Impacts of a Fluorine Gas Ban on Households, Businesses, CO_2 Emissions, and California's Economy

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Executive Summary

Fluorine gases (F-gases) are widely use in refrigerants for heat pumps, air conditioners, commercial refrigeration systems, and building insulation materials because of their stability, low costs, favorable thermal properties, efficiencies, and low toxicity. Despite their many favorable attributes, unsubstantiated concerns reliant on overly broad definitions of PFAS chemistries have led to calls for their ban, contrary to recommendations by federal regulators and international bodies.

This report addresses the economic and fiscal consequences of such a ban. A fundamental problem is that alternatives to F-gas-based refrigerants – such as propane, and ammonia – are flammable and toxic, and they would not even be allowed in central air conditioners under existing state and local laws and regulations. Absent a suitable alternative, tens of thousands of jobs involved in HVAC manufacturing, distribution, and installation industries would be at risk. (This does not include the adverse health and economic effects of a loss in effective air conditioning to millions of California residents living in hot regions of the state.) Even if the safety issues could be overcome, use of alternative systems would still present major financial and climate-related challenges for California. Specifically:

A ban on F-gases would sharply raise households' heating and cooling expenses. Homeowners would face higher upfront expenses for heat pumps and air conditioners that run on alternative refrigerants. These alternative systems cost up to 50 percent more than comparable F-gas-based systems, which translates into additional purchase and installation costs of over $5,000 for a four-ton heat pump system.

Households would also face higher monthly energy bills. This is because systems using alternative refrigerants are 15 percent less energy efficient than F-gas based systems, meaning that it would take 15 percent more electricity to achieve the same amount heating or cooling in a house. The ban on F-gases used in building insulation materials would reduce their efficiency ratings, resulting in an additional 15 percent in energy needed to maintain indoor temperatures in a comfortable range. The combined impacts of these efficiency losses on summer electricity bills for a typical new detached home would be approximately $200 per month in warmer inland counties of the state.

The cost impacts would be regressive. Additional heating and cooling expenses would disproportionately affect low- and moderate-income households, which spend a higher proportion of their income on utilities than their higher-income counterparts. The effect is magnified in California because inland regions of the state – where energy needs for cooling are the highest – have, on average, lower household incomes than their counterparts living near the coast. For example, the median income for a 4-member household in the Central Valley is $103,000, or one-third less than the $157,000 median for a 4-member household in the Bay Area. At the same time, air conditioning costs in the Central Valley are about 4 times greater.

Businesses would also be hard hit. Like households, businesses would pay much more for space heating and cooling. For example, summer cooling costs for a 6,000 square foot restaurant would increase by as much as $600 per month in the Central Valley, and by $775 per month in inland counties of Southern California, due to reduced energy efficiencies of alternative HVAC systems and, for newly constructed buildings, less effective insulation. The additional monthly air conditioning cost for a 20,000 square foot supermarket would reach $2,000 in the warmer inland regions of the state.

In addition, substantial expenses would be incurred for businesses that rely on refrigeration for perishable products – such as grocery stores, restaurants, and food distributors. For these typically-low-margin businesses, the switch to a system using alternative refrigerants would mean substantially higher installation and maintenance costs, as well as a 36 percent increase in annual electricity usage. For a typical 20,000 square foot supermarket, the annual cost increase for their food refrigeration system would reach over $3,400 per month, or $41,000 per year. Increases in energy costs will put upward pressure on retail food prices, further increasing cost burdens on households in the state.

Aggregate statewide economic impacts would be large. On a broader scale, an F-gas ban would have substantial impacts on California's economy. We estimate that a ban would put over 115,000 jobs and $15 billion in annual gross state product at risk by 2035 due to two main factors:

- Workers involved in the production, installation, and maintenance of HVAC and refrigeration systems would be put at risk as F-gas-based systems are phased out following the ban, and cost and safety barriers limit the production, sales, installation, and maintenance of the alternative systems.

- Higher purchase and installation costs, and additional ongoing operating expenses associated with HVAC systems using alternative refrigerants would leave households with less disposable income to spend on other goods and services in California's economy. (Our analysis assumes that higher costs to businesses will be "passed on" to consumers through higher product prices.) The spending reductions would negatively impact a wide range of economic sectors, including retail, personal services, healthcare and hospitality.

A ban would also negatively impact state and local governments. Both levels of government would face challenges both as users of heating and cooling systems, and as recipients of taxes tied to economic strength. We estimate that a ban would put $880 million in annual state revenues and $466 million in local revenues at risk by 2035.

A ban would undermine California's environmental goals. We estimate that a ban on F-gases would increase greenhouse gas emissions by up to 19 million tons over the next decade. This would occur because the reduced efficiency of alternative systems would drive up electricity consumption and emissions from California's electrical grid.

And it would negatively impact the reliability and affordability of California's electrical grid. Finally, state policymakers are already struggling to control electricity costs in California, where residential rates are the second highest in the country, and are likely to rise even more in the future as California shifts to an all-renewable electrical power supply. The added electrical load resulting from a shift to less-efficient refrigerants would make it even more challenging for the state to meet sharply rising electricity demands stemming from electrification of its transportation, manufacturing, residential and commercial building sectors, as well as AI-driven growth in data centers. As a result, the state would find it even more difficult to achieve its decarbonization goals, while controlling costs, maintaining grid reliability, and meeting the surging power needs of a modern digital economy.

Introduction and Background

Per- and polyfluoroalkyl substances (PFAs), are synthetic chemicals that have strong carbon-fluorine bonds. PFAs are found in numerous products – such as non-stick cookware, water-repellent fabrics, firefighting foams, and numerous industrial processes – because of their durability and resistance to heat, water, and oil. Fluorine gases (F-gases) – including hydrofluoroolefins (HFOs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) – are a type of PFA used in refrigeration and air conditioning due to their favorable thermodynamic characteristics and low toxicity.[1] F-gases are also employed in the production of insulation materials, particularly rigid foam boards used in building construction. These gases act as blowing agents, enabling the formation of closed-cell foam structures that provide superior thermal insulation.

Potential Ban

Despite the many favorable attributes of F-gases, unsubstantiated concerns reliant on overly broad definitions of PFAS chemistries have led to calls for their ban, contrary to recommendations by federal regulators and international bodies.[2] In 2025, the California Legislature passed SB 682, which would have prohibited sales of a variety of products that contain PFAs, including cookware cleaning products, dental floss, food packaging, and ski waxes containing intentionally added PFAS beginning in 2028.[3] Early versions of the bill would have applied the bans to F-gases used in heat pumps, air conditioning, and as blowing agents in insulation materials. While SB 682 was ultimately vetoed by the

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[1] F-gases replaced chlorinated gases in the 1980s following international agreements like the Montreal Protocol that Canada adopted in response to concerns about depletion of the ozone layer caused by chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), collectively known as C-gases. Scientific evidence at the time revealed that C-gases released into the atmosphere could break down under ultraviolet light, releasing chlorine atoms that catalyze the destruction of ozone molecules. This contributed to the thinning of the ozone layer, which protects life on Earth from harmful ultraviolet radiation.

[2] See, for example, U.S. Environmental Protection Agency, Significant New Alternative Policy (SNAP). "Substitutes in Residential and Light Commercial Air Conditioning and Heat Pumps." https://www.epa.gov/snap/substitutes-residential-and-light-commercial-air-conditioning-and-heat-pumps, and "Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance. Series on Risk Management No. 61, July 9, 2021. https://one.oecd.org/document/ENV/CBC/MONO(2021)25/En/pdf.

[3] https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202520260SB682

Governor, interest persists in limiting or banning PFAS, including F-gas applications, in the state.

The Costs of an F-gas Ban to California

A phase-out of F-gases would impose major financial and environmental costs on California at a time when the state is struggling with enormous affordability challenges and is falling behind its environmental goals.

Regarding financial costs, HVAC systems using alternative refrigerants – mainly propane, ammonia, and CO_2 – are much more expensive to purchase, install and maintain than F-gas based systems. They are also less efficient and thus require more electricity to achieve the same amount of heating or cooling. Similarly, the elimination of F-gases used in insulation materials would significantly reduce their effectiveness thereby requiring HVAC systems to work harder to maintain comfortable inside temperatures.

Regarding environmental costs, the lower efficiency of systems using alternative refrigerants implies more electricity usage and greater CO_2 emissions, which is in direct conflict with California's environmental goals. Over the past two decades, California leaders have adopted legislative measures calling for progressively deeper cuts in CO_2 emissions.[4] The California Air Resources Board's 2022 Scoping Plan (Scoping Plan) sets forth specific targets, timelines and actions needed in each major sector of California's economy to achieve an 85 percent reduction in CO_2 emissions by 2045.[5]

