SUSTAINABILITY

REPORT

CFA Institute Research & Policy Center

# Global Compliance Carbon Markets: Auction Mechanisms

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## Executive Summary

Carbon allowance allocation methods in global compliance carbon markets (CCMs) are key market design choices. The allocation of allowances influences the formation of carbon prices, the emission costs for covered entities, and market efficiency. The decision to allocate allowances freely or via auction mechanisms is a critical design feature that affects all stakeholders in the carbon market ecosystem, including covered emitters, market operators, financial intermediaries, and investment firms. In recent years, global CCMs have shifted from free allocation toward auction-based allowance distribution. The calibration of auction mechanisms is a policy choice that plays a critical role in determining market outcomes.

This report reviews the auction mechanisms of global CCMs and evaluates their effectiveness, measured by various indicators of market quality. The research is designed to inform the investment industry about various auction mechanisms and to provide practical guidance on participating in auction markets. By reading this report, financial intermediaries and investment firms will be better informed to guide their decisions to participate in the primary market, while policymakers and market operators will be able to determine how best to calibrate allowance allocation in their respective markets.

This report is the latest addition to CFA Institute Research and Policy Center's carbon market research portfolio. Given the global expansion of carbon markets, Yang and Preece (2024) and Mak (2025) provided detailed overviews of global compliance and voluntary carbon markets, respectively, to help investment industry participants better understand their mechanisms. In light of the rapid growth of carbon-related trading products in secondary markets, Yang (2025) provided an in-depth analysis of the market structure of global CCMs' secondary markets, offering practical guidance for the investment industry on engaging with CCMs.



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Given the significant increase in carbon auction market participation by financial intermediaries and investment firms, as well as the broadened global impact of carbon pricing on firms arising from the EU's Carbon Border Adjustment Mechanism (CBAM), this report complements previous studies by focusing on the primary markets of global CCMs. The report consists of three main sections:

- The "Auction Mechanisms" section reviews the auction mechanisms of major CCMs that adopt auctioning. It explains the auction rules, frequency, processes, auction share of allowances, and market development. It covers CCMs in the European Union, New Zealand, California, Quebec, Washington state, and the United Kingdom, analyzing the similarities and unique features of each system.
- Next, the "Auction Effectiveness" section evaluates the effectiveness of CCM auction mechanisms. It applies three indicators from different dimensions—auction-market price stability (difference between the auction price and prevailing secondary market price, relative to the market price), demand depth (bid-to-cover ratio), and reserve price bindingness (auction clearing price premium)—to assess CCMs in the EU, California, and the United Kingdom. The analysis links these indicators to the specific characteristics of each system.
- The section "Auction Effectiveness Determinants" explores the key factors that may influence the effectiveness of CCM auctions.

This report presents the following key findings:

- The share of allowances auctioned in global CCMs has steadily increased over time. Among CCMs that use auctioning, the primary auction structure is a single-round, sealed-bid, uniform-price auction. To conduct auctions, CCMs use dedicated platforms—the European Energy Exchange (EEX) for the EU, the Western Climate Initiative, Inc. (WCI, Inc.) for California, and the Intercontinental Exchange (ICE) Futures Europe for the United Kingdom. Beyond these similarities, each CCM displays distinct characteristics. The EU Emissions Trading System (EU ETS) has the longest auction history, the largest auction volumes, and the highest frequency (three days per week), making it the most mature auction market. The California Cap-and-Invest Program, formerly the Cap-and-Trade Program, conducts quarterly auctions and uses a relatively strict, annually increasing auction reserve

price mechanism that can directly influence auction price levels.[1] The UK Emissions Trading Scheme (UK ETS) holds biweekly auctions. As a newer and smaller CCM, the UK ETS has a tighter auction supply.

- Investment professionals participating in primary auction markets should be mindful of differences in auction effectiveness across CCMs.
  - As the most mature CCM, the EU ETS has auction clearing prices that are broadly aligned with prevailing secondary market prices. Its auction mechanism demonstrates strong resilience to external shocks and capacity for post-shock self-adjustment. In the long run, the auction mechanism maintains stable, moderate demand depth and a steady auction supply.
  - As a developing CCM, the UK ETS auction tends to clear at a small discount relative to secondary market prices. The alignment between auctions and the secondary market improves over time. The auction mechanism also exhibits stable, moderate demand depth and a steady auction supply. Auction clearing prices are consistently above the constant auction reserve price.
  - As a CCM with a strictly annually increasing auction reserve price and relatively low auction frequency, California's auction clearing prices are generally aligned with secondary market prices, although occasional large deviations occur because of the strict reserve price policy and the frequency mismatch between auctions and secondary market trading. Demand depth is more volatile, driven by fluctuations on both the demand and supply sides, and oversupply can occur. In most cases, the reserve price is binding; clearing prices are close to it. Auction outcomes are therefore more constrained by reserve prices than driven by market forces.

- Policymakers and CCM market operators that wish to strengthen the effectiveness of allowance auctions may focus on the efficacy of holding more frequent auctions and increasing the share of allowances auctioned versus free allocation, thereby promoting broader participation in the primary market and enhancing the trading volume and liquidity of allowances in the secondary market. The market design choices discussed in this report can strengthen market functioning by improving transparency, reducing price dispersion and volatility, and stimulating demand.

Investment professionals can use this report to guide their participation in global carbon auctions, such as by determining which CCMs to participate in and whether it is profitable to engage in the primary markets. Policymakers can draw on this report's findings to make targeted improvements to auction mechanisms.

[1] The California Cap-and-Trade Program was renamed to the Cap-and-Invest Program in 2025. For simplicity, the new name is used throughout this report.

# Introduction

As a market-based mechanism to support decarbonization, compliance carbon markets price carbon emissions by setting an emission cap, allocating allowances in the primary market, and facilitating secondary market trading of allowances. The mechanisms for allocating allowances affect carbon prices, emission costs, and market efficiency and may influence overall emission-reduction outcomes. In recent years, global CCMs have shifted from free allocation of allowances toward auction-based allocation, reflecting the continued maturation of carbon markets. For example, in 2024, the EU ETS—the largest CCM by trading volume—auctioned 57% of its cap, maintaining its highest auction share since inception in 2005. Auction mechanisms play a critical role in the design of global CCMs and, therefore, in the effectiveness of market outcomes.

The primary auction market is essential for three reasons. First, auctions determine the price and quantity of carbon allowances entering the market, thereby serving as the point of origin for the entire CCM. Second, unlike the secondary market, regulators can directly influence supply and demand through the design of auction mechanisms in the primary market, thereby transmitting price signals to the market. Third, the primary auction market directly affects secondary market price levels and volatility. An effective auction mechanism enables efficient price discovery, generates stable price signals, and ensures the fair allocation of carbon allowances.

In recent years, the investment industry has become increasingly active in the primary auction markets of global CCMs. According to the European Securities and Markets Authority (2024), investment firms and banks acquired around 45% of auctioned EU allowances (EUAs) in 2023. The investment firms simultaneously serve as financial intermediaries and incorporate allowances into their trading strategies and investment portfolios. In addition, as the EU's Carbon Border Adjustment Mechanism (CBAM) entered its definitive regime on 1 January 2026, carbon emission costs are increasingly being incorporated into firms' decision making worldwide, even in markets currently without domestic carbon pricing mechanisms.[2] This development broadens the impact of carbon pricing on the global investment industry. Importantly, the price of CBAM certificates (similar to carbon allowances) is set by the auction price of EUAs, underscoring the long-term role of auction mechanisms. Therefore, a clear understanding of auction mechanisms is essential for the investment industry to participate more effectively in global CCMs. Moreover, it is critical for policymakers to understand whether the existing auction mechanism is effective and which determinants may enhance its effectiveness so that

[2] CBAM is an EU policy that imposes a carbon price on carbon-intensive goods imported into the EU based on the carbon emissions generated during their production. The price of the CBAM certificate is based on the auction price of EUAs. The goals of CBAM are (1) preventing EU firms from relocating production to regions with less strict environmental regulations, (2) protecting EU firms from unfair competition by producers in regions with less stringent carbon emission regulations, and (3) encouraging trading partners to implement their domestic carbon pricing mechanisms.

as auctions become more widely used in existing and emerging CCMs, policymakers can calibrate their implementation to improve market functioning.

Yang and Preece (2024) provided a detailed summary of the mechanisms, advantages, and disadvantages of CCMs and compared carbon markets with carbon taxes. Mak (2025) complemented that work by offering an overview of voluntary carbon markets. Yang (2025) conducted an in-depth analysis of the market structure of secondary markets of global CCMs, offering practical guidance for the investment industry to engage with CCMs to gain exposure to carbon as an asset class and providing insights to enhance market efficiency. The current report complements these studies by focusing on the primary markets of global CCMs and providing a comprehensive analysis of auction mechanisms, effectiveness, and key determinants that may enhance auction performance.

The previous literature on CCM auction mechanisms falls into two main categories. The first consists of auction reports published by CCM regulators, which summarize overall auction results and present various auction indicators.[3] The second consists of academic studies that explore how to design an effective auction mechanism, primarily from a theoretical perspective (Chen, Ma, Ren, and Lei 2023; Cong and Wei 2012; Cramton and Kerr 2002; Fankhauser and Hepburn 2010; Ji, Hu, and Tang 2018; Lopomo, Marx, McAdams, and Murray 2011; Tang, Wu, Yu, and Bao 2017; Wang, Zhao, Zhang, Fu, and Xie 2022; Yu, Zhang, and Zhang 2024).

The existing literature has two limitations. First, it focuses on individual CCMs rather than comprehensively examining auction features across global CCMs. As a result, it lacks the context and international comparisons needed for the investment industry to understand primary auction markets. Second, the literature lacks a multidimensional evaluation of auction effectiveness, which prevents it from providing practical guidance to investment professionals who seek to participate in primary auction markets.

This report addresses both gaps. It first introduces the similarities and differences in the design of auction mechanisms across various CCMs. It then evaluates the auction effectiveness of major CCMs from three perspectives: auction-market price stability, demand depth, and reserve price bindingness. Finally, it discusses factors that may enhance auction effectiveness.

Investment professionals can use this report to guide their participation in global carbon auctions, such as by determining which CCMs to participate in

[3] These reports can be found at the following websites: California Air Resources Board, https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/auction-information; EU ETS, www.eex.com/en/markets/environmental-markets/eu-ets-auctions; German National Emissions Trading System, www.eex.com/en/markets/environmentals/german-nehs; New Zealand Emissions Trading Scheme, www.eex.com/en/markets/environmental-markets/nz-ets-auctions; Switzerland Emissions Trading System, www.bafu.admin.ch/en/emissions-trading; UK Emissions Trading Scheme, www.ice.com/emissions/auctions/uk-emission-allowances; Regional Greenhouse Gas Initiative, www.rggi.org/auctions/auction-results.

and whether it is profitable to engage in the primary markets. Policymakers can draw on its findings to make targeted improvements to auction mechanisms.

