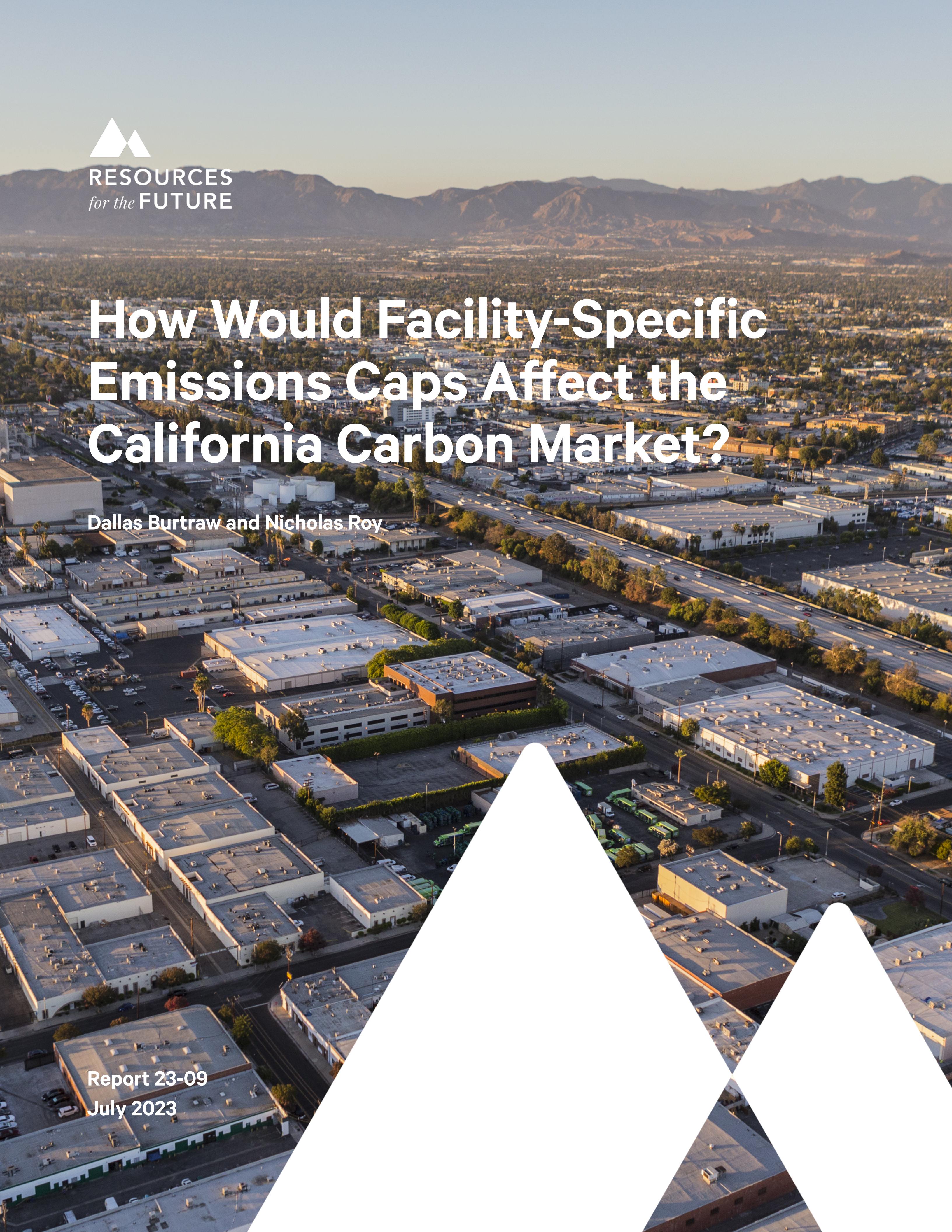

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How Would Facility-Specific Emissions Caps Affect the California Carbon Market?

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Abstract

Incentive-based approaches to addressing air pollution, such as cap-and-trade, enable flexible compliance that can reduce costs compared with prescriptive regulations. Flexibility implies that emissions reductions happen where abatement costs are lowest, but that may not be where emissions reductions are needed to mitigate preexisting inequities in pollution exposure. This paper examines the California carbon market and finds that emissions from stationary sources in disadvantaged communities have fallen overall as quickly and often more quickly than the state average, but with notable outliers often in densely populated areas. This paper considers additional requirements on individual facilities to ensure an equitable rate of progress and finds they would likely have little effect on the allowance market.

Contents

Executive Summary

California's greenhouse gas cap-and-trade program does not direct where emissions reductions occur, and in principle, trading could increase emissions in already overburdened communities. The same outcome could result from the introduction of a carbon tax.[1] Because emissions of greenhouse gases are correlated with emissions of conventional air pollutants, trading could lead to inequitable distribution of air quality benefits from emissions reductions.

A recommendation of the California Environmental Justice Advisory Committee (EJAC) would have the California Air Resources Board implement facility-specific emissions caps to ensure that emissions at all facilities in disadvantaged communities fall at least as fast as the state average. We estimate that a facility-specific cap that required all facilities covered by the cap-and-trade program in disadvantaged communities to reduce emissions at least as quickly as the economywide emissions cap, without increasing emissions at other facilities, would have led to 29.3 million metric tons fewer emissions of carbon dioxide in disadvantaged communities cumulatively between 2013 and 2020.[2] If the ratio between pollutants and greenhouse gases were constant at each facility in each year, these facility caps would have resulted in 5.9 thousand tons fewer emissions of correlated nitrogen oxide between 2013 and 2020 (677 tons lower in 2019) and 1.7 thousand tons fewer of sulfur oxide emissions (78 tons lower in 2019) in those communities.

In total, greenhouse gas emissions at regulated facilities in disadvantaged communities have fallen by 21 percent, compared with 13.8 percent at facilities outside those communities. Emissions at stationary facilities as a group fell by 16.9 percent. Emissions at facilities not regulated by the cap-and-trade program have fallen more slowly than at regulated facilities.

The annual rate of emissions reductions at in-state electricity generation facilities has outpaced the annual rate for the overall program statewide, while reductions at petroleum production and refining facilities have lagged, with rates that are slower than the overall program. Electricity generation and petroleum production facilities in disadvantaged communities reduced greenhouse gas emissions at a rate that was slower than similar facilities in other communities. However, partly reflecting the role of other regulations, the rate of reductions in sulfur oxides and nitrogen oxides across all sectors has been greatest at facilities in disadvantaged communities.

Emissions changes over time can be caused by many factors. We do not seek to assess the causal effects of the cap-and-trade program on air pollution outcomes in different communities, as other studies have done (Cushing et al. 2018, OEHHA 2022, Hernandez-Cortes and Meng 2023, Sheriff 2023). Moreover, sources of most

1 Carbon dioxide is the most important greenhouse gas. We use the terms interchangeably in describing the cap-and-trade program.

2 All emissions are given in metric tons.

air pollution in disadvantaged communities have not been subject to the cap-and-trade program (Anderson et al. 2018). Rather, we ask more simply whether the rate of emissions decline over time at facilities covered by the cap-and-trade program has been comparable across communities and how a facility-specific cap that ensured emissions reductions occurred at least as rapidly in disadvantaged communities as elsewhere would affect the carbon market.

One approach to implementing a facility-specific cap might focus on facilities that receive free allocation, which accounted for 70 percent of emissions from stationary sources in disadvantaged communities in 2019. However, generally under cap-and-trade, emissions reductions at one source could reappear as an increase in emissions at another source. To help avoid increases in emissions at facilities that do not have a facility-specific cap or that otherwise would exceed the requirements of a cap, EJAC recommended that the state emissions allowance budget be reduced by the size of the necessary emissions reductions to achieve the facility-specific cap at facilities where the cap would have been binding. The effect of facility-specific caps and the size of the potential rebound is impossible to know ex ante. A general strategy might use past performance to estimate the change in the total allowance supply that would have been necessary to implement the EJAC recommendation.

This paper examines the potential effect of facility-specific requirements in disadvantaged communities in the future based on how such requirements would have affected outcomes historically. We find the annual emissions cap would have to be reduced by approximately 2 million tons, or 0.72 percent of total allowances to be issued in 2024. We use a model to estimate the future effect of such a percentage reduction in allowance supply on carbon market outcomes. The directional effect on the allowance price and auction proceeds depends on whether the allowance price is on the price floor, but regardless, we find the effect to be small. We also note that facility-specific caps could help facilitate linking with other jurisdictions by providing an assured annual rate of emissions reductions at facilities in disadvantaged communities and possibly accelerating reductions due to the anticipated increased cost effectiveness from a broader program.

1. Introduction

This report examines the potential effect and important considerations of designing into the California emissions market a safeguard to limit unintended harm and potentially accelerate environmental health improvement in disadvantaged communities. The term "disadvantaged community" is a broad label that is applied in California to help identify and address disparities among communities. The term was incorporated into the climate policy framework in 2012 with **Senate Bill 535**, which requires that minimum funding levels from California's Greenhouse Gas Reduction Fund be allocated to disadvantaged communities. In 2016, **Assembly Bill 1550** specified the levels of funding required for disadvantaged communities and required the California Environmental Protection Agency to set a precise definition of which census tracts qualify as disadvantaged communities. The **requirements for disadvantaged communities designation** were finalized in 2022, mostly on the basis of relative pollution scores compared with other tracts using CalEnviroScreen 4.0, as well as tribal communities and other communities identified as disadvantaged in 2017.[3]

Residents in disadvantaged communities experience relatively greater exposure to air pollution, resulting in greater health harm.[4] Increasingly, the health effects from pollution have been found to be exacerbated by other community-level stressors.[5]

Many environmental advocates believe that disadvantaged communities have not been prioritized in environmental policy, and some observers argue they could be relatively harmed by the way climate policy is implemented.[6] This complaint is salient in the California greenhouse gas trading program because the program, as would a carbon tax, gives no weight to where or when emissions reductions occur and does not prioritize any specific source of emissions reductions.[7] The approach in the carbon market exemplifies a cost-effectiveness criterion aiming to achieve the greatest reduction in greenhouse gas emissions at the least

3 As of 2020, **73 percent of the money** invested in California Climate Investments projects benefited the identified priority populations.