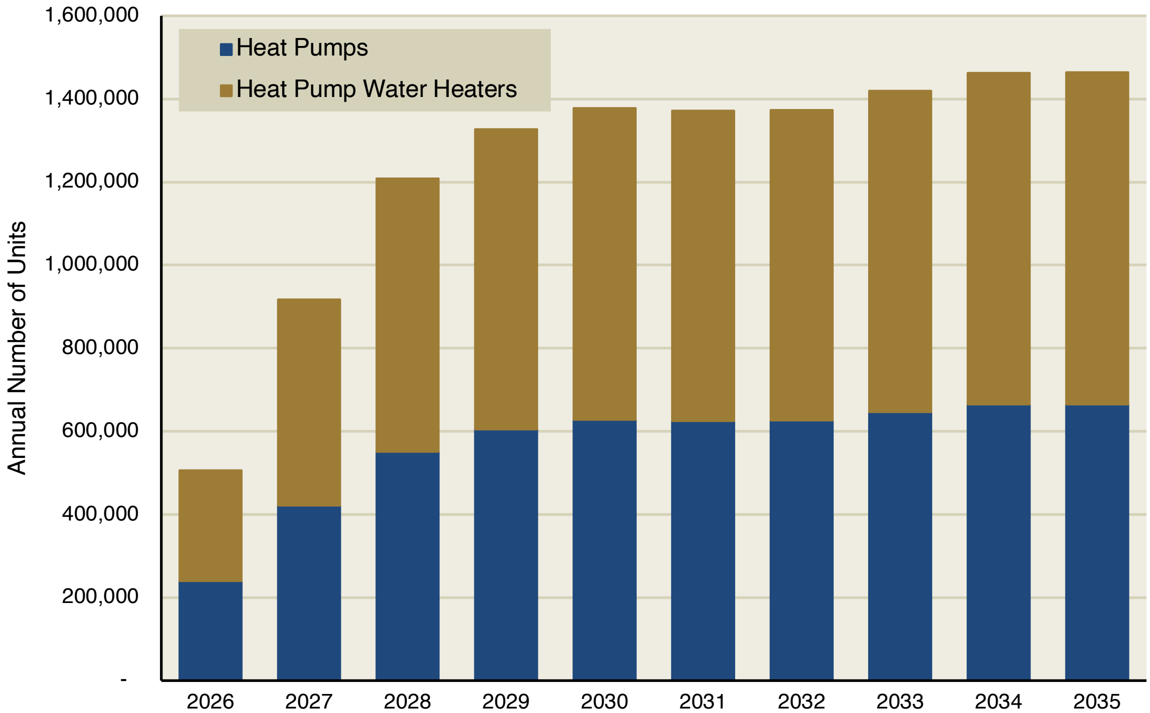
Under the Scoping Plan, emissions from the state's residential and commercial sector need to decline from 33 million tons in 2025 to 17 million tons in 2035, and to 4.5 million tons by 2045. These reductions are to be accomplished through a phase-out of natural gas and a shift to near 100 percent electrical power for appliances, boilers, cooking, and space and water heating. A major assumption in the Scoping Plan is that annual sales of residential heat pumps (including heat pump water heaters) will increase from 500,000 units in in 2026 to 1.5 million units by 2035 (see Figure 1, next page).[6] Similarly large increases in heat pump sales are also assumed for the commercial sector. A ban on F-gases would interfere with these objectives, by raising costs of heat pumps (which run on electricity and are needed to replace natural gas heaters), and boosting electricity usage and associated CO_2 emissions in the state.

[4] Most recently, the Governor signed AB 1279 in 2022, which declares that it is the state's policy to (1) achieve net zero greenhouse gas emissions as soon as possible, but no later than 2045; (2) achieve and maintain net negative greenhouse gas emissions thereafter; and (3) ensure that by 2045, statewide anthropogenic greenhouse gas emissions are reduced by at least 85 percent from 1990 levels.

[5] 2022 Scoping Plan Documents. California Air Resources Board. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

[6] AB 32 GHS Inventory Sectors Modeling Data Spreadsheet. California Air Resources Board. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

Figure 1
Residential Heat Pump and Heat Pump Water Heater Sales Under California's Scoping Plan



Purpose of This Report

This report quantifies impacts of an F-gas ban on California's economy. Our estimates are based on detailed information from public sources such as the U.S. Energy Information Agency (EIA), the U.S. Environmental Protection Agency (EPA), the Oak Ridge National Laboratory, the California Energy Commission (CEC), and the California Air Resources Board (CARB). Our assumptions and methods are highlighted in Appendix Tables 1 through 3.

In the following section we examine the impacts of an F-gas ban on purchase and usage costs for *individual* households and small businesses, and in the subsequent section we evaluate *broader economic impacts* (including direct and multiplier effects) of such a ban on California's economy and state and local government revenues.

Cost Impacts of an F-gas Ban on Typical Households and Businesses

Before discussing specific cost comparisons between F-gas-based systems and alternative systems using propane, ammonia, and CO_2 refrigerants, it is important to note that such alternative systems may not even be viable options – at any price – given their higher levels of toxicity and flammability. Propane is classified by the U.S. Environmental

Protection Agency as a highly flammable refrigerant, and it is not presently considered to be a suitable alternative in the U.S. for central AC systems, which circulate refrigerants throughout a building.[7] Currently, propane-based refrigerants are limited by California law to just small self-contained units (like refrigeration units in vending machines) due to their high flammability**.**

The health and safety challenges facing alternatives to F-gas-based systems have major implications for the HVAC installation and manufacturing industry. While repair and maintenance of existing systems would continue, the lack of viable alternative options would put tens of thousands of jobs in the HVAC industry at risk as existing systems wear out without viable replacement alternatives. We discuss these impacts more fully in the subsequent section titled “Statewide Economic Impacts of an F-gas Ban.”

Impact on Purchase and Installation Costs for Residential HVAC Systems

Even if the health and safety issues could be addressed, California residents would face major cost increases for HVAC equipment using alternative refrigerants. Manufacturers of propane units must add extra safety components, such as enhanced leak detection systems and specialized containment measures, to minimize the risk of ignition. CO_2-based HVAC systems operate at higher pressures, and thus need advanced pressure controls, reinforced piping, and specialized valves, all of which raise manufacturing costs.

Our review finds that propane-based heat pumps marketed in Europe cost nearly 50 percent more than comparable models that use F-gas refrigerants.[8,9] Labor costs for installing such systems are also higher due to the specialized training needed to handle the flammability risks associated with propane-based systems, and the increased time and expertise needed to install high-pressure CO_2 systems. We conservatively estimate that these factors would raise installation costs by roughly 5 percent. The combined impact of the higher equipment prices and installation costs would be substantial. We estimate that the combined cost increase for a 4-ton capacity heat pump with a relatively high efficiency rating would be about $5,200 per unit in California (see Figure 2, next page).

[7] See, for example, “Questions and Answers About R-22a Safety.” U.S. Environmental Protection Agency. https://www.epa.gov/snap/questions-and-answers-about-r-22a-safety

[8] https://www.theheatpumpwarehouse.co.uk/shop/heat-pumps/air-source-heat-pumps/samsung-heat-pumps/samsung-ehs-gen-7-r290-heat-pump-8kw/

[9] https://www.theheatpumpwarehouse.co.uk/shop/heat-pumps/air-source-heat-pumps/samsung-heat-pumps/samsung-8kw-r32-monobloc-air-source-heat-pump/

Figure 2
Comparison of Purchase and Installation Costs
Typical 4-Ton Residential Heat Pump

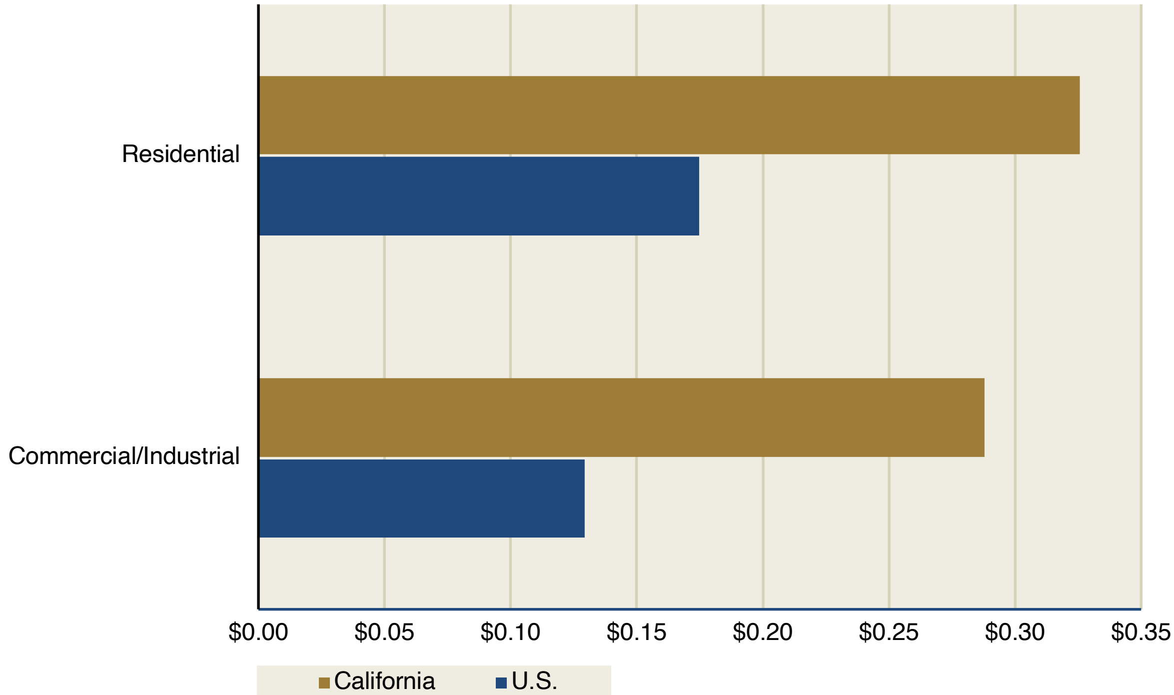
The Scoping Plan assumes that heat-pumps will be used in all newly constructed homes and increasingly in existing homes as existing HVAC systems wear out and are replaced over time. An F-gas ban implies that over the next decade, 5.7 million households will face cost increases of several thousand dollars for heat pump installations.

