ANNUAL REPORT ON THE MARKET FOR RGGI CO_2 ALLOWANCES: 2022

Prepared for:

RGGI, Inc., on behalf of the RGGI Participating States

Prepared By:

April 2023

This report was prepared by Potomac Economics (the contractor) in the course of performing work contracted for and sponsored by RGGI, Inc. on behalf of the RGGI Participating States (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania,[1] Rhode Island, Vermont, and Virginia). The opinions expressed in this report do not necessarily reflect those of RGGI, Inc. or any of the Participating States, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, RGGI, Inc., the Participating States, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. RGGI, Inc., the Participating States, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort of Eastern states of the US to reduce emissions of carbon dioxide (CO_2) from the power sector.

RGGI, Inc. is a non-profit corporation created to provide technical and administrative services to the states participating in the Regional Greenhouse Gas Initiative.

[1] While technically a RGGI participating state, Pennsylvania is currently under order from the state's Commonwealth Court prohibiting it from actively participating in RGGI & RGGI Inc. related activities. Final adjudication of these matters is not expected until sometime in 2023.

Table of Contents

Table of Figures

I. EXECUTIVE SUMMARY

The Regional Greenhouse Gas Initiative ("RGGI") became the first mandatory cap-and-trade regional initiative to limit CO_2 emissions in the United States in 2009. Electric power generators with generating capacity at or above 25 MW located in the states participating in RGGI have been required to obtain the number of CO_2 allowances equal to the number of short tons of CO_2 they emit.[2]

RGGI distributes CO_2 emissions allowances to the market primarily through auctions, making it distinctive among existing cap-and-trade programs. Ninety-four percent of the CO_2 allowances that have entered circulation initially entered the market through one of the auctions. Through the end of 2022, RGGI has conducted 58 successful auctions, selling a total of 1.27 billion CO_2 allowances for $5.9 billion.

The RGGI CO_2 emissions cap increased from 96.2 million short tons for the ten states participating in 2020 to 119.8 million short tons when Virginia began participating in 2021. In 2022, the cap for the eleven states was 116.1 million short tons.[3] The cap will be reduced gradually each year until it reaches 86.9 million short tons in 2030. For each year from 2021 to 2025, the annual cap is further adjusted downward by 19.1 million allowances in each year to account for the 95.5 million allowance surplus that remained at the end of 2020.[4]

This report evaluates activity in the market for RGGI CO_2 allowances in 2022, focusing on the following areas: allowance prices, trading and acquisition of allowances in the auctions and the secondary market, participation in the market by individual firms, and market monitoring. For reporting purposes, firms are often broken up into the following categories:

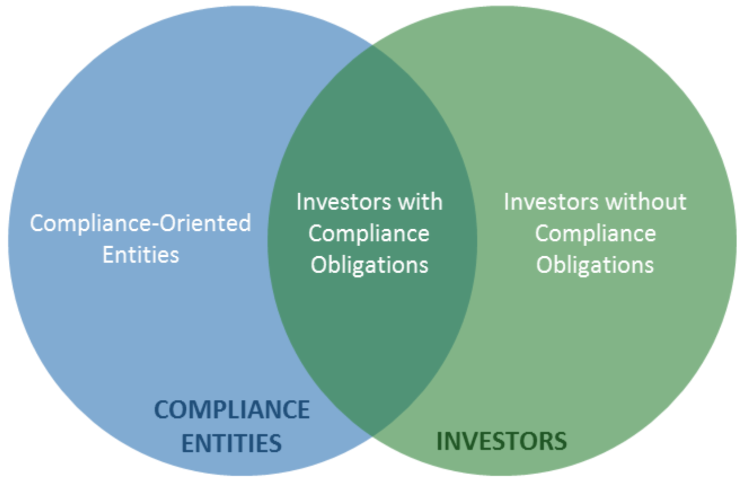
---

2 Since 2020, New York uses a limit of 15 MW for units which are physically co-located with an existing budget source and for any unit at a facility with two or more units with 15 MW or greater nameplate capacities.

3 Pennsylvania began participating in RGGI as of July 1, 2022, making it the 12th state; however, its participation is being disputed in court. As such, Pennsylvania did not sell allowances in the 2022 RGGI auctions.

4 The details of the annual emission caps are described further in Section II.A.

- *Compliance-Oriented Entities* – Compliance entities that appear to acquire and hold allowances primarily to satisfy their own compliance obligations.
- *Investors with Compliance Obligations* – Firms that have compliance obligations, but which hold a number of allowances that exceeds their estimated compliance obligations by a margin suggesting they also buy for re-sale or some other investment purpose. These firms often transfer significant quantities of allowances to unaffiliated firms.[5]



- *Investors without Compliance Obligations* – Firms without any compliance obligations.

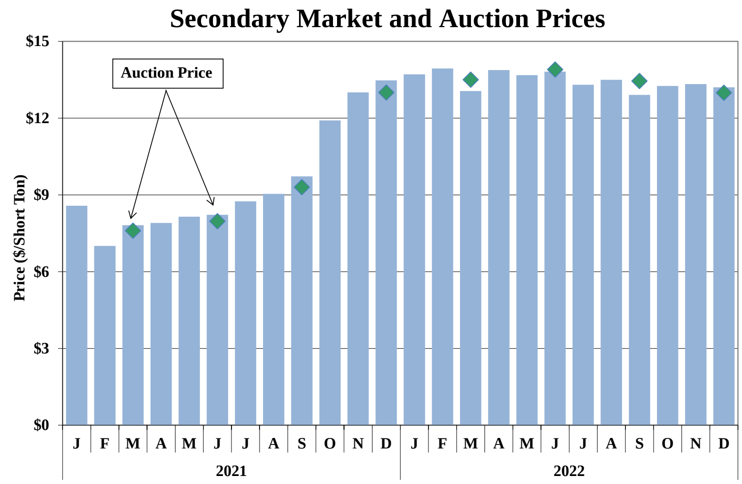
In this report, the "Investors with Compliance Obligations" category is sometimes combined with one of the other two categories when discussing market trends and participation. In all such cases, the text of this report clearly defines the grouping as either: "compliance entities" combining the first and second categories or "investors" combining the second and third categories. These categories are illustrated by the diagram above.

CO_2 Allowance Prices

Secondary market prices began 2021 just below $9 and fell briefly to about $7 in February. Prices rose steadily in each subsequent month to around $10 in September 2021, rose rapidly to nearly $12 in October, and then increased to about $13.50 by the end of 2021. Prices peaked in February 2022 at $13.94, the highest monthly-average price since RGGI has been in operation.

---

5 The assessment of whether a compliance entity holds a number of allowances that exceeds its compliance obligations by a margin that suggests they are also buying for re-sale or some other investment purpose is based on: (a) the entity's forecasted share of the total compliance obligations for the entire RGGI footprint through 2026, (b) the total number of allowances in circulation, and (c) consideration of the pattern of the entity's allowance transfers to unaffiliated firms versus affiliated firms. Since the designation of a compliance entity as an investor is based on a review of its transactions and holdings, the designation of a particular firm may change over time as more information becomes available. Therefore, some of the quantities in this report may not match previous reports because of changes in the classification of particular firms.



In March 2022, monthly secondary prices fell for the first time in 13 months but then quickly rose again in April. Subsequently, prices declined modestly, remaining between about $13 and $13.50 throughout the remaining months and settling at about $13.20 at the end of the year.

The average auction clearing price increased 40 percent from $9.61 in 2021 to $13.46 in 2022, and secondary market prices were generally consistent with contemporaneous auction clearing prices throughout both years.[6]

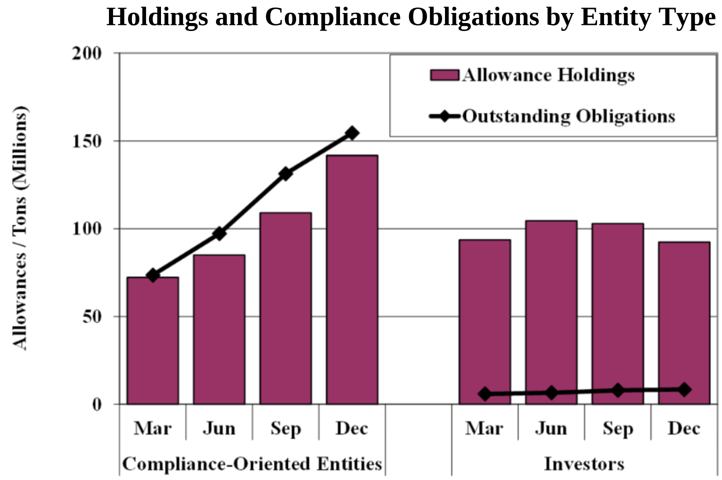
The Cost Containment Reserve ("CCR") strongly influenced RGGI allowance price formation in 2021 and 2022.[7] The CCR is designed to limit upward price movements by increasing auction sales if the clearing price is above the CCR Trigger Price level. The CCR helped reduce the momentum of rising prices in late 2021 by releasing additional allowances for sale in the auctions at the 2021 CCR Trigger Price of $13.00. In 2022, the CCR Trigger Price rose to $13.91, and the June 2022 auction clearing price was set just $0.01 below the trigger price. The CCR will likely continue to influence prices and is scheduled to rise 7 percent each year from 2022 to 2030.

Acquisition and Holdings of CO_2 Allowances

Firms initially acquire CO_2 allowances in the primary market, mainly by purchasing them in the quarterly auctions. Firms can also buy and sell CO_2 allowances in the secondary market. Secondary market activity consists mainly of trading of futures and options contracts on the

[6] Allowance prices are summarized in more detail in Section III.A.

[7] The CCR and other program details are described further in Section II.A.



public exchange and transfers of ownership recorded in COATS ("CO_2 Allowance Tracking System").

The large private bank of surplus CO_2 allowances (which accumulated primarily before 2013) fell during 2022 from 87 million at the beginning of the year to 68 million at the end of the year.[8] The decrease in the surplus is expected since the Participating States have adopted "interim adjustments" in each Program Review that are designed to gradually reduce the allowance surplus.[9] Because of the Third Adjustment to the cap, the current surplus of allowances is expected to fall considerably by the end of 2025.

The figure above summarizes the holdings of CO_2 allowances at the end of each quarter in 2022 for two categories of firms.[10] It shows that, as a group, compliance-oriented entities held about 92 percent of the CO_2 allowances needed to satisfy their current compliance obligations for the fifth control period at the end of 2022. These entities held 142 of the 234 million allowances in circulation at the end of 2022, 13 million allowances below their outstanding compliance obligations.

Although some compliance-oriented entities used the secondary market as the primary means of acquiring CO_2 allowances, overall, compliance-oriented entities as a group relied more on the auctions in 2022. Of the CO_2 allowances held by compliance-oriented entities at the end of

---

8 We define the "private bank of allowances" as the number of allowances in circulation (i.e., in Compliance Accounts or in General Accounts). We define the "private bank of *surplus* allowances" as the number of allowances in circulation minus the compliance obligations for which allowances have not been surrendered.

9 The First Control Period Interim Adjustment ("FCPIA"), the Second Control Period Interim Adjustment ("SCPIA"), and the Third Adjustment for Banked Allowances are described in Section II.A.

10 Monthly totals are provided with additional detail in Section IV.D.

2022, 68 million were acquired through auctions or state allocations during 2022, 34 million were acquired from the secondary market during 2022, and 39 million were retained from the prior year. The largest allowance transfers between unaffiliated firms occurred in December due to the settlement of the most liquid RGGI allowance futures contract. A robust secondary market is beneficial because it provides compliance entities with more flexibility about when they can purchase CO_2 allowances.

Investors without compliance obligations purchased significant quantities of allowances in the auctions, but overall investor holdings remained similar at the end of 2022 compared to the beginning of the year. These investors purchased 23 million (26 percent) of the allowances auctioned in 2022. While some investors used the secondary market to acquire allowances, overall investors sold more in the secondary market than they acquired, transferring a net of 25 million allowances in the secondary market to compliance entities by the end of 2022. Investors with compliance obligations purchased over 3 million allowances in the auctions and decreased their holdings by the end of the year. Investors play an important role in the RGGI allowance market by ensuring that compliance entities have liquid options for purchasing allowances outside of the quarterly auctions. This allows compliance entities to purchase RGGI allowance futures throughout the year to financially hedge the compliance costs they incur from producing electricity.

Participation in the Market by Individual Firms

Participation by many firms promotes competition and helps ensure that CO_2 allowance prices are determined efficiently. Over time, firms that need CO_2 allowances for compliance should be able to acquire them through the auctions and/or the secondary market, and the holdings of individual firms should be relatively consistent with their potential uses for allowances.[11]

In 2022, we observed broad participation in the RGGI market. The demand for CO_2 allowances is dispersed relatively widely across firms as the three largest compliance-oriented entities

[11] Participation in the auctions and the secondary market by individual firms is evaluated in Section V.

accounted for 35 percent of the total projected demand, similar to 2021. The average number of auction participants increased to 69 from 61 in the previous year, reflecting increased participation by both compliance-oriented entities and investors.