4 For example, see Clark et al. (2014).

5 For example, the US Environmental Protection Agency **published a proposed rule** April 25, 2023, setting air toxic standards for hazardous air pollutants; it involves a community-based risk assessment that goes beyond facility-specific risks and considers risks posed by other facilities in the area.

6 See, for example, Carley and Konisky (2020), Food and Water Watch (2019), and Schlosberg et al. (2017).

7 The California program explicitly considers some distributional criteria, including the distribution of the asset value created by introducing a price on carbon and the costs of compliance.

possible cost.[8] Reductions in greenhouse gases are expected to lead to associated reductions in conventional air pollution (Thompson et al. 2016). However, nitrogen oxides, volatile organic compounds, and other pollutants that are emitted coincidentally with greenhouse gas pollutants have shorter atmospheric lifetimes and hence highly variable local effects (Pappin and Hakami 2013). Consequently, although the location and timing of greenhouse gas emissions reductions make little difference to their climate impact, their correlation with other pollutants can significantly affect local public health. The resulting distributional effects of where and when emissions reductions occur have cast the cost-effectiveness approach to greenhouse gas regulation in a new light.[9]

Some emissions trading programs do account for the geographic or temporal pattern of emissions. One was in California, where the RECLAIM trading program (initially covering nitrogen oxides and sulfur oxides but subsequently applied only to nitrogen oxides) implemented two zones, and the transfer of emissions allowances between zones could occur only in one direction; the rule was intended to anticipate the prevailing direction that pollution travels (Johnson and Pekelney 1996). An example at the federal level is the Cross State Air Pollution Rule, which implements regional trading zones and seasonal controls for nitrogen oxides and sulfur dioxide from stationary sources. Recently, the US Environmental Protection Agency proposed the "good neighbor rule," which would regulate upwind emissions based on their effects in downwind states.[10] These examples are built on the direct effects of the pollutant that is being regulated, not the indirect effects of coincident pollutants, and they are not focused on environmental justice—that is, they do not take into account the legacy of pollution in overburdened communities.

Direct regulation of coincident pollutants would be superior to their ancillary control through the regulation of greenhouse gases because the correlation of pollutants is not perfect (Anderson et al. 2018). However, for many reasons, direct regulation of pollution has not rectified the environmental legacy in disadvantaged communities. Consequently, advocates have turned to other regulatory processes to push for prioritizing actions that will help disadvantaged communities, including in the carbon market.

8 The Cap-and-Trade Program does not regulate toxins and conventional air pollutants. These pollutants are regulated through stationary source permits and mobile source vehicle standards and other prescriptive regulations. Primary responsibility for regional air quality planning, monitoring, and stationary source and facility permitting is the responsibility of California's 35 local air districts. One way the carbon market has been linked to air quality outcomes is through the concurrent passage of AB 398 and AB 617 in 2017. AB 398 extended the cap-and-trade program from 2021 to 2030. AB 617 requires frequent reporting of criteria air pollutant and air toxics emissions data and targets pollution reduction in California communities most impacted by poor air quality.

9 Distributional outcomes are elevated in benefit-cost analysis in the **Biden administration proposal** for updating the Office of Management and Budget guidance for benefit-cost analysis.

10 **https://www.epa.gov/newsreleases/epa-announces-final-good-neighbor-plan-cut-harmful-smog-protecting-health-millions**

In this paper we compare the emissions changes at stationary facilities in disadvantaged communities regulated under the California cap-and-trade program with those at facilities in other communities and with the statewide performance of the program. We consider a hypothetical counterfactual in which greenhouse gas emissions at stationary sources in disadvantaged communities were constrained to fall at a rate that was at least as great as the economywide emissions cap. We estimate that if facility-specific emissions caps had been in place, emissions reductions at these facilities would have totaled 29.3 million tons of carbon dioxide between 2013 and 2020. In 2019, the last year before COVID, these emissions reductions would have been 3.4 million tons. California has witnessed substantial air quality improvements through regulatory measures and technological changes that we do not account for separately from the trading program, and which cause changes in greenhouse gas emissions and conventional air pollution to be imperfectly correlated. We estimate the coincident changes in emissions of nitrogen oxides and sulfur oxides that could be expected to have resulted from changes in emissions of carbon dioxide.[11] If the ratio between coincident pollutants and greenhouse gases were constant at each facility in each year, we calculate that these facility caps would have resulted in 5.8 thousand tons fewer emissions of correlated nitrogen oxide between 2013 and 2020 (677 tons lower in 2019) and 1.6 thousand tons fewer of sulfur oxide emissions (78 tons lower in 2019) in those communities.

One approach to implementing a facility-specific cap might focus on facilities that receive free allocation, which account for 70 percent of emissions from stationary sources in disadvantaged communities in 2019 (see Table 1). We cannot distinguish the allocation that goes to specific facilities above the subsector level, but as a group, facilities that receive free allocation have emissions that are 147 percent of their allocation. The difference could result from the use of banked allowances or offsets or purchase of allowances. These facilities might be restricted in the amount of compliance instruments in excess of their free allocation that they can use, but that would imply a reduction of nearly one-third in their emissions which would exacerbate concerns about job losses and emissions leakage.

However, generally under the trading program, emissions reductions at one group of facilities free up emissions allowances that can be used for an increase in emissions at other facilities, perhaps even in disadvantaged communities where facilities that may otherwise have reduced emissions at a rate exceeding the facility-specific cap could increase their emissions. One approach to lessen the emissions rebound is to reduce the allowances issued in the program. We estimate that in 2024, the required reduction to allowance supply would total about 2 million tons. This represents 0.72 percent of the annual allowance cap in 2024 and would seem likely have a small effect on the market equilibrium. We address this question with RFF's Haiku model. The outcome is likely to be highly dependent on the size of the bank of existing allowances, the future price path of the program, success of complementary policies, and importantly,

11 Nitrogen oxides cause health damage by contributing to the formation of nonatmospheric ozone and fine particulates. Sulfur oxides can damage the respiratory system and contribute to fine particulates. Nitrogen and sulfur deposition both contribute to acidification of ecosystems.

whether the allowance price is on the price floor. Holding these factors constant and assuming the allowance price is off the price floor, we estimate that this reduction in allowance supply would increase the market price in the latter part of the decade by about 3.3 percent and would increase the asset value of allowances by about 2.53 percent. Moreover, if all sources of supply were reduced proportionately, including freely allocated allowances, the value of contributions to the Greenhouse Gas Reduction Fund would increase by 2.53 percent. However, if the price is on the price floor, potentially because of successful sector-specific emissions reduction policies outside the carbon market, then the reduction in supply would not affect the price and the value of allowances would fall by 0.6 percent.

We find that between 2013 and 2020, emissions of carbon dioxide at facilities regulated by cap-and-trade in disadvantaged communities have fallen by 21 percent, compared with 13.8 percent at regulated facilities outside those communities. Emissions at unregulated facilities have fallen more slowly than at facilities regulated by cap-and-trade. However, we find several instances where the opposite is true, and some facilities in disadvantaged communities have failed to keep pace. Providing a safeguard to ensure that the benefits of the emissions trading program accrue at least as fully in disadvantaged communities as in other communities could broaden public support for the cap-and-trade program, enabling greater cost-effectiveness and greater ambition in the state's climate policy.

The next four sections of this paper describe the coverage of stationary sources in the cap-and-trade program, the reduction in greenhouse gases and coincident reduction in conventional air pollution that have been observed. We then examine how a facility-specific cap may have affected these outcomes and what effect such a market reform would have on the carbon market.

2. Stationary Sources in California's Cap-and-Trade Program

A primary focus of environmental justice advocates has been the community-level effects of emissions from stationary sources, specifically the industrial facilities, refineries, and electricity generating units that are regulated in the carbon market.[12] Carbon emissions from the transportation sector are regulated in the carbon market through an upstream obligation placed on refineries. Although transportation-related emissions of conventional air pollutants are of local concern, especially from medium- and heavy-duty trucks, vehicles cannot practically be regulated in a cap-and-trade program; this mobile source must be addressed through other policies, such as fuel and vehicle technology performance standards, green zones, or congestion fees. Buildings are an important stationary source of NOx emissions, but buildings are not obligated parties, and their emissions are covered in the trading program upstream in the fuel supply.

In 2019, California had 284 stationary facilities regulated in the carbon market responsible for about 105 million tons, or about 26 percent of the state's total greenhouse gas emissions, and 34 percent of emissions covered in the carbon market (Table 1).[13] Of those regulated stationary facilities, 166 are in disadvantaged communities, responsible for 56 million tons and representing about 14 percent of statewide emissions and 18 percent of emissions covered in the carbon market. Stationary sources receiving free allocation had emissions of 65 million tons, and sources receiving free allocation in disadvantaged communities had emissions of 39 million tons.[14] About 70 percent of the stationary source emissions in disadvantaged communities were observed at facilities receiving free allocation.

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12 See, for example, **letter to Rajinder Sahota** (Deputy Executive Officer, California Air Resources Board) and Members of the AB 32 Environmental Justice Advisory Committee, February 25, 2022.

13 The carbon market primarily covers carbon dioxide emissions associated with fossil fuel combustion. These emissions account for about 75 percent of the total greenhouse gas emissions in the state. The 2006 Global Warming Solutions Act (AB 32) that launched California's climate program covers all greenhouse gas emissions from facilities emitting more than 25,000 metric tons annually in the state and those associated with imported electricity. The program covers 76 industries; only 16 have 100 percent of their facilities covered. Industries for which a majority of emissions are excluded from the program include hospitals, correctional facilities, sewage treatment facilities, and wineries.

14 Energy-intensive, trade-exposed industries receive free allocation of allowances at a benchmark emissions rate (tons of emissions per unit of output) associated with industrial best practice and calibrated to the level of economic output for each individual facility. See **https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/allowance-allocation/allowance-allocation-industrial**. This "output-based allocation" intends to prevent out-of-state leakage of economic activity and emissions while preserving an incentive for facilities to reduce their own emissions. Electricity and natural gas distribution companies also receive free allocation, but it is not tied to individual facilities.