## Auction Mechanisms

This section introduces the auction mechanisms of several representative CCMs. In the primary market for carbon allowances, the main allocation methods are free allocation, auctioning, or a combination of the two. In the early stages of development, CCMs typically rely heavily on free allocation, as seen in China, Kazakhstan, and Mexico. This approach helps covered emitters transition smoothly toward carbon reduction by avoiding a sudden increase in compliance costs (from having to purchase emission allowances) that could lead to higher consumer prices and carbon leakage.[4] As CCMs mature, they tend to shift toward a mix of free allocation and auctioning, as seen in the EU, California, and the United Kingdom. The consensus among policymakers is that CCMs should ultimately adopt an auction-based allocation system to achieve effective carbon pricing and emission-reduction goals.

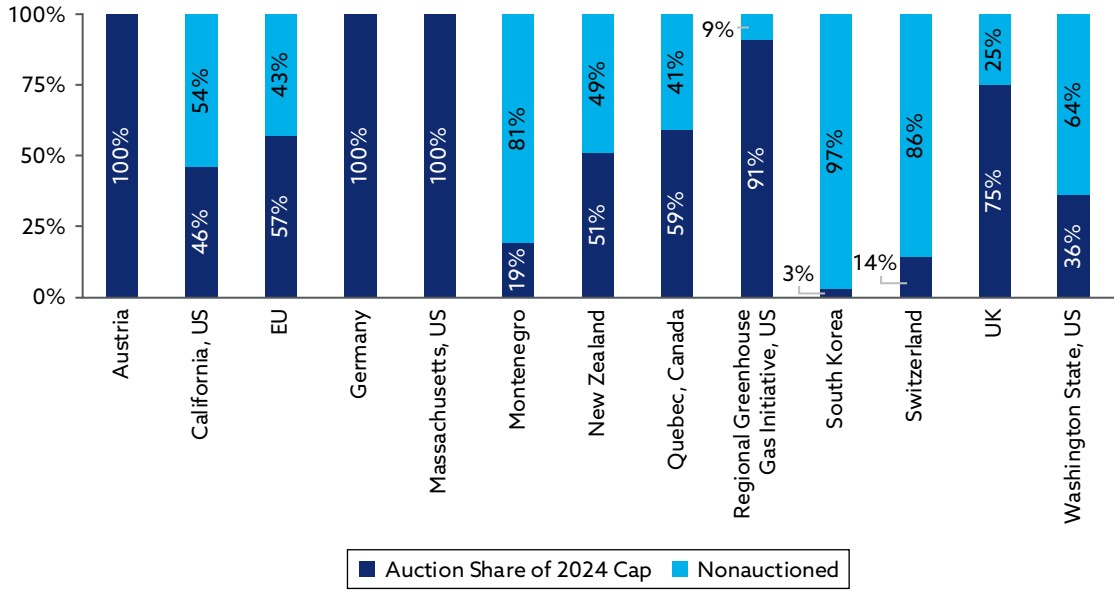
Compared with free allocation, auctioning offers several advantages:

- It improves the efficiency of resource allocation. When operating efficiently, auctions tend to allocate allowances to the covered emitters with the highest marginal abatement costs and the greatest need for additional allowances.
- It provides a more effective price discovery mechanism. Competitive bidding in auctions directly reflects the market's true demand for carbon allowances and expectations of allowance prices.
- It generates fiscal revenue. Auction proceeds provide governments with a stable source of income to fund emission-reduction projects, invest in renewable energy, or offset the impact of higher energy prices on vulnerable groups.

The International Carbon Action Partnership (ICAP) reported that of the 38 existing CCMs in 2024, 13 have adopted auctioning to varying degrees, with an average auction share of 58% (ICAP 2025). **Exhibit 1** presents the auction share of the carbon cap in these CCMs in 2024.

[4] In an economic context, carbon leakage occurs when a company facing increased costs caused by carbon emission regulations in its original market relocates its operations to another market that has no such regulations.

## Exhibit 1. Auction Shares of the Carbon Cap in CCMs Adopting Auctioning, 2024




*Source:* ICAP (2025).

### EU ETS and New Zealand ETS

The EU ETS was established in 2005. As the first CCM, its evolution clearly illustrates the shift from free allocation to auctioning.[5] In Phase 1 (2005–2007), the EU ETS relied almost entirely on free allocation. In Phase 2 (2008–2012), eight member states introduced auctions, selling about 3% of total allowances.[6] By Phase 3 (2013–2020), auctioning had become the primary allocation method, accounting for up to 57% of total allowances. In the current Phase 4 (2021–2030), the EU ETS has maintained this 57% auction share target. Of the volume of auctioned allowances, 90% is allocated to member states according to their share of verified emissions, while the remaining 10% is distributed to lower-income member states under the EU's solidarity provision.

Based on the target auction share of 57%, the EU ETS directive specifies the annual auction volume, which is also influenced by the Market Stability Reserve. A joint procurement agreement has been signed by 28 EU ETS member states to auction their allowances on the common auction platform, currently operated by EEX in Leipzig.[7] EEX has been conducting EUA auctions since 2010. As of the

[5] Yang and Preece (2024, pp. 15–22) provided an overview of the EU ETS, covering governance, scope, supply and demand factors, and the evolution of the four phases.

[6] The eight member states were Germany, the United Kingdom, the Netherlands, Austria, Ireland, Hungary, Czechia, and Lithuania.

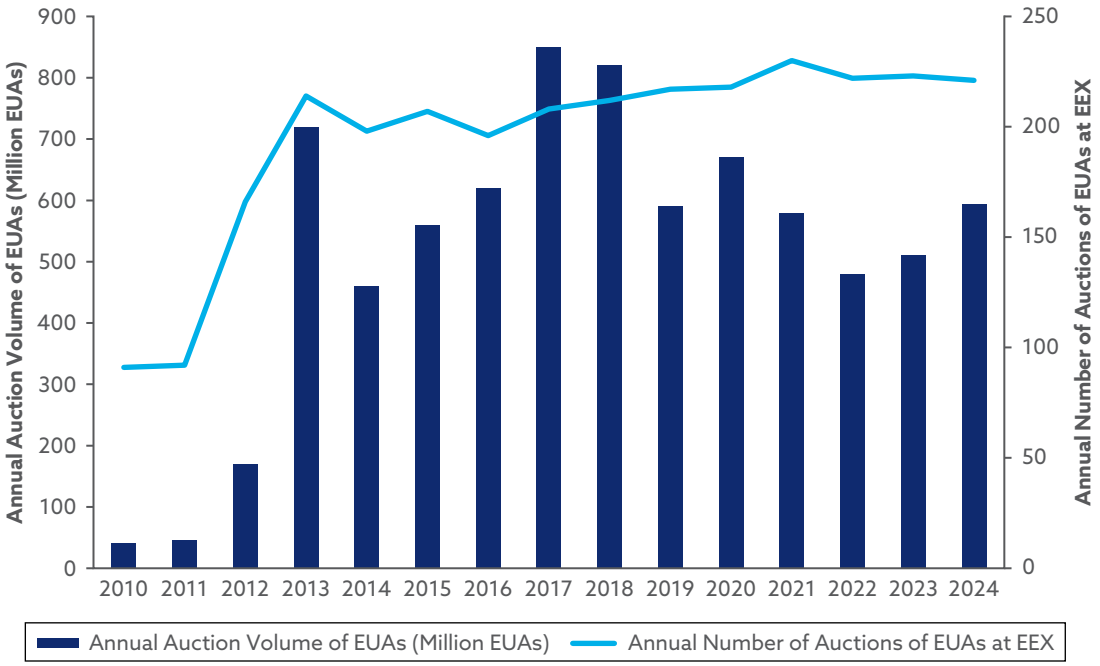
[7] The EU ETS covers 27 EU member states and three European Economic Area/European Free Trade Association countries (Iceland, Liechtenstein, and Norway). Germany and Poland have opted out of the common platform and conduct their own auctions.

end of 2024, EEX has held more than 2,800 successful EUA auctions. In 2024, EEX hosted 221 auctions, with 593 million EUAs sold.

**Exhibit 2** shows the auction volumes and the number of auctions for EUAs at EEX from 2010 to 2024. EUA auctions take place on Mondays, Tuesdays, and Thursdays from 9:00 a.m. to 11:00 a.m. CET. Under Article 18 of the EU Auctioning Regulation, eligible participants include covered emitters, investment firms and credit institutions, business groups of covered emitters, and other intermediaries specifically authorized by a member state. Participants may either obtain direct access to bid by purchasing an EEX membership or bid indirectly through an intermediary.

**Exhibit 3** illustrates the EEX EUA auction process. The EU ETS uses uniform-price, single-round, sealed-bid auctions.[8] After the bidding window closes, EEX sorts bids in descending order by price. If two or more bids are tied, EEX uses a random selection algorithm to rank them. It then aggregates bid volumes starting with the highest bid. The price at which the cumulative bid volume matches or exceeds the auctioned volume becomes the auction clearing price for all successful bidders, meaning the last successful bidder sets the clearing price for all. If multiple bidders tie at the clearing price, EEX randomly

## Exhibit 2. Auction Volumes and Number of Auctions of EUAs at EEX, 2010–2024




*Source:* EEX.

[8] A uniform-price auction means all winning bidders pay the same price—the clearing price, which is the lowest accepted bid that equates supply with demand—rather than paying their individual bid prices.

## Exhibit 3. EEX EUA Auction Timeline

| Time (CET) | Stage | Details |
|---|---|---|
| 9:00 a.m.–11:00 a.m. | Bidding window | • Participants may submit, modify, and withdraw bids without seeing other participants' bids.<br>• Each lot equals 500 EUAs. |
| 11:00 a.m.–11:01 a.m. | Clearing price determination | • EEX sorts bids by price (descending).<br>• EEX uses an algorithm to randomly sort tied bids.<br>• EEX aggregates bid volumes from the highest price downward until the total meets or exceeds the auctioned volume.<br>• The last accepted price becomes the clearing price for all successful bidders.<br>• EEX publishes the main auction results in the Auction System. |
| 11:01 a.m.–11:05 a.m. | Publication | • EEX publishes the detailed auction results on its website. |
| Auction day + 1 European Commodity Clearing (ECC) business day | Payment and delivery | • Buyers pay ECC. ECC pays the auctioneer.<br>• The auctioneer transfers allowances within the ECC Union Registry to buyers. |

*Source:* EEX.

allocates the remaining volume to one bidder. All winning bidders pay the same clearing price.

**Exhibit 4** illustrates the auction clearing process with a concrete example. Suppose the auction offers 100,000 EUAs in total. Four bidders—A, B, C, and D—submit bids (from highest to lowest) of EUR20 for 30,000 EUAs, EUR15 for 50,000 EUAs, EUR10 for 20,000 EUAs, and EUR5 for 10,000 EUAs, respectively. The price of EUR10 is the level at which total demand (at that price and above) equals the available supply of 100,000 EUAs, which therefore becomes the clearing price for all winning bidders. As a result, all winning bidders pay the clearing price of EUR10 and receive their bid quantities, rather than the individual bid prices they submitted.

