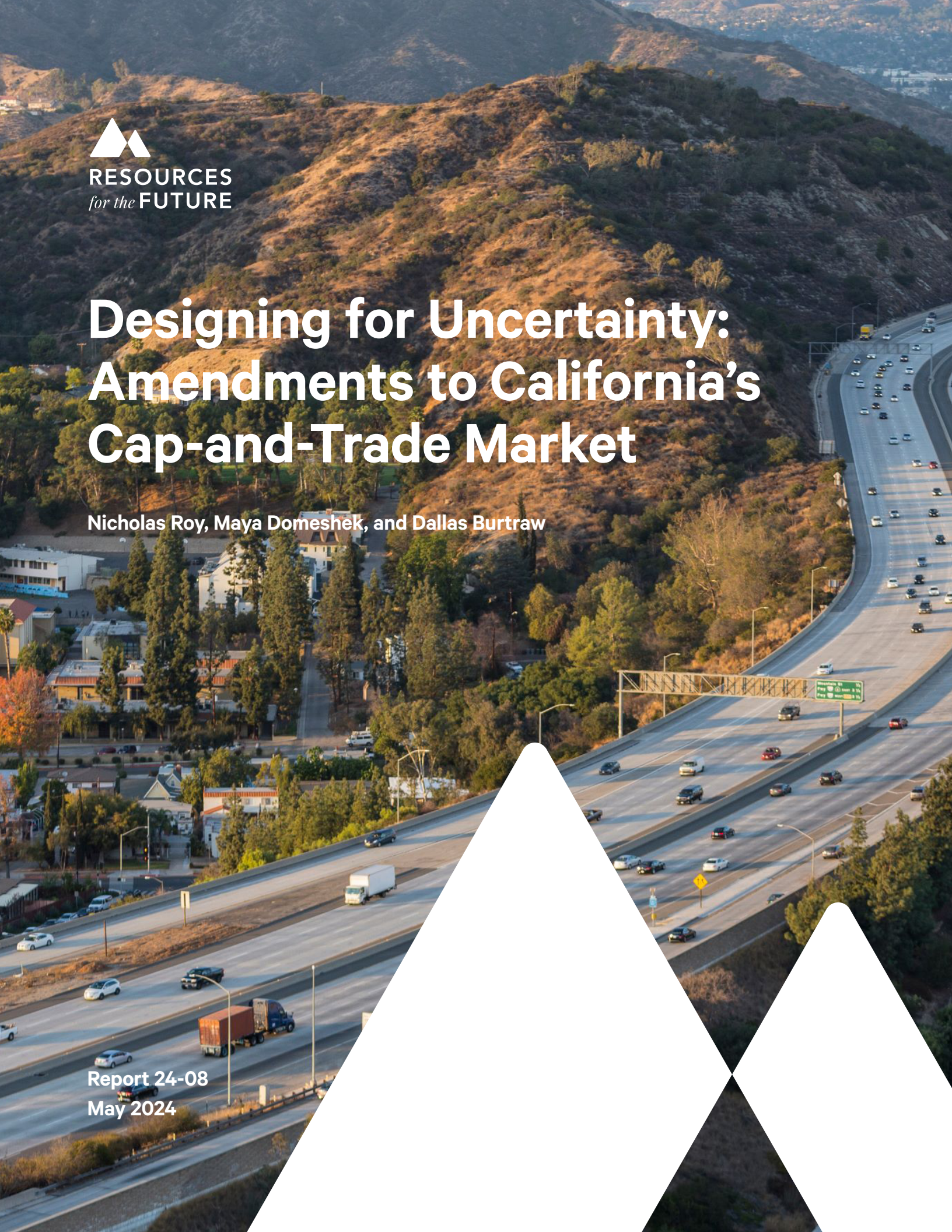

RESOURCES *for the* FUTURE

Designing for Uncertainty: Amendments to California's Cap-and-Trade Market

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About the Project

This research was supported by Resources for the Future's (RFF) Electric Power Program. Dalllas Burtraw serves on the California Independent Market Advisory Committee. This work is solely the work of RFF.

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Sharing Our Work

Executive Summary

California is looking to extend its greenhouse gas cap-and-trade program forward in time and to make adjustments to the trajectory of the annual emissions cap. This report looks at the possible reforms suggested by the California Air Resources Board (CARB) using RFF's Haiku Emissions Market Model. We analyze the allowance price, emissions, revenue, and banking impacts of cap reduction options proposed by CARB given uncertainty about technology, the effectiveness of regulatory programs, investment strategies, economic activity, and banking behavior. We consider the three methods of implementing the "48 percent target cap" adjustment proposed in the Standard Regulatory Impact Assessment (SRIA) that intend to reduce cumulative allowance supply by 265 million tons by 2030:[1]

- Option A, nominal cap reduction;
- Option B, partial nominal cap reduction and partial allowance price containment reserve (APCR) reduction; and
- Option C, APCR reduction.

The nominal cap describes the introduction of new emissions allowances in a given year. The emissions outcome will differ from the cap because of the availability of banked allowances and offsets.

Additionally, we examine the full set of options included in CARB's October 5, 2023, workshop (the 40, 48, and 55 percent "budget" and "target" cap reductions) that would achieve cumulative reductions in allowance supply ranging from 115 - 390 million tons by 2030. We also consider the impact of additional potential program design features, including an emissions containment reserve (ECR); facility-specific caps, as suggested by the California Cap-and-Trade Environmental Justice Advisory Committee (EJAC); and modifications to free allocation.

Key Findings focusing on the Options A, B, and C for the 48 percent target scenario as identified in the SRIA:

- Future emissions and allowance price pathways vary across scenarios. In sensitivity analysis investigating uncertain technology and energy demand, we find greater variation in allowance demand, emissions, and prices.
- Removing allowances from the nominal emissions cap will lead to a higher allowance price. However, removing APCR allowances increases price variability.
- Although Options A, B, and C appear to have the same cumulative allowance supply, the tighter nominal cap (A) yields lower emissions than B and C, especially if, as CARB's SRIA assumes and this report reaffirms, APCRs are never triggered.

1 The SRIA reports 264 million tons. CARB's workshop and our modeling assumes 265 million tons.

- Tightening the cap in any of the ways CARB proposes will increase allowance value above baseline even as allowances decrease, but the choice of where to remove allowances (from auctioned supply or freely allocated allowances, or from the APCR) will have distributional impacts by changing the share of allowance value accruing to the Greenhouse Gas Reduction Fund (GGRF) relative to that accruing to recipients of free allocation.
- Assuming the program continues beyond 2030, tightening cumulative allowance supply leads to roughly 40 percent reduction in the size of the bank by 2030, after which the bank continues to be drawn down slowly through 2045. Increased cap stringency will raise the value of banked allowances.
- Adding an ECR would support allowance prices and revenue in low-demand scenarios and reduce uncertainty about prices, revenues, and emissions.
- Adding facility-specific caps would have very little impact on the market (less than a 2.8 percent increase in allowance prices) but could reduce uncertainty around health outcomes for disadvantaged communities.

Looking beyond the 48 percent target scenario options, we consider 40, 48, and 55 percent budget and target cap reductions. We find the qualitative impact of tighter caps on prices, missions, revenue, and banking remains consistent. However, the range of outcomes varies widely, with prices at the floor in the less stringent cases and rising to the price ceiling in the more stringent cases. An ECR, or facility-specific caps, can be added to any of these cap adjustments with the same effects as for the 48 percent target A, B, and C options.

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1. Introduction

This report examines market and distributional outcomes that could result under various approaches to reforming the California greenhouse gas (GHG) cap-and-trade market. These reforms are motivated in part by the California Air Resources Board (CARB) 2022 update to its Scoping Plan (SP) (CARB 2022) that identified technology choices that could achieve the state's GHG reduction goals, reflecting increased ambition identified by AB 1279 (Muratsuchi 2022), which established an 85 percent reduction goal from 1990 levels by 2045, and reinforced in the state's Climate Commitment plan. In 2023, CARB began a series of informal workshops to examine reforms to the market to enable it to achieve those goals.

The cap-and-trade program is an important element of the state's regulatory landscape, accompanying other policies, including performance standards and other regulations. The performance standards, including for vehicles, energy efficiency, the renewable energy, and the low carbon fuel standard, affect emissions outcomes primarily by reducing the emissions intensity, not the levels, of activity in specific sectors. Other regulations include those for building and land use planning and those intended to improve air quality outcomes, which together point the state in the direction of environmental improvements.

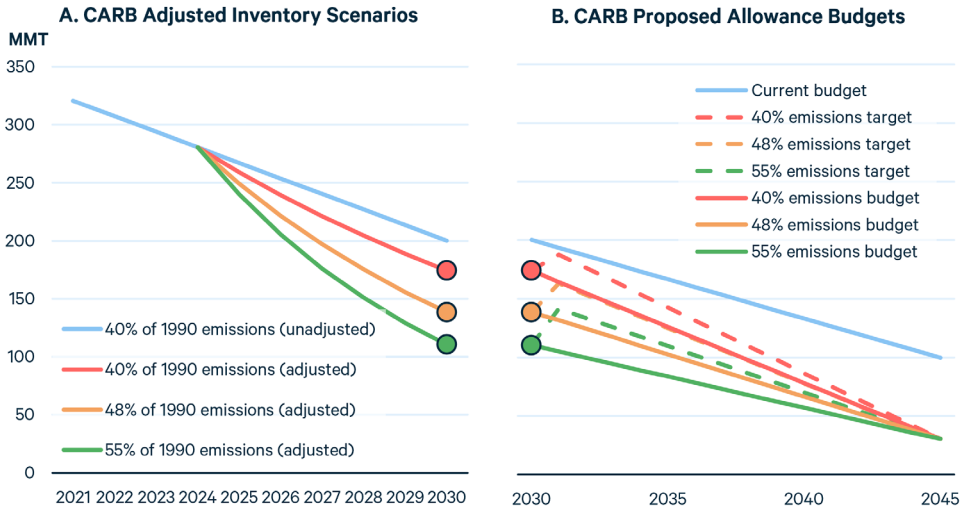
Most of the state's reductions in GHG emissions have been driven not by cap and trade but by the regulatory measures that accompany it (Cullenward et al. 2017). Nonetheless, the cap-and-trade program offers important contributions. The emissions impacts of most regulations are uncertain, making it difficult to design policy to meet codified targets; the emissions cap provides assurance. The carbon price and emissions bank that result from the cap respond to changes in economic activity, energy demand, and technology evolution. The emissions cap covers about three-quarters of the state's total GHG emissions and so boosts confidence that the state's economywide climate goals will be realized.

The carbon price also improves the cost-effectiveness of emission reduction efforts. Historically, the carbon price has been moderate, yet it provides an incentive to realize low-cost opportunities that might not be realized by direct regulations. The emissions cap contributes to the credibility of the state's overall commitment to decarbonization, providing incentives for the private sector that align with the forcing influence of regulations.

Finally, the carbon price provides an important source of funding for the state's climate priorities. The Greenhouse Gas Reduction Fund (GGRF) has received $27.9 billion raised by in the allowance auction. The state has been able to spend this money on affordable housing units, transit agency projects, and zero-emission vehicle rebates, among other programs (CCI 2024). SB 535 and AB 1550 require allocating 35 percent of GGRF revenues toward disadvantaged communities, assisting the state in its goals of equity and environmental justice (De León 2012; Gomez 2016). California Climate Investments has found that 76 percent of investments are benefiting priority populations.

In previous workshops, CARB identified the goal of reducing cumulative allowance supply to correct historical overallocation and meet more stringent future annual targets (CARB 2023a). It has proposed fixing the overallocation by reducing cumulative allowance issuance by 115 tons before 2030, referred to as an "inventory adjustment." CARB proposed reducing allowance issuance further to align with statutory goals (SB32: 40 percent below 1990 levels by 2030; AB 1279: 85 percent below 1990 levels by 2045) or administrative goals (Scoping Plan 2022: 48 percent below 1990 levels). In the fall, CARB identified six different cap adjustments to meet these aims: the 40, 48, and 55 percent "budget" and "target" scenarios, that would reduce cumulative allowance supply by 115-390 million tons by 2030. The adjustments follow three pathways before 2030 (40, 48, and 55 percent reductions) (Figure 1) (CARB 2023b).[1] After 2030, the pathways diverge with the "budget" pathways decreasing directly to the 2045 goal and the "target" pathways returning to the emissions target after the end of the inventory adjustment period and then decreasing to the 2045 goal (Figure 1). The bump up in allowance issuance in the "target" scenarios yields greater cumulative supply, leading to higher emissions and lower prices than the equivalent budget scenarios. Regardless of the cap adjustment, allowance supply will not equal emissions outcomes due to the availability of banked allowances[2] and offsets as compliance instruments.

Figure 1. Proposed Allowance Supply Budgets in CARB



Source: CARB Cap and Trade Workshop October 5, 2023

1 A 48 percent 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 the inventory adjustment that is implemented concurrently.

2 Allowances not used for compliance retain value as compliance instruments in the future.

RFF submitted comments to CARB in December 2023 summarizing preliminary modeling to address allowance prices, annual emissions outcomes, banking behavior, and the interaction with potential changes in cost containment mechanisms, including the allowance price containment reserve and a suggested emissions containment reserve (ECR) (Roy et al. 2023). We found that prices remain close to the price floor if levels of demand for emissions allowances anticipated in the 2022 Scoping Plan update are realized, and they rise to trigger the allowance price containment reserve (APCR) under our representation of a delay in achieving the 2022 Scoping Plan outcomes. Cumulative emissions reductions are 1,257–1,825 million metric tons (MMT) by 2045 relative to business-as-usual emissions with the current allowance budget.[3] Anticipating the issues we explore in detail in this report, we find that how allowance supply is reduced matters for both cumulative emissions and allowance prices. In low-price scenarios, removing allowances from the APCR would appear not to reduce emissions, and introducing ECR could rectify this. Prices would likely be higher and emissions outcomes lower if allowances were removed from the annual nominal emissions caps. The distribution of allowance value between GGRF and recipients of free allocation varies greatly. Furthermore, we see the financial value of the existing bank growing substantially and potentially gaining $9 billion under scenarios that lead to increased allowance prices.[4]

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 (CARB 2024). SRIA mainly focused on options for a cumulative reduction of 265 million allowances to implement the inventory adjustment and align with the 2030 target.[5] One approach (Option A) would be to reduce the cap by reducing the number of new allowances issued through free allocation and the auction. Another (Option B) would be to reduce the APCR by 50 percent to meet part of the reduction and to meet the remainder of the reduction by reducing the cap. The APCR contains allowances that are made available at relatively high market prices. The third approach (Option C) would remove all allowances in the APCR and meet the residual need with a small reduction in the cap.[6] Another major topic in the SRIA is the potential change to the free allocation to investor-owned and public utilities.