Table 1. Greenhouse Gas Emissions Sources

California (2019)	Million metric tonnes	Percent of total GHG	Percent covered in the market
Total GHG	404.50	100%	"--"
Covered in carbon market	311.16	76.9%	100%
Stationary source emissions	105.13	26.0%	33.8%
At facilities receiving free allocation	64.42	15.9%	20.7%
In disadvantaged communities	55.56	13.7%	17.9%
At facilities receiving free allocation in disadvantaged communities	38.68	9.6%	12.4%

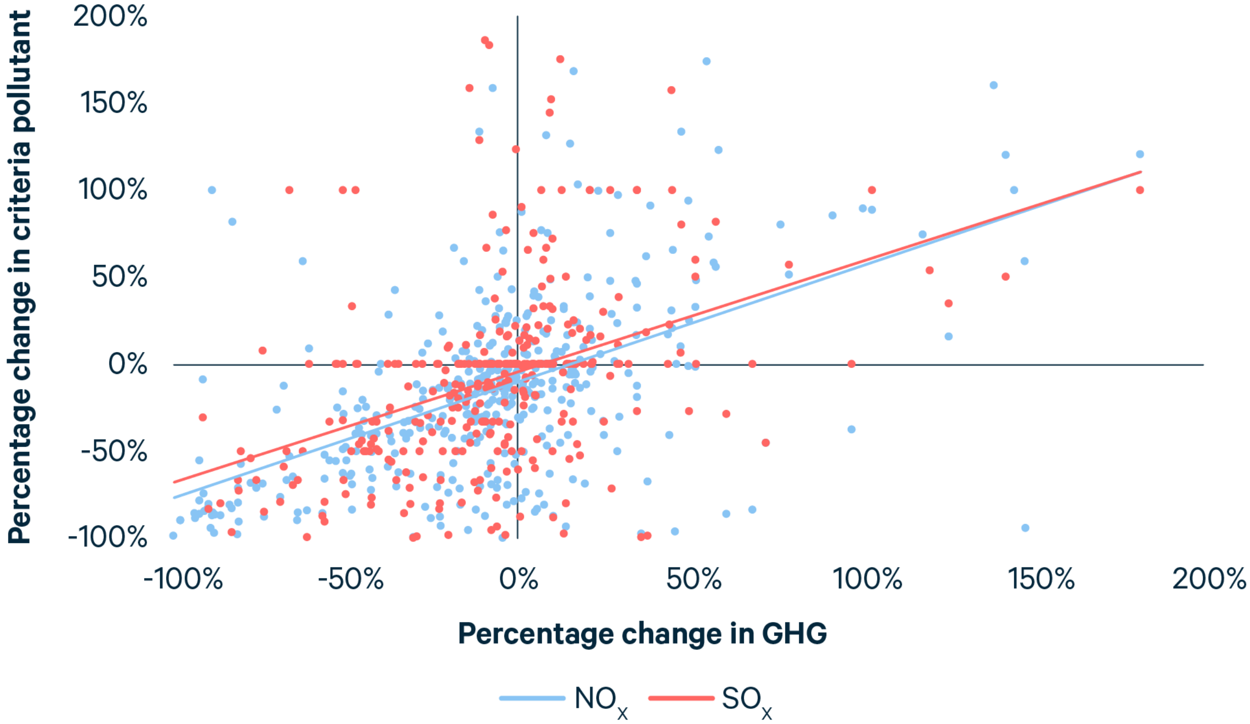
Notes: This covers about 60 percent of emissions at facilities designated as energy intensive and trade exposed and qualifying for free allocation. Data are for 2019 to avoid changes that are attributable to the pandemic. GHGs = greenhouse gases.

In 2017, the most recent year when all sources of nitrous oxide and sulfur oxide emissions were reported, regulated facilities in disadvantaged communities were responsible for 13 percent of nitrogen oxides, 31 percent of sulfur oxides, and 18 percent of carbon dioxide emissions in the cap-and-trade program.[15] Because nitrogen oxide and sulfur oxide emissions are associated with greenhouse gas emissions, emissions trading of greenhouse gases could affect air quality outcomes. Figure 1 illustrates the simple correlation between the percentage change in nitrogen oxides and sulfur oxides emissions and greenhouse gas emissions in California between 2013 and 2020.[16]

15 **California Air Resources Board – Criteria Pollutant Emissions Inventory Data**

16 A few outliers beyond the range displayed include facilities that substantially changed their level of economic activity or increased emissions by more than 200 percent; they are omitted from the figure.

Figure 1. Percentage Change in NO_x–SO_x GHG Emissions in California, 2013–2020



Note: NO_x = nitrogen oxides; SO_x = sulfur oxides.

Data source: **CARB Pollution Mapping Tool**

Emissions do not remain local: communities are affected by emissions from upwind facilities. The pattern of emissions resulting from trading in the carbon market may affect downwind communities, and some communities would see increases in emissions and others, decreases, compared with a regulation that required an equal percentage reduction at all facilities. Cushing et al. (2018) focused on the first years of the program through 2015 and found that neighborhoods that experienced increases in greenhouse gas emissions from nearby regulated facilities had higher proportions of people of color and poor, less educated, and linguistically isolated residents, compared with neighborhoods that experienced decreases. The authors suggested additional policy and regulatory elements to incentivize more local emissions reductions in disadvantaged communities. Subsequent research finds that the gap between air pollution reductions in disadvantaged communities and the rest of the state closes with the presence of a cap-and-trade program (Hernandez-Cortes and Meng 2023).[17] What is clear generally, however, is that while the greatest benefits of emissions reductions on environmental and public health outcomes are local, the benefits also would extend beyond the communities closest to the facilities.

17 Hernandez-Cortes and Meng (2023) identify a closing of a preexisting environmental justice gap in air pollution concentration levels that is associated with compliance under the cap-and-trade program but do not identify the relative performance of the emissions cap in affecting emissions from facilities in disadvantaged communities compared with elsewhere.

A recommendation of the California Environmental Justice Advisory Committee (EJAC 2022a) called for the California Air Resources Board (CARB) to consider limiting compliance flexibility under the cap-and-trade program by preventing facilities operating in disadvantaged communities from banking allowances and trading emissions credits.[18] This has been characterized as removing these facilities from the market. The California Independent Emissions Market Advisory Committee (IEMAC 2023) addressed this and other options and described an approach that would prohibit facilities in disadvantaged communities from acquiring allowances or offsets in excess of a facility-specific cap reflecting an annual rate of emissions reduction that met the statewide reduction in the emissions cap. The Committee sought to preserve the requirement to acquire and surrender allowances to cover their emissions to preserve the economic incentive to reduce emissions below the facility-specific cap. Doing so would also maintain revenues accruing to the Greenhouse Gas Reduction Fund.

We investigate the IEMAC proposal by considering the outcome if facilities in disadvantaged communities were required to reduce emissions at a rate that met or exceeded the average rate for the state. This outcome likely would improve air quality and health outcomes in these communities. In this paper, we consider an annual facility-specific emissions limit that declines at the same annual rate as the overall reduction in the aggregate emissions cap.[19] This limit would constrain emissions at a facility to fall at least as rapidly as the annual decline in the aggregate cap. Using data from CARB's **Mandatory GHG Reporting** and its **Pollution Mapping Tool**, we investigate the potential effect of this idea by comparing the performance of industrial facilities over the past decade with the pace of emissions reductions in the program overall.

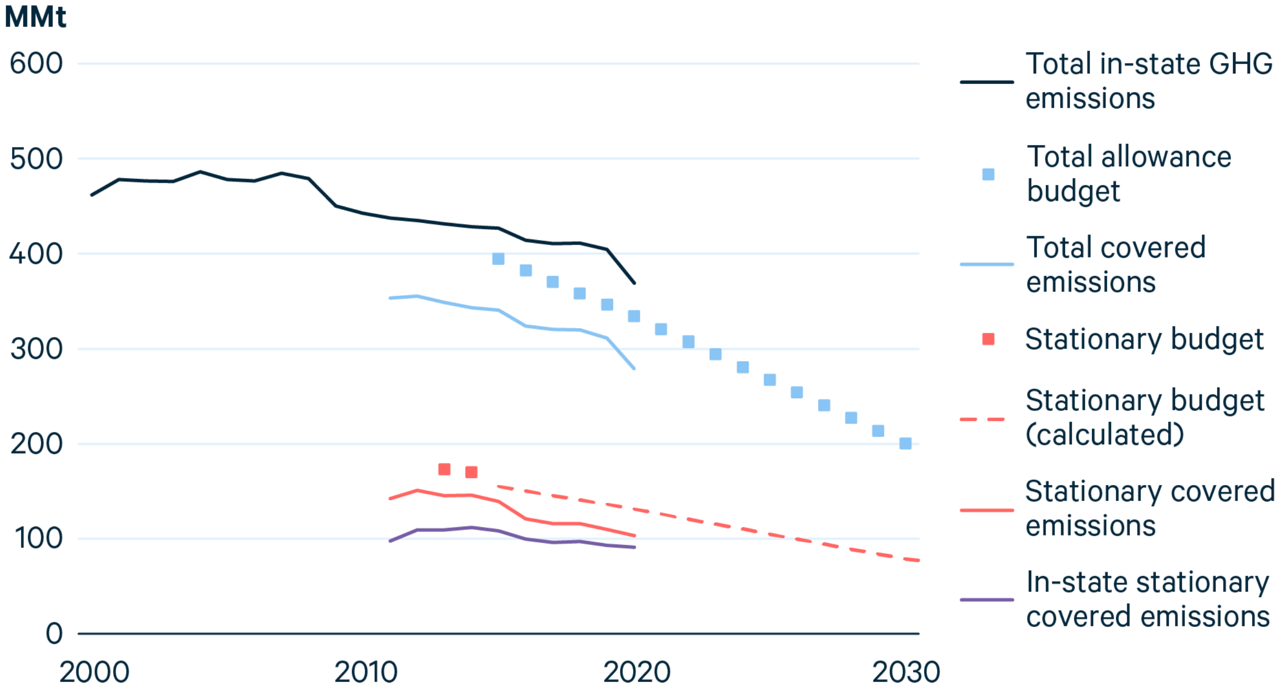
Figure 2 displays the decreasing trends in regulated emissions, emissions allowances, and overall greenhouse gas emissions in California. Total greenhouse gas emissions (excluding emissions associated with imported electricity) are represented by the solid black line and decline by 14.4 percent between 2013 and 2020 and by 13.5 percent between 2015 and 2020.[20] The emissions budget for sources covered by the cap-and-trade program (including emissions associated with imported electricity) is represented by the dotted blue line and declines by 15.3 percent between 2015 and 2020; realized emissions, represented by blue solid red line, decline by 20 percent. The difference between the emissions budget and emissions outcomes constitutes contributions to the allowance bank. We focus the remainder of this paper on emissions inside California (i.e., excluding emissions associated with imported electricity) corresponding to the definition of disadvantaged communities in SB 535. The stationary source emissions from in-state electricity and industrial production that are our focus were brought into the program in 2013 and are illustrated by the purple line. Between 2013 and 2020, their emissions declined in aggregate by 16.8 percent.

