed that these homes undergoing structural changes would electrify all end-uses. An additional percent of existing homes would be triggered to comply with the regulation based on remodel rates for space heating, water heating, and cooking, as outlined below.

1) All-electric: 3.3% of existing buildings triggered annually.
2) Space heat: 0.448% additional existing buildings triggered annually.
3) Water heat: 1.8% additional existing buildings triggered annually.
4) Cooking: 1.05% additional existing buildings triggered annually.

Table 5 summarizes the assumptions used to calculate costs for alterations. The assumptions for new construction costs are the same as the main proposal (Table 1). Alternative 2 includes costs for both newly constructed residential buildings and alterations to existing buildings.

A statewide discounted cost of $21.4 billion was estimated over a 25-year life of Alternative 2. An estimated $8.5 billion (discounted) would be spent over a 3-year life of Alternative 2 from January 1, 2026 to December 31, 2028. An estimated upfront average cost of $5,512 per housing unit may be passed on to individuals.

For alternative 2, approximately $1.8 billion of the total statewide discounted cost ($21.4 billion) is for updating electrical panels for alterations in existing buildings.

When accounting for avoided gas construction costs, an estimated $141 million could be saved annually, $422 million (discounted) could be saved over a three-year lifetime of this regulation, and $1.2 billion (discounted) could be saved over a 25-year life of the proposed regulation.

Social Cost of Carbon: Accounting for the social cost of carbon, an estimated $64 million to $304 million benefit over a three-year lifetime of this regulation or $3.34 billion to $13.3 billion over the 25-year lifetime of the regulation is expected (estimate range based on 5% and 2.5% discount rates, adjusted to 2021 dollars).[57]

[56] Primen. 2001. *California Residential Remodeling/Renovation Market Study*.

[57] IWG. 2016. TSD for Social Cost of Carbon.

Table 5 Alternative 2: Alterations Cost Table: Equipment and Installation Costs. The costs for new construction under Alternative 2 are the same as the Main Proposal. This table summarizes the cost assumptions for appliances installed in existing buildings (retrofits) only.

	Baseline	**Proposed**	**Incremental Cost**
Space Conditioning	A. Gas Furnace:[58] $5,180 B. Gas Furnace ($5,180) + Air Conditioner ($7,500)	1. Single-family air source heat pump:[59] $15,869 2. Multi-family air source heat pump:[60] $3,775	A.1. $10,689 A.2. - $1,405 B.1. $3,189 B.2. - $8,905
Water Heating	Efficient Gas Storage Heater (0.62EF):[61] $1,489	1. Heat Pump Water Heater (single-family):[6] $6,400 2. Heat Pump Water Heater (multi-family):[7] $3,983	1. $4,910 2. $2,494
Cooking[62]	$920	$1,230	$310
Clothes Drying (EIA)	*Same as New Construction*	*Same as New Construction*	*Same as New Construction*
Pool Heating	*Same as New Construction*	*Same as New Construction*	*Same as New Construction*
Electric Service Panel Upgrade[63]	$0	$1,500 per upgrade[64]	$1,500

[58] Brennan Less and Iain Walker, 2023. Lawrence Berkeley National Laboratory, The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes.

[59] TECH Single-Family Program Working Data Set. Median of reported single-family HPWH installation costs. <https://techcleanca.com/documents/2509/TECHWorkingDataset_Single-Family_2023-09-27.xlsx>

[60] TECH Multi-Family Program Installation Working Data Set < https://techcleanca.com/documents/2510/TECHWorkingDataset_Multifamily_2023-09-27.xlsx>

[61] CEC Fuel Substitution Scenario Analysis Tool

[62] References are the same as equivalent gas unit retrofit costs were not available.

[63] In order to estimate the volume of potentially needed electric service upgrades, each end-use replacement was assigned a relative share of service panel upgrade "responsibility" based upon its typical relative typical amperage needs (Space Heat: 0.16, Dryer: 0.11, Cooking: 0.33, Water Heat: 0.1).

[64] D. Sarkisian, D. Kirwan, S. Parker, A. Hotaling, M.Fink. 2023. "Heat Pump HVAC Retrofit Cost Drivers." TECH Clean California.

II. Fiscal Impact Statement

A. Fiscal Effect on Local Government

Other. Explain. (A-6 Item)

Currently, local government building departments are responsible for enforcing the California Green Building Standards Code, Title 24, Part 11. Therefore, there should not be any major fiscal effect on local governments to enforce new construction of zero-emission buildings. This building standard will support local governments so that they do not need to spend resources to develop code language and justification as several dozen jurisdictions have already done. However, if there is a minor increase in costs in local governments to review and check plans for compliance, any increase in costs can be recovered from increases in permit fees.

Some local governments may construct new residential buildings. There is no data available on how many total new residential buildings will be constructed by local governments on an annual basis.

Local tax revenues from appliance sales would increase by an average of $1.9 million per year, or $16.6 million (discounted) over a 25-year lifetime of the regulation under the main proposal.

Local revenues from net changes in energy consumption would increase revenues by $294,000 per year (undiscounted), based on an estimated 3.53% local utility users tax rate.

B. Fiscal Effect on State Government

Other. Explain. (B-4 Item)

There is no data available on how many total new residential buildings will be constructed by the state government on an annual basis.

State tax revenues from appliance sales would increase by an average of $2.3 million per year, or about $19.7 million (discounted) over a 25-year lifetime of the regulation under the main proposal.

Further changes to state revenue would include an approximately $25,000 (25-year discounted) increase to state revenue from the $0.0003/kwh state electricity surcharge.[65] This regulation could also lead to decreases to state

[65] *California Department of Tax and Fee Administration Special Notice; 2023 Energy Resources (Electrical Energy) Surcharge Rate*

revenue from various gas utilities' surcharges, totaling approximately $13,000 (25-year, discounted).[66]

[66] *California Department of Tax and Fee Administration Special Notice; New Natural Gas Surcharge Rates Effective January 1, 2023*