Allowance holdings were generally distributed across compliance-oriented entities consistent with their compliance obligations, although the surplus of allowances in circulation led many individual firms to hold substantial surpluses. The top ten compliance-oriented entities, by estimated demand for allowances, accounted for about 43 percent of total holdings and smaller compliance-oriented entities accounted for 18 percent. The top ten investors (ranked by surplus holdings) held about 34 percent of allowances, a decrease from 2021. These levels are consistent with competitive expectations given that the current private bank of allowances far exceeds the outstanding compliance obligations of firms in the fifth control period. With increased or steady participation by compliance-oriented entities, passive investment funds, and other financial investors with active trading operations, the number of firms with reportable positions in ICE futures and options grew in 2022, peaking at 60 firms with positions in the most liquid RGGI futures contract compared to 49 such firms in the prior year.

Market Monitoring

As the RGGI Market Monitor, we evaluate the conduct of market participants in the auctions and in the secondary market to identify potential anti-competitive conduct. We also assess whether the auctions were administered properly by Enel X.

In our reviews of the four auctions in 2022, we found no material concerns regarding the auction process, barriers to participation in the auctions, or the competitiveness of the results. Large numbers of firms participated in the offerings of CO_2 allowances. Further, we found that the auctions were administered in accordance with the noticed rules and bids received.

We find no evidence of anti-competitive conduct in the secondary market for CO_2 allowances, and we find that firms have generally purchased quantities of allowances that are consistent with their expected needs.

II. Background on the CO_2 Allowance Market

In 2009, RGGI became the first mandatory market-based regional initiative to limit CO_2 emissions in the United States. Market-based cap-and-trade programs work by setting an aggregate emissions limit for a particular class of emitters and requiring them to acquire a number of allowances sufficient to cover their emissions. Firms that own allowances can decide whether it is more profitable to use them to cover their emissions or to sell them to an emitter that can use them more efficiently. In this manner, the goal of market-based programs is to use market forces to reduce overall emissions in the most cost-effective ways.

In the eleven states participating in RGGI in 2022, electricity generating plants with 25 MW[12] of capacity or greater ("CO_2 budget sources") must acquire a number of CO_2 allowances sufficient to cover their CO_2 emissions by the end of each control period. Firms that own budget sources ("compliance entities") can acquire CO_2 allowances through a variety of means, including by purchasing them in the quarterly RGGI auctions or in the secondary market for allowances.

The market for RGGI CO_2 allowances has several key elements, which are discussed in this section: the regional cap, compliance obligations, the CO_2 Allowance Tracking System ("COATS"), the primary market for allowances, and the secondary market for allowances.

A. Regional CO_2 Emissions Cap

The RGGI CO_2 cap for the period from 2021 to 2030 was initially determined at the end of the 2016 Program Review for the nine states participating at the time.[13] The CO_2 cap for the nine states was scheduled to fall by 30 percent from approximately 78.2 million short tons for 2020 to 54.7 million short tons for 2030. The RGGI Model Rule is designed to allow additional states to

---

12 As of December 2020, the New York DEC adopted revisions to Part 242 which has lowered this limit to 15 MW for units which are physically co-located with an existing budget source, and to any 15 MW unit that resides at a facility with two or more units with 15 MW or greater nameplate capacities.

13 For a list of changes made to the Model Rule following the 2016 Program Review, see www.rggi.org/sites/default/files/Uploads/Program-Review/12-19-2017/Summary_Model_Rule_Updates.pdf.

join RGGI, so the annual cap is adjusted when new states begin to participate. Since New Jersey became the tenth Participating State in January 2020, the cap was raised to 96.2 million short tons in 2020 and scheduled to fall gradually to 67.3 million short tons in 2030. With the addition of Virginia in January 2021, the cap was raised to 119.8 million short tons in 2021 and scheduled to fall gradually to 86.9 million short tons in 2030. The 2016 Program Review also set forth cap adjustments to account for allowances banked before 2021 and the implementation of an Emissions Containment Reserve, which are both described below in more detail.

Interim Adjustments to Account for Banked Allowances

Three adjustments have been made to the cap to account for the surpluses of allowances that were banked from allocation years 2009 to 2013 and again from allocation years 2014 to 2020.[14] The first two interim adjustments were set forth in the 2012 Program Review, while the third interim adjustment was set forth in the 2016 Program Review.[15] These are described below.

First Control Period Interim Adjustment for Banked Allowances ("FCPIABA") – This was a reduction in the number of CO_2 allowances to be sold over the seven-year period from 2014 to 2020. The amount of the reduction was equal to the private bank of first control period CO_2 allowances (i.e., allocation years 2009, 2010, and 2011) that were in circulation after compliance was completed for the first control period. The FCPIABA was approximately 8.2 million CO_2 allowances per year from 2014 to 2020.

Second Control Period Interim Adjustment for Banked Allowances ("SCPIABA") – This was a reduction in the number of CO_2 allowances to be sold over the six-year period from 2015 to 2020. The amount of the reduction was equal to the private bank of 2012 and 2013 allocation year allowances that were in excess of 2012 and 2013 emissions. The SCPIABA was approximately 13.7 million CO_2 allowances per year from 2015 to 2020.

---

14 Also, the emissions cap was reduced from 188 million short tons to 165 million short tons in 2012 to account for the departure of New Jersey at the end of the first control period, which ran from 2009 to 2011.

15 See www.rggi.org/program-overview-and-design/elements.

Due to the two interim control period adjustments for banked allowances that resulted from the 2012 Program Review, the adjusted CO_2 cap fell from approximately 82.8 million in 2014 to 62.5 million in 2017 and was planned to eventually fall to 56.3 million in 2020. However, with the addition of New Jersey as a participating state in 2020, the adjusted cap for 2020 was raised to 74.3 million short tons. Including New Jersey, the number of CO_2 allowances that were distributed for the period from 2014 to 2020 was approximately 467 million. Including the 140 million surplus allowances that were already in circulation at the end of 2013, the total supply was 607 million allowances from 2014 to 2020 (not including allowances sold from the Cost Containment Reserve, which is discussed in the next part of this section.).

Third Adjustment for Banked Allowances – This is a reduction in the number of CO_2 allowances that is to be sold over the five-year period from 2021 to 2025. In each year, the reduction will be approximately 19.1 million allowances. The amount of the reduction is based on the private bank of allowances (approximately 95.5 million allowances) that existed after the compliance deadline for the fourth control period, which ran from 2018 to 2020.[16]

Cost Containment Reserve

RGGI implemented a provision known as the Cost Containment Reserve ("CCR") in 2014.[17] The CCR allows for the sale of a fixed number of allowances in addition to the cap when the clearing price in the quarterly auction exceeds the CCR Trigger Price. The CCR is replenished at the start of each calendar year. In 2014, the CCR had a withdrawal limit of five million allowances, and the CCR Trigger Price was $4.00. In 2015, 2016, 2017, 2018, and 2019, the CCR had a withdrawal limit of ten million allowances, and the CCR Trigger Prices were $6.00, $8.00, $10.00, $10.25, and $10.51, respectively. In 2020, the annual withdrawal limit was 11.8 million allowances and the CCR Trigger Price was $10.77.

16 See https://www.rggi.org/sites/default/files/Uploads/Press-Releases/TABA_Announcement_2021-03-15.pdf.

17 See https://www.rggi.org/sites/default/files/Uploads/Design-Archive/Model-Rule/2012-Program-Review-Update/Summary_of_Model_Rule_Changes_02_07_13.pdf.

All 15 million allowances were sold from the CCR for the period from 2014 to 2015, but the CCR was not triggered in 2016, 2017, 2018, 2019, 2020. Ultimately, the sale of these allowances from the CCR increased the surplus of allowances that was included in the Third Adjustment for Banked Allowances.

From 2021 to 2030, the size of the CCR is 10 percent of the cap in each year, so the CCR falls from nearly 12.0 million allowances in 2021 to 8.7 million in 2030. The CCR Trigger Price is planned to rise from $13.00 in 2021 by 7 percent each year, so it will reach $23.89 in 2030. In 2021, one auction cleared at the CCR Trigger Price of $13.00 and 3.9 million allowances were sold from the CCR. The CCR Trigger Price of $13.91 was not met in 2022.

Emissions Containment Reserve

RGGI implemented a provision known as the Emissions Containment Reserve (“ECR”) in the first auction of 2021. The ECR is intended to reduce the supply of allowances in the market if emissions reduction costs are lower than expected by allowing for states to withhold allowances from circulation if the auction clearing price falls below the ECR Trigger Price. Allowances withheld under this program will not enter circulation. Up to 10 percent of a participating state’s allowance budget can be withheld using the ECR. The ECR Trigger Price was set at $6.00 in 2021, and it is scheduled to rise by 7 percent each year. At the time of this writing, Maine and New Hampshire do not plan to utilize the ECR mechanism. In 2021 and 2022, the auction clearing prices exceeded the ECR Trigger Price and, thus, the ECR has not been invoked.

B. Compliance Obligations

CO_2 budget sources are fossil fuel-fired electricity generating plants with at least 25 MW of capacity.[18] Shortly after the end of each control period, compliance entities must hold sufficient CO_2 allowances to cover their CO_2 emissions during the control period. The first four control

18 Apart from New York; see footnote 12.

periods were each three years-long, running through the ends of 2011, 2014, 2017, and 2020. The fifth control period will run from January 1, 2021 to December 31, 2023.

The compliance process is conducted in the first quarter after the end of each control period. Thus, beginning in March 2021, RGGI and the Participating States conducted the compliance process for the fourth control period which ended December 2020. By January 30, 2021, compliance entities were required to submit all CO_2 emissions data for CO_2 budget sources for the fourth control period to the Environmental Protection Agency's ("EPA's") Clean Air Markets Division ("CAMD") Business System. By March 1, 2021, the Compliance Account for each CO_2 budget source was required to hold first, second, third, or fourth control period CO_2 allowances sufficient to satisfy its compliance obligation. Each CO_2 budget source was also required to submit a Compliance Certification Report certifying that it was in compliance with its state's CO_2 Budget Trading Program.[19]

RGGI also has interim compliance requirements whereby compliance entities are required to surrender CO_2 allowances for 50 percent of their compliance obligations after the first and second years of each three-year control period. Thus, since 2021 was the first year of the fifth control period and covered CO_2 emissions totaled approximately 108 million short tons in 2021, compliance entities were obliged to surrender nearly 54 million allowances before the March 2022 deadline for 2021 interim compliance. For 2022, the second year of the fifth control period, compliance entities were obliged to surrender an additional 55 million allowances before the March 2023 deadline for 2022 interim compliance.

C. CO_2 Allowance Tracking System ("COATS")

COATS is the registry for RGGI CO_2 allowances. Each CO_2 allowance has a unique serial number and can be used to satisfy one short ton of compliance obligation. When firms trade CO_2

[19] The Compliance Summary for the first, second, third, and fourth control periods may be found at https://rggi-coats.org/eats/rggi/.

allowances in the secondary market, the seller must record the transfer of ownership in COATS before the buyer is recognized as the owner.[20]

D. Primary Market for RGGI CO_2 Allowances

The participating states have taken the approach of using auctions rather than free allocations as the primary means for distributing RGGI CO_2 allowances to the market. Accordingly, the primary market for CO_2 allowances consists mainly of the quarterly auctions.

Auctions – Through the end of 2022, 94 percent of the CO_2 allowances that have been put into circulation initially entered the market through one of the 58 auctions that had taken place on a quarterly basis since September 2008.

Offset Projects – Additional CO_2 allowances can also be awarded for approved CO_2 emissions offset projects (project-based greenhouse gas emissions reductions or carbon sequestration that occurs outside the capped electricity generation sector), although fewer than 0.1 million such allowances have been awarded thus far.

Early Reduction Allowances – In 2009, there was a one-time award by certain participating states of 2.4 million early reduction allowances (ERAs), which were awarded for qualifying CO_2 emissions reductions achieved at CO_2 budget sources during 2006 through 2008, prior to the start of the first control period.

Allocations & Sales by States – Approximately 29.7 million CO_2 allowances for the first control period were allocated by individual states through either fixed-price sales or free allocations. Approximately 16.0 million CO_2 allowances for the second control period were allocated by individual states. Approximately 11.7 million CO_2 allowances were allocated for the third control period, while 13.5 million have been allocated for the fourth control period and 9.8 million have been allocated for the fifth control period as of the end of 2022.

[20] Public information related to the COATS registry may be found at https://rggi-coats.org/eats/rggi/.

Regardless of how CO_2 allowances initially enter the market, they can be traded to other firms in the secondary market.