## Exhibit 4. EEX EUA Auction Example

| Bidder | Bid Price | Quantity | Winning Bid? | Clearing Price Paid |
|---|---|---|---|---|
| A | EUR20 | 30,000 | ✓ | EUR10 |
| B | EUR15 | 50,000 | ✓ | |
| C | EUR10 | 20,000 | ✓ | |
| D | EUR5 | 10,000 | × | — |

As of the end of 2024, EEX has canceled approximately 12 auctions. According to EEX, cancellations occur under three conditions:

- Insufficient demand, under Article 7(5) of the Auctioning Regulation: total bid volume lower than the auctioned volume
- Abnormally low clearing price, under Article 7(6) of the Auctioning Regulation: clearing price significantly below the prevailing secondary market price
- Technical issues, under Article 9 of the Auctioning Regulation

When EEX cancels an auction, it immediately informs market participants, adjusts the auction calendar, and evenly redistributes the auction volume across the next four scheduled auctions.

EEX also conducts auctions for New Zealand emission units (NZUs) under the New Zealand Emissions Trading Scheme (NZ ETS). The NZ ETS launched in 2008 and since 2021 has gradually made auctioning the default allocation method for NZUs. In 2024, the NZ ETS offered 14.1 million NZUs for auction, representing 51% of the cap (27.9 million), and sold 7 million of them.[9] According to EEX, the New Zealand Exchange (NZX) and EEX jointly manage the auction process: NZX hosts and operates all auction-related activities, and EEX provides the bidding system and support.

In 2026, the NZ ETS plans to auction a total of 5.2 million NZUs, evenly across four scheduled auctions on 3 March, 9 June, 8 September, and 1 December. The specific auction volume is adjusted according to the clearing price. The auction floor price will rise to NZD71 (USD43) in 2026. The NZ ETS uses a cost containment reserve (CCR) to prevent a rapid increase in compliance costs caused by sharp increases in auction clearing prices. The CCR follows a two-tier design, with two trigger prices set annually by the regulator. When the auction clearing price exceeds a trigger price, a predetermined volume of additional allowances is released for auction.

## California and Quebec Carbon Markets

The California Cap-and-Invest Program, launched in 2012, and the Quebec Cap-and-Trade System, launched in 2013, linked in January 2014.[10] A carbon allowance from one market can be used in the other. Through WCI, Inc., a nonprofit organization that supports emission trading programs, the two CCMs jointly hold quarterly auctions, with the first joint auction held in

[9] Under the NZ ETS auction rules, if the clearing price falls below the auction reserve price—the price floor set by the regulator—the auction fails and all allowances offered are rolled forward to the next auction. Any allowance unsold at the end of the calendar year is canceled and removed from the future supply. Consequently, although the NZ ETS scheduled 14.1 million NZUs for auction in 2024, only 7 million were successfully sold. The remaining 7.1 million NZUs were canceled at year-end.

[10] Yang and Preece (2024) provided an overview of the California Cap-and-Invest Program and WCI, Inc., covering governance, carbon offsets, market activity, and price trend (pp. 22–27). The authors highlighted that both the EU ETS and the California Cap-and-Invest Program allow banking of unused allowances for use in future years. Note that banking applies only to covered emitters. Covered emitters may bank unused allowances that they have already obtained, either through auctions or through free allocation.

November 2014. In 2026, the four scheduled auction dates are 18 February, 20 May, 19 August, and 18 November.

In the Quebec Cap-and-Trade System, electricity and fuel distributors included after 2015—except for a few rare cases—receive no free allocation and must obtain all allowances through auctions or purchases from other covered emitters. Covered emitters in other sectors, however, receive partial free allocation. Unsold allowances from past auctions are gradually resold at auction once two consecutive auctions clear above the minimum price. If they remain unsold, the allowances are placed in the reserve.

According to ICAP (2025), during the first three compliance periods (covering 2013–2020), approximately 256 million allowances in total—63% of the cap for the period—were auctioned or directed to reserves. In the fourth compliance period (2021–2023), about 96.6 million allowances—60% of the cap—were auctioned or directed to reserves. The Quebec Cap-and-Trade System is currently in its fifth compliance period (2024–2026), with 59% of the 2024 cap auctioned. In 2024, the California Cap-and-Invest Program auctioned 207 million allowances. Because any allowances unsold for 24 months in California allowance auctions move to the reserve, 37 million California Carbon Allowances (CCAs) offered initially at auction have been placed in the reserve.

Each year, each CCM calculates its own annual auction reserve price, calculated as the previous year's reserve price multiplied by the sum of 1.05 (5% annual increase) and the jurisdiction's inflation rate.[11] The higher reserve price of the two CCMs under WCI, Inc., becomes the uniform auction reserve price (the minimum selling price) for the joint auctions.

WCI, Inc., has published the 2026 joint auction reserve price, calculated as follows. California's 2025 annual auction reserve price was USD25.87. With US inflation at 3.01%, California's 2026 reserve price is USD27.94.[12] Quebec's 2025 reserve price was CAD24.73 (USD18.08). With Canadian inflation at 2.05%, Quebec's 2026 reserve price is CAD26.47 (USD19.35). The higher value—USD27.94 for California—sets the 2026 joint auction reserve price for both markets.

Like EUA auctions, California and Quebec joint auctions use a single-round, sealed-bid, uniform-price format. All bids remain confidential. One lot equals 1,000 allowances. After the bid window closes, the auction administrator allocates allowances from the highest bid price down to the last unit sold. The lowest price at which total demand equals the available supply becomes the settlement price for all successful bidders. If tie bids occur at the settlement price, the remaining allowances are allocated proportionally among buyers based on their bid volumes.

[11] The auction reserve price is the minimum acceptable clearing price set by the regulator. If the clearing price falls below this level, the auction fails. The auction reserve price serves three main functions: (1) preventing allowances from being sold at excessively low prices, (2) acting as a price floor that sustains a minimum carbon price signal, and (3) reducing price volatility and discouraging coordinated low bidding among bidders.

[12] USD25.87 × (1.05 + 3.01%) = USD27.94.

## Exhibit 5. California and Quebec Quarterly Joint Auction Timeline

| Time | Action |
|---|---|
| –60 Days | Auction notice publication |
| –40 Days | Deadline to update information in CITSS |
| –30 Days | Deadline to submit an application |
| –12 Days | Deadline to submit a financial guarantee |
| –2 Days | Approval of auction participants |
| –1 Day | Minimum price and exchange rate publication |
| *Auction event* | |
| +7 Days | Publication of auction results |
| +14 Days | Deadline to pay for allowances |
| +26 Days | Transfer of allowances into CITSS accounts |

*Source:* WCI, Inc.

An emitter or participant must open an account in the Compliance Instrument Tracking System Service (CITSS) and indicate the intention to participate at least 30 days before the auction. WCI, Inc., implements the cap-and-trade system and administers auctions for both the California and Quebec markets. **Exhibit 5** outlines the joint auction timeline.

WCI, Inc., also conducts auctions for the State of Washington's Cap-and-Invest Program, which began on 1 January 2023 and held its first allowance auction on 28 February 2023.[13] The state plans to hold four auctions each year, with the 2026 auctions scheduled for 4 March, 3 June, 2 September, and 2 December. In 2025, 22 million allowances were auctioned.

### UK ETS

After leaving the EU ETS, the United Kingdom launched the UK Emissions Trading Scheme (UK ETS) in January 2021. The scheme is currently in its first phase, which runs until 2030. Auctioning is the primary method for allocating allowances. In 2024, the UK ETS auctioned approximately 69 million allowances—around 75% of the cap—and raised about GBP2.6 billion (USD3.3 billion). In December 2020, ICE was appointed to conduct allowance auctions in preparation for the UK ETS's launch. The first UK allowance (UKA) auction took place on 19 May 2021. ICE holds UKA auctions every other Wednesday throughout the year, from 12:00 p.m. to 2:00 p.m. local time.

[13] For additional detail, see the State of Washington Department of Ecology webpage on cap-and-invest auctions and markets: https://ecology.wa.gov/air-climate/climate-commitment-act/cap-and-invest/auctions-and-market.

## Exhibit 6. ICE UKA Auction Timeline

| Period | Time | Actions |
|---|---|---|
| Period 1 | Prior to the auction | • The auctioneer delivers the allowances to ICE<br>• Participants set up trading limits |
| Period 2 | Two-hour bidding window | • Bidders enter, edit, and withdraw orders |
| Period 3 | 10 minutes after the bidding window closes | • ICE checks bids |
| Period 4 | 15 minutes after the bidding window closes | • Matching completed<br>• Auction results published |

*Source:* ICE.

**Exhibit 6** outlines the ICE UKA auction timeline. Covered emitters, financial institutions, and business groups/public bodies acting on behalf of covered emitters are eligible to participate in auctions. Each lot equals 500 UKAs. Auctions are conducted on WebICE, ICE's front-end trading platform, using a single-round, sealed-bid, uniform-price format. During the two-hour bidding window, bidders may submit, modify, and withdraw bids without knowing other bids. After the bidding window closes, the auction administrator ranks bids by price from highest to lowest and matches them against the offered volume. The price at which the total bid volume meets or exceeds the available volume becomes the auction clearing price. If tied bids occur at the clearing price, ICE allocates the remaining allowances randomly among the tied bidders. Successful bidders must pay ICE Clear Europe, the clearing-house for ICE, by 9:00 a.m. local time on the day following the auction. ICE Clear Europe then transfers the allowances from its registry account to the buyers' accounts. The UK ETS sets an auction reserve price of GBP22 (USD28.12). Allowances will not be sold below this price. Even if some allowances remain unsold, the auction clears. Unsold allowances transfer forward to the next four auctions, but the total volume in each auction may not exceed 125% of the allowance originally scheduled for sale. If all four following auctions reach this 125% threshold, ICE transfers any remaining unsold allowances to the Market Stability Mechanism Account.

## Summary

Global CCMs are shifting from free allocation to auction-based allowance distribution as the dominant method. Among CCMs that use auctioning, the most common structure is a single-round, sealed-bid, uniform-price auction. CCMs use dedicated platforms to conduct auctions: EEX for the EU ETS and the New Zealand ETS; WCI, Inc., for California, Quebec, and Washington state; and ICE for the UK ETS.

Each CCM has distinct characteristics. The EU ETS has the longest auction history, the largest auction volumes, and the most frequent schedule (three days per week), making it the most mature auction market. The California Cap-and-Invest Program conducts quarterly auctions and uses a relatively strict, annually increasing auction reserve price mechanism, which can directly

influence auction prices. The UK ETS holds biweekly auctions. As a newer and smaller CCM, the UK ETS has a tighter auction supply. These structural differences directly affect each CCM's auction effectiveness.

The next section analyzes the auction performance of CCMs, taking these differences into account.

## Auction Effectiveness

An effective carbon market auction mechanism should

- consistently generate clearing prices that are aligned with prevailing market valuations (auction-market price stability),
- attract sufficient demand (demand depth), and
- allow prices to be determined by the market rather than being constrained by policy floor prices (reserve price bindingness).