3 Those comments focused on reductions from the business-as-usual emissions case from the scoping plan with the current budget; this report compares reductions from that budget with the same initial emissions demand.

4 The current allowance bank of roughly 330 million tons valued at roughly $40 per ton has a value of approximately $13.2 billion.

5 The SRIA reports 264 million tons. CARB's workshop and our modeling assumes 265 million tons.

6 The SRIA was followed by an informal workshop on April 23, 2024 that explained potential changes in market rules that would become relevant if one of the SRIA approaches were finalized.

The SRIA does not entertain other potential structural adjustments, such as changing the auction price floor that specifies the minimum price at which allowances will be sold into the market. It also does not consider the introduction of an ECR, which would condition the availability of a portion of the allowance supply on an auction price trigger that is above the price floor and below the APCR. Both mechanisms reduce allowance supply if allowance prices are low in a symmetric way to the APCR, which expands supply if prices are high. The SRIA discusses and rejects the introduction of no-trade zones (restricting allowance trading for nearby facilities) in disadvantaged communities to prioritize emissions reductions in these communities, and it does not discuss other approaches, such as facility-specific emissions caps.

This report approaches these issues by exploring in detail the emissions and allowance price pathways and distributional outcomes associated with the three potential approaches to implementing the SRIA 48 percent target scenario. We provide context by comparing these scenarios with the full range of possible emissions and allowance price pathways that result from the supply adjustments initially considered by CARB, which remain viable options for the regulatory proposal CARB is expected to present later this year. We also examine some topics that the SRIA did not embrace including an ECR to reduce cumulative emissions when prices are low, and facility-specific caps to address environmental justice concerns.

We find that future energy use and emissions and thus allowance demand are uncertain, stemming from uncertain future technology, regulatory outcomes, and economic activity that is apparent in CARB's analysis and represented explicitly in our model. The allowance market can dynamically respond to these uncertain outcomes through adjustments in the allowance price. The market also exhibits dynamic allowance supply that is enabled by the price floor, APCR, and potentially an ECR, that moderate sudden changes in the allowance price and together provide greater confidence about the emissions pathway and achievement of California's interim and 2045 emissions goals.

An important feature of the modeling is the difference between anticipated prices and currently observed prices (and implied price paths for the future). This difference is partially due to optimistic assumptions in the CARB modeling about energy demand and technology described in the 2022 Scoping Plan update. We explore these assumptions by considering potentially higher emissions outcomes that would result from a delay in realizing Scoping Plan projections. Cost management features, such as the price floor, APCR and potentially an ECR, contribute to price and revenue stability under variation in levels of demand. In addition, we find that introducing an ECR would increase revenue accruing to the GGRF.

If CARB chooses to reduce allowance supply by removing allowances from the APCR, that could result in prices close to the price floor, but overall greater price volatility. We find that the option of tightening the nominal cap yields lower emissions than removing allowances from the APCR.

We also find that the financial value of allowances will increase under all the approaches considered in the SRIA. Reducing the nominal emissions cap yields the greatest increase in market value, compared to removing allowances from the APCR. How a reduction in the nominal emission cap is achieved—specifically the reduction in auctioned versus freely allocated supply—has important effects on revenues to the GGRF. The increased market value will also increase the value of banked allowances.

An ECR withholds allowances from the market until a predetermined price is reached. We find that introducing an ECR can increase allowance prices and revenues when allowance demand is low, thereby decreasing uncertainty about those outcomes. Adding an ECR also increases program stringency when demand is low, so it can decrease cumulative emissions.

The Environmental Justice Advisory Committee (EJAC) request for guaranteed emissions reductions in disadvantaged communities could be met using facility-specific caps rather than the no-trade zones discussed in the SRIA. Such a program would require facilities in disadvantaged communities to reduce their emissions at the rate of the overall cap. If the facilities reduced emissions faster than the cap, they would be permitted to sell the extra allowances to facilities outside of disadvantaged communities, but the overall cap would be reduced by a small amount to take this possibility into account. Our modeling shows that reducing the cap by that small additional amount would have very little impact on allowance prices, so facility-specific caps could be added to the program reforms CARB is considering without being disruptive to the program as a whole.

Modeling the other cap adjustment options (40, 48, and 55 "target" and "budget" scenarios) shows that they largely follow the patterns described across the 48 percent A, B, and C scenarios: tighter caps yield lower emissions and higher prices and revenues. Adding an ECR to these other budgets would reduce uncertainty about future prices and revenue. Adding facility-specific caps would have small price impacts like those under the 48 percent target scenarios.

The next section of this report provides regulatory background, followed by an introduction to the methods and scenarios we examine. Section V reports allowance price pathways, emissions outcomes, and banking behavior under the SRIA scenarios presented. We also examine the potential roles of an ECR (Section VI) and facility-specific caps (Section VII), which were not embraced in the SRIA. Finally, in Section VIII, we revisit emissions scenarios beyond the 48 percent target scenario selected in the SRIA.

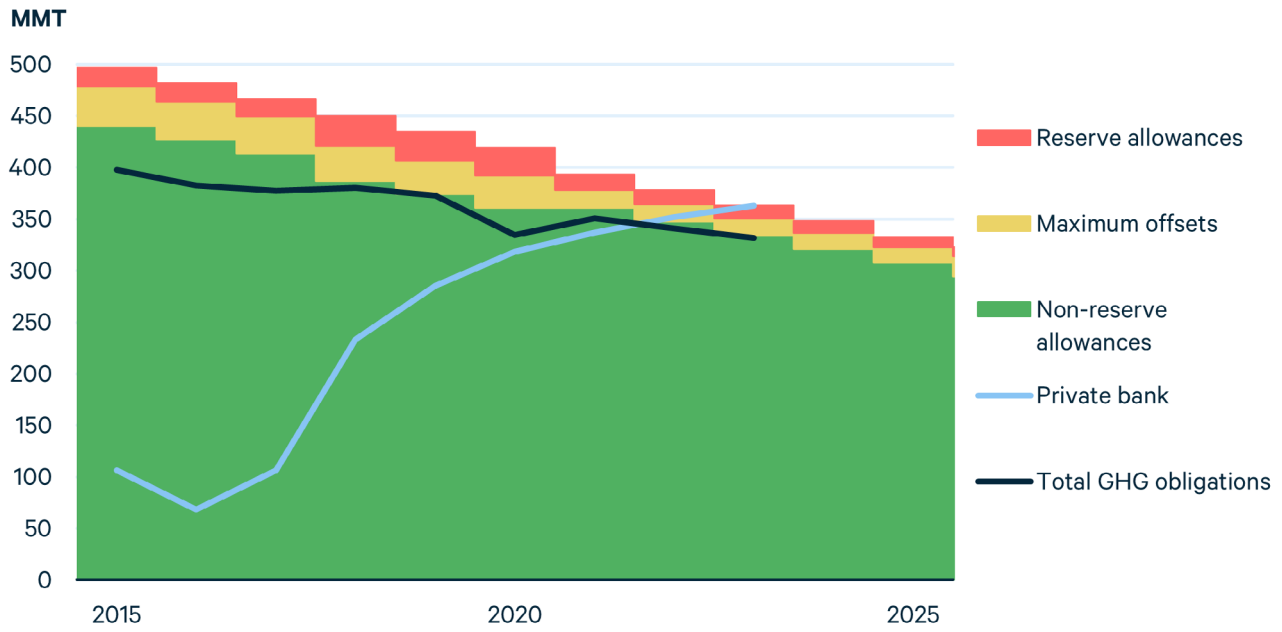
2. Regulatory Background

The California GHG emissions trading program, referred to as the "cap-and-trade program" throughout this report, began in 2013 initially covering stationary facilities from the power and industrial sectors that emitted more than 25,000 carbon dioxide equivalent (CO_2e) MMT each year. The sectoral scope of the program expanded in 2015 to include natural gas suppliers and transportation emissions by including oil refineries.

The cap-and-trade program works by limiting the number of emissions allowances issued by the government, with one allowance enabling the emission of one metric ton of CO_2e. Allowances are initially distributed in two ways. For emissions intensive trade exposed (EITE) industries, natural gas suppliers, and electric distribution utilities (EDUs), CARB allocates allowances at no cost at levels that are close to the levels of emissions expected from those sectors. The allocation to EITE industries is conditional on economic activity at each facility to provide a production incentive designed to prevent emissions leakage and lower the compliance cost. For the remaining compliance entities, allowances are purchased at a quarterly auction or in the secondary market.

After issuance, allowances can be used in any compliance period, enabling the buildup of an allowance bank that can be held by compliance entities or other investors. Banking of allowances implies that emissions reductions are "brought forward" from when they would occur without banking, enhancing the near-term investments and associated air quality improvements. Figure 2 illustrates supply of compliance instruments including allowances and offsets, the declining nominal cap, and buildup of the allowance bank.

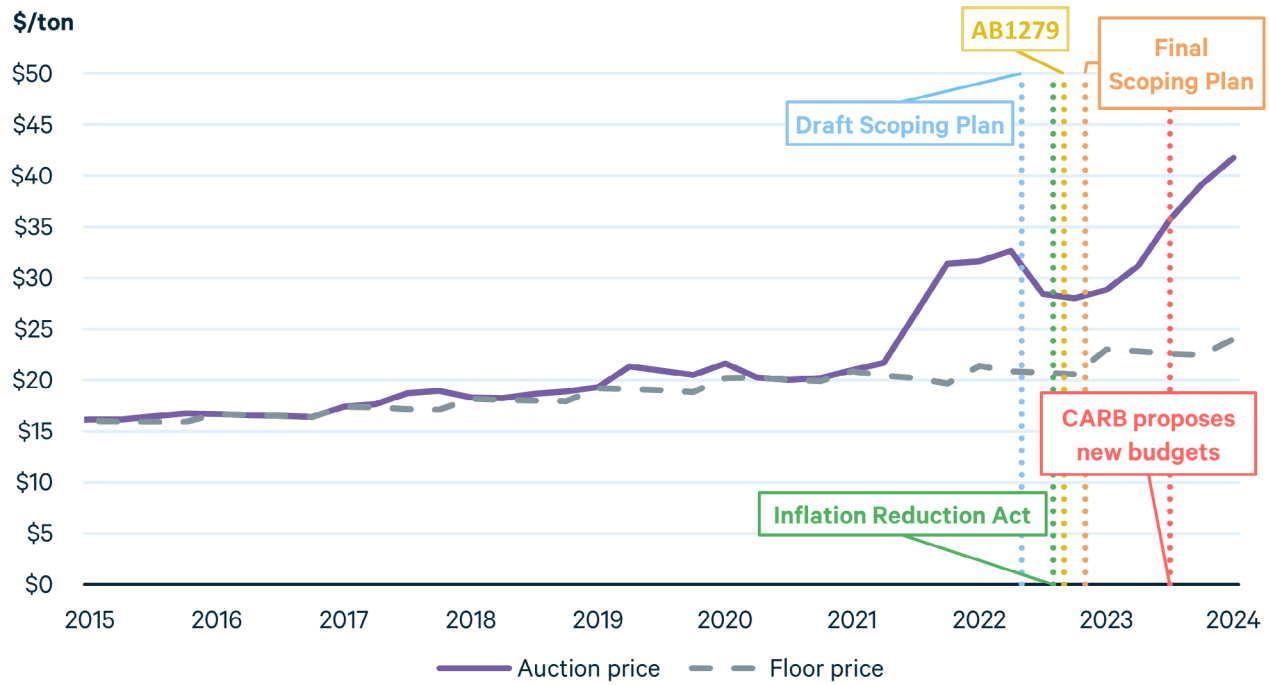
Figure 2. Compliance Instruments, Emissions, and the Bank Over Time in the California–Quebec Cap-and-Trade Market



Note: Data comes from CARB's compliance reporting and extends analysis in Cullenward et al. (2019) through 2023. The dip in Total GHG Obligations in 2020 reflects the influence of the pandemic. The bank has grown to its current size in part through the use of offsets as compliance instruments. Entities have been able to purchase some of each year's maximum allowable offsets and use them for compliance while saving allowances for later use. Figure 2 shows how the difference between the top of the black line (GHG obligations) and the top of the green and yellow area (available allowances and maximum offsets) cumulates over time to the blue bank.

CARB reaffirmed in the SRIA the intent to have a steadily increasing allowance price. Figure 3 shows the historical allowance price throughout the past decade. In 2021, the price began to rise precipitously, buoyed further in 2022 by AB1279 and other legislation, the governor's Climate Commitment plan, and release of the Scoping Plan update that identified scenarios for increasing program ambition. Other factors, including the federal Inflation Reduction Act and uncertainty about economic and technological costs, have been reflected in allowance price volatility during its aggregate rise (Figure 3).

Figure 3. Allowance Price Over the History of the Program



Note: Irregularity of the dashed line (price floor) reflects one-time annual increases in the price floor level adjusted within the year for inflation. All prices are displayed in 2024$.

3. Methodology

The Haiku Emissions Market Model is a multisector emissions market equilibrium model extending the Haiku Electricity Market Model, a capacity-expansion model of the national electricity system that has been used in more than two dozen peer-reviewed papers and reports for federal and state agencies to evaluate environmental regulations in the electricity sector, including emissions trading programs (Burtraw et al. 2023), tradable performance standards (Shobe et al. 2021), tax credits (Roy et al. 2022), carbon taxes (Palmer et al. 2012), Clean Air Act regulations (Domeshek and Burtraw 2021), and other policies. Most analyzed standing policies have a representation in the model used for this report. This report uses the extended emissions market model to address interactions among the electricity, transportation, building, and industry sectors in California.