18 The EJAC position presented at the Joint Meeting of CARB and the Assembly Bill 32 EJAC (September 1, 2022) is summarized at **https://progressivereform.org/cpr-blog/environmental-justice-advocates-call-for-stronger-climate-protections-for-impacted-california-communities/.**

19 The term "emissions cap" is a misnomer because it applies to that issuance of new allowances each year. Emissions are not capped and can exceed this amount because of banking.

20 We present trends through 2020 and discuss results for the most recent year only to 2019 to avoid the effects of the pandemic.

Figure 2. California GHG Emissions, Cap-and-Trade Emissions, and Emissions Budgets, 2000–2030



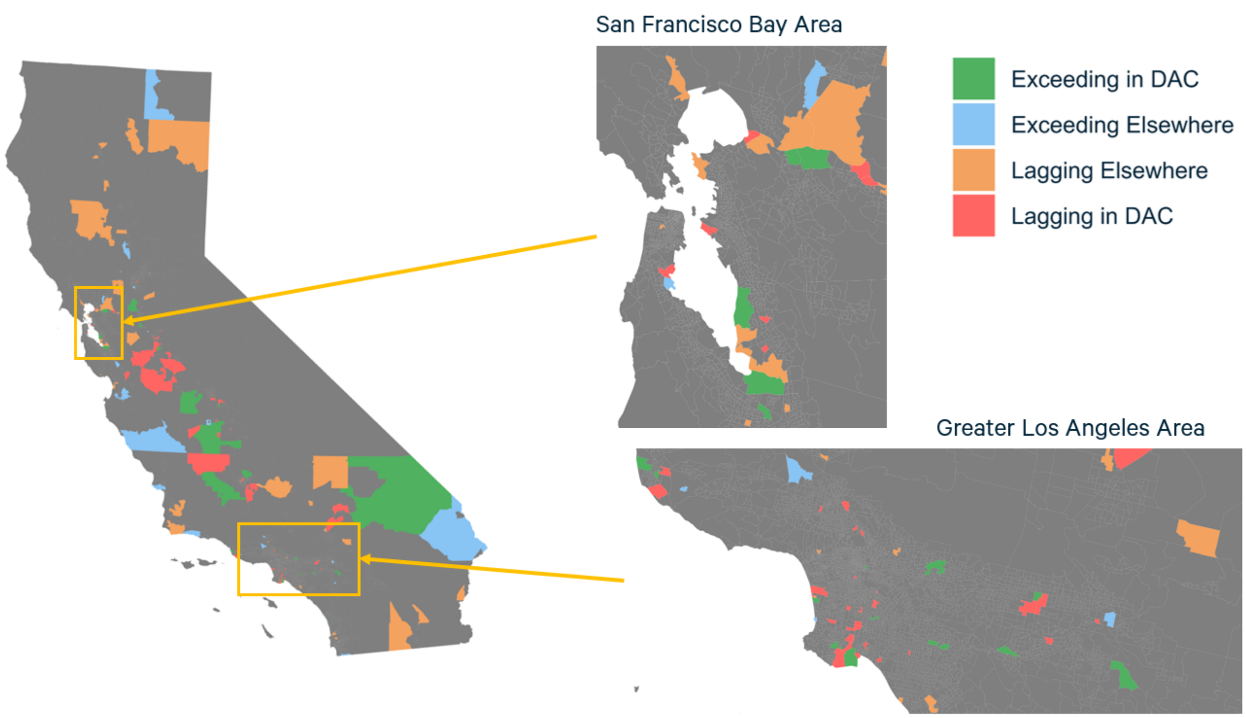
Notes: Stationary sources and emissions associated with imported electricity were covered beginning in 2013. The program was expanded in 2015 to cover transportation and buildings. We calculate the share of the total emissions budget for stationary sources after 2015 by extrapolating equivalent annual percent reductions in emissions as the overall emissions cap. Total emissions and stationary covered emission include only in-state outcomes (e.g., exclude imported electricity).

Data sources: **Final Cap-and-Trade Regulation**, **Mandatory GHG Reporting**, **CARB Pollution Mapping Tool**.

A number of challenges have surfaced in attempts to account for emissions and air quality outcomes in disadvantaged communities. An update to the identification of disadvantaged communities in Enviroscreen 4.0 is captured in this paper and in OEHHA (2022), while Cushing et al. (2018) and OEHHA (2017) rely on Enviroscreen 3.0. Further, facilities may be near the border of census tracts that form the basis of our analysis. Cushing et al. include a 2.5-mile buffer radius around facilities to incorporate neighboring census tracts when facilities are near a border. Pastor et al. (2022) show that the physical location of emissions does not always align with the location identified in data, which sometimes is the location of the reporting organization. We rely on the location identified in the data to site facilities in census tracts. The distinction becomes important in empirically assessing air quality outcomes. For simplicity, we proceed on the assumption that it does not importantly affect emissions quantities and the market implications of policy adjustments that we examine. We use updated data through 2020 compared to previous studies although when examining a specific year, we look at 2019 to avoid the disruptions associated with the COVID epidemic.

State-level trends mask the heterogeneity of performance across geographic areas. Figure 3 compares the relative average annual rate of emissions reductions of stationary facilities aggregated at the census tract level for 2015–2020 with the average overall cap. The results are displayed in four bins, including census tracks in disadvantaged communities and elsewhere that show emissions reductions that under- or overperform compared with the statewide emissions budget. The statewide picture presents a fallacy because census tracts are population based, and in a tract with a large geographic area, a given volume of emissions is likely to result in lower population-weighted exposure to air pollution than a more densely populated area. In contrast, the insets illustrate the two most densely populated regions in the state, the San Francisco Bay Area and the Greater Los Angeles Area. Because of greater population density, they are likely to have greater population-weighted exposure to air pollution.[21] Not pictured are the disadvantaged communities without polluting facilities that border tracts emitting pollutants. Disadvantaged communities with a large number of stationary sources, such as the ports of Long Beach, Los Angeles, and Oakland, demonstrate underperformance. Meanwhile, other disadvantaged communities have seen emissions fall faster than the cap.

Figure 3. Facility Performance Relative to Cap, by Census Tract, 2015–2020

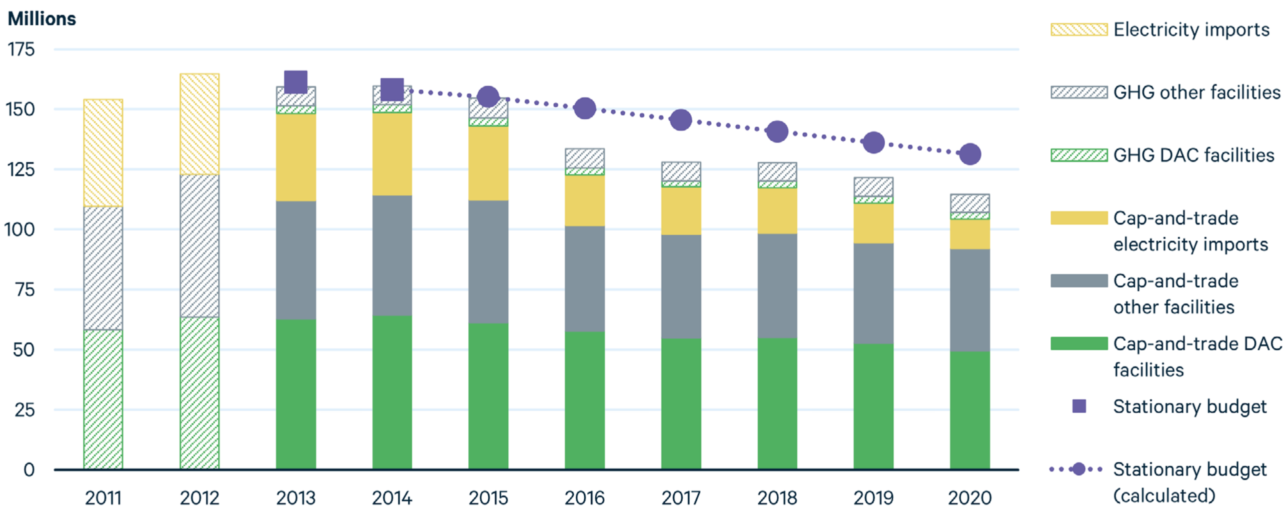


21 The closing of a facility could lead to overperformance in a census tract, even if another facility in that tract is not reducing emissions at a similar rate to the cap.

3. Greenhouse Gas Reductions

As noted above (Table 1), most greenhouse gas emissions from stationary sources occur in disadvantaged communities.[22] Figure 4 displays the emissions trends at stationary sources in disadvantaged communities compared with other communities and compared with a *calculated* emissions budget for all regulated stationary facilities, including imported electricity covered by the cap.[23] The share of in-state greenhouse gases from stationary sources (including sources not covered by cap-and-trade) in disadvantaged communities was about 53.5 percent in 2013 and 52.8 percent in 2019. About 62 percent of stationary facilities located in disadvantaged communities are regulated by the cap-and-trade program, compared with 46 percent in other communities, with about 10 percent of total stationary source emissions coming from unregulated facilities overall. Ninety-eight percent of greenhouse gas emissions at stationary sources in disadvantaged communities are regulated.