Based on the availability of auction data published by CCMs, this section evaluates the auction effectiveness of three representative CCMs—the EU ETS, the California Cap-and-Invest Program, and the UK ETS—from the perspectives of auction-market price stability, demand depth, and reserve price bindingness.

### Auction-Market Price Stability

The auction mechanism serves not only as a tool for allowance allocation but also as a process of price discovery. An effective CCM auction mechanism generates stable price signals that, in the long run, remain aligned with market valuations.[14] Such stability and alignment support emitters' long-term investment decisions for abatement and reduce market uncertainty. The auction clearing prices in the primary market should therefore not deviate significantly from prevailing market valuations, proxied by secondary market prices, across auction rounds. Otherwise, auctions can become a source of price uncertainty rather than providing robust price signals.

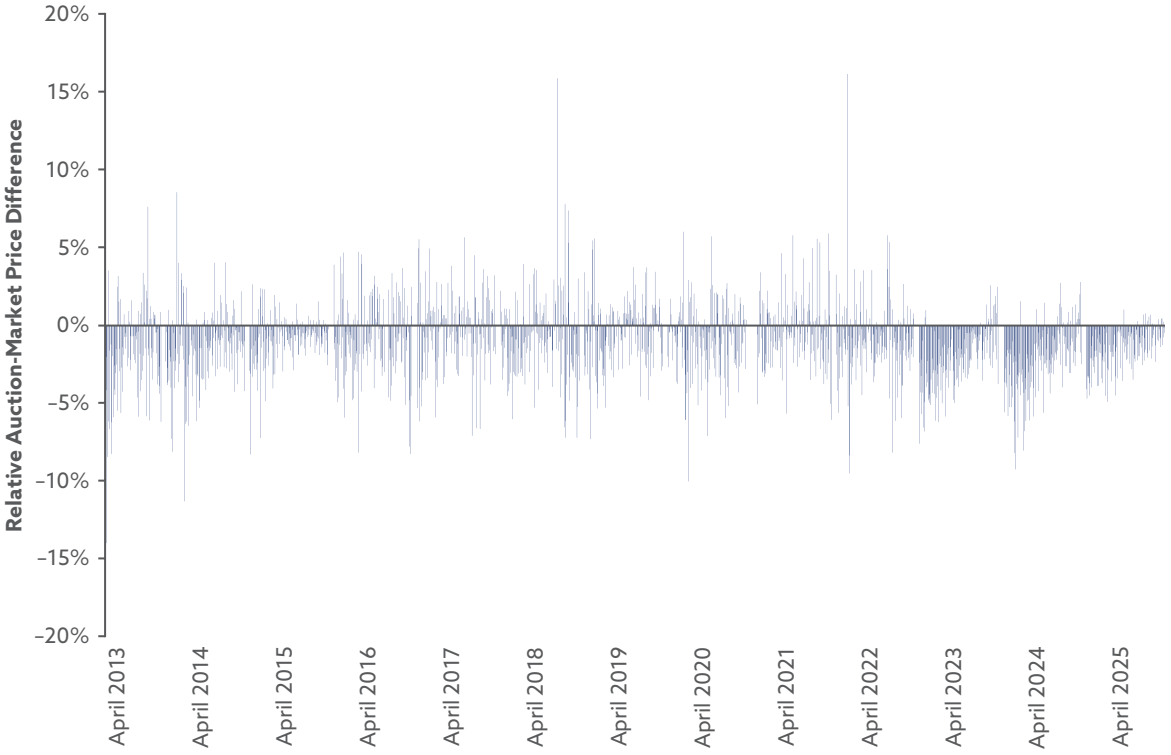
The auction-market price difference, defined as the difference between the auction clearing price and the prevailing secondary market price, measures the extent to which the clearing price of a single auction deviates from the market valuation benchmark. The relative auction-market price difference, defined as the auction-market price difference divided by the prevailing market price, expresses this deviation as a proportion of the market price and thus removes scale effects associated with price-level changes, facilitating comparison over

[14] Maintaining long-term stability and alignment between auction clearing prices and secondary market prices is a key policy objective for CCM regulators. Many CCMs, such as those in the EU, California, and the United Kingdom, use such tools as market stability reserves, cost containment mechanisms, and supply adjustment mechanisms to achieve this objective. These mechanisms release additional allowances (or reduce auction supply) when auction prices are excessively high (or low) in order to mitigate short-term price shocks in the auction market.

time and across markets.[15] A relative auction-market price difference close to zero indicates strong alignment between the auction outcome and market valuation, while a large positive or negative value indicates a decoupling between them. Importantly, an auction mechanism's effectiveness is assessed not according to a deviation in an individual auction but rather on the basis of the long-term trend of the relative auction-market price difference.

The next two exhibits illustrate the long-term trend and overall distribution of the relative auction-market price difference in the EU ETS. As shown in **Exhibit 7**, relative auction-market price differences in the EU ETS are largely concentrated around zero, with small deviations, mostly within the range of –5% to 5%. In the early stage following the introduction of auctions (2013–2014), relative deviations were predominantly negative. This finding may be attributed to the combination of low price levels and limited market depth at the time, a dynamic that made secondary market prices more susceptible to short-term trading pressure while auction bidding behavior remained relatively conservative.

## Exhibit 7. Relative Auction-Market Price Differences in the EU ETS, 2013–2025



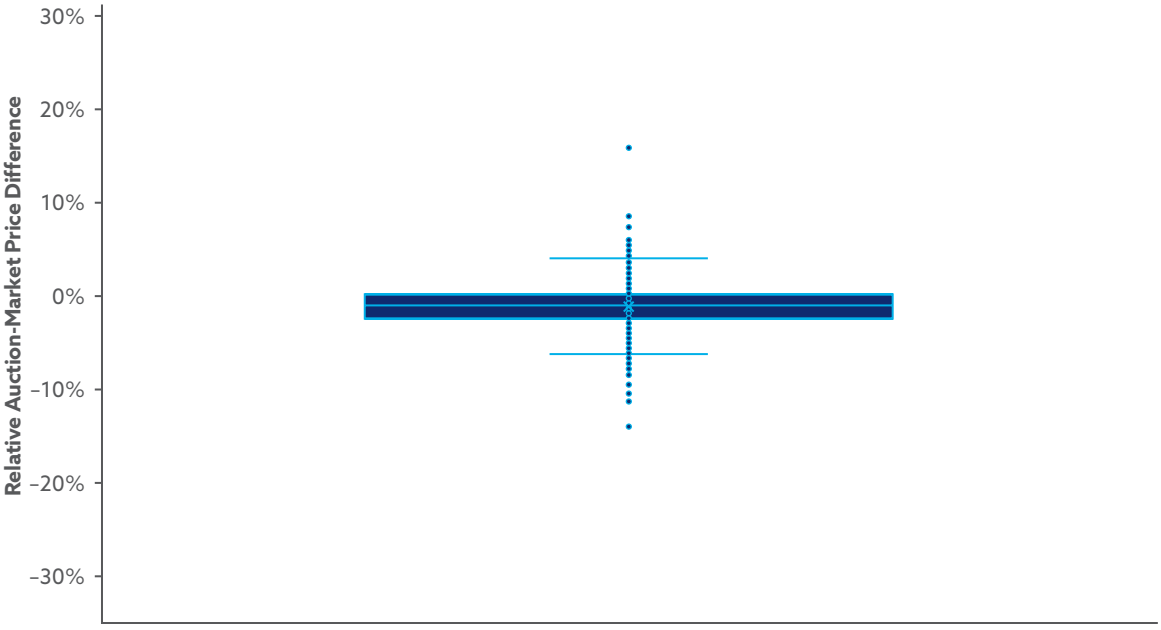

*Source:* Data on 1,776 auctions from 2013 to 2025 from EEX and London Stock Exchange Group (LSEG).

[15] For example, when the secondary market price is EUR20 and the auction price is EUR21, the auction-market price difference is EUR1 and the relative auction-market price difference is 5%. When the secondary market price is EUR100 and the auction price is EUR105, the auction-market price difference is EUR5 but the relative auction-market price difference remains 5%. Although the absolute difference is larger in the second case, the degree of deviation is identical. This illustrates how the relative measure avoids exaggerating deviations at higher price levels and enables meaningful comparisons over time and across markets, especially when carbon prices rise substantially during the sample period.

From 2015 to 2019, the auction market was in a relatively stable phase, with deviations tightly clustered around zero. Although extreme values occasionally occurred, positive and negative deviations were broadly balanced, and the distribution remained stable without persistent directional bias. Auction prices during this period were broadly aligned with market prices. Between 2020 and 2022, the EU ETS experienced substantial external shocks, including the COVID-19 pandemic and the energy crisis, leading to pronounced volatility in secondary market prices.[16] Despite these shocks, the relative auction-market price difference maintained the same stable pattern observed during 2015–2019, without widening deviations or sustained directional drift. This stable pattern suggests that even under substantial external shocks, the EU ETS auction mechanism maintained close alignment between auction and market prices. The resilience reflects the maturity of the EU ETS and the role of price-stabilizing mechanisms, such as the Market Stability Reserve.

Since 2023, the EU ETS has been in a post-shock adjustment phase, during which secondary market prices have exhibited short-term volatility while auction prices have remained conservative. This dynamic resulted in a negative overall bias in the relative deviation, although the magnitude diminished over time and gradually converged toward zero. As shown in **Exhibit 8**, for the full sample period, most relative auction-market price differences are concentrated

## Exhibit 8. Box Plot of Relative Auction-Market Price Differences in the EU ETS, 2013–2025



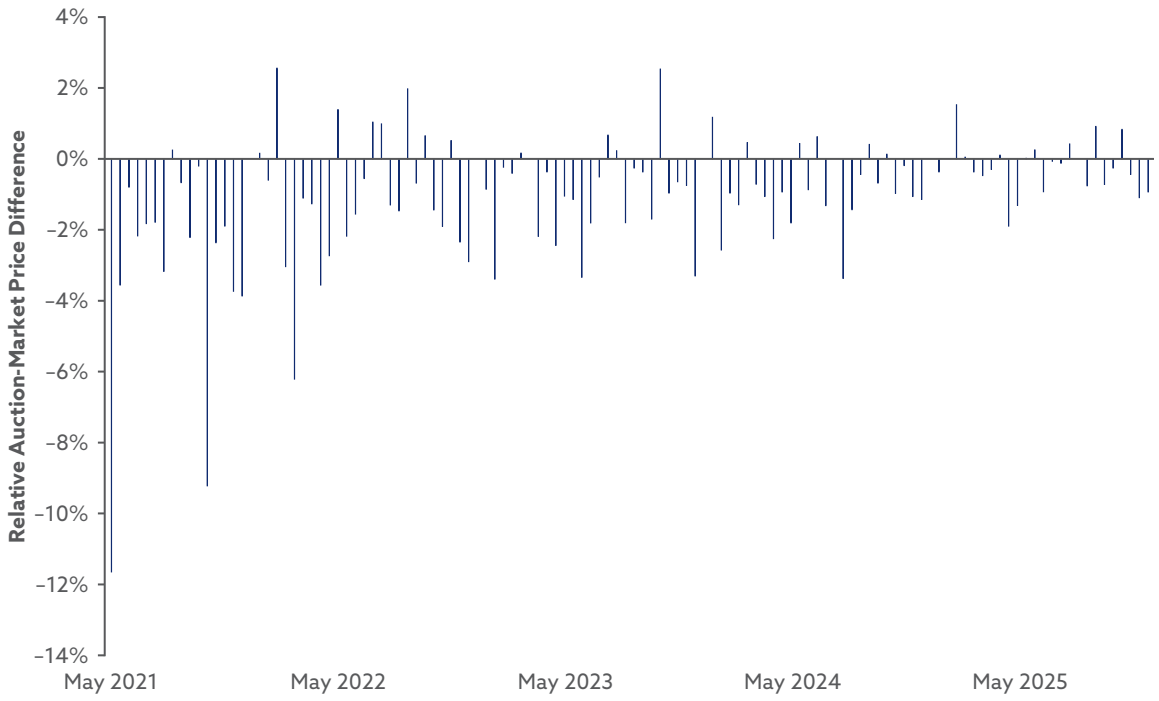

*Source:* Data on 1,776 auctions from 2013 to 2025 from EEX and LSEG.

