RESEARCH NOTE

Removing excess cap-and-trade allowances will reduce greenhouse gas emissions

A response to Severin Borenstein and Jim Bushnell

Danny Cullenward
dcullenward@nearzero.org

Mason Inman
minman@nearzero.org

Michael Mastrandrea
mikemas@nearzero.org

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Last month, the California Air Resources Board (ARB) identified the cap-and-trade program as the single largest component of its approved Scoping Plan for meeting California's ambitious 2030 target for greenhouse gas (GHG) emission reductions. However, the program has a large oversupply of emission allowances—that is, the number of allowances issued to date have been far in excess of the emissions from sources regulated under the program.

Several prominent economists have argued that this oversupply could undermine the effectiveness of the cap-and-trade system in achieving emission reductions in support of the 2030 target. If oversupply spurs companies to "bank" extra allowances for future use, polluters could be able to comply with the program while their emissions significantly overshoot the emission cap in 2030. To address this risk, some have suggested that ARB lower the emissions cap for the period 2021-2030, reducing the supply of allowances to ensure that the program delivers its intended reductions.

A new analysis this month by two prominent economists—Professors Severin Borenstein of UC Berkeley and Jim Bushnell of UC Davis—argues that lowering program caps to address market oversupply would not actually have much effect on the state's emissions. Borenstein and Bushnell argue that the program cap is no longer binding because ARB must sell unlimited allowances at a new ceiling price. If prices reach this level, they argue, removing excess allowances to address market oversupply would not have any additional effect.

Although Borenstein and Bushnell's analysis makes important contributions to the state climate policy discussion, their assertion that addressing market oversupply would not substantially affect emissions depends on several core assumptions that differ from ARB's views as well as what the cap-and-trade extension bill, AB 398, now requires. In this note, we review their calculations and offer three responses:

1. **AB 398 requires ARB to reduce additional emissions for every allowance sold at the price ceiling.** Although ARB has not identified how it would achieve this outcome and there are reasons to be skeptical of this requirement, AB 398's environmental integrity provision is current law. If enforced, it would give full effect to strategies that address market oversupply, resulting in a much greater benefit than what Borenstein and Bushnell project—although some of those benefits may accrue outside California.

2. **The new analysis suggests that ARB may need to set a higher price ceiling to ensure the effectiveness of the cap-and-trade program.** Borenstein and Bushnell calculate that a market design which eliminates oversupply has a nearly two-thirds chance by 2030 of reaching a price ceiling close to what is set in current regulations. Many of these scenarios would not constrain the emissions covered by the cap-and-trade program. Rather than justify inaction on oversupply, the new analysis suggests it may be necessary for ARB to consider a higher price ceiling than that in current regulations in order to deliver on the reductions the Scoping Plan calls for from cap-and-trade.

3. **ARB's expectations for the program suggest that addressing market oversupply will reduce emissions more than Borenstein and Bushnell calculate.** ARB asserts that cap-and-trade will be much more effective at reducing emissions than do Borenstein and Bushnell. Although ARB hasn't publicly justified its view, the Board's assumptions would, if true, cause oversupply adjustments to be much more effective at reducing emissions.

Fundamentally, this discussion illustrates how different market design choices can interact and why it is important to analyze proposed market designs on a comprehensive basis. It also indicates the need for ARB to explain how the market reforms it will adopt under AB 398 are consistent with the role the Board has identified for cap-and-trade in the final 2017 Scoping Plan.

ARB has not yet produced any analysis of how its cap-and-trade market design choices will produce the emission reductions identified in the Scoping Plan. We hope that such an analysis is forthcoming and will be as transparent in its assumptions and model structure as the work that Borenstein and Bushnell have published.

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Introduction: What's a few hundred million tons between friends?

In a recent post at the UC Berkeley Energy Institute blog, noted economists Severin Borenstein (UC Berkeley) and Jim Bushnell (UC Davis) weighed in on the debate over what to do about the California cap-and-trade program's oversupply problem (Borenstein and Bushnell 2018).[1]

Borenstein and Bushnell are well known for their important work on the design of California's cap-and-trade policy, including their public service with the now-defunct Emissions Market Advisory Committee (EMAC). More recently, they released a July 2017 working paper (along with their former EMAC colleague, Stanford Professor Frank Wolak) that estimates likely market outcomes for the cap-and-trade program's extension through 2030 (Borenstein et al. 2017).

