Assessing the Affordability Implications of California's GHG Cap and Trade Program[1]

Meredith Fowlie and Dallas Burtraw

California is grappling with the impacts of a changing climate. Extreme heat, prolonged droughts, rising sea levels, and escalating wildfire risks are threatening the health, safety, and well-being of Californians across the state. The costs of adapting to climate change are starting to manifest in the form of increased insurance premiums and higher utility bills. For households with limited resources, these impacts can be particularly acute.

Reauthorization of the GHG cap-and-trade program would affirm California's commitment to reducing statewide GHG reductions and could inscribe a tighter GHG emissions cap to provide stronger incentives to invest in GHG abatement. At the same time, higher GHG allowance prices induced by a tighter cap could increase some consumer prices, raising concerns around the "affordability" of climate action.

It is important to note that, in contrast to other factors that can drive retail energy price increases (such as increased spending on wildfire mitigation in the electricity sector, or hard-to-predict oil and natural gas price fluctuations in the transportation and building sectors), **GHG allowance price increases are relatively predictable and generate revenues for the state of California. These revenues can be used to offset affordability impacts and help California households reduce their reliance on fossil fuels.**

This chapter begins with an overview of energy affordability concerns in California. We assess the extent to which California's carbon prices have impacted consumer energy prices and expenditures, starting with electricity. We show that **California's cap-and-trade program has not been a significant driver of retail electricity price increases.** Using data from 2023, we estimate that carbon pricing increased retail PG&E electricity rates by approximately 4%. These electricity price impacts have largely been offset by a bi-annual "climate credit" that sends carbon revenues back to utility consumers.

The consumer price impacts of carbon pricing in California have been more significant for natural gas and gasoline, in part because these fuels are more carbon-intensive. The costs of complying with the cap-and-trade program increased retail natural gas prices by an estimated 8% in 2023. This carbon price increase was largely offset by a "climate credit" on consumers' utility bills. We estimate that carbon pricing increased 2023 gasoline prices by approximately **26 cents per gallon** (this assumes complete cost pass through to consumers). Although carbon pricing has put

[1] For outstanding research assistance we thank Thor Larson and Kaixin Wang. For valuable comments we thank …

upward pressure on these consumer costs, **retail gasoline and natural gas prices are still *lower* than estimated social marginal costs of gas and natural gas consumption, respectively.**

We survey recent carbon market modeling exercises that forecast carbon price increases under alternative market reforms. While projections of higher carbon prices would lead to higher retail natural gas and gasoline prices (all else equal), the impacts of these higher energy prices on household energy expenditures will diminish as households reduce their reliance on fossil fuels to meet their energy needs. For this future to be realized, however, we need to fix retail electricity price structures and give customers the right signals (1) for electricity consumption and (2) for fuel substitution. **Importantly, higher carbon prices generate carbon market revenues which can be used to offset energy affordability impacts on energy consumers while preserving the incentive to reduce reliance on more carbon intensive fuels**.

Context: Rising Consumer Costs in California

Overall consumer prices have increased by more than 20% across the nation since 2020. Retail energy prices have increased even faster in California. The charts below show how retail gasoline, natural gas, and electricity prices in the Bay Area of California are high and increasingly out of line with the rest of the country. Retail prices for other metropolitan areas of California show similar patterns.