The current version of Haiku represents the electricity sector as 49 nodes for the contiguous states and the District of Columbia with constrained interstate transmission capability. The model distinguishes between competitive and regulated power market regions with regional fuel and capital costs. The model is a linear program covering a 26-year time horizon, 2019–2045, with perfect foresight. It minimizes system operating and investment costs over 24-time blocks representing three seasons, day and night,

at baseload, shoulder, peak, and super peak levels of electricity demand. Renewable resource availability is distinguished by state and time block. Existing fossil plants in each state are binned in up to 18 levels of efficiency for each fuel type and technology.[7] Existing plant data is sourced from S&P Global, initial electricity demand from EIA's AEO 2023, and capital costs from AEO2021 and the National Renewable Energy Laboratory's Annual Technology Baseline 2022. We represent the level of electricity demand in California by drawing from the 2022 Scoping Plan.

We expand the electricity model to an economywide emissions accounting platform using outputs of emissions and technology stock options from the 2022 Scoping Plan. Sectoral emissions in the model respond to electricity and carbon market prices. We integrate elasticities from RFF's general equilibrium model (DR-GEM) and the outputs from the Pathways model in the 2022 Scoping Plan to analyze the linkages between sectoral electrification and decarbonization and carbon market outcomes in the California context.

In representing uncertainty, we implement alternative assumptions about technology adoption and energy demand in each sector and the associated demand for emissions allowances, which affects electricity and carbon market outcomes. We consider two scenario representations of energy demand: the Scoping Plan scenario and our modified "Delayed Scoping Plan" scenario. The Delayed Scoping Plan scenario assumes three variations on outcomes anticipated in the Scoping Plan catalogued next and visualized in the appendix.

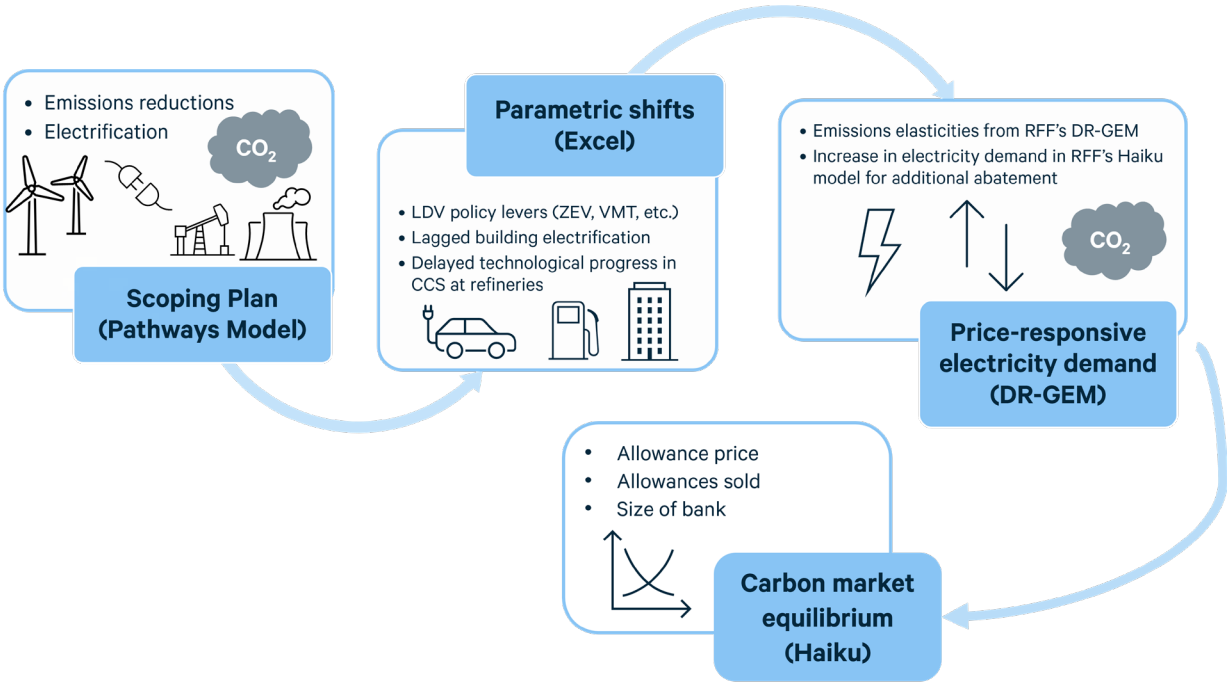
1. Reductions in vehicle miles traveled that are anticipated in the Scoping Plan are not realized, leading to increased vehicle sales. We preserve the vehicle composition, including the electric vehicle share of the vehicle fleet described in the Scoping Plan.
2. Building electrification and decarbonization are delayed by three years.
3. Refinery investments in carbon capture and sequestration (CCS) are delayed by three years (beginning in 2031 instead of 2028).

The Delayed Scoping Plan scenario is a representation of initial higher emissions than are projected in the Scoping Plan. Although it serves as an upper bound for emissions in our report, it is by no means an upper bound on potential emissions in California.

Initialized at these two alternative emissions levels, the model optimizes to minimize electricity system costs, accounting for changes in electricity and emissions allowance demand across sectors. Emissions abatement for industry, buildings, and light-duty vehicles occur as emissions allowance prices rise above the price floor level. Each additional unit of emissions reduction across sectors requires the same level of electrification but has increasing costs to represent the increasing marginal costs of abatement. Figure 4 displays a general overview of the Haiku Emissions Market Model.

7 For example, existing natural gas combustion turbines and natural gas combined cycle plants are two different plants each with 18 different efficiency bins. 18 Efficiency bins also exist for coal plants.

Figure 4. Overview of Haiku Emissions Market Model



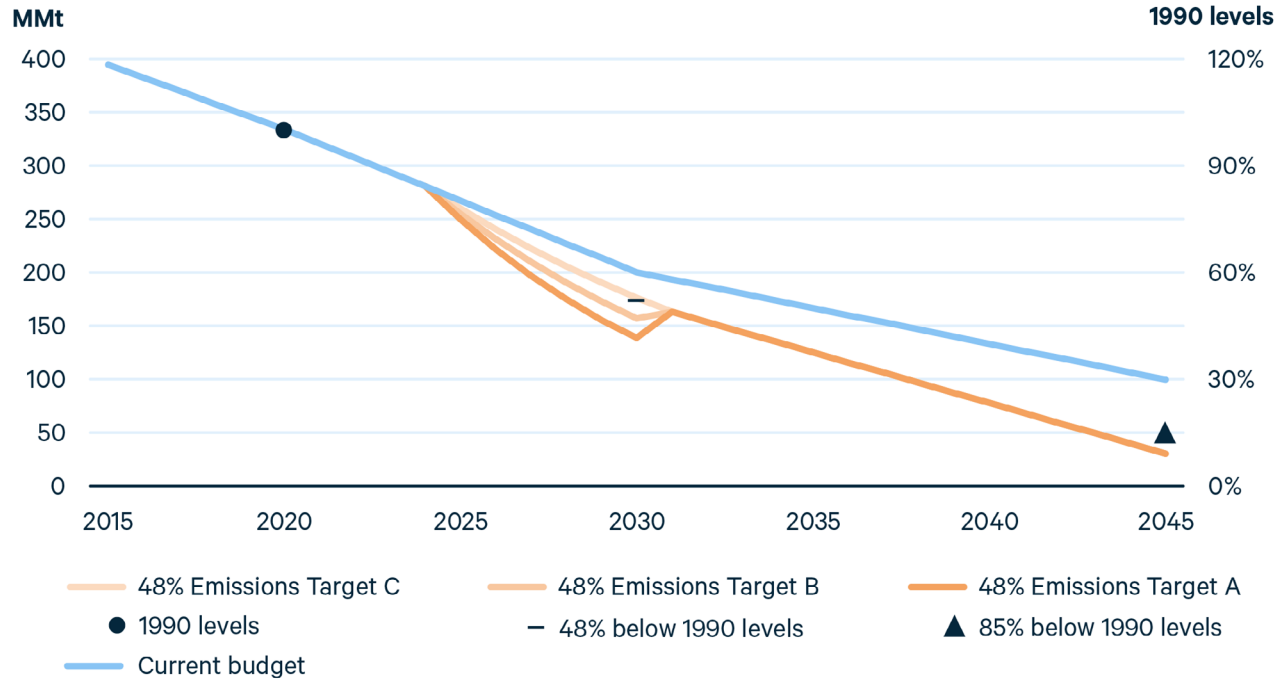
Allowance demand is a function of technology costs in the power sector and reduced-form emissions elasticities for the buildings, industrial, and light-duty vehicles sectors. Additional abatement in these sectors requires an increase in electricity demand that is based on the average electricity consumption per unit of emission reduction in each sector in the Scoping Plan. In this way, allowance demand is responsive to the price of an allowance and higher allowance prices can incentivize more decarbonization, whereas higher power prices can incentivize less. The flexible supply mechanisms and dynamic response of allowance demand in the model generate price formulation, allowance purchasing behavior, and emissions outcomes that we describe throughout this report.

4. Modeled Scenarios

We organize the analysis around the three approaches that reduce allowance supply to implement the SRIA 48 percent target scenario. In addition, we compare these scenarios to the broader set of allowance supply schedules identified by CARB in fall 2023, including 40 and 55 percent emissions reduction targets. Allowance supply differs greatly across the three allowance budgets CARB identified previously (40, 48, or 55 percent below 1990 levels by 2030). For each scenario, we consider budgets after 2030 that decline linearly from 2031-2045 either from the "target" emissions level in 2030 or the 2030 "budget" levels that are lower than their respective target, maintaining a smooth allocation schedule.

The allowances entering the market may vary from the anticipated allowance supply pathway due to elements of price-responsive allowance supply embodied in the APCR. If the allowance price reaches the APCR trigger price, additional allowances are contributed to the allowance supply. The number of allowances in the APCR varies across the three SRIA approaches. In one, the 265 million tons reduction in allowance supply is implemented by removing allowances from the annual emissions budget while leaving the APCR intact (48 percent target A). A second approach removes 50 percent of the APCR and the remainder of the inventory adjustment from the annual emission budget (48 percent target B); the third removes all available allowances from the APCR, and only the necessary residual reduction comes from the annual budget (48 percent target C). Figure 5 illustrates the levels of non-reserve allowances issued under these three scenarios and how they compare to the 2030 target.

Figure 5. Non-Reserve Allowances Issued Under SRIA Scenarios



We also model a structural adjustment to allowance supply with the introduction of an ECR. In the SRIA, CARB illustrated allowance prices that would be in the neighborhood of an ECR trigger price level. We examine the operation of such a mechanism, which is especially relevant given uncertainty about technology options and economic activity. In addition, we consider the introduction of facility-specific emissions caps, including removing allowances from the market to achieve accelerated emissions reductions in disadvantaged communities. These three supply mechanisms offer 12 possible permutations of the original six budgets CARB proposed last year. We also consider the current allowance budget in the law.

For each of these 84 supply pathways, we ran two allowance demand scenarios. The first demand scenario is based on the 2022 Scoping Plan. The alternative scenario delays the emissions reductions and associated increase in electricity demand from refinery carbon capture and storage and building electrification in the Scoping Plan by three years. This alternate scenario also assumes the business-as-usual levels for light-duty vehicle miles traveled from the Scoping Plan, while holding the composition of sales constant, leading to higher electricity demand from light-duty vehicles and emissions from traditional gasoline vehicles. This alternate scenario is labelled "Delayed Scoping Plan" to represent potential delays in Scoping Plan outcomes. Demand is initiated at these levels, and the market equilibrium determines how much additional abatement is induced by the carbon price.

In total we consider 168 possible combinations of emissions allowance supply and demand (Figure 6), resulting in an array of equilibrium outcomes in the power and carbon markets. Both allowance supply and demand are endogenous. Allowance supply is dynamic in many scenarios. The presence of the two tiers of APCR allowances and a price ceiling allows for increases in supply at higher prices. The presence of the price floor and potential addition of an ECR allow for restriction in supply when abatement costs are low.

Figure 6. Scenarios Considered in This Analysis

5. Analysis of SRIA Proposed 48 Percent Target Pathway

5.1. Allowance Price Pathways

A central concern of modeling efforts of the cap-and-trade program is future allowance prices. CARB contracted with researchers at UC Davis (Bushnell et al. 2023) to model the allowance market across a range of supply scenarios, and the preliminary analysis was presented in a workshop on November 16, 2023. CARB staff have also created their own price projections for the SRIA 48 percent target scenarios. This report adds its own modeled allowance prices. Each set of projections is based on different techniques and assumptions discussed here.

