



Comments on the  
***Joint California-Quebec Workshop: Potential  
Amendments to the Cap-and-Trade Regulation***  
November 16, 2023

Submitted by  
Nicholas Roy, Dallas Burtraw, and Maya Domeshek  
December 15, 2023

# Comments to the California Air Resources Board

We are pleased to share the accompanying comments to the California Air Resources Board in response to the Joint Cap-and-Trade Program Workshop (in cooperation with Quebec) held on November 16, 2023.

The comment authors are researchers at Resources for the Future (RFF). RFF is an independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. RFF is committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy.

While RFF researchers are encouraged to offer their expertise to inform policy decisions, the views expressed here are those of the individual authors and may differ from those of other RFF experts, its officers, or its directors. RFF does not take positions on specific policy proposals. Dr. Burtraw serves on the California Independent Emissions Market Advisory Committee. These comments are not submitted on behalf of the Committee and are not associated with Committee activities.

If you have any questions or would like additional information, please contact us at the email addresses below. Any references cited are available from the authors.

Sincerely,

Nicholas Roy [Roy@rff.org](mailto:Roy@rff.org)

Dallas Burtraw [Burtraw@rff.org](mailto:Burtraw@rff.org)

Maya Domeshek [Domeshek@rff.org](mailto:Domeshek@rff.org)



## Summary of Comments (1)

We consider CARB's options for changes to allowance supply, and three scenarios to characterize allowance demand.

- Business as Usual (BAU) demand from the 2022 Scoping Plan
- Scoping Plan (SP) projection of demand
- Delayed Scoping Plan (DSP) demand, describing three-year delays in CCS, electrification of buildings, and no decline in VMT from BAU levels.

**Allowance prices:** Prices remain close to the price floor with Scoping Plan projections of allowance demand in the less stringent scenarios. Prices rise to the APCR with the 55% Target, or 48% and 55% Budget scenarios.

**Emissions:** Annual outcomes across allowance supply scenarios vary modestly for a given allowance demand scenario, compared to relatively larger differences in the allowance price and banking behavior. Cumulative emissions fall by 1,257 to 1,825 MMt by 2045 across scenarios.

**Allowance Price Containment Reserve (APCR):** Compared to reducing the annual emissions cap, removing and canceling the APCR allowances can have positive or negative price effects. It leads to more sales in the auction that decreases the allowance price.

In scenarios where the APCR would not be triggered, this approach can appear to adjust cumulative allowances without achieving the same emissions reductions.

**Emissions Containment Reserve (ECR):** In a low-price scenario, introducing an ECR can reduce allowance supply and emissions, increase prices, and decrease the size of the bank. The ECR increases revenues to the GGRF and prevents prices and emissions from backsliding.



## Summary of Comments (2)

**Distributional effects:** Various approaches are possible for reducing allowance supply. Under the middle stringency (48% Budget) scenario:

**Reduce auctioned allowances:** This approach would increase revenue to the GGRF compared to the Current Budget by 25% and increase the value of free allocation to utilities and industry by substantially more than 100%.

**Proportional reduction:** Reducing all channels of allowance supply proportionately would increase the GGRF and the value of free allocation by 84% compared to the Current Budget.

**Electricity distribution utilities adjustment:** Across scenarios, free allocation to electric distribution utilities totals nearly 30% of allowance value or equal to nearly 8% of the residential customer rate base in the state. Adjustments to this allocation through rate reductions or targeted investments present opportunities to accelerate electrification.

**Banking behavior:** We find the bank is drawn down before the allowance price reaches the APCR because of the large size of the APCR and our assumption about the opportunity cost of capital. In moderate scenarios a bank remains available through 2045.

**The value of banked allowances:** The value grows in proportion to the allowance price and would more than double under the moderate and stringent scenarios, potentially gaining \$9 billion.



## **The CARB workshop on 11/16/23 described alternative allowance supply pathways and asked for comment on approaches to adjusting allowance supply.**

These comments describe approaches to adjusting allowance supply in the cap-and-trade program to bring the program into alignment with the California emissions reduction goals and updates to the states GHG inventory. The California carbon market is examined in isolation from the linked Quebec market. We present results of modeling conducted with RFF's Haiku emissions market model. We examine variations on the 40%, 48%, and 55% emissions allowance budgets and associated approaches to reduce allowance supply described in the November 16th workshop and those before it.

In brief, the allowance supply adjustments we consider are:

1. Changing stringency in various allowance budget scenarios
2. Program adjustments
  - a. Changes to the Allowance Price Containment Reserve
  - b. Introduction of an Emissions Containment Reserve
  - c. Changes to free allocation for industry and utilities

We resist expressing a preference over program design and use this opportunity to highlight several findings that should be important considerations and, in some cases, to describe important issues that have not been previously discussed.



# Outline

## **1. Model (slides: 7–14)**

- a. Description
- b. Representation of Abatement

## **2. Allowance Supply Scenarios from CARB (slides: 15–17)**

## **3. Approaches to Adjusting Allowance Supply (slides: 19–53)**

- a. A cap reduction
- b. Removal and cancellation of allowances from the Allowance Price Cost Containment Reserve (APCR)
- c. Introduction of an Emissions Containment Reserve (ECR)
- d. Reduced free allocation

## **4. Cumulative Emissions Changes (slides: 54–57)**



# 1. Model

Description of our modeling used to evaluate the cap-and-trade market under different abatement options, sectoral assumptions, and market design

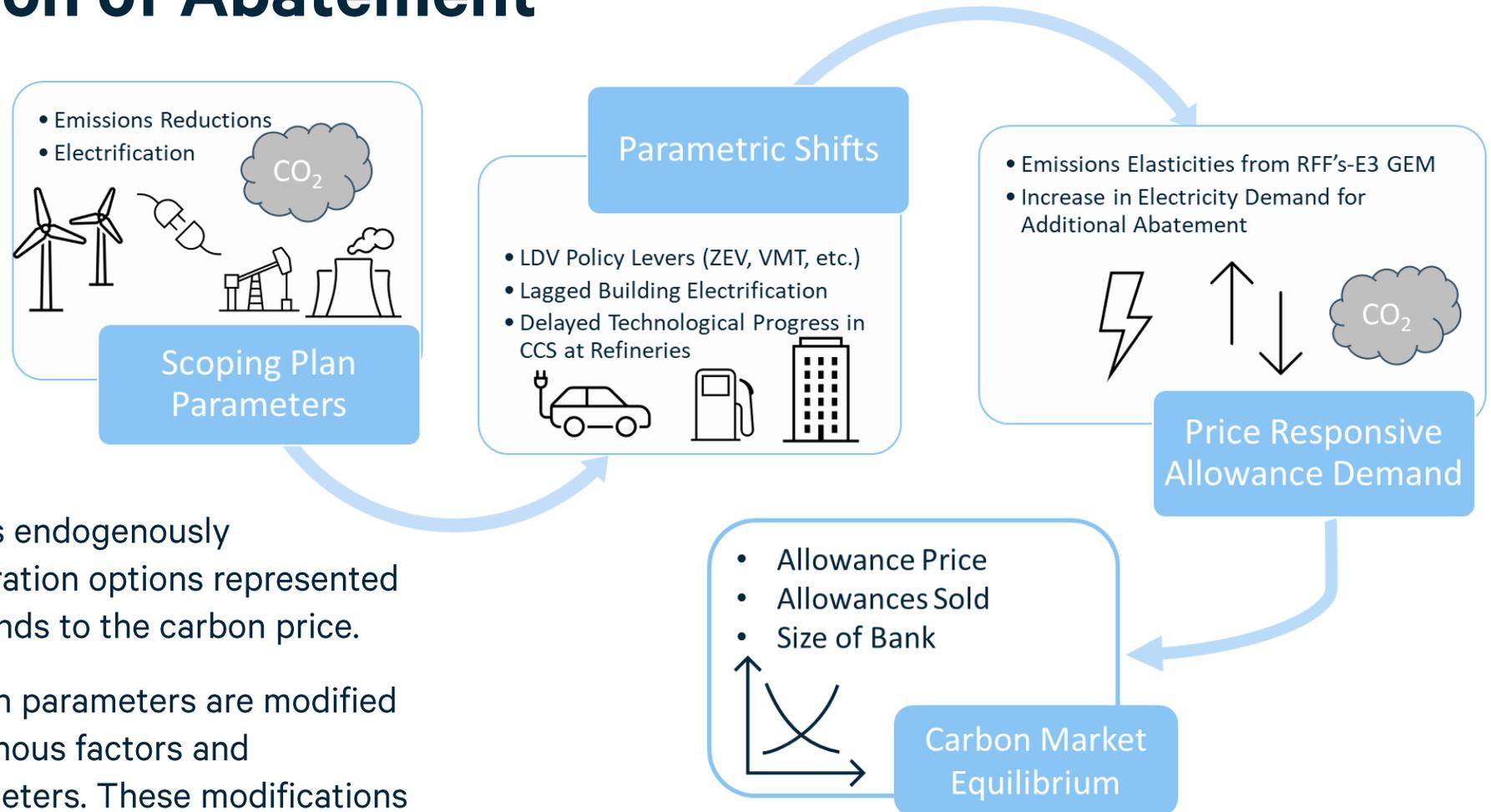


# Description of the Haiku Emissions Market Model

- This project uses Haiku, a power sector linear program capacity expansion optimization model identifying equilibria for 3 seasons, and 8 times of day, for 26 modeled years (2019-2045). Electricity demand is taken from the *Annual Energy Outlook 2023*. The model includes a representation of tax credits for renewable energy and carbon capture and storage from the Inflation Reduction Act. The model also includes federal and state support for nuclear plants, importantly the Diablo Canyon extension.
- The model solves to achieve annual compliance in the California carbon market. The model describes the market including dynamic inter-temporal banking of emissions allowances and price steps at the price floor, allowance price containment reserves, and price ceiling that rise at 5% in real terms. The real opportunity cost of capital is 6% per year, which governs inter-annual changes in the allowance bank.
- The Haiku model is built out with simple representations of transportation, buildings, and industry sectors. We apply sectoral emissions pathways drawn from the 2022 Scoping Plan. Elements of uncertainty are examined in scenario analysis to consider technologies and companion policies in the state that affect emissions.
- Alternative emissions pathways in each sector are implemented through exogenous adjustments to technologies and other assumptions. These adjustments affect emissions directly, and feed back to affect emissions indirectly through changes in the carbon market equilibrium price. Representation of the elasticity of sectoral emissions to the carbon price and related electrification are drawn from a computable general equilibrium model.



# Representation of Abatement



**Electricity sector** abatement is endogenously determined with detailed generation options represented in the model. Abatement responds to the carbon price.

For **other sectors**, Scoping Plan parameters are modified with assumptions about exogenous factors and implemented as shifts in parameters. These modifications are supplemented with sector-level abatement elasticities that affect allowance prices and electricity demand.



# Uncertainty in allowance demand is represented through alternative technology and policy pathways.

Examples of uncertain outcomes include changes in electricity demand, fuel prices, hydropower availability, and other resource specific sensitivities. Additional sectoral policies include electric vehicle mandates or a clean heat standard.

In these comments, we consider **three scenarios** to characterize allowance demand. The first two are taken from the 2022 Scoping Plan and are described in more detail below:

## 1. Business as Usual (BAU)

## 2. Scoping Plan (SP)

The third allowance demand scenario is constructed by modifying the Scoping Plan scenario projections to account for three of the many forms of uncertainty that are likely to influence market outcomes.

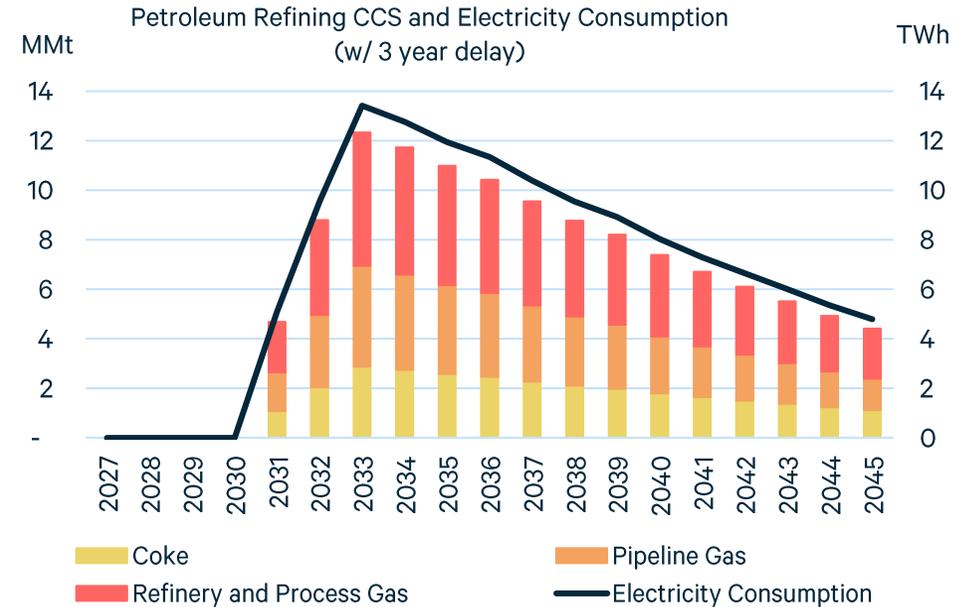
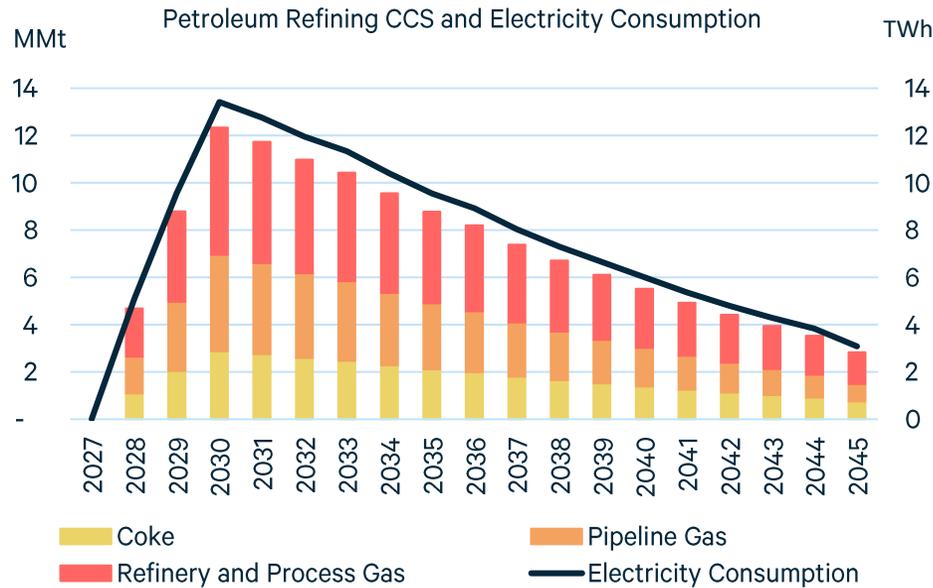
## 3. Delayed Scoping Plan (DSP)

- We examine uncertainty in technological progress by varying the Scoping Plan assumptions about the availability of carbon capture and storage at refineries.
- We also examine sector progress, which could be affected by the introduction of alternative policies or the performance of existing policies that might be observed by building electrification or different changes in vehicle miles traveled.

These variations on the Scoping Plan are three of many possible outcomes. We summarize these as a shift in the demand for emissions allowances in the model.



# An example of an alternative technology pathway is a delay in the introduction of CCS at refineries compared to Scoping Plan projections.

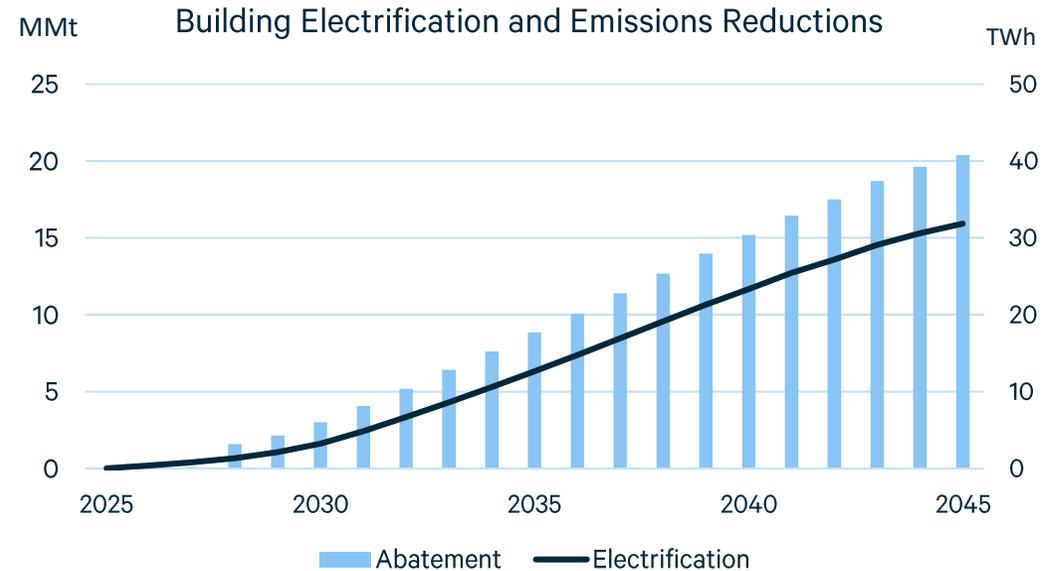
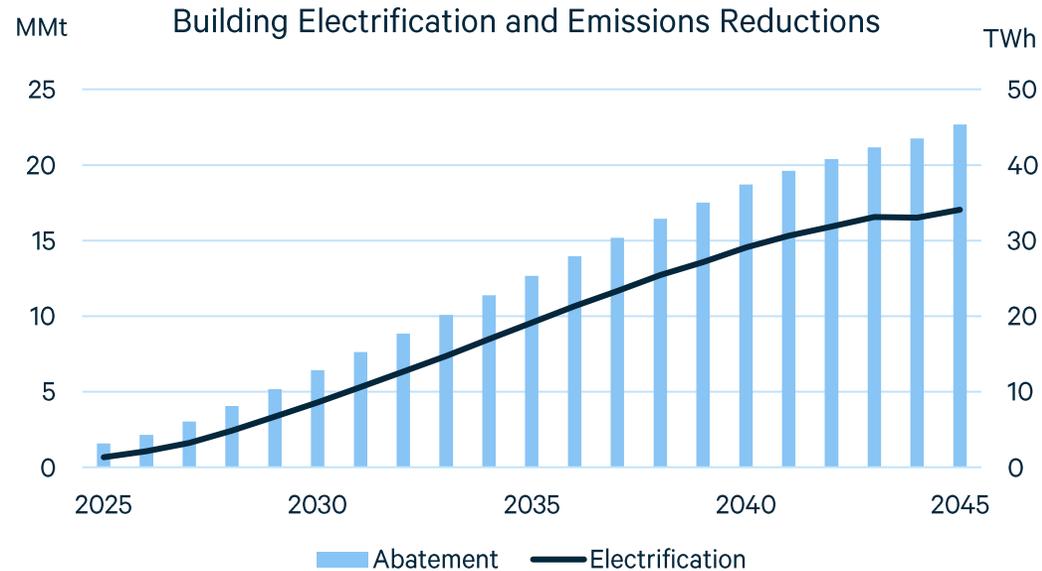


Petroleum refining is characterized as the subsector with the largest adoption of CCS in the 2022 Scoping Plan. We compare the Scoping Plan assumptions (on the left) with a three-year delay (on the right) in the construction and adoption of CCS over the course of the market.