Figure 1: Average Bay Area Retail Energy Prices

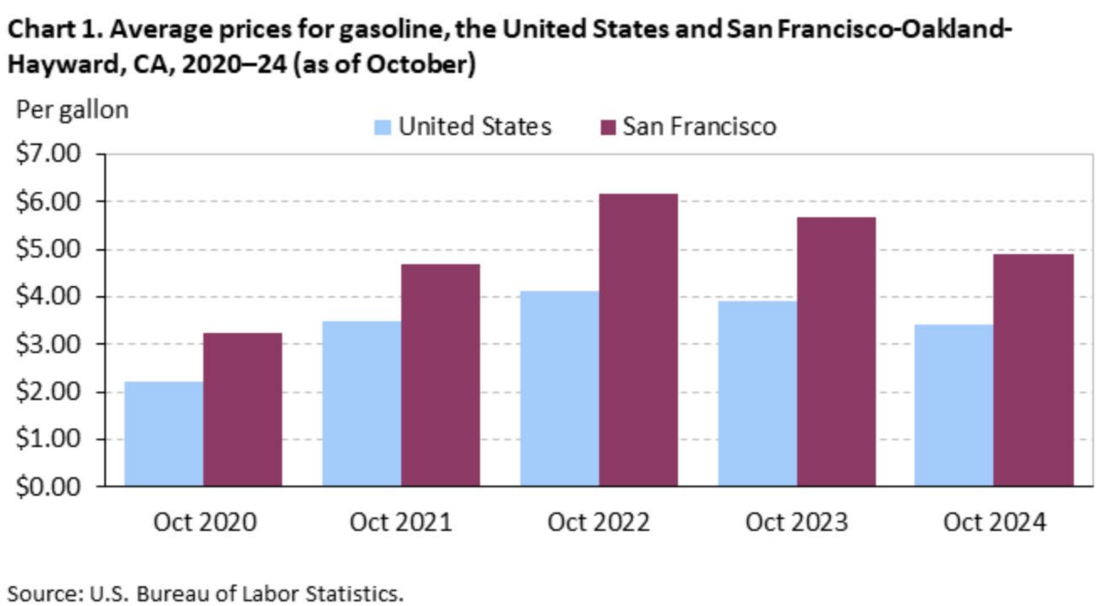
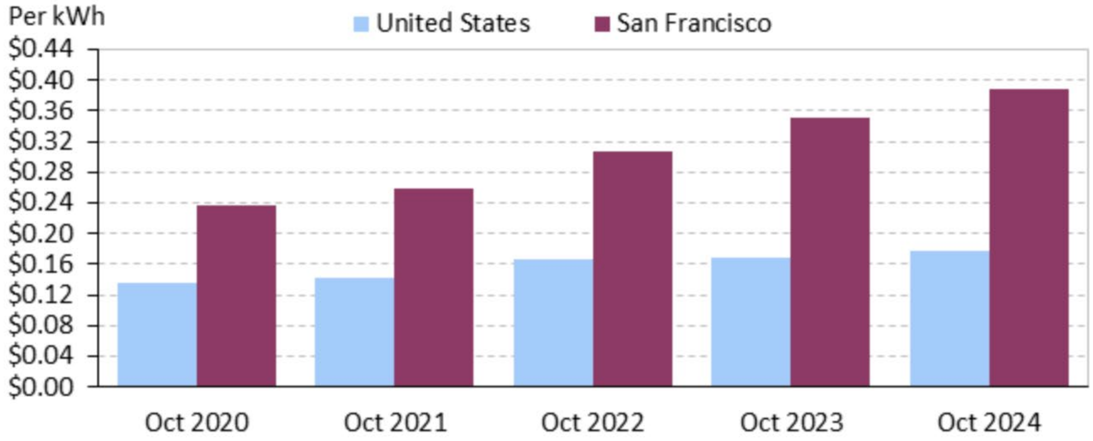
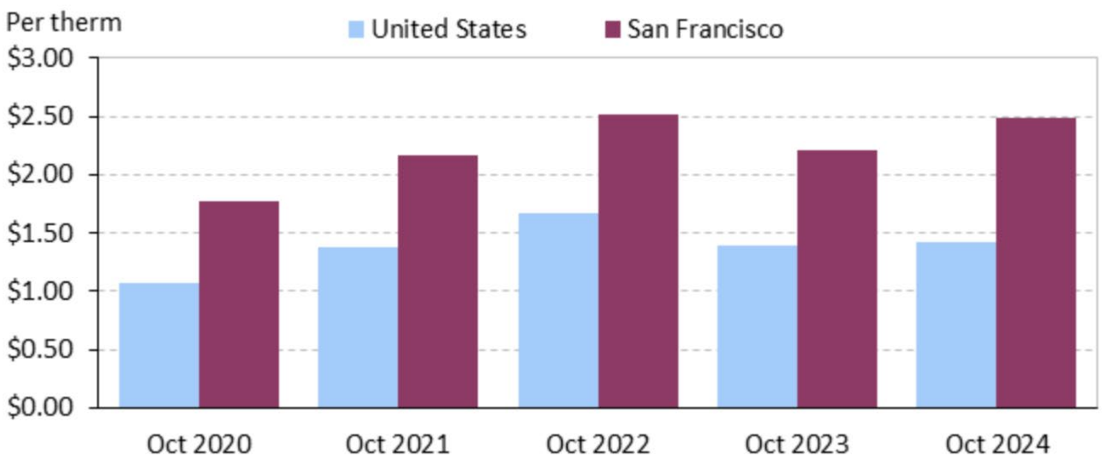


Chart 2. Average prices for electricity, the United States and San Francisco-Oakland-Hayward, CA, 2020–24 (as of October)



Source: U.S. Bureau of Labor Statistics.

Chart 3. Average prices for utility (piped) gas, the United States and San Francisco-Oakland-Hayward, CA, 2020–24 (as of October)

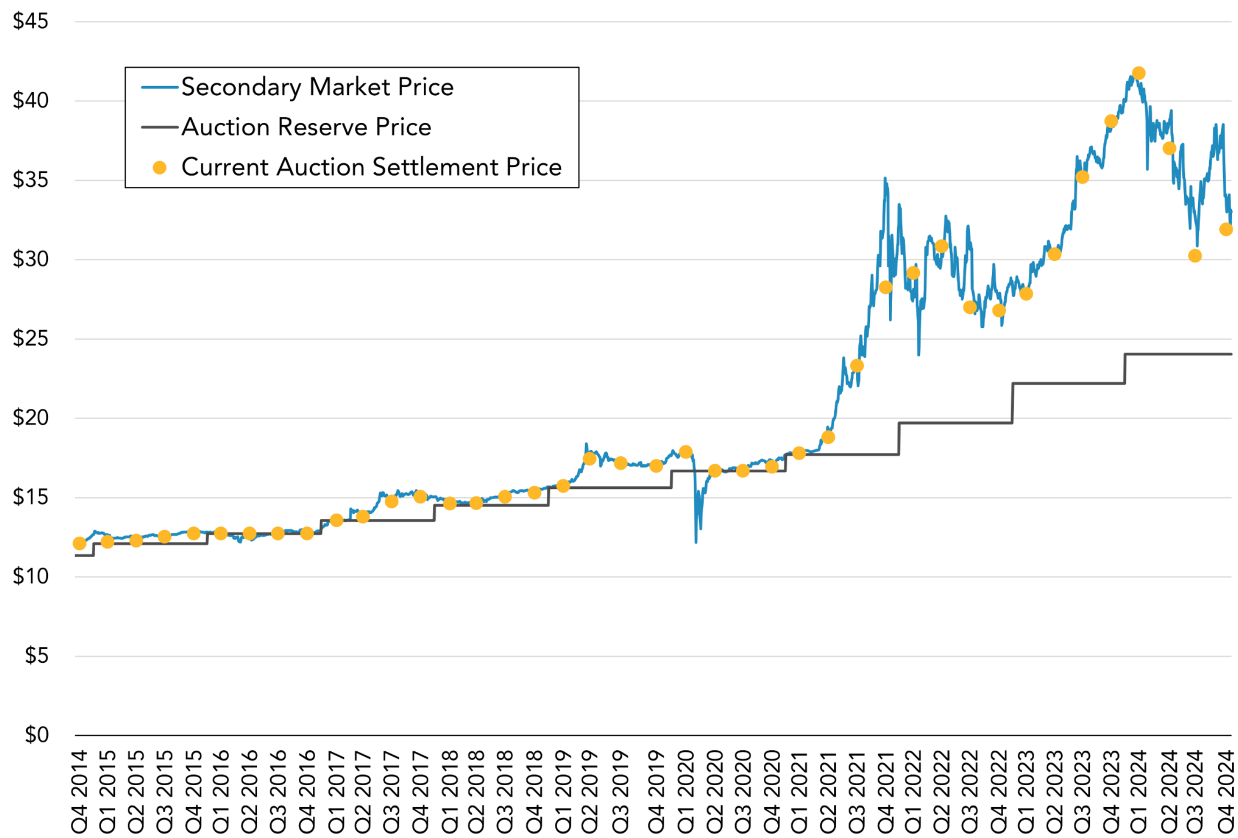


Source: U.S. Bureau of Labor Statistics.