[16] Exhibit 5 in Yang and Preece (2024, p. 18) illustrates price volatility in EU ETS allowances.

within a very narrow range around zero (although this range is slightly below zero because of a large number of negative deviations at the beginning and end of the period).

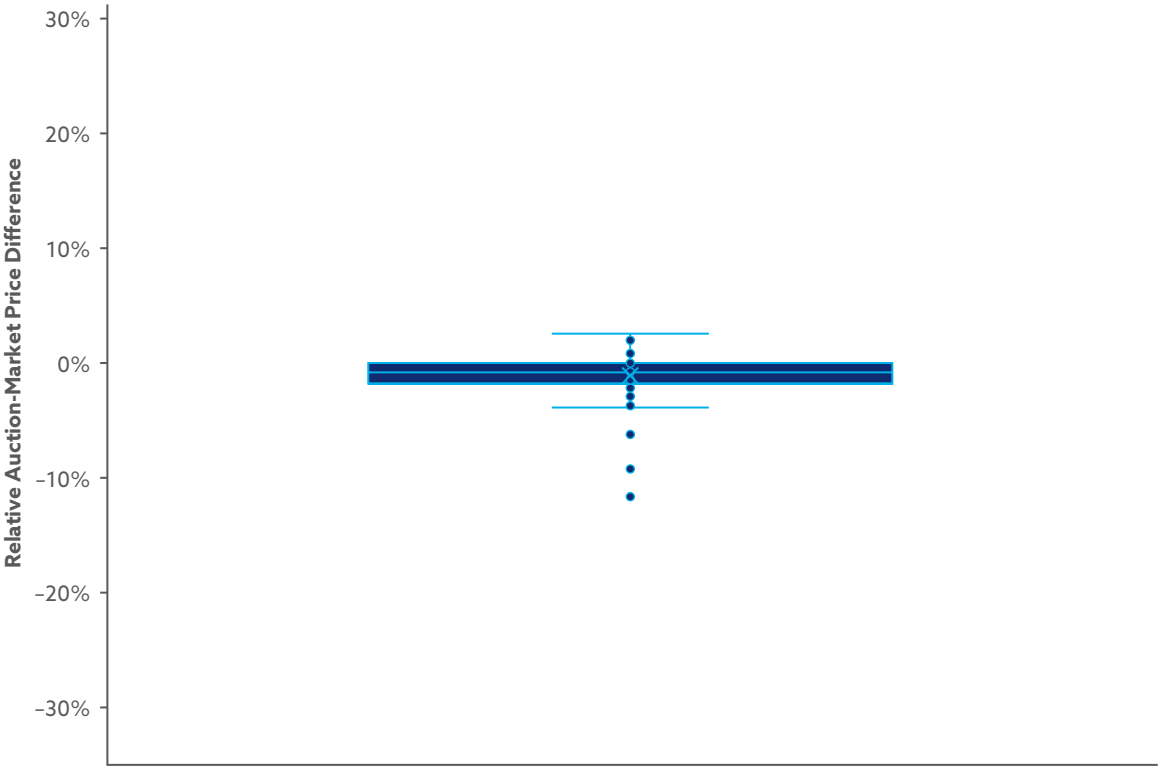
**Exhibits 9** and **10** present the long-term trend and distribution of the relative auction-market price difference in the UK ETS. As shown in Exhibit 9, the relative auction-market price difference in the UK ETS is persistently negative, indicating that auction clearing prices are systematically lower than prevailing market prices. In the early phase of the market, for reasons similar to those observed in the early EU ETS phase, a small number of extreme negative values occurred, reflecting short-term volatility in the secondary market and conservative bidding behavior in auctions. As the market developed, deviations gradually converged, indicating improved integration between auction and secondary prices. However, the negative bias remains pronounced, suggesting a systematic discount in UK ETS auction prices compared to market prices. Despite the negative bias, the auction price discount is relatively small, typically less than 5%. Over the 2023–25 period, the EU ETS exhibited a similar magnitude of negative bias. Exhibit 10 confirms this pattern, showing a concentration of relative deviations slightly below zero.

## Exhibit 9. Relative Auction-Market Price Differences in the UK ETS, 2021–2025




*Source:* Data on 115 auctions from 2021 to 2025 from ICE and LSEG.

## Exhibit 10. Box Plot of Relative Auction-Market Price Differences in the UK ETS, 2021–2025

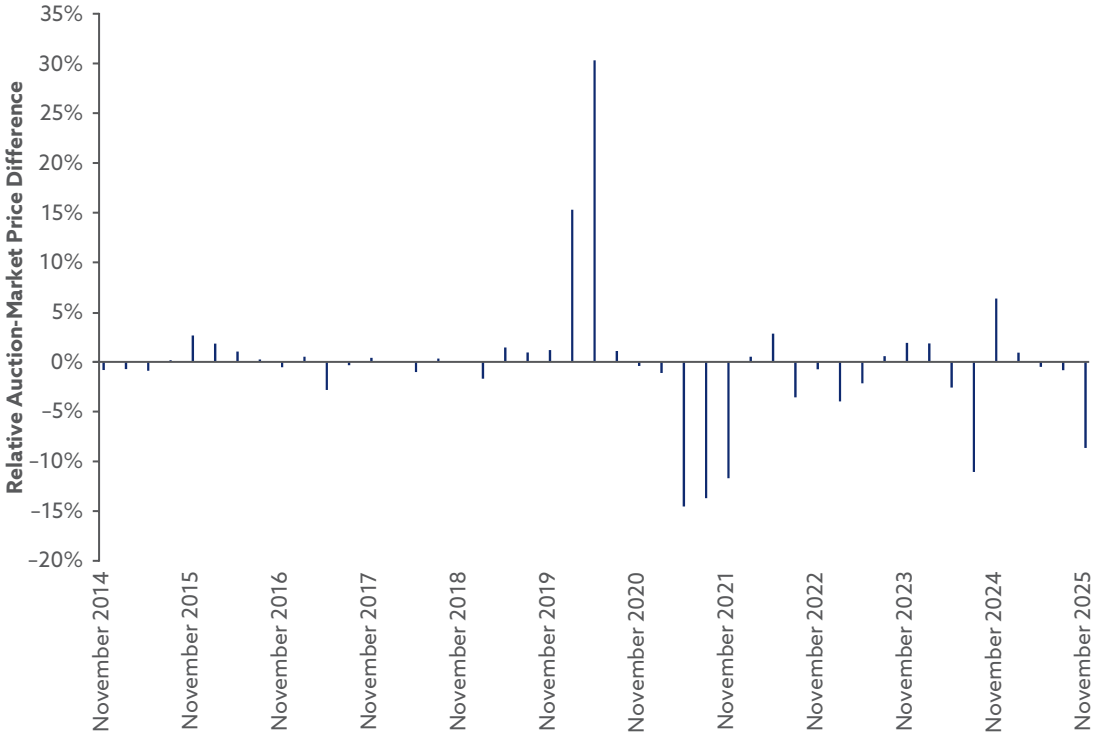



*Source:* Data on 115 auctions from 2021 to 2025 from ICE and LSEG.

**Exhibits 11** and **12** illustrate the long-term trend and distribution of the relative auction-market price difference in the California Cap-and-Invest Program. Unlike the EU ETS and UK ETS, the California carbon market exhibits small deviations most of the time, but with pronounced extreme values—particularly large positive deviations—and frequent switches between positive and negative deviations. Two factors may contribute to this pattern. On one hand, as discussed in the previous section, the California carbon market uses a strictly increasing annual auction reserve price. When market prices fall below the auction reserve price, auction clearing prices cannot adjust downward, resulting in extreme positive deviations. On the other hand, California conducts auctions at a relatively low frequency (quarterly) compared to the EU and the United Kingdom. Thus, auction prices provide low-frequency price signals, whereas secondary market prices adjust continuously. During periods of substantial secondary market volatility, auction prices may lag market prices, leading to directional reversals in relative deviations.[17] As shown in Exhibit 12, the overall distribution of the relative auction-market price difference in California remains concentrated around zero, with large tails.

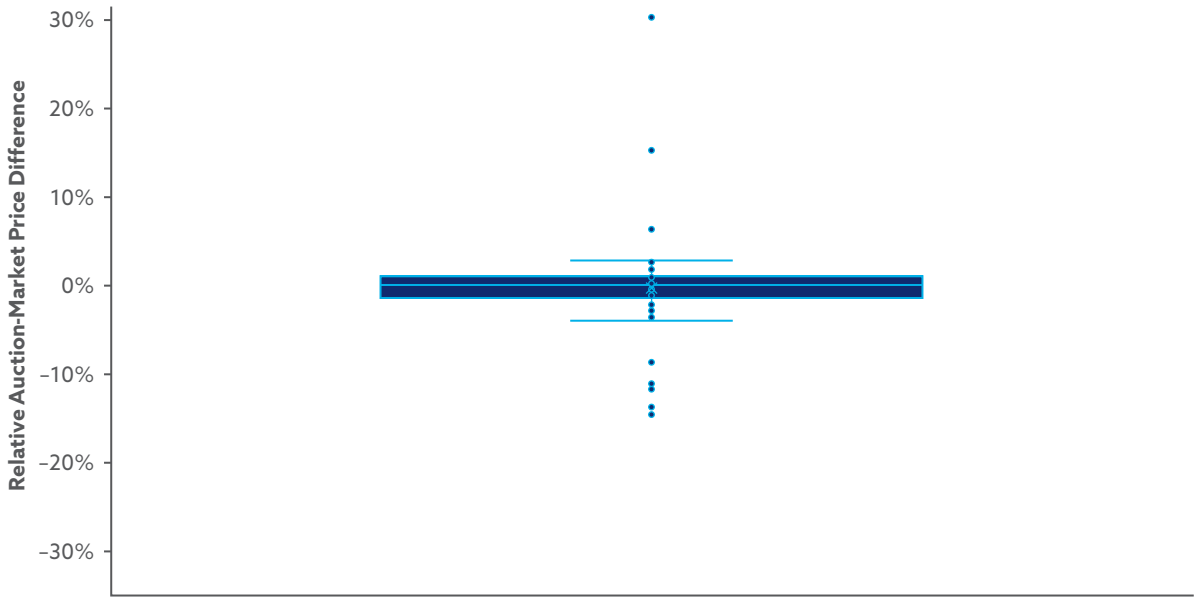
[17] The concentration of extreme values during 2020–2021 coincides with the period of pronounced secondary market price volatility caused by the COVID-19 pandemic and energy crisis.