CCS is a developing technology and assuming commercialization prior to 2030 may be relatively optimistic compared to most modeling exercises, even when consideration of the incentives in the Inflation Reduction Act (IRA).



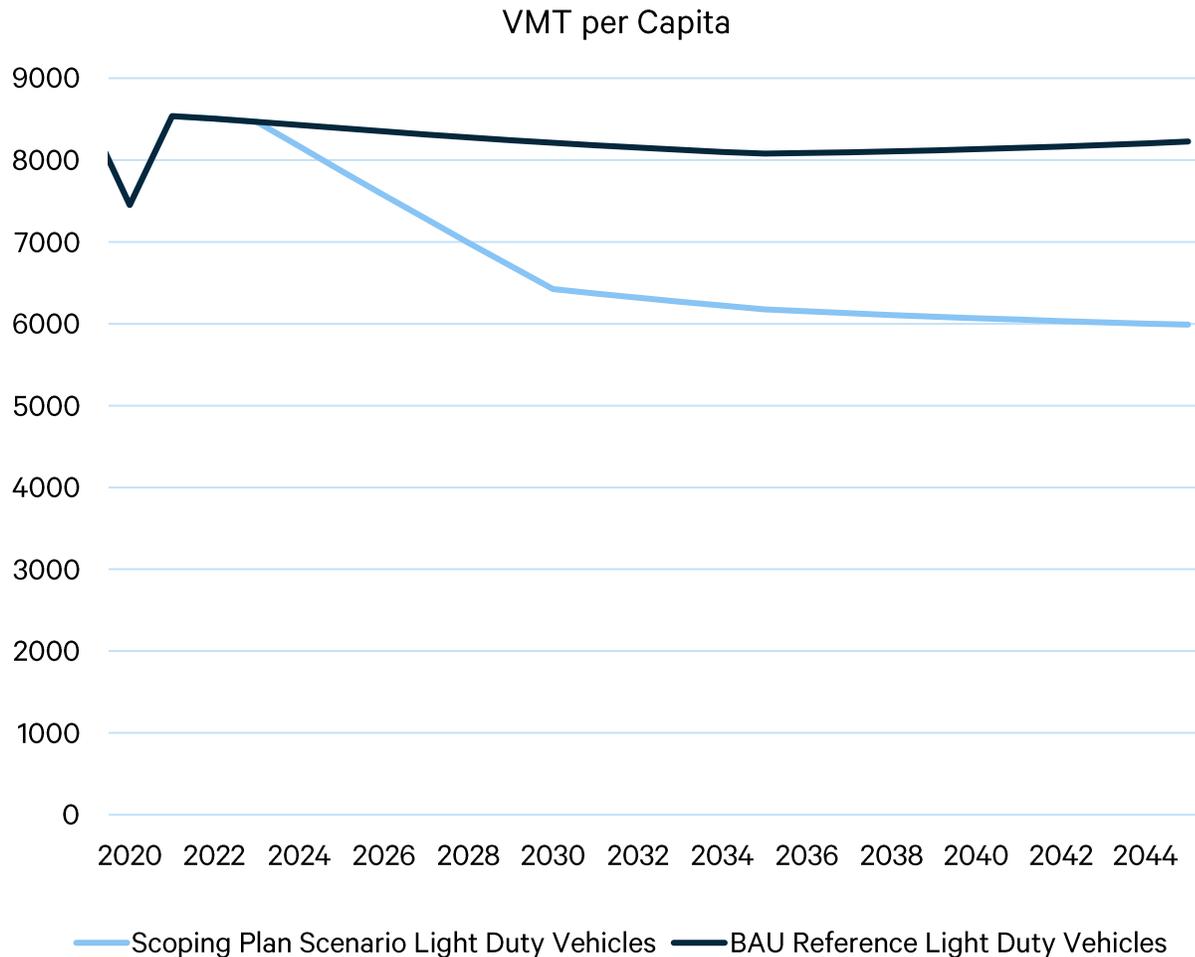
## Similarly, we consider a 3-year delay in the electrification and abatement in the buildings sector



This delay would lead to 65 MMt more emissions from the residential and commercial sectors and about 100 TWh less cumulative electricity demand over the next 2 decades. While California has robust programs for building electrification, it does not have an enforcement mechanism such as a clean heat standard to promote additional building electrification. Residential electricity rates are also relatively higher than other building fuel prices. (We note that these emissions reductions identified in the Scoping Plan do not account for the incentives for building electrification and decarbonization included in the IRA.)



# The Scoping Plan describes an ambitious reduction in Vehicle Miles Traveled (VMT) per capita for Light Duty Vehicles (LDVs)



The Scoping Plan expects Californians to reduce per capita VMT in LDVs by 260 miles by next year and by 2045 annual LDV VMT to reach 6000 miles per person. This is a 27% reduction from the BAU scenario.

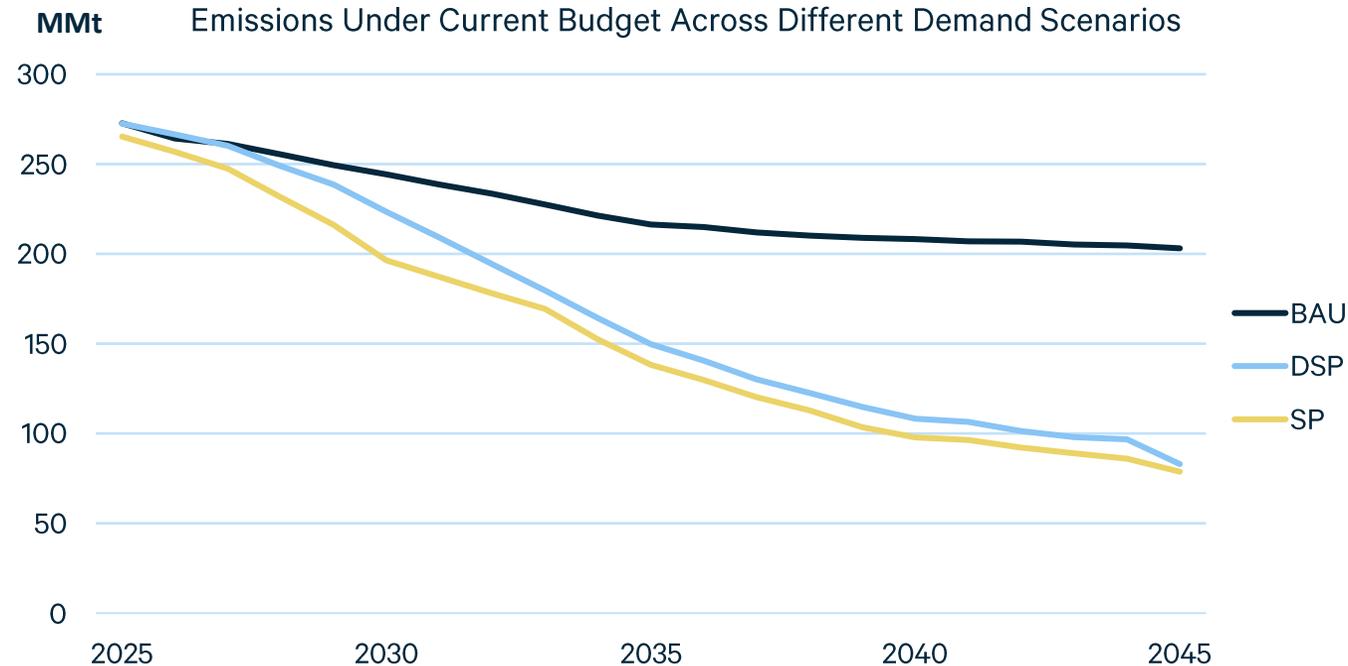
There is no identified enforcement mechanism for achieving ambitious VMT reductions. To represent the possibility that anticipated VMT reductions will not be achieved, we maintain VMT per capita as represented in the BAU scenario. We assume the same changes in the LDV fleet as described in the Scoping Plan.

This VMT scenario accounts for tailpipe emissions but it is not linked back to associated increase in refinery output, which would produce additional demand for emissions allowances.



# Emissions projections under the current allowance supply “Budget”

Carbon market equilibria depend on the interaction of emissions allowance demand and supply. This figure displays the Haiku model projection of emissions outcomes under the current allowance supply “Budget.”



The delay in the realization of the three emissions reduction mechanisms that we describe in our Delayed Scoping Plan (DSP) emissions demand scenario still maintain an emissions pathway close to the Scoping Plan. Nonetheless, these modest variations in emissions demand lead to interactions with the policy mechanisms under consideration.



## **2. Allowance Supply Scenarios from CARB**

Allowance supply scenarios CARB has proposed, modeled, and our additions



# Allowance Supply Schedules Proposed July 27<sup>th</sup>, 2023

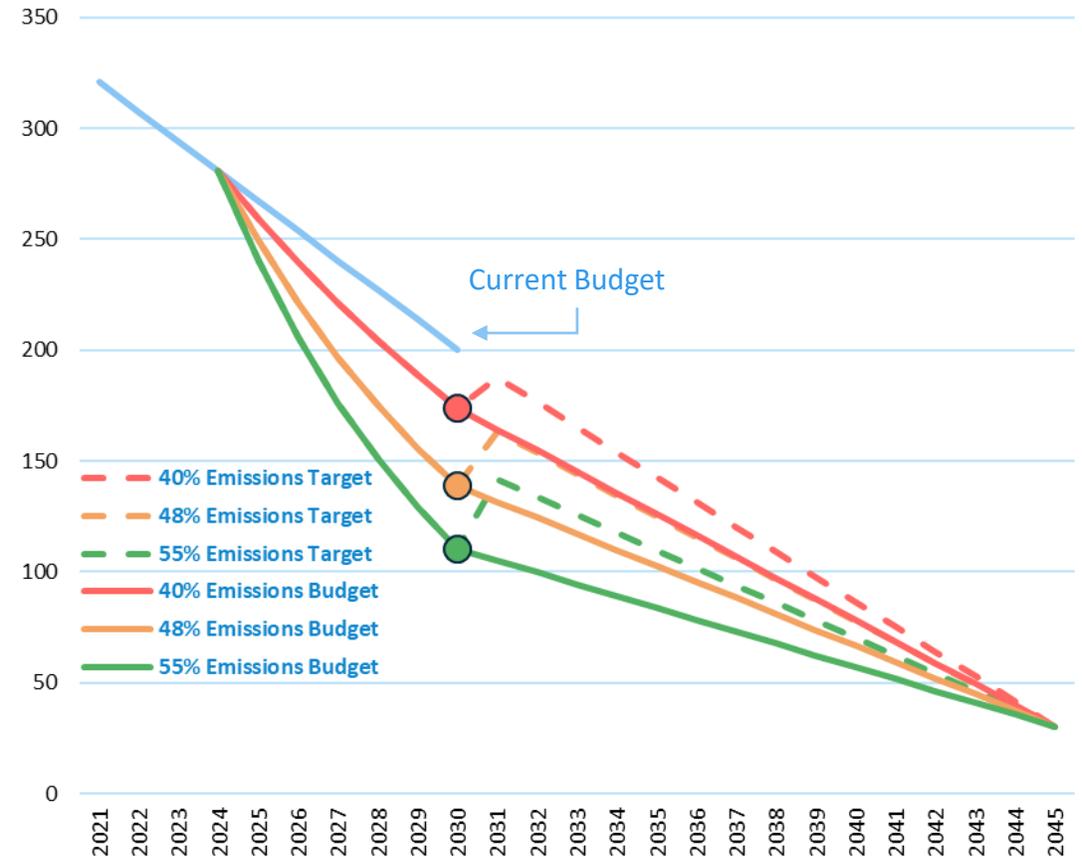
The **Current Allowance Budget** reduces the issuance of allowances (the emissions cap) by 40% by 2030 compared to 2020 levels (-6.7 MMt /year after 2031).

The **2025-2030 Inventory Adjustment** adjusts the current allowance supply schedule to account for updates in the GHG inventory. CARB has outlined the 3 allowance supply pathways for this adjustment of 40%, 48%, and 55% emissions reduction targets by 2030.

**After 2030**, CARB has identified two approaches to identifying an allowance budget, resulting in six potential pathways.

- The **Emissions Targets** approach would reset the allowance budget pathway to the 40%, 48%, and 55% targets for 2030 (after implementing the inventory adjustment by 2030) and continue with a straight line to 85% reduction by 2045.
- The **Emissions Budgets** approach would continue from the adjusted 2030 budgets to 85% by 2045.

Illustrative Allowance Budgets for 2021-2045



## In the 11/16/23 workshop, CARB presented five allowance supply scenarios. RFF modeled these scenarios with alternative approaches to adjusting allowance supply, and with the exogenous changes in allowance demand described above.

CARB modeled five scenarios that were reported in the 11/16/23 workshop:

- Business As Usual (BAU) 40% by 2030 without the inventory adjustment

Other scenarios include an inventory adjustment by 2030

- 40% by 2030 with allowances removed from APCR.
- 55% by 2030 with allowances removed from future budgets.
- 48% by 2030 with allowances removed from future budgets.
- 48% by 2030 with allowances removed from the APCR and remaining necessary adjustment taken from future budgets.

RFF modeled the following scenarios:

- ✓ **All scenarios** described in latest workshop
- + Proposed cap adjustments with the APCR intact
- + Other proposed cap adjustments coupled with APCR adjustment
- + ECR scenario
- + Delays in emissions reductions described in the 2022 Scoping Plan

Additional scenarios that will be reported separately (not in these comments) include higher price ceiling and APCR trigger prices.



# Comparison of Models Examining California’s Future Emissions

	E3-Pathways (Scoping Plan)	Bushnell et al. (CARB Workshop)	RFF’s Haiku Emissions Market Model
Model Type	Technology-economic simulation model	Econometrically estimated simulation model	Technology-economic optimization model
Carbon Market		✓	✓
IRA			✓
CCS	✓		✓
Hydrogen	✓		
Direct Air Capture	✓		
Statistical Variation		✓	
Scenario Analysis		✓	✓
Price-Responsive Behavior		✓	✓



# 3. Approaches to Adjusting Allowance Supply

The mechanisms CARB can use to achieve the inventory adjustments and its goals



# Four Approaches to Adjusting Allowance Supply

In these comments, we investigate four approaches to adjusting the allowance supply.

- a) A **cap reduction** can be described as a change in the annual rate of decline in the cap. Through this decade, that rate of reduction has been approximately 4% per year. This approach assumes no change in the Allowance Price Containment Reserve.
- b) **Removal and cancellation of allowances from the Allowance Price Cost Containment Reserve (APCR) tier 1 and 2 supplies.** These allowances enter the market only if the market price reaches the APCR trigger price level. We do not model a resupply of the APCR after 2030. We do not adjust the price ceiling allowances. Additional reductions in supply that may be necessary are implemented through an additional cap reduction.
- c) **Introduction of an Emissions Containment Reserve (ECR)** would increase the minimum price for a portion of allowances that are available each year. The auction provides a mechanism to identify the price level and enables ECR containment to be implemented instantaneously in the auction, analogous to the reserve price (price floor).
- d) Various channels exist for reducing allowance supply to the market, including **reducing auctioned allowances or reduced free allocation to industry or utilities** with cancellation of those allowances in alignment with a cap adjustment.

The next set of slides examine the first approach, a **cap reduction** that reduces the annual allowance supply.