E. Secondary Market for RGGI CO_2 Allowances

The secondary market is important for several reasons. First, it gives a firm the ability to obtain CO_2 allowances at any time during the three months between the RGGI auctions. Second, it provides a way for a firm to protect itself against the potential volatility of future auction clearing prices. Third, it provides price signals that can assist a firm in making investment decisions in markets affected by the cost of RGGI compliance.

The secondary market for RGGI CO_2 allowances comprises the trading of physical allowances and financial derivatives, such as futures, forwards, and option contracts. A physical CO_2 allowance trade occurs when the parties to the transaction register the transfer of ownership in COATS. Financial derivatives include any contracts whereby parties agree to exchange funds and/or allowances at some future date, depending in many cases on factors such as the price of allowances at some future date. Many financial derivatives eventually result in the transfer of physical CO_2 allowances (i.e., the transfer is registered in COATS), but this may occur months or years after the parties enter into a financial transaction. These include the following types of transactions:

- *Futures* – Under these contracts, two parties agree to exchange a fixed number of CO_2 allowances of a certain vintage year at a particular price at a specific point in the future (called the "delivery month"). At the end of the delivery month, the contracted number of CO_2 allowances must be physically transferred to the buyer's account in the COATS registry and funds must be transferred to the seller. The vintage year refers to the allocation year of the CO_2 allowance that is to be transferred. One standard futures contract equals 1,000 RGGI CO_2 allowances. These contracts are listed by an exchange with simple standardized terms to promote liquidity.

- *Forwards* – These are like futures contracts, but a forward contract typically requires that all financial settlement occur at expiration. These contracts can be made off an exchange between two parties, allowing the parties to agree to less standardized terms.

- *Call Options* – Call options give the purchaser the option to buy a fixed number of CO_2 allowances of a certain vintage year at a particular strike price at the expiration date. For example, suppose a firm holds a call option with a $4 strike price and a December 2020 expiration date. If the price of the corresponding forward contract rose to $5 at expiration, the firm would exercise the option to buy CO_2 allowances at $4 and immediately sell them at $5. Alternatively, if the price of the forward contract was below $4, the firm would let the option expire without exercising it. One standard options contract can be exercised for 1,000 RGGI allowances.

- Put Options – Put options are similar to call options but they give the purchaser the option to *sell* a certain number of CO_2 allowances of a particular vintage year at a specified strike price at the expiration date.

Futures, forwards, and options contracts allow firms to manage risks associated with unforeseen swings in commodity prices. Futures and forwards allow firms to lock-in the prices of future purchases or sales. Options allow firms to limit their exposure to price volatility. Call options protect the purchaser if the price of the commodity increases, while put options protect the purchaser if the price of the commodity decreases. Although options provide less certainty than futures and forward contracts, they generally require less financial security since they do not obligate the holder to exercise the contract if its value declines, which could make them more attractive to some firms.

The terms of futures, forward, and option contracts vary in the degree to which they are standardized. "Exchange-traded" contracts typically have the most standardized provisions, while the term "over-the-counter" ("OTC") is applied to contracts with less standardized provisions. However, OTC contracts, once entered into, are often settled through a clearinghouse in order to protect the parties from the risk that the counterparty defaults.

The amount of *open interest* is the net amount of futures, forwards, or options contracts that have been traded for a contract with a particular set of specifications (i.e., vintage year, delivery month, etc.), but have not reached the time of delivery, expired, or been exercised. For example, if Firm A sells 100 contracts of a particular type to Firm B, Firm A will have a short position of 100 contracts, Firm B will have a long position of 100 contracts, and the total open interest for the particular type of contract will be 100 contracts. Hence, the total open interest can be determined by summing across all of the long positions of market participants or by summing across all of the short positions.

III. CO_2 ALLOWANCE PRICES

The market for RGGI CO_2 allowances consists primarily of purchases in the quarterly auctions and trading of allowances and allowance futures and options contracts in the secondary market. The clearing prices from quarterly auctions provide public information about the market value of CO_2 allowances four times per year, while the prices of futures and forwards trades on public exchanges and transaction prices recorded in COATS provide price information more frequently. This section of the report evaluates prices in the markets for RGGI CO_2 allowances in 2022.

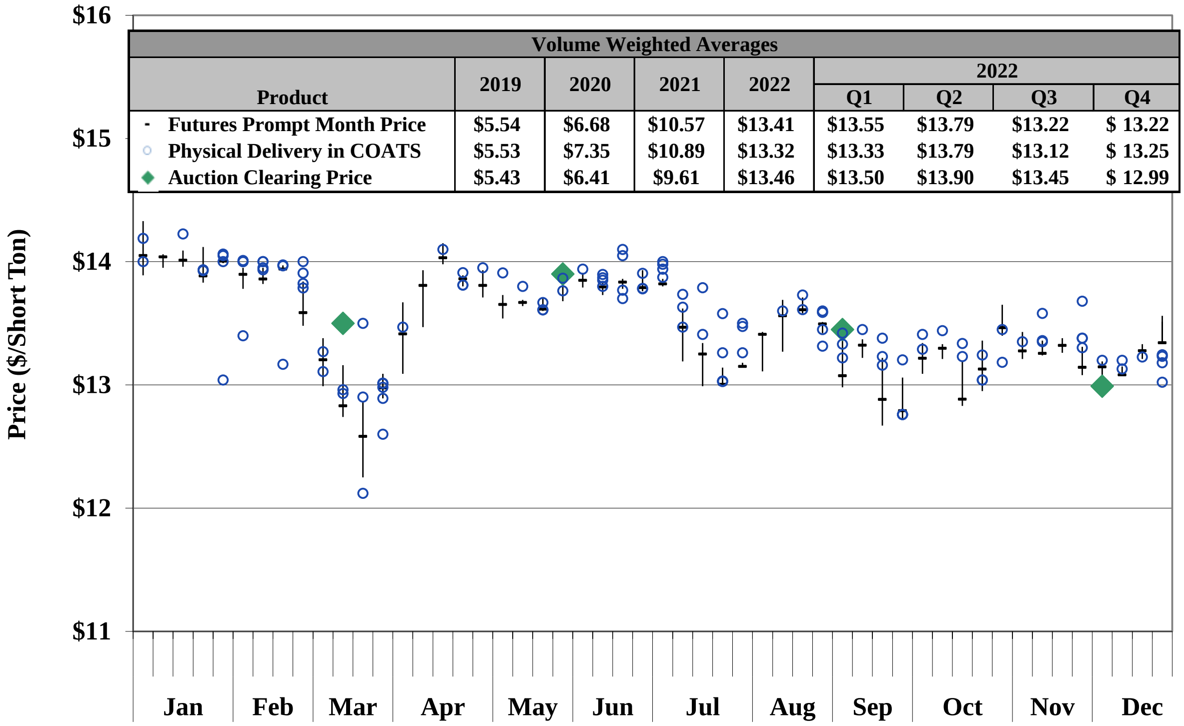
Key observations regarding RGGI CO_2 allowance prices:

- *Price Trends* – At the start of 2022, prices in the secondary market hovered around $14, near the CCR trigger price of $13.91, before falling to a weekly low of about $13 in March. Prices then rose to about $14 in April and remained between $13.50 and $14 until the end of June. For the rest of the year, prices generally stayed between $13 and $13.50, averaging about $13.25 in December.
- *Physical Deliveries in COATS* – Although the majority of physical transactions were priced similar to futures contracts, a few of these transactions differed significantly from prevailing market trends.
- *Auction Clearing Prices* – The volume-weighted average auction clearing price increased 40 percent from $9.61 in 2021 to $13.46 in 2022. The auction clearing prices were generally consistent with prices in the secondary market at the time of the auction.
- *Secondary Market Price Volatility* – Option-implied volatility of RGGI allowance prices declined over the course of 2022 after being high (>50 percent) early in the year. Prices began the year at around $14, then fell briefly to a low of $12.50 in February. By July, secondary prices became more stable, and option-implied volatility fell to about 20 to 25 percent. The CCR helped to dampen price volatility in 2022 by limiting the potential for auction clearing prices to be set above the CCR Trigger Price of $13.91.

A. Prices in the Auctions and the Secondary Market

Figure 1 summarizes prices in the auctions and the secondary market on a weekly basis in 2022. Intercontinental Exchange ("ICE") and Nodal Exchange ("NEX") futures contract prompt-month prices are summarized for each week by a black vertical line from the minimum transaction price to the maximum transaction price in the week and by a black horizontal tick mark at the volume-weighted average price for each week. The volume-weighted average price of physical deliveries of CO_2 allowances recorded in COATS are shown by blue circles for each day when a transaction took place at a price that was recorded by the transacting parties.[21] The figure also shows the auction clearing prices of CO_2 allowances in the four quarterly auctions held during 2022, which are represented by the green diamonds.

Figure 1: CO_2 Allowance Prices in the Auctions and Secondary Market 2022



Volume Weighted Averages								
Product	2019	2020	2021	2022	2022 Q1	2022 Q2	2022 Q3	2022 Q4
Futures Prompt Month Price	$5.54	$6.68	$10.57	$13.41	$13.55	$13.79	$13.22	$ 13.22
Physical Delivery in COATS	$5.53	$7.35	$10.89	$13.32	$13.33	$13.79	$13.12	$ 13.25
Auction Clearing Price	$5.43	$6.41	$9.61	$13.46	$13.50	$13.90	$13.45	$ 12.99

Observations regarding prices in auctions and the secondary market:

- *General Price Levels* – At the start of 2022, prices in the secondary market hovered around $14, near the CCR trigger price of $13.91. Prices fell briefly to an average weekly low of about $13 in March before rising to about $14 in April and remaining between $13.50 and $14 until the end of June. For the rest of the year, prices generally stayed between $13 and $13.50, averaging about $13.25 in December.
- *Physical Deliveries in COATS* – The volume-weighted average transaction price of CO_2 allowances increased 25 percent from $10.89 in 2021 to $13.32 in 2022. The pricing of transactions was generally consistent with futures trades and auction clearing prices occurring at the same time. However, a minority of transactions were reported at much

[21] Parties must report the transaction price if there is an underlying financial transaction related to the transfer.

higher or lower price levels. These likely reflect transactions whose price terms were determined at an earlier date.

- *Auction Clearing Prices* – The volume-weighted average auction clearing price increased 40 percent from $9.61 in 2021 to $13.46 in 2022. Auction clearing prices peaked in June at $13.90, just $0.01 less than the CCR Trigger Price, and fell in each successive auction in 2022.
- *Comparison of Auction Prices and Secondary Market Prices –* The auction prices were generally consistent with secondary market prices for transactions around the time of the auctions.

B. Volatility of CO_2 Allowance Prices

Cap-and-trade markets are designed to give firms efficient incentives to reduce or offset emissions. In the short-term, high-emitting generators operate less frequently in favor of low-emitting generators. In the long-term, the market will affect the decisions of firms to develop offset projects, to retire old inefficient generation, to retain existing zero-emissions generation, and to perform maintenance that increases fuel efficiency and lowers carbon-intensity. Predictable CO_2 allowance prices decrease the risks associated with making long-term investments in reducing CO_2 emissions. Since CO_2 allowance prices can be volatile, the availability of futures and options contracts allows firms to protect themselves from the risks of such investments. This subsection evaluates two measures of price volatility in the market for RGGI CO_2 allowances.

One measure of volatility is known as *historic volatility*,[22] which is a measure of volatility based on day-to-day price variations over a recent period (e.g., several months or one year). This is a useful measure when factors influencing the volatility of prices in the recent period are likely to be the same as the factors influencing the volatility of prices in the future.

Observations regarding historic volatility of CO_2 allowance prices:

[22] Historic volatility is a measure of the standard deviation of the day-over-day percentage change in price. Volatility is normally expressed as an estimated standard deviation for a one-year period, even if it is calculated from a shorter period of time. In this report, volatility is calculated based on quarters and annualized for each quarter. Annual volatility discussed here is the average of the annualized quarterly-based volatility.

- *Historic Volatility in 2021 & 2022* – In the first quarter of 2021, annualized price volatility was 26 percent. It fell to a low of 15 percent in the second quarter but by the fourth quarter it rose once again to 28 percent. In the first quarter of 2022, the price volatility fell to 18 percent and continued to decline each quarter thereafter. The second, third, and fourth quarter price volatility was 15, 14, and 12 percent, respectively. The annual 2022 average price volatility was 15 percent compared to 22 percent in 2021.

Another measure of the volatility of CO_2 allowance prices is known as *option-implied volatility*,[23] which measures the volatility that is implied by the trading of option contracts for CO_2 allowances. If a firm perceives that CO_2 allowance prices are volatile, the firm may be willing to pay a high price for an option contract that protects it from unforeseen allowance price fluctuations. Likewise, if a firm perceives that CO_2 allowance prices are relatively stable, the firm will be willing to pay relatively little for the same option contract.[24]

The following scatter plot reports the option-implied (i.e., expected) volatility of RGGI CO_2 allowance futures contracts, which can be inferred from the trading of options contracts in 2021 and 2022.[25] The vertical axis shows the option-implied (expected) volatility of CO_2 allowance futures prices, and the horizontal axis shows the trade date. The figure excludes contracts if the trade date is fewer than 90 days from the contract expiration date. This is to focus on contracts that provide insight about the expected volatility of allowance prices over the long term rather than price variations around the quarterly auctions.