Figure 4. GHG Emissions from Stationary Sources, 2011–2020



Notes: The cap-and-trade program began covering stationary sources in 2013. The stationary budget includes electricity imports.

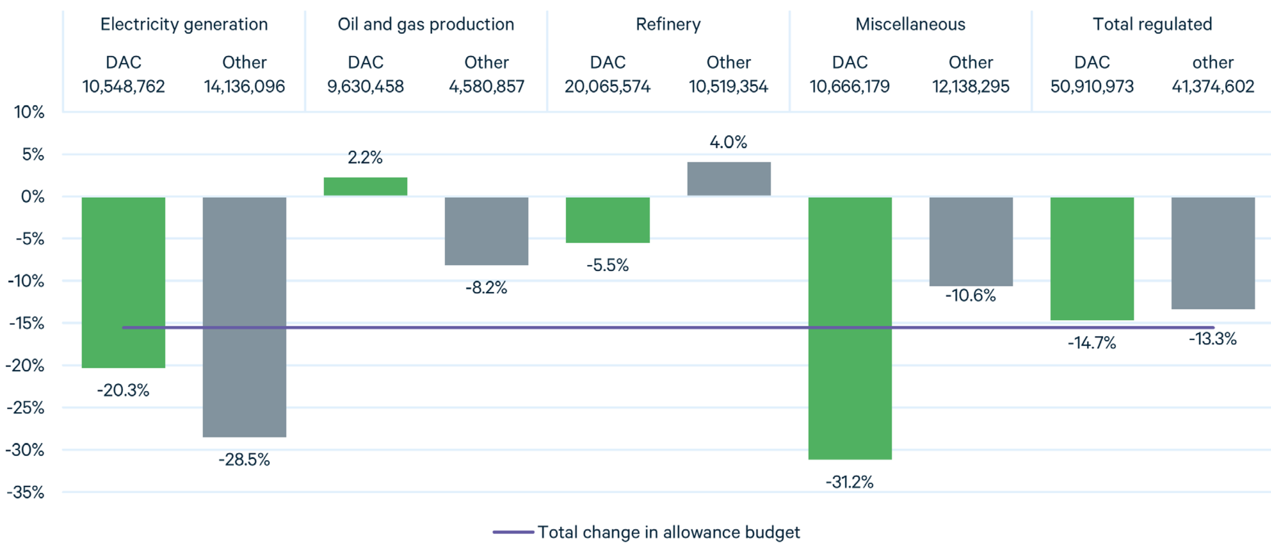
Data sources: **Mandatory GHG Reporting**, **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

22 A larger number of sources (and a larger share of emissions) not covered by the cap-and-trade program are outside disadvantaged communities.

23 The program does not have a budget for stationary sources distinct from the overall cap. Some stationary sources receive freely allocated emissions allowances, and all sources may purchase allowances in the auction or secondary market. We infer a budget for these sources according to their initial share of emissions, applying the same annual percentage reduction to stationary facilities after 2015 as applies to the overall emissions budget. For 2015, we assume the same reduction in stationary allowances as was seen from 2013 to 2014. The difference between the budget and observed emissions can be interpreted as emissions and contributions to the allowance bank.

Differences in emissions in disadvantaged communities and other communities vary by sector. Figure 5 illustrates that cumulatively, from 2013 to 2019, emissions reductions have been greatest overall at electricity generating units and miscellaneous sources. The purple line in the figure describes the percentage reduction in the calculated annual allowance budget for stationary sources overall. In disadvantaged communities, emissions reductions for electricity generation and miscellaneous sources have outpaced the change in the overall allowance budget but fallen short (or increased) in the oil and gas production and refinery sectors.[24] In total from 2013 to 2019, emissions at facilities in disadvantaged communities regulated by cap and trade have fallen by 14.7 percent, compared with 13.3 percent at regulated facilities outside those communities. Pastor et al. (2022) found that through 2017, disadvantaged communities saw reductions in pollutants at a rate of progress that lagged other communities. Our analysis includes data through 2020 but does not incorporate the buffer or data correction that was implemented by Pastor et al. Between 2017 and 2020, we find many facilities in disadvantaged communities improved their rate of emissions reductions. In 2019, emissions at these facilities in disadvantaged communities fell by 15.9 percent compared with 15.4 percent at facilities outside these communities. Emissions at unregulated facilities, most of which are outside disadvantaged communities, have fallen more slowly.

Figure 5. Cumulative Percentage Reductions at Stationary Sources, 2013–2019



Notes: Cumulative percentage reductions at stationary sources. Emissions (metric tons) from each category in 2019 are reported above the figure.

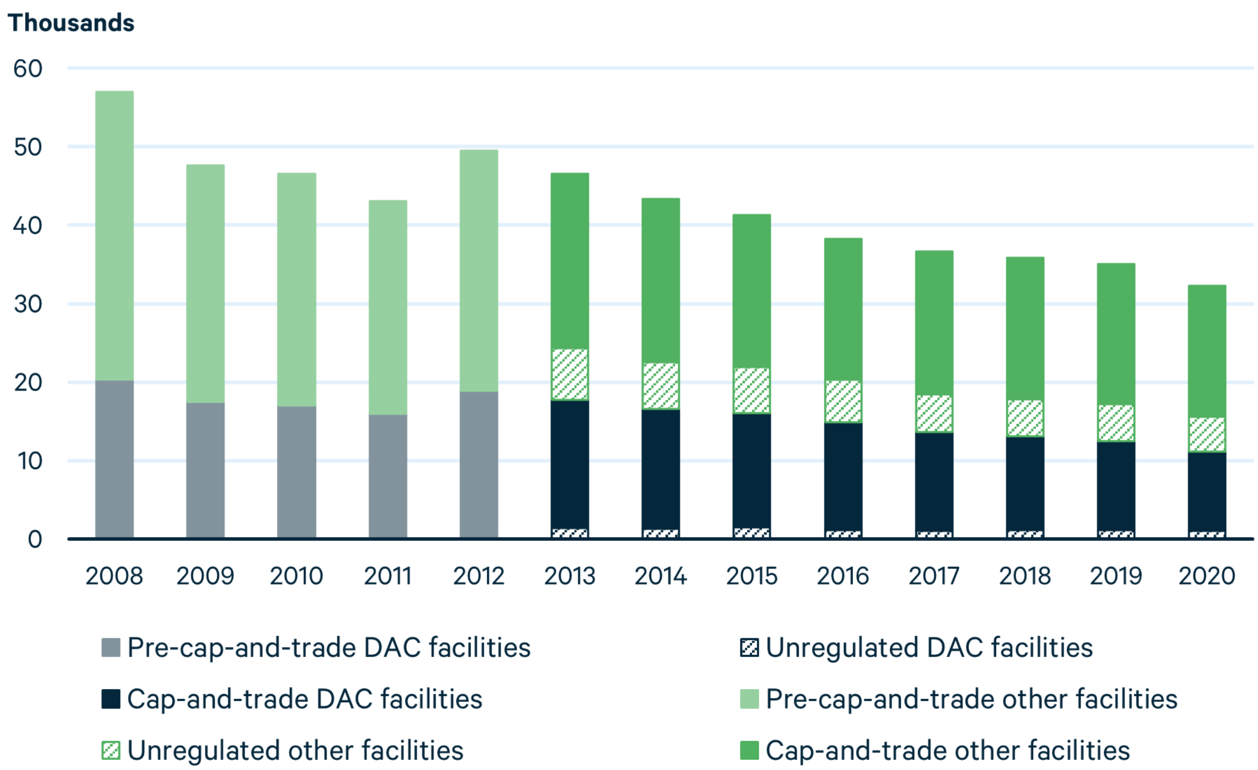
Data sources: **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

24 California has 19 refineries, many of which are in densely populated areas. Six refineries are clustered in Carson, Wilmington, and Torrance, which have heavily minority populations and average income below that for the Los Angeles area. See **https://ww2.arb.ca.gov/resources/documents/california-refineries**.

4. Nitrogen Oxide Reductions

As stated above, conventional air pollutants are correlated with carbon emissions. Figure 6 illustrates that annual nitrogen oxide emissions from stationary sources have fallen by 24.6 percent between 2013 and 2019, faster than the 14.6 percent overall decline in greenhouse gas emissions (see Figure 4). In disadvantaged communities, nitrogen oxide emissions have fallen by 29.6 percent on average, compared with 21.5 percent for facilities outside disadvantaged communities. The largest share of nitrogen oxide emissions is observed at facilities that are not in disadvantaged communities.

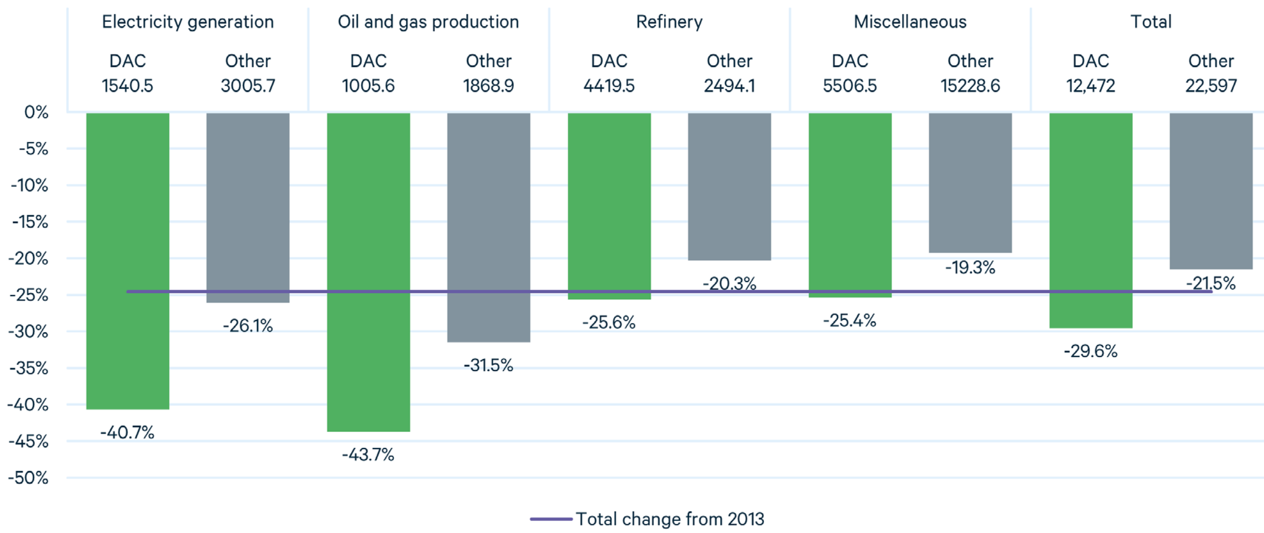
Figure 6. NO_x Emissions from Stationary Sources, 2008–2020



Data sources: **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

On average, cumulative emissions of nitrogen oxides in disadvantaged communities have decreased more quickly than in other communities (Figure 7). From 2013 to 2019, the greatest reduction, in percentage terms, has been in electricity generation and oil and gas production. In total, nitrogen oxide emissions at facilities regulated by cap-and-trade in disadvantaged communities have fallen by 30.2 percent, compared with 19.5 percent at regulated facilities outside those communities. The greatest magnitude of stationary source nitrogen oxide emissions is from miscellaneous sources.