Impact on Household Electricity Consumption and Energy Bills

Based on a recent study by the Oak Ridge National Laboratory, we estimate that shifting from a standard F-gas refrigerant to a common propane-CO_2-based alternative would reduce efficiency of heat pumps and air conditioners by about 15 percent.[10] The cost impacts of efficiency losses are magnified by California's nearly highest-in-the-nation electricity rates (see Figure 3, next page), which are almost double the national average, and are likely to go higher due to costs related to fire-prevention (including undergrounding transmission wires), a shift to all renewable power generation, and major expansions to the grid to accommodate electrification of the state's economy and AI-related electricity demands.[11]

[10] Building Technologies Office 03.02.02.38 Milestone Report – Technology Options for Low Environmental Impact Air-Conditioning and Refrigeration Systems. Oak Ridge National Laboratory. August 2023. https://info.ornl.gov/sites/publications/Files/Pub200582.pdf
[11] Electric Power Monthly. Energy Information Administration. Accessed October 8, 2025. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

Figure 3
Electricity Rates: California Versus U.S. Average in July 2025
($ Per kWh)

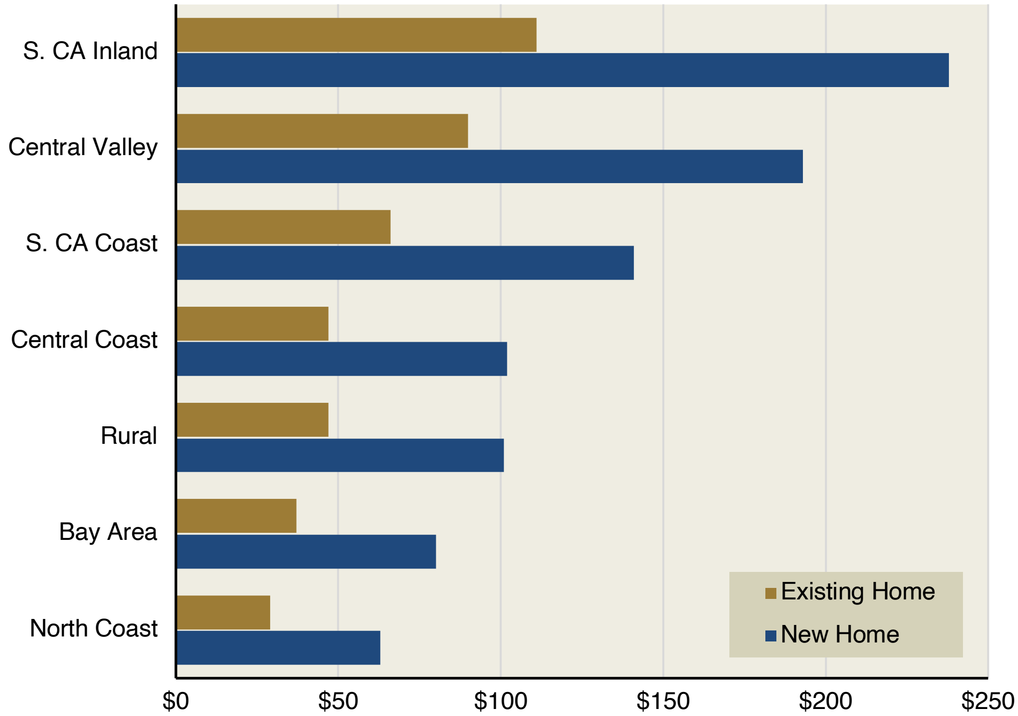


High rates are already stretching budgets of California residences and businesses. The state's three investor-owned electric utility providers (IOUs) report that in April 2025, 1.9 million households had overdue electricity bills, and as many as 50,000 had service disconnected as a result.

While the cost impacts of a 15 percent efficiency loss may be only moderate for households located in coastal regions with temperate year-around climates and limited HVAC usage, the impacts would be substantial for households in inland regions where summers are hotter and winters are cooler. We estimate that the average increase in air conditioning bills for an existing 2,300 square foot home would range from $29 per month in the North Coast and $37 per month in the Bay Area, up to $90 per month in the Central Valley and $111 per month in inland regions of Southern California (see Figure 4, next page).[12]

[12] CMC estimates are based on a 4-ton,14 SEER air conditioning unit using about 3.9 kWh when operating. Regional variation is based on (1) average summertime temperatures for individual counties within each region, 2) the relationship between outside temperature and hours of operation per day, and (3) the published electricity rates for the primary electricity service provider in each county. Regarding the relationship between outside temperatures and hours of operation, see, for example, https://www.researchgate.net/figure/Relationships-between-the-total-air-conditioner-usage-hours-in-a-day-and-daily-outdoor_fig4_363908532

Figure 4
Increase in Summer Monthly Air Conditioning Bill
Four Ton Unit, 2,300 Square Foot Home



The increases would be larger for homes built after the ban on F-gases used in building insulation materials takes effect. Insulation materials using F-gases have R-ratings of up to 7.5 per inch or nearly double the 3.6 to 3.9 R-ratings for non-F-gas alternatives such as open-cell water blown foam.[13] Based on the relationship between R-ratings and energy consumption, we estimate that a shift from insulation materials using F-gases to an alternative product would result in energy consumption increases of 15 percent.[14]

Owners of new homes would face the compounded effects of less-efficient HVAC units and less effective insulation material, which could add up to 30 percent increases in heating and cooling bills. As indicated in Figure 4, the increase in summertime electricity bills for air conditioning in new homes would range from $63 per month in the North Coast and $80 per month in the Bay Area, up to $193 per month in the Central Valley and $238 per month in the inland counties of Southern California.

As shown in Figure 5 (next page), increases in heating bills during the winter would also be substantial. For a standard 2,300 square foot home, we estimate that the increase in average monthly heating costs would range from $45 (in the Southern California Inland

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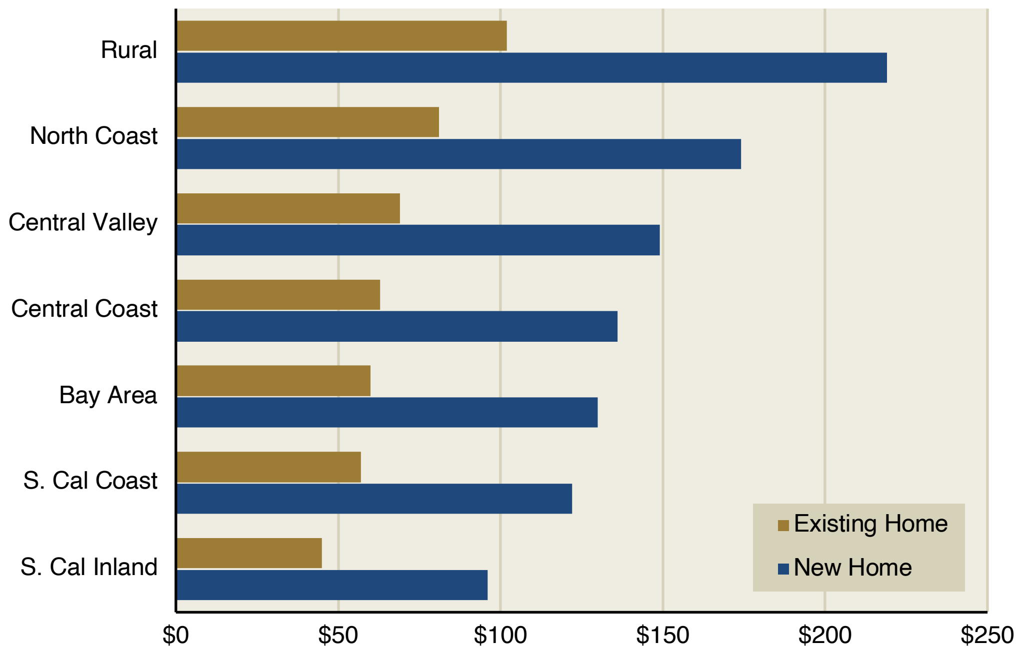
[13] R-values, or R-ratings, measure an insulations material's resistance to heat flow. The higher the R-value, the greater its thermal resistance and hence its effectiveness.
[14] This estimate is consistent with those produced by EnergyStar, which found that properly insulating a home can result in a 15 percent reduction in energy usage for heating and air conditioning relative to a typical home (i.e., one that was built between 1970 and 1990 with batt insulation in the walls and blown insulation in the attic). https://www.energystar.gov/saveathome/seal_insulate/methodology

counties) to $102 (in California's rural mountainous counties) during peak winter months for existing homes due to loss in heat pump efficiencies, and from $96 to $219 per month for new homes due to the combined loss of both heating and insulation efficiencies under an F-gas ban.[15]

Figure 5
Increase in Winter Monthly Heating Bills
Four Ton Unit, 2,300 Square Foot Home



Impacts would be regressive. This is because heating and cooling costs account for a higher share of the total budgets of low- and moderate-income households as compared to their higher-income counterparts. The disparity is magnified in California because electricity usage for, especially, cooling is particularly high in inland regions of the state where household incomes tend to be lower.

The disparity is most notable between the San Francisco Bay area, where the median income for a four-member household is $158,000, and the Central Valley, where the median income for a four-member household is $103,000.[16] In the example shown above in Figure 4, the increase in electricity costs for cooling resulting from an F-gas ban would consume 2.3 percent of total monthly income for a typical (median-income) household of four living in the Central Valley and 2.8 percent of total monthly income in the inland counties of Southern California. (*Total* air conditioning costs after the increase would

[15] CMC estimates are based on a 4-ton,14 SEER heat pump unit using an average of about 4 kWh when running. Regional variation is based on (1) average winter temperatures for each county, (2) the relationship between outside temperature and hours of operation per day (based on industry reports and empirical studies), and (3) the published residential electricity rates for the primary electricity service provider in each county.
[16] 2025 Income Limits. California Department of Housing and Community Development. https://www.hcd.ca.gov/sites/default/files/docs/grants-and-funding/income-limits-2025.pdf

consume as much as 15 percent of a typical household's budget in inland counties of Southern California). The up-to 2.8 percent increase for a typical household in inland regions is more than *four times* the 0.6 percent increase experienced by a median-income household of four living in the Bay Area. The increase in electricity costs would have particularly large impacts on low- and moderate-income households in inland regions of the state, who-have limited funds to absorb electricity bill increases after paying rent, gasoline, other utilities, food, health care and other necessities.