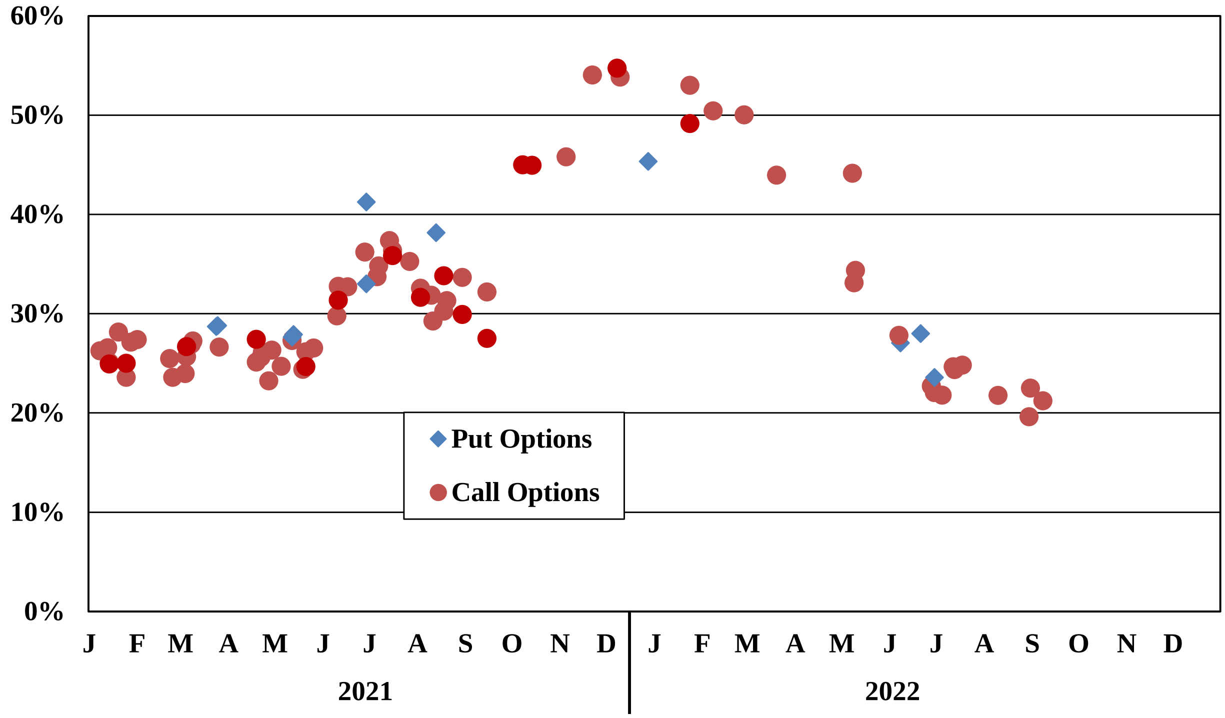
---

23 The option-implied volatility of a CO_2 allowance refers to the expected standard deviation of the distribution of allowance prices one year in the future. For example, if the expected value of the price one year in the future is \$1 and the option-implied volatility is 25 percent, this implies that the probability that the price will be within 25 percent of \$1 (i.e., between \$0.75 and \$1.25) is 68.2 percent assuming that the price is distributed log-normally.

24 The price of an option contract depends primarily on two factors: (i) the expected value of a CO_2 allowance relative to the strike price of the option, and (ii) the expected volatility of an allowance over the period until the expiration date. When call option prices and put option prices move in opposite directions, it signals a change in the expected price of allowances. Conversely, when call option prices and put option prices move in the same direction, it signals a change in the expected volatility of allowance prices.

25 Black's model for valuing futures options is used to estimate the option-implied volatilities of RGGI allowance futures prices.

Figure 2: Option-Implied Volatility of CO_2 Allowance Futures Prices 2021 & 2022



Observations regarding the option-implied volatility of CO_2 allowance prices:

- *General Patterns of Volatility* – Option-implied volatility ranged between 23 and 30 percent in the first half of 2021 and increased significantly in the second half of the year. The first quarter of 2022 continued to exhibit high option-implied volatility with some transactions exceeding 50 percent. By the end of the second quarter, the volatility dropped considerably, falling to a low of 23 percent by the end of June. Option-implied volatility was low in the third quarter, averaging 23 percent. No transactions are shown in the last quarter because all trades in that quarter had expirations within 90 days of their transaction date and are excluded from the calculation.

- *Cost Containment Reserve and Emissions Containment Reserve* – The CCR and the ECR provisions were introduced into RGGI in February 2013 and December 2017, respectively. Since 2013, the CCR has been a significant factor in reducing the volatility of allowance prices. The CCR reduces volatility directly by making additional supply available if allowance prices rise to the prescribed levels. The ECR, first implemented in 2021, reduces volatility directly by reducing supply if allowance prices fall to the prescribed levels. Both the CCR and the ECR also have significant indirect effects on expectations, reducing the likelihood of price variations far outside the ECR and CCR values (adjusted for expectations of inflation and the time-value of money). For example, the placement of the ECR trigger price at $6.42 and the CCR trigger price at $13.91 in 2022 reduced the likelihood that prices would fall outside of this range in 2022.

IV. Trading and Acquisition of CO_2 Allowances

This section evaluates the trading and acquisition of CO_2 allowances in the primary and secondary allowance markets. Firms initially acquire CO_2 allowances in the primary market, mainly by purchasing them in the quarterly auctions. Firms then buy and sell CO_2 allowances in the secondary market. Secondary market activity can be observed from information about the trading of futures and options contracts on public exchanges and in the OTC market as well as from the transfers of ownership recorded in COATS. This section analyzes the movement of CO_2 allowances from their initial introduction to the market and in the secondary market.

Key observations regarding trading and acquisition of CO_2 allowances:

- *CO_2 Allowances in Circulation* – The number of allowances in circulation increased from 194 million at the end of 2021 to 234 million at the end of 2022 as the amount purchased in the auctions exceeded the total surrendered for fifth control period compliance. In 2022, 109 million short tons were emitted and 52 million allowances were surrendered. The private bank of surplus allowances (in excess of outstanding compliance obligations) decreased from 87 million at the end of 2021 to about 68 million at the end of 2022 and will continue to fall each year through 2025 because of annual reductions in the emissions cap and the Third Adjustment for Banked Allowances.
- *Participation by Compliance-Oriented Entities* – Of the allowances circulating at the end of 2022, 142 million (61 percent) were held by compliance-oriented entities. This was less than their outstanding compliance obligations (154 million) at the end of 2022.
- *Participation by Investors* – Ninety-two million CO_2 allowances (39 percent) were held by investors at the end of 2022. Large allowance holdings by investors are expected given the large current surplus of allowances. As the CO_2 emissions cap tightens in the coming years, the proportion of allowances held by investors is likely to fall.
- *Trading Activity in the Secondary Market* – The volume of futures trading increased 23 percent from 366 million CO_2 allowances in 2021 to 450 million in 2022. The volume of allowance transfers between unaffiliated firms in COATS decreased 16 percent from approximately 145 million CO_2 allowances in 2021 to 122 million in 2022. Overall, the secondary market was relatively liquid and competitive in 2022.
- *Patterns of CO_2 Allowance Acquisition* – Of the CO_2 allowances in circulation at the end of 2022, 43 percent were held by firms since the beginning of the year, 40 percent were held by firms that acquired them through auctions or state allocations in 2022, and 17 percent were held by firms that purchased them in the secondary market in 2022.
- *Reliance on the Auctions versus the Secondary Market* – Of the CO_2 allowances held by compliance-oriented entities at the end of 2022, more than 68 million were held by firms that directly acquired them through auctions or state allocations during 2022, while 32

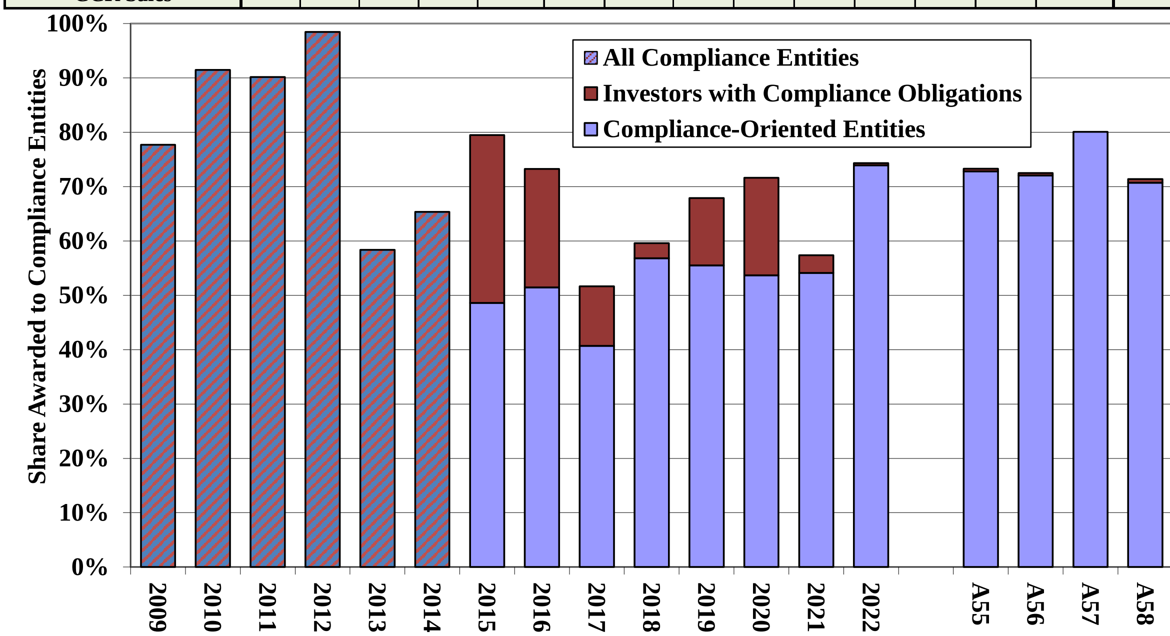
million (24 percent of holdings in 2022 compared to 16 percent in 2021) were held by firms that purchased them in the secondary market during 2022. Most compliance-oriented entities relied primarily on the auctions to acquire CO_2 allowances in 2022, while others relied primarily on the secondary market to obtain allowances.

A. Distribution of Auction Awards

Figure 3 reports the quantity of CO_2 allowances that were offered and sold in each auction held in 2022 (i.e., Auctions 55 through 58) and in each year from 2009 to 2022. The height of each bar represents the percentage of CO_2 allowances (as a share of allowances sold) that was purchased by compliance entities, while the remaining share was purchased by investors without compliance obligations. Before 2015, all compliance entities are shown together. Beginning in 2015, compliance entities are divided into two categories: blue bars showing the percentage of allowances purchased by compliance-oriented entities, and red bars showing the percentage of allowances purchased by investors with compliance obligations. The table in the figure shows the numbers of offered, unsold, and sold allowances in each calendar year since 2009.