## Exhibit 11. Relative Auction-Market Price Differences in the California Cap-and-Invest Program, 2014–2025




*Source:* Data on 45 auctions from 2014 to 2025 from the California Air Resources Board (CARB).

## Exhibit 12. Box Plot of Relative Auction-Market Price Differences in the California Cap-and-Invest Program, 2014–2025




*Source:* Data on 45 auctions from 2014 to 2025 from CARB.

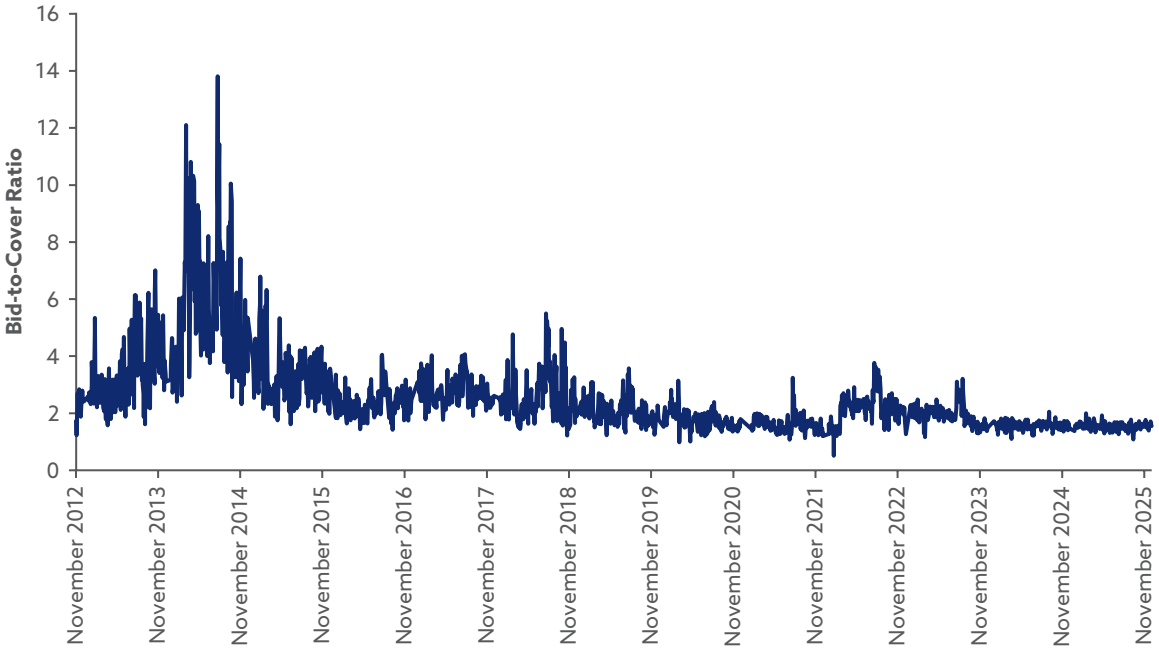
In summary, auction clearing prices in the EU ETS are highly aligned with market prices for most of the sample period. Its auction mechanism demonstrates the resilience to external shocks and capacity for post-shock self-adjustment. The UK ETS exhibits a persistent small discount between auction clearing prices and market prices. As a developing market, its auction-market alignment improves over time. In California, auction clearing prices are broadly aligned with market prices overall, but the strict auction reserve price and the mismatch between low-frequency auctions and high-frequency secondary market trading lead to more pronounced extreme deviations.

## Demand Depth

An effective auction mechanism should attract sufficient demand. In return, active market participation enhances auction efficiency. The bid-to-cover ratio (BCR), defined as bid volume divided by auction volume, serves as an indicator of the depth of aggregate demand in allowance auctions. A high ratio indicates strong demand relative to supply and high participation, whereas a low ratio signals weak market interest, which may result in low liquidity and potentially high price volatility.

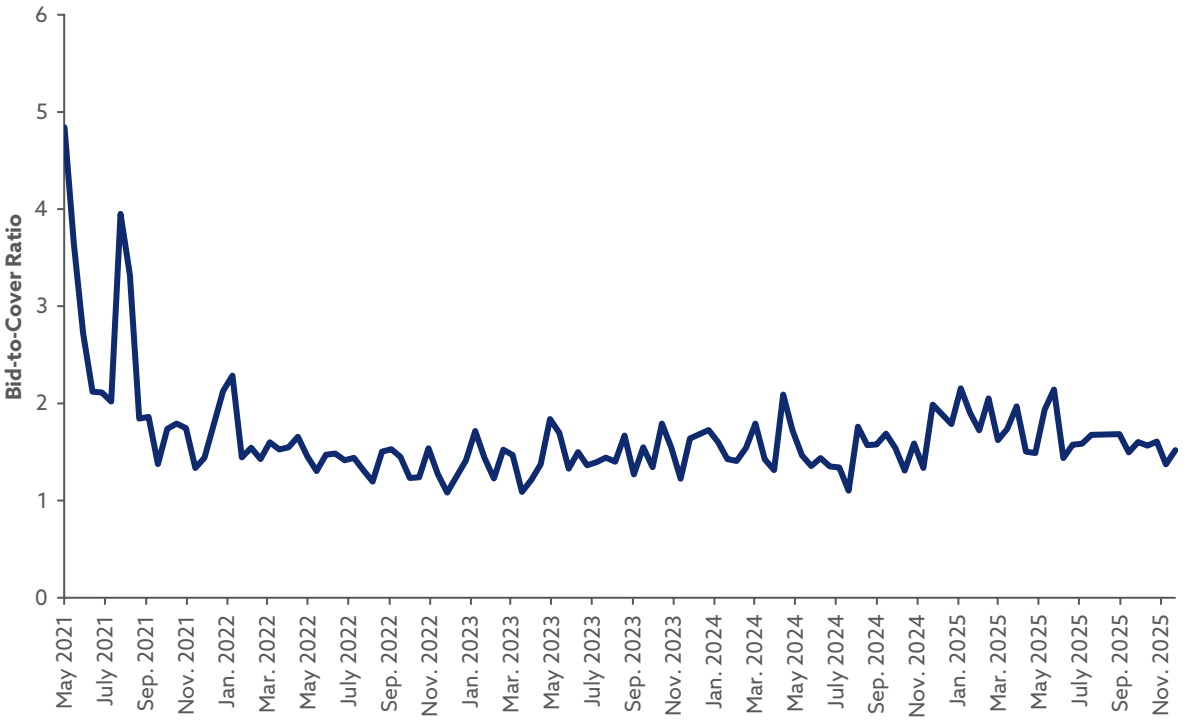
**Exhibits 13**, **14**, and **15** illustrate the evolution of BCRs across the three carbon markets. The EU ETS experienced substantial fluctuations in the early years, peaking at 14 in 2014. Since 2015, the BCR has gradually stabilized and now remains around 2. Similarly, the UK ETS experienced an initial phase with a

### Exhibit 13. EEX EUA Auction Bid-to-Cover Ratio, 2012–2025



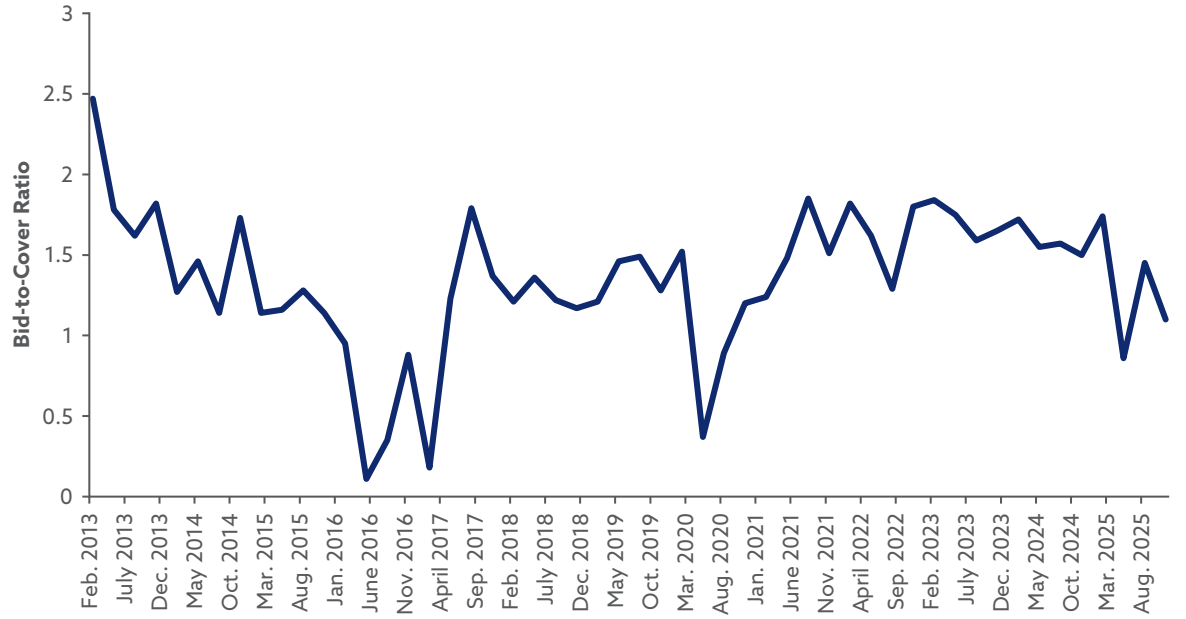

*Source:* Data on 1,829 auctions from 2012 to 2025 from EEX.

## Exhibit 14. ICE UKA Auction Bid-to-Cover Ratio, 2021–2025




*Source:* Data on 115 auctions from 2021 to 2025 from ICE.