Using the quantitative model developed for their working paper, Borenstein and Bushnell argue in their new blog post that whatever ARB decides to do about the glut of allowances currently in the market will have only "a modest impact on the state's emissions through 2030."

This conclusion is striking, especially given the concern many other prominent economists have expressed about the risks oversupply creates with respect to California's ability to meet its 2030 climate target:

- Energy Innovation's Chris Busch recently calculated that cumulative market oversupply through 2020 is on the order of 270 (±70) $MMTCO_2e$. This amount could "allow for significantly more emissions than intended under the 2017 Scoping Plan, cutting into planned cumulative emissions and possibly leaving 2030 emissions above the SB 32 target" (Busch 2017).

- Resources for the Future's Dallas Burtraw reviewed multiple options to resolve the market oversupply problem, drawing on experiences from other cap-and-trade programs around the world. Although fundamentally optimistic that the Air Resources Board (ARB) will address market oversupply, he acknowledged that the "magnitude of the [oversupplied] allowances could undermine the state's intent" to achieve its climate targets, if left unaddressed (Burtraw 2017).

- Finally, the non-partisan Legislative Analyst's Office addressed market oversupply in a recent report (LAO 2017). In a section titled "Effect of Oversupply on 2030 Target Could Be Substantial," the LAO considered a scenario in which 200 $MMTCO_2e$ worth of allowances are banked into the post-2020 period. In this scenario, LAO concluded that 2030 emissions in capped sectors could end up 30% higher

[1] A note on terminology: there are multiple terms in use to describe the same phenomenon, including *oversupply*, *overallocation*, and *overhang*. All terms refer to the number of extra allowances in the cap-and-trade program as a result of program caps that were set above where GHG emissions covered under the program have been to date. This is calculated on a cumulative basis, meaning that oversupply is the sum of extra allowances from the program's first year of compliance in 2013 through a benchmark year—typically 2020, the end of the program's third compliance period.

than the nominal program caps, even under the assumption that no additional allowances are sold at the market's price ceiling.

In their new post, Borenstein and Bushnell adapted the Borenstein et al. (2017) model to simulate a scenario in which California lowers its emissions caps to eliminate the large oversupply of allowances building up in the market today. According to their calculations, the probability-weighted emission reductions from this intervention would be only 42 million tons ($MMTCO_2e$) through 2030—an amount they consider "not chump change," but also not a "fundamental change" to the cap-and-trade system's large role in the final Scoping Plan.

In particular, they point to the fact that AB 398, the bill extending the cap-and-trade program through 2030, directs ARB to determine a maximum price, or price ceiling, and to allow unlimited sales of allowances at that ceiling. Thus, after 2020, there will no longer be a hard cap on the number of allowances that can be sold if prices reach the ceiling. Borenstein and Bushnell argue that if the market is already going to reach the price ceiling, removing extra allowances to compensate for oversupply won't have any effect.

Because of the importance of the oversupply issue as a potential risk to California's ability to reach its 2030 climate target, we wanted to review Borenstein and Bushnell's analysis to better understand the conditions under which their conclusion holds true.

Two key concepts

Before we address Borenstein and Bushnell's arguments, it is important to clarify two conceptual issues:

Concept #1: Annual vs. cumulative emissions

Key California policies operate on an *annual* emissions accounting basis—most notably, AB 32's requirement that ARB return statewide GHG emissions back to their 1990 levels by 2020, and SB 32's requirement to cut a further 40% by 2030.

In contrast, California's cap-and-trade program features unlimited banking of allowances from one year to the next, and therefore effectively operates on a *cumulative* emissions accounting basis. In ARB's cap-and-trade market, emitters may shift the timing of their emissions (as well as emission reductions) by adjusting how many allowances they submit for compliance with program rules in each year, such that the program controls not the timing of annual emissions but rather the cumulative total over time. As a result, there is a mismatch between the way emissions are handled in the cap-and-trade system and the way California's climate policies are evaluated under AB 32 and SB 32.