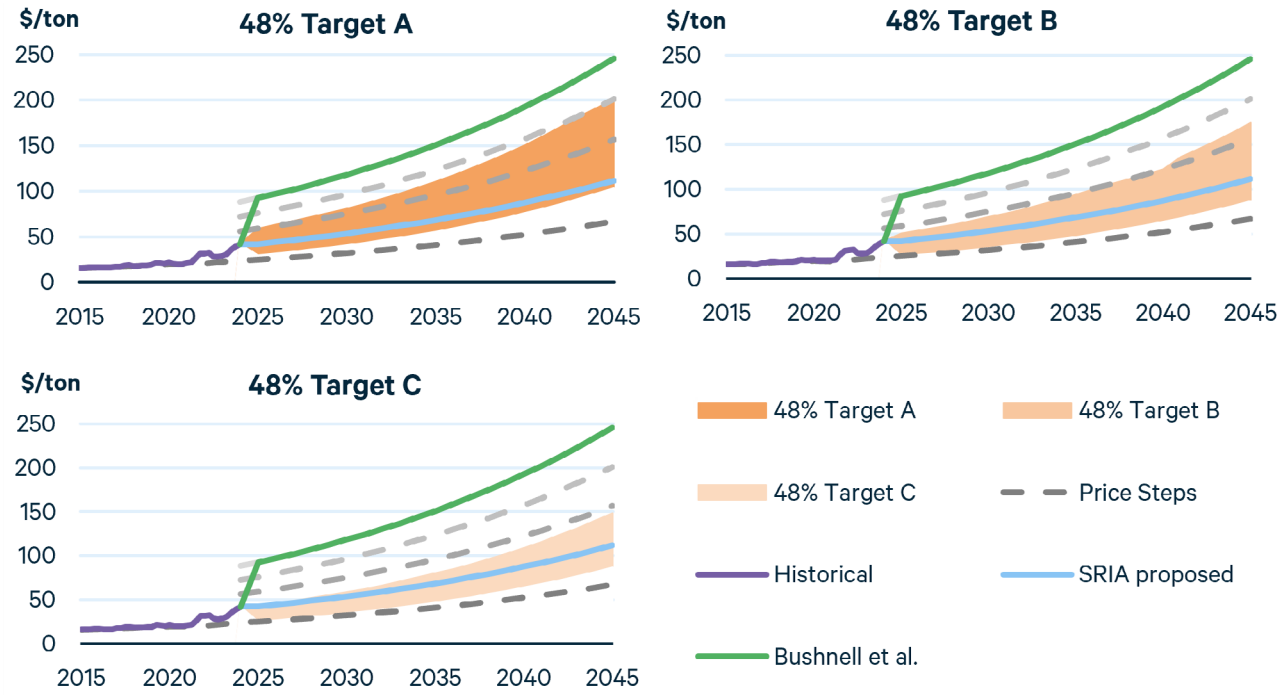
Bushnell et al. (2023) used a statistical model to project a range of business-as-usual California emissions and emissions abatement under uncertainty about economic activity and abatement, based on the abatement expected from the 2022 Scoping Plan update. They compared the levels of allowance demand derived from these emissions to cumulative allowance supply under different cap adjustments to project the price. For the 48 percent target A scenario that removes allowances from the annual emissions cap and leaves the price reserves intact, Bushnell et al.'s central (median) draw from their probability distribution projected allowance prices at the price ceiling (Figure 7). They also modeled a scenario similar to 48 percent target C but with a looser cap because, in addition to removing allowances from the APCR reserves, some were removed from the price ceiling reserve,[8] requiring a smaller removal from the emissions cap. That scenario had prices just below the price ceiling.[9] They did not include the impacts of the Inflation Reduction Act, which might increase the capacity for future abatement and decrease allowance prices.[10]

8 The Price Ceiling Reserve is a set of allowances similar to the allowances in the two APCRs that is reserved from the market until the price reaches the price ceiling. After the Price Ceiling Reserve allowances are exhausted, entities can purchase price ceiling units, which can only be used for compliance.

9 **Joint Cap-and-Trade Workshop Nov 16**, slide 34

10 **Joint Cap-and-Trade Workshop Nov 16**, slide 17

Figure 7. Allowance Price Ranges Across SRIA Scenarios



Note: The range of prices has an upper bound set by the Delayed Scoping Plan allowance demand and the lower bound by the Scoping Plan allowance demand.

In the SRIA, CARB staff created their allowance price projection by reducing emissions and allowance demand based on the Scoping Plan, with minor adjustments, and compared the resulting allowance demand to supply under different cap adjustment scenarios. According to the SRIA, "staff analysis assumes that average allowance prices during 2025-46 will fall halfway between the price floor and the APCR Tier 1 price. The price floor is a reasonable lower bound on prices, and the APCR Tier 1 price is a reasonable upper bound because projected allowance demand under the Proposed Scenarios [48 percent target A, B, and C] does not result in prices that reach levels that would trigger the availability of APCR allowances."[11] CARB did not create separate allowance price assumptions for the different methods of reducing supply in A, B, and C.[12] CARB's price assumption for the 48 percent target scenarios appears in blue in Figure 7. The SRIA notes that if the complementary policies in the Scoping Plan do not perform as expected or if emissions are higher than projected for some other reason, "then the source of allowance removals may further affect compliance costs by altering the price at which allowances are sold at auction."[13]

11 SRIA, 46

12 "This analysis does not provide insight into how the differences in removal of allowances from the auction and allowance pool could result in minor impacts on compliance costs for the Program overall but could potentially change the leakage potential for covered sectors" (SRIA, 48).

13 SRIA, 48

Figure 7 describes each scenario with two levels of initial allowance demand—one if all emissions reductions in the Scoping Plan occur, 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. These two levels of allowance demand bookend a range of plausible allowance price pathways under each 48 percent target scenario supply scenario (Scenarios A, B, and C). Scenario A has the tightest annual nominal allowance budget because all allowance removals are taken from the annual nominal cap; Scenarios B and C achieve the allowance supply reduction by removing some or all the allowances in the APCR. When prices are low, APCR allowances may not be brought into the market and the supply adjustment may have little effect on prices. Hence, the allowance prices for Scenario A are greater than those for Scenario B, which in turn are greater than those for Scenario C.

Compared to CARB, Haiku's allowance prices are lower under Scoping Plan levels of demand but higher under Delayed Scoping Plan levels. Because Haiku includes the investments from the Inflation Reduction Act, allowance prices are lower than Bushnell et al. (2023) in both cases. The continued existence of the APCR in scenarios A and B allows for price containment.

5.2. Emissions

Each allowance is equal to one metric ton of CO_2 emissions, so cumulative emissions are determined by the cumulative supply of allowances plus offsets, which provide additional compliance instruments. The timing of emissions differs from that of the allowance supply due to emissions banking and offset availability. Table 1 illustrates cumulative emissions over five-year intervals through 2045. Fewer emissions reductions occur when allowances are removed from the APCR (Scenario C) versus the annual nominal emission budget (e.g. Scenario A). As discussed, when prices are low, the APCR is not triggered, and those allowances are not made available and would not have been used. Preserving the APCR and reducing the nominal emissions budget (e.g. Scenario A) also leads to emissions reductions earlier, which enhances the benefit of GHG emissions abatement and associated air quality outcomes.

Under the Scoping Plan (SP) demand scenario, Options A, B, and C never reach a price level that triggers availability of allowances in the APCR. The tighter allowance supply in Scenario A leads to fewer cumulative emissions with a higher price that can incentivize additional abatement. In contrast, Options B and C start at the price-floor level in 2025. The Delayed Scoping Plan (DSP) demand scenario has a more complex story with similar lessons. Option C has no ACPR allowances and the largest annual allowance supply. Option B has a tighter annual allowance supply, which induces higher prices. APCR allowances are injected later in the program under Option B, but because the second APCR tier is not triggered, there are fewer emissions than Option C. Option A triggers the second APCR tier, and because annual allowance supply is tighter, emissions are lower than either of the other two scenarios. In summary, retaining the APCR and instead reducing the nominal emissions cap preserves emissions reductions and improves climate benefits under both demand scenarios.

Table 1. Cumulative Emissions Over Time Across SRIA Options A, B, and C for Reducing Allowance Supply (MMT) Under the Scoping Plan (SP) and Delayed Scoping Plan (DSP) Demand Scenarios

	2025		2030		2035		2040		2045	
Scenario	SP	DSP	SP	DSP	SP	DSP	SP	DSP	SP	DSP
48% Target A	258	254	1388	1415	2193	2256	2727	2807	3102	3177
48% Target B	259	256	1396	1424	2207	2272	2747	2831	3133	3217
48% Target C	259	258	1396	1442	2207	2301	2747	2869	3133	3267

Our estimates could be considered underestimations of the differences among Options A, B, and C. Our representation of emissions abatement is based on existing technologies and costs. However, higher carbon prices from Option A may incentivize and fund further investment in decarbonization technologies and accelerate emissions abatement. This feedback effect is difficult to model but is an anticipated benefit of a strong cap-and-trade programs.

5.3. Distributional Effects

A reduction in the allowance supply and associated increase in allowance price leads to an overall increase in the financial value of allowance supply. The tighter the allowance budget, the greater the allowance value available to the state through the GGRF and to industry and utilities through free allocation.

Figure 8 shows cumulative allowance value between 2025–2030 for the three 48 percent target options (A, B, and C) and the baseline. The lefthand panels report outcomes under the Scoping Plan level of allowance demand and the righthand stack reports outcomes under our Delayed Scoping Plan.

Option A, which reduces allowance supply by reducing the annual allowance budget while leaving the APCR intact, is the tightest budget and so yields the highest allowance value, cumulatively totaling $39 billion from 2025-2030 under the Scoping Plan scenario and 81 billion under the Delayed Scoping Plan scenario (Figure 8). In contrast, Option C, which retires all allowances from APCR Tiers 1 and 2 and introduces only a small change in the annual allowance budget, is the loosest budget and thus yields the lowest allowance value, cumulating to $35–64 billion. These approaches to reducing allowance supply increase allowance value above what would be available under the current (baseline) budget, shown in the bottom panels ($28-32 billion).

Decisions about free allocation under Option A, B, or C will have important impacts on the distribution of the allowance value between the GGRF, industry, and utilities.[14] Each panel of Figure 8 contains three columns representing three different allowance allocation schemes. The first column, "reduce auctioned allowances," assumes that the number of free allowances that accrue to industry and utilities remain unchanged regardless of the size of the cap adjustment, so any reduction comes out of the GGRF's share. The second column, "proportional reduction," assumes that free allocation to industry and utilities is reduced proportional to the cap adjustment so that the GGRF's share of allowances remains constant.

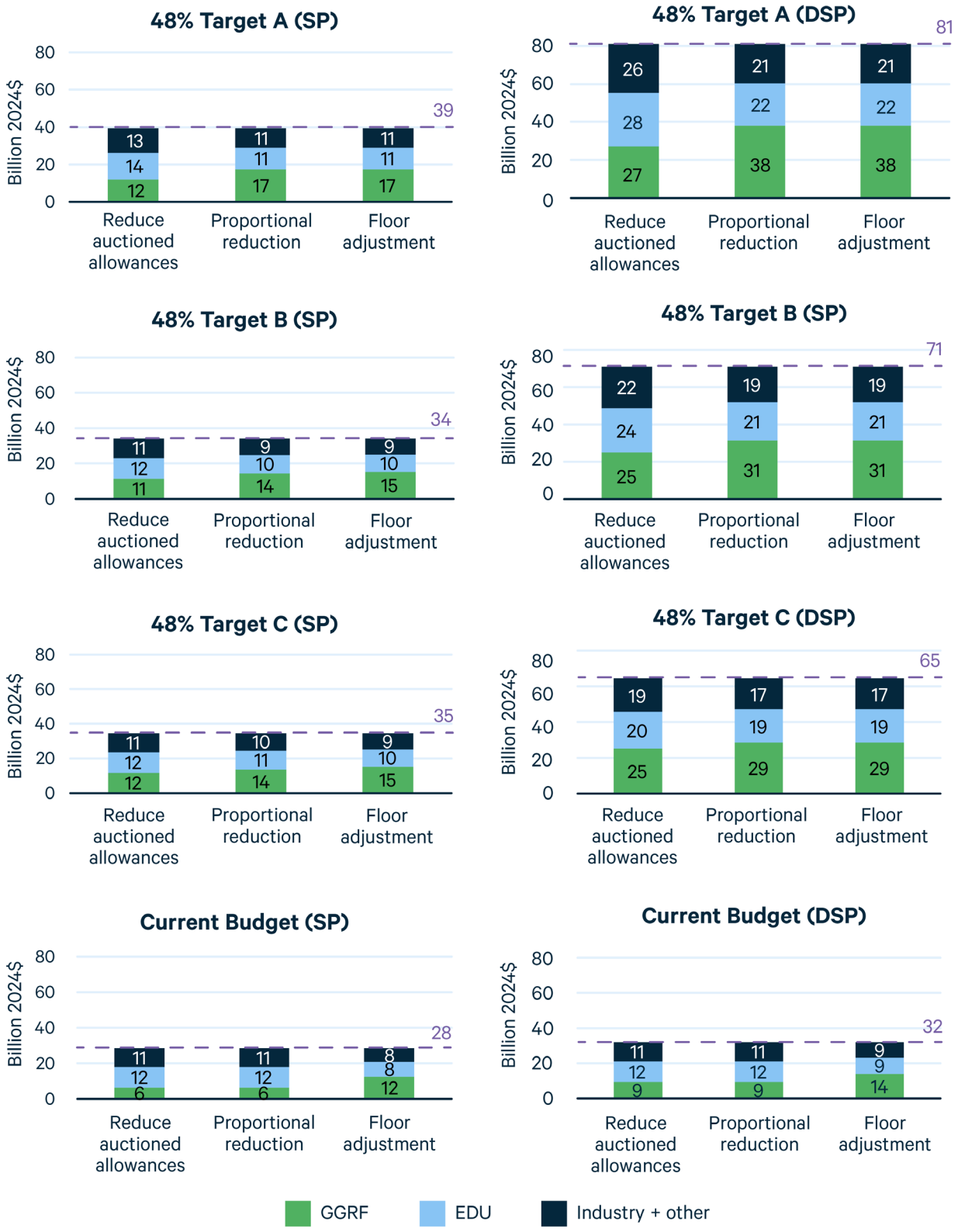
If the auction price falls to the price floor, allowances entering the market will be less than the nominal cap in that year. The first and second columns represent current auction rules with priority sale of consigned utility allowances before sale of state-owned allowances that deliver proceeds to the GGRF. The third column, "floor adjustment," makes an additional change to allowance allocation by proportionately reducing free allocation to industry and utilities when fewer allowances than the nominal cap are sold, which preserves the GGRF's share of allowances even in cases of extremely low allowance demand.[15]

Rising allowance prices triggered by the tighter budget mean that the GGRF still receives more allowance value ($12–27 billion in Scenario A, $12–25 billion in Scenario C) than in the current budget ($6–9 billion), even if its share of value falls relative to the share directed to free allocation (Figure 8, Column 1). If the reduction in the annual allowance supply were proportionately reduced across auction and free allocation, reducing allocation to industry and EDUs proportional to the overall cap reduction, more revenue would accrue to the GGRF ($17–38 billion in Scenario A, $14–29 billion in Scenario C) (Figure 8, Column 2). The floor adjustment helps the GGRF retain additional revenue under the low-demand (SP) scenarios and thus reduces uncertainty about the amount of revenue even under uncertainty about allowance demand. Reducing free allocation when allowance demand is lower than the nominal cap would preserve significant revenue under a current budget (baseline) cap, $12–14 billion for the GGRF instead of $6–9 billion.