Source: https://www.bls.gov/regions/west/news-release/averageenergyprices_sanfrancisco.htm

California GHG allowance prices have also been increasing since 2020. The graph below tracks the market price per ton of CO_2 over time. For the first ten years of the program, the carbon market clearing price was close to the floor price (the minimum price at which allowances can sell in the auction). Post-2020, the GHG allowance price has increased, presumably reflecting market expectations that future reforms to the cap-and-trade program will reduce GHG allowance supply.

Figure 2: California and Quebec Carbon Allowance Prices



Source: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/program-data/cap-and-trade-program-data-dashboard

How have California carbon prices impacted California's retail energy prices?

If energy prices do not reflect the full social cost of energy production and consumption (including the climate change related damages), households and firms will not account for these costs in their consumption and investment choices. One important purpose of carbon pricing is to signal the climate-related damages in the price of fuels, goods, and services that are bought and sold throughout the economy so that consumers can account for these costs.

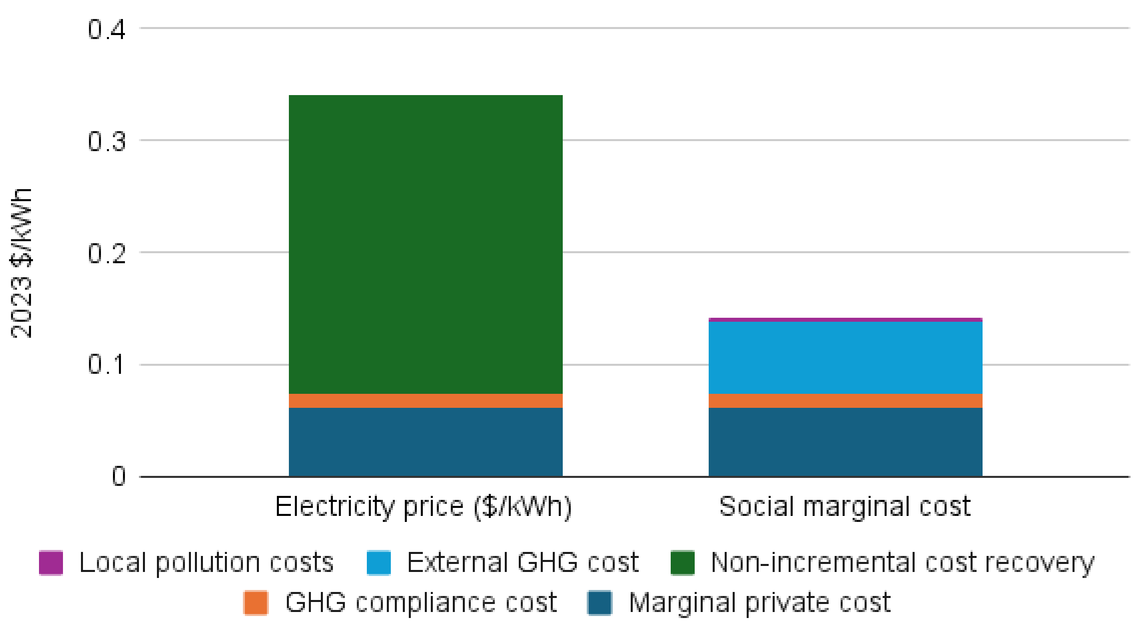
In theory, increasing consumer energy prices to better reflect the associated environmental damages will support more efficient consumption decisions, investments, and market outcomes. However, carbon pricing can lead to *less* efficient outcomes if retail energy prices are already set higher than the social marginal cost of energy consumption. This can happen, for example, if energy consumption is subject to other forms of taxation. It is, therefore, important to understand how carbon pricing will impact consumer energy prices, and how these retail energy prices compare against efficient energy price benchmarks.

In what follows, we use 2023 data on retail energy prices and the private marginal costs of energy consumption to assess the impacts of California's GHG allowance prices on retail residential energy prices. We then compare 2023 retail energy prices against estimates of the corresponding "social marginal cost" (SMC) of fuel consumption which serve as an efficient price benchmark. This SMC benchmark includes not only the private costs of producing an additional unit of energy (e.g. fuel costs, distribution costs, losses), but also "external" marginal costs that are not reflected in supplier costs (i.e. pollution damages). Comparing the energy prices consumers are paying for energy versus the social marginal cost helps put the California carbon price into perspective. A detailed discussion of methodology and assumptions is included in the Appendix.

Carbon pricing impacts on retail electricity prices

We begin with an illustrative analysis of 2023 residential retail electricity prices, focusing on California's largest utility (PG&E). The bar to the left in the figure below decomposes the average retail electricity price paid by PG&E residential customers in 2023 into three estimated cost components:

Figure 3: 2023 Retail electricity price versus social marginal cost ($/kWh)



Marginal private (utility) costs: Utility marginal costs capture all of the variable costs incurred by the utility when electricity demand increases incrementally or "marginally". We estimate these marginal private costs using average hourly wholesale electricity prices in 2023. We adjust for distribution line losses using the same approach as Borenstein and Bushnell (2022). The navy blue bar in the figure above corresponds to the average marginal cost across all hours in 2023.