Reflecting the cumulative nature of cap-and-trade programs, Borenstein and Bushnell's work models the cumulative supply/demand balance in the cap-and-trade market through 2030, not the annual emissions in any given year. We'll retain that approach in our discussion here for convenience. But we want to emphasize

that ultimately AB 32 and SB 32 charge ARB with the responsibility of meeting annual targets in 2020 and 2030, not a cumulative target expressed over a period of time.

Concept #2: Prices vs. quantities

Further complicating matters is the distinction between price- and quantity-based instruments. For example, consider the classic price instrument, a carbon tax: the tax sets a fixed price on emissions, but the resulting emission reductions are uncertain, depending on how regulated parties respond to the fixed price signal. In contrast, the classic quantity instrument, a cap-and-trade program, sets a fixed limit on emissions but leaves the price of allowances up to the market. As these examples illustrate, a policy can produce certainty in only prices or quantities, but not both at the same time.

ARB initially adopted a hybrid model that combines the features of price- and quantity-based instruments. California's program includes an auction reserve price that sets a minimum price—called the floor price—at which ARB will sell new allowances. If California did not have a floor price, market prices for allowances would probably have been significantly lower to date, as a result of the oversupply of allowances currently in the market (Cullenward 2014; Cullenward & Coghlan 2016).

In adopting AB 398, California doubled down on its hybrid model by adopting a hard price ceiling that complements the price floor. ARB will implement the hard price ceiling by offering an unlimited number of allowances at a ceiling price (at a level yet to be determined). If market prices rise to this level, ARB will issue as many new allowances as buyers demand to cover their emissions.

California's cap-and-trade program is now a true hybrid. If allowance prices would naturally fall below the price floor, the price floor will kick in and the program will operate like a tax. If allowance prices would naturally fall between the price floor and the price ceiling, the program will function like a market. But if allowance prices would naturally rise above the price ceiling, the price ceiling will kick in and the program will again operate like a tax. In other words, at low demand the program operates like a tax (a price instrument), at moderate demand it operates like a market (a quantity instrument), and at high demand it again operates like a tax (a price instrument)—a hybrid approach.

Critically, if allowance prices reach the price ceiling, the program will no longer provide a "backstop" that limits total covered emissions. In essence, a price ceiling makes a tradeoff: although the program can no longer guarantee a certain level of environmental performance, a price ceiling ensures market prices remain at or below a politically determined level.

The Borenstein and Bushnell critique

In their Energy Institute post, Borenstein and Bushnell make two key arguments.

- First, they argue that the program's "cap" is not really a cap—that is, that because of the hard price ceiling required under AB 398, the cap-and-trade program no longer sets a hard limit on cumulative emissions. If market prices rise to the price ceiling, ARB will issue unlimited allowances and the program will no longer contain covered emissions at the nominal program cap levels—neither in annual nor in cumulative terms. (Later in this report, we examine their argument that the cap is not really a cap.)

- Second, they argue that addressing market oversupply will not have a particularly large effect on state GHG emissions because of interactions that occur when market prices reach the price ceiling. Specifically, Borenstein and Bushnell argue that if the cap is lowered in a scenario that reaches the price ceiling by 2030, then lowering the cap by a certain number of allowances won't deliver a corresponding amount of emission reductions. Removing excess allowances from the market would increase market prices and therefore incentivize emission reductions in the short term. But once the market reaches the price ceiling, they argue that no additional reductions would occur.[2]

In their July 2017 working paper, Borenstein et al. use their model to estimate the probability of the cumulative market supply/demand balance reaching the price floor, the price ceiling, or somewhere in between the minimum and maximum prices.

To assess the impact of removing excess allowances to account for market oversupply, Borenstein and Bushnell adjust their model by reducing the cumulative supply of allowances (i.e., lowering the emissions cap) in their model by between 250 and 300 $MMTCO_2e$.[3] We compare the original 2017 paper and the new results from the Energy Institute blog post here:

[2] Similarly, for scenarios in which market prices stay at the price floor through 2030, removing excess allowances doesn't matter because in these scenarios, the resulting market price would still be at the price floor. As we explain below, however, Borenstein and Bushnell expect that removing excess allowances would make such an outcome much less likely.