Impact on Small Business Costs

Businesses would face potentially substantial increases in costs from an F-gas ban. Heating and cooling costs vary by business type and size, and by geographic region. Figure 6 provides an example for a 6,000 square foot restaurant. It shows that an HVAC system using an alternative refrigerant would increase summer monthly air conditioning costs by $89 in the North Coast and $114 in the Bay Area, up to $278 in the Central Valley and $361 in the inland regions of Southern California.[17] If the restaurant operates in a newly-constructed building with less efficient insulation materials, the monthly cost increases would range from $192 to $775 per month, depending on the location. Again, these increases would be on top of air conditioning bills that are already among the highest in the U.S.

[17] CMC estimates are based on a 20-ton,14 SEER heat pump unit using about 18 kWh when operating. Regional variation is based on (1) average summertime temperatures for each county, (2) the relationship between average outside temperature and hours of heating operation per day (based on industry reports and empirical studies), and (3) the published commercial electricity rates for the primary electricity service provider in each county.

Figure 6
Increase in Monthly Air Conditioning Bills During the Summer
6,000 Square Foot Restaurant

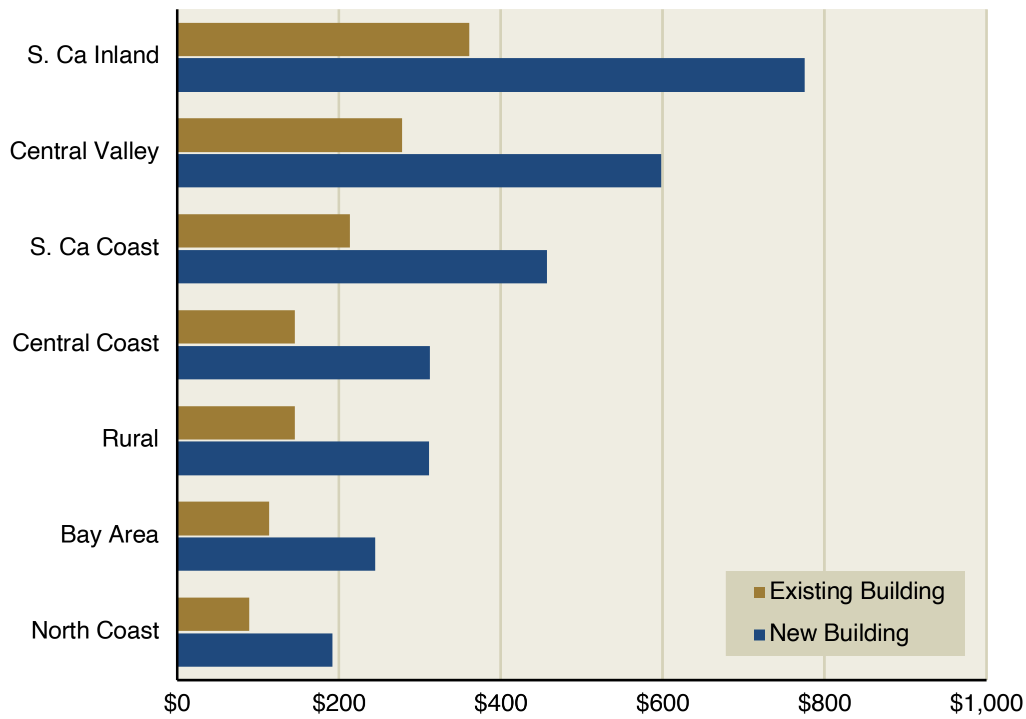
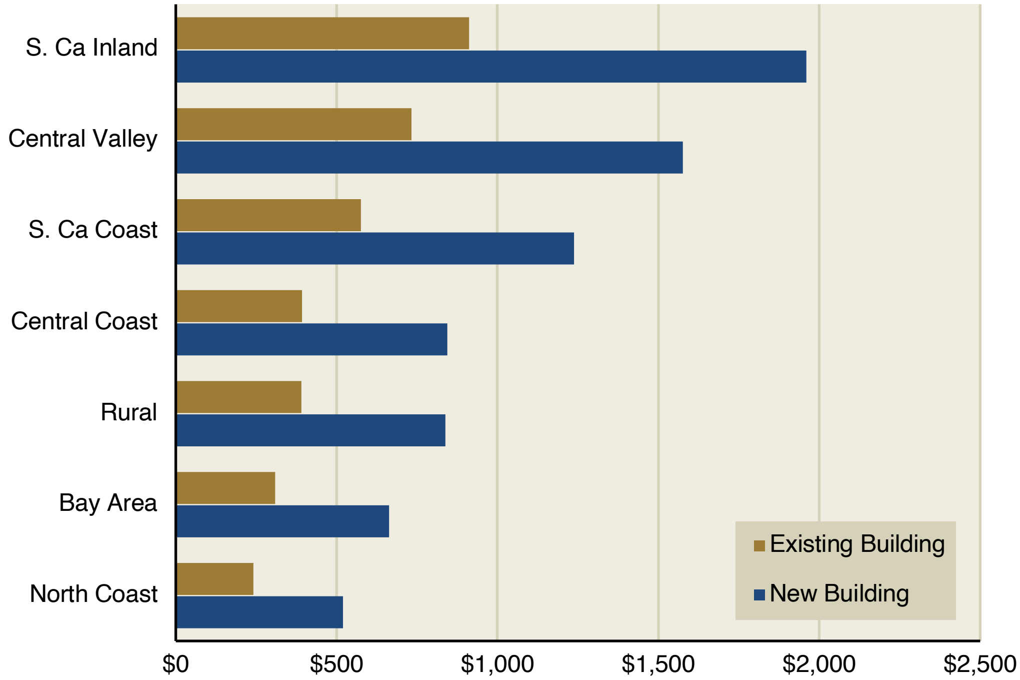


Figure 7 provides our estimate for a 20,000 square foot supermarket. It shows that use of an HVAC systems would drive up monthly bills during the summer by $242 in the North Coast and $308 in the Bay Area, up to $733 in the Central Valley and $911 in the inland regions of Southern California. If the building is constructed after the F-gas ban with less efficient insulation materials, the cumulative increase would range from $519 to $1,959 per month depending on location.[18]

[18] CMC estimates are based on a 50-ton,14 SEER heat pump unit using an average of 47 kWh when running. Estimates are based on (1) average summertime temperatures for each county, (2) the relationship between outside temperature and hours of heating operation per day (based on industry reports and empirical studies), and (3) the published commercial electricity rates for the primary electricity service provider in each county.

Figure 7
Increase in Monthly Air Conditioning Bills During the Summer
20,000 Square Foot Supermarket



Cost Increases for Commercial Refrigeration Units

An F-gas ban would have an even greater impact on costs of commercial refrigeration systems. These systems are used by businesses in a variety of industry sectors, but they play an especially important role in supermarkets and convenience stores by ensuring that perishable products such as dairy, meat, produce, and frozen goods are kept at safe temperatures. According to data from the U.S. Energy Information Administration, refrigeration accounts for nearly one-half of electricity consumption in food stores, and over one-quarter of electricity consumption in food service facilities.[19]

Figure 8 provides annual cost data based on estimates developed by Solstice Advanced Materials (Solstice) for a commercial refrigeration unit used in a 20,000 square foot supermarket. It shows that up-front purchase costs for a Propane/CO_2-based unit would be $1.2 million, or $350,000 more than the cost for a F-gas based system. Annual operating costs are 37 percent higher – about $41,000 per year ($3,416 per month).

[19] Commercial Buildings Energy Consumption Survey (CBECS)
https://www.eia.gov/consumption/commercial/data/2018/ce/pdf/e4.pdf

Figure 8
Cost Comparison:
Refrigeration System for 20,000 Square Foot Supermarket

Unit	Energy Usage (Megawatts)	Purchase/Installation ($ Thousands)	Annual Operating Cost ($ Thousands)
F-gas (R455A) System	277	$900	$112
Propane/CO_2 System	378	$1,250	$153
Additional Usage/Cost	101	$350	$41
Percent Increase	36%	39%	37%

Food sales and services are low-margin businesses, with profits typically in the range of 1 percent to 3 percent of sales.[20] Significant increases in operating costs for refrigeration, heating, and air conditioning will cut into profits and put upward pressures on retail food prices.

Statewide Economic Impacts of an F-gas Ban

In this section, we look at the broader impacts of an F-gas ban on California, focusing on jobs, economic output, labor income, and state and local revenue put at risk because of the ban. Our economic impact estimates account for both direct and multiplier effects of the ban, using the IMPLAN input-output model of the California economy (see box on next page). We also estimate the impact of the ban on CO_2 emissions and discuss how the ban would interact with California's climate goals over the next two decades.

Our projections of both economic activity and CO_2 emissions tie to the California Air Resource Board 2022 Scoping Plan, which has annual estimates of grid emissions, sales of heat pumps and other factors consistent with California's ambitious plan to achieve net carbon neutrality by 2045.

Our analysis covers impacts in five main areas:

- HVAC installations put at risk by the ban.

- Manufacturing put at risk by the ban.

- The negative impacts of higher costs for equipment and installations of residential equipment on disposable income and spending by households in California.

- The negative impacts of efficiency losses of alternative HVAC systems in both the residential and commercial sectors on disposable household income and spending.

[20] "Grocery Store Chains Net Profit." The Food Industry Association. https://www.fmi.org/our-research/food-industry-facts/grocery-store-chains-net-profit. Accessed December 7, 2025.

- The negative impacts of F-gas bans on the performance of products used to insulate homes.

These are only a subset of the full impacts that an F-gas ban would have on California's economy. For example, because of data limitations, we did not estimate the impact of an F-gas ban on building insulation for non-residential buildings. Nor did we estimate the negative impacts of higher purchase and installation costs of commercial HVAC equipment on business expenses and, ultimately, consumer prices. In this regard, our estimates understate the full magnitude of risks posed by an F-gas ban. Moreover, our estimates do not include the potentially major impacts that the lack of viable HVAC alternatives would have on the broader economy, especially in warmer inland areas of the state.