GHG cap and trade compliance costs (orange bar) are estimated on a per kWh basis. Electricity generators in California must hold allowances to offset GHG emissions. This compliance obligation increases wholesale electricity prices when the marginal (i.e. price-setting) supplier is a fossil-fueled generator. To estimate the impact of these compliance costs on wholesale electricity prices in 2023, we multiply the average hourly marginal GHG intensity of electricity supply in 2023, adjusting for line losses, by the average California allowance price in 2023 ($33/ton CO2e). Using this approach, we estimate that complying with the GHG cap-and-trade program increased residential electricity prices by 1.3 cents per kWh (less than 5 percent of the retail rate)

Non-incremental costs (green bar) incurred in the power sector are primarily recovered via retail electricity prices. These include fixed capital investment costs in power system infrastructure, wildfire risk mitigation costs, clean technology incentives, etc. What distinguishes these utility costs from "marginal" costs is that they do not vary with marginal changes in electricity consumption. To estimate this cost component, we subtract marginal private costs (including compliance costs) from the average retail price. This fixed cost recovery component amounts to an estimated 78 percent of the retail rate.

Social marginal cost: Some of the costs caused by electricity generation are incurred by society but not borne by electricity suppliers or consumers. One important example: the climate costs associated with GHG emissions that are not reflected in the California GHG allowance price. To monetize these "external" climate damages, we use EPA's central estimate of the global climate costs per ton of CO2e emissions, $190 per metric ton. Because this significantly exceeds the 2023 California GHG allowance price, we estimate that a large share of climate damages are "external" to private cost calculations. In addition, fossil-fueled electricity generators contribute to local air quality problems that are not reflected in supplier costs. The externality costs associated with local air pollution from electricity generation depend not only on the marginal emissions intensity of electricity generation, but also on the air transport of emissions, downwind population densities, and health impacts. Incorporating both the assessed climate costs and local air pollution impacts, we estimate a 2023 social marginal cost of 14 cents/kWh.

Comparing the retail electricity price (left) against our estimated social marginal cost (right) in the graphic above implies that PG&E consumers are paying too much for their electricity (because electricity rates are used to recover revenues to cover non-incremental costs). This has broad efficiency implications for California's general climate policy portfolio which hinges on expanding electrification of transportation, buildings, and industry. Inefficiently high retail electricity prices slows progress on electrification. Because retail electricity rates already reflect a sizable effective charge for costs that are not associated with the incremental use of energy, *the carbon price might be understood to push electricity prices in the wrong direction*.

This retail electricity pricing regime also poses affordability challenges for lower income households who spend a relatively large share of income on utility bills. Currently, a portion of carbon revenues associated with electricity sector compliance with cap and trade are rebated to electricity consumers on an equal per-customer-account basis, adjusted according to the utility service territory, reflecting variations in the emissions intensity (tons CO2/MWh) of electricity consumed and the household level of electricity consumption. This is known as the "climate credit" that appears biannually on residential electricity bills. Although it helps address distributional concerns, it does not address the problems associated with too-high volumetric electricity prices.

To improve the efficiency of electricity pricing, the Air Resources Board should consider an alternative climate rebate design. GHG allowance revenues could be used to reduce *volumetric* (retail) electricity prices as this would move retail electricity prices closer to the social marginal cost. Revenue recycling could also be restructured to address affordability concerns more directly. For example, per-household rebates could be eliminated and allowance revenues could instead be used to provide larger electricity price discounts for lower income households who are disproportionately impacted by higher electricity prices.

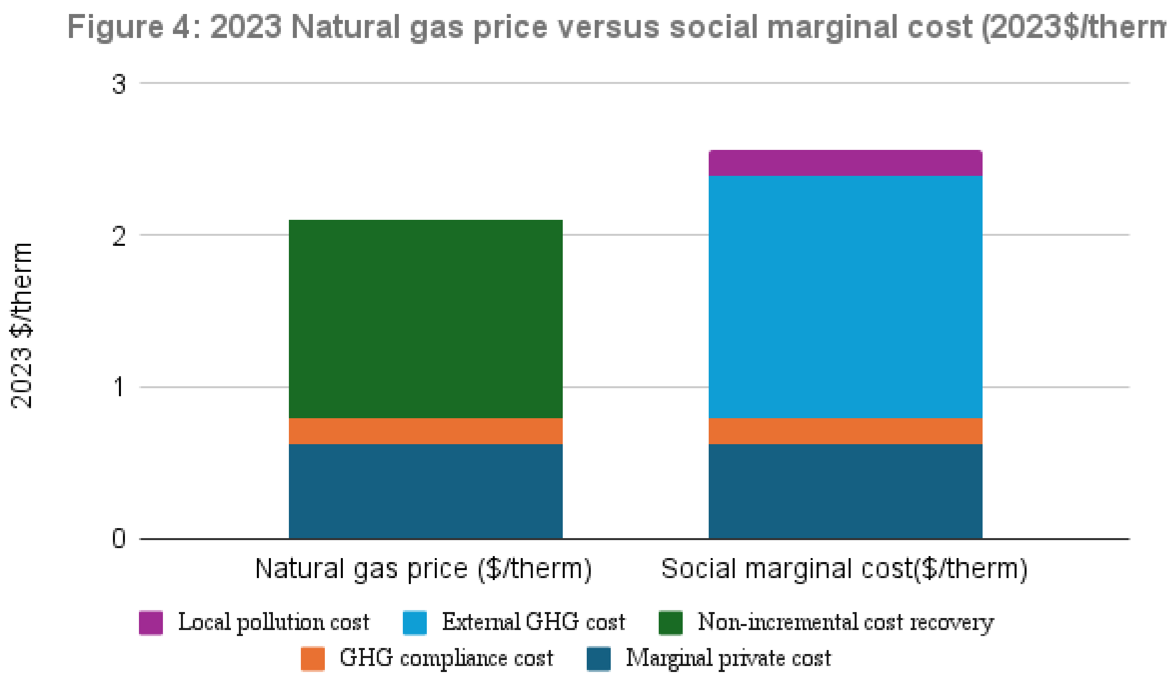
Carbon pricing impacts on retail natural gas prices

We conduct a similar analysis of California's retail natural gas prices, again focusing on 2023 PG&E rates and costs. These calculations are summarized in the graphic below.