## Exhibit 15. WCI, Inc., CCA Auction Bid-to-Cover Ratio, 2014–2025

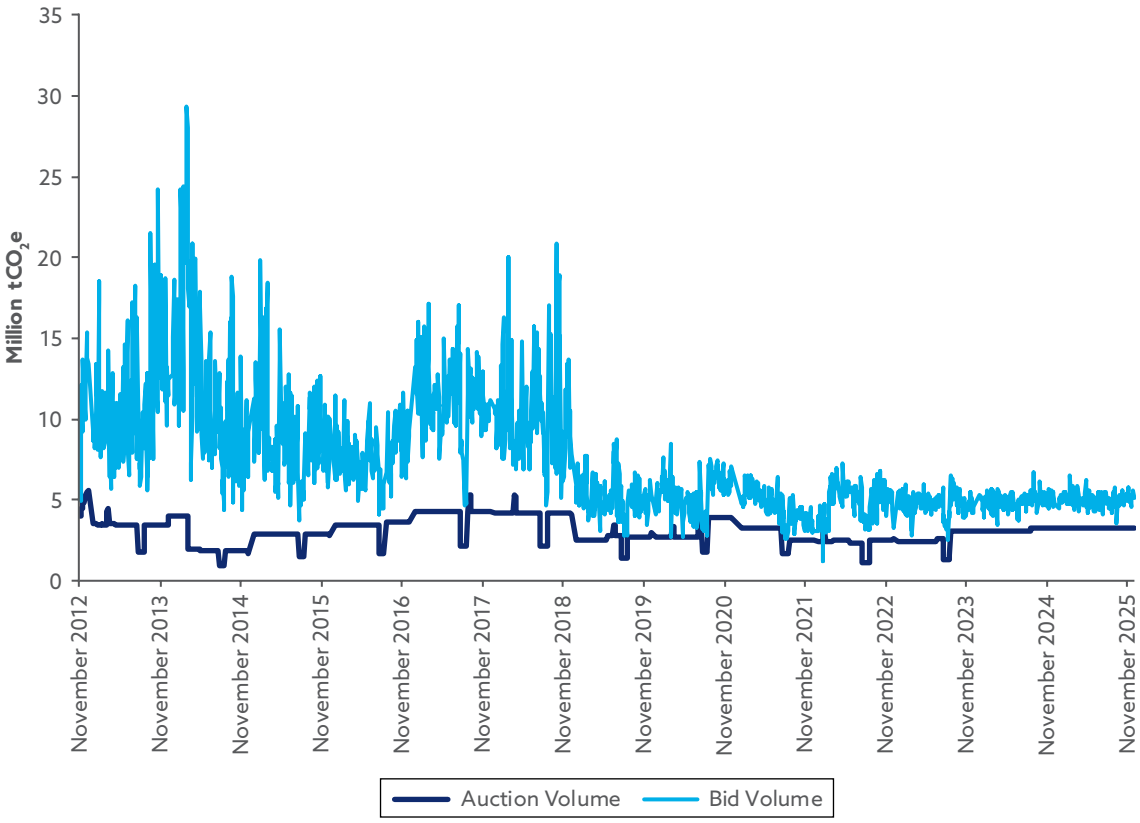



*Source:* Data on 52 auctions from 2014 to 2025 from CARB.

high BCR, followed by a rapid decline and subsequent stabilization at 1–2. Both the EU ETS and the UK ETS exhibit a long-term pattern of stable, moderate demand depth. In contrast, the BCR of the California carbon market shows fluctuations between oversupply and undersupply. The BCR fell below 1 at times, indicating that demand fell short of supply. This finding indicates the strong fluctuations in demand depth in the California carbon market. Since 2021, however, the BCR has gradually stabilized at around 1.5.

To further analyze the cause of the fluctuations in BCRs, **Exhibits 16**, **17**, and **18** present the corresponding auction and bid volumes. In both the EU ETS and the UK ETS, auction volumes have remained stable over time, and short-term demand fluctuations account for the observed BCR fluctuations. In the California carbon market, by contrast, the pronounced fluctuations in the BCR result from combined changes in both auction and bid volumes, although auction volumes have stabilized in recent years.

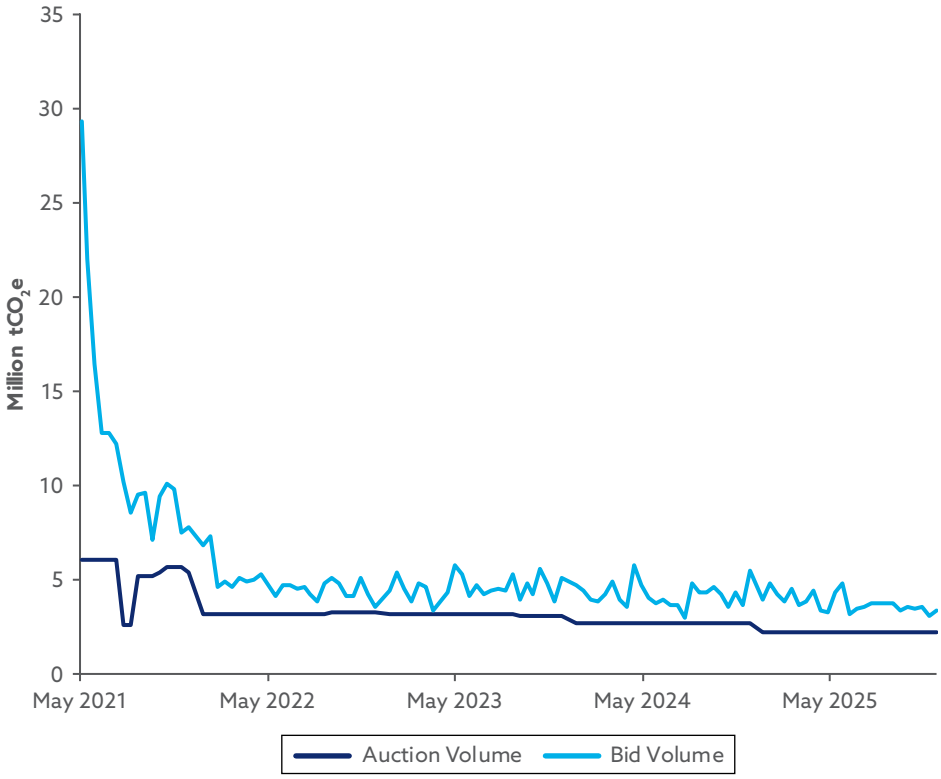
## Exhibit 16. EEX EUA Auction and Bid Volumes, 2012–2025




*Note:* $tCO_2e$ stands for tonnes of carbon dioxide equivalent.

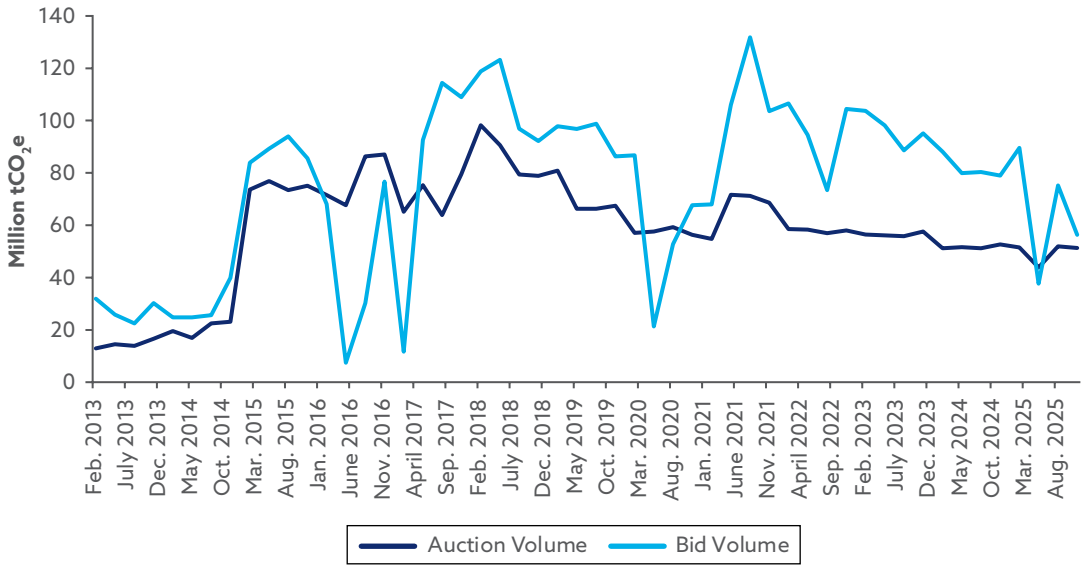
*Source:* Data on 1,829 auctions from 2012 to 2025 from EEX.

## Exhibit 17. ICE UKA Auction and Bid Volumes, 2021–2025




*Source:* Data on 115 auctions from 2021 to 2025 from ICE.

## Exhibit 18. WCI, Inc., CCA Auction and Bid Volumes, 2014–2025



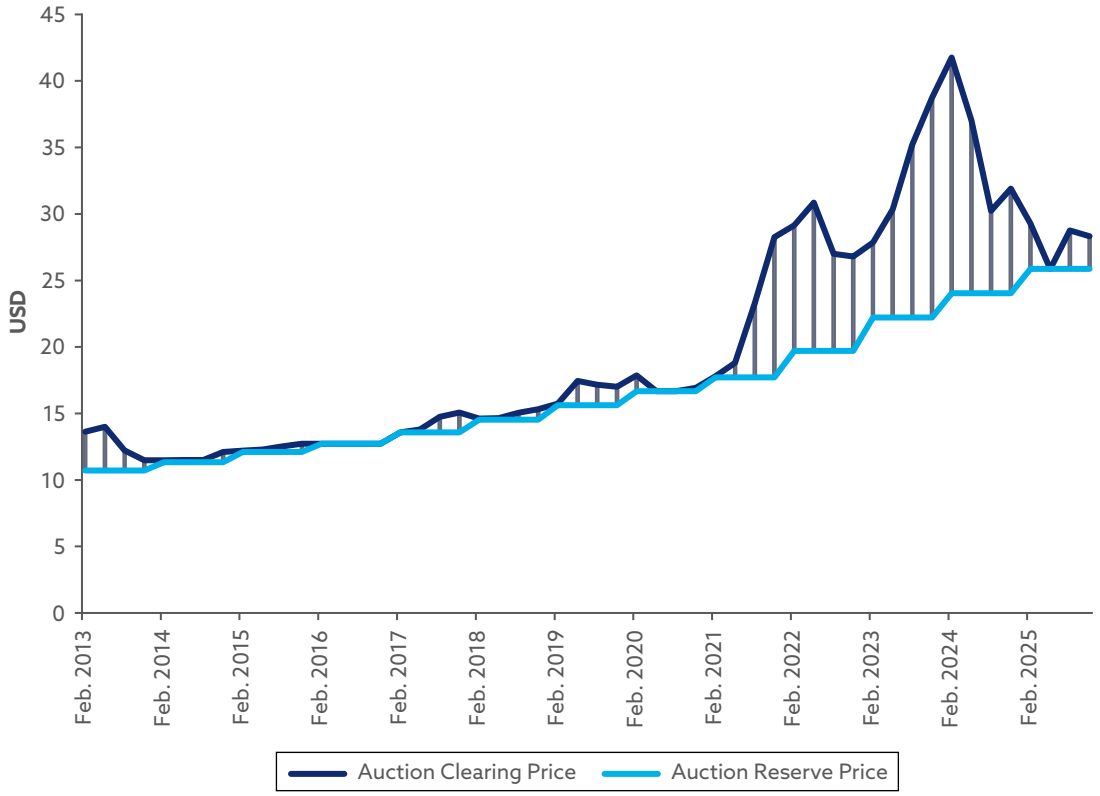

*Source:* Data on 52 auctions from 2014 to 2025 from CARB.