14 In Table 7 of the SRIA, CARB includes GGRF revenue projections. Without a cap adjustment and using 2022$, CARB projects $19.4 billion in cumulative 2025–2030 GGRF revenue. With a cap adjustment, CARB projects $27.1–29.3 billion, most likely reflecting the range from Scenario C on the low end to Scenario A on the high end. All of these projections are higher than in the Delayed Scoping Plan RFF projections, which, given that CARB assumed a lower price path than the price paths in that scenario, indicates that CARB is allocating more allowances to the GGRF than we are. CARB has proposed an adjustment to EDU allocation in the SRIA that we were unable to replicate, which likely explains this difference.

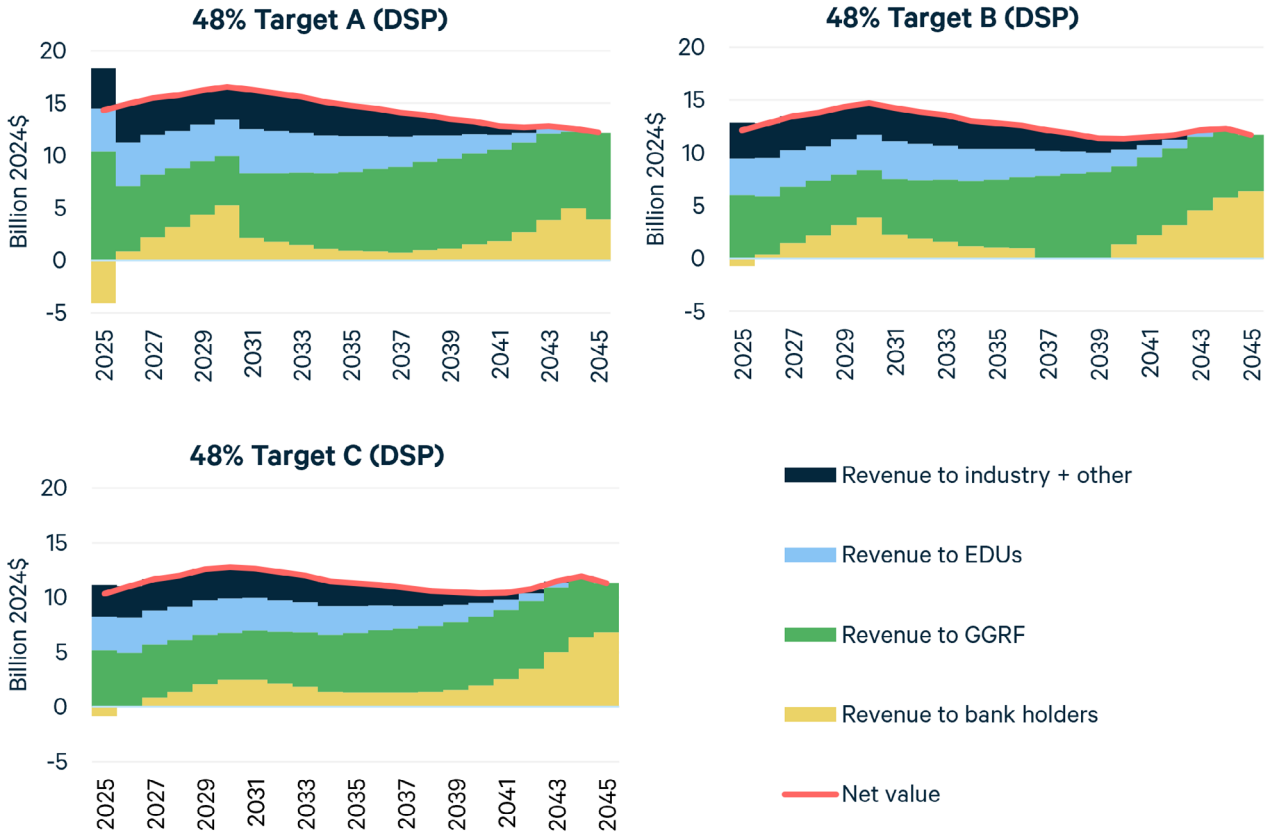
15 At the height of the COVID pandemic, when California allowance prices fell to the price floor and fewer allowances were sold than the nominal cap, the entities receiving free allocation still got their full amount, but the GGRF received less, so its share of allowance value fell at a time when total allowance value was already falling. The floor adjustment would have preserved the GGRF's share of allowance value.

Figure 8. Cumulative Allowance Value Across SRIA Scenarios Under Different Allocation Schemes (2025–2030)



For the distributional impact of the program, it can also be useful to consider the allowance value going to holders of the allowance bank. Figure 9 shows the allowance value accruing to the GGRF, industry, EDUs, and bank holders of the bank over time under the Delayed Scoping Plan allowance demand, which shows the largest effects. The allowance value going to bank holders is assigned to them in the year that allowances are taken from the bank and used for compliance, so a negative value indicates that allowances are being added to the bank. The tightest cap adjustment (Option A) results in the highest allowance value throughout the program and a larger share of value going to the GGRF (relative to bank holders) in the long run.

Figure 9. Allowance Value Accruing to Different Interests Across SRIA Scenarios with Delayed Scoping Plan Allowance Demand



5.4. Banking Behavior

The cap-and-trade program has built up a significant private bank, approaching 360 million tons, which is more than the annual emissions cap. Banking helps incorporate expectations about future program stringency and abatement costs into current prices—because market participants choose to buy allowances now and save them if they believe that these will be worth more in the future—thereby raising prices in the early years of the program. Banking brings emissions reductions forward in time because it both raises near-term prices, encouraging additional abatement, and means that fewer are available for emissions in the present. Early emissions reductions in the cap-and-trade program imply near-term improvements in air quality and the development of technological systems to advance the clean energy transition. Banking also builds constituencies for the program's existence; any entity that holds allowances will not want the program to disappear, as their value is contingent on the program's continuation.

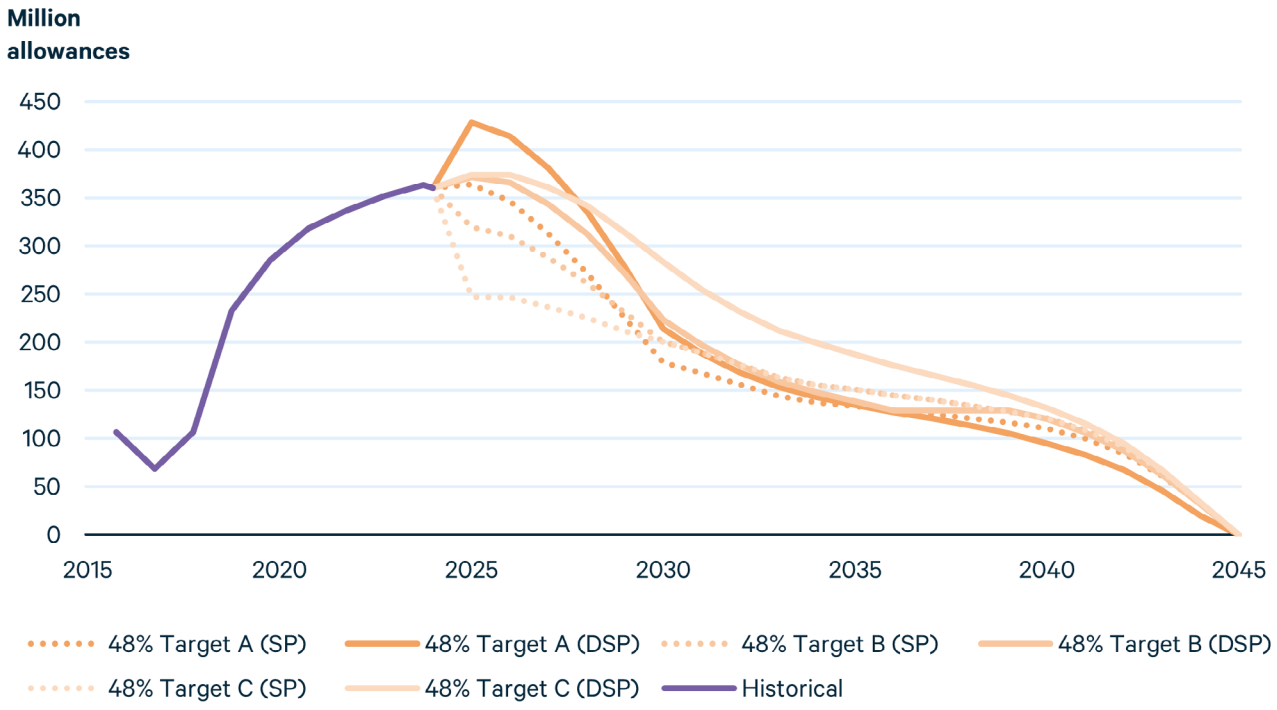
The existence of a large bank can be a problem for environmental outcomes, however, if the program ends early. Observers have pointed out that if the program were to end in 2030 without reauthorization, the bank could have enough allowances for all compliance obligations in the next five years to be met without any additional abatement (IEMAC 2021).[16] If the program is extended as expected, the allowance bank would likely be carried into the next decade. Bushnell et al. (2023) reflect this result when they show that allowance prices in the program will be very low if the program ends in 2030 but quite high if the program extends to 2045.[17]

In our modeling, we assume that the program is extended until 2045, so banked allowances remain valuable after 2030. We find that a tighter program and higher allowance price in the near term (because of either higher allowance demand or lower allowance supply) will lead to further contributions to the bank in the near term, so that those banked allowances will be available for compliance in the long term. The effect of tighter supply on the allowance bank is reflected in Figure 10. We see that for each 48 percent target scenario, the higher allowance demand scenario (Delayed Scoping Plan) leads to more banking in the early years than in the low-demand scenario (Scoping Plan). We also see the influence of the approach to reducing allowances. Scenario A, which implements the supply adjustment solely by reducing the annual emissions cap, creates the greatest short-term scarcity and builds up the bank more than the 48 percent target B and C scenarios (which instead remove half or all of the APCR allowances), for each given level of allowance demand.

16 The 2017 Scoping Plan estimated that cap-and-trade would drive about 305 MMT of emissions reductions between 2021–2030.

17 Bushnell et al. p 28 and 29(2023). Other emissions trading programs have addressed the issue of large banks in a variety of ways. The EU Emissions Trading System introduced the market stability reserve, which conditions the availability of allowances in the auction on the number of allowances in circulation (the bank). The Regional Greenhouse Gas Initiative (RGGI) has twice introduced a "bank adjustment" where it reduces future allowance issuance to account for the size of the bank; CARB's proposed "inventory adjustment" is similar to RGGI's "bank adjustment."

Figure 10. Allowance Banking Across SRIA Scenarios



Tightening the program increases not only the size of the bank but also its financial value because of the increase in prices. Figure 11 shows that if Scoping Plan levels of allowance demand are achieved, the value of the existing bank is about $9 billion (2024). This value is calculated by multiplying the size of the existing bank by the price of allowances, which we find to be on the price floor in 2025 under both the Scoping Plan and Delayed Scoping Plan demand scenarios.

Under the Scoping Plan assumptions about allowance demand, the 48 percent target A scenario, which reduces allowance supply by reducing the annual emissions cap, leads to tighter cumulative supply and a higher allowance price, increasing the value of banked allowances. However, under Scoping Plan assumptions about allowance demand, in the B and C scenarios that draw down the APCR and have a smaller reduction in the emissions cap, the allowance price remains at the price floor in 2025 (see Figure 7), leaving unchanged the value of banked allowances.

Under the Delayed Scoping Plan scenarios, allowance demand is higher, leading to higher prices and higher values for banked allowances in all scenarios. In the 48 percent target A scenario, the financial value of the bank more than doubles, growing from $9 billion to $11–21 billion. In the B and C scenarios, the bank value grows to $9–18 billion and $9–16 billion, respectively.

Figure 11. The Financial Value of Banked Allowances Across SRIA Scenarios (2025)

5.4.1. Considering Alternative Banking Behavior

The model results we have reported assume that allowances can remain in the bank and their value would increase following the Hoteling path, increasing annually at the opportunity cost of capital, which we assume to be 6 percent per year. In our previous comments to CARB after the November 16, 2023 workshop, we assumed that the allowance bank would be drawn down before APCR allowances would be purchased. Which outcome is observed depends on the behavior of compliance entities that currently hold banked allowances and CARB's potential actions limiting access to the APCR.[18]

The uncertainty stems from the rules governing access to APCR allowances. Only compliance entities are eligible to draw allowances, and they cannot do so if they own banked allowances. Furthermore, the purchased APCR allowances must be deposited in a compliance account, meaning that they cannot be transferred or banked but must be used for compliance in the period in which they are purchased.

The APCR trigger price rises at 5 percent per year, which is less than the assumed rate of change in the value of banked allowances (6 percent). If the allowance price path surpasses the APCR trigger price, compliance entities will want to capture the relatively low-cost APCR allowances, but to do so, they must use or transfer allowances in their

18 We benefitted from conversations with Steve Salant in framing these alternatives. The representations and modeling remain our responsibility.

bank. CARB has visibility into account holdings, and it may disallow access to APCR allowances for an entity that has sold off its bank for that purpose.

Hence, uncertainty arises about the timing of the use of privately held banked allowances and APCR allowances (which constitute a sort of public bank). Although CARB regulations forbid compliance entities to buy allowances from the APCR if they hold a bank, there are also noncompliance entities in the market. We believe that if the allowance prices were to exceed the APCR trigger price, compliance entities would purchase APCR allowances even while noncompliance entities continued to hold a bank. For this reason, in this modeling effort, we have assumed that APCR allowances are purchased before the bank is exhausted. Although this choice has only small impacts on our modeled allowance prices, it does change the timing of revenue to the GGRF and bank holders. If APCR allowances are purchased early, the GGRF receives revenue (at a lower allowance price) in early years while bank holders receive revenue (at a higher allowance price) in later years. If APCR allowances are purchased after the bank is exhausted, the GGRF receives revenue (at a higher allowance price) in later years while bank holders receive revenue (at a lower allowance price) in earlier years. This issue is only relevant if the APCRs are triggered, which only happens in some of our high allowance demand scenarios.