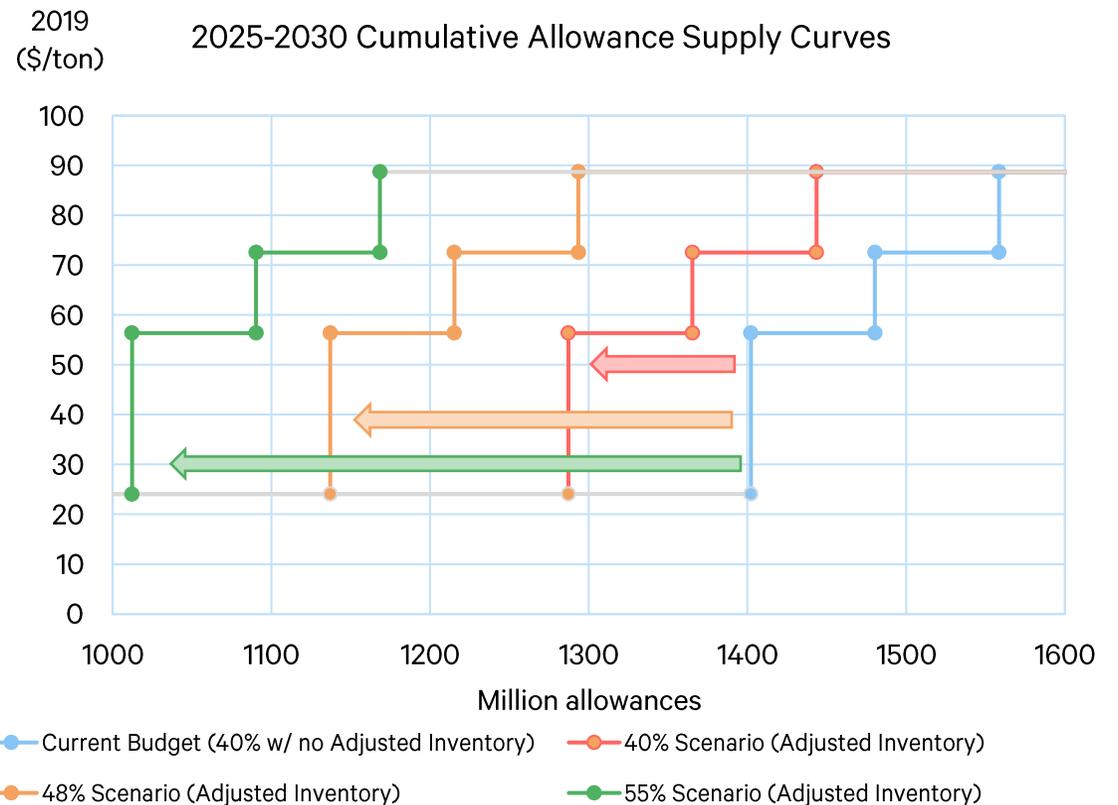


### 3.a: Cap Reduction

## CARB’s alternative allowance supply adjustments consider an adjusted inventory in addition to changes in ambition.

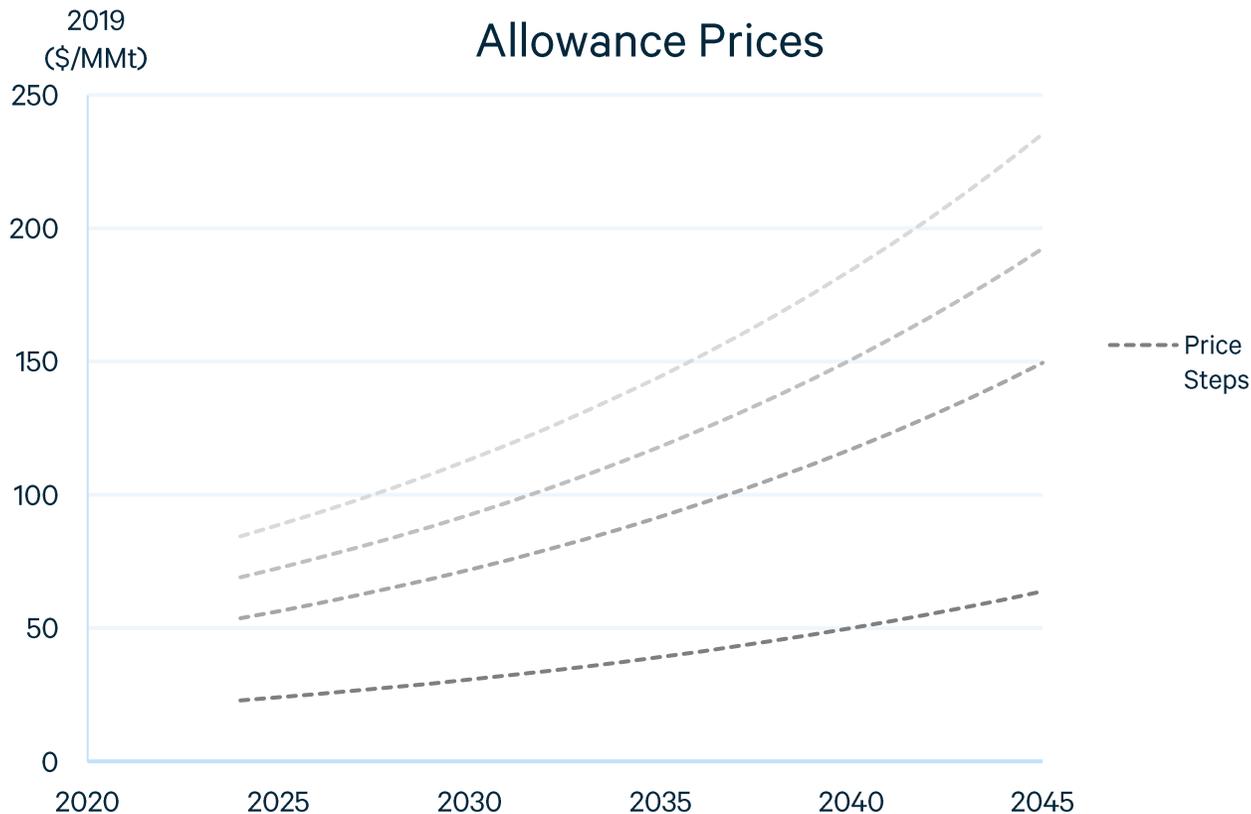
This figure illustrates the changes in cumulative allowance supply from 2025 to 2030, including a representation of price-responsive allowance supply at the price floor, APCR, and price ceiling.

Scenario	Cumulative Supply Reduction (MMt)	Annual % Change in the Budget	% Change in Cumulative Supply
40%	115	-7.6%	-8.2%
48%	265	-11.1%	-18.9%
55%	390	-14.4%	-27.8%



## The market allowance supply is responsive to allowance prices.

The auction withholds allowances if prices fall to the reserve price (price floor). In a separate sale, APCR allowances and reserve allowances available at the price ceiling can enter the market at two fixed price tiers and are bankable but not transferable.

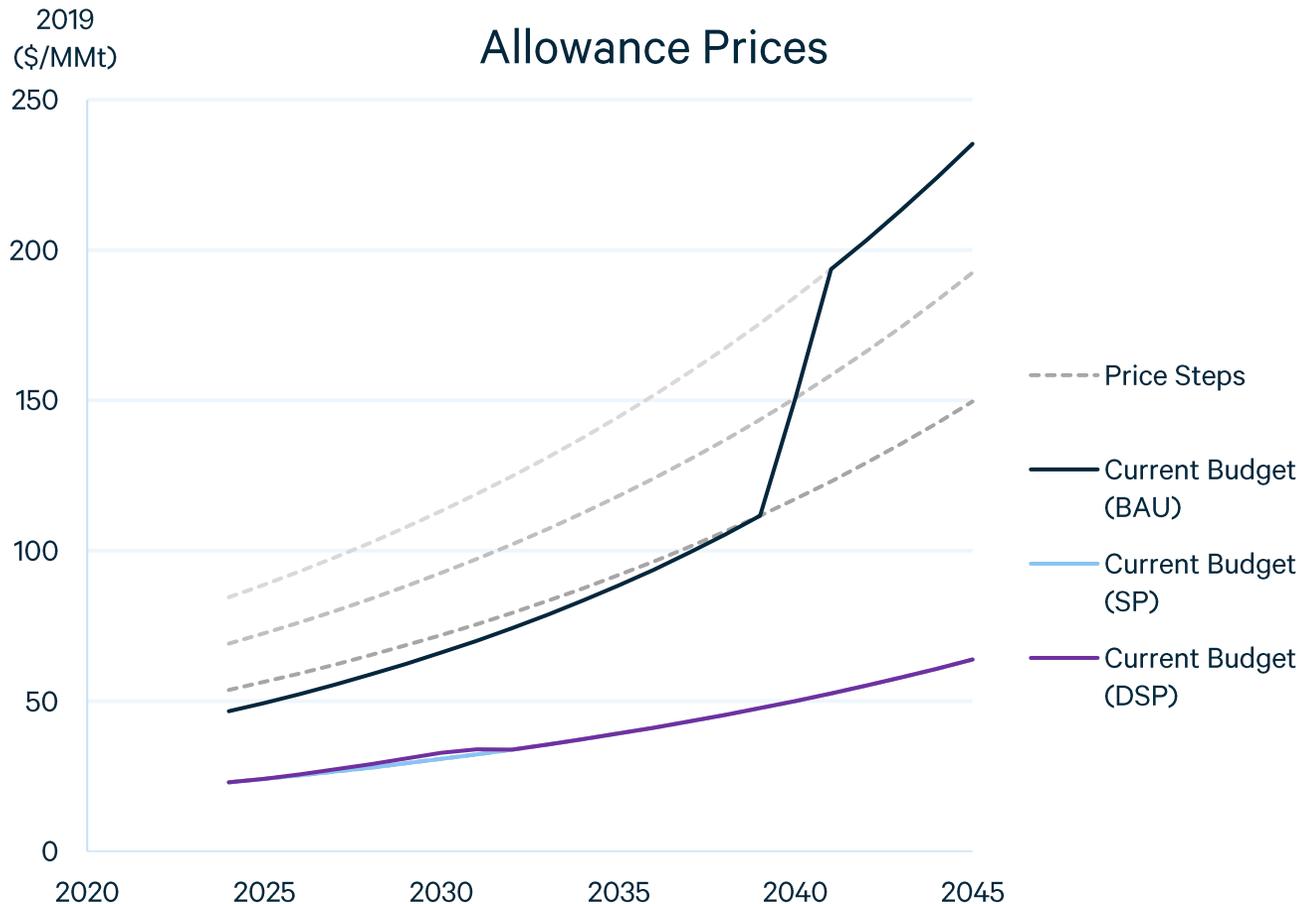


The APCR is populated with approximately 156.3 allowances split evenly across the two tiers. Those allowances are all available at any given sale. The allowance price triggers rise at 5% per year plus inflation.

At the price ceiling, an additional 77.7 million allowances are available. After they are sold, an unlimited supply of nonbankable price ceiling units would be available.



# Allowance demand and allowance supply identify allowance market equilibria.



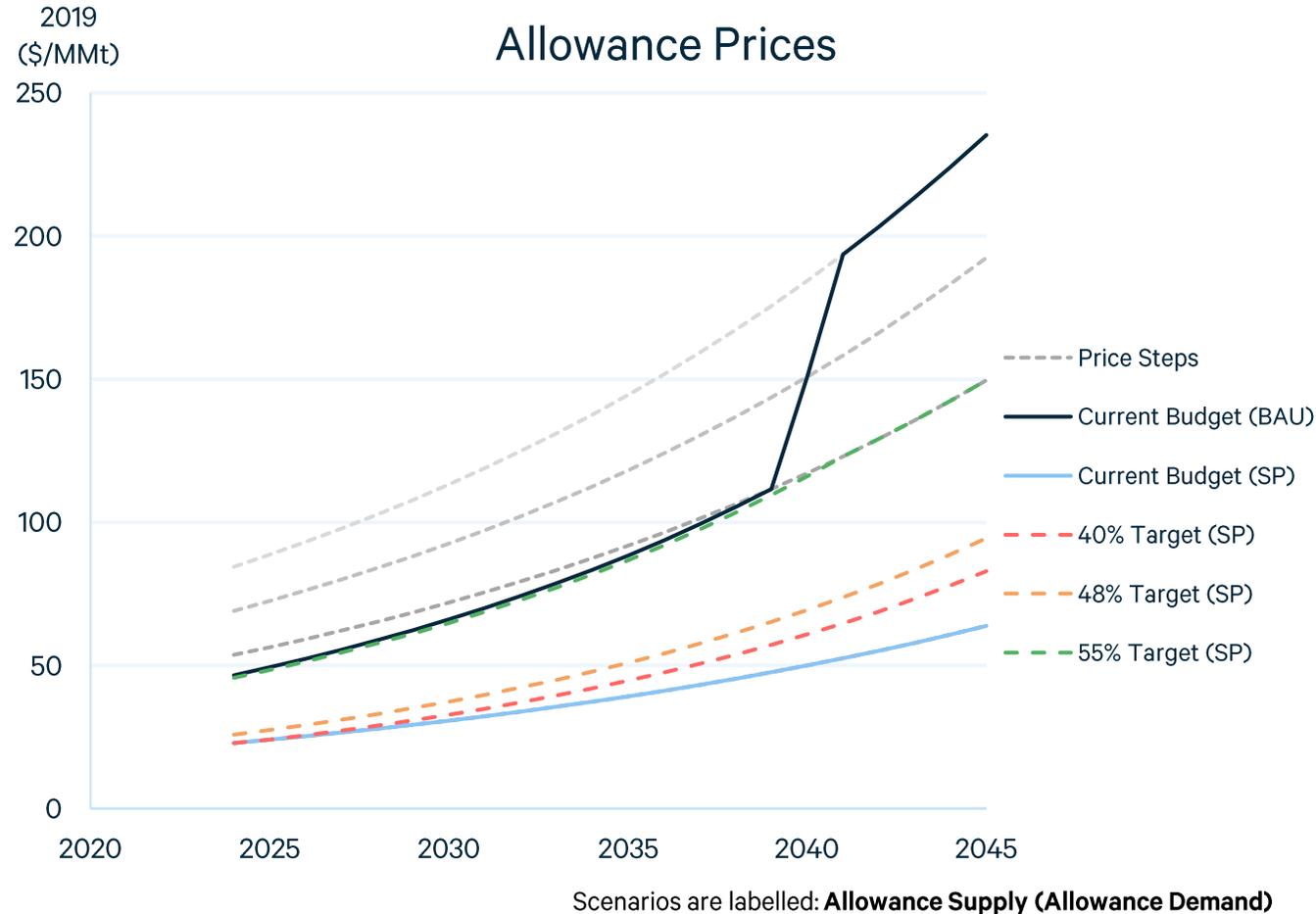
This figure identifies a path of allowance prices under Business as Usual (BAU) and Scoping Plan (SP) representations of allowance demand, given the Current Budget for allowance supply.

In the BAU scenario, the APCR would be triggered by 2038. A few years later, the price ceiling would also be triggered due to high allowance demand.

In the SP scenario, under the current budget, we'd expect prices to be at the price floor and stay at the price floor due to low allowance demand.



## With SP levels of allowance demand, reduced allowance supply in the more ambitious allowance supply scenarios lift the price above the price floor.



The figure shows BAU or SP levels of **allowance demand** coupled with **allowance supply** “target” scenarios that vary in stringency.

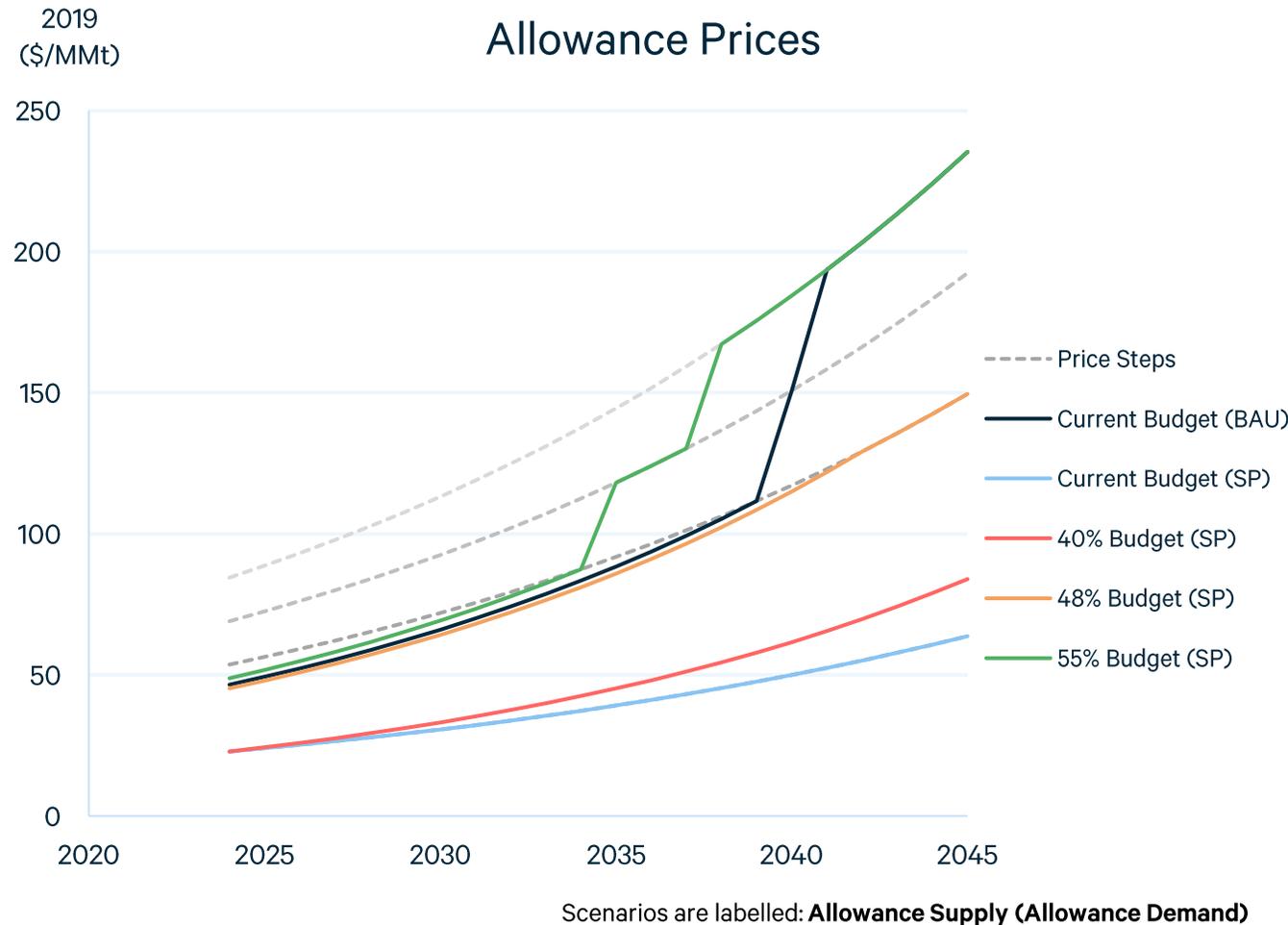
The SP representation of allowance demand coupled with any modeled alternative allowance supply schedule shows higher prices than the SP scenario and lower prices than the BAU.

However, SP description of allowance demand never rises above APCR tier 1 under any “target” allowance supply scenario.

The 55% Target (SP) scenario triggers the first tier of the APCR in 2041.



# Allowance supply “budget” scenarios are more stringent than the “target” scenarios and result in modestly higher price paths.



The figure shows BAU and SP levels of **allowance demand** coupled with **allowance supply** “budget” scenarios.

SP demand coupled with a 40% Budget leads to prices steadily rising above the price floor.