Variable natural gas supply costs are calibrated based on 2023 citygate prices adjusted for loss (or LAUF) rates.

GHG cap and trade compliance costs: We estimate that California's carbon pricing raised retail natural gas prices in 2023 by approximately $0.18/therm, i.e. it contributed about 8% of the residential retail prices paid by households.

Non-incremental costs: Retail natural gas prices, like electricity prices, are set above the private marginal cost of supplying natural gas to recover non-incremental supply costs including the costs of building and maintaining the natural gas distribution system.



In contrast to electricity, retail natural gas rates in 2023 were significantly below the estimated social marginal cost of natural gas consumption. To calibrate our social marginal cost estimates for natural gas, we rely on standard measures of natural gas emissions intensity. We account for both combustion emissions, upstream methane leaks; we assume a 0.17% leakage rate for the distribution system. We again rely on EPA estimates of the social cost of GHGs ($190/ton CO2e) net of the allowance price to estimate unpriced climate costs. In principle, because our estimated social marginal cost exceeds the retail natural gas price, increasing the California carbon price would move natural gas prices closer to the true social cost of natural gas production and consumption.

Revenues from the sale of GHG allowances are rebated to households on an equal-per-customer account basis. Unlike electricity, this “lump-sum” approach is preferable because it preserves the high volumetric retail price signal while offering rebates to offset impacts on household finances. To better address affordability concerns, these consumer rebates could be targeted toward low-income households that spend a larger share of income on natural gas.

Carbon pricing impacts on retail gasoline prices

We follow a similar approach to decomposing retail gasoline prices in 2023, and contrasting these prices against an estimate of the social marginal costs associated with producing and consuming a gallon of gasoline in California.

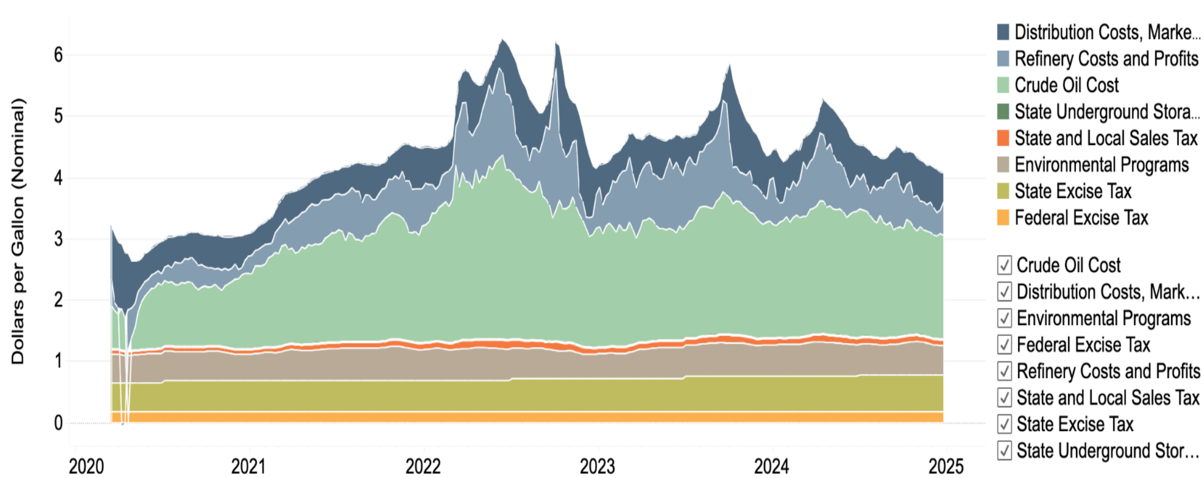
Variable gasoline supply costs: We assume full pass through of rack prices, credit card fees, and other variable costs incurred per gallon of gasoline sold in California.

GHG cap and trade compliance costs: Carbon market compliance costs reflect the costs that suppliers incur to hold GHG allowances to offset tailpipe emissions. We do not include any costs of holding GHG allowances to offset refinery GHG emissions; these should be close to zero on net due to output-based free allowance allocation. Gasoline suppliers must also comply with the low carbon fuel standard (LCFS), a companion policy which increases supplier costs in California. Estimates below reflect the costs of complying with the LCFS in 2023. Recent amendments to the LCFS will require a deeper reduction in the carbon intensity of transportation fuels by 2030.

We estimate that the California carbon price increased retail gasoline prices by approximately 26 cents (or 5%), in contrast with the $1.97/gallon in social cost associated with GHG emissions (including estimates of upstream emissions and valued at EPA social cost of carbon numbers).

To put these retail price impacts into perspective, the graphic below illustrates the impacts of environmental programs (namely the LCFS and the GHG cap-and-trade program) in addition to other cost components. The money that Californians spend on the "crude oil" component of gasoline prices is sent to global oil producers. Distribution and refinery costs and profits flow to California's refineries and fuel distributors. LCFS costs go to alternative fuel producers, many of whom are located outside California. But cap-and-trade costs are collected as carbon market revenues and can be put to work in service of our affordability objectives, while at the same time incentivizing Californians to find more socially cost-effective ways to meet their energy needs.

