Cost Containment through Offsets in the Cap-and-Trade Program under California's Global Warming Solutions Act[1]

July 2011

This document outlines the results of the economic modeling performed by the Environmental Defense Fund on the effect offsets will have on allowance prices in California's greenhouse gas cap-and-trade program. The analysis assesses the cost of attaining the Global Warming Solutions Act (Assembly Bill 32, "AB 32") emissions reduction targets in the presence of varying levels of offsets, and uncertainty about the effectiveness of complementary measures. This work builds upon the modeling of the strategic allowance reserve program in December 2010 by Environmental Defense Fund. [2]

In this current analysis, we modeled probabilistically core policy scenarios of AB 32. In our model, as in California's cap-and-trade program, there is a reserve of 123 million 1-ton allowances for sale at a price of $40 per ton. Offsets are incorporated into the system and there is a $10/ton price floor. We then evaluate two additional scenarios; one in which offsets are limited to half of the quantity proposed in the program and another eliminating offsets altogether.

We find that offsets greatly reduce the market price of allowances, thereby decreasing the cost of attaining the AB 32 emissions cap.[3] More specifically:

- With full offsets, we estimate that the reserve will not be needed at all more than 85 percent of the time; even in cases where the reserve is needed, it is never exhausted, with prices successfully being limited to $40/ton in all iterations.

- Cutting the quantity of offsets in half increases the probability of the reserve being accessed to approximately 89 percent, with the reserve being insufficient to limit prices to $40/ton in a few rare instances (one-tenth of a percent (0.1%) of the time).

- When eliminating offsets from the cap-and-trade program altogether, allowances reach or exceed the trigger price of $40/ton in all iterations, with the reserve fully exhausted approximately 66 percent of the time.

The remainder of this memorandum summarizes our methods and assumptions, and presents the full results of our analysis.

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[1] This document was prepared by Chikara Onda, Research Assistant, Office of Economic Policy and Analysis and James Fine, Economist, Energy and Climate Program. Contact: jfine@edf.org.

[2] EDF (2010), "Modeling the Effectiveness of a Strategic Allowance Reserve in a Cap and Trade Program in California" by Golub, S., Keohane, N. and Fine, J.

[3] Note that these costs refer to compliance costs to regulated entities, as opposed to the net macroeconomic effects of the climate policies in question, which are expected to be a net positive.

Methods and Assumptions

Our analysis is based on modeling work previously performed by Environmental Defense Fund examining the effectiveness of the allowance reserve in California's cap-and-trade program at mitigating allowance prices. [4]

The original model explicitly considered price uncertainty in the proposed program using a widely used statistical technique called Monte Carlo analysis. This analysis allows us to model the probability of certain outcomes by replaying a scenario over and over again and recording the outcome. Probability distributions are assigned to various inputs, after which a value is randomly selected from each of these inputs' distributions to compute one possible outcome. This computation is then repeated a large number of times, using a different number randomly drawn from each distribution for each input, the results of which are aggregated to generate a probability distribution for the desired output.

In this case, allowance prices depend on drivers such as emissions that would occur without implementing AB 32 (i.e., BAU emissions), the level of the cap in each year of the program, abatement costs for capped sectors, the supply of offsets and the extent of emissions abatement from complementary policies including a renewable portfolio standard (RPS), aggressive energy efficiency measures, tighter automobile emission controls, and a low-carbon fuel standard. Staff at the California Air Resources Board (CARB) provided estimates of BAU emissions, cap levels for each program year, the marginal abatement cost curves for capped sectors, and the probability distributions for complementary policies and offset supply estimates. Again, these distributions capture different possible outcomes from each program component.[5]

The model is then run 100,000 times with each iteration using a different value for complementary policy reductions and offset quantities drawn from the probability distributions. By compiling the results of each iteration, we expect to get a simulated picture of the range of possibilities that might actually occur. The results of the model are expressed as the frequencies of certain outcomes over those many simulations. For example, the statement that "the estimated probability that the allowance reserve is triggered is less than X percent" means that the allowance reserve is needed in less than X percent of the simulations.