[3] Borenstein and Bushnell did not specify the precise number of allowances they removed. For context, Chris Busch estimated cumulative oversupply through 2020 of 270 (±70) $MMTCO_2e$. A number in the range of 250 to 300 $MMTCO_2e$ should be roughly representative of Dr. Busch's median estimate.

Table 1: Probability that market prices reach three allowance price scenarios in 2030

Scenario	Source	2030 Allowance Price Scenarios		
		Price floor ($25/tCO$_2$e)	**In between price floor and ceiling**	**Price ceiling ($85/tCO$_2$e)**
No adjustment for oversupply	Borenstein et al (2017): Table 2, Row 1[4]	46.2%	19.9%	33.9%
Lower cap by 250-300 MMTCO$_2$e to address oversupply	Borenstein & Bushnell blog[5]	16%	20%	64%
Change due to lower program caps		–30%	N/A	+30%

In essence, Borenstein and Bushnell's model calculates that lowering the cap to address oversupply would shift the range of outcomes, making the market about 30% more likely to hit an $85 price ceiling by 2030, and about 30% less likely to stay at a $25 price floor through 2030. The chance of being somewhere in between the floor and ceiling remains roughly the same across both scenarios.

To estimate the emission reductions attributable to removing excess allowances to account for market oversupply, Borenstein and Bushnell address two issues:

- **Fixed emission reductions at price ceiling or price floor.** This issue reflects Borenstein and Bushnell's first core assumption—that allowances ARB sells at the price ceiling represent additional emissions above and beyond program caps. Borenstein and Bushnell make an important contribution to the

[4] In their Energy Institute blog post, Borenstein and Bushnell combine two supplies of allowances available at the current price ceiling that are identified separately in Table 2 of Borenstein et al. (2017): the allowances currently held in the APCR ("In APCR at C Price") and supplemental allowances issued at the price ceiling ("Beyond APCR at C Price"). The probability of reaching each is 18.7% and 15.2%, respectively. For the purposes of discussing market prices, their assumption is sensible. However, the allowances currently in the APCR are part of the cumulative program caps, whereas those sold at the new price ceiling are in excess of the cumulative program caps.

[5] Borenstein and Bushnell do not offer their full results, stating only that the probability of market prices reaching the price ceiling in 2030 increased from "about 34% to about 64%" with the probability of market prices staying at the price floor "decreasing by a similar amount." We extrapolated accordingly.

state climate policy discussion by observing that implementing a price ceiling could limit how effective it would be to lower the cap to address the oversupply problem.

The argument goes like this: despite oversupply, if the market is already going to hit the price ceiling by 2030, removing allowances only accelerates the date at which ARB starts issuing extra allowances at the price ceiling and indeed will increase the number of allowances sold at the price ceiling as a result. In turn, this dilutes the emission reductions that would be expected from reducing the supply of allowances because, once the market reaches the price ceiling, every new allowance sold enables polluters to emit a new ton of pollution without increasing market prices. Borenstein and Bushnell conclude that if market conditions are going to equilibrate at the price ceiling anyway, removing allowances to account for oversupply will only marginally accelerate higher prices but ultimately have little long-term impact.

Similarly, for scenarios where prices are projected to remain at the price floor whether or not program caps are reduced, addressing market oversupply has no long-term effect on emissions. This is because in these scenarios allowance prices (and emissions) are projected to remain low through 2030 in the absence of the cap-and-trade policy, e.g. as a result of low economic growth and high gasoline prices.

- **Estimated price-induced mitigation.** Their main calculation addresses price-induced emissions reductions under the cap-and-trade program. Borenstein and Bushnell's model uses price elasticities of demand to estimate how demand for energy changes in response the prices of three key fuels—electricity, transportation fuels, and natural gas. A higher carbon price raises fuels costs, and therefore reduces fuel consumption and associated GHG emissions.

  Their model projects that a market that remains at the price floor ($25 in 2030) will reduce a cumulative 78.2 $MMTCO_2e$ through 2030. At a market equilibrium that reaches the price ceiling ($85 in 2030), their model projects a cumulative reduction of 217.7 $MMTCO_2e$ (see Table 1 in Borenstein et al. 2017). Thus, the price-induced reduction from a scenario that shifts from the price floor to the price ceiling is therefore 139.5 $MMTCO_2e$, or about 140 $MMTOC_2e$.