Figure 3: Distribution of Auction Awards

Initial Auction Offering (millions of Allowances)	Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
	Offered	128	179	177	147	153	73	62	60	58	54	52	65	92	89	1388
	Unsold	1	31	85	60	0	0	0	0	0	0	0	0	0	0	176
	Sold	128	147	92	87	153	73	62	60	58	54	52	65	92	89	1211
CCR Sales							5	10	0	0	0	0	0	4	0	19



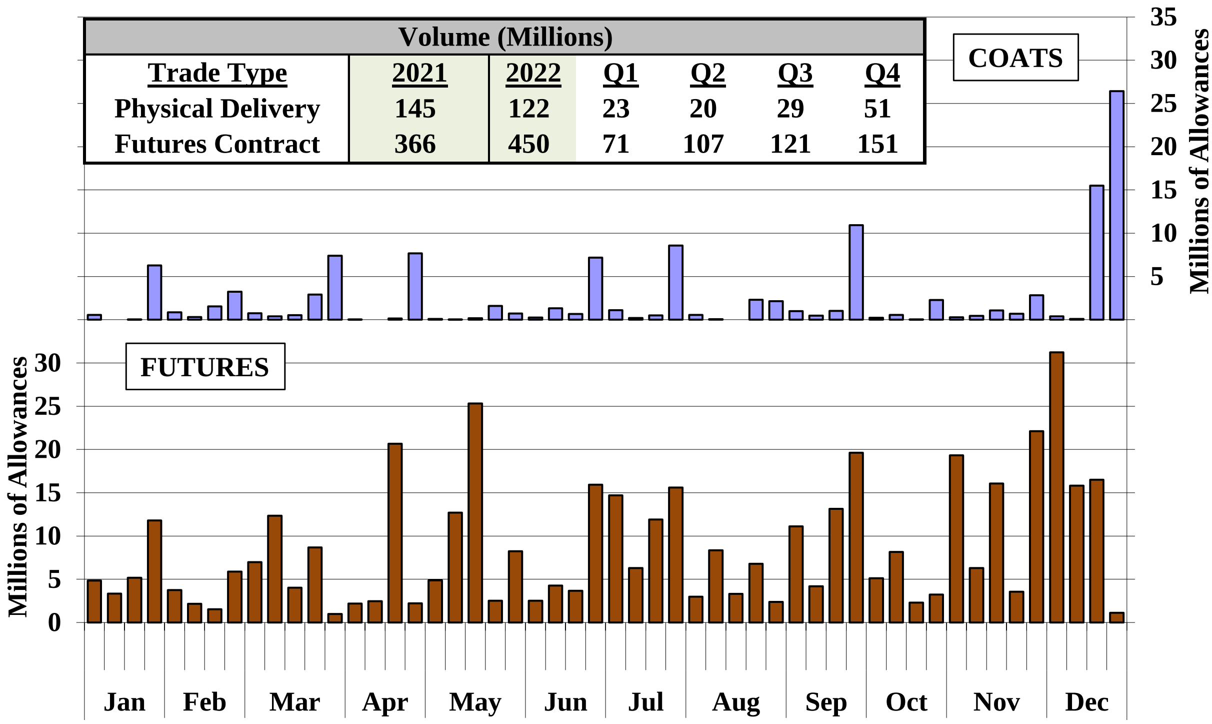
Observations regarding the distribution of auction awards in Figure 3:

- *Compliance Entities* – The share of CO_2 allowances purchased in the auctions by compliance entities (excluding investors with compliance obligations) increased from 54 percent in 2021 to 74 percent in 2022.
- *Investors* – The share of allowances purchased in the auctions by investors with compliance obligations fell to zero in 2022. The share of allowances purchased by investors without compliance obligations averaged 26 percent in 2022. The total number of allowances purchased by investors fell to 23 million from 41 million in 2021.

B. CO_2 Allowance Trading Volumes

The following figure summarizes the volume of trading of futures and forward contracts on the Intercontinental Exchange ("ICE") and Nodal Exchange ("NEX") and CO_2 allowances transfers between unaffiliated parties that were recorded in COATS in 2022. The bottom portion of the figure is plotted against the left vertical axis and shows the weekly volume of futures trading of CO_2 allowance contracts. The top portion of the figure is plotted against the right vertical axis and shows the weekly volume of CO_2 allowance transfers between unaffiliated firms that are reported in COATS. The table shows quarterly volumes in 2022 as well as a year-over-year comparison of the total volume of futures trading and CO_2 allowance transfers in COATS.

Figure 4: Volume of Trading of CO_2 Allowances and Allowance Futures



Volume (Millions)						
Trade Type	**2021**	**2022**	**Q1**	**Q2**	**Q3**	**Q4**
Physical Delivery	**145**	**122**	**23**	**20**	**29**	**51**
Futures Contract	**366**	**450**	**71**	**107**	**121**	**151**

Observations regarding CO_2 allowance trading volumes:

- *Volume of Futures Trading* – The volume of futures trading totaled approximately 450 million CO_2 allowances in 2022, up 23 percent from 2021. About one-third of the 2022 volume occurred in the fourth quarter, when 151 million was traded.
- *CO_2 Allowance Transfers* – The volume of allowance transfers between unaffiliated firms was 122 million in 2022, down from 145 million in 2021. Allowance transfers rose dramatically in December as a result of the settlement of the benchmark futures contract. Forty-one percent of 2022 allowance transfer volume occurred in the fourth quarter.

C. Acquisition of CO_2 Allowances in the Secondary Market

This section evaluates how the ownership of CO_2 allowances is affected by trading in the secondary market. Net changes in the ownership of CO_2 allowances are quantified in Figure 5 for 2022 using two measures: the open interest in ICE RGGI futures contracts and the net purchases and sales of CO_2 allowances by individual firms. Futures open interest is based on futures positions at the end of the last business day of each month, while net purchases and sales are based on registered holdings in COATS at the end of the last business day of each month. The figure reports net changes that have occurred since January 1, 2022.[26]

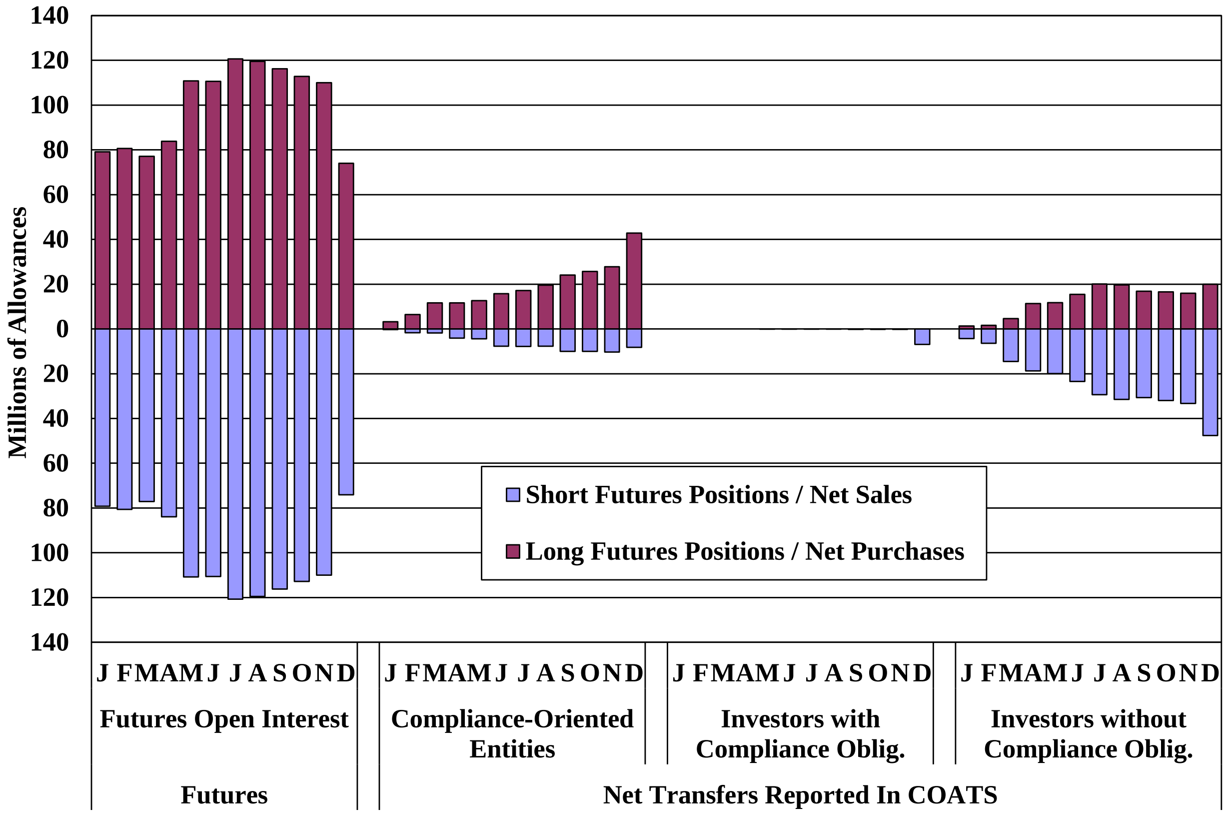
Observations regarding the acquisition of CO_2 allowances in the secondary market:

- *Open Interest in Futures* – The net change in open interest of futures contracts from the beginning of 2022 peaked at 120 million allowances on July 31 before falling to 74 million after the settlement of the benchmark contract.
- *Net Transfers Reported by Compliance-Oriented Entities* – Overall, compliance-oriented firms used the secondary market to increase their holdings in 2022, purchasing a net of 43 million allowances in 2022.
- *Net Transfers Reported by Investors with Compliance Obligations* – Investors with compliance obligations are reported separately from compliance-oriented entities because they have exhibited different transaction patterns in the past. However, investors with compliance obligations were much less active in the secondary market in 2022.

[26] Open interest is defined in Section II.E. Net purchases/sales of CO_2 allowances by a particular firm include the net change in the amount of CO_2 allowances in a firm's COATS account that has resulted from trading (rather than the auctions or allocations). For example, if a firm purchases 100,000 CO_2 allowances from another firm, and then sells 30,000 allowances, the firm's net purchase of allowances would be 70,000.

- *Net Transfers Reported by Investors without Compliance Obligations* – Investment-focused entities without compliance obligations continued to be active in the secondary market in 2022. They used the secondary market primarily to decrease their CO_2 allowance holdings during 2022. Collectively, these entities sold a net of 28 million CO_2 allowances over the year, primarily to compliance-oriented entities.
- *Total Net Acquisition Reported in COATS* – The total net purchase of CO_2 allowances by firms that used the secondary market to increase their holdings in 2022 (about 40 million as shown in Figure 6) is much lower than the gross volume of transactions between unaffiliated firms (122 million as shown in Figure 4). This is because some firms have both purchased and sold CO_2 allowances in the secondary market such that the net change in their position is smaller than the total volume of their transactions. The total net purchase of CO_2 allowances by firms that increased their holdings was smaller than the 89 million CO_2 allowances that were acquired in the auctions in 2022. Some compliance entities relied primarily on the auctions to acquire CO_2 allowances in 2022, while others relied primarily or exclusively on the secondary market.

Figure 5: Net Changes in Futures Open Interest and Net Transfers of CO_2 Allowances From December 31, 2021 to December 31, 2022



D. Patterns of CO_2 Allowance Holdings

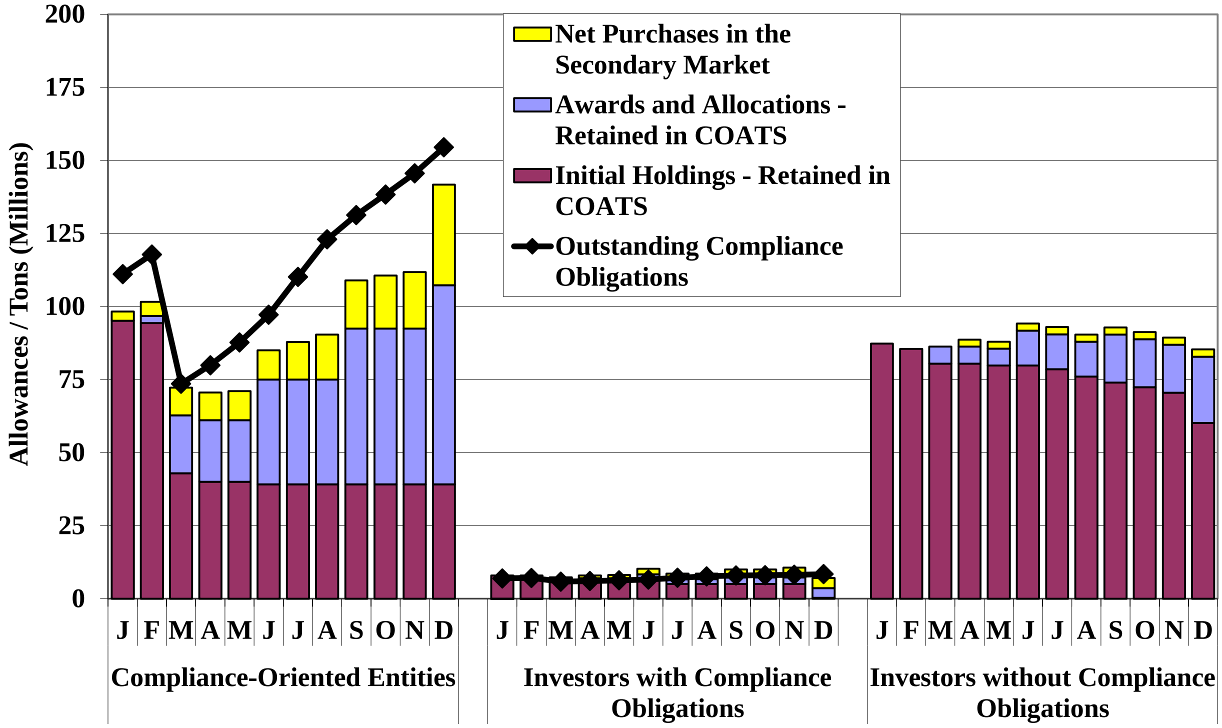
Figure 6 below combines information on the acquisition of CO_2 allowances from the auctions and state allocations with information on the purchase and sale of allowances in the secondary market and the initial holdings of allowances on January 1, 2022. Together, this information provides a summary of the holdings of CO_2 allowances in COATS accounts according to whether the allowances was acquired: (i) prior to 2022, (ii) through the primary market in 2022, or (iii) through the secondary market in 2022. The figure shows holdings and emissions information for three categories of firm: compliance-oriented entities, investors with compliance obligations, and investors without compliance obligations**.**

Figure 6 reports several categories of CO_2 allowances that are described below:

- *Net Purchases in the Secondary Market* includes CO_2 allowances that were held by the category of firm that purchased them in the secondary market after January 1, 2022.
- *Initial Holdings – Retained in COATS* includes CO_2 allowances that were held within a particular category of firm from the beginning of 2022. If a category of firm was a net seller of CO_2 allowances at any point in 2022, then the CO_2 allowances were first deducted from this holding category.
- *Awards and Allocations – Retained in COATS* includes CO_2 allowances that were still held by the category of firm that purchased them in an auction or acquired them through an allocation in 2022. If a particular category of firm was a net seller of CO_2 allowances in 2022, those allowances were deducted from this category after any initial holdings were exhausted.