In order to examine the effect of varying quantities of offsets in the program, we analyze three scenarios. In the core scenario ("Full Offsets") we represent offsets using the probability distribution developed with input from CARB. We then successively reduce the number of offsets available in the program; in one scenario ("Half Offsets"), we divide the minimum, maximum, and modal values of offset supply by two, and in our last scenario ("No Offsets"), we eliminate offsets altogether. The remainder of the model inputs were held constant in all three scenarios, assuming a trigger price of $40/ton, rising at 5 percent per year in real terms (i.e., above inflation), and a reserve size of 123 million allowances for the period 2012-2020.

One key assumption is worth mentioning regarding the supply of offsets. We assume that offset supply is not responsive to the allowance price (i.e., offset supply is inelastic). Note that this is

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[4] EDF (2010), Op cite 2.

[5] Details on the underlying assumptions from the original analysis are provided verbatim in the Appendix.

not the same thing as saying that offset supply is constant: it varies widely among simulations. However, there is no feedback between the estimated allowance price and the supply of offsets. This is clearly an oversimplification. In the real world, we would expect offset supply (in particular) to respond to prices. That is, the higher the allowance price, the greater the returns to generating offsets, so we would expect the volume of offsets supplied into the market to rise. Nonetheless, this assumption is not as unrealistic as it might first appear. Given the long lead times required to get offset projects up and running, it is unlikely that higher-than-usual prices in the first few years of a cap-and-trade program could lead to a larger supply of offsets (or vice versa).

All prices are expressed in constant 2010 dollars. We assume a discount rate of 5% per year, implying that the market price of allowances will rise at the same rate. An implication of this assumption is that we can describe the entire allowance price trajectory using only its level in the first year. Accordingly, in what follows all prices are expressed in the first year of the program (2012).

Results

Reserve required given varying offsets

In order to examine the effect of the presence of varying levels of offsets on the market price of allowances, and, thus, on the capped entities' aggregate cost of attaining the AB 32 emissions reduction, we examine the size of the allowance reserve required to prevent allowance price from exceeding $40/ton. In cases where allowance prices do not reach the trigger price of $40/ton, the results will indicate that no allowance reserve is required. Conversely, in cases where the allowance reserve is depleted and allowance prices will exceed $40/ton, the size of the reserve required will be greater than 123 million allowances.

The following figures represent the distribution of estimates of the size of the reserve needed to limit allowance prices at the trigger price of $40/ton, produced by the 100,000 iterations of our model for each scenario. For instance, a 95th percentile value of 20.0 indicates that, given an allowance reserve containing 20.0 million allowances, there is a 95% chance that prices can be limited to $40/ton. Additionally, a value of 0.0 indicates that, in that particular iteration, allowance prices do not reach the trigger price of $40/ton, and a value exceeding 123.0 indicates that the 123-mmt reserve has been exhausted and that prices will exceed $40/ton.