5.4.2. Results Summary for 48 Percent Target Scenario Options A, B, and C

- Future emissions and thus allowance demand are uncertain; program design choices about how to adjust allowance supply should take this into account. This uncertainty is visible in the difference between Bushnell et al. (2023), CARB, and RFF modeling, which all make different assumptions about emissions demand. Such uncertainty means that prices and revenue may diverge significantly from CARB projections.
- Removing allowances from the nominal emissions cap will lead to a higher allowance price. However, removing APCRs increases price volatility. Unless CARB makes a cap adjustment, program prices could be very close to the price floor, and if Scoping Plan emissions are achieved, Scenarios B and C will also leave prices very close to the price floor.
- Although Options A, B, and C appear to have the same cumulative allowance supply, a tighter nominal cap (A) yields lower emissions than the looser nominal caps (B and C) especially if, as CARB assumes, the APCRs are never triggered.
- Tightening the cap in any of the ways CARB proposes will increase allowance value above baseline even as the number of allowances decrease. This effect is even more true the tighter the allowance cap, so Option A, despite having the lowest nominal cap and issuing the fewest new allowances, has the greatest allowance value. How CARB chooses to reduce the supply has important distributional implications—reducing free allocation at the same time as reducing the overall cap preserves more GGRF revenue than just reducing auctioned allowances.

- Tightening cumulative allowance supply under a program that is extended beyond 2030 will lead bank holders to continue to purchase and bank allowances for later use. Increased cap stringency will raise the value of banked allowances, and the more the cap is tightened, the more the value increases. Changes in how CARB enforces the issuance of APCR allowances may result in different distributions of value to the GGRF and bank holders.

6. Emission Containment Reserve

An additional program reform that CARB might consider is an Emissions Containment Reserve (ECR), which has been suggested by the Independent Emissions Market Advisory Committee (IEMAC 2019) and the Environmental Justice Advisory Committee (EJAC 2022). An ECR is an additional step in the allowance supply curve that withholds a share of total annual allowances until the allowance price reaches a specific level.[19] This allows the program to achieve additional emissions reductions when prices are low and supports allowance prices generally (contributing to more stable revenue). When prices are not low, the ECR has no effect.

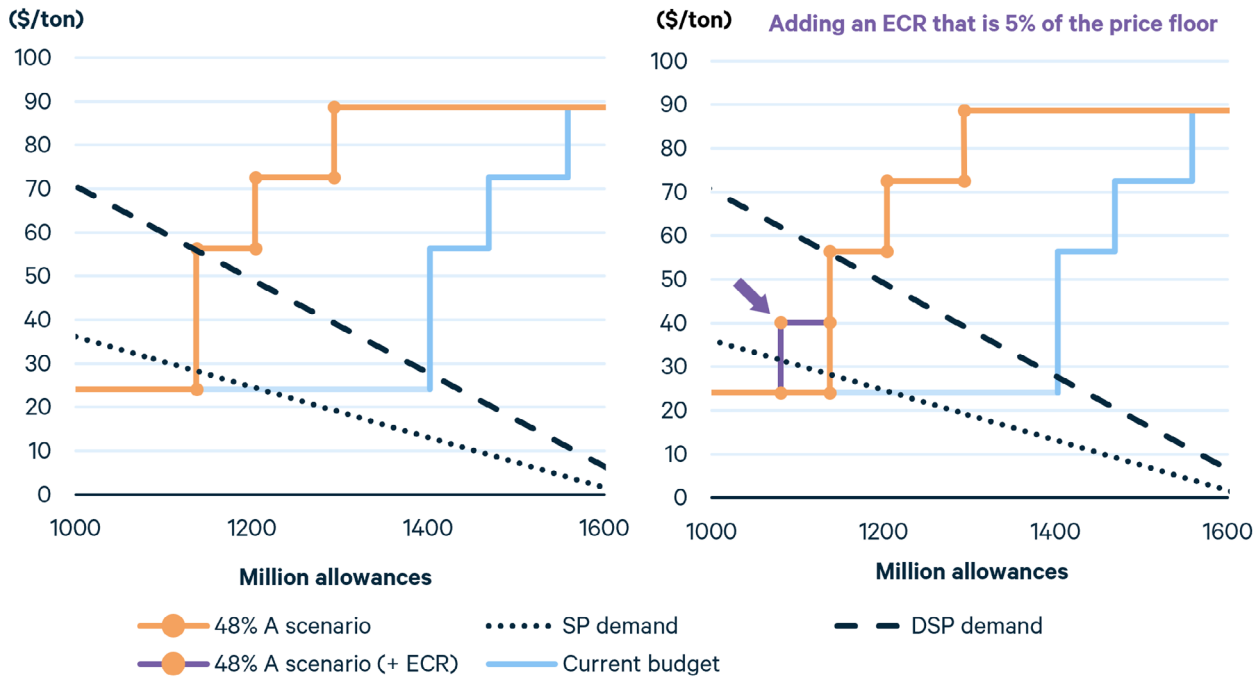
ECR's are features of other cap-and-trade programs in the US. Washington State, which CARB has shared a joint statement intending to link, has a dormant ECR codified in its legislation (WA-CCA 2021). In the northeast Regional Greenhouse Gas Initiative (RGGI), an ECR already exists. RFF helped develop this idea before it was adopted by RGGI (Burtraw et al. 2017; Burtraw et al. 2022). Much of the analysis for the RGGI program is applicable in the California context.

Figure 12 displays allowance supply schedules as they respond to market prices and what it looks like to add an ECR to CARB's proposed Option A. The left panel illustrates cumulative allowance supply under the current allowance budget and the proposed option. The steps in the supply schedules represent the price floor and APCR Tiers 1 and 2. The right panel adds the ECR as an additional price step above the price floor, holding 5 percent of the annual nominal allowance budget (i.e., not accounting for APCR allowances). The trigger price for the ECR is set halfway between the price floor and the first APCR. Coincidentally, this is the price that CARB assumes allowances will follow in the SRIA. Implementing an ECR is one way to sustain prices at that level.

Figure 12 contains two lines that represent a stylized version of the two demand scenarios modeled in this exercise: the Scoping Plan (SP/dotted line) and Delayed Scoping Plan (DSP/ dashed line) scenarios. When allowance demand is low (SP), the ECR reduces the number of available allowances and raises the allowance price. When allowance demand is at a price above the ECR trigger price (DSP), the ECR has no effect on the allowance price or availability.

19 **RGGI has an ECR** set to withhold 10 percent of allowances from the auction until the price reaches $7.35. This trigger price increases by approximately 5 percent in real terms each year.

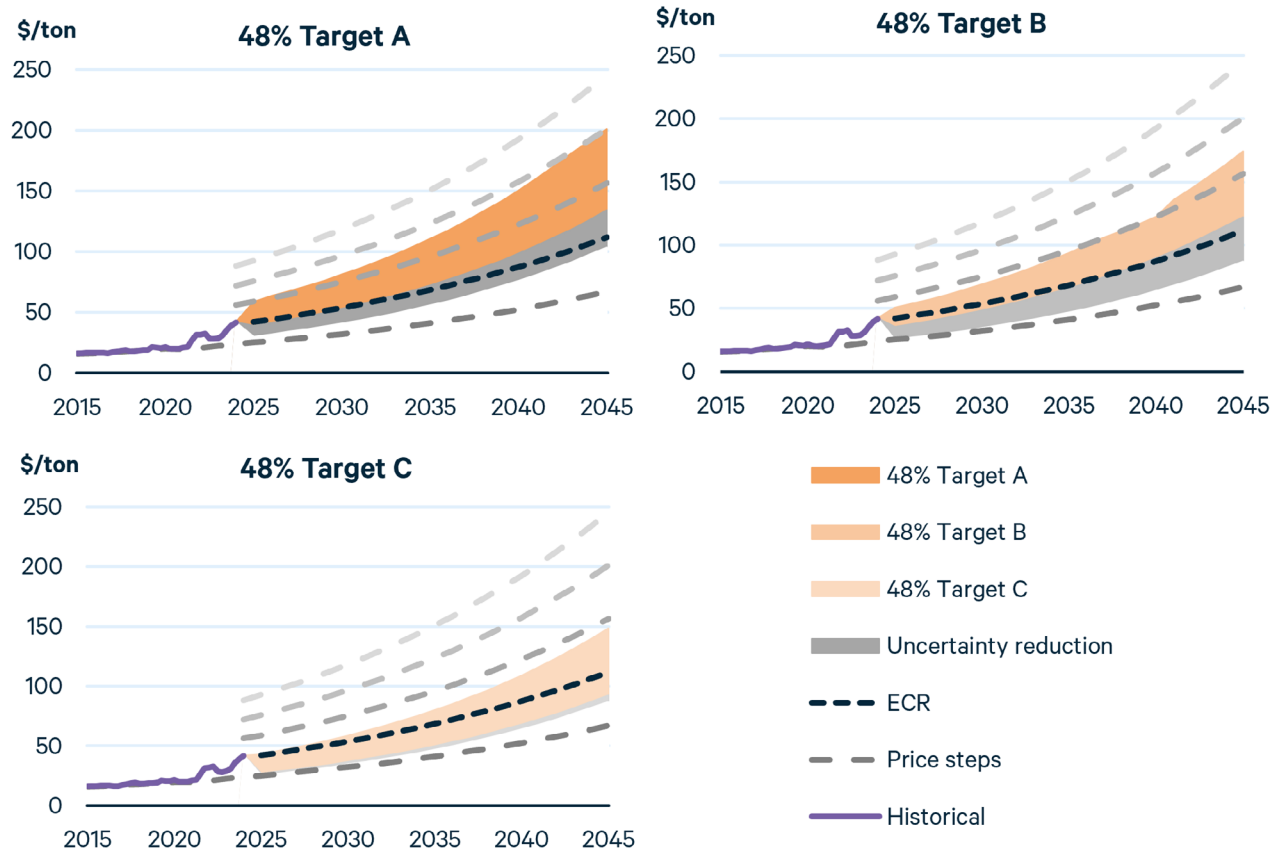
Figure 12. Adding an Emissions Containment Reserve to Cumulative Allowance Supply Curves (2025-2030)



6.1. Results

Adding an ECR supports the allowance price in low-demand scenarios and reduces uncertainty by narrowing the range of expected prices. Figure 13 shows the allowance prices achieved under CARB's A, B, and C options when a 5 percent ECR is added between the price floor and APCR Tier 1. Across all options, the ECR increases the price in the Scoping Plan demand scenario but does not affect outcomes in the Delayed Scoping Plan demand scenario. The influence of the ECR tightens the range of prices in our model outputs. For Options B and C, the price is raised off the price floor. For Option B, the price under Scoping Plan demand assumptions nearly follows the proposed SRIA allowance price path.

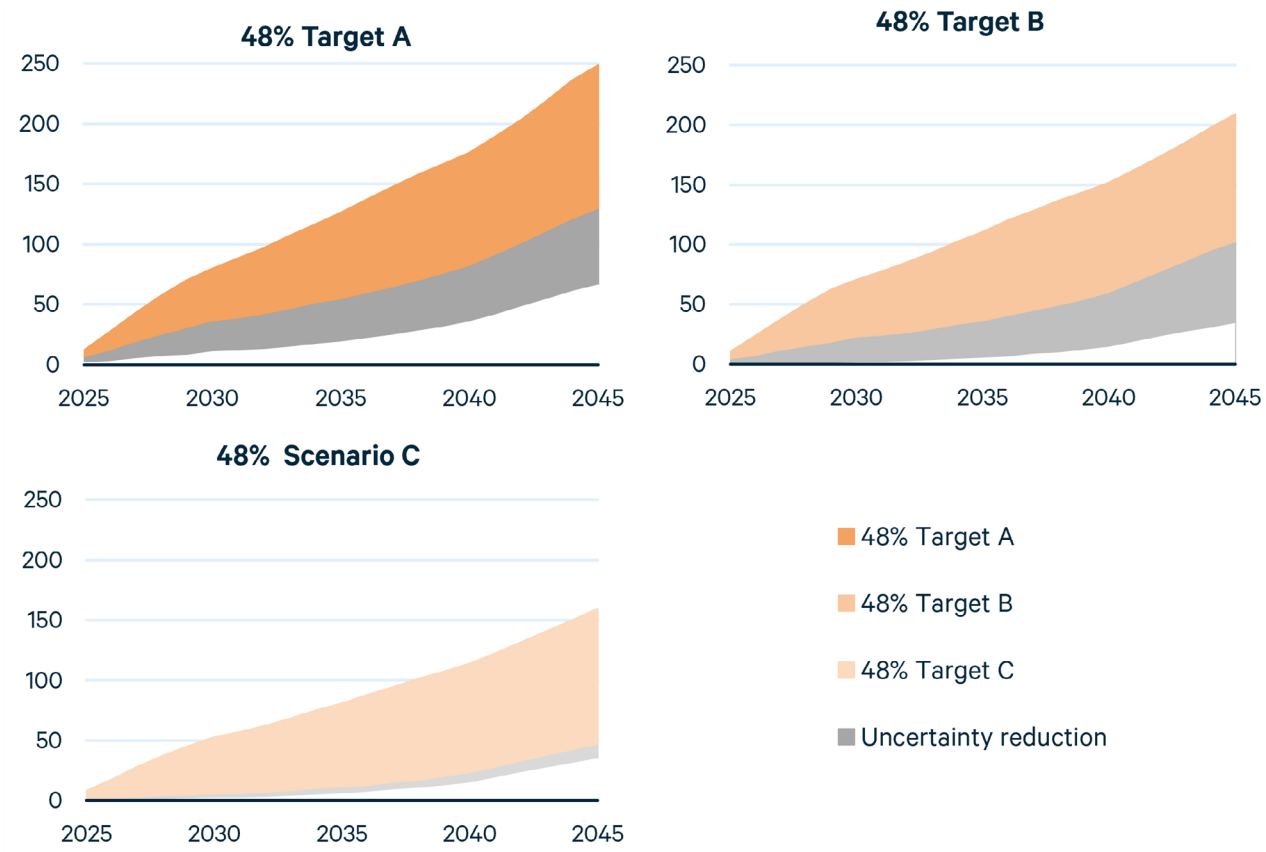
Figure 13. Allowance Price Ranges Across SRIA Scenarios with an Emissions Containment Reserve



Note: The range of prices has an upper bound set by the Delayed Scoping Plan allowance demand and the lower bound by the Scoping Plan allowance demand.