Figure 7. Percentage Change in NO_x Emissions from Stationary Sources, by Sector, 2013–2019

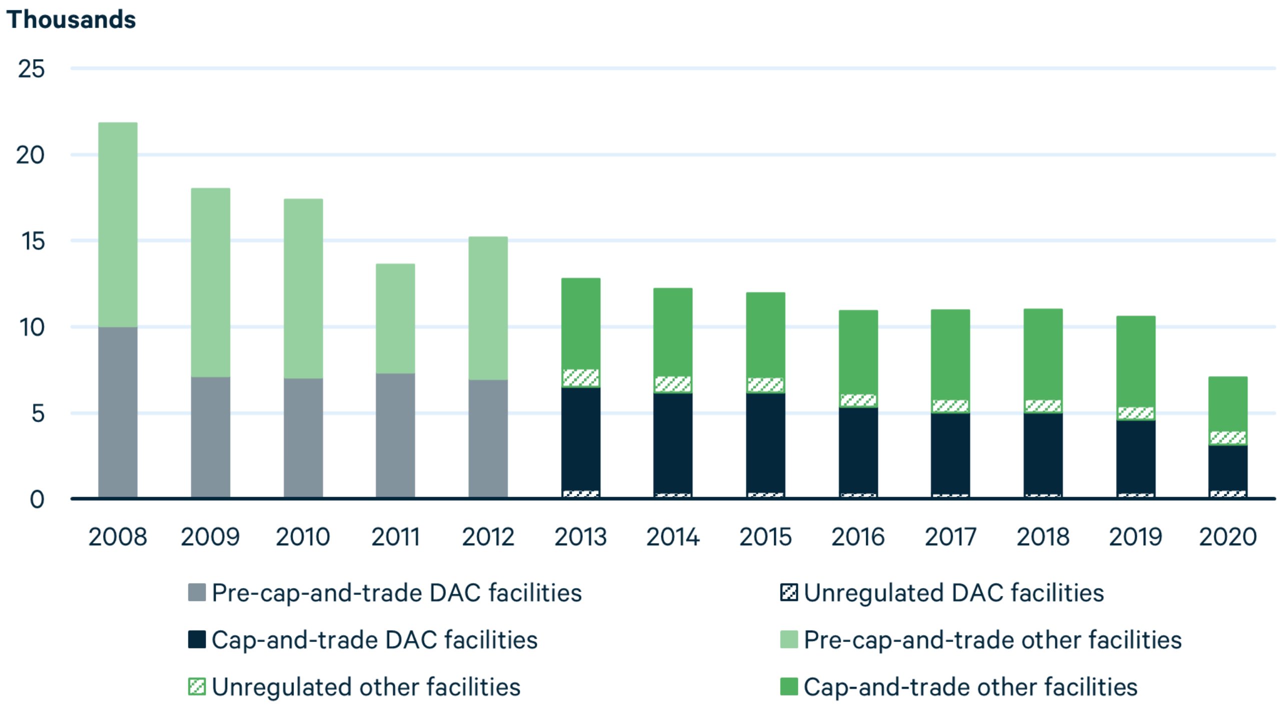


Data sources: **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

5. Sulfur Oxide Reductions

In 2013, most sulfur oxide emissions from stationary sources occurred in disadvantaged communities (Figure 8). Total emissions at stationary sources fell by 17.2 percent between 2013 and 2019. The fastest rate of reductions occurred in disadvantaged communities, where emissions fell by 1.9 thousand tons (29.2 percent) between 2013 and 2019, compared with reductions of 0.3 thousand tons (4.7 percent) in other communities. By 2019, most sulfur oxide emissions from stationary sources no longer occurred in disadvantaged communities.

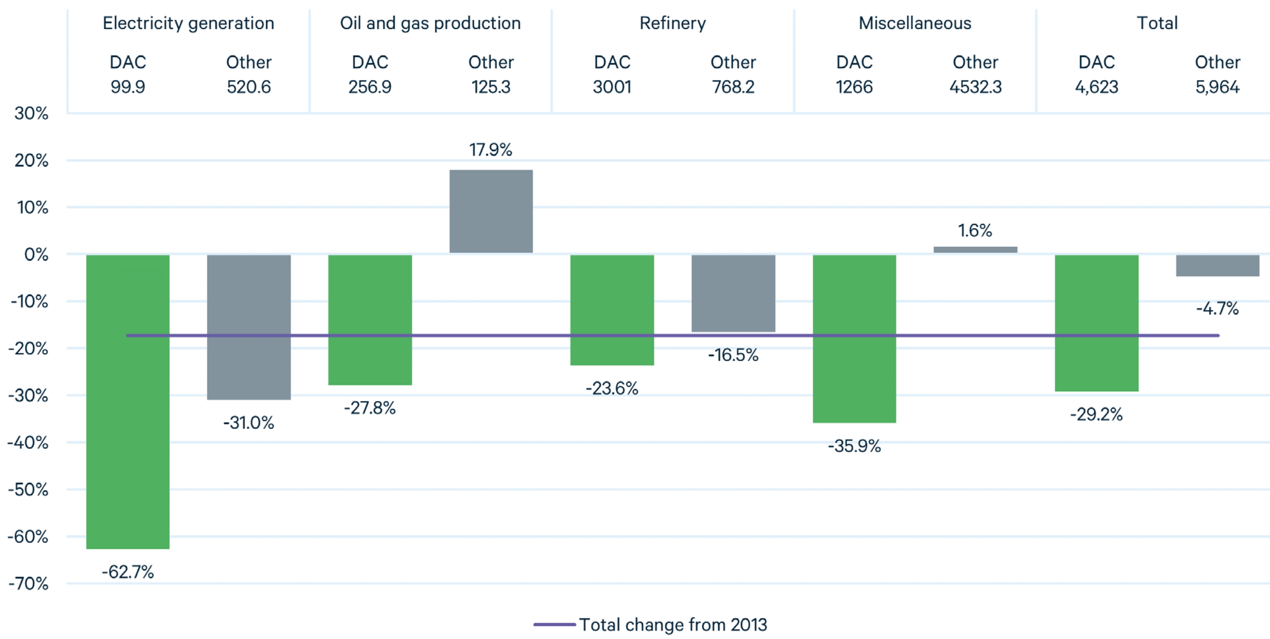
Figure 8. SO_x Emissions from Stationary Sources, 2008–2020



Data sources: **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

On average, cumulative emissions of sulfur oxides at facilities in each of the sector groupings we examine have decreased more quickly, in percentage terms, in disadvantaged communities than in other communities (Figure 9). In total, sulfur oxide emissions at facilities regulated by cap-and-trade in disadvantaged communities have fallen by 29.2 percent, compared with 4.7 percent at regulated facilities outside those communities. The greatest magnitude of stationary source sulfur oxide emissions is from refineries and miscellaneous sources in disadvantaged communities. From 2013 to 2019, the greatest reduction, in percentage terms, has been in electricity generation.

Figure 9. Percentage Change in SOx Emissions from Stationary Sources, by Sector, 2013–2019



Note: Emissions (metric tons) from each category in 2019 are reported above the figure.

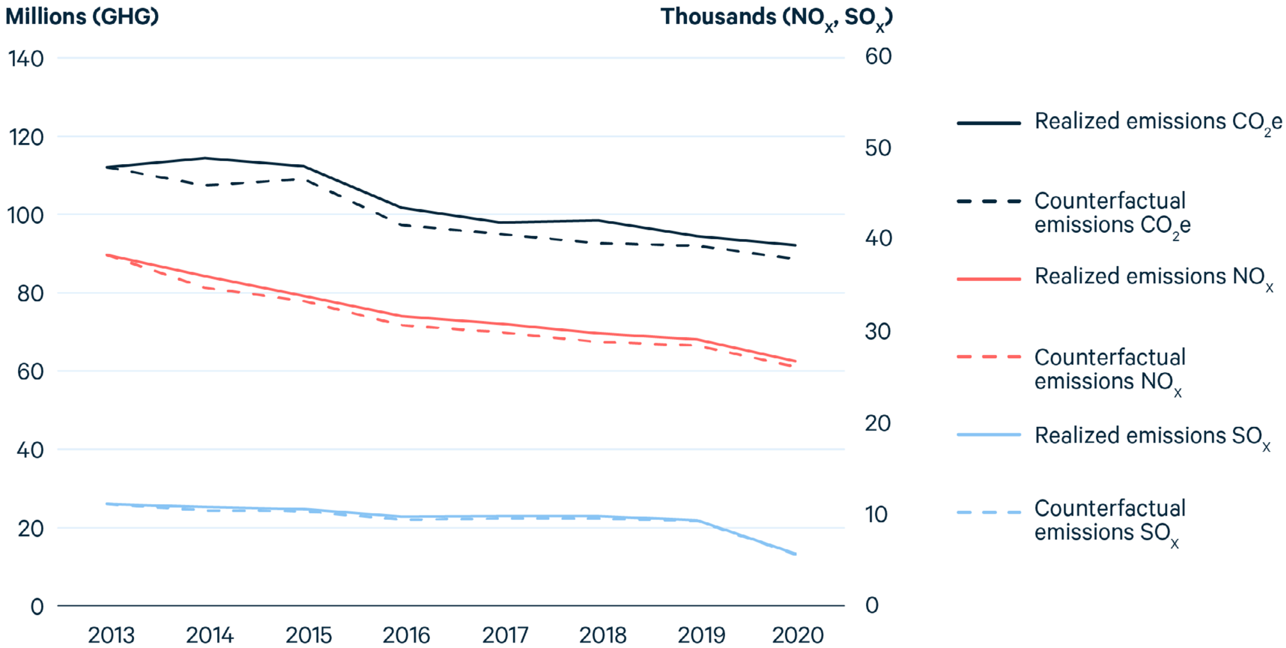
Data sources: **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