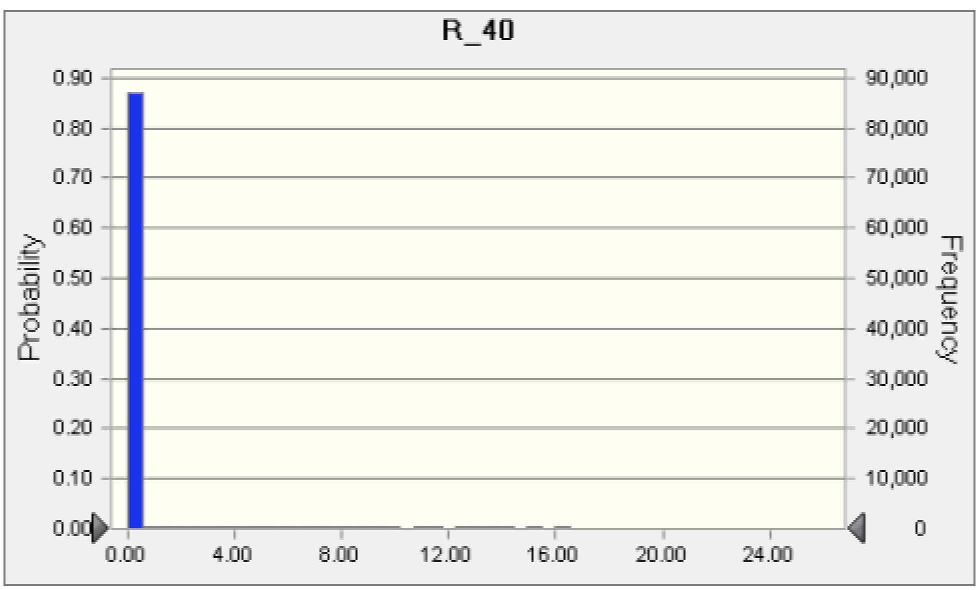
Full Offsets Scenario

In our first scenario, offset supply follows the probability distribution developed with input from CARB and outlined in the appendix. As expected, this enables prices to remain low, as summarized in Table 1 and Figure 1. In this Full Offsets scenario, we estimate that the reserve will not be needed at all more than 85 percent of the time, indicating that allowance prices do not hit the reserve price ($40 per ton) in the vast majority of iterations. Even in cases where the reserve is needed, it is never exhausted, with prices successfully being limited to $40/ton in all iterations.

Table 1 – Distribution of reserve tons needed in Full Offsets scenario, for 100,000 trials.

Statistics	**Reserve needed (million tons)**
Mean	2.5
Median	0.0
Mode	0.0
Standard Deviation	8.4
Percentiles	
Minimum	0.0
5th	0.0
10th	0.0
25th	0.0
Median	0.0
75th	0.0
80th	0.0
85th	0.0
90th	6.5
95th	20.0
99th	44.2
Maximum	93.4

Figure 1 – Distribution of quantity of reserve tons needed in Full Offsets scenario, for 100,000 trials. Estimated probability is on the vertical axis; quantity of reserve tons (in millions) is on the horizontal axis.



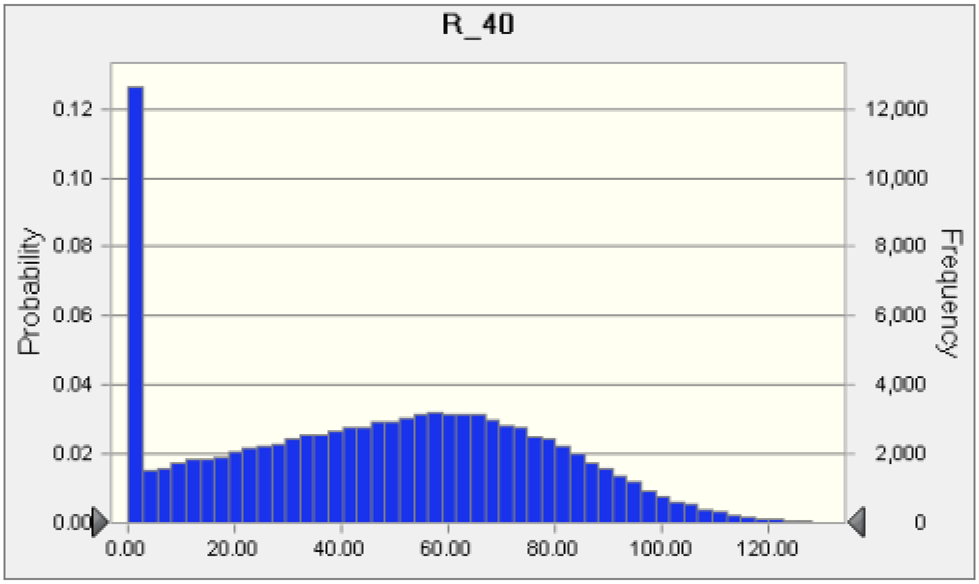
Half Offsets Scenario

Cutting the quantity of offsets in half increases the probability of the reserve being accessed to approximately 89 percent; in other words, the proportion of iterations where the allowances prices do not hit the trigger price of $40/ton decreases to only 11 percent of iterations, compared to more than 85 percent in the Full Offsets scenario. Additionally, the reserve is unsuccessful in limiting prices to $40/ton with all 123 mmt of allowances in the reserve being exhausted, in a few rare instances (0.1 percent of iterations), as illustrated in Table 2.

Table 2 – Distribution of reserve tons needed in Half Offsets scenario, over 100,000 trials.

Statistics	**Reserve needed (million tons)**
Mean	46.2
Median	47.7
Mode	0.0
Standard Deviation	30.2
Percentiles	
Minimum	0.0
5th	0.0
10th	0.0
25th	21.2
Median	47.7
75th	69.3
80th	74.1
85th	79.4
90th	85.6
95th	94.4
99th	109.8
Maximum	141.7

Figure 2 – Distribution of reserve tons needed in Half Offsets scenario, for 100,000 trials. Estimated probability is on the vertical axis; quantity of reserve tons (in millions) is on the horizontal axis.