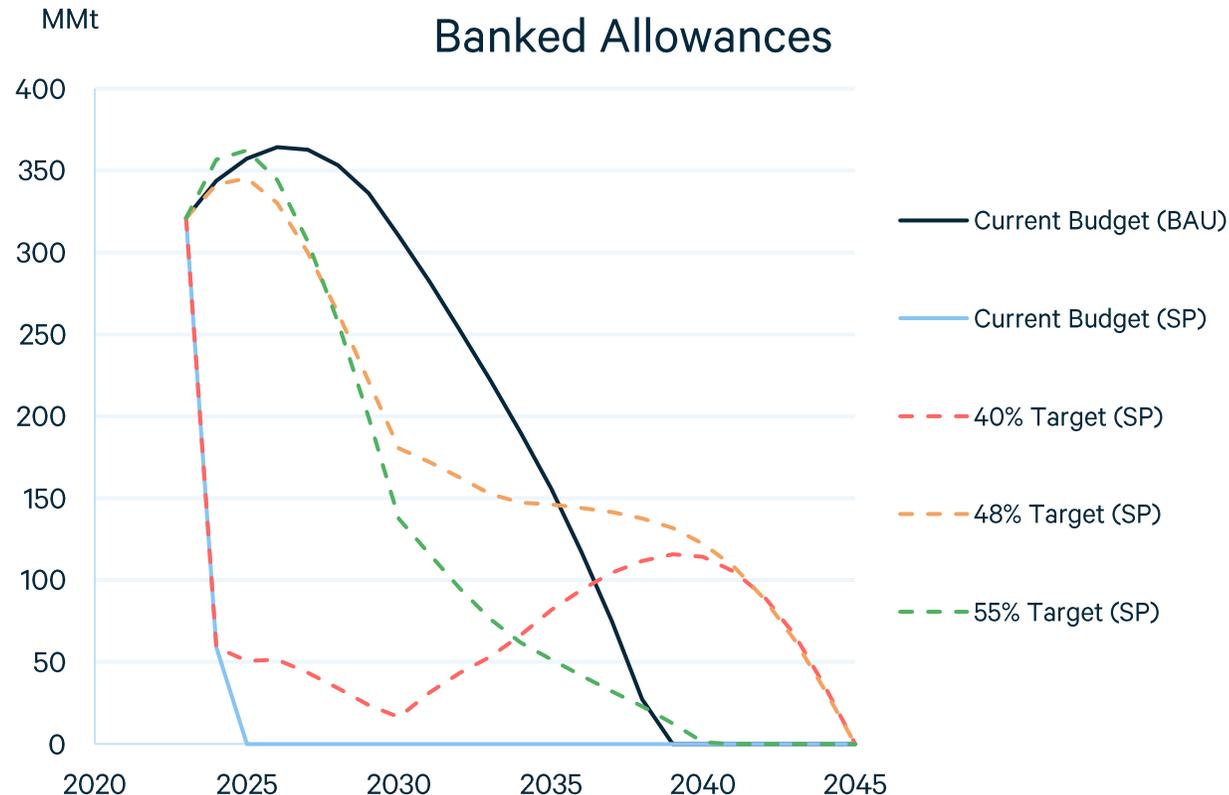
The SP level of allowance demand coupled with the most stringent 55% Budget is the only SP scenario that reaches the APCR tier 2 and ultimately the price ceiling.

The 48% Budget scenario is very similar in price path to the 55% Target scenario, triggering the APCR one year later (2042).



# The size of the allowance bank varies over time across allowance demand and supply scenarios.

Generally, the bank is exhausted before allowances are drawn from the APCR or are purchased at the price floor.



Scenarios are labelled: **Allowance Demand (Allowance Supply)**

The bank is drawn down before reaching the APCR for two reasons.

1. The relative size of the APCR, which is potentially available in a single sale.
2. The opportunity cost of capital (6%) that determines the price path for banked allowances is greater than the annual increase (5%) in the APCR price.

BAU allowance demand coupled with the current budget maintains a large allowance bank until 2039, when the APCR tier 1 is initially reached.

SP allowance demand coupled with the least stringent (40%) allowance supply pushes prices toward the floor, drawing down the bank. In 2030, allowance supply jumps up under the “Target” scenarios, and the bank is rebuilt before being drawn down again.

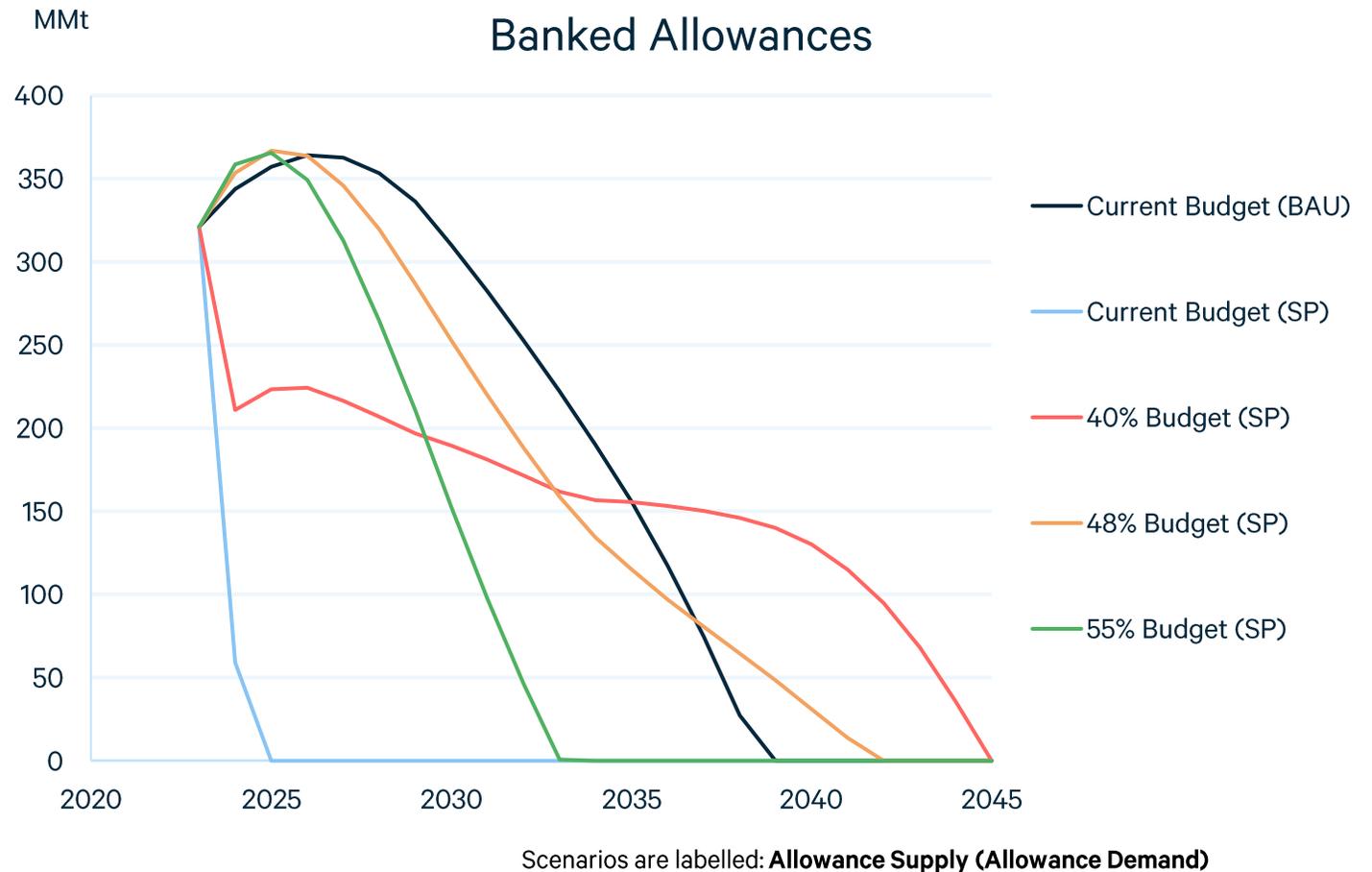


## The relatively more stringent allowance supply scenarios similarly draw down the bank before reaching the APCR price levels.

The SP level of allowance demand coupled with the 40% Budget causes prices to fall to the floor in 2025, drawing down the bank initially. Prices promptly rise off the price floor and the bank is drawn down through 2045.

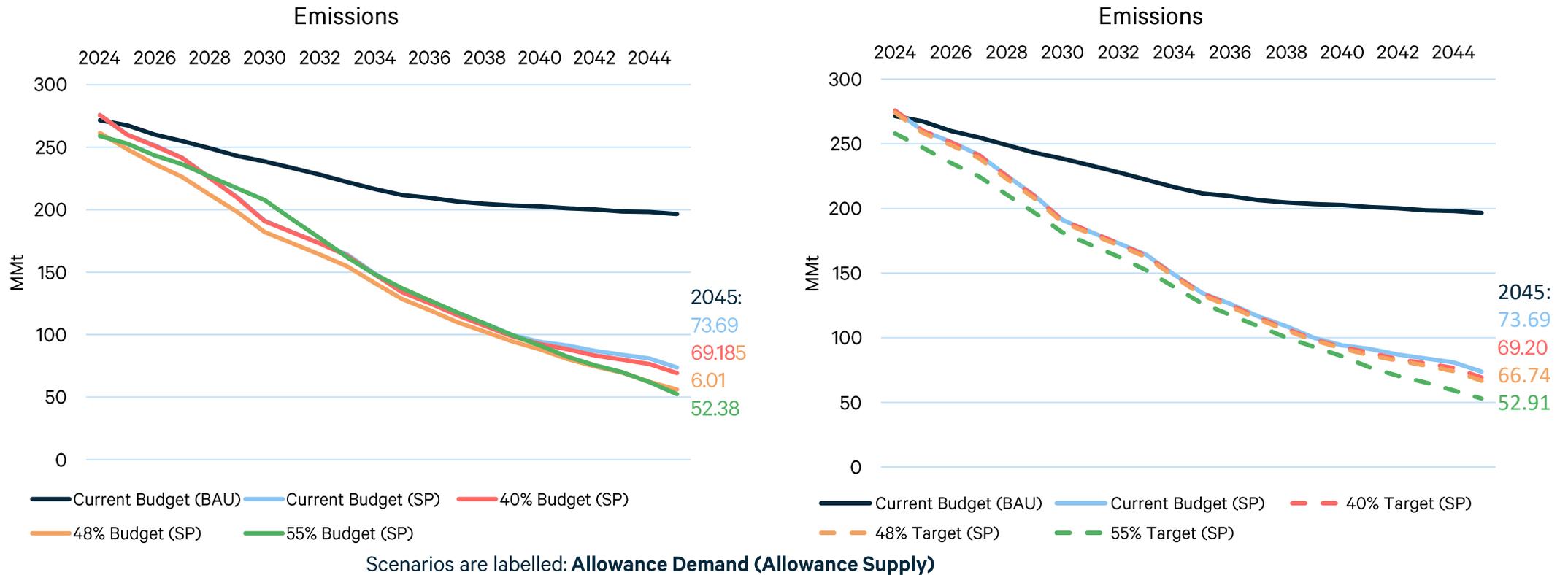
The 55% and 48% Budget scenarios draw down their banks when they reach the APCR tier 1.

Importantly, different banking behaviors reflect changes in the allowance price that are recognized in the first year after a program adjustment and constitute shifts in the value of banked allowances that we examine later.



# Annual emissions outcomes across allowance supply scenarios vary modestly for a given allowance demand scenario, compared to relatively larger differences in the allowance price and banking behavior.

The allowance “Budget” scenarios are more stringent than the “Target” scenarios. Differences in emissions in 2045 result from utilization of the allowance banks.



The Current Budget (BAU) and (SP) scenarios implement the budget in the final 2019 regulation after 2030.



## Summary of outcomes from the allowance supply scenarios

Given SP levels of emissions demand, relatively large variations in the 2030 price result from variations in allowance supply, with direct implications for revenue accruing to the Greenhouse Gas Reduction Fund.

Revenues to the GGRF are greatly affected because we assume in the calculations in this table that there is no change to free allocation from current practice across allowance supply scenarios.

Emissions Demand (Emissions Pathway)	Allowance Supply (Budget)	2030 Emissions* (MMT)	2030 Price (2019 \$/ton)	Annual Average 2025-2030 GGRF** (2019 billion USD)	2030 GGRF** (2019 billion USD)
BAU	Current Budget	244.3	66.06	5.88	5.52
SP	Current Budget	196.5	30.70	2.14	1.98
	40% Target	196.1	32.77	2.24	1.87
	40% Budget	196.1	33.20	2.35	1.89
	48% Target	194.5	37.35	1.81	0.82
	48% Budget	187.5	64.21	3.15	1.42
	55% Target	187.0	64.82	1.97	<0***
	55% Budget	183.7	69.27	2.11	<0***

We revisit alternative distributions of allowance value and the affect on affordability in a later section.

\* Emissions include newly issued and banked allowances used for compliance

\*\* Annual revenue accruing to the GGRF excludes freely allocated allowances which are a pre-determined decreasing quantity in each year

\*\*\* In the 55% budget scenarios, emissions allowances issued in 2030 are less than currently listed free allocation allowances



# Four Approaches to Adjusting Allowance Supply

In these comments, we investigate four approaches to adjusting the allowance supply.

- a) A **cap reduction** can be described as a change in the annual rate of decline in the cap. Through this decade that rate of reduction has been approximately 4% per year. This approach assumes no change in the Allowance Price Containment Reserve.
- b) Removal and cancellation of allowances from the Allowance Price Cost Containment Reserve (APCR) tier 1 and 2 supplies.** These allowances enter the market only if the market price reaches the APCR trigger price level. We do not model a resupply of the APCR after 2030. We do not adjust the price ceiling allowances. Additional reductions in supply that may be necessary are implemented through an additional cap reduction.
- c) **Introduction of an Emissions Containment Reserve (ECR)** would increase the minimum price for a portion of allowances that are available each year. The auction provides a mechanism to identify the price level and enables ECR containment to be implemented instantaneously in the auction, analogous to the reserve price (price floor).
- d) Various channels exist for reducing allowance supply to the market, including **reducing auctioned allowances or reduced free allocation to industry or utilities** with cancellation of those allowances in alignment with a cap adjustment.

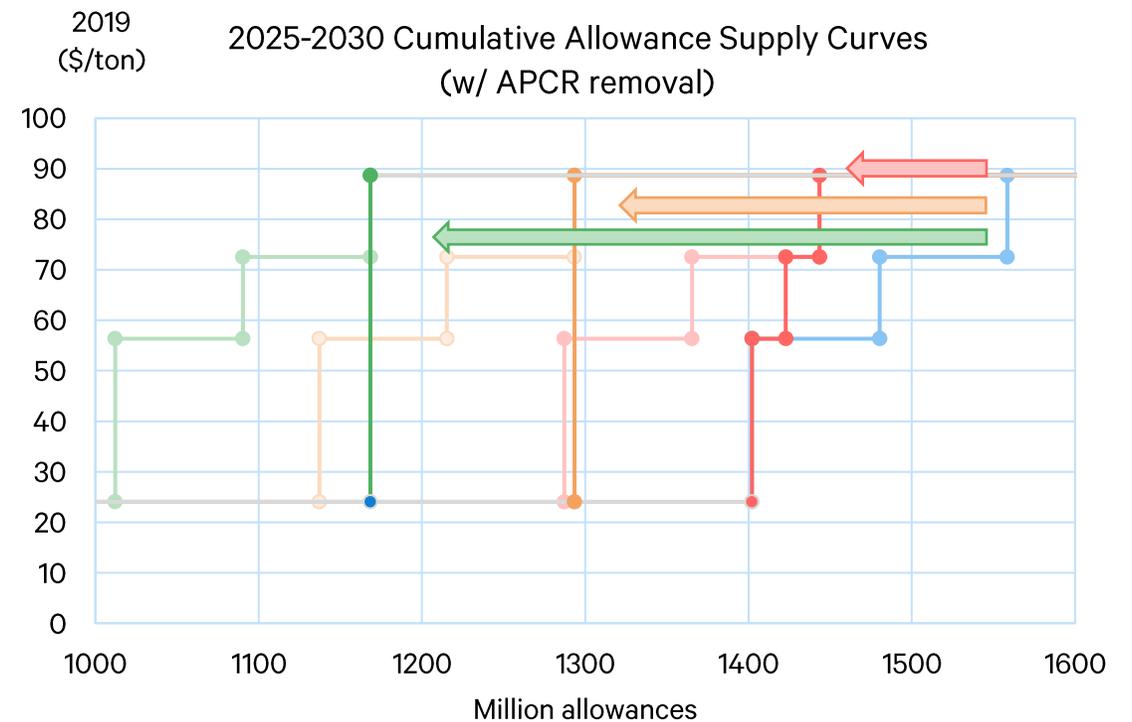
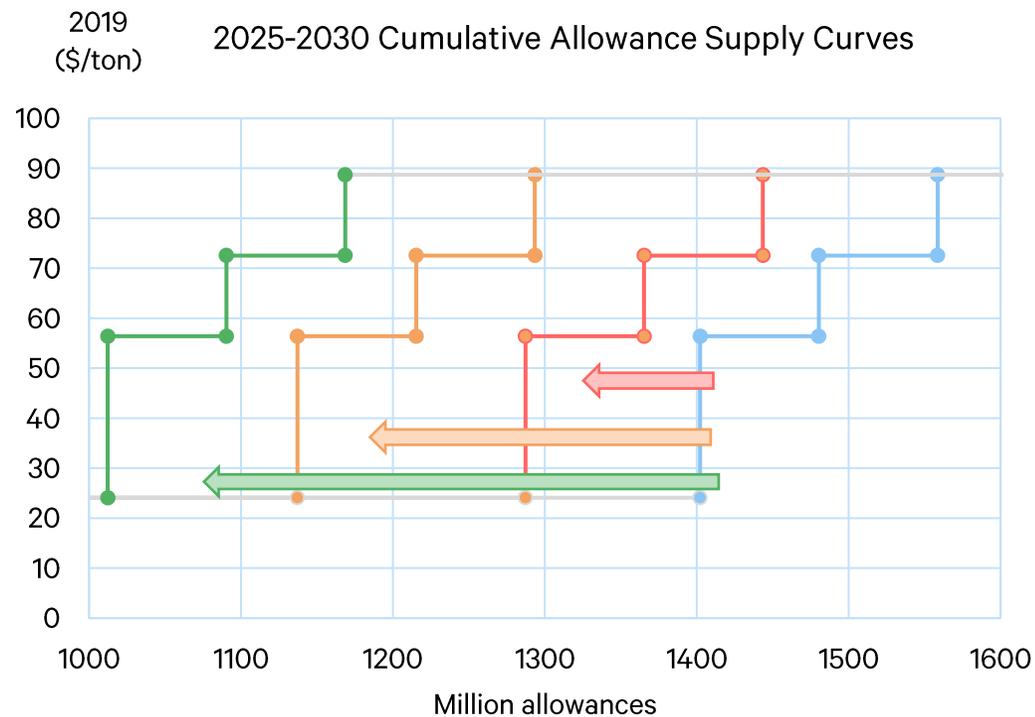
The next set of slides exam the **removal and cancellation of allowances from the Allowance Price Containment Reserve**, with an additional cap reduction if necessary to achieve a given allowance supply scenario.