IMPLAN and Input-Output Modeling

The proprietary IMPLAN input-output model for California is utilized to estimate both direct and multiplier economic impacts resulting from policy changes. This method evaluates the effects of events, such as decreases in HVAC installations due a mandated phase-out of F-gases, on various industries and workers across the economy.

- **Direct impacts** are the immediate changes in employment, income, and output in businesses affected by a policy or spending change, such as HVAC companies experiencing reduced sales following a ban on F-gas systems.
- **Indirect impacts** involve effects on suppliers to these businesses – in the above example, a demand reduction facing transportation, warehousing, and manufacturing firms because of fewer HVAC sales.
- **Induced impacts** reflect changes in household spending among employees working at firms impacted by policy changes or shifts in spending. In the HVAC example, this includes reduced sales of companies providing goods and services to households whose members experience reduced work hours or job losses due to an F-gas ban.

Together, indirect and induced impacts are known as *multiplier* effects.

Key Assumptions Behind Our Estimates

Our estimates are based on dozens of specific assumptions and methods that are covered in Appendix Tables 1 through 3. Key assumptions include:

- New housing construction starting at 139,000 units in 2026, growing in line with state population to 153,000 units by 2035. California's recent and projected share of housing starts is slightly below its share of the U.S. population, reflecting ongoing challenges relating to housing development in this state.

- HVAC labor costs are about 30 percent above the national average.

- About 60 percent of California's 13.4 million housing units have central air conditioning, and over 90 percent of new constructions include central air.[21,22] The percentage of existing households with air conditioners is significantly below the national average.[23]

- Annual residential heat pump sales will increase from 260,000 units in 2026 to 665,000 units by 2035, consistent with the Scoping Plan.

- Annual residential sales of heat pump water heaters will increase from 267,000 to 800,000 units in the same period, also consistent with the Scoping Plan.[24]

- Residential electricity prices (in constant 2026 dollars) increase from 33 cents per kWh in 2026 to 39 cents per kWh by 2035, an inflation-adjusted increase of 1.8 percent per year.

- Annual installations of commercial heat pumps increase from 57,000 in 2026 to 112,000 by 2035, consistent with the Scoping Plan. Heat pump water heater installations grow from 18,000 in 2026 to 56,000 by 2035.[25]

- About 3.8 percent of the nation's HVAC manufacturing industry is in California.[26]

- Commercial electricity rates average 26 cents per kWh in 2026, rising at an inflation-adjusted rate of 1.8 percent per year to 31 cents per kWh by 2035.

- Efficiency losses are 15 percent for heat pumps and heat pump water heaters using alternative refrigerants, consistent with data from the Oak Ridge National Laboratories; and 37 percent for refrigeration systems, consistent with documents provided by Solstice.[27]

- Under our primary projections, emissions from California's electrical grid decline from 497 lbs. per megawatt hour (mWh) in 2026 to 276 lbs. per mWh by 2035 as California shifts toward an all-renewable power grid. This is consistent with current law (SB 100/2018) and assumptions in the Scoping Plan.[28] We note, however, that the shift toward renewables is facing headwinds from (1) rising costs and fewer federal subsidies for renewables; and (2) rapid increases in state energy demand stemming from growth in AI-related data centers. For these reasons, we also show

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[21] Highlights for Air Conditioning in Homes. U.S. Energy Information Administration. 2020. https://www.eia.gov/consumption/residential/data/2020/state/pdf/State%20Air%20Conditioning.pdf
[22] Characteristics of New Housing. U.S. Census. https://www.census.gov/construction/chars/current.html
[23] Supra 18.
[24] Ibid.
[25] Scoping plan source (supra)
[26] 2022 SUSB Annual Data Tables by Establishment Industry. U.S. Census. https://www.census.gov/data/tables/2022/econ/susb/2022-susb-annual.html
[27] Source of commercial refrigeration efficiency losses
[28] Current emissions rate from "Greenhouse Gas Equivalencies Calculator - Calculations and References." U.S. Environmental Protection Agency. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-calculations-and-references

emissions estimates under the assumption that emission rates from California's electrical grid hold steady over the next decade.

Total Jobs and Gross State Product at Risk

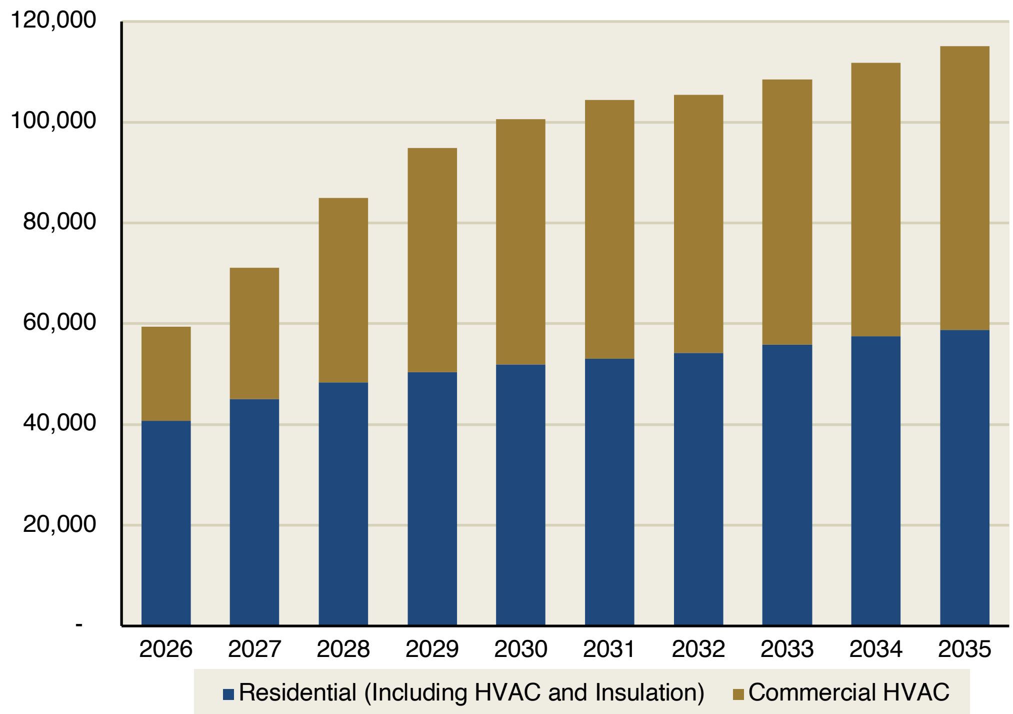
An F-gas ban would put at risk over 96,000 jobs and $12.8 billion in annual gross state product for an average year over the next decade (see Figure 9). Approximately 52,000 of the jobs and $7.2 billion in gross state product is related to a ban on F-gases used in residential heating, cooling and building insulation, and the remaining 44,000 jobs and $5.6 billion in gross state product is related to commercial space heating, cooling, water heating, and refrigeration. The totals include economic activity directly related to HVAC sales, installation and manufacturers. They also indirect impacts on other sectors. These include (1) businesses that supply goods and services to the HVAC businesses as well as households of their employees, and (2) businesses throughout the economy that would be impacted by losses in household discretionary income due to higher costs for HVAC systems using alternative refrigerants

Figure 9
California Jobs and Gross State Product at Risk From F-gas Ban
Annual Average, 2026 to 2035

	Residential Heating and Cooling	Residential Building Insulation	Commercial Heating and Cooling	Total
Employment at Risk				
Direct	21,825	NA	23,671	45,496
Indirect	5,060	NA	4,823	9,883
Induced	23,658	1,028	15,578	40,263
Total	50,544	1,028	44,071	96,642
Gross State Product at Risk ($ Millions)				
Direct	$2,471	NA	$2,706	$5,178
Indirect	$781	NA	$778	$1,560
Induced	$3,790	$152	$2,156	$6,098
Total	$7,043	$152	$5,640	$12,836

The number of jobs and related economic activity at risk would increase over time as less efficient systems are installed in new houses and in existing homes once current HVAC systems wear out and need to be replaced. As shown in Figure 10, annual jobs at risk would expand from 59,000 in 2026 to 115,000 by 2035.

Figure 10
Annual Jobs at Risk From an F-gas Ban



In the following sections, we discuss the various components of our estimate in more detail.

Installation Labor

A phase-out of F-gases would present major challenges to the HVAC industry due to high costs, a loss in efficiency, and usage restrictions due to flammability and safety concerns.

Residential installations. We estimate that approximately 33,000 jobs, $2.8 billion in labor income, and $4.0 billion in gross state product would be put at risk by an F-gas ban on the residential sector (see Figure 11, next page). Roughly two-thirds of the job impacts are in HVAC and related businesses that would directly lose sales because of the ban. The other one-third is related to businesses that provide goods and services to HVAC businesses and the households of their employees and thus would be indirectly affected by the ban.

Figure 11
Installation and Related Jobs at Risk From an F-gas Ban on Residential Heat Pumps, Heat Pump Water Heaters, and Air Conditioners ($ Millions)

	Jobs	Labor Income	Gross State Product	Sales
Direct	20,575	$1,759	$2,262	$3,212
Indirect	4,017	$352	$605	$1,049
Induced	8,372	$657	$1,099	$1,773
Total	**32,964**	**$2,768**	**$3,966**	**$6,034**

Commercial Installations. We estimate that an F-gas ban on heat pumps, air conditioners and refrigeration units in the commercial sector would put at risk about 35,000 installation and related jobs, $2.9 billion in labor income, and $4.3 billion in gross state product (See Figure 12).