No Offsets Scenario

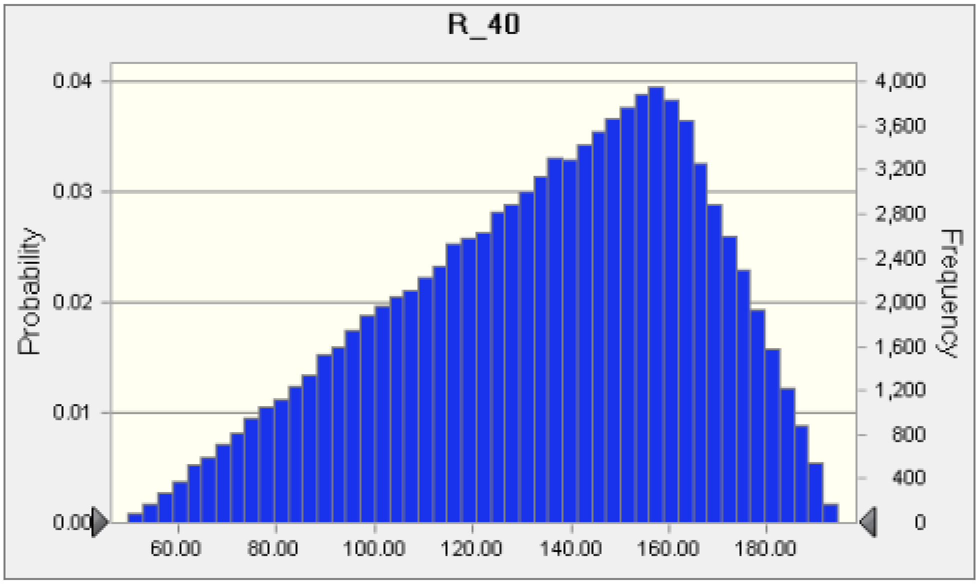
Finally, when eliminating offsets from the program, allowances reach the trigger price of $40/ton in all iterations. Moreover, in almost two thirds of iterations, the reserve is fully exhausted, indicating that allowance prices exceed $40/ton in the majority of iterations.

Table 3 – Distribution of reserve tons needed in No Offsets scenario, over 100,000 trials.

Statistics	Reserve needed (million tons)
Mean	134.4
Median	138.6
Mode	---[6]
Standard Deviation	30.8
Percentiles	
Minimum	49.9
5th	77.9
10th	89.6
25th	112.5
Median	138.6
75th	158.7
80th	162.6
85th	166.8
90th	172.0
95th	178.4
99th	187.2
Maximum	194.2

[6] In the two previous scenarios there are "spikes" in the distributions at 0.0, indicating that there is a high probability that the allowance reserve won't be needed. Because the allowance reserve is always accessed when offsets are eliminated from the program (as can be seen by the 49.9 minimum value), the mode isn't 0.0, which is why we've inserted "—".

Figure 3 – Distribution of quantity of reserve tons needed in No Offsets scenario, for 100,000 trials. Estimated probability is on the vertical axis; quantity of reserve tons (in millions) is on the horizontal axis.



Cost savings from offsets

From the above analysis, we can determine that offsets will serve as a powerful cost containment measure in the California's AB 32 cap-and-trade program. As a rough estimate of the cost savings obtained from offsets, in Table 4, we calculate the difference in compliance costs over the 2012-2020 period with allowance prices of $10/ton and $100/ton, cited by CARB as credible estimates with and without offsets, respectively. This produces cost savings from offsets of $241 billion over the nine-year period.

Table 4 - Compliance Cost Difference between $10 and $100 per ton

	2012	2013	2014	2015	2016	2017	2018	2019	2020		
Number Allowances[7]	165.8	162.8	159.7	394.5	382.4	370.4	358.3	346.3	334.2		
Price	$10	per ton									
Total Value at $10/ton ($2007 millions)	$1,658	$1,628	$1,597	$3,945	$3,824	$3,704	$3,583	$3,463	$3,342		
Price	$100	per ton									
Total Value at $100/ton ($2007 millions)	$16,580	$16,280	$15,970	$39,450	$38,240	$37,040	$35,830	$34,630	$33,420		
										Offset Savings, if $100 --> $10	
Diff, 2012-2020, $10 -- $100	$14,922	$14,652	$14,373	$35,505	$34,416	$33,336	$32,247	$31,167	$30,078	**$240,696**	$2007 millions

[7] CARB (2010). Proposed Regulation to Implement the California Cap-and-Trade Program, PART I, Volume I, Staff Report: Initial Statement of Reasons, Table II-2, Page II-18.