Borenstein and Bushnell then compare their model results when the model is run with or without removing allowances to eliminate oversupply. To calculate the expected emission reductions attributable to lowering the cap, Borenstein and Bushnell use a probability-weighted average that takes the probability that removing excess allowances would lead to emission reductions (30%) and multiply by that by the expected reductions (140 $MMTCO_2e$).[6] The result is an expected cumulative reduction of 42 $MMTCO_2e$, which Borenstein and Bushnell describe as "not chump change" but also not a "fundamental change" in a larger program.

[6] In fact, more than 30% of all scenarios feature some emission reductions. For example, some scenarios would reach the price floor without a cap adjustment but because of a cap adjustment would equilibrate in between the price floor and price ceiling, delivering some but not all of the 140 $MMTCO_2e$ projected for a full transition from the floor to the ceiling. Similarly, some scenarios will reach an intermediate price without a cap adjustment, but because of the cap adjustment will eventually reach the price ceiling, delivering some but not all of the

Our responses to Borenstein and Bushnell

We genuinely appreciate the work that Borenstein and Bushnell have done and hope our response will contribute to a productive discussion about how to manage California's climate policy goals. However, we are not convinced by their argument that whether or not ARB reduces program caps to address oversupply won't have much impact on GHG emissions. We offer three responses below.

Response #1: If ARB maintains the environmental integrity that AB 398 requires of price ceiling sales, strategies to address market oversupply will have their full intended effect.

Borenstein and Bushnell assume that allowances sold at the market price ceiling lead to additional emissions beyond the cumulative program cap. That would be the case if California's cap-and-trade system were using a "classic" hard price ceiling, but AB 398 requires ARB to take a different approach. Although ARB must issue unlimited allowances at the price ceiling, ARB is also obligated to use revenue raised from extra allowance sales at the price ceiling to achieve at least as many GHG reductions as are enabled by the sale of extra allowances.[7] If implemented as written, this provision would ensure the environmental integrity of the cumulative program cap; for every extra allowance sold at the price ceiling, another equal reduction must take place somewhere outside the cap-and-trade program.

There are good reasons to be skeptical about the feasibility, policy wisdom, or even the political sustainability of this requirement. One issue is that ARB might need to spend revenue from extra allowance sales at the price ceiling on out-of-state GHG reductions. Another issue is that ensuring reductions outside the program cap that are truly "additional" could be very difficult (as some of us have expressed previously in the context of carbon offsets). Nevertheless, current state law requires ARB to reduce emissions to fully account for extra allowances sold at the market price ceiling.

We recognize that the stakeholder community is split between those who believe this environmental integrity provision is a critical part of AB 398 and those who see it as lacking credibility. But for those who have faith in the environmental integrity of allowance price ceiling sales or those who merely want analyses to reflect current law, Borenstein and Bushnell's argument about the limited effect of oversupply corrections is wrong.

Rather than leading to no net reductions, the removal of excess allowances for a market that reaches the price ceiling will lead to higher sales of price ceiling allowances and therefore greater accompanying investments in GHG reductions outside of the cap-and-trade program on at least a 1:1 basis. In other words, removing 250 million allowances will cause cumulative emissions to fall by at least 250 $MMTCO_2e$. Those

140 $MMTCO_2e$ projected for a full transition from the floor to the ceiling. Because Borenstein and Bushnell report approximately equally sized shifts in model outcomes at the price floor and the price ceiling, with no significant change in the share of scenarios equilibrating in between the price floor and price ceiling, their simplified calculation accurately captures the net impact of a broader set of shifts in their modeled outcomes.

[7] Cal. Health & Safety Code § 38562(c)(2)(A)(ii)(II).

reductions will occur in different sectors as a result of the price ceiling: emissions within the cap-and-trade program will exceed cumulative program caps, but emissions outside the cap-and-trade program (including, potentially, out-of-state emissions) will see corresponding reductions.

Again, we are only observing that the assumption Borenstein and Bushnell make is not consistent with the current legal status of the environmental integrity of the hard price ceiling. Theirs is a defensible position. But those who think AB 398's provision will ensure the integrity of the cap should also expect that removing excess allowance to eliminate for market oversupply would lead to much larger effects than Borenstein and Bushnell estimated. Because these corresponding reductions could occur outside of California, however, ensuring environmental integrity in this way may not ensure the same level of in-state reductions and contribution to meeting California's 2030 statewide GHG emissions target.