Figure 12
Installation and Related Jobs at Risk From an F-gas Ban: Commercial HVAC and Refrigeration Systems (Annual Average, 2026 to 2035) ($ Millions)

	Jobs	Labor Income	Gross State Product	Sales
Direct	22,421	$1,867	$2,497	$3,178
Indirect	3,779	$343	$602	$1,175
Induced	8,989	$643	$1,182	$1,908
Total	**35,189**	**$2,852**	**$4,281**	**$6,261**

Manufacturing Output and Jobs

As of the most recent business (2022) census, the Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing sector employed 5,593 workers and had $2 billion in receipts in California.[29] We estimate that at least one-half of the industry would be at risk from an F-gas ban in California (the remainder are mostly businesses engaged in the production of ventilation systems and other equipment not dependent on refrigerants).

[29] California accounted for about 3.8 percent of U.S. employment and receipts in the HVAC industry during the year – much less than the state's 11 percent of U.S. population. This implies that a considerable portion of risks from an F-gas ban would be faced by out-of-state manufacturers of HVAC equipment.

As shown in Figure 13, we estimate that a ban would directly put at risk 2,500 employees and $419 million in gross state product related to HVAC manufacturing in California. When multiplier jobs and output are included, total potential losses in California would reach about 6,300 jobs and $1 billion in gross state product.

Figure 13
California Manufacturing at Risk From F-Gas Ban
(Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing Sector)
($ Millions)

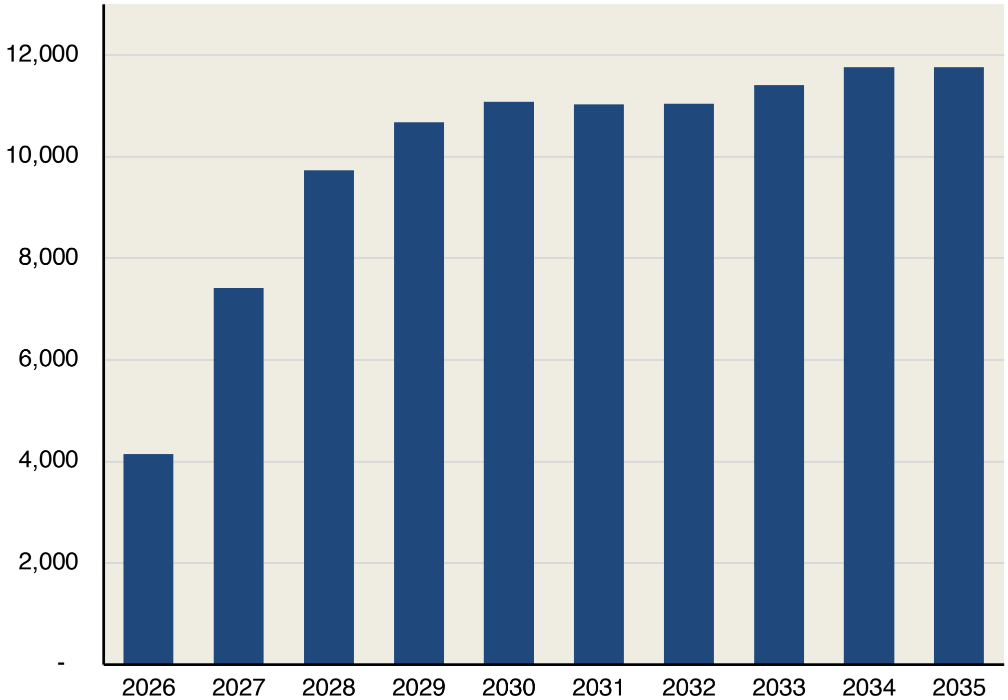
	Jobs	Labor Income	Gross State Product	Sales
Direct	2,500	$236	$419	$1,241
Indirect	2,086	$216	$352	$640
Induced	1,701	$129	$244	$375
Total	**6,287**	**$581**	**$1,015**	**$2,256**

Higher Purchase and Installation Costs for Residential HVAC Systems

California's Scoping Plan indicates that to meet the state's climate goals, over 5.7 million residential heat pumps and 6.8 million heat pump water heaters will need to be installed over the next decade. As noted previously, heat pumps that use alternative refrigerants cost 48 percent more than F-gas systems, and installation costs for alternative systems will likely run at least 5 percent higher. In total, these additional expenses will raise outlays for HVAC equipment by $17.5 billion over the next decade, or about $1.75 billion per year.

These additional outlays would reduce resources that households have available to purchase other goods and services in the economy. We modeled the impacts in IMPLAN as a loss in household disposable income, which in turn reduces spending in the economy. We estimate that these impacts would put at risk an average of 10,000 jobs, $752 million in annual labor income, $1.5 billion in annual gross state product and $2.5 billion in annual sales in an average year during the next decade. Impacts would be felt in industries ranging from retail trade, health care, information, transportation, finance and personal services. As shown in Figure 14 (next page), the annual effects would grow over the decade in line with assumed increases in heat pump installations.

Figure 14
California Jobs at Risk Due to Higher Costs for Alternative Residential HVAC Systems.

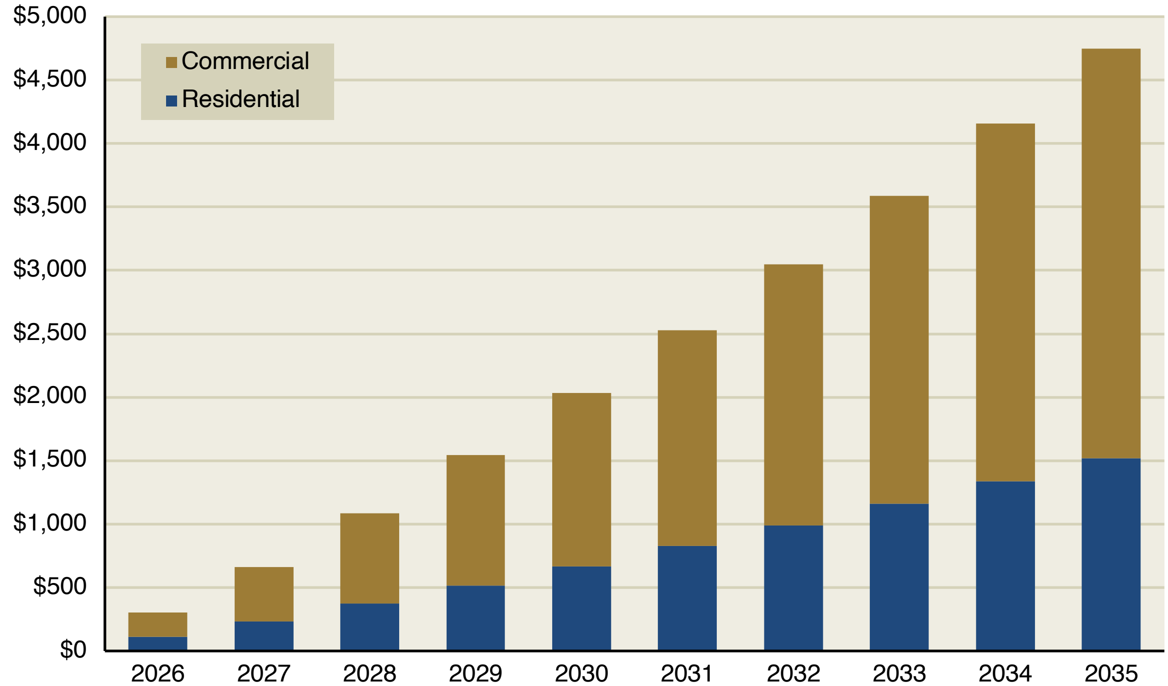


Efficiency Losses in the Residential and Commercial Building Sectors

As noted previously, HVAC systems that use alternative refrigerants are less efficient than systems using F-gas base refrigerants. For heat pumps, heat pump water heaters, and air conditioners, the loss of efficiency is about 15 percent, and for refrigeration systems, the loss is 36 percent. The consequence of these efficiency losses is that a given amount of space heating or cooling will require 15 percent more electricity, and refrigeration units will require 36 percent more electricity.

In aggregate, we estimate that additional annual spending on electricity would average $775 million per year for households and $1.6 billion for businesses over the 10-year period, with the annual amounts increasing over the period as additional households and businesses install less-efficient heat pumps and air conditioners each year.
(see Figure 15, next page).

Figure 15
Additional Spending on Electricity Resulting from Efficiency Losses of Alternative HVAC Systems ($ Millions)



We modeled the impacts of both higher residential and commercial expenditures on electricity as a reduction in household disposable income, under the assumption that additional electricity spending by businesses is "passed along" to households in the form of higher product prices.[30] Figure 16 shows a ban would put at risk an average of 11,200 jobs and $1.7 billion in gross state product during the 2026 to 2035 period.