# 3.b: Removal of Allowances from the APCR

## Removal and cancellation of APCR allowances allows for a smaller cap reduction.

To conceptualize the supply schedule, we first consider a cap reduction to achieve each supply schedule (left panel). Removal of the APCR enables a smaller cap reduction (right panel). Under the 40% scenarios, no additional cap reduction is necessary, and some allowances could remain in the APCR.



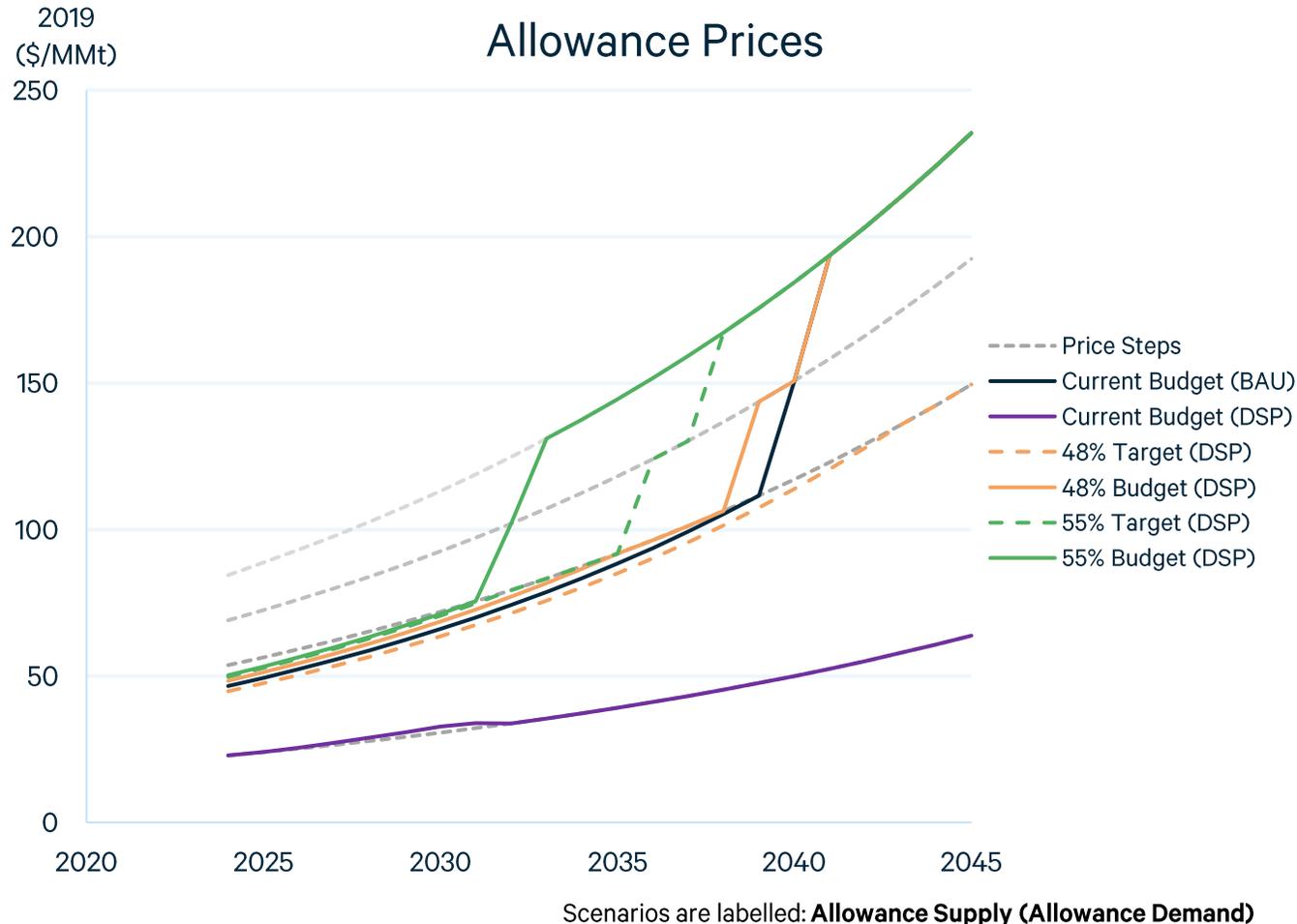
- Current Budget (40% w/ no Adjusted Inventory)
- 48% Scenario (Adjusted Inventory)
- 40% Scenario (Adjusted Inventory)
- 55% Scenario (Adjusted Inventory)

- Current Budget (40% w/ no Adjusted Inventory)
- 48% Scenario (Smaller Adjusted Inventory -APCR)
- 40% Scenario (Smaller Adjusted Inventory -APCR)
- 55% Scenario (Smaller Adjusted Inventory -APCR)



# The APCR can reduce the allowance price under more stringent supply scenarios.

This example represents the **Delayed Scoping Plan (DSP)** allowance demand scenario, which sometimes triggers the APCR when it would not under the SP demand scenario.



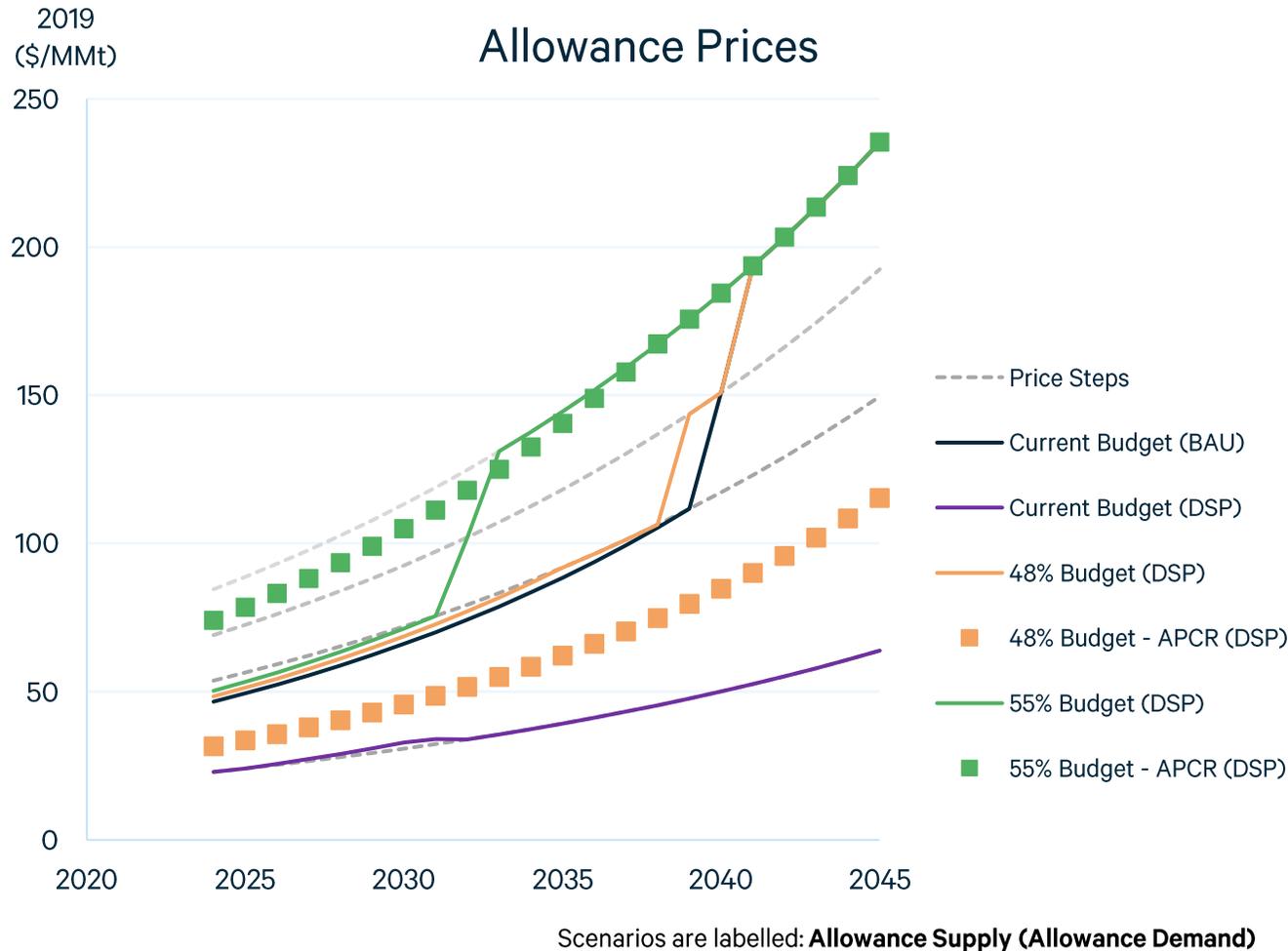
In the SP demand scenario, only the 55% budget scenario triggered the APCR tier 2. Under the DSP scenario all the 48% and 55% scenarios trigger the APCR.

In most scenarios, the DSP scenarios with cap reductions trigger the APCR sooner than BAU demand would trigger the APCR under the current budget.

Removing the APCR in these scenarios could increase the allowance price path due to the inelastic allowance supply. On the other hand, in some scenarios the allowance price could fall because removal and cancellation of APCR allowances allows for greater sales at the auction price.



# Compared to reducing the cap, removing the APCR can have positive or negative price effects.



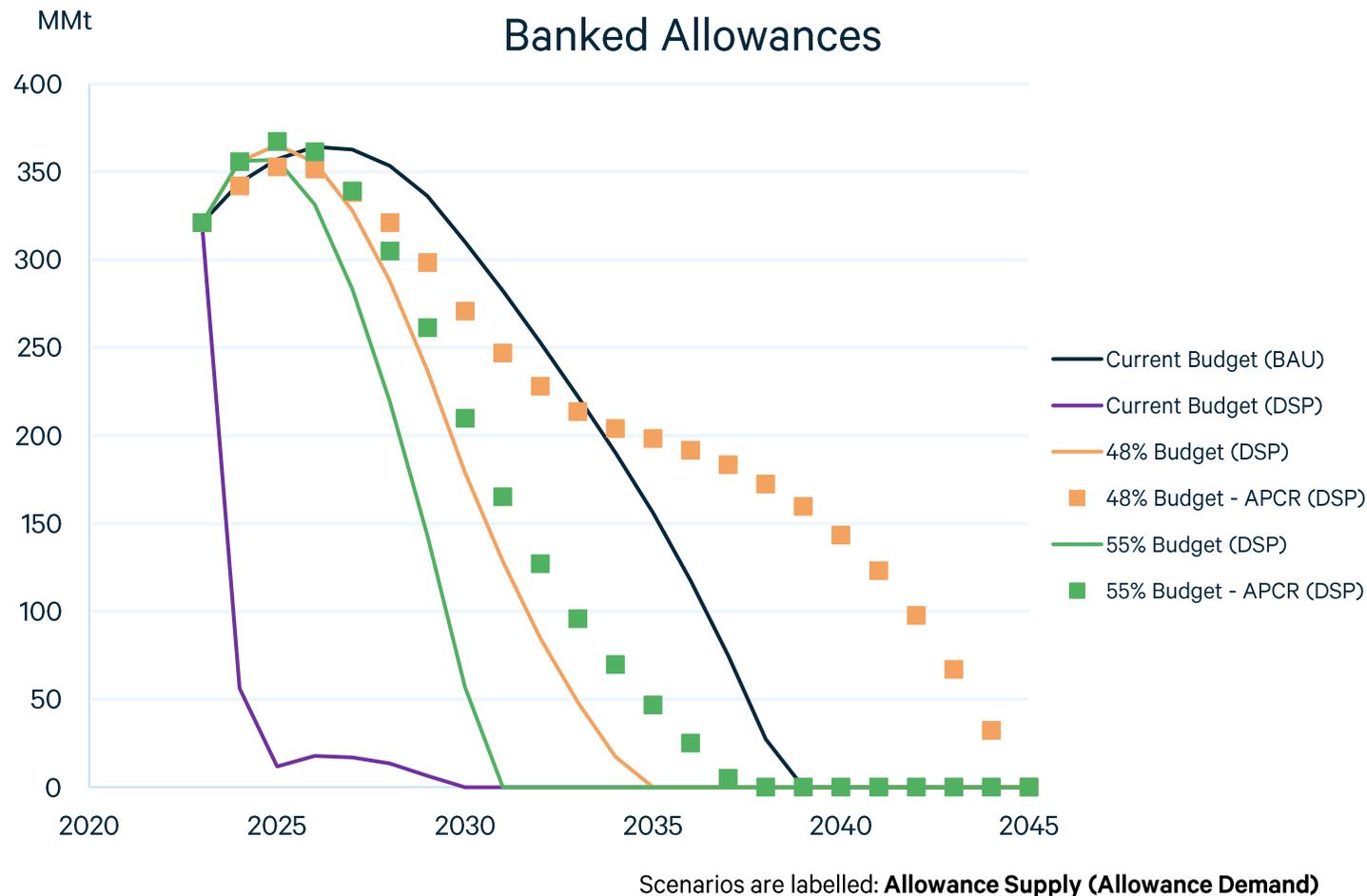
In the 55% budget scenario with Delayed Scoping Plan (DSP) demand, removal of the APCR results in higher prices through 2033 and the price ceiling is not reached until 2038. In contrast, with the APCR, prices are initially lower but jump to the price ceiling in 2033.

In the 48% budget scenario, we see that removing the APCR allows for a less stringent cap and more sales in the auction, that decreases the allowance price.

Scenarios where the APCR would not be triggered at all would lead to reductions in allowance price as well.



## Compared to changing the cap, the differing prices stemming from removal of the APCR leads to increases in banked allowances.

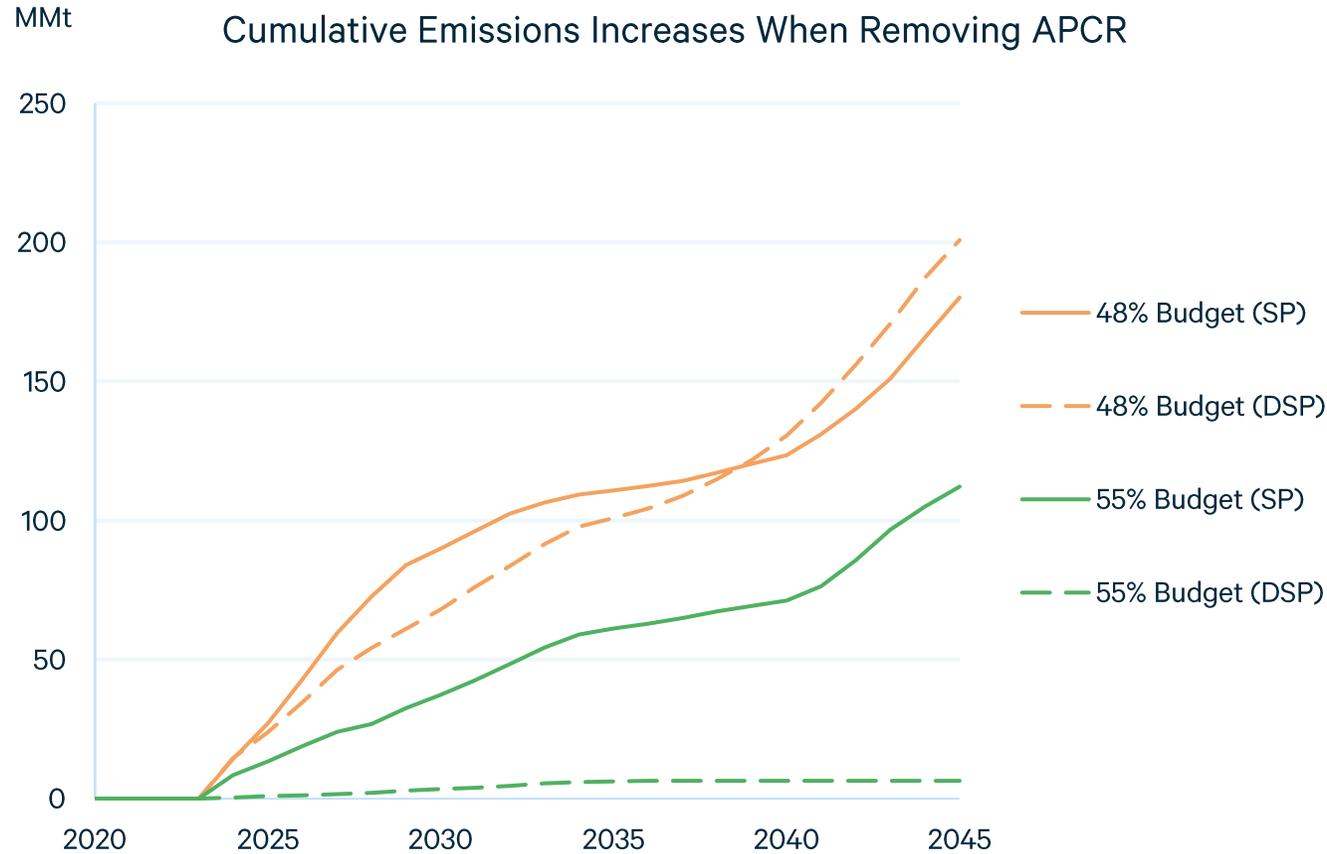


When removing the APCR allowances, there is increased availability of allowances at the cap. This allows compliance entities to purchase allowances that otherwise would have been available at the APCR trigger prices at the auction value and store them in their allowance banks.

In short, the removal of the APCR is the selling of the publicly held bank at the price set in the auction. If the new auction price is higher than the nonexistent APCR trigger price, then government revenues will go up. If the auction settles lower than the previous APCR trigger price, then the allowances are sold at a relative discount.



# Across the budget scenarios and both demand scenarios, we see an increase in cumulative emissions when removing the APCR



Scenarios are labelled: Allowance Supply (Allowance Demand)

When removing the APCR, emissions can be higher in many scenarios because a greater number of allowances are available at the auction value.

In many low-price scenarios, the APCR is not triggered. Consequently, removing and cancelling those allowances can appear to adjust cumulative allowances without achieving the same emissions reductions.

Emissions can also increase in the scenario where the price rises due to the removal of the APCR if banking behavior causes the price to reach the price ceiling earlier, where additional compliance instruments become available.



# Summary of outcomes from removing the Allowance Price Containment Reserve

Compared to reducing the cap, removing the APCR can lead to a higher or lower allowance price. A different price path leads to different banking behavior, and in the scenarios we examine, we see a large bank resulting. High and low-price scenarios can lead to higher emissions and in no scenario have we observed lower emissions. Parenthetical values represent changes from prior row.