For each category of firm, holdings of CO_2 allowances in COATS are equal to the sum of three categories: *Initial Holdings – Retained in COATS Account, Awards and Allocations – Retained in COATS Account,* and its *Net Purchases in Secondary Market*. Figure 6 shows the three categories of CO_2 allowances at the end of each month in 2022. The figure also shows the cumulative compliance obligations for compliance entities at the end of each month in 2022.

Figure 6: Sources of CO_2 Allowances Held in COATS Accounts 2022



Observations regarding registered CO_2 allowance holdings in Figure 6:

- *Holdings by Compliance-Oriented Entities* – One hundred and ninety-four million CO_2 allowances were in circulation at the beginning of January 2022. Of these, 95 million (about 50 percent) were held by compliance-oriented entities. These firms remained active in purchasing allowances throughout the year, but they also surrendered 52 million for fifth control period compliance by March 2022. At the end of 2022, the number of allowances held by compliance-oriented entities was 142 million.
- *Holdings by Investors with Compliance Obligations* – Approximately 8 million of the CO_2 allowances in circulation at the beginning of 2022 were held by investors with compliance obligations. These firms surrendered about 1 million allowances to satisfy their fifth control period compliance obligations. At the end of 2022, some of these firms no longer held substantial surplus allowances.
- *Outstanding Compliance Obligations in the Fifth Control Period* – While 53 million allowances were surrendered for fifth control period compliance during 2022, and most

compliance entities have fully complied, about 2 million of the interim compliance obligation have not been satisfied yet.[27]

- *Holdings by Investors without Compliance Obligations* – The share of allowances held by these entities decreased from 46 percent at the beginning of 2022 to 36 percent at the end of the year. At the end of 2022, entities without compliance obligations held 86 million of the allowances in circulation. Investors without compliance obligations acquired most allowances through the auctions (23 million) in 2022.
- *Surrenders of Allowances for Compliance* – In the first quarter of 2022, 53 million allowances were transferred to surrender accounts for compliance. Some allowances were transferred to surrender accounts early, including 0.7 million in February, but the vast majority were transferred to surrender accounts in March.

[27] For detailed information regarding outstanding compliance obligations for the fifth control period, see the Compliance Summary report located at rggi-coats.org.

V. Participation in the CO_2 Allowance Market

This section evaluates participation by individual firms in the CO_2 allowance market. Participation by many firms promotes competition and helps ensure that CO_2 allowance prices are determined efficiently. Over time, firms that need CO_2 allowances for compliance should be able to acquire them through the auctions and/or the secondary market, and the holdings of individual firms should be relatively consistent with their potential uses for allowances.

This section evaluates the level of participation by individual firms in four ways: (i) the demand for allowances by individual firms, (ii) the breadth of participation in the quarterly auctions, (iii) the holdings of individual firms relative to their demand for allowances, and (iv) the breadth of participation in the trading of allowance futures contracts.

Key observations regarding participation in the CO_2 allowance market:

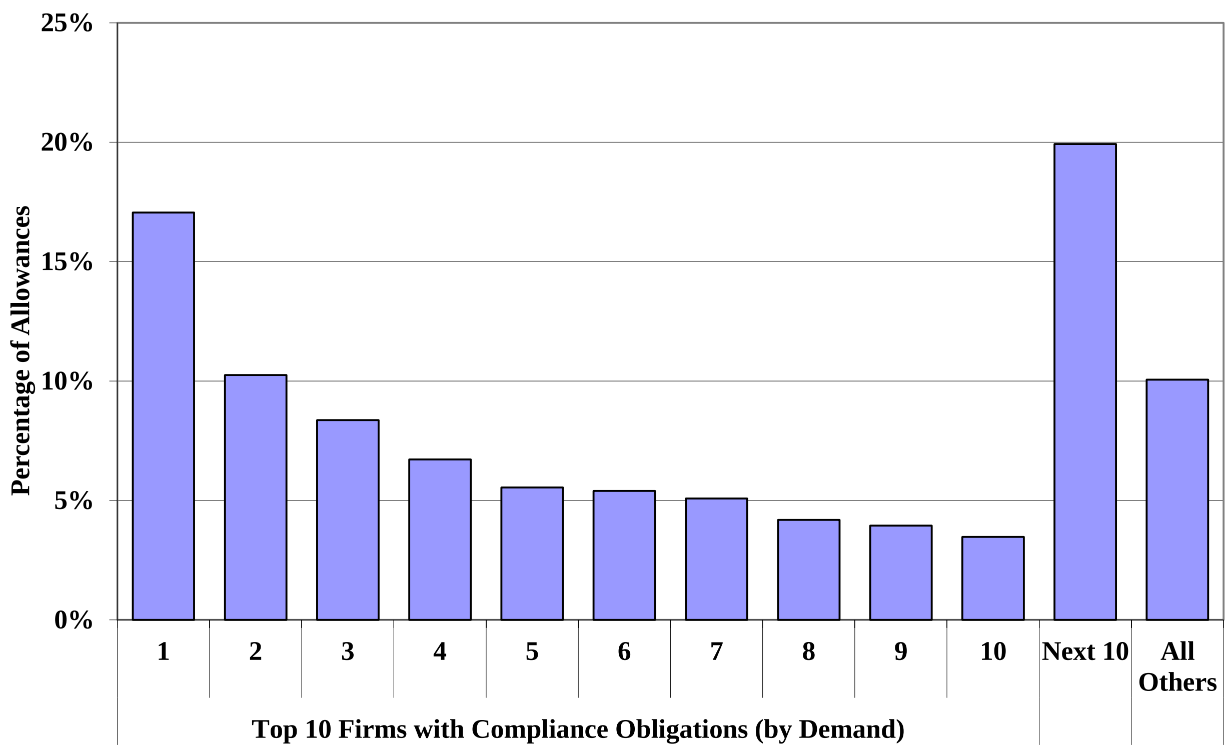
- *Demand for CO_2 Allowances* – The demand for CO_2 allowances is dispersed widely across firms, leading large numbers of firms to participate in the auctions. The three firms with the largest compliance obligations accounted for 36 percent of the total projected demand and the top ten accounted for 70 percent.
- *Participation in the Auctions* – Participation in the quarterly auctions increased significantly after New Jersey and Virginia joined RGGI. The average number of compliance-oriented entities submitting bids in the 2022 auctions increased to 48 (compared to 35 in 2019), while the average number of participating investors increased to 22 in 2022 (compared to ten in 2019).
- *Participation in the Derivatives Market* – The number of firms with reportable positions in RGGI futures and options peaked in 2022 with 60 traders because of increased participation by compliance-oriented firms, passive investment funds, and investors with active trading.
- *Distribution of CO_2 Allowances Awarded* – Auction awards were widely distributed across different types of firms as the top ten (by awards) compliance-oriented entities accounted for 61 percent of the total awarded, while the top ten (by awards) investors accounted for 25 percent.
- *Distribution of CO_2 Allowance Holdings* – Holdings are distributed widely across firms. The ten compliance-oriented entities with the largest outstanding obligations accounted for 43 percent of the total holdings and other compliance-oriented entities with smaller outstanding obligations accounted for 18 percent of holdings at the end of 2022. The share of allowances held collectively by the ten investors with the largest holdings decreased from 45 percent at the end of 2021 to 34 percent at the end of 2022.

- *Concentration of Futures and Options Holdings* – Many firms have open interest in RGGI CO_2 allowance futures and options, but a relatively small number of firms account for large shares of the net long and short positions futures contracts. During 2022, four firms accounted for an average of 51 percent of the total net long positions in ICE Vintage 2022 contracts, while four firms accounted for an average of 73 percent of the total net short positions in ICE Vintage 2022 contracts.

A. Demand for CO_2 Allowances

The following figure summarizes the projected demand for CO_2 allowances of individual compliance entities at the end of 2022. We project the demand of each compliance entity for CO_2 allowances based on historical CO_2 emissions patterns and expected changes in future market conditions. The projected demand is shown for each of the top ten compliance entities (i.e. the ten firms with the highest projected demand), the second ten compliance entities as a group, and all other compliance entities as a group. The projected demand is reported in Figure 7 as a percentage of the total projected market demand.

Figure 7: Estimated Demand for CO_2 Allowances
By All Firms with Compliance Obligations



Observations regarding demand for CO_2 allowances:

- *Demand for CO_2 Allowances* – The demand for CO_2 allowances is dispersed relatively widely across firms. The three compliance entities with the largest compliance obligations account for 36 percent of the total projected demand. The top ten compliance entities account for 70 percent of the total projected market demand, while the next ten compliance entities account for about 20 percent, and compliance entities that are not among the top 20 account for 10 percent.
- *Concentration of Demand* – The concentration of demand by compliance entities increased following the expansion of RGGI to include Virginia in 2021.

B. Participation in RGGI Auctions

The following figure summarizes the breadth of participation in the four auctions during 2022. The figure reports the number of firms that submitted bids in each auction. For 2022, the number of bidders is shown separately based on whether the bidder is a compliance-oriented entity or an investor in the RGGI marketplace. The figure shows these quantities averaged across the auctions in each year from 2015 to 2022.[28]

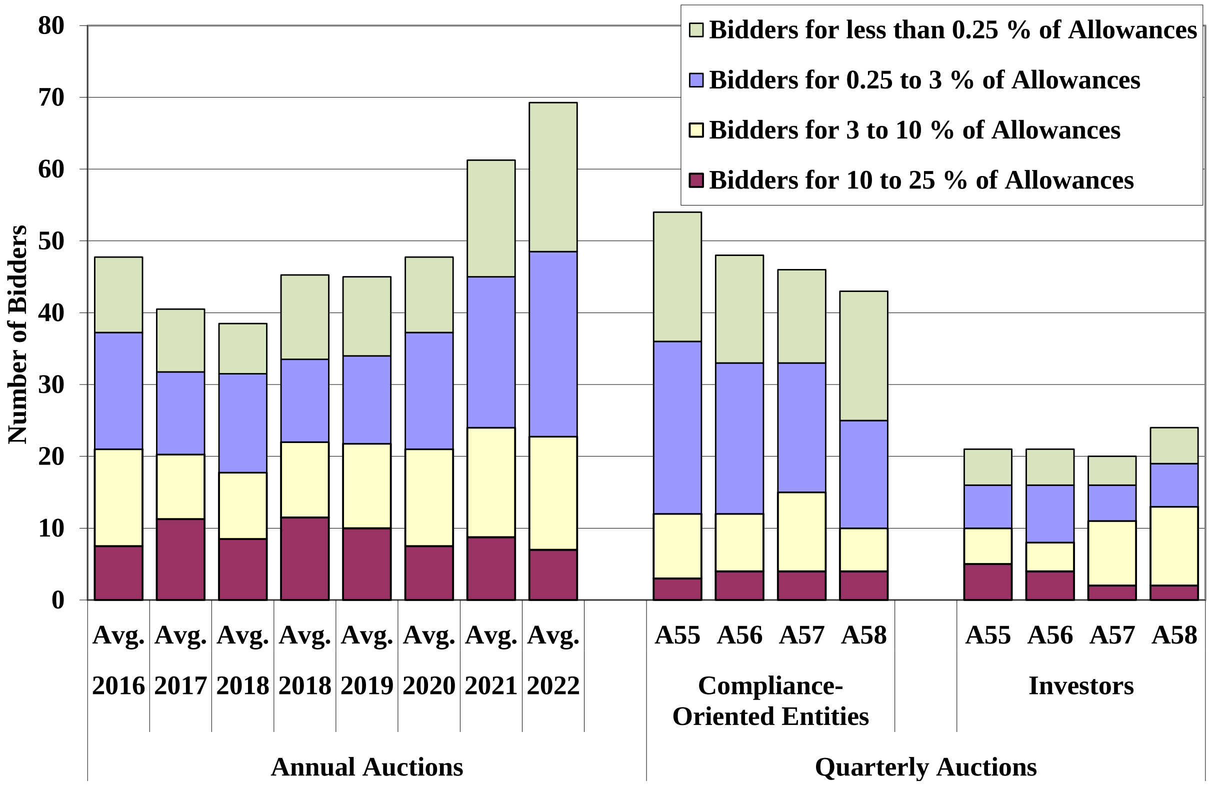
Observations regarding participation in the RGGI auctions:

- *Participation* – In the 2022 auctions, the number of bidders ranged from 67 to 75 and averaged 69, a higher average than the number of bidders in the 2021 auctions. The number of compliance-oriented entities submitting bids increased from an average of 44 in 2021 to 48 in 2022, while the number of participating investors increased from 17 in 2021 to 22 in 2022.
- *Large and Small Bidders* – The number of large bidders (i.e., firms submitting bids for more than three percent of the allowances in a current control period offering) averaged 23 in 2022, a slight decrease from 2021. The average number of small bidders (i.e., firms submitting bids for up to three percent of allowances offered for sale) was 47, which was greater than the level of participation in 2021.
- *Competition* – Participation by a large number of firms promotes competition and helps ensure that the auction clearing price reflects the market value of CO_2 allowances. The levels of participation in 2022 were higher than those in 2021, and we found no material evidence of anti-competitive conduct or significant barriers to participation in our reviews of the bids and the qualification process of each auction.