Figure 16
California Economic Activity at Risk From F-gas Ban's Impact on HVAC and Building Insulation Efficiencies (Average Annual Totals, 2026 to 2035) ($ Millions)

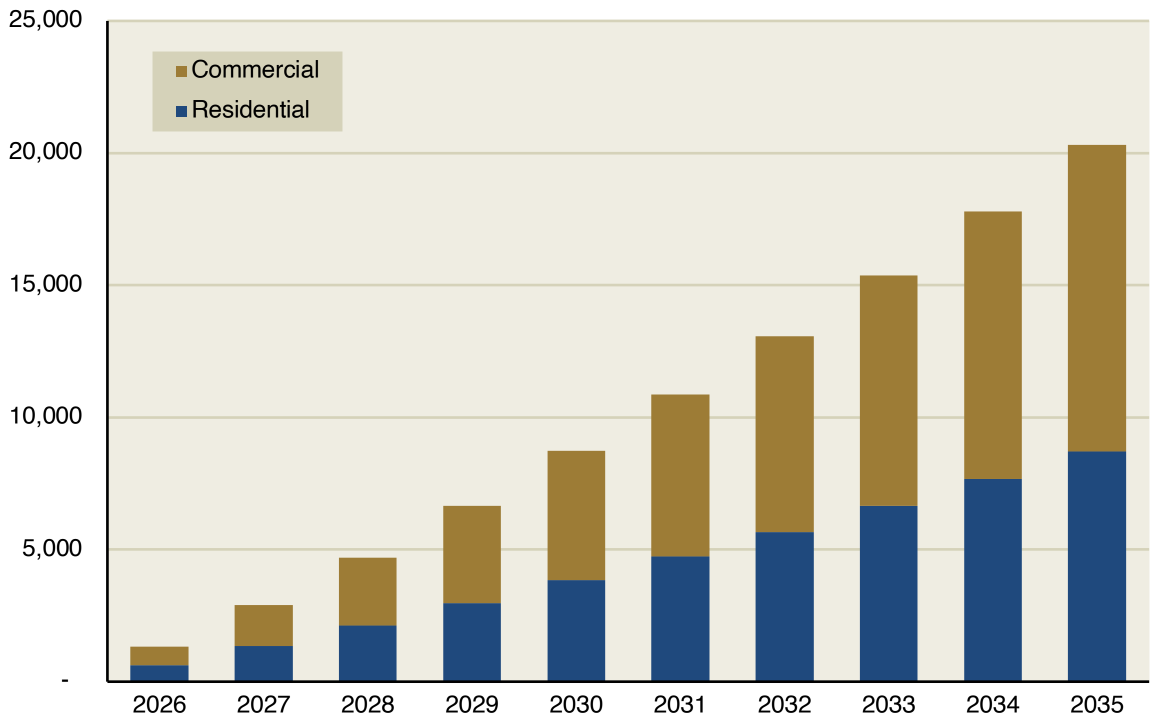
	Jobs	Labor Income	Gross State Product	Sales
Household Sector*	5,459	$411	$810	$1,232
Commercial Sector*	5,738	$432	$851	$1,295
Total	11,197	$842	$1,661	$2,528

*Residential sector includes effects of both HVAC and building insulation efficiency losses. Commercial sector includes effects of HVAC efficiency losses only.

[30] There would be negative economic repercussions even if the energy cost increases were absorbed by the business, which in order to maintain profitability would need to offset higher heating and cooling expenses through cost-cutting in other areas, such as capital expenditures, staffing levels, and employee working hours.

The annual impacts will grow over the period as additional less efficient HVAC units are installed. Figure 17 shows that the annual number of jobs put at risk rises from 1,300 in 2026 up to 20,000 by 2035.

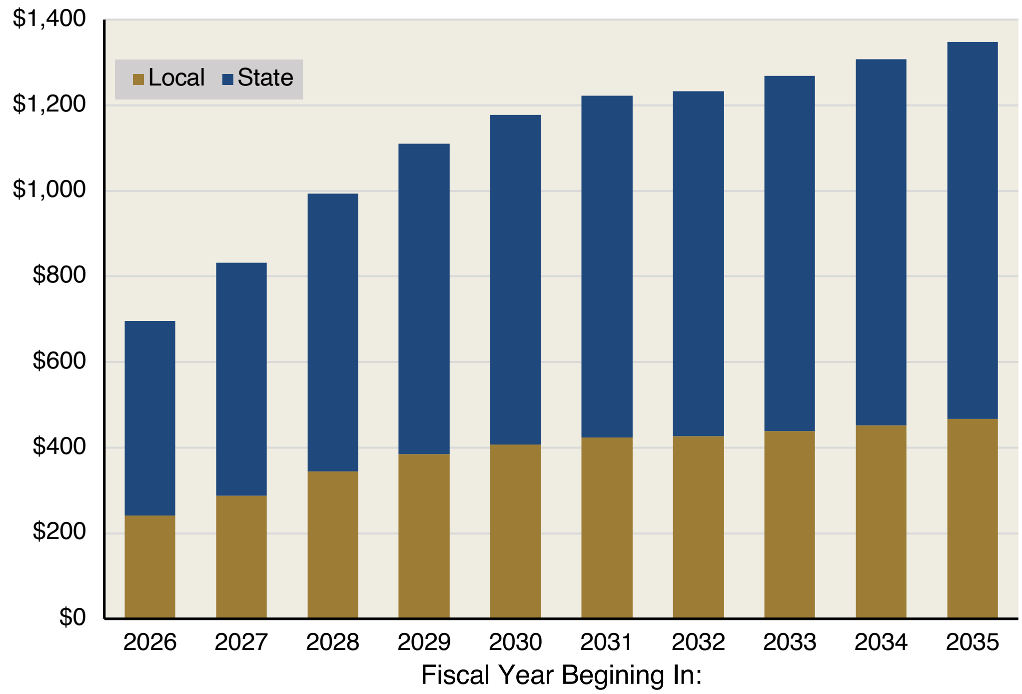
Figure 17
Annual Jobs at Risk Due to Efficiency Losses of Alternative Heating and Cooling Equipment



State and Local Government Revenue at Risk

An F-gas ban would impact state and local governments, both as users of HVAC equipment affected by the ban and as recipients of tax dollars paid by workers and businesses in industries put at risk by the ban. Over the next decade, we estimate that an average of $732 million in state revenues and $387 million in local revenues would be at risk. As shown in Figure 18 (next page), the annual amounts would increase each year – with state taxes at risk reaching $881 million and local revenues at risk reaching $466 million by 2035 – as additional households and businesses are affected by the bans.

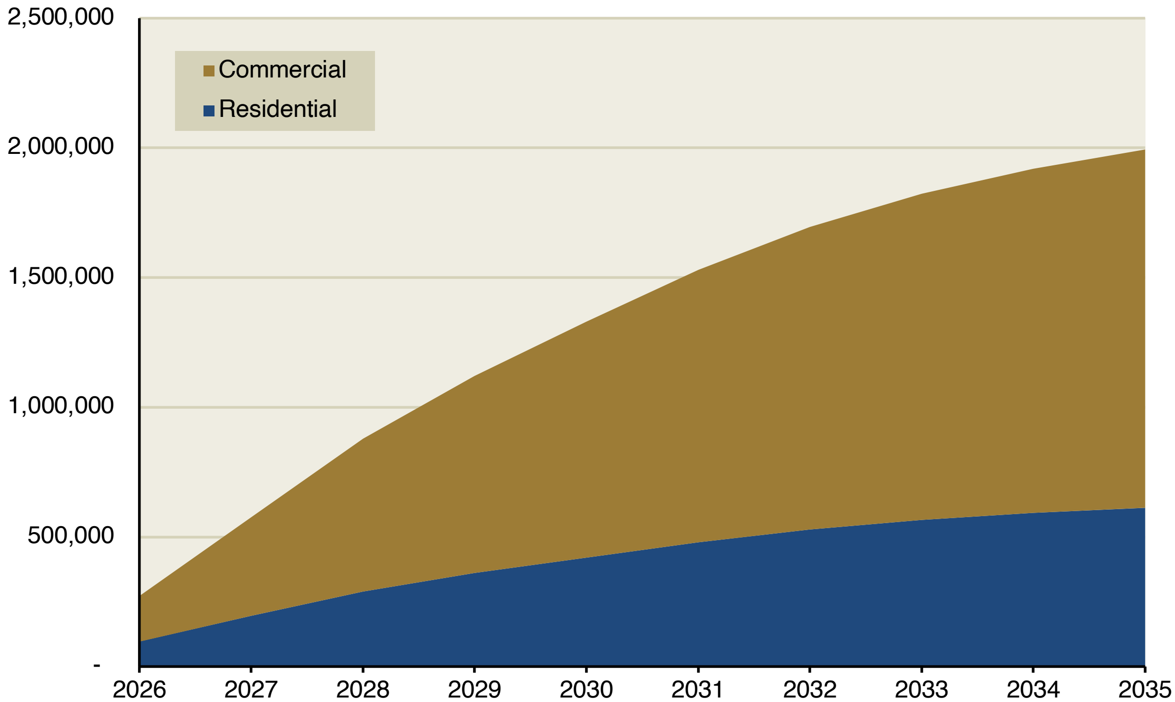
Figure 18
State and Local Government
Revenues at Risk From an F-gas Ban
($ Millions)



Effects on Emissions

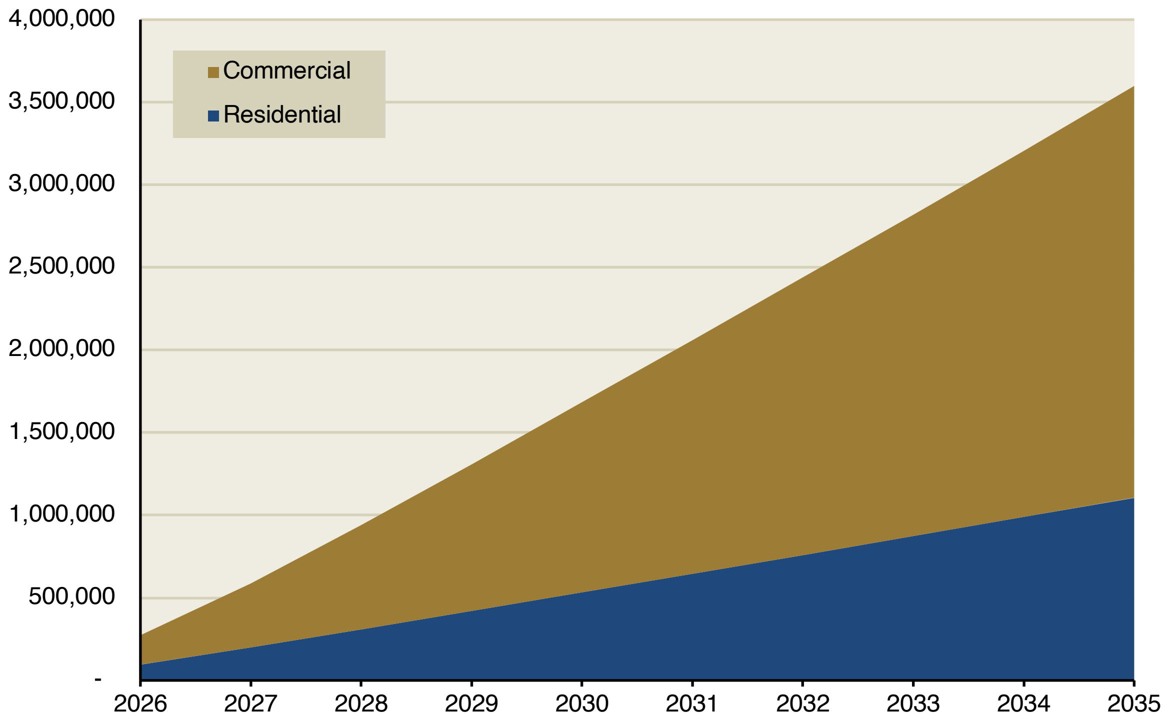
An F-gas ban would undercut California's CO_2 emission-reduction goals. This is because alternative systems will run less efficiently and use more electricity, which translates into additional emissions from California's electrical power grid. We estimate that the loss in efficiencies associated with alternative systems would raise total emissions by at least 13 million metric tons over the 2026 to 2035 period, with annual amounts increasing sharply over the ten-year period to 2 million metric tons by 2035 (see Figure 19, next page).