Emissions Demand (Emissions Pathway)	Allowance Supply (Budget)	2030 Emissions* (MMT)	2030 Price (2019 \$/ton)	Annual Average 2025-2030 GGRF** (2019 billion USD)	2030 GGRF** (2019 billion USD)
Scoping Plan	48% Budget	187.5	64.21	3.15	1.42
	48% Budget (- APCR)***	193.4 (+5.8)	33.20 (-31.0)	2.38 (-0.8)	1.96 (+0.5)
	55% Budget	183.7	69.27	2.11	<0 ****
	55% Budget (- APCR)***	187.8 (+4.1)	56.94 (-12.3)	3.03 (+0.9)	1.63 (+1.6)
Delayed Scoping Plan	48% Budget	213.4	68.62	3.37	1.51
	48% Budget (- APCR)***	219.6 (+6.2)	45.57 (-23.0)	3.27 (-0.1)	2.69 (+1.2)
	55% Budget	212.9	71.27	2.17	<0 ****
	55% Budget (- APCR)***	213.4 (+0.5)	104.93 (+33.7)	5.64 (+3.5)	3.01 (+3.0)

\* Emissions include newly issued and banked allowances used for compliance

\*\* Annual revenue accruing to the GGRF excludes freely allocated allowances which are a pre-determined decreasing quantity in each year in these scenarios.

\*\*\* Retiring the APCR enables a smaller cap reduction.

\*\*\*\* In the 55% budget scenarios, emissions issued in 2030 are less than currently listed free allocation allowances



# Four Approaches to Adjusting Allowance Supply

In these comments, we investigate four approaches to adjusting the allowance supply.

- a) A **cap reduction** can be described as a change in the annual rate of decline in the cap. Through this decade that rate of reduction has been approximately 4% per year. This approach assumes no change in the Allowance Price Containment Reserve.
- b) **Removal and cancellation of allowances from the Allowance Price Cost Containment Reserve (APCR) tier 1 and 2 supplies.** These allowances enter the market only if the market price reaches the APCR trigger price level. We do not model a resupply of the APCR after 2030. We do not adjust the price ceiling allowances. Additional reductions in supply that may be necessary are implemented through an additional cap reduction.
- c) **Introduction of an Emissions Containment Reserve (ECR)** would increase the minimum price for a portion of allowances that are available each year. The auction provides a mechanism to identify the price level and enables ECR containment to be implemented instantaneously in the auction, analogous to the reserve price (price floor).
- d) Various channels exist for reducing allowance supply to the market, including **reducing auctioned allowances or reduced free allocation to industry or utilities** with cancellation of those allowances in alignment with a cap adjustment.

The third approach we examine **introduces an ECR**, which constrains allowance supply when prices are low. Additional necessary supply adjustments are achieved through a cap reduction.



# 3.c: Introducing and Emissions Containment Reserve (ECR)

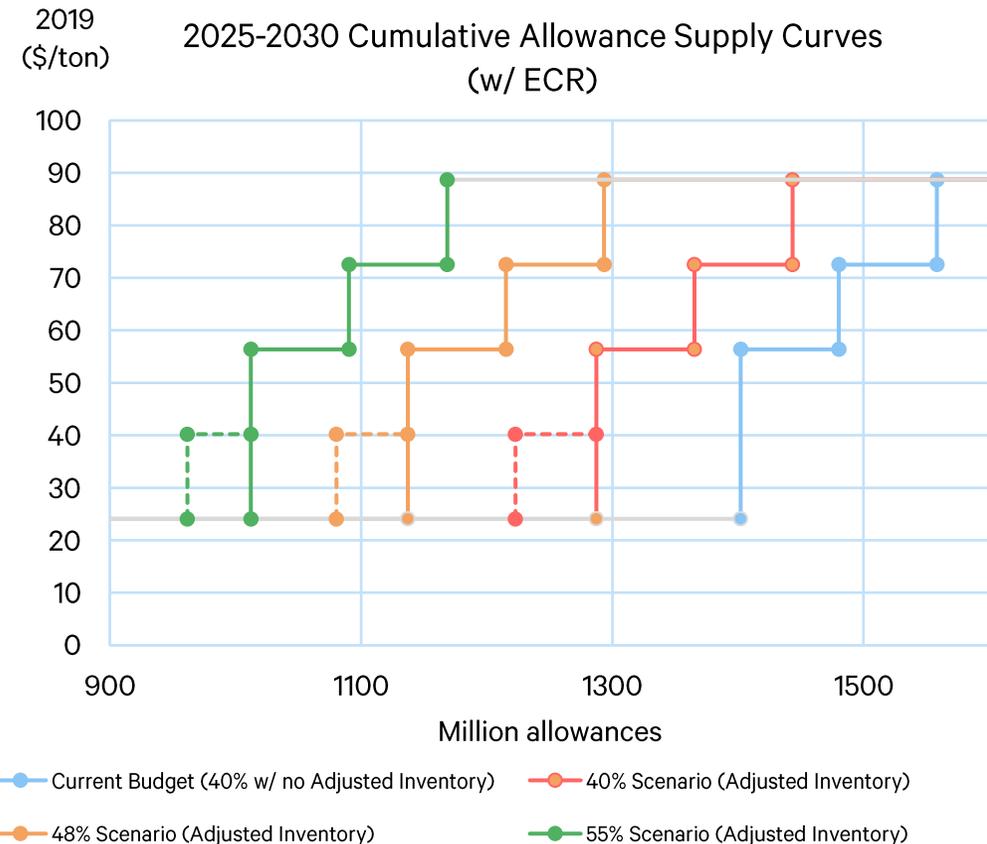
## The introduction of an ECR would reduce auctioned allowance supply at low prices.

An ECR can be implemented as a reserve price in the auction, analogous to the price floor. A designated share of allowances in the auction would not be sold at prices below the ECR price trigger.

An ECR mitigates falling prices in the auction which could occur due to the success of regulatory policies or technological innovation. If allowance supply does not adjust, these outcomes that reduce abatement cost do not translate to reduced emissions. Other cap-and-trade programs such as the Regional Greenhouse Gas Initiative (RGGI) have implemented this mechanism.

Shown in the picture is the dotted step that would raise the reserve price of 5% of allowances in any auction to the ECR price trigger level.

We assume the ECR trigger price rises at 5% per year plus inflation.

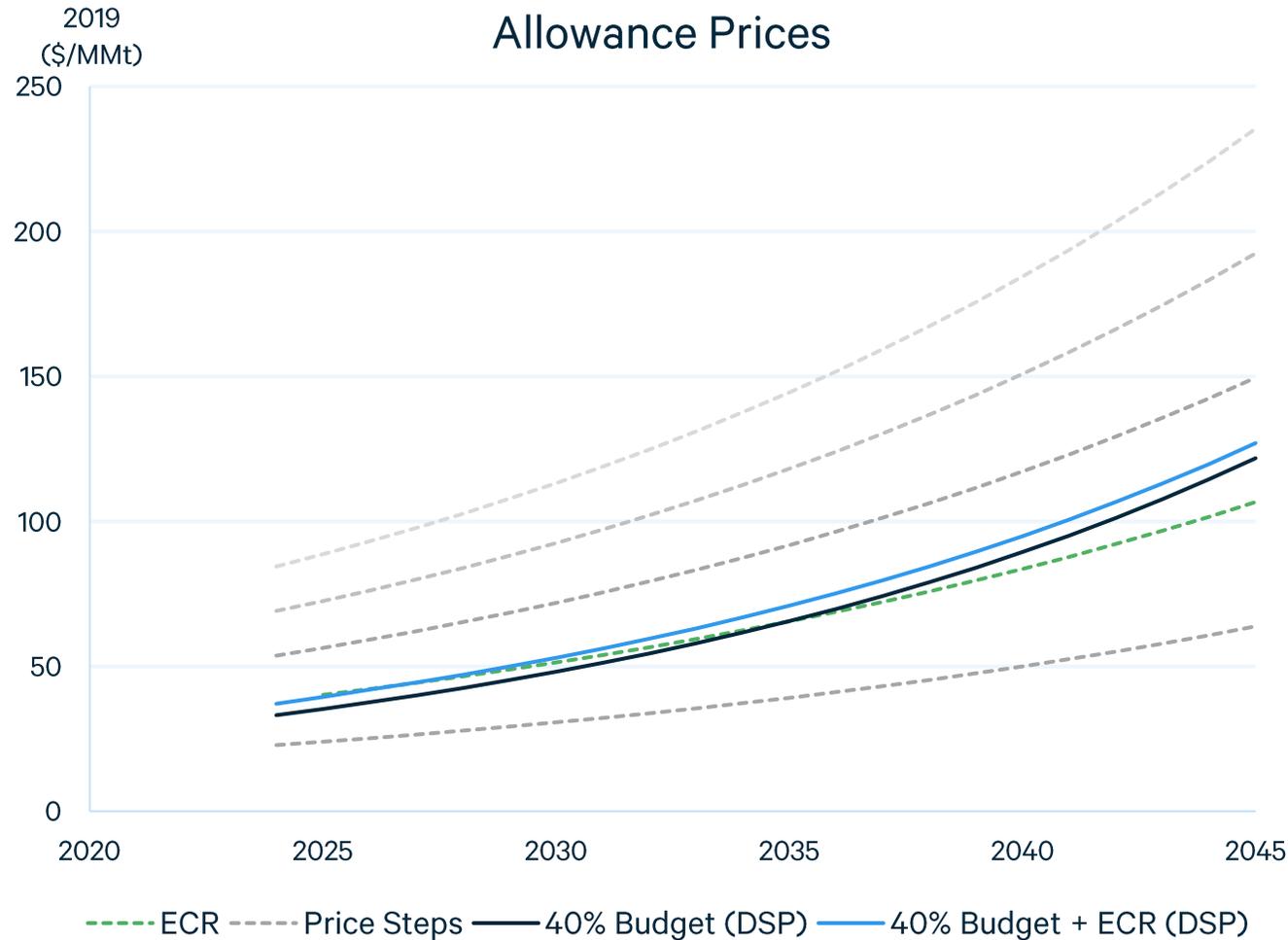


## We evaluate an ECR that is implemented at the missing 25% step on the price staircase between the price floor and price ceiling.

Like the price floor, we assume an ECR would be an element of every quarterly auction. Modeled results represent a scenario where free allocation also is adjusted through annual true-up so that reductions in supply due to triggering the ECR are shared across all channels of allowance supply.



## Introducing an ECR can reduce allowance supply and increase prices in scenarios where the auction price would be below the ECR price trigger.



Prices under the 40% Budget allowance supply scenario with Delayed Scoping Plan (DSP) allowance demand start below the ECR trigger price.

The price rises to be above the ECR trigger price level in 2027, continuing a 6% annual increase in value consistent with banking behavior. Cumulative allowance supply is reduced by the ECR quantity in 2025-2026.

The ECR has an impact if prices would be at or below the ECR price path in our model. Other behavioral phenomena could lead to additional effects when introducing the ECR (Salant et al. 2022, 2023).

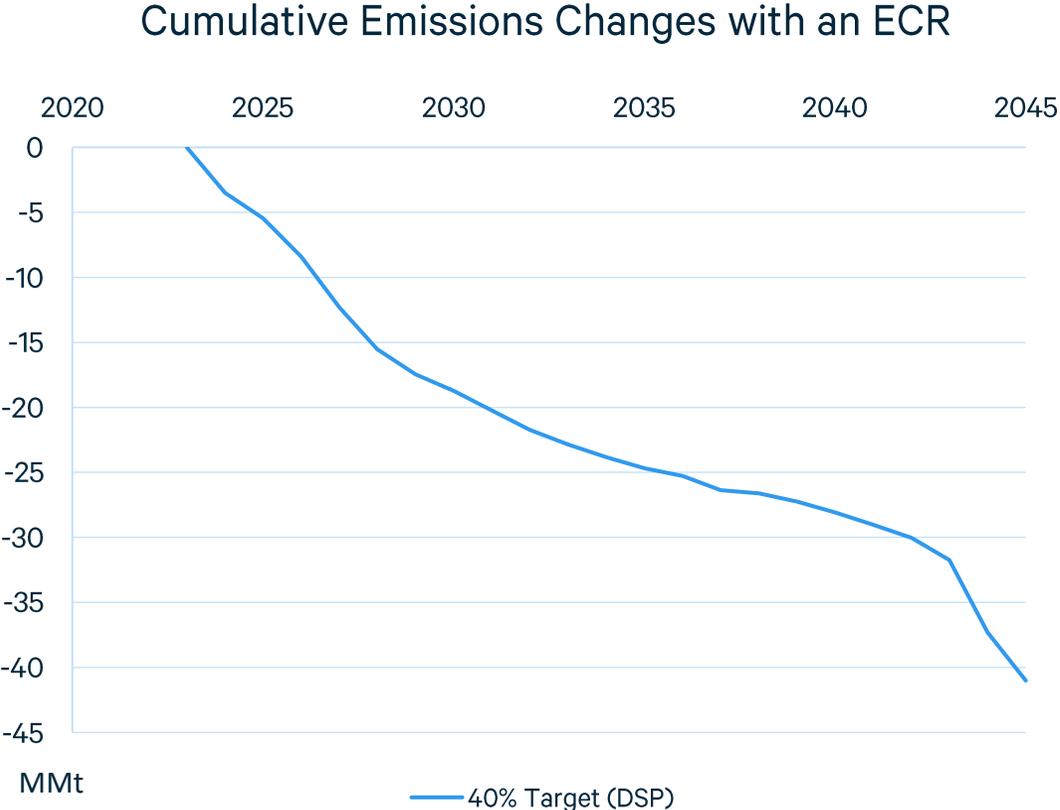
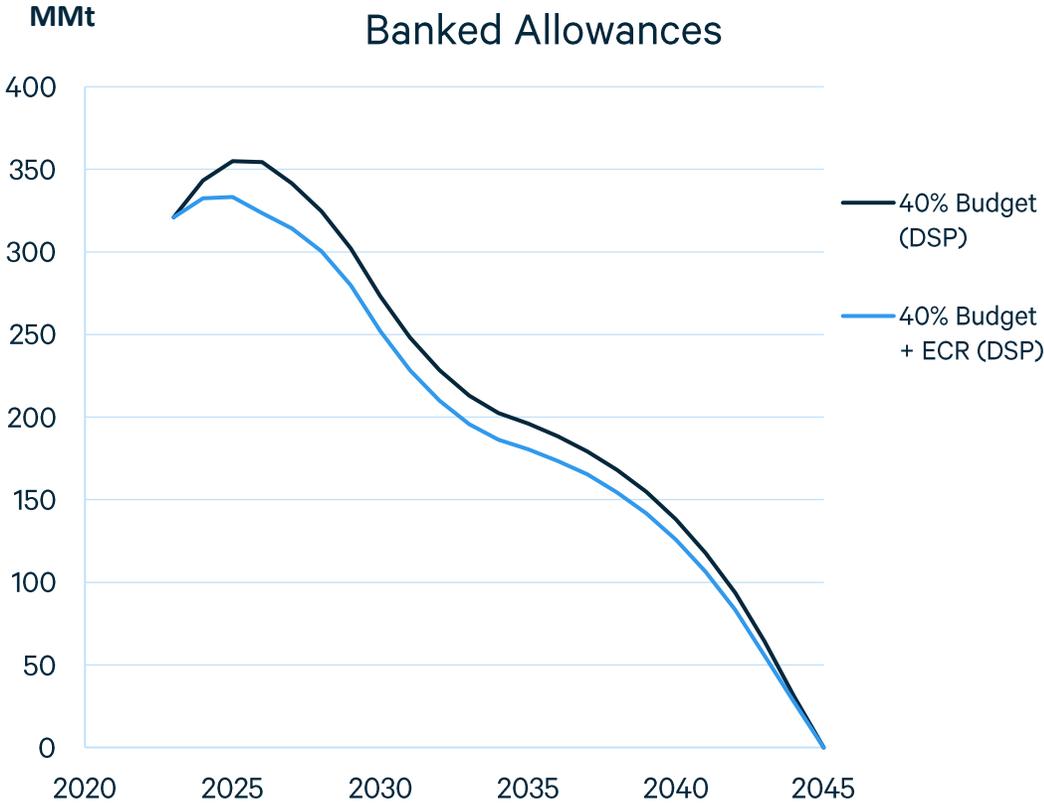
Salant, Shobe, and Uler 2023. *Eur Econ Rev* 159.  
Salant, Shobe, and Uler 2022. *Eur Econ Rev* 145.



# If triggered, an ECR decreases the size of the allowance bank and reduces emissions.

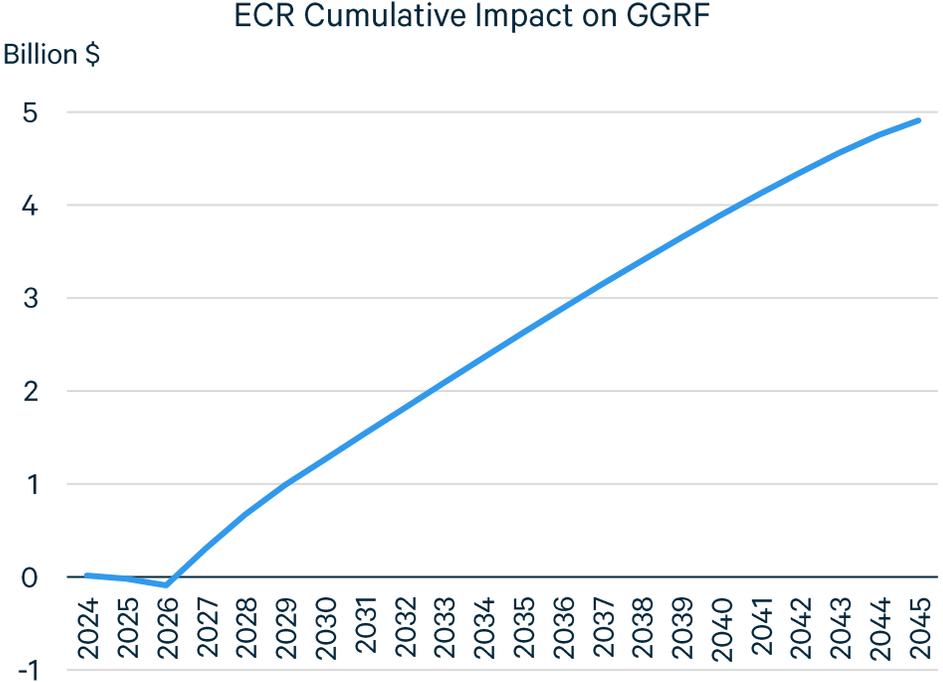
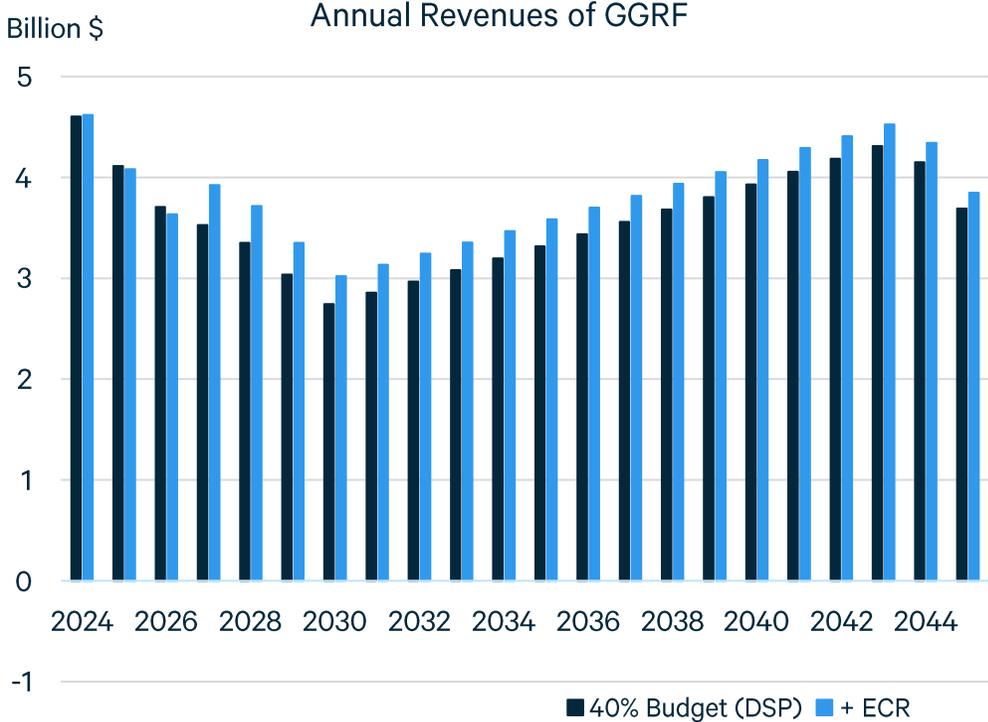
By supporting the auction price through adjusting supply at low prices, the ECR forces a slightly accelerated draw down of the bank.