Response #2: If the price ceiling means there is no longer a hard cap, ARB may need to consider a higher price ceiling to deliver the reductions it calls for from cap-and-trade.

Borenstein and Bushnell assume that ARB will not actually mitigate the extra emissions that occur as a result of additional allowance sales at the price ceiling—allowances which are in excess of the cumulative program caps. In this situation, addressing market oversupply will be less effective than it would at first appear. Rather than provide a justification for inaction, however, their analysis actually shows the need for ARB to consider setting the price ceiling at a higher level than the price ceiling in current regulations.

Since the original Borenstein et al. (2017) analysis was published, several economists have argued that ARB risks putting the 2030 target at risk because of the oversupply of allowances currently in the system. According to Borenstein and Bushnell's model, if these excess allowances are removed then the probability of the market reaching an $85 price ceiling rises from a one-in-three chance to a two-in-three chance. In turn, their model concludes that there is a significant chance that the cap-and-trade program will not contain cumulative emissions—hence their conclusion that there is longer any program "cap."[8] We note that even

[8] As Table 1 shows, the probability of market prices reaching the price ceiling rises from about 34% (no adjustment for oversupply) to 64% (with adjustment for oversupply). However, Borenstein and Bushnell do not provide the complete model results that would be necessary to show what share of these scenarios involve cumulative program emissions exceeding cumulative program caps. As discussed in note 4, *supra*, and Table 2 in Borenstein et al. (2017), market scenarios that reach the price ceiling include two sets of scenarios: (1) those in which the market equilibrium reaches the current APCR level but no additional price ceiling allowances are sold because existing APCR allowances (which are part of the cumulative program cap) are sufficient to cover demand, and (2) those in which the market equilibrium reaches the current APCR level and additional allowances must be sold at the price ceiling to cover emissions that exceed cumulative program caps. Borenstein et al. (2017) show that 33.9% of scenarios without oversupply adjustments reach the current APCR price, of which 18.7% are satisfied with existing APCR allowances and no new price ceiling allowances and 15.2% require additional allowances sold at the price ceiling. In other words, Borenstein et al. (2017) conclude that cumulative emissions exceed cumulative program caps in only 15.2% of scenarios. Without further information on the breakdown of the 64% of scenarios that reach the price ceiling when the Borenstein et al. (2017)

when the program delivers the stated cumulative reductions, oversupply can cause the annual emissions in 2030 to be significantly higher than program caps that year (see Burtraw 2017, Busch 2017, LAO 2017)—and this is why it is important for ARB to consider measures to resolve the market's current oversupply conditions.

We agree with Borenstein and Bushnell that the implementation of AB 398 requires ARB to make important political and policy judgments that cannot be set by technical analysis alone. Nevertheless, ARB is obligated to produce a Scoping Plan that is consistent with the SB 32 target for 2030 and has identified in the final Scoping Plan a large role for the cap-and-trade program. If ARB ultimately decides to implement a market design that is unlikely to deliver the reductions called for in the Scoping Plan, then the Scoping Plan would not be consistent with SB 32's instruction to achieve the SB 32 target.

Response #3: Price-induced emission reductions depend on assumptions and could be higher than what Borenstein and Bushnell calculate.

Borenstein and Bushnell's model uses significantly different assumptions than ARB does in the Scoping Plan. Specifically, ARB's assumed effects appear to reflect much greater optimism about the potential for carbon prices to reduce emissions subject to the cap-and-trade program. If more optimistic assumptions are warranted, adjusting the cap-and-trade program to account for oversupply will reduce emissions more than what Borenstein and Bushnell conclude.

Borenstein and Bushnell's model uses historical relationships between energy prices and energy consumption to estimate how future changes in the carbon price will affect fuel consumption, and therefore GHG emissions. Although their approach transparent and reflects standard economic methods, one shortcoming is that it would not capture new technological developments that could change the historical relationship between prices and consumption, such as a breakthrough in electric vehicle costs.