Figure 19
Additional CO_2 Emissions From an F-gas Ban
Assuming Future Emission Reductions from California's Power Grid
(Metric Tons)



This estimate is based on the optimistic assumption that California meets its clean-energy goals with respect to electrical power generation, and that emission rates from the California grid fall by nearly one-half over the next decade. If the phase-out of fossil fuel powered electricity generation is delayed because of rising demands and high costs of renewables, an F-gas ban could add 19 million metric tons of CO_2 emissions over the decade, with annual emissions increases expanding to 3.6 million metric ton by 2035 (see Figure 20, next page).

Figure 20
Additional CO_2 Emissions From an F-gas Ban
Assuming Emission Rate From California's Power Grid Remains Constant
(Metric Tons)



Conclusion

An F-gas ban would force households to purchase more expensive and less efficient HVAC systems and building insulation materials at a time when the state is already struggling with a serious affordability crisis. Costs for new residential HVAC systems would rise by several thousands of dollars, and heating and air conditioning bills would increase by as much as $200 per month for a typical newly constructed home. Higher costs would be felt by all Californians but especially by lower-income households and small businesses located in warmer inland areas of the state.

An F-gas ban would have broad repercussions for the California economy, putting 115,000 jobs and $15 billion in annual gross state product at risk by 2035. The ban would also interfere with California's climate goals by (1) substantially raising energy consumption and CO_2 emissions, and (2) raising costs of heat pumps, which are crucial to the decarbonization of homes and commercial buildings. Higher electricity consumption would be occurring at a time when California's electricity grid is already facing enormous challenges related to the state's planned transition to an all-electric economy and soaring energy usage from in AI-related data centers. It is important that state policymakers keep these major issues in mind when evaluating any proposal that would restrict or ban the use of F-gases in refrigerants or building insulation materials.

Appendix Table 1
Sources and Methods: Residential Heating and Cooling

Sources and Methods for Estimates Related to:	Main Sources/Methods
Number of residential heat pumps and central air conditioners installed 2026 to 2035.	• Heat pumps from CARBs 2022 Scoping Plan Scenario (see AB 32 CHG Inventory Sectors Modeling Data Spreadsheet). • Stand-alone central air conditioners sold independently from heat pumps estimated based on the difference between (1) the total stock of central air conditioning units (from the EIA Residential Electricity Consumption Survey (RECS) data) **times** a turnover rate of 1/15th and (2) the projected number of heat pumps sold under the **2022 Scoping Plan**.
Labor costs for installation and associated economic impacts.	• Number of units (from above) **times** average installation costs per unit, based on national average installation costs provided by the EIA. • National totals adjusted to California using "**RS Means**" data on relative labor costs for electricians and equipment construction in several California cities. • Prevalence of air conditioners and heat pumps installed in existing homes based on EIA Residential Electricity Consumption Survey (**RECS**) data. • Cost data is adjusted for inflation using the BLS CPI.
Impact of higher purchase/installation costs on consumers.	• Assumed that transition from F-gases to propane as a refrigerant will increase average manufacturing cost ($3,000) by 48 percent. Increase based on a U.K. price comparison of similar propane and **f-gas** refrigerant units. • For air conditioners the increase is 5% based on a CEC study. • Increased installation costs (derived from above) by 5 percent to reflect added training and time needed to install propane-based systems.
Number of residential heat pumps and air conditioning units manufactured each year.	• Data from Air Conditioning, Heating and Refrigeration Institute (**AHRI**) • Allocated AHRI national data to CA using Economic Census Data for California, which shows that HVAC manufacturing production in CA accounts for about 3.8 percent of national total.
Manufacturing-related output at risk due to elimination of f-gases.	• Assumed base cost of $3,000 per unit, which was multiplied by number of installations to arrive at total value of heat pumps and air conditioners at risk due to a f-gas ban. • Ran results through IMPLAN to derive multiplier effects.
Percentage efficiency loss on newly installed residential units.	• Assumed 15 percent loss for both heat pumps and air conditioners if switch to propane, based on a study by **the Oak Ridge National Laboratory**.

Sources and Methods for Estimates Related to:	Main Sources/Methods
Resulting additional electricity consumption/costs.	• 15 percent efficiency loss ***times*** projected installations of heat pumps and central air conditioners installed ***times*** average consumption of electricity for space heating and cooling and water heating ***times*** average price of electricity. • Source for average consumption is the *EIA Residential Electricity Consumption Survey.* (**RECS**).
Full impact on consumers	• Additional consumer costs modeled in IMPLAN as a loss in consumer disposable income to derive full multiplier effects.
Emission Impact	• Additional electricity usage ***times*** EPA's state-level **eGRID** emissions rates for CO_2. • Assumed decline in future emissions based on Scoping Plan, which accounts for SB 100 decarbonization targets

Appendix Table 2
Sources and Methods:
Commercial Heating and Cooling

Estimates Related to:	Sources and Methods
Number of commercial heat pumps, air conditioners and refrigeration systems installed	• 2022 Scoping Plan (which expresses commercial installations in terms of kBTUH/hr) and various projections of energy load profiles to arrive at a state number of air conditioners and heat pumps. • Assumed a representative commercial unit of 150 k BTUH for space heaters/coolers and 140 k BTUH for water heaters based on industry sales, based on data from AHRI. • Divided Scoping Plan energy output projections by maximum output for the typical unit, then multiplied the result by the ratio of peak demand to average demand in California based on review of CEC data on load factors. Result is number of units installed. • Made similar calculation for refrigeration systems.
Labor Costs for Installation	• Based on number of units ***times*** average installation cost per unit. Latter is based on the national average installation costs provided by the EIA data, and, for regions, adjusted by RSMeans data on regional construction costs. All data is adjusted for inflation using the CPI. • The resulting installation cost per unit was multiplied the number of units installed to arrive at total installation spending at risk to the ban on f-gases. • This total was then inputted into IMPLAN to estimate multiplier impacts.
Number of commercial heat pumps and air conditioning units manufactured each year.	• Data from Air Conditioning, Heating and Refrigeration Institute (AHRI).
Current HVAC output at risk due to elimination of f-gases.	• Assumes manufacturing cost of $7,500 per unit, which was multiplied by number of commercial units installed to arrive at total value of heat pumps and air conditioners at risk due to a f-gas ban. • Ran results through IMPLAN to derive multiplier effects.
Impacts on consumer spending of increased equipment and installation costs due to elimination of f-gases.	• Not included due to variability of size and types of units involved on the commercial side.
Percentage efficiency loss	• Applied the 15 percent reduction in efficiency for air conditioners and heat pumps – same as for residential units. • Used a 37 percent efficiency reduction for refrigeration units based on data supplied by Solstice.

Estimates Related to:	Sources and Methods
Resulting additional electricity consumption/costs	• Percent efficiency loss ***times*** projected installations of heat pumps and central air conditioners ***times*** average consumption of electricity for space heating and cooling and water heating ***times*** average price of electricity for commercial users. • Source for average consumption is Commercial Buildings Electricity Consumption Survey("CBECS") • Modeled economic impacts by treating the additional electricity cost as a reduction in disposable income, assuming that higher business costs are passed along in form of higher product prices. Ran through IMPLAN model to develop estimated impacts on jobs, labor income, and economic output.
Emissions impacts	• Additional energy consumption times emissions per unit of production based on data from EPA's Emission Factor Hub and eGRID database.

Appendix Table 3
Sources and Methods:
Residential Building Materials

Estimates Related to:	CMC Sources and Methods
Percentage efficiency loss	• 15 percent based on our internal calculations and Energy Star estimates that a properly insulated home can see up to a 15 percent reduction in home heating and cooling.
Number of new residential units	• Historical data based on 2023 Building Permits Survey ("BPS") – 2023 Survey of Construction ("SOC"). Assumed 139,000 units in 2026, and slow growth in line with population through 2035.
Additional energy usage	• Number of homes built ***times*** average consumption per home (from RECS data) ***times*** 15 percent.
Impact on consumers	• Additional energy consumption ***times*** average costs of energy, almost exclusively electricity given California's electrification goals. • Used EIA data for average energy costs for electricity in California. • Modeled increase annual energy costs in IMPLAN as a drop in disposable income.
Emissions impacts:	• Additional energy consumption ***times*** weighted average emissions per unit of production (for natural gas as well as electricity) based on data from EPA's Emission Factor Hub and eGRID database. Future emissions assumed to decline in line with Scoping Plan assumptions.