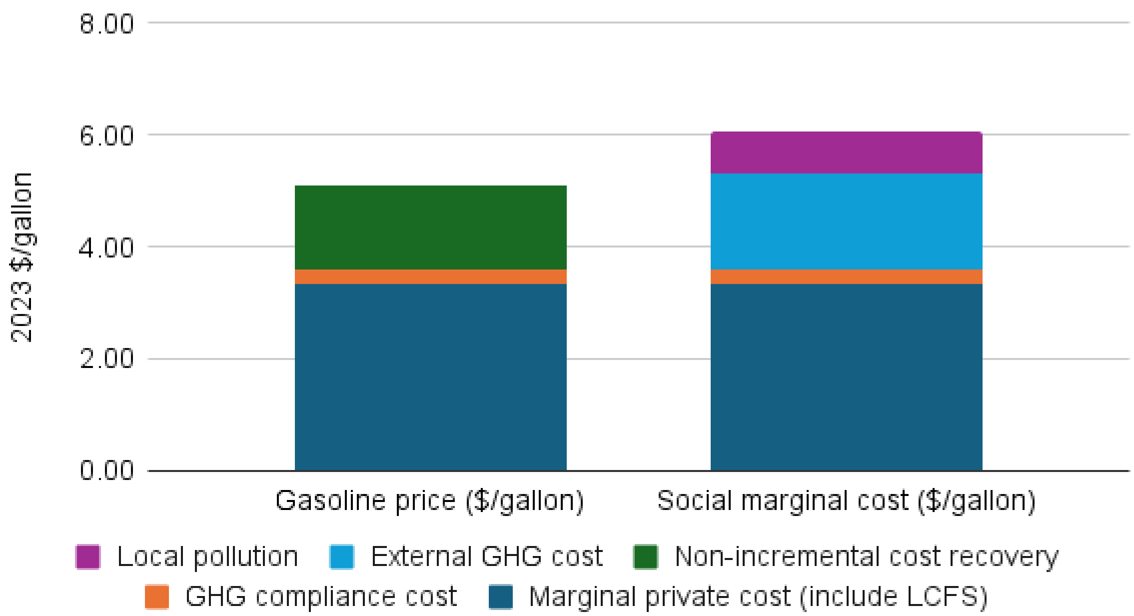
Figure 5: Estimated California Retail Gasoline Price Decomposition



Source: https://www.energy.ca.gov/estimated-gasoline-price-breakdown-and-margins

To further contextualize California's retail gasoline prices, the bar on the right in the graphic above summarizes our estimate of the social marginal cost of a gallon of gasoline. These calculations are based on the EPA social cost of GHG emissions (including upstream emissions) and local air pollution damage estimates per gallon.

Figure 6: 2023 Gasoline price versus social marginal cost (2023 $/gallon)



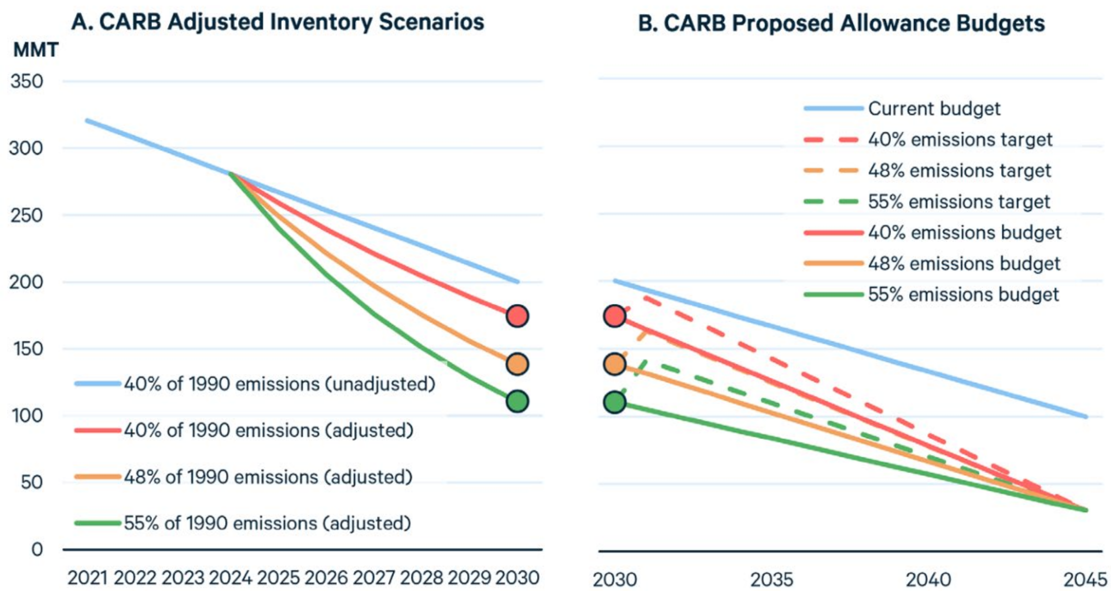
In contrast to natural gas (and electricity), carbon market compliance costs associated with retail gasoline are not rebated to consumers. There is no mechanism in place to rebate GHG allowance costs to households. However, GGRF revenues can be used to reduce the costs of less carbon intensive transportation alternatives (such as EVs and public transportation). We discuss some of these alternatives in Chapter X).

Forecasting future GHG allowance prices

The current cap-and-trade program budgets include more GHG allowances through 2030 than regulated entities are expected to need. The blue line in the figure below tracks the current allowance allocation schedule which does not put California on track to meet its 2030 or 2045 GHG reduction goals. This has prompted some important discussions around reducing the supply of GHG allowances in the market.

The Air Resources Board has convened a series of workshops to develop a potential update to the program regulation to reduce the cumulative supply of allowances and align it with the state's emissions reduction goals considering a variety of strategies illustrated in the figure. The percentage levels describe the budget for 2030 and the alternative pathways describe allowance budgets after 2030. Subsequently in the workshop series, CARB has analyzed several alternative ways to attain the 48% emissions target allowance supply budget. A 48% reduction would align the program with the needed ambition identified in the 2022 Scoping Plan Update to be on track to achieve statutory 2045 targets. The emissions caps in 2030 are below the associated percentage reduction target to accommodate an inventory adjustment that is implemented concurrently. Looking forward, in 2025 the California Legislature is expected to pursue a reauthorization of the cap-and-trade program.