We find emissions are reduced if the ECR is triggered.



# The ECR increases annual revenue to the GGRF before 2035.

Revenue is increased with the introduction of the ECR because the increase in the price outweighs the reduction in allowances. In 2026, the annual revenues are slightly lower. We assume all channels of allowance supply are reduced proportionately if the ECR is triggered, which contributes greater revenues to the GGRF than if only auctioned supply is affected.



## Summary of outcomes influenced by the introduction of an ECR

Compared to a scenario with a similar reduction in the cap, the addition of an ECR has several effects in low-price scenarios.

- The ECR reduces allowance supply and increases the auction price
- The ECR decreases the number of banked allowances
- The ECR decreases cumulative emissions
- The ECR increases annual and cumulative revenues to the GGRF
- The ECR prevents prices and emissions from backsliding in cases where regulatory policies, technology, or other secular trends reduce compliance costs. Another benefit to the ECR is its influence in augmenting price-responsive allowance supply to support price discovery in the auction, stabilize prices and revenues, and help compliance entities and regulators to better anticipate and handle uncertainty.



# Four Approaches to Adjusting Allowance Supply

In these comments, we investigate four approaches to adjusting the allowance supply.

- a) A **cap reduction** can be described as a change in the annual rate of decline in the cap. Through this decade that rate of reduction has been approximately 4% per year. This approach assumes no change in the Allowance Price Containment Reserve.
- b) **Removal and cancellation of allowances from the Allowance Price Cost Containment Reserve (APCR) tier 1 and 2 supplies.** These allowances enter the market only if the market price reaches the APCR trigger price level. We do not model a resupply of the APCR after 2030. We do not adjust the price ceiling allowances. Additional reductions in supply that may be necessary are implemented through an additional cap reduction.
- c) **Introduction of an Emissions Containment Reserve (ECR)** would increase the minimum price for a portion of allowances that are available each year. The auction provides a mechanism to identify the price level and enables ECR containment to be implemented instantaneously in the auction, analogous to the reserve price (price floor).
- d) Various channels exist for reducing allowance supply to the market, including **reducing auctioned allowances or reduced free allocation to industry or utilities** with cancellation of those allowances in alignment with a cap adjustment.

The final approach we examine reduces the ways that a **reduction in allowance supply** can be implemented.



## 3.d: Channels for Reducing Allowance Supply

### A cap reduction can be implemented through various channels of allowance supply.

Roughly half of allowance supply enters the market through the auction with revenues accruing to the Greenhouse Gas Reduction Fund, and half through free allocation with asset value accruing to electricity and natural gas utilities, and energy intensive, trade exposed industries. The way in which a reduction in the allowance cap is implemented will have important effects on distributional outcomes.

We discuss distributional outcomes in two price regimes driven by different adjustments to allowance supply, both with Delayed Scoping Plan levels of allowance demand. We describe a high-price regime as the 48% Budget allowance supply scenario and a low-price regime as the 40% Budget scenario. We compare both to the Current Budget scenario.

We consider three alternatives to span the approaches that CARB might consider for reducing allowance supply.

1. **Reduce auctioned allowances.** This approach would increase revenue to the GGRF, but the share would fall compared to the value of allowances entering the market through free allocation in the Current Budget.

In the high-price scenario, cumulative allowances entering the market between 2025-2030 falls from 1,346 million under the **Current Budget (DSP)** to 1,137 million under **48% Budget (DSP)**. If this reduction is taken entirely from auctioned supply, the supply falls from 564 million to 356 million. Cumulative GGRF revenues rise even with the fall in auctioned allowances due to the higher auction price, increasing from \$15.94 billion to \$20.21 billion.

In the low-price **40% Budget (DSP)** scenario, outcomes depend on the presence of an Emissions Containment Reserve. Without the ECR, cumulative allowances entering the market between 2025-2030 total 1,287 million. If these are taken entirely from the auction, cumulative auction supply is 506 million and auction proceeds are \$20.48 billion. With an ECR, cumulative allowances total 1,262 million and auction proceeds are \$21.72 billion.



## The value of free allocation increases even when the share of allowance supply assigned to free allocation is reduced.

2. **Proportional reduction.** This approach would proportionately reduce the share of allowance supply entering the market through each channel of allowance supply.

In the high-price **48% Budget (DSP) scenario**, cumulative allowances 2025-2030 total 1,137 million. The cumulative value of free allocation remains (69%) greater than under the Current Budget, even while market prices are low in the market.

In the low-price **40% Budget (DSP) scenario** without an ECR, cumulative allowances total 1,287 and the value of free allocation remains proportionately like the high-price scenario. However, with an ECR the cumulative supply falls in the low-price scenario to 1,262. The way that the supply reduction associated with the ECR is implemented will affect the distribution of allowance value.

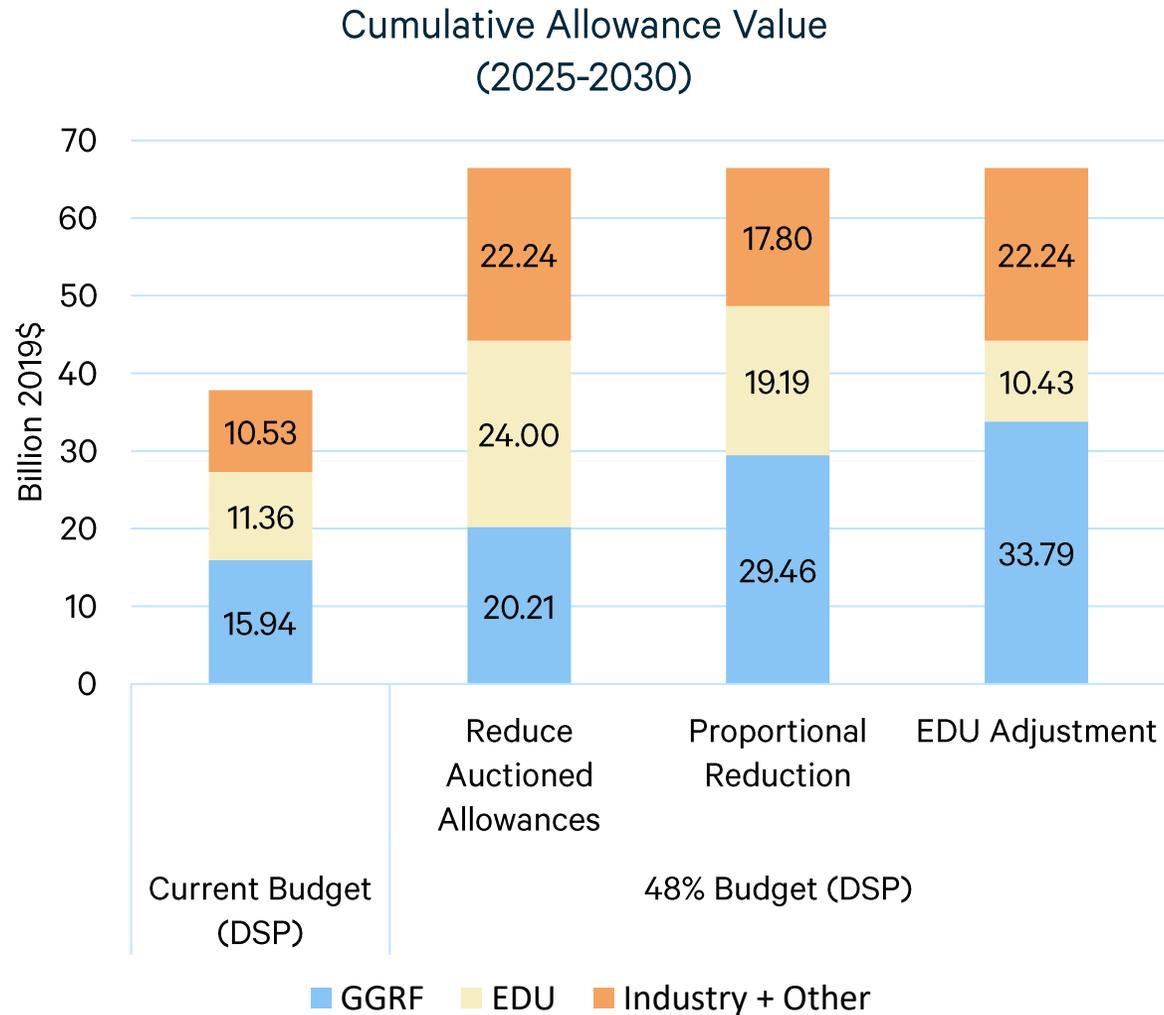
3. **Adjustment to electricity distribution utility (EDU) allocations.** This approach singles out and reduces the allocation to EDUs, preserving quantities in other channels. This would significantly impact the size of climate dividends to residential ratepayers. There is relatively little incremental effect in how the ECR is enforced.

The annual value of free allocation to EDUs would grow to roughly \$3 billion across various scenarios, representing about 8% of the residential customer rate base. Adjustments to the way this value is channeled could address affordability for low-income households, accelerate electrification through rate reductions or investments.

Other approaches may be equally viable, with different shares of the supply drawn from free allocation to natural gas utilities or subsets of industry. The scenarios we describe are selected to span the set of likely outcomes and to identify significant impacts of the choices.



# Allowance Supply Scenarios: Changing Allocation and Distributional Burden



Reducing the cap raises the allowance price and thus increases total allowance value from the program.

Depending on which party has its allowances reduced, the share of allowance value accruing to each party can change dramatically. We consider three of many possible approaches:

- **Reduce auctioned allowances:** If CARB only reduces auctioned allowances, the value of the GGRF would increase but the share of total allowance value that accrues to the GGRF would fall
- **Proportional reduction:** If CARB reduces auctioned allowances and freely allocated allowances proportional to the overall cap reduction, the GGRF maintains its share of revenue
- **Adjustment to electricity distribution utility (EDU) allocations:** If CARB reduces allocation to EDUs, the share of allowance value to the GGRF rises



## Allowance Supply Scenarios: Changing Allocation and Value under High Prices

When the reduction in allowance supply to achieve the 48% Budget scenario is implemented through a reduction in the auctioned allowances, the value of the GGRF increases. However, the value is just more than half compared to a proportional reduction in all channels of allowance supply.

The adjustment to Electric Distribution Utilities is imagined as a reduction equal to the difference between free allocation and emissions from the sector. This scenario would reduce the climate dividend returned to households.

Emissions Demand (Emissions Pathway)	Allowance Supply (Budget)	Allocation	Cumulative Allowances 2025-2030 (MMT)				Cumulative Value 2025-2030 (Billion 2019\$)				Allowance Price 2030 (2019\$/ton)
			GGRF	EDU	Industry + Other	Total	GGRF	EDU	Industry + Other	Total	
Delayed Scoping Plan	Current Budget*	Reduce Auctioned Allowances	564	405	376	1346	15.94	11.36	10.53	37.83	32.77
	48% Budget	Reduce Auctioned Allowances	356	405	376	1137	20.21	24.00	22.24	66.45	68.62
		Proportional Reduction	506	327	304	1137	29.46	19.19	17.80	66.45	68.62
		EDU Adjustment	585	176	376	1137	33.79	10.43	22.24	66.45	68.62

\* The Current Budget (DSP) scenario has prices proximate to current prices, but it is not an explicit representation of the market expectations. It is included only for a point of reference.



# Allowance Supply Scenarios: Changing Allocation and Value under Low Prices

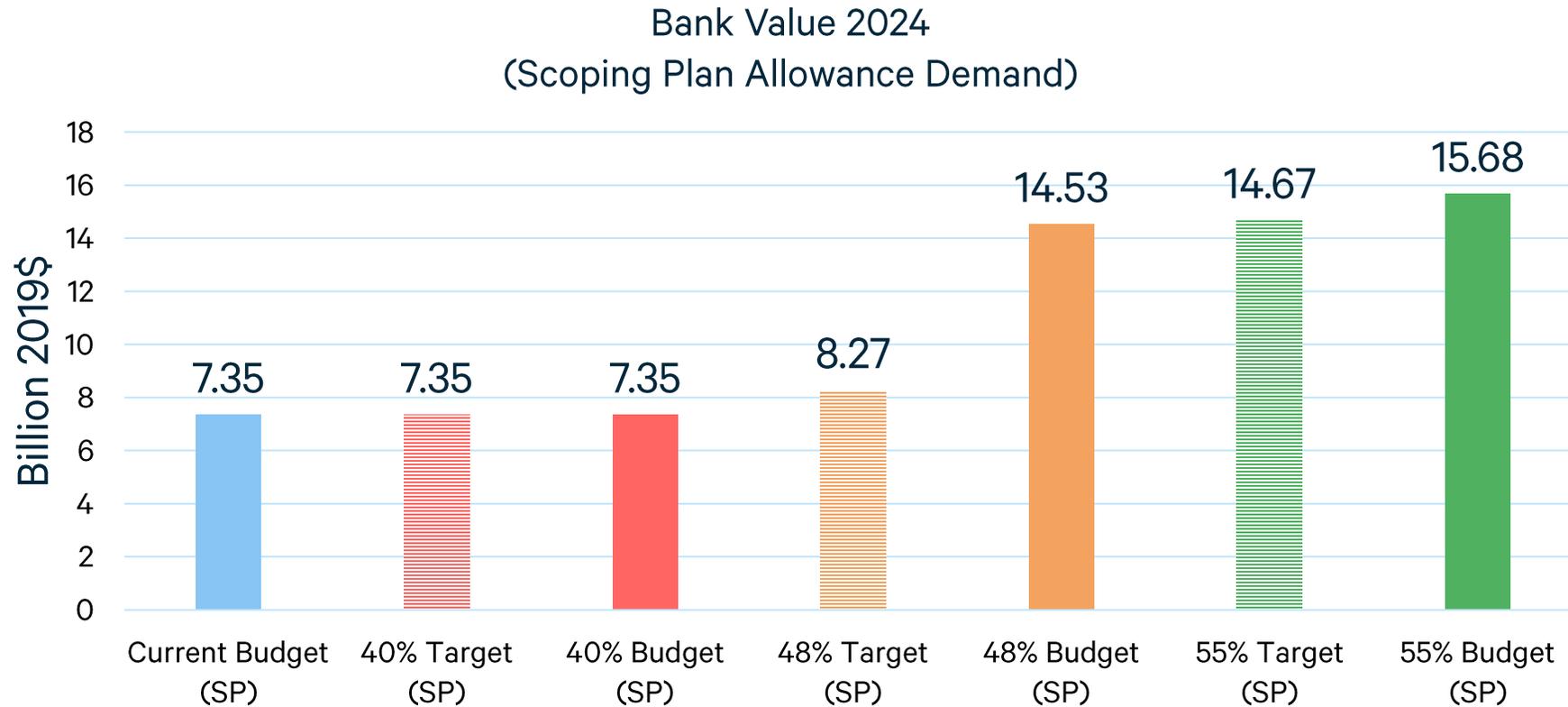
In the absence of an Emissions Containment Reserve, the outcomes are proportionately like the previous table. However, the existence of an ECR could affect the distribution of allowance value. For example, the ECR could be implemented only on auctioned allowances or within various channels of supply as indicated in the indented lines.