Unfortunately, the final 2030 Scoping Plan is essentially silent on what market prices ARB expects from the cap-and-trade program and exactly how ARB projects the program will deliver on California's 2030 climate target. However, ARB provides some information in the Scoping Plan's Appendix E that indicates the Board takes a much more optimistic perspective than does the Borenstein et al. paper with respect to the cap-and-trade program's ability to deliver emission reductions.

Here, we compare the cumulative emission reductions projected by Borenstein et al. (2017) and by ARB in its final Scoping Plan analyses. We note that ARB states that its assumed cap-and-trade effects "should not be used as a forecast of emission responses to allowance prices"—even though that is exactly how ARB uses them in Appendix E's economic analysis and in the summary of those results in the main Scoping Plan

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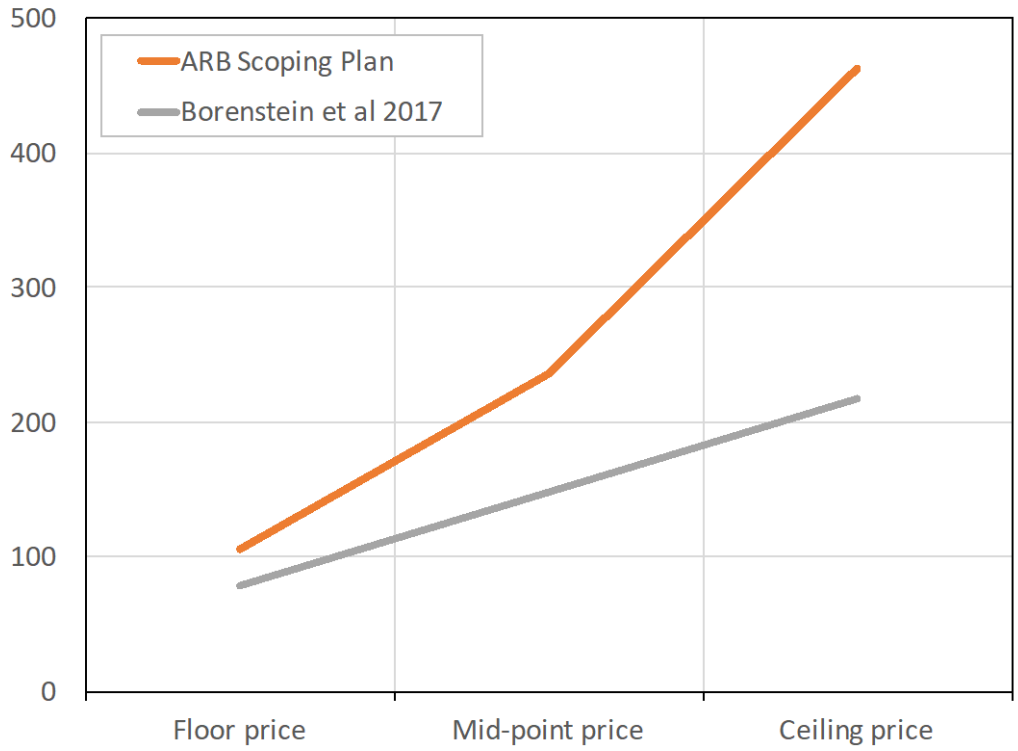
model adjusts program caps to address oversupply, we cannot say for sure in what share of these scenarios cumulative emissions exceed cumulative program caps. Nevertheless, we do know that this share will rise to substantially more than the 15.2% reported in the original Borenstein et al. (2017) paper that does not account for market oversupply.

(ARB 2017b: 65). Nevertheless, since ARB has offered no other insights into how it expects the cap-and-trade program to perform, we decided it was appropriate to compare these assumptions against those in Borenstein et al. (2017).