## Reserve Price Bindingness

An effective auction mechanism should provide sufficient space for market-based price discovery. In a competitive market, the auction clearing price should be determined by market demand and supply rather than being supported by a policy-imposed price floor. When the auction clearing price in a carbon market consistently tracks the auction reserve price, the auction effectively becomes equivalent to selling allowances at a fixed price rather than discovering a market price. The auction clearing price premium, defined as the difference between the clearing price and the reserve price, measures the bindingness of the reserve price. A larger clearing price premium indicates that the auction outcome is primarily market driven and that the auction clearing price serves a genuine price discovery function. In contrast, a smaller premium suggests that auctions clear near the reserve price and that the reserve price is binding, implying that price floor policy plays a dominant role in determining the auction outcome.

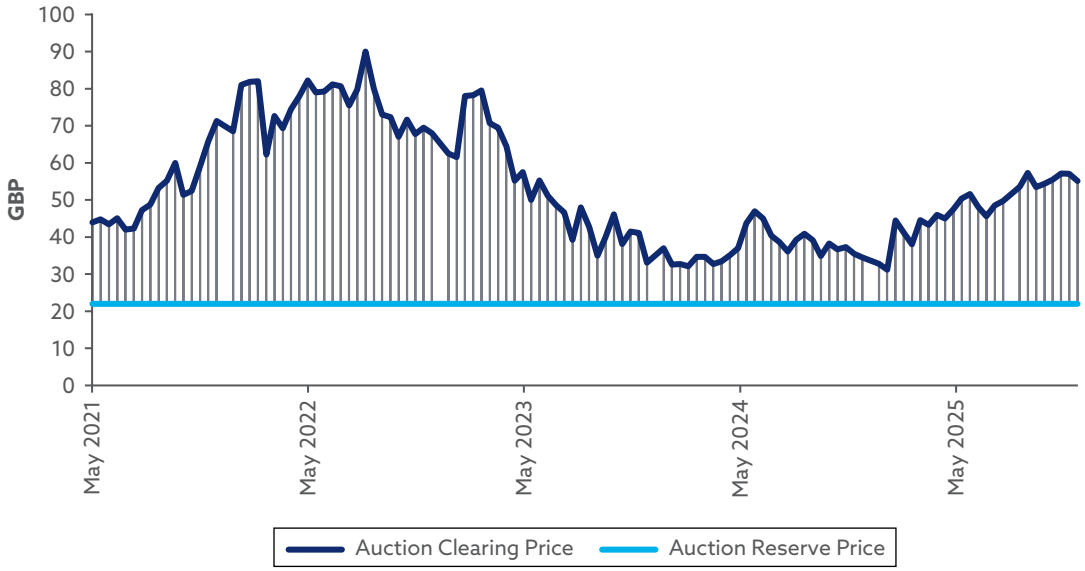
**Exhibit 19** presents the WCI, Inc., CCA auction clearing price premium from 2013 to 2025, with up-and-down bars indicating the magnitude of the premium. As discussed previously, California's reserve price increases annually according

### Exhibit 19. WCI, Inc., CCA Auction Clearing Price Premium, 2013–2025




*Source:* Data on 52 auctions from 2013 to 2025 from CARB.

## Exhibit 20. ICE UKA Auction Clearing Price Premium, 2021–2025




*Source:* Data on 115 auctions from 2021 to 2025 from ICE.

to a predetermined rule, resulting in a steady upward trend. For most of the period, clearing and reserve prices were nearly identical, indicating that reserve prices were binding in most auctions. Only during the 2021–24 period did the clearing price premium rise substantially, with clearing prices significantly above reserve prices. Since 2024, however, the premium has gradually converged toward zero again. Overall, this pattern suggests that auction outcomes in the California carbon market are driven more by the reserve price policy than by market forces. A binding reserve price has the advantage of reducing volatility by providing market participants with a reliable price floor, which stabilizes expectations and market sentiment. The tradeoff, however, is that it limits the space for market-based price discovery.

By contrast, the EU ETS does not have an explicit auction reserve price. The UK ETS adopts an auction reserve price, but its level has remained constant at GBP22 (USD28.12) since 2021, rather than increasing annually as in the California carbon market. As shown in **Exhibit 20**, the reserve price in the UK ETS is nonbinding; clearing prices consistently exceed it.

## Summary

By analyzing the effectiveness of auction mechanisms from the perspectives of auction-market price stability, demand depth, and reserve price bindingness, the three major carbon markets show the following characteristics:

- As the most mature CCM, the EU ETS auction clearing prices are broadly aligned with prevailing secondary market prices. Its auction mechanism

demonstrates strong resilience to external shocks and capacity for post-shock self-adjustment. In the long run, the auction mechanism maintains stable, moderate demand depth and a steady auction supply.

- As a developing CCM, UK ETS auctions tend to clear at a small discount relative to secondary market prices. The alignment between the auction and the secondary market improves over time. The auction mechanism also exhibits stable, moderate demand depth and a steady auction supply. Auction clearing prices are consistently above the constant auction reserve price.
- As a CCM with a strictly annually increasing auction reserve price and relatively low auction frequency, California's auction clearing prices are generally aligned with secondary market prices, although occasional large deviations occur because of the strict reserve price policy and the frequency mismatch between auctions and secondary market trading. Demand depth is more volatile, driven by fluctuations on both the demand and supply sides, and oversupply can occur at times. In most cases, the reserve price is binding; clearing prices are close to it. Auction outcomes are thus affected more by reserve prices than by market forces.

## Auction Effectiveness Determinants

Differences in auction effectiveness among CCMs may be caused by variations in auction mechanism design, as illustrated earlier. Thus, this section provides a qualitative discussion of features, including both design choices and indirect desirable features, that may enhance auction effectiveness. Rather than identifying strict causal relationships, this section discusses how specific features can contribute to the effectiveness of auction mechanisms.

Auction frequency, auction share, and auction reserve price are key design choices in carbon market auction mechanisms that regulators can directly determine, and they may affect auction effectiveness. In addition to design choices, a well-functioning carbon market has indirect desirable features that are not directly set by regulators but may still affect auction effectiveness, such as the number of bidders and secondary market trading volume.[18]

### Auction Frequency

Auction frequency is one of the most fundamental differences in carbon market auction design. A higher auction frequency enables auction mechanisms to reduce the discrepancy between the clearing price and market valuation, as observed in the EU ETS. By contrast, a lower frequency may lead to larger deviations between price and valuation, particularly when secondary market price volatility is high. More frequent auctions provide a steadier, more

[18] Unlike design choices, regulators cannot directly determine indirect desirable features, such as the number of bidders and secondary market trading volume. Regulators may influence these features indirectly, however, through auction design choices. For example, increasing auction frequency and auction share may attract more bidders and enhance secondary market trading volume.

continuous supply and improve the convenience and accessibility of auction markets, thereby increasing participation and enhancing demand depth. Lower frequency may discourage participation and lead to oversupply, as seen in the California carbon market. Higher frequency also narrows the bid price range because frequent auctions generate more consistent price signals, improve market transparency, and reduce pricing disparities. In addition, bidders face repeated opportunities to acquire allowances, which reduces the incentive to submit extreme bids in a single auction.

## Auction Share

An increase in the share auctioned indicates a shift from free allocation to auction-based allocation, making auctions the primary way to obtain allowances. This transition encourages broader market participation from covered emitters and enhances their reliance on the auction market. A larger auction share attracts more demand into the auction market, significantly enhancing the demand depth.

## Auction Reserve Price

When deciding whether to introduce an auction reserve price, regulators face a tradeoff between price stability and market-based price discovery. As discussed previously, setting an auction reserve price can help reduce price volatility and stabilize market expectations, but it also limits the space for market-based price discovery. In addition, regulators must decide not only whether to introduce an auction reserve price but also whether it should be a constant reserve price, as in the UK ETS; a variable reserve price, as in the California carbon market; or one linked to other indicators.

In the early stages of a CCM, a reserve price can help establish price expectations. It provides a reliable price floor and prevents clearing prices from falling excessively below market valuations. Thus, during market development, the reserve price can support the formation of a credible price signal. As the CCM matures, however, the clearing price should be determined primarily by demand and supply rather than by policy interventions. A reserve price—especially one that increases over time—may limit clearing prices to a binding price floor, causing significant deviations from market valuations. At low auction frequency, a reserve price can also lead to frequent switches between positive and negative deviations between clearing prices and market prices, as observed in the California carbon market. In the long term, even without a reserve price, a high auction frequency can help establish stable, reliable price signals in CCMs, as seen in the EU ETS and the UK ETS.

## Number of Bidders

An increase in the number of bidders reduces market power and the influence of large buyers on auction outcomes, thereby increasing the efficiency of price discovery. A broader participant base also strengthens demand. At the

same time, an increase in the number of bidders leads to more aligned price expectations, discourages extreme bids, and narrows the bid price range.

### Secondary Market Trading Volume

Greater secondary market trading volume indicates stronger liquidity in the secondary market for allowances. A more active secondary market provides richer and more timely price information. It enables bidders to form more accurate price expectations, thereby narrowing the bid price range and reducing the deviation between the auction price and market valuation. Higher secondary-market liquidity also increases the attractiveness of the auction in the primary market, thereby leading to greater demand depth.

## Conclusion

In recent years, global CCMs have shifted from free allocation toward auction-based allowance distribution. The auction mechanisms play a critical role in the further development of global CCMs. In the meantime, the investment industry has become increasingly active in the primary auction markets of global CCMs, serving as financial intermediaries and also incorporating allowances into investment strategies.

Investment professionals participating in primary auction markets should be mindful of differences in auction effectiveness among different CCMs. The most mature CCM, the EU ETS, exhibits strong resilience to external shocks and maintains stable and moderate demand depth. As a developing CCM, the UK ETS auction tends to clear at a small discount relative to secondary market prices. In the California Cap-and-Invest Program, demand depth is more volatile because of lower auction frequency, and auction outcomes are driven more by reserve prices than by market forces.

Policymakers and CCM market operators that want to strengthen the effectiveness of allowance auctions may focus on the efficacy of holding more frequent auctions and increasing the share of allowances auctioned versus free allocation, thereby promoting broader participation in the primary market and enhancing the trading volume and liquidity of allowances in the secondary market. The market design choices discussed in this report can strengthen market functioning by improving transparency, reducing price dispersion and volatility, and stimulating demand.

As carbon markets expand in coverage, they will play an increasingly important role in climate transition policies and actions, increasing the opportunities for investors and financial market intermediaries to participate in these markets and build trading and investment strategies. Transparent and efficient primary markets, as well as secondary market trading, will become essential to underpin the financialization of carbon as an asset class.

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