Figure 7: Proposed Allowance Supply Budgets (CARB)



Source: CARB Cap and Trade Workshop October 5, 2023

To inform these important conversations and deliberations, economists and analysts have been exploring the likely implications of market reforms for market clearing GHG prices.

- Bushnell et al. (2023) use a statistical model to project a range of business-as-usual California emissions and emissions abatement under uncertainty about economic activity and abatement.
- In April 2024, CARB released a Standardized Regulatory Impact Assessment (SRIA) for the anticipated 2024 amendments to the carbon market, singling out the 48 percent target scenario (2030 GHG emissions reach 48% of 1990 levels).
- In May 2024, RFF released a report (Roy et al. 2004) summarizing Haiku modeling of GHG prices and distributional impacts under CARB's various considered approaches to achieving the 48 percent target scenarios.

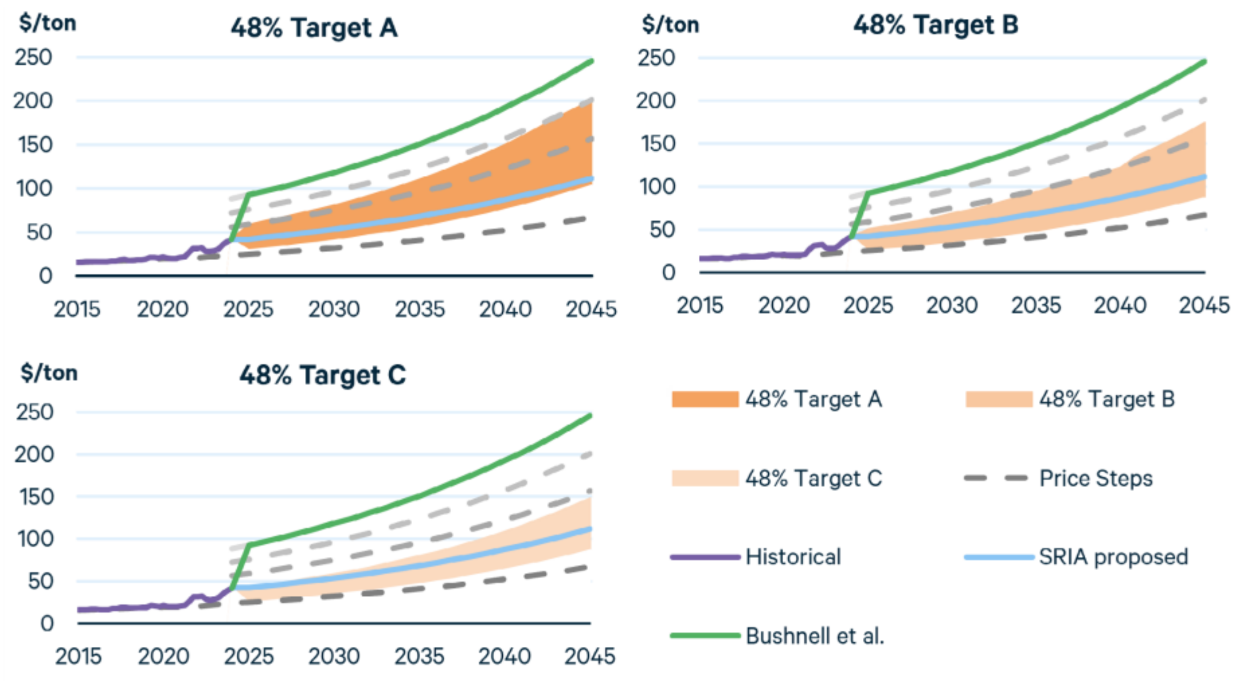
These model projections are illustrated in Figure 8 for the three approaches to achieve the 48% target considered by CARB during its recent workshop series. Scenario A would remove allowances from cumulative supply by reducing the annual budget of new allowances. Scenario B would remove half from the annual budget and half from the Allowance Price Containment Reserves, which otherwise would make these allowances available if the allowance price reaches specified levels. Scenario C removes all available allowances from the price containment reserves and only the necessary residual from the annual budget. The figure includes price steps as dashed lines illustrating the price floor, the two Allowance Price Containment Reserves, and the price ceiling, where potentially an unlimited number of (non-transferable) additional compliance instruments could be available.

It is important to note that future energy costs, energy use, and energy-related emissions trajectories are highly uncertain due to uncertainty about future technology costs, regulatory outcomes, global economic conditions, etc. Different modeling approaches and underlying assumptions lead to different price projections. The Bushnell et al. results embody uncertainty as probability distributions over these factors. The central (median) draw from a probability distribution of projected allowance prices is illustrated in the figure by the solid green line which quickly reaches the allowance price ceiling in Scenario A. The same outcome is illustrated for Scenario B although it is not explicit in the Bushnell et al. results. They also modeled a scenario similar to Scenario C that had prices just below the price ceiling. The Bushnell et al. results do not account for the impacts of the Inflation Reduction Act, nor many of the assumptions built into the 2022 Scoping Plan regarding the deployment of nascent technology, which might lower allowance prices in the future.

The SRIA projections shown as the blue solid lines reflect future allowance demand as described in the 2022 Scoping Plan, with minor adjustments. As illustrated in the figure, the SRIA assumes that the average allowance prices will fall halfway between the price floor and the first Allowance Price Containment Reserve. The SRIA did not distinguish among the different approaches to reducing allowance supply in Scenarios A, B, and C. It should be noted the SRIA is a conceptual analysis, not reflective of a specific policy proposal by CARB.

RFF’s analysis presents two levels of initial allowance demand—one if all emissions reductions in the Scoping Plan occur leading to a lower price path, and another assuming that emissions reductions in the buildings and industrial sector are delayed and light-duty vehicles reduce vehicle miles travelled less than expected leading to a higher price path. These two levels of allowance demand bookend a range of price paths illustrated by the brown bands of prices. The Haiku results include investments from the Inflation Reduction Act.