Adding an ECR reduces emissions when allowance demand and allowance prices are low and has no effect when allowance demand is high. It thus decreases uncertainty about the number of emissions reductions that will be achieved. Figure 14 shows the cumulative emissions reductions under the A, B, and C supply scenarios with an added ECR: reductions achieved with an ECR are in orange, and the grey region shows the additional possible emissions that result without ECR. In each case, adding an ECR reduces both uncertainty for emissions reductions and leads to greater emissions reductions than without an ECR.

Figure 14. Emissions Reductions Relative to Baseline Across SRIA Scenarios with an Emissions Containment Reserve



Note: The range of emissions reductions is set by the allowance demand from the Delayed Scoping Plan and Scoping Plan demand scenarios.

When implementing an ECR, it is important to consider the type of allowances that will be withheld from the market. ECR allowances can be withheld only from auctioned allowances (i.e., the portion going to the GGRF) or proportionally from auctioned and freely allocated allowances. The latter could require that all freely allocated allowances, including those to industry, be consigned to the auction as is currently done for free allocation to utilities. Figure 15 shows the cumulative allowance value accruing to different parties under the Scoping Plan level of allowance demand. The figure illustrates outcomes without the ECR ("no ECR"), with an ECR taken exclusively from auctioned allowances ("ECR"), and with the ECR taken from auctioned and freely allocated allowances ("ECR + Floor Adjustment"). When allowance demand is low, as in the Scoping Plan scenarios, adding an ECR increases the allowance value accruing to all parties relative to a program without an ECR. The ECR reduces both auctioned and freely allocated allowances and still increases allowance value to all parties, but the GGRF has a larger share.

Figure 15. Cumulative Allowance Value Across SRIA Scenarios with an Emissions Containment Reserve (2025–2030)

6.2. Summary

In summary, we find that introducing an ECR reduces uncertainty for both prices and emissions, especially in scenarios with low allowance demand resulting in low allowance prices. When the ECR is triggered, it also leads to greater proceeds for the GGRF and less variability in proceeds across demand scenarios. Its influence becomes even greater when considering a wider set of potential program reforms, technology availability, and levels of energy demand. The introduction of an ECR can be part of a comprehensive strengthening of the cap-and-trade program to amplify the influence of sector-specific regulations in reducing emissions and general uncertainty associated with California's portfolio of climate policies. Reduced variability in these program outcomes can enable better program planning by the state and on behalf of compliance entities.

7. Facility-Specific Caps

The California Cap-and-Trade Environmental Justice Advisory Council (EJAC) recommends that CARB modify the program to ensure direct emissions reductions in disadvantaged communities (EJAC 2022). Cap-and-trade programs do not require emissions reductions at any particular facility, so emitting facilities in disadvantaged communities, as defined by **CalEnviroScreen 4.0 (OEHHA)**, may not see emissions fall at the pace of the cap or could even see emissions increases (Pastor et al. 2022). Because local air pollutants, such as SO_2, NO_x, and particulates, are highly correlated with CO_2, and disadvantaged communities already experience higher levels of local air pollutants, the cap could lead to continued inequality in pollution exposure. To avoid this, EJAC would like to see CARB prioritize emissions reductions in disadvantaged communities.

In the SRIA, CARB describes only one way to ensure direct emissions reductions in disadvantaged communities: no-trade zones. No-trade zones would require that facilities in or near disadvantaged communities be excluded from the emissions trading market and instead meet facility-level emissions reduction targets. CARB rejects this approach because it could require significantly downsizing the cap-and-trade program in terms of allowances supplied, allowances demanded, and revenue and might reduce the program's efficiency.

A different approach to guaranteeing emissions reductions in disadvantaged communities not mentioned in the SRIA is facility-specific emissions caps, which require that emissions reductions at identified facilities in these communities are realized at a pace that meets or exceeds the average statewide rate of reduction. If facilities exceed that rate, they can sell allowances to other facilities outside of disadvantaged communities, keeping facilities in the market and preserving the incentive to achieve additional emissions reductions. That ability to sell allowances distinguishes facility-specific caps from no-trade zones and preserves some of the cost-effectiveness of the cap-and-trade program even while achieving more equitable air pollution.

In a 2023 report (Burtraw and Roy 2023), we examined the impact of facility-specific caps. We calculated the difference between the emissions reductions achieved at facilities in disadvantaged communities and what would have to have been achieved had they reduced emissions at the rate of the cap. We then reduced the overall cap by the number of additional allowances that the facilities in disadvantaged communities would otherwise have used. This prevents reductions in disadvantaged communities from being negated by increased emissions elsewhere—a waterbed effect concern identified by EJAC—while still preserving the incentive for these facilities to reduce their emissions and sell allowances. We estimated a reduction in supply of about 0.7 percent from the annual emissions budgets in the current regulation would be sufficient (Burtraw and Roy 2023). We modeled this reduction of the cap in Haiku and found that it would have little impact on the allowance price.

In this modeling effort, we applied the same quantity adjustment to supply from the 2023 report to all currently proposed SRIA budgets and reexamined the price impacts of the facility-specific caps policy. Although this does not lead to proportional reductions relative to the new budgets, it does preserve the proportional reductions under the current regulation.

7.1. Results

The allowance adjustment that is required to implement facility-specific caps so as to preserve the program's environmental integrity could be accomplished in two ways. One method would be to implement the reduction in allowances as part of the budget reductions taking place for the emissions inventory adjustment. If facility-specific caps were implemented and the allowance adjustment was seen to address the waterbed concern, then changes in emissions outcomes across the state would remain the same, but where they occurred would be different, and allowance prices would be identical to those in the main results (Figure 7).

A second method for implementing facility-specific caps would be to reduce the nominal cap in addition to reductions currently considered in the 48% scenario. We estimate the impacts of this approach to facility specific caps in Table 2. This is the method which we consider from this point forward.

Replicating our analysis from 2023 with the new SRIA budgets, facility-specific caps are estimated to increase prices 1.5–2.8 percent on average across scenarios. When prices were already on a price step (price floor, APCR, price ceiling, or even the ECR described in the previous section), the facility-specific cap has no effect on the price as the reductions in supply and demand do not shift the equilibrium from the price step.

Table 2. Cumulative Market Impacts of Facility-Specific Caps Under the Scoping Plan (SP) and Delayed Scoping Plan (DSP) Demand Scenarios for the SRIA Options 2025-2030

	Average annual price change (%)		Cumulative emissions reductions (MMT)		GGRF revenue change (billion 2024$)	
Scenario	SP	DSP	SP	DSP	SP	DSP
48% Target A	2.8%	0.0%	9.9	8.3	0.4	(0.2)
48% Target B	0.0%	2.5%	8.5	10.1	0.1	0.6
48% Target C	0.0%	1.5%	8.5	11.2	0.1	0.3

Note: Graphs similar to those in other sections were generated, but the changes are so small that a table is necessary to convey the differences.

However, when the price is at the price floor, allowance purchasing behavior might increase in the near term (increasing revenues even if the price is the same) to bank allowances for the long-term allowance reductions imposed by facility-specific caps.

Facility-specific caps lead to a small cumulative reduction of emissions of 8.3–11.2 MMT by 2030. Although the climate benefits are small, these would be reductions directly located near or in disadvantaged communities and concentrate the air quality improvement and consequent health benefits in these important areas.

Because fewer allowances are issued, a concern arises that GGRF revenues could go down. This is only true for the 48 percent target A with delayed Scoping Plan demand, the highest-price scenario from the SRIA scenarios we analyzed. In this case GGRF revenues decrease by $143 million because the price path remains the same, as it is contained by the second APCR tier, but allowances auctioned are reduced. However, the price increases in other scenarios offset the allowance reduction for facility-specific caps enough to increase cumulative revenues by $120–461 million 2025–2030. In all cases, changes in revenue are small (hundreds of millions) compared to the changes from the cap adjustments (billions).

7.2. Summary

Facility-specific caps would be more flexible than the no-trade zones described in the SRIA and would minimize the market impacts of implementing policies proposed by EJAC. The implementation could be considered in addition to the current adjustments such that the price increases by less than 3 percent, emissions are reduced by at least 8 MMT, and (if APCR is not triggered), GGRF will usually continue to increase revenue. The emissions reductions, although not substantial in the state's broader climate goals, matter specifically to communities that would experience air quality improvements that would reduce historical inequities. Facility-specific caps bring both reductions in emissions and reductions in uncertainty about air quality improvements benefiting disadvantaged communities.

8. Alternatives to the 48 Percent Target Scenario

CARB proposed six possible cap adjustments in its July 27th workshop, of which the 48 percent target scenario discussed in Section V is only one. These six cap adjustments follow three pathways between 2025–2030 designed to help the state achieve one of three different 2030 goals (40, 48, and 55 percent below 1990 levels; Figure 1). After 2030, the "target" scenarios jump up to the level described in the 2030 goal, while the "budget" scenarios continue on a path to the 2045 goal. In the SRIA, CARB described the macroeconomic and climate impacts of the 40 percent target (Alternative 1[20]) and 55 percent target (Alternative 2[21]) scenarios as suboptimal compared to the 48 percent target. CARB did not evaluate the impacts of the other three budget scenarios proposed in 2023. However, CARB or the legislature may consider changes in allowance supply that differ from the SRIA 48 percent target scenario. We have evaluated the price path, emissions outcomes, and revenue impacts with the same uncertainty of demand that we applied throughout the rest of this report.[22]

8.1. Results

The six cap adjustments offer six levels of program stringency. All raise the allowance price off the price-floor levels that would occur without a cap adjustment. The tighter the cap, the higher the range of allowance prices and the greater the emissions reductions. Figure 16 shows the allowance price across the six cap adjustments under different levels of allowance demand. The 55 percent budget and target scenarios have higher prices than those of the 48 percent budget and target scenarios which in turn have higher prices than the 40 percent budget and target scenarios. The "budget" scenarios also generally have higher price ranges than the "target" scenarios because of their lower cumulative allowance supplies. The APCRs and price ceiling contain prices in the 48 and 55 percent cases.

The six caps reduce emissions more than what would be achieved in the current cap. Figure 17 shows cumulative emissions reductions relative to baseline across the six cap adjustments, including the familiar 48 percent target A. The 55 percent scenarios have the largest additional emissions reductions, and the 40 percent scenarios have the smallest. Because cumulative allowance supply is the main driver of additional cumulative emissions reductions, the 55 percent target and budget scenarios have very similar results as the 48% budget scenario.

20 SRIA, 78

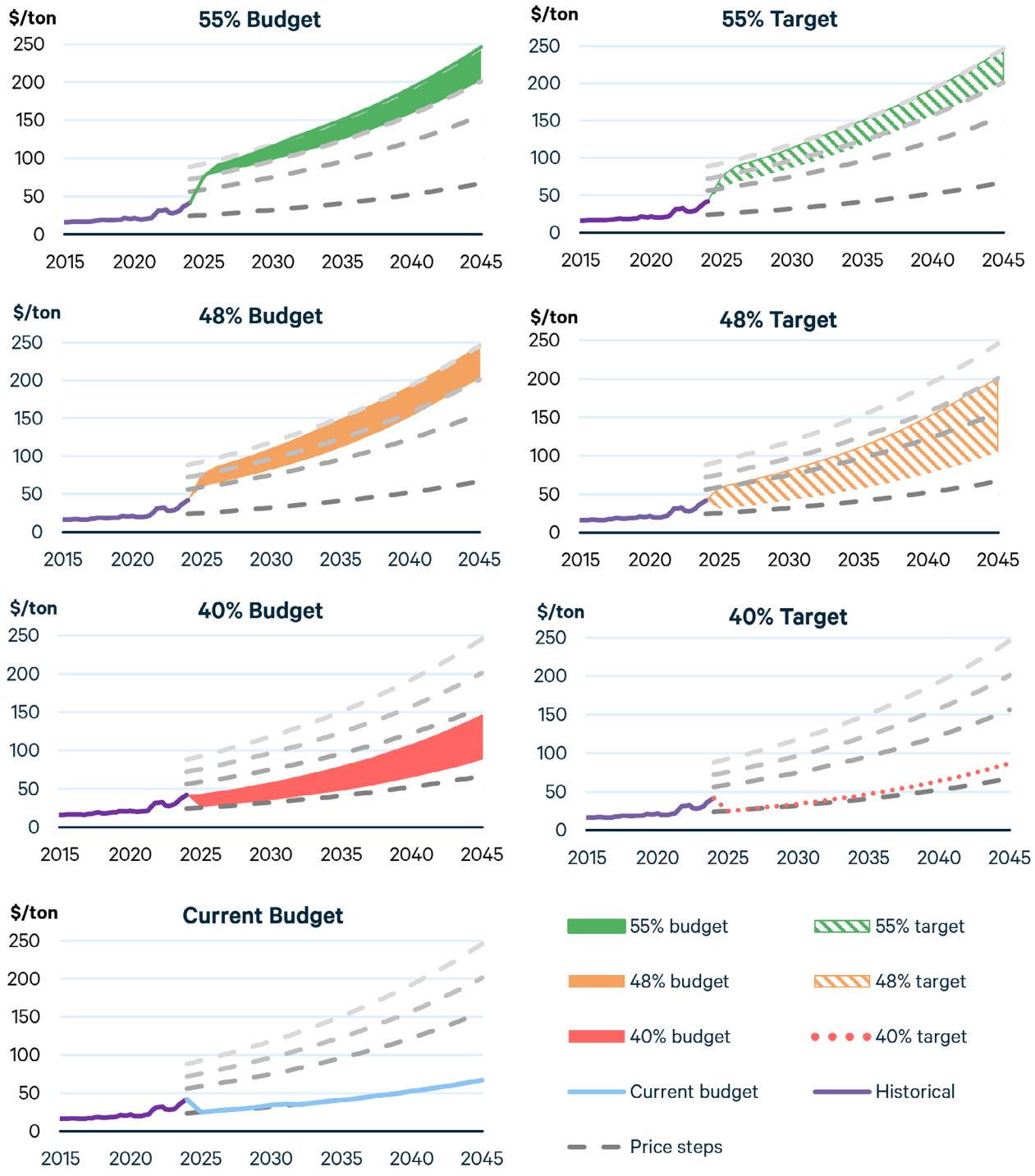
21 SRIA, 85

22 All budgets assume no reductions in the APCR (similar to 48% target A scenario from SRIA) for brevity.

Tightening the allowance supply results in higher allowance prices and higher allowance value in almost all cases. Figure 18 assumes that when supply is reduced, all allowances are taken from the auctioned portion of supply (the "reduce auctioned allowances" scenario described in Section V, distributional impacts), so the quantity of freely allocated allowances to industry and utilities are unchanged. Adjusting the caps this way leaves the GGRF with a falling share of allowances and thus of allowance value even as total GGRF revenue rises. Should CARB reduce industrial and utility free allocation proportional to the cap adjustment factor, then the GGRF can preserve its share of allowances and allowance value even as total number of allowances decrease.