6. How Facility-Specific Caps Might Have Affected Emissions Outcomes

Holding other stationary source emissions constant, we calculate an alternative emissions path that aligns with a hypothetical requirement that facilities in disadvantaged communities reduce emissions at least as fast as the rate of reduction in the overall program cap (Figure 10). In this formulation, we identify emissions reductions where necessary to comply with the hypothetical constraint without changing emissions elsewhere. We find aggregate greenhouse gas emissions at stationary sources would have been 3.4 million tons (3.7 percent) lower in 2020, and cumulative emissions from 2013 to 2020 would have fallen by 29.3 million tons (3.6 percent). Greenhouse gases and conventional air pollutants are imperfectly correlated. Conventional air pollutants are regulated through a variety of different regulations and permitting programs implemented through local air districts. In this section, we assumed observed emissions ratios between the pollutants were constant at each facility in each year when quantifying air pollutant reductions. This formulation would correspond to cumulative additional reductions of 5.9 thousand tons of nitrogen oxides (2.3 percent) and 677 fewer tons in 2019, and cumulative additional reductions of 1.7 thousand tons of sulfur oxides (2.2 percent) and 78 fewer tons in 2019.

Over time, from 2008 to 2020, the ratio of nitrogen oxide emissions to greenhouse gas emissions has fallen for all industrial categories we examine in both disadvantaged and other communities, with the exception of oil and gas production, where it has increased. The ratio of sulfur oxide emissions to greenhouse gas emissions has also fallen in most subsectors, although the ratio is volatile for oil and gas production in disadvantaged communities and miscellaneous sources elsewhere. The emissions ratios by year are reported in the appendix.

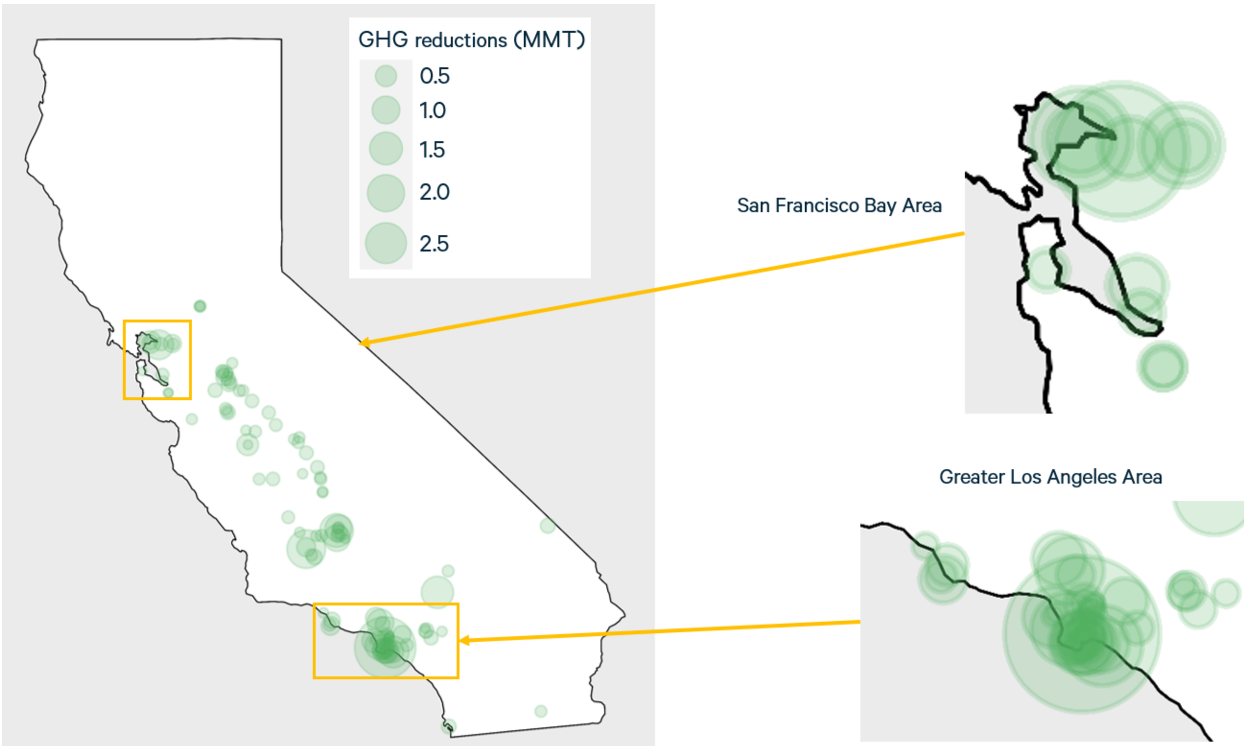
Figure 10. Emissions of GHGs, NO_x, and SO_x: Counterfactual Outcomes under Facility-Specific Emissions Caps, 2013–2020



Note: The counterfactual displays the change if all stationary sources in disadvantaged communities reduced emissions at least as quickly as the reduction in the statewide emissions budget and if the ratios of nitrogen oxides and sulfur oxides to carbon dioxide were constant.

Data sources: **CARB Pollution Mapping Tool**, **SB 535 Disadvantaged Communities**.

Figure 11. Geographic Distribution of Emissions Reductions from Facility-Specific Cap Counterfactual



Note: The size of the overlapping circles represents the magnitude of emissions reductions that would have occurred from 2013 to 2020.

In Figure 11 we see how the GHG emissions reductions from the counterfactual scenario are distributed across the state. As suggested in Figure 3, the Greater Los Angeles Area and the San Francisco Bay Area have large clusters of reductions. The former would have reduced emissions more than the other 18 affected counties combined in this counterfactual scenario. Los Angeles County is the most populous in the country and ranks third in population density within the state. The facility that would see the largest reductions is the Tesoro Refinery in Carson, whose population density (5,101.60/sq mi) is more than twice that of Los Angeles County (2,430/sq mi). These findings highlight the location-specific relevance of where disadvantaged communities exist and emissions reductions occur.

7. Market Effects of a Facility-Specific Cap Adjustment

The counterfactual formulation illustrated in Figure 10 does not consider the potential equilibrium effects of a market response that increases emissions elsewhere. Stationary facilities that would be affected by the hypothetical facility-specific cap in disadvantaged communities actually exceeded that target by about 3 million tons from 2013 to 2020. Conceivably, the 2 million tons of additional emissions reductions that facilities in disadvantaged communities would have achieved with the facility-specific caps in 2019 could have reappeared as increases at other facilities in those communities.[25] In anticipation of this leakage challenge, EJAC recommended that the overall cap be reduced to ensure further reductions in disadvantaged communities to achieve the facility-specific constraint without allowing an increase at other facilities. This result is implicit in Figure 10.[26]

Using RFF's Haiku model, we estimated the influence that reducing allowance supply by 2 million tons in that year, or 0.72 percent beginning in 2024, which represents the emissions in excess of the hypothetical facility-specific cap. We decrease allowance supply by 0.72 percent each year going forward. We examined market outcomes for 2027–2029 under two scenarios (assuming no changes to the program).

In one scenario we assume that vehicle miles traveled remain at business-as-usual levels while adopting other emissions trends as described in the 2022 Scoping Plan (CARB 2022), resulting in an allowance price that is above the price floor. The reduction in allowance supply leads to a market price increase of 3.3 percent. Although fewer allowances are issued, the higher price yields a 2.53 percent increase in the value of newly issued allowances.[27] If all sources of allowances are reduced proportionately, this corresponds to an equivalent increase in the value of auction revenues accruing to the Greenhouse Gas Reduction Fund. We do not account for the existing allowance bank, which might be expected to soften the influence on prices of the adjustment supply that we model.

25 In some years the pattern goes the other way. Cumulatively, from 2013 to 2020, the additional emissions from the hypothetical cap would have totaled 26 million tons, compared with 29 million tons of reductions in excess of that target that actually occurred over the period.

26 Additional reductions at facilities in disadvantaged communities could enable increases at other facilities under the cap-and-trade program. EJAC (2022b) recommended preventing this by removing from circulation "a proportional number of allowances … to avoid further exacerbating existing oversupply issues."

27 See Burtraw et al. (2022) for an explanation and examples of this result.

In a second scenario, we assume the emissions forecasts identified in the 2022 Scoping Plan are fully achieved, resulting in an allowance price at the price floor. In this scenario, reducing the allowance supply by 0.72 percent beginning in 2024 does not affect the carbon price and leads to an approximately 0.6 percent decrease in the asset value of newly issued allowances.

We model these scenarios as a one-time adjustment applied uniformly to allowance supply in future years. A different approach, which we do not model, might be implemented dynamically by further ratcheting the allowance supply down to absorb subsequent incremental emissions reductions in disadvantaged communities that exceed the statewide annual rate of change in the allowance supply (the cap adjustment factor). Using this approach, the sum of emissions in disadvantaged communities below the facility specific cap reduction at the end of a compliance period would be subtracted from the allowance budget in the next year as a new starting point for the allowance budget moving forward. This dynamic process would further mitigate potential emissions rebound at other facilities and accelerate statewide emissions reductions based on what is achieved in disadvantaged communities.