Figure 8: Allowance Price Ranges Across SRIA Scenarios (2023$)



Source: Roy et al.2024.

As noted above, given the multiple sources of significant uncertainty in these modeling exercises, allowance price projections vary across studies and scenarios. Directionally, and intuitively, all studies project increases in allowance prices if allowance supply is reduced and/or the program is re-authorized.

How would projected carbon prices impact energy prices?

A detailed analysis of how projected GHG allowance prices would impact consumer energy prices in California is beyond the scope of this report. We can, however, multiply allowance price projections by fuel-specific GHG intensities to coarsely assess how higher permit prices impact supplier costs (and thus consumer prices under full pass through assumptions).

The impact of higher allowance prices on electricity rates is not only a function of the allowance price, but will also be determined by the share of fossil fuel generation in the electric generation mix. As the carbon intensity of grid electricity decreases, the impact of rising allowance prices on electricity bills will be mitigated. We therefore report two sets of electricity rate calculations: one assuming the current GHG intensity of marginal electricity generation and one that assumes a 50 percent reduction in GHG intensity.

Table 1: Calibrated Retail Energy Price Impacts of California Carbon Pricing (2023$)

	2023 Marginal Private Cost of Energy	2023 Marginal Social Cost	2023 Retail Prices	Cost Impact at 2023 GHG Price ($33/ton)	Cost Impact at SRIA GHG Price Projection ($53.72/ton)	Cost Impact at 2030 GHG Ceiling Price ($118.26/ton)
Electricity ($/kWh) Current grid	$0.07	$0.14	$0.34	$0.02	$0.03	$0.05
Electricity ($/kWh) 2040 grid (assume 50% reduction in GHG intensity)	$0.07	$0.11	$0.33	$0.01	$0.01	$0.02
Natural gas ($/therm)	$0.80	$2.56	$2.10	$0.18	$0.29	$0.63
Gasoline ($/gallon)	$3.86	$6.34	$5.08	$0.26	$0.42	$0.93

Table 1 shows the impact of higher allowance prices compared to the 2023 average carbon price ($33/ton CO2e) on fuel supplier costs and retail energy prices. These are very simple calculations that ignore any supplier and consumer responses to higher energy prices. Our aim with these “all else equal” calculations is to put the compliance cost impacts of higher GHG allowance prices into some context. Impacts on electricity costs are small, especially when we account for the declining GHG intensity of California’s electricity supply system. Impacts of higher carbon prices on natural gas and gasoline supply costs are more substantial.

This table focuses on retail energy prices. But the impacts of higher retail energy prices on future household expenditures will depend on the extent to which Californians continue to rely on gasoline and natural gas for their transportation and building energy needs. If electricity use constitutes a growing share of household energy consumption relative to other fuels, while the carbon intensity of electricity generation falls, the impacts of rising allowance prices on household energy bills will be mitigated. For this future to be realized, however, GHG allowance prices and retail electricity prices need to be structured in a way that more accurately reflects the true cost of electricity, natural gas, and gasoline consumption.

Conclusion

California carbon prices are projected to increase if the cap-and-trade program is re-authorized. The extent of this price increase is uncertain. Projected allowance price paths vary depending on what is assumed about the pace of technological change, the stringency of the GHG cap, the availability of low cost GHG abatement opportunities, macroeconomic factors, the performance of overlapping prescriptive climate policies, among other factors. GHG allowance prices in California have been lower than many observers anticipated fifteen years ago when the program was being designed. Going forward, California has numerous regulatory tools to influence the price path inside and outside the carbon market, including the development of companion regulations to accelerate technical change in specific sectors.

Even at moderate price levels, California's GHG cap-and-trade program will impact retail energy prices. Targeted climate credits can ease the burden on household budgets in the short run. In the longer run, elements of program design such as strategic investments from the GGRF can accelerate the electrification of transportation and buildings. This transition, together with efforts to decarbonize California's electricity grid, will mitigate the impacts of higher GHG prices on household energy costs.

We offer the following observations and recommendations to CARB and the legislature.

1. **Over time, a reduced reliance on fossil fuels will benefit household finances and public health.** The GHG cap-and-trade program has a critical role to play in providing incentives to reduce fossil fuel consumption, delivering cost-effective GHG reductions across the economy.

2. **Carbon prices have played a small role in driving retail electricity price increases because the California electricity grid is not very carbon intensive (and getting cleaner by the year).** We estimate that carbon prices increased retail electricity prices by less than 5% in 2023. Climate change adaptation costs, such as wildfire risk mitigation, are causing more significant increases. Importantly, the utility bill impacts of carbon pricing have been largely offset by the climate credit.

3. **Restructuring the climate credit to reduce volumetric electricity rates would make electrification a more affordable choice for investments by households and businesses.** This design would improve the efficiency of regulatory pricing in general by bringing electricity prices closer to their full social marginal cost. The state should also consider making this credit more salient to households, and targeting the credit towards lower income groups to improve economic outcomes for the most vulnerable households. See, for example, Smith et al. 2024.

4. **Carbon pricing has increased natural gas prices by an estimated 8%.** This increase notwithstanding, retail natural gas prices in California are still below estimates of social marginal cost. Thus, climate credits that transfer revenues to households in lump sum serve to mitigate financial impacts while preserving the incentive to move away from relatively carbon intensive natural gas.

5. **The climate credit for natural gas customers could be made more salient and more targeted towards low income households.**

6. **A higher carbon price would increase retail gasoline prices in California, more accurately signaling the assessed social cost of gasoline consumption.** Transportation represents the largest source of GHG emissions in the state. Transmitting the climate costs of gasoline consumption will support more sustainable transportation choices, and retail gasoline prices in California are below the estimated marginal social cost of gasoline consumption.

7. **Auction revenues could be used to help households transition away from gasoline consumption.** A growing share of GHG allowance revenues come from the transportation sector; some of these revenues could be used to ease the burden of transportation-related costs, while at the same time accelerating the transition away from fossil fuels.

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