An ECR withholds a portion of annual allowances from the market unless allowance prices reach a predetermined level. Figure 19 shows allowance price ranges for the six budgets with an ECR. For the 48 percent target scenario, the greyed-out portion shows prices no longer achieved at the given demand levels due to the ECR, just as in Figure 13. In the 40 percent budget scenario, a price increase of a few cents in the allowance price occurs for the Scoping Plan demand scenario but is not visible in the figure. The 40 percent target scenario, where the demand sensitivities previously made little difference, now has a higher price with the Delayed Scoping Plan and the price range expands. These higher prices in less stringent budget scenarios make the prices more like the tighter supply paths. The ECR increases prices (and thus also revenues and emissions reductions) for the small cap adjustment scenarios and for the low demand scenarios. The ECR has no effect on prices (or emissions or revenues) when demand is high, or supply is tight.

Figure 16. Allowance Price Ranges Under Alternative Cap Adjustments



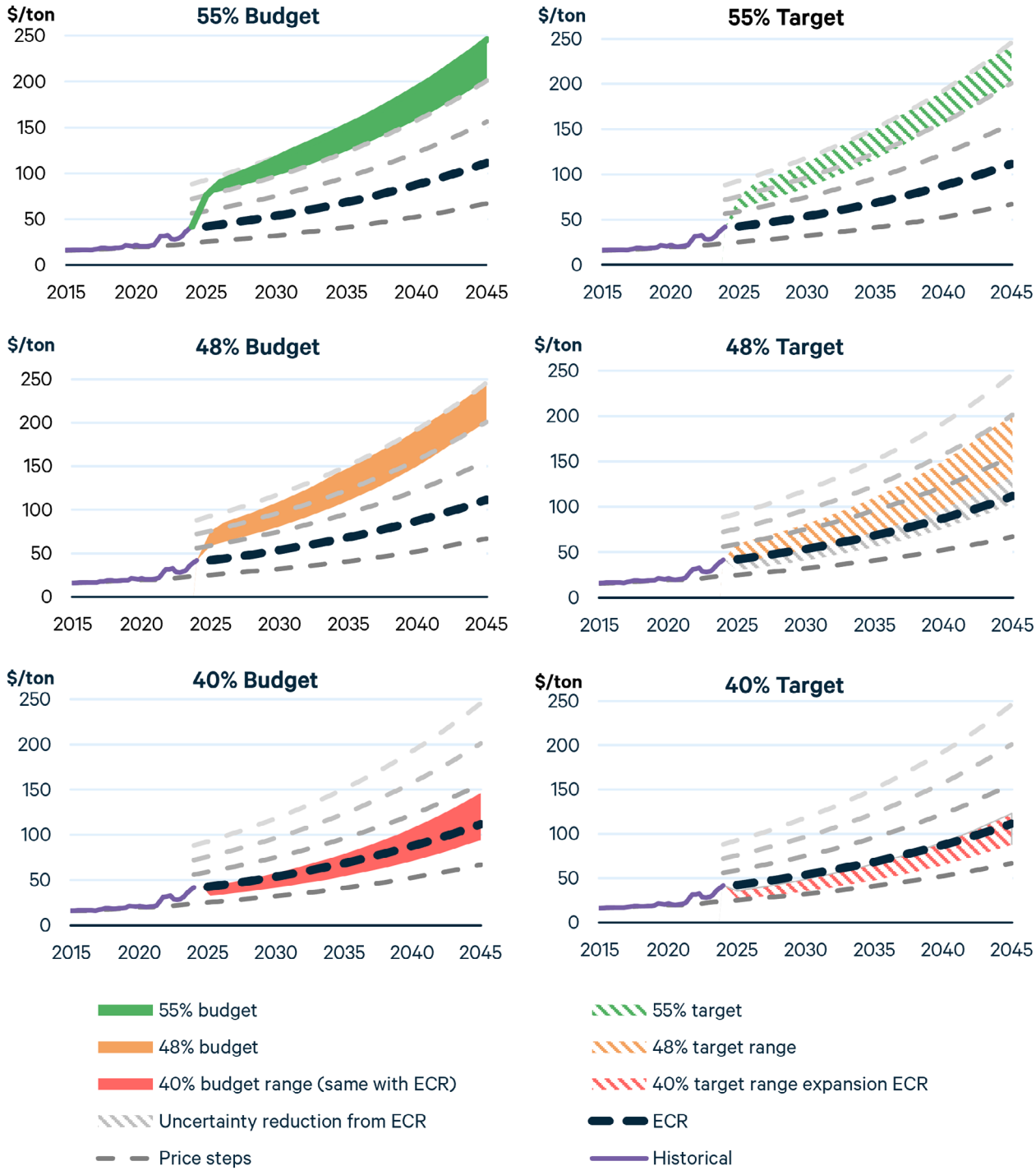
Note: The range of prices has an upper bound set by the Delayed Scoping Plan allowance demand and the lower bound by the Scoping Plan allowance demand.

Figure 17. Emissions Abatement Relative to Baseline Under Alternative Cap Adjustments

Note: The range of emissions reductions is set by the allowance demand from the Delayed Scoping Plan and Scoping Plan demand scenarios

Figure 18. Cumulative Allowance Value Under Alternative Cap Adjustments (2025–2030)

Figure 19. Allowance Price Ranges Under Alternative Cap Adjustments with an Emissions Containment Reserve



Note: The range of prices has an upper bound set by the Delayed Scoping Plan allowance demand and the lower bound by the Scoping Plan allowance demand.

Table 3. Market Impacts of Facility-Specific Caps Under the Scoping Plan (SP) and Delayed Scoping Plan (DSP) Demand Scenarios Under Alternative Supply Scenarios

	Average annual price change (%)		Cumulative emissions reductions (MMT)		GGRF revenue change (billion 2024$)	
Scenario	SP	DSP	SP	DSP	SP	DSP
55% Budget	0.0%	0.0%	7.72	7.71	(0.4)	(0.4)
55% Target	0.2%	-5.4%	7.80	8.07	(0.3)	(1.6)
48% Budget	0.9%	0.2%	8.32	7.75	(0.0)	(0.3)
48% Target	3.3%	0.0%	9.51	7.79	(0.3)	0.4
40% Budget	0.0%	2.3%	8.05	11.50	0.0	0.4
40% Target	0.0%	0.0%	8.05	8.05	0.0	0.0

As was the case across the SRIA budgets, facility-specific caps have only small impacts on allowance prices, emissions, and GGRF revenues across the alternate budgets (Table 3). With tighter budgets, the price increase is much smaller; in the 55 percent target scenario, it actually decreases. Emissions reductions are comparable to those observed under the SRIA budgets, but GGRF revenues decrease for all budgets that are more stringent than the 48 percent target scenario. These market impacts would be even smaller if CARB chose to implement the supply reduction for facility-specific caps as part of the current reductions to allow for a looser cap.

9. Conclusion

In its July 2023 workshop, CARB requested public input on how to achieve the goals of the program amendments at the same or greater benefits. It also noted that the Scoping Plan "relies heavily on new technologies and fuels" that have not been broadly commercialized yet. In October, CARB proposed six possible cap adjustments, the 40, 40, and 55 percent "budget" and "target" scenarios. The SRIA narrowed focus to just the 48 percent target scenario and considered different approaches to implementing that scenario. This report responds to CARB's requests by incorporating uncertainty into the analysis of proposed amendments and alternatives.

This analysis incorporates uncertainties in the Scoping Plan VMT reductions, CCS deployment at refineries, and building electrification. Under these uncertainties, retiring APCR allowances to meet the proposed SRIA reductions leads to more emissions, lower prices, and lower revenues. Alternative amendments, such as the ECR, can ensure emissions reductions and revenues under low demand. Dynamic allowance supply, such as the APCR and potential ECR, provides flexibility in the market that reduces uncertainty in price, emissions reductions, and revenues. Facility-specific caps ensure emissions reductions occur in disadvantaged communities with minimal impact on the market. These findings are robust across stricter budgets that CARB previously considered. Maintaining price-responsive allowance supply mechanisms and ensuring reductions occur in disadvantaged communities can be critical elements to insuring against uncertainty.

This analysis does not include second-order macroeconomic impacts in the state. Job impacts, for example, were discussed in the SRIA but are not highlighted here.

Although this analysis focuses on CARB's current rulemaking, some of its lessons may be useful outside of that context. During the legislative reauthorization process, many of the same questions about the impact of tighter budgets, ECRs, and facility-specific caps are likely to emerge. Moreover, in March 2024, CARB released a joint statement with the government of Quebec and Washington State Department of Ecology expressing a common interest in a shared carbon market across the three jurisdictions. The Washington State Climate Commitment Act (2021) has language about an ECR and avoiding adverse impacts to disadvantaged communities. As these existing carbon markets merge, this report can serve as a resource for the alignment of the programs.

Uncertainty can come from future technological development, macroeconomic conditions, political trends, and regulatory processes. Designing for uncertainty in California's cap-and-trade program can improve its robustness, maintaining the state's status as a climate leader.

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Appendix

Figure A1. Delayed Scoping Plan Petroleum Refining CCS

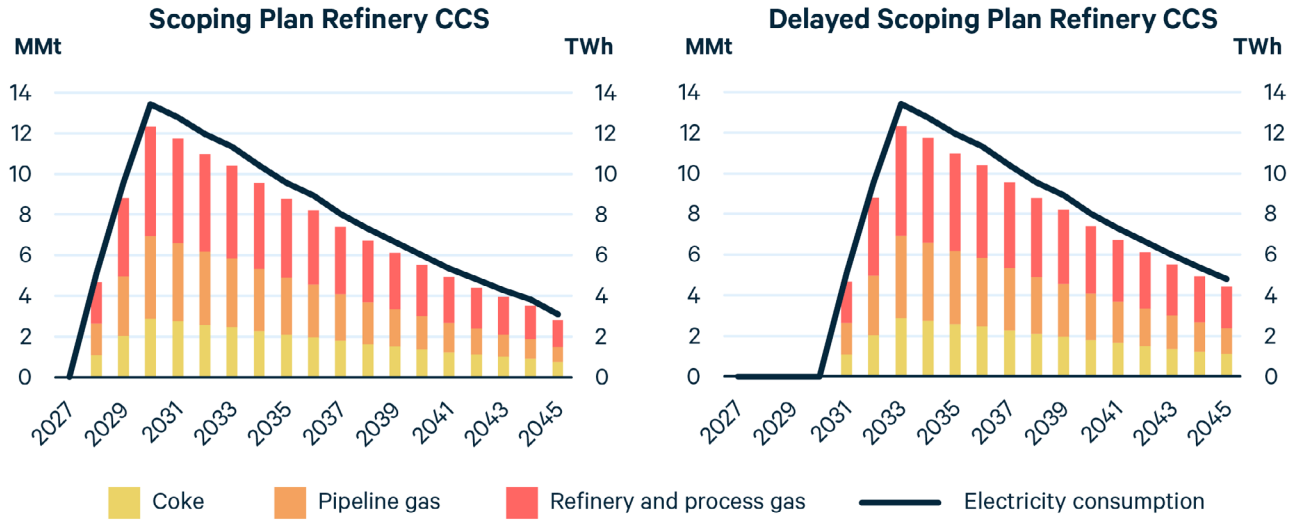

Figure A2. Delayed Scoping Plan Electrification of Buildings

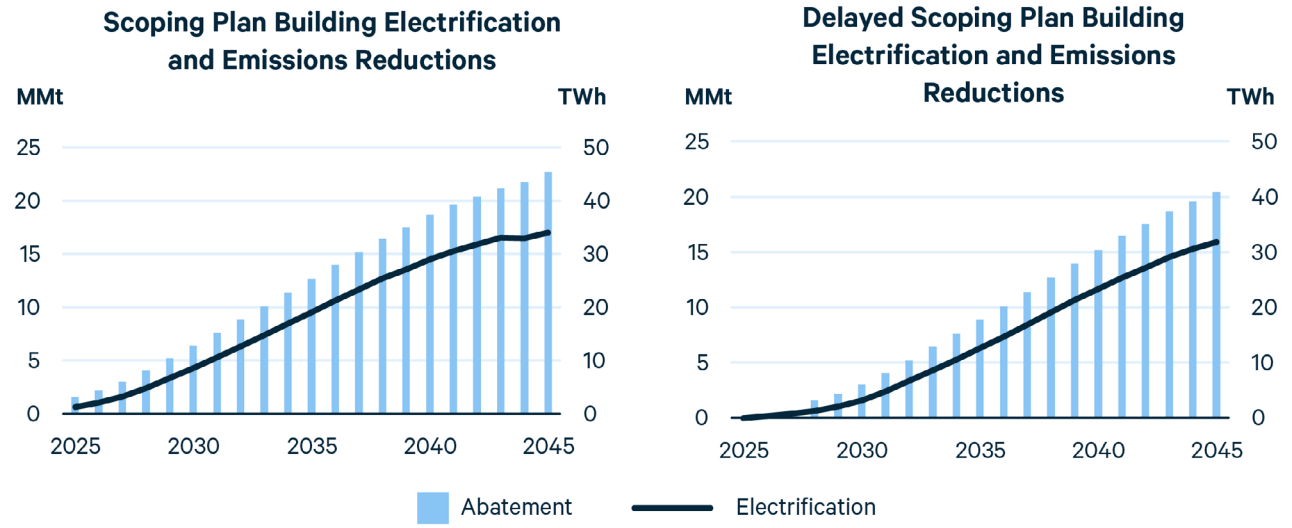

Figure A3. Scoping Plan and BAU/Delayed Scoping Plan VMT per Capita