Emissions Demand (Emissions Pathway)	Allowance Supply (Budget)	Allocation	Cumulative Allowances 2025-2030 (MMT)				Cumulative Value 2025-2030 (Billion 2019\$)				Allowance Price 2030 (2019\$/ton)
			GGRF	EDU	Industry + Other	Total	GGRF	EDU	Industry + Other	Total	
Delayed Scoping Plan	Current Budget	Reduce Auctioned Allowances	564	405	376	1346	15.94	11.36	10.53	37.83	32.77
	40% Budget	Reduce Auctioned Allowances	506	405	376	1287	20.48	16.70	15.47	52.64	48.16
		Proportional Reduction	571	371	345	1287	23.29	15.23	14.12	52.64	48.16
		EDU Adjustment	668	243	376	1287	27.17	10.01	15.47	52.64	48.16
		Reduce Auctioned Allowances	481	405	376	1262	21.72	18.53	17.16	57.41	52.99
	40% Budget (+ ECR)	Proportional Reduction	546	371	345	1262	24.84	16.90	15.67	57.41	52.99
		Proportional Reduction (ECR)	560	364	338	1262	25.39	16.62	15.40	57.41	52.99
		EDU Adjustment	661	225	376	1262	29.96	10.29	17.16	57.41	52.99
	EDU Adjustment (ECR)	665	221	376	1262	30.12	10.12	17.16	57.41	52.99	



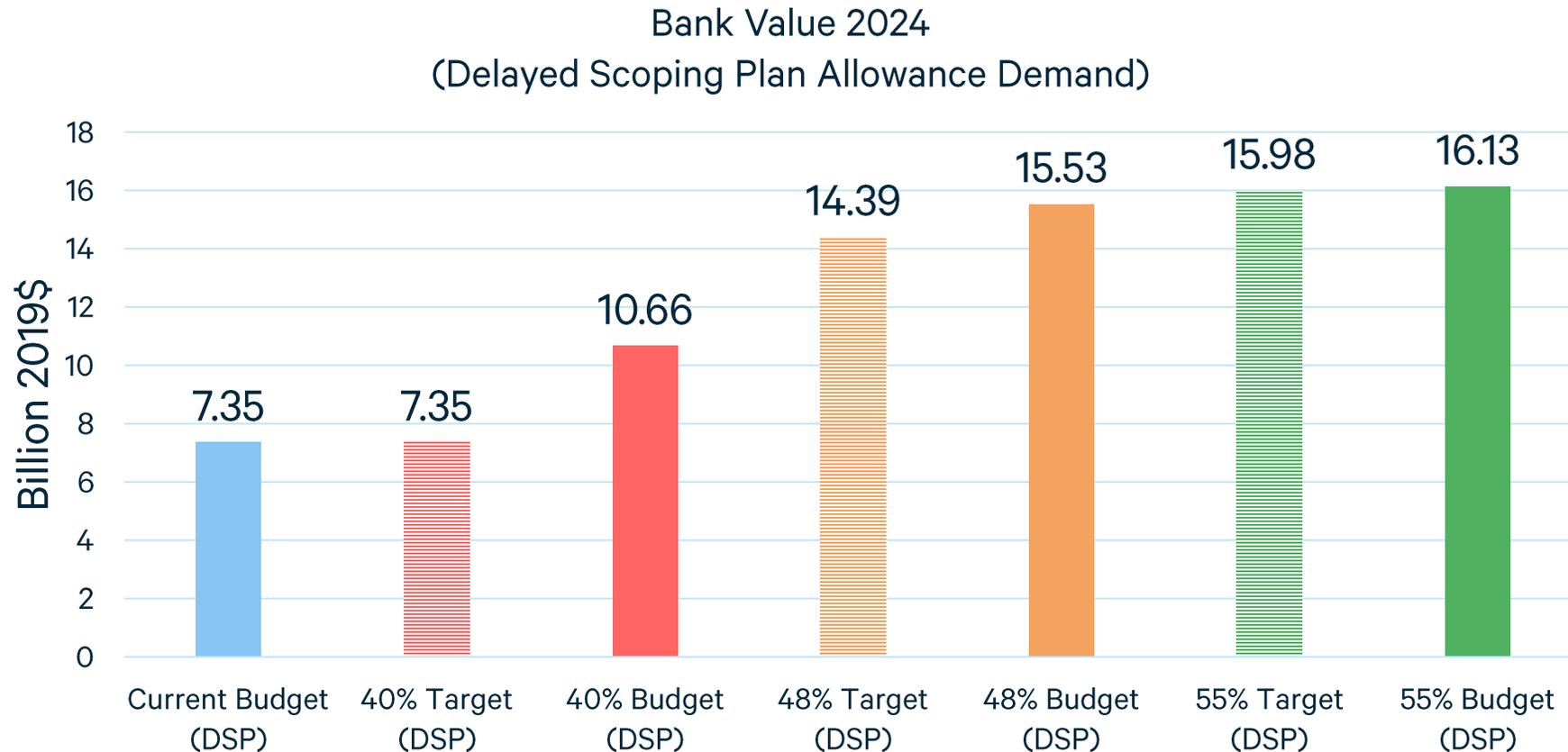
# Reducing allowance supply can substantially increase the value of banked allowances.

The value of the allowance bank grows in proportion to the change in allowance price. The bank quantity does not change in proportion to the change in the cap, so the change in value may be viewed as windfall, especially because the change is the result of an administrative change to the program.



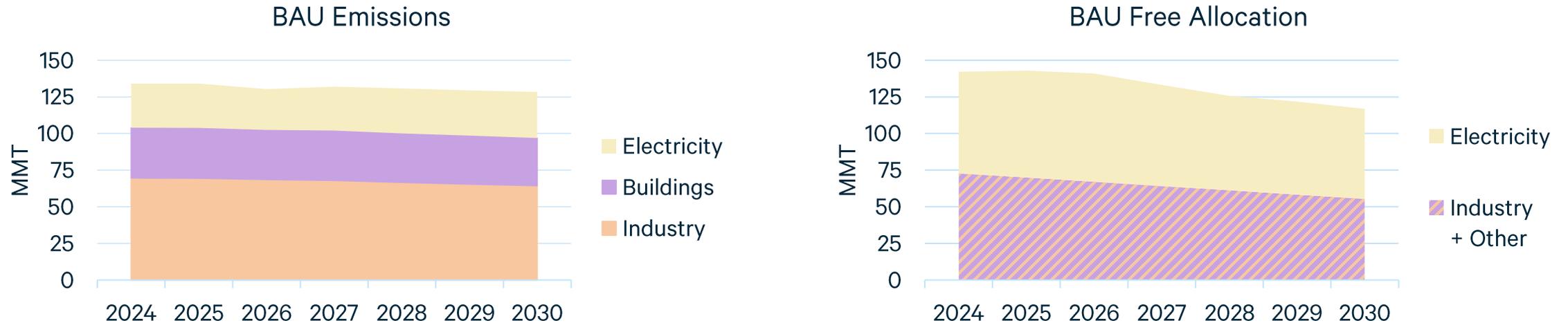
## The value of the bank is slightly greater with Delayed Scoping Plan allowance demand.

Much of the allowance bank is owned by noncompliance entities so the instantaneous change in value of the bank due to an administrative change in the program does not necessarily accrue to California businesses, but it will always be paid for by California consumers.



### 3.d. There are various potential reforms to allocation to electric utilities.

The figure on the left shows anticipated emissions trends in the BAU scenario and on the right is the trend in anticipated free allocation. The allocation to electric utilities exceeds their emissions.



The value of the allocation flows through to households as a climate credit, contributing to affordability on an equal customer account basis. Two possible reforms might better address program goals of affordability and emissions reductions.

1. One possible reform to more specifically address affordability would be to target the climate credit based on household income.
2. Another option would be to direct the value to reducing electricity prices to accelerate electrification of transportation and buildings and associated emissions reductions.



### 3.d. Allowance supply changes and the impact on the Greenhouse Gas Reduction Fund: Summary Table

The Current Budget coupled with Scoping Plan levels of allowance demand has low prices and low revenue to the GGRF. Increasingly stringent program design has higher prices and greater overall allowance value but under current program design, if free allocation is preserved without change, the increased value will not accrue to the GGRF, and revenues could fall to zero.

Emissions Demand (Emissions Pathway)	Allowance Supply (Budget)	2030 Emissions* (MMT)	2030 Price (2019 \$/ton)	2030 GGRF** (2019 billion USD)	Annual Average 2025-2030 GGRF** (2019 billion USD)	Annual Average 2025-2030 GGRF with proportional reduction**** (2019 billion USD)	Annual Average 2025-2030 GGRF with EDU adjustment***** (2019 billion USD)
BAU	Current Budget	244.3	66.06	5.52	5.88	5.88	8.05
SP	Current Budget	196.5	30.70	1.98	2.14	2.14	2.74
	40% Target	196.1	32.77	1.87	2.24	2.56	2.86
	40% Budget	196.1	33.20	1.89	2.35	2.68	2.99
	48% Target	194.5	37.35	0.82	1.81	2.65	2.58
	48% Budget	187.5	64.21	1.42	3.15	4.60	5.03
	55% Target	187.0	64.82	<0 ***	1.97	4.11	4.02
55% Budget	183.7	69.27	<0 ***	2.11	4.39	4.39	

\* Emissions include newly issued and banked allowances used for compliance

\*\* Annual revenue accruing to the GGRF excludes freely allocated allowances which are a pre-determined decreasing quantity in each year

\*\*\* In the 55% budget scenarios, emissions issued in 2030 are less than currently listed free allocation allowances

\*\*\*\* The proportional reduction reduces free allocation proportional to the overall reduction in the cap

\*\*\*\*\* The EDU adjustment consists of removing the reduction in the budget first from free allocation to utilities, and then from the general allowance supply



# 4. Cumulative Emissions Changes

Evaluation of different policy instruments in terms of emissions changes



## Electricity sector emissions changes relative to BAU and Current Budget allowance supply

Allowance Supply (Budget)	Emissions Demand (Pathway)	Changes in Cumulative CO <sub>2</sub> Emissions 2025-2030 (MMt)	Changes in Cumulative Power NO <sub>x</sub> Emissions 2025-2030 (kMt)
Current Budget	SP	-133.6	-13.79
Current Budget	DSP	-37.3	-15.51
40% Target	SP	-135.2	-14.24
40% Target	DSP	-37.1	-16.86
40% Target (- APCR)	SP	-134.9	-15.60
40% Target (- APCR)	DSP	-37.1	-16.85
40% Budget	SP	-135.8	-14.37
40% Budget	DSP	-85.7	-18.03
40% Budget (+ ECR)	DSP	-100.9	-19.33
48% Target	SP	-148.0	-16.13
48% Target	DSP	-115.7	-19.36
48% Budget	SP	-211.1	-18.97
48% Budget	DSP	-128.1	-15.62
48% Budget (- APCR)	SP	-135.7	32.39
48% Budget (- APCR)	DSP	-77.8	-17.34
55% Target	SP	-217.7	-10.68
55% Target	DSP	-129.5	32.78
55% Target (- APCR)	DSP	-127.4	31.18
55% Budget	SP	-228.9	28.01
55% Budget	DSP	-130.6	35.22
55% Budget (- APCR)	SP	-202.8	-18.38
55% Budget (- APCR)	DSP	-127.8	31.84

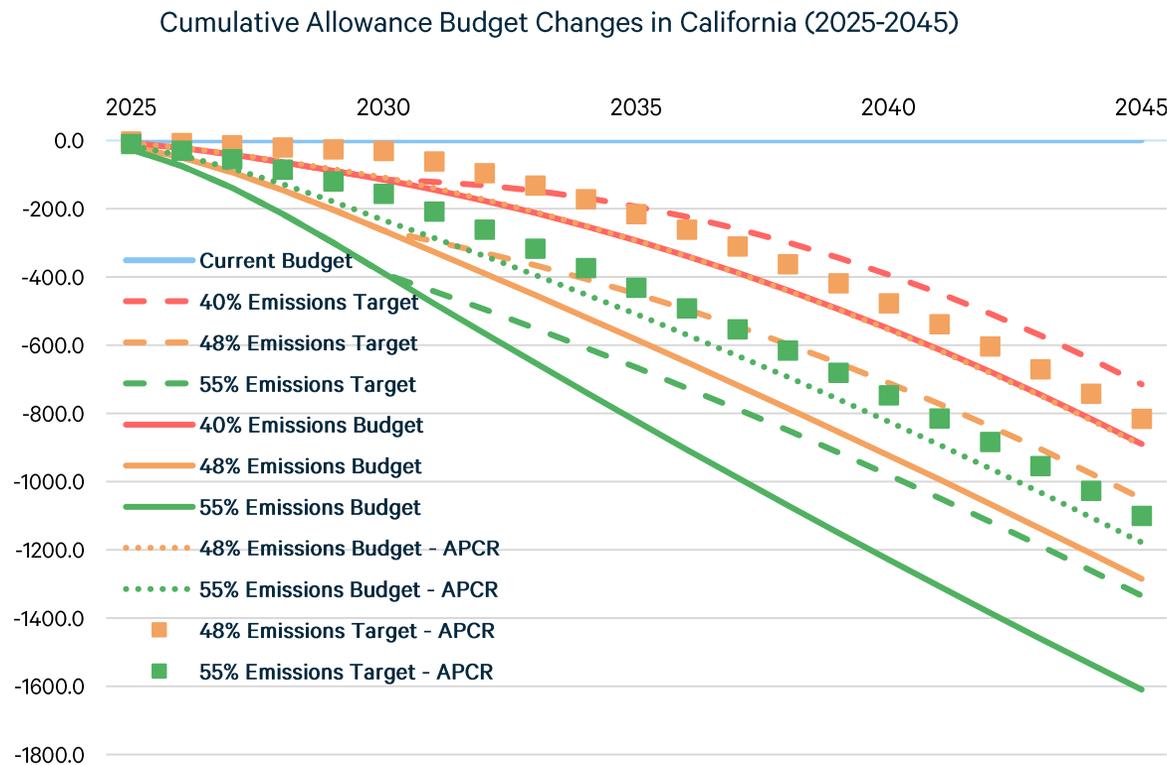
The Current Budget allowance supply scenario shows reductions of NO<sub>x</sub> from the power sector are less under Scoping Plan level of allowance demand because of reduced electrification.

In cases with the greatest CO<sub>2</sub> reduction, we see an increase in NO<sub>x</sub> emissions from power plants. Not shown, however, is the expected decrease in building and roadside emissions that would also occur.



# Changes in cumulative allowance supply (freely allocated or sold in auction) vary with the stringency of the change in the cap and the approach to supply adjustment.

The supply schedules illustrated here do not include allowances in the Allowance Price Containment Reserve. Removing and cancelling the APCR enables a different number of allowances to enter under the cap.



Note: 40% with no APCR would be at Current Budget levels so it is not shown.

The range of cumulative allowance supply adjustments CARB is considering ranges from approximately 700-1600 allowances removed from the current cap by 2045.

Choosing the right allowance supply schedule, approach to free allocation, and market design mechanisms is key to ensuring a robust carbon market.

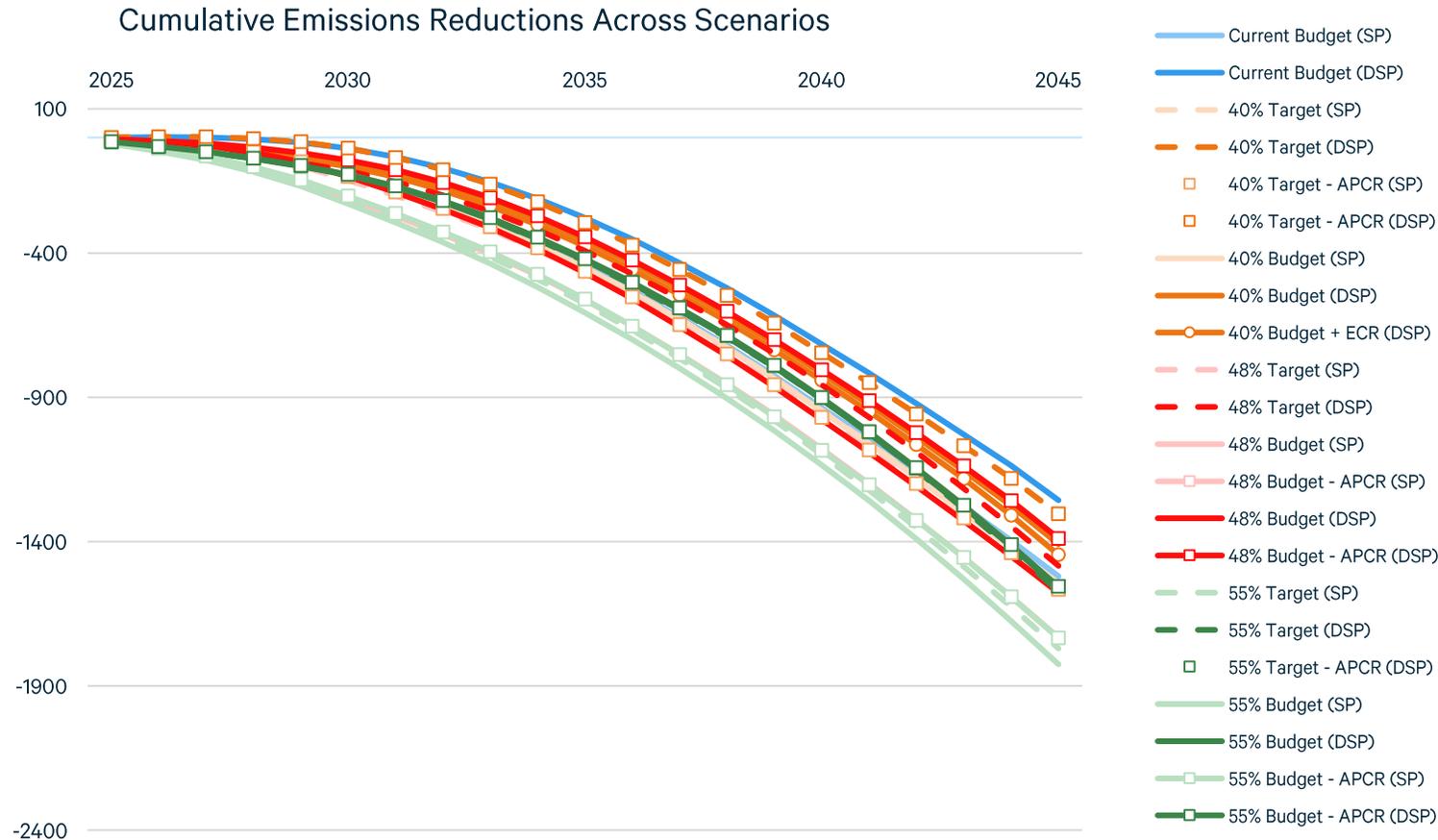
Considerations in the design of a robust carbon market include:

- Maximum emissions reductions
- Revenue for investing into accelerating decarbonization
- A steadily increasing price signal that gives predictable guidance for compliance entities about the financial risk of delaying further decarbonization
- Other metrics such as affordability to households that CARB might consider



# Different approaches to reducing allowance supply yield different market behavior in equilibrium and different emissions outcomes.

The range of estimated emissions reductions from these adjustments range from 1200-1800 MMT abated by 2045.



Equilibrium prices determine the supply of allowances and the use of the bank.

Our model assumes that emissions allowance demand is relatively inelastic with respect to the allowance price (congruent with much of the literature and empirically validated).

Most emissions reductions result from direct changes in allowance supply and assumptions about technology and policy that shape allowance demand.





# Thank you.

- Find out more about RFF online: [www.rff.org](http://www.rff.org)
- Follow us on Twitter: [@rff](https://twitter.com/rff)
- Subscribe to receive updates: [rff.org/subscribe](http://rff.org/subscribe)