---

[28] For example, if 13.5 million CO_2 allowances were offered in an auction, a firm that submitted bids for 200,000 allowances would be counted in the "0.25 to 3 percent" category, since 200,000 ÷ 13.5 million = 1.5 percent.

Figure 8: Number of Bidders According to the Quantity of Bids Submitted Auctions for Current Control Period Allowances



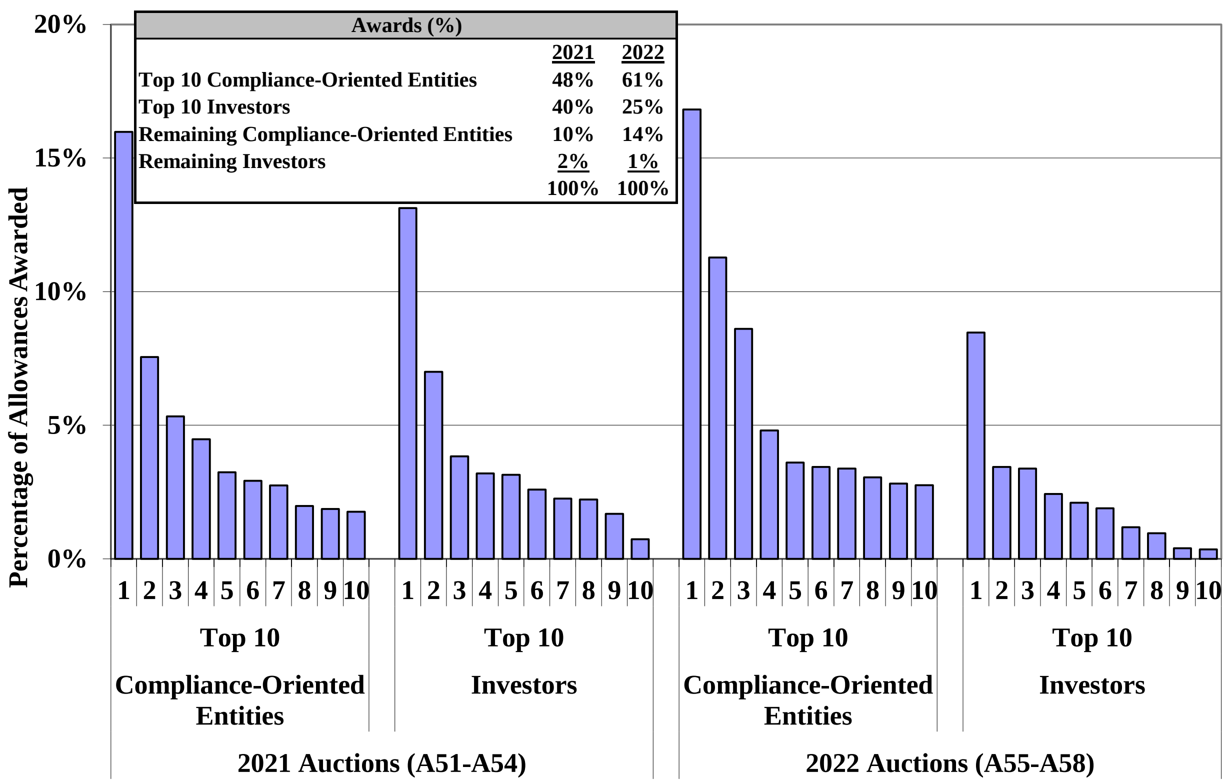
C. Acquisition of CO_2 Allowances by Individual Firms

In a well-functioning market, we expect a compliance-oriented firm to purchase a number of CO_2 allowances that is generally consistent with its demand. An investor is more likely to hold a number of CO_2 allowances exceeding its demand for extended periods. Individual firms may purchase a larger or smaller share according to how the current price of CO_2 allowances compares to their expectations of allowance prices in the future. Firms that believe CO_2 allowances are currently undervalued can be expected to purchase a larger share, while firms that believe allowances are overvalued can be expected to purchase a smaller share. Thus, competition by many firms helps ensure that the current price of CO_2 allowances in the auctions and in the secondary market reflects reasonable expectations.

The following two figures examine the distribution of CO_2 allowances across individual firms following the twelfth full year of the RGGI market's operation. Figure 9 illustrates how broadly CO_2 allowances were distributed in the auctions, while Figure 10 illustrates how the holdings of allowances in COATS accounts were distributed after the close of 2022. The figures show that CO_2 allowances have generally been acquired by firms in quantities that are consistent with their demand, which is a positive indicator regarding the competitiveness of the market.

Figure 9 reports the average quantities of CO_2 allowances that were awarded to firms in the auctions in 2021 and 2022. The awards are shown for each of the top ten compliance-oriented entities (i.e. the ten firms with the highest projected demand) and for each of the top ten investors (i.e., the ten firms with the largest total awards). Compliance-oriented entities are ranked in descending order based on total awards rather than demand. The table also shows the level of awards given to remaining (not included in the top 10) firms in each category as a group.

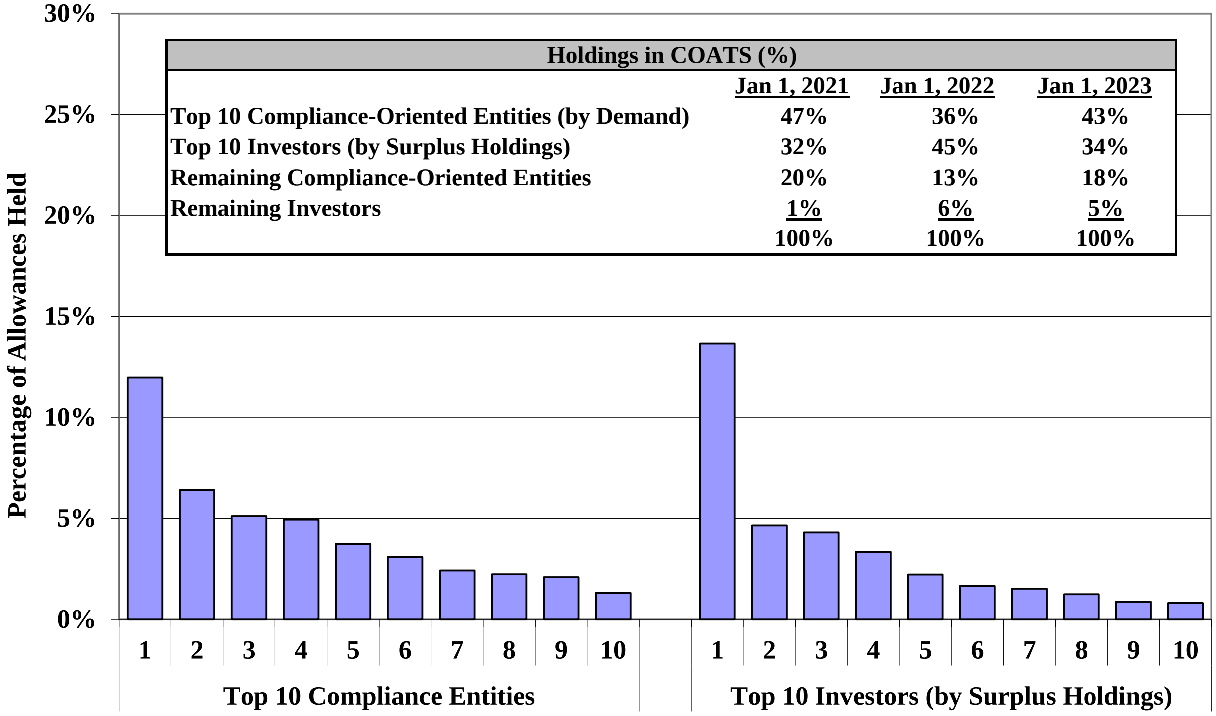
Figure 9: Distribution of Auction Awards 2021 – 2022



Awards (%)	2021	2022
Top 10 Compliance-Oriented Entities	48%	61%
Top 10 Investors	40%	25%
Remaining Compliance-Oriented Entities	10%	14%
Remaining Investors	2%	1%
	100%	100%

Figure 10 reports the quantities of CO_2 allowances that were held in the COATS accounts of individual firms at the beginning of January 2023, following the delivery of contracts dated for December 20222 delivery. The holdings are shown for each of the top compliance-oriented entities (i.e. the ten firms with the highest projected demand) and for the top ten investors. The top ten investors are ranked in descending order based on total holdings rather than demand. The table also shows the level of holdings of the remaining (not included in the top ten) compliance-oriented entities as a group and investors as a group.

Figure 10: Distribution of CO_2 Allowance Holdings January 1, 2023



Observations regarding the distribution of CO_2 allowances:

- *Distribution of CO_2 Allowances Awarded* – The share of awards allocated to the top ten compliance-oriented entities increased from 48 percent in 2021 to 61 percent in 2022, while the share of awards allocated to the top ten investors decreased from 40 percent in 2021 to 25 percent in 2022.
- *Distribution of CO_2 Allowance Holdings Among Compliance-Oriented Firms* – The holdings of CO_2 allowances were distributed across compliance-oriented entities at the close of 2022 at levels that were generally consistent with their demand, and a small number of these entities owned a moderate surplus. The share of holdings of the top ten compliance-oriented entities was 43 percent at the end of 2022, while the share of holdings of smaller compliance-oriented entities was 18 percent.
- *Distribution of CO_2 Allowance Holdings Among* Investors – The share of allowances held by the top ten investors was 34 percent at the end of 2022. The share had been higher in 2021 because compliance-oriented firms surrendered a large number of allowances for the fourth control period compliance thereby reducing their overall holdings as well as

their share. The distribution of allowance holdings is consistent with competitive expectations given that the private bank of allowances far exceeds the anticipated compliance obligations of firms in the fifth control period. The large surplus makes it more difficult for one firm or a small number of firms to hoard allowances.

D. Participation in the CO_2 Allowance Futures Market

Additional information about the trading of futures, forwards, and options is available in the weekly Commitments of Traders ("COT") reports, which are published by the Commodity Futures Trading Commission ("CFTC") [29] for each week when greater than 20 firms have reportable positions in a particular product.

Figure 11 summarizes the concentration of open interest in Vintage 2021, 2022, and 2023 ICE futures and options contracts during months when information was available from the CFTC. The figure reports the average monthly net long positions in three categories: (i) the four firms with the largest long positions, (ii) the four firms with the largest long positions not including the Top 4 (see "Next 4 Firms"), and (iii) all other long positions. The figure also reports the average monthly net short positions for three categories.

Figures 12 and 13 summarize the concentration of open interest in Vintage 2022 ICE futures and the number of firms participating in the market for Vintage 2022 futures and options contracts, respectively. The figures show similar aggregations by category of trader including producers/merchants, swap dealers, money managers, spread, and unspecified or other as defined by the CFTC:

- *Producers/Merchants* – Firms that hold the "physical commodity and use the futures markets to manage or hedge risks associated with those activities,"
- *Swap Dealers* – Firms that "deal primarily in swaps for a commodity and use the futures markets to manage or hedge the risk associated with those swaps transactions. The swap dealer's counterparties may be speculative traders, like hedge funds, or traditional commercial clients that are managing risk arising from their dealings in the physical commodity,"

[29] Each day, firms with an open interest of 25 contracts or more are required to report their positions to the CFTC. Each Tuesday, the CFTC publishes the COT report, which summarizes the positions of market participants.