Appendix

The table below presents details on our underlying assumptions.

Table A1 – Distribution of quantity of reserve tons needed.

Description	**Value**	
<u>Fixed</u>		
Business as usual (BAU) emissions, 2012-2020	2,948	million metric tons (mmt)
Total allowable emissions	2,674	mmt
Total size of allowance reserve	123	mmt
Trigger price (year 2012 value, assuming annual increase of 5% above inflation)	40	$/ton (constant 2010 dollars)[8]
<u>Random</u>		
Abatement from complementary policies*		
Triangular distribution with…		
Minimum	75	mmt
Mode	110	mmt
Maximum	220	mmt
Offset supply*		
Triangular distribution with…		
Minimum	80	mmt
Mode	230	mmt
Maximum	230	mmt
Allowance price after 2020*		
Lognormal distribution with…		
Mean	24	2010$/ton
Standard deviation	12	2010$/ton

* *See explanation below.*

Abatement from complementary policies

To derive the distribution of abatement from complementary policies, we started by assuming maximum abatement potential of 280 mmt over the period 2012-2020, based on information provided by CARB staff. We then made two adjustments: first, to reflect the possibility that actual reductions would be less than the maximum amount; second, to correct for possible double-counting between complementary policies and abatement under the cap.

[8] A trigger price of $50/ton was used in the original analysis; this has since been revised to $40/ton, used in the current analysis.

The maximum potential of 280 mmt reflected the expected abatement opportunities from four complementary policies: (1) a 33% renewable electricity standard; (2) aggressive energy efficiency programs; (3) tighter automobile standards (Pavley II); and (4) a low-carbon fuel standard.

We then assumed a simple triangular distribution for abatement from complementary policies, with a minimum, mode, and maximum. For the minimum, we derived a "worst case scenario" in which the RES policy achieved *no* additional emissions reductions and the other policies (energy efficiency, clean cars, and LCFS) achieved only half of their estimated reductions. These assumptions imply reductions of 95 mmt. For the mode, we assumed a "most likely scenario" in which all policies, including the RES, achieved half of their estimated abatement potential, resulting in 140 mmt.

Next, we adjusted these figures for the possibility of double-counting. Based on the marginal abatement cost curves for covered sectors provided by CARB, we estimated that low- or no-cost reductions (e.g., improvements energy efficiency that could yield net savings) amounted to 20% of the estimated reductions from complementary policies. These reductions correspond to abatement on the left-hand side of the marginal cost curve, and therefore should not be counted as helping to meet the target (since they would be assumed to be met regardless of the complementary policies). For each of the three complementary policy scenarios outlined above (minimum, modal, and maximum), we therefore subtracted 20% of the associated abatement. The resulting values of 75/110/220 mmt are shown in the table above.

Offset supply

Assumptions on offset supply were provided by CARB staff. Again, we used a simple triangular distribution. The most-likely and maximum values of 230 mmt reflect best-guess estimates of the availability of offsets over the period 2012-2020. The minimum value of 80 mmt reflects a "worst-case scenario" in which offsets are significantly more difficult to generate than expected.

In the Half Offsets scenario, the most-likely, maximum, and minimum values were scaled down to 115 mmt, 115 mmt, and 40 mmt, respectively, and offsets were eliminated altogether in the No Offsets scenario.

Allowance prices after 2020

In the case where firms are assumed to bank allowances beyond 2020 (see discussion in text), some assumption is needed about the subsequent market price of allowances. We chose to use the distribution of prices that results from our study of a prospective national carbon market. This study assumes comprehensive cap-and-trade legislation similar to the American Clean Energy and Security Act (H.R. 2454), enrolled by the House of Representatives in June 2009, and to the American Power Act proposed by Senators John Kerry and Joe Lieberman in the U.S. Senate.