The effect of the policy is dependent on the future price path of the market, which is correlated to other complementary policy decisions and implementation. However, in both scenarios we find the effect on the carbon market would be relatively small. The analysis does not specifically consider hard-to-abate sectors that have process emissions as well as combustion emissions. Economic dislocation and emissions leakage might occur where abatement of greenhouse gas emissions might not be possible without a reduction in economic activity. Balancing the effects in disadvantaged communities with the goal of protecting trade exposed industry in California is an important function of the California Air Resources Board and the legislature.

8. Conclusion

Emissions of greenhouse gases are correlated, though imperfectly, with emissions of harmful pollutants, and California's greenhouse gas cap-and-trade program can be expected to cause significant emissions reductions of all conventional pollutants as fossil fuel combustion is reduced. The trading program has raised environmental justice concerns, however, because the distribution of environmental benefits under a trading program could be uneven.

Environmental and public health outcomes in California's disadvantaged communities depend on many factors, including not just air pollution but also a legacy of land use and industrial permitting decisions as well as community-level stressors. Conceptually, the pattern of emissions trading might not improve community air pollution outcomes, and potentially could worsen them. A less perverse outcome might be that because of emissions trading, air pollution and public health outcomes in disadvantaged communities improve more slowly than in other communities.

Empirically we observe that reduction in air pollution has occurred more rapidly in disadvantaged communities than the average for the state if measured in emissions quantities. Air quality outcomes have also improved more rapidly (OEHHA 2022) in absolute terms. Measured in percentage terms, however, the rate of improvement in disadvantaged communities has been less pronounced because these communities started from a worse air quality baseline, and they remain relatively overburdened compared to other communities.

There are a variety of regulatory tools that are available to the state to address air quality disparities outside of the greenhouse gas cap-and-trade program.[28] In this paper we consider only the indirect effect on emissions changes coincident with compliance in the carbon market.

To protect against inequitable outcomes, regulators could impose facility-level constraints on emissions trading and facilities covered by cap-and-trade that are in disadvantaged communities to reduce greenhouse gas emissions at least as fast as the overall economy-wide reduction in the emissions cap. This paper has examined the performance of cap-and-trade on emissions of greenhouse gases and associated air pollutants in disadvantaged communities, and considered the potential effect that facility-level constraints would have had if they had been in place since the trading program began.

We find a facility-level emissions cap would have reduced greenhouse gas emissions by 3.4 million tons in 2019 and by 28 million tons from 2013 to 2020 (about 3.5 percent), compared with what the program has achieved. If the ratio of annual emissions reductions for other pollutants to annual reductions in greenhouse gas emissions

28 For example, in May 2023 the South Coast Air Quality Management District **agreed to remove** the exemption for small refineries from required monitoring of air quality around their perimeter.

were constant for each facility in a disadvantaged community, this would correspond to additional reductions of 5.9 thousand tons of nitrogen oxides (2.3 percent) and 1.7 thousand tons of sulfur oxides (2.2 percent).

Emissions reductions resulting from facility-specific caps could reappear if emissions increase at other facilities. An approach to address emissions rebound is to reduce the overall emissions budget in accordance with the reductions that could be expected at these facilities. We estimate the annual emissions cap would have to be reduced by about 2 million tons in 2024 to mitigate emissions rebound at other facilities. This constitutes 0.72 percent of total allowances to be issued in 2024. In a scenario with the allowance price above the price floor, the reduction in allowance supply leads to a 3.3 percent increase in the market price. This boosts the asset value of newly issued allowance supply by 2.53 percent. The way this would affect the value of auction revenues accruing to the Greenhouse Gas Reduction Fund depends on how the reduction in supply is implemented, but if all sources of supply were reduced proportionately the revenues to the Fund would increase. If the allowance price were at the price floor, there would be no change in the carbon price and the adjustment would lead to a 0.6 percent decrease in the asset value of newly issued allowances.

The good news is that aggregate reductions in greenhouse gas emissions, nitrogen oxides, and sulfur oxides in disadvantaged communities have been achieved at a faster rate than in other communities and in the state overall. These reductions are not necessarily wholly attributable to the cap-and-trade program, because they are partly the result of other regulatory programs, and they are not evenly distributed. The greatest emissions reductions in greenhouse gases have been achieved in electricity generation and miscellaneous emissions sources. Emissions reductions in oil and gas production and refining have been achieved at a slower rate than the change in the emissions budget, with oil and gas production even increasing emissions in disadvantaged communities.

Important reductions in percentage terms for nitrogen oxides have been achieved across sectors in disadvantaged communities. The greatest reductions in absolute terms have been by refineries and miscellaneous sources, although emissions remain greatest in these categories. The greatest reductions in sulfur oxide emissions have been from refineries and miscellaneous sources in absolute terms. Similar to nitrogen oxides, however, emissions remain the greatest in these sectors.

A map of census tracks illustrates the local nature of exposure to pollution, and the depth of exposure will be more severe where population density around an emitting facility is greater. An emissions limit on every facility in disadvantaged communities would help ensure that they benefit from local air quality improvements at least as much as residents throughout the state, on average.

Advocates for efficiency in the carbon market might object to the notion that the outcome of emissions trading would be constrained away from the least-cost outcome. In principle, lower costs in reducing emissions will preserve economic opportunities in the state and lessen the possibility of emissions leakage—that is, pushing economic activity and associated emissions outside the state. In addition, affordability is a crucial issue in disadvantaged communities, and measures to restrict trading that raise the cost of compliance are likely to increase the cost of business in California and raise prices for consumers. There also may be downstream employment effects from the increased compliance obligation of these entities.

On the other hand, environmental pollution constitutes a hidden tax on communities, imposing costs and harming residents' welfare. The legacy of disproportionate exposure to air pollution in disadvantaged communities amplifies the harm that ongoing exposure creates. Improved air quality and consequent reductions in healthcare costs can improve residents' economic welfare and opportunity,[29] leading to a more robust economy and attractive environment for business investment. Moreover, community support is an increasingly important part of the political coalition for the cap-and-trade program, especially in vulnerable communities likely to bear the greatest burdens from a changing climate.

Because the overall emissions reductions in disadvantaged communities have outpaced those in the state, facility-specific caps would have a limited effect in aggregate and on the carbon market as we have seen it so far. However, in communities where emissions reductions have not kept pace with the state's average rate, facility-specific caps could provide important benefits. An indirect contribution of a facility-specific cap may be to facilitate linking the California program with other jurisdictions. Concern has been expressed that linking could impede environmental improvement if it were to delay emission reductions in specific communities. Washington's legislation that launched its cap-and-invest program addressed this concern with the stipulation that potential linking should not have an overall negative effect on highly impacted communities not only in Washington but in any jurisdiction with which it was to link. New York is aiming to integrate environmental justice concerns in its rulemaking from the outset. The facility-specific cap in disadvantaged communities would provide assurance that an annual rate of emissions reductions at the affected facilities would be maintained and possibly accelerated due to the cost effectiveness anticipated to arise from a broader program.

We conclude that facility-specific caps may be important to lock in benefits for disadvantaged communities. A core element of the credibility of the cap-and-trade program in disadvantaged communities stems from SB 535, which directs that a portion of program revenues be invested in these communities. Air quality improvements are another major benefit of the program. Facility-specific caps may reinforce the credibility of the program by distributing air quality benefits to important stakeholders without disrupting the efficiency of the carbon market.

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Appendix

Table A1. Ratio of NO_x Emissions to GHG Emissions, by Year

	Disadvantaged communities				Other			
Year	Electricity generation	Oil and gas production	Miscellaneous	Refinery	Electricity generation	Oil and gas production	Miscellaneous	Refinery
2008	0.15	0.11	0.53	0.31	0.25	0.30	1.30	0.35
2009	0.15	0.09	0.47	0.28	0.24	0.35	1.25	0.33
2010	0.17	0.10	0.48	0.28	0.24	0.35	1.22	0.32
2011	0.21	0.24	0.36	0.26	0.20	0.55	1.05	0.27
2012	0.18	0.23	0.46	0.27	0.16	0.53	1.17	0.28
2013	0.16	0.18	0.40	0.28	0.17	0.51	1.09	0.31
2014	0.14	0.15	0.40	0.27	0.16	0.50	0.97	0.28
2015	0.14	0.15	0.40	0.28	0.15	0.36	0.96	0.25
2016	0.14	0.13	0.40	0.27	0.17	0.37	0.88	0.28
2017	0.16	0.11	0.37	0.25	0.17	0.33	0.93	0.25
2018	0.13	0.11	0.37	0.24	0.17	0.34	0.92	0.23
2019	0.13	0.10	0.41	0.22	0.17	0.39	0.93	0.24
2020	0.12	0.09	0.43	0.19	0.14	0.40	0.92	0.23

Table A2. Ratio of SO_x Emissions to GHG Emissions, by Year

	Disadvantaged communities				Other			
Year	Electricity generation	Oil and gas production	Miscellaneous	Refinery	Electricity generation	Oil and gas production	Miscellaneous	Refinery
2008	0.03	0.01	0.14	0.30	0.04	0.08	0.22	0.56
2009	0.03	0.04	0.13	0.20	0.04	0.05	0.24	0.56
2010	0.04	0.03	0.14	0.19	0.05	0.08	0.27	0.42
2011	0.04	0.09	0.13	0.19	0.04	0.03	0.26	0.09
2012	0.03	0.04	0.13	0.19	0.03	0.01	0.35	0.09
2013	0.02	0.04	0.11	0.18	0.03	0.02	0.26	0.09
2014	0.01	0.03	0.10	0.19	0.03	0.02	0.25	0.08
2015	0.01	0.03	0.11	0.20	0.03	0.01	0.25	0.08
2016	0.01	0.03	0.10	0.16	0.03	0.02	0.24	0.08
2017	0.01	0.03	0.10	0.15	0.03	0.01	0.27	0.07
2018	0.01	0.03	0.09	0.15	0.03	0.02	0.26	0.08
2019	0.01	0.03	0.10	0.15	0.03	0.03	0.28	0.07
2020	0.01	0.02	0.11	0.09	0.03	0.02	0.17	0.06