- *Managed Money* – "Investors that are generally seeking exposure to a broad index of commodity prices as an asset class in an unleveraged and passively-managed manner,"
- *Spread (Figure 12)* - Traders with offsetting short and long positions, and
- *Unspecified (Figure 13) or Other (Figure12)* – Firms with reportable positions not included in the other categories.

Figure 11: Concentration of Open Interest in Futures and Options

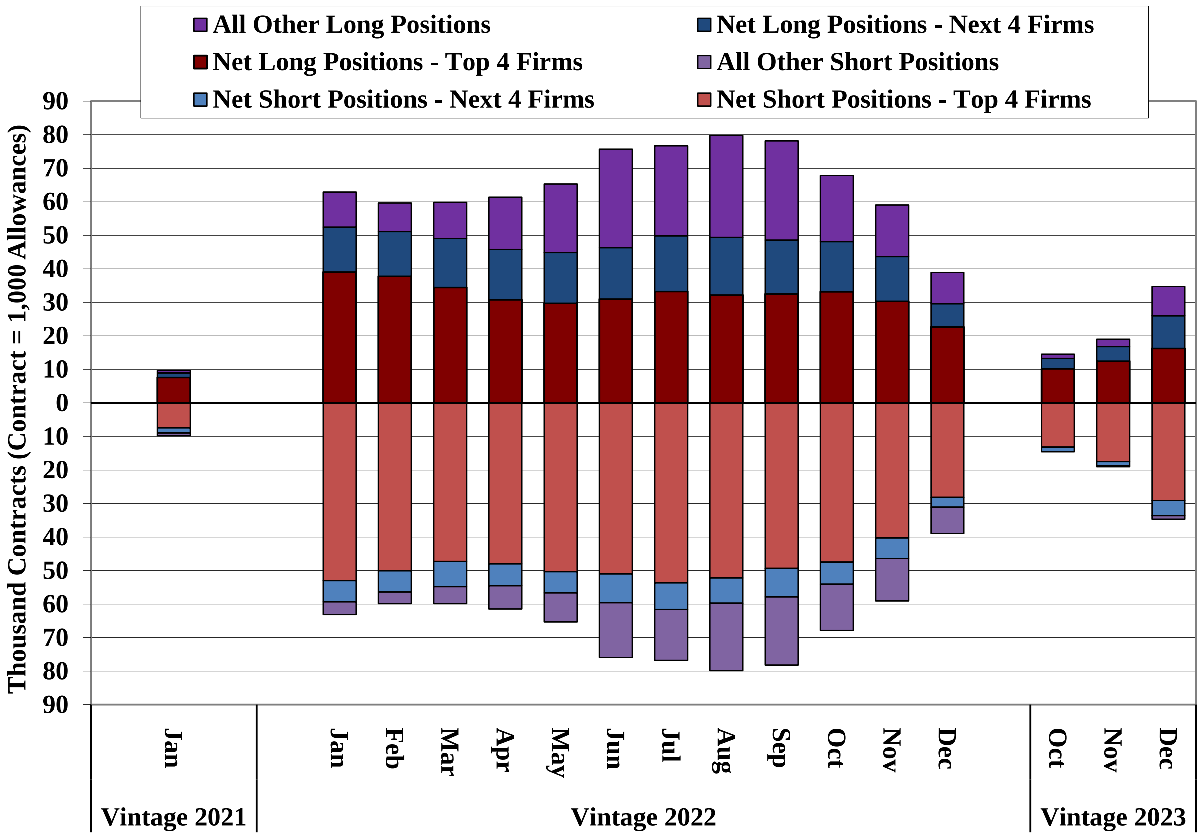


Figure 12: Concentration of Open Interest in Futures and Options by Trader Type

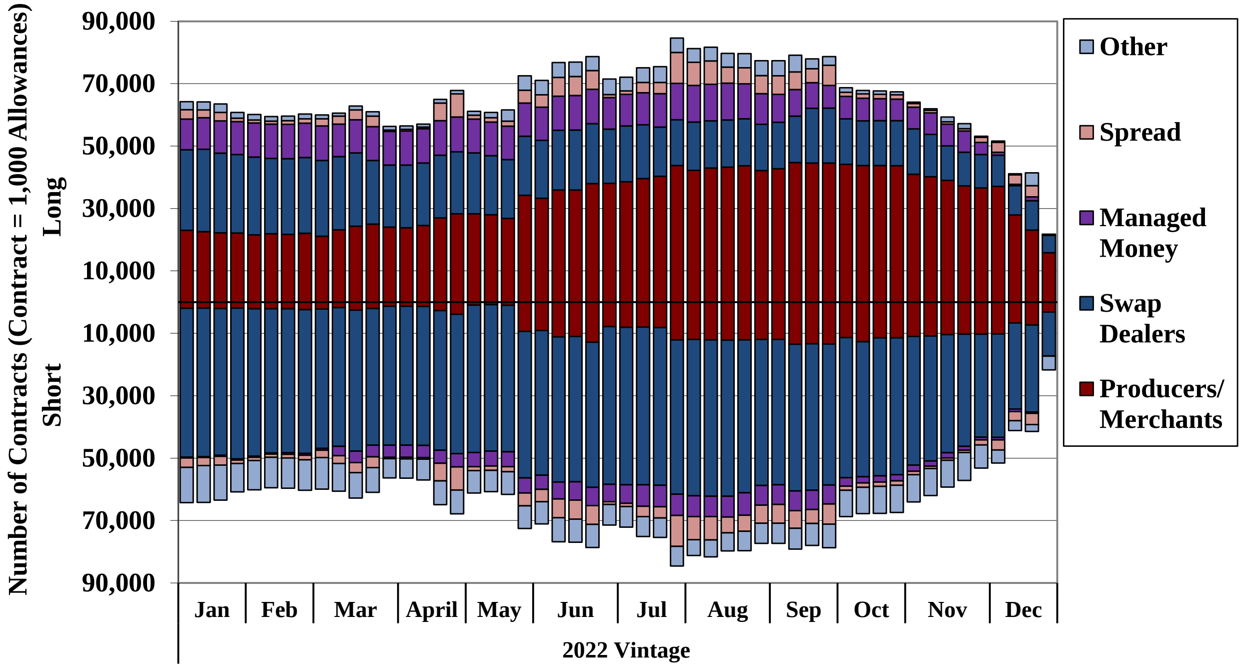
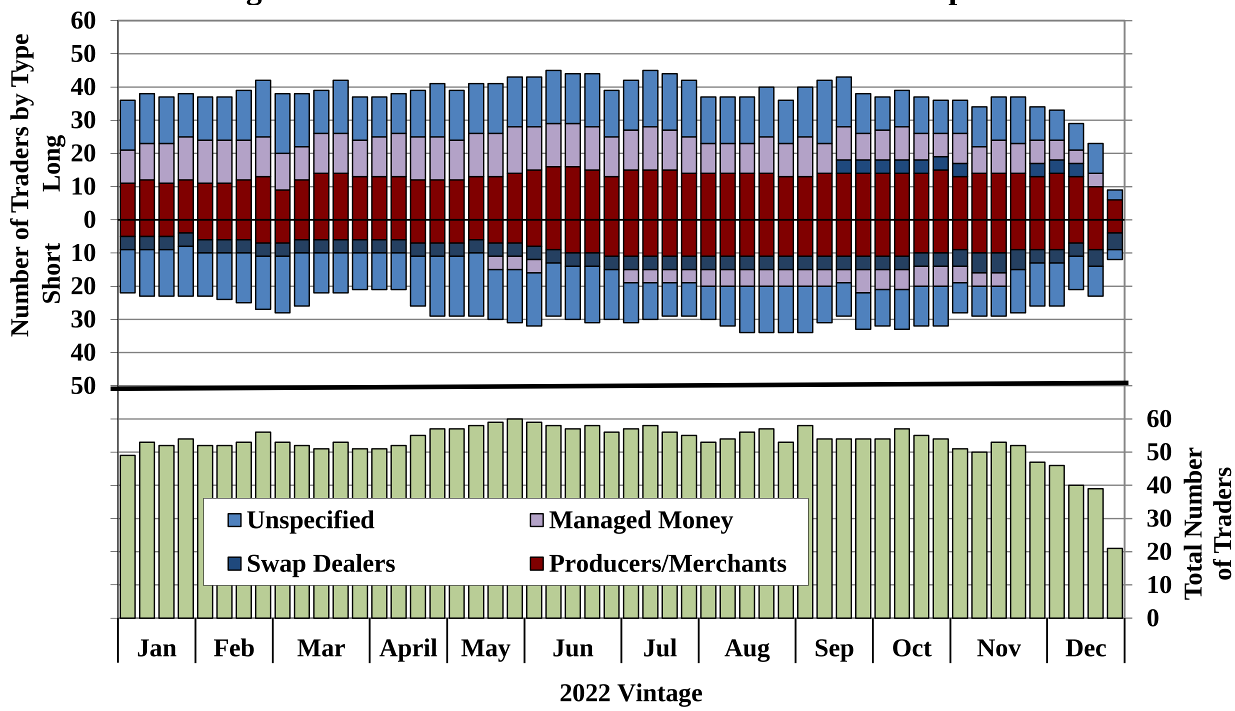


Figure 13: Number of Traders in ICE Futures and Options



Observations regarding the concentration of open interest in futures and options contracts and participation in the market by individual firms:

- *Number of Participants* – The number of participants in the market for ICE vintage 2022 derivatives with reportable positions rose gradually during the year but fell off at the end of the year as contracts expired and activity increased for Vintage 2023 contracts. The number of swap dealers and managed money firms increased during the course of the year, particularly in October and November when approximately 50 firms had reportable positions.
- *Concentration of Ownership* – Many firms have open interest in RGGI CO_2 allowance futures and options, although a small number of firms account for large shares of the net long and short positions in Vintage 2022 contracts. The net long positions of the top four firms accounted for an average of 51 percent of the total long positions in Vintage 2022 contracts, while the net short positions of the top four firms accounted for an average of 73 percent of the total short positions. Starting in June, producers/merchants (compliance entities) began taking a larger share of Vintage 2022 long positions; the volume peaked at about 45 thousand contracts in September while the share peaked in December at about 77 percent. The net long positions of the top four firms accounted for an average of 61 percent of the total long positions in Vintage 2023 contracts, while the net short positions of the top four firms accounted for an average of 89 percent of the total short positions in Vintage 2023 contracts.
- *Contract Vintage* – January was the last reportable month of open interest for Vintage 2022 contracts. Open interest in Vintage 2022 contracts was relatively steady through May and then began to rise in July, peaking in July before falling to its lowest levels in December. Between October and the second to last week of December, the amount of reportable Vintage 2022 open interest fell by 23 million allowances while the amount of reportable Vintage 2023 interest increased by 25 million allowances.

VI. Discussion of Market Monitoring

As the RGGI Market Monitor, we evaluate the conduct of market participants in the auctions and in the secondary market to identify potential anti-competitive conduct. We also assess whether the auctions were administered properly by the auction administrator.

Participation in the auctions by a large number of firms promotes competition and helps ensure that the auction clearing price reflects the market value of allowances. Hence, the participation by a substantial number of firms as observed in Figure 8 is a positive indicator regarding the competitiveness of the first 58 auctions. We have found no material evidence of anti-competitive conduct or significant barriers to participation in our reviews of the bids and the qualification process for each product in each auction. We also found that the auctions were conducted in accordance with the noticed rules and bids received.

In our monitoring of the secondary market, we evaluate whether firms could potentially hoard a substantial share of the supply of allowances to influence prices or to prevent a competitor from obtaining allowances. Based on our review of the holdings of individual firms, we find no evidence that hoarding is a significant concern, and that the holdings of individual firms are generally consistent with their expected need for allowances over the current control period. Figure 6 shows that compliance-oriented entities as a group hold a quantity of allowances consistent with their obligation thus far for the fourth control period, while Figure 10 demonstrates that the allowances are adequately distributed across the COATS accounts of individual compliance-oriented entities.

Another potential concern is that a firm expecting to purchase CO_2 allowances in the auction might sell a large number of futures contracts in an effort to push prices in the secondary market below the competitive level. Such a firm might profit from buying a large number of CO_2 allowances in the auction at a discount if the bidding in the auction were influenced by the depressed futures price. For this to be a profitable strategy, the firm would need to be able to substantially depress the futures price with a relatively small amount of sales—an amount smaller than the amount of CO_2 allowances it planned to buy in the auction. The best protection against this strategy is a market where other firms respond by making additional purchases.

Firms that are looking for an opportunity to reduce their short positions or to purchase CO_2 allowances for their future compliance needs help limit the effectiveness of a strategy to depress prices below the competitive level. Such firms have a strong incentive to make additional purchases if a firm deliberately attempts to depress the futures price.

We have found no material evidence of anti-competitive conduct or significant barriers to participation in the auctions and in the secondary market, and we have found that price variations are generally driven by reasonable expectations related to the long-term supply and demand for allowances.