Figure 1: Cumulative emission reductions at different market prices ($MMTCO_2e$) [9]



As the figure above shows, ARB and Borenstein et al. share roughly comparable assumptions around the price-induced response that would occur at the market floor price. However, ARB projects significantly greater emission reductions at the price ceiling—about double what Borenstein et al. calculate. The difference between the response ARB expects at the price floor and the price ceiling is 356 $MMTCO_2e$, two and

[9] The figure does not make a strictly apples-to-apples comparison. There are several minor differences between the two sets of estimates. For example, ARB assumes a slightly lower price ceiling of approximately $\$82/tCO_2e$, as compared to Borenstein et al.'s $\$85/tCO_2e$. Most important, ARB calculates cumulative emission reductions over the period 2021-2030, whereas Borenstein et al. calculate cumulative emission reductions over the period 2016-2030. We cannot tell from the Borenstein et al. paper how to adjust their estimate to harmonize the time periods with ARB's estimates, but note that the difference is likely minor because cap-and-trade has not yet produced significant emission reductions as a result of program caps consistently being higher than covered emissions. In any case, a proper adjustment to harmonize the time periods would show a reduced projection from Borenstein et al., and thus larger differences between their results and ARB's assumptions. Full details on ARB's approach can be found in ARB (2017b): page 65 for the January 2017 draft scoping plan analysis and on page 90 for the final November 2017 Scoping Plan analysis. Finally, we note that unlike ARB, Borenstein et al. do not offer an explicit estimate of the emissions response at a price point halfway in between the floor and the ceiling.

a half times greater than Borenstein and Bushnell's estimate of 140 $MMTCO_2e$, which drives their final estimate of the environmental benefit of addressing market oversupply.

We do not claim to know what the "correct" values are for how much cap-and-trade would reduce emissions at any given price. We express no views on whether or not ARB's assumptions are defensible because we have no information from ARB on how it developed these assumptions nor why they are appropriate.[10] Rather, we argue that it is crucial for ARB to provide additional information on these points and for the expert community to continue with discussion and analysis of the effects of cap-and-trade at various possible allowance prices to inform the AB 398 implementation process.

The bottom line: ARB still needs to show its work

We appreciate the many insights Borenstein and Bushnell have offered on state climate policy and provide our reactions to their most recent work with the goal of contributing to the broader discussion that is already underway. In particular, their work highlights that individual aspects of the post-2020 cap-and-trade program design should not be considered in isolation; instead, the program design should be guided by a comprehensive analysis that includes all major factors and how they interact. In addition, Borenstein and Bushnell's working paper with Frank Wolak offers one of the only public analyses of possible market outcomes (Borenstein et al. 2017)—and, crucially, one that is transparent about its assumptions and model structure.

Borenstein and Bushnell are also right to point out that the price ceiling and market oversupply solutions can interact in counterproductive ways. If they are correct in assuming that unlimited sales at the price ceiling won't control cumulative emissions, then under a significant share of plausible scenarios the cap-and-trade program will not be able to serve as a backstop guarantee that limits cumulative emissions. Instead, the program will function like a carbon tax under these conditions.

In our view, when ARB sets the level of the price ceiling pursuant to AB 398, ARB should be explicit about the likely emissions consequences. If ARB asserts the program can still function as a backstop due to AB 398's requirement to mitigate emissions outside of the cap-and-trade program for every allowance sold at the price ceiling, it should explicitly identify the strategies and sectors where such reductions could take place—including whether these reductions are expected to occur in California or in other jurisdictions.

ARB has called for cap-and-trade to play a significant role in supporting California's 2030 Scoping Plan—indeed, the largest single contribution. Despite the Scoping Plan's emphasis on emission reductions from cap-and-trade, however, ARB has not yet analyzed what market designs are consistent with the program's greater role in the next decade. Nor has ARB evaluated concerns related to how oversupply could enable

[10] We are not criticizing the macroeconomic impact analysis in the Scoping Plan (ARB 2017b). Rather, we are pointing out that ARB has not substantiated its views on how different carbon prices and cap-and-trade market designs will deliver the reductions called for in the final Scoping Plan.

emissions under the program to exceed annual caps and potentially cause statewide emissions to exceed the SB 32 target.

We repeat our earlier call (see Mastrandrea and Inman 2017) for ARB to provide further insights into the Board's thinking on these matters so that a robust public discussion can continue as we work together to deliver on California's ambitious climate goals.

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About Near Zero

Near Zero is a non-profit environmental research organization based at the Carnegie Institution for Science on the Stanford University campus. Near Zero provides credible, impartial, and actionable assessment with the goal of cutting greenhouse gas emissions to near zero. This research note is for informational purposes only and does not constitute investment advice.

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