Memorandum

To: EAAC Members

From: Cal/EPA and ARB EAAC Policy Team

RE: Estimates of Allowance Prices

Date: October 20, 2009

1. Objective

This memo summarizes estimates of allowance prices to help inform the EAAC regarding the potential value of emission allowances in California's cap-and-trade program. This memo supplements the October 5, 2009 memo provided to the Committee ("Factors Affecting Allowance Value") that described the quantity of emission allowances and the factors that affect allowance prices.

All the studies examined here include numerous assumptions about program design, fuel prices, economic growth, complementary policies, technologies, and other factors. A detailed description of the assumptions affecting the estimates from each study is beyond the scope of this memo. Nevertheless, despite the differences in approaches and assumptions used in the studies, the review of allowance price estimates shows that allowance prices are most often estimated to be in the range of roughly $20 to $60 per metric ton of emissions in 2020. Lower and higher estimates have also been published, in some cases based on sensitivity analyses that are constructed to assess the impacts of assumptions that lead to lower and higher allowance prices (and program costs).

Of particular note for the Committee is that program design decisions that affect expected allowance prices are guided in part by the types of analyses summarized here. Consequently, program design recommendations, such as those adopted by the WCI or included in HR 2454 (Waxman-Markey), tend to produce allowance price estimates within this range.

2. Allowance Prices in a California Program

The following allowance price estimates are summarized:

- 2007 Climate Action Team Analysis.
- Companion Analyses to the 2007 Climate Action Team Analysis.
- 2008 WCI Analysis.
- Scoping Plan Analysis.
- 2007 Deutsche Bank Analysis.
- 2008 CRA Offsets Study.

2.1 2007 Climate Action Team Analysis

In 2007, the Economics Subgroup of the Climate Action Team (CAT) updated the macroeconomic analysis performed for the 2006 CAT Report.[1] Using E-DRAM, the study examined the macroeconomic impacts to California of achieving the 2020 emission target adopted in AB 32. The study included estimates of the costs, savings, and emission reductions

[1] "Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report: Final Report," Economics Subgroup, Climate Action Team, October 15, 2007. Available at: http://www.climatechange.ca.gov/climate_action_team/reports/index.html.

associated with the measures described in the 2006 CAT Report.[2] E-DRAM was also used to estimate the range of allowance prices needed in 2020 to achieve the emissions target under a range of assumptions.

Exhibit 1 lists the scenarios examined in the study, and Exhibit 2 lists the results from E-DRAM. As shown in the exhibit, the estimated allowance prices are in the range of $13 to $45 per metric ton in 2020. The analysis showed that the use of offsets has the potential to reduce allowance prices, and that complementary policies can have a substantial impact on allowance prices.

2.2 Companion Analyses to the 2007 Climate Action Team Analysis

As part of conducting the 2007 CAT analysis, the Economics Subgroup collaborated with Charles River Associates, International (CRA) and Dr. David Roland-Holst (U.C. Berkeley). CRA used its MRN-NEEM model and Dr. Roland Holst used the Berkeley Energy and Resources (BEAR) model to analyze the same policies and targets examined in the CAT analysis. The three models were harmonized in terms of:

- fuel prices;
- real state output;
- personal income;
- population and household formation;
- electricity consumption and generation; and
- reference case emissions by major sector, with particular reference to the electric sector.

A common set of assumptions was also used to describe the emission reductions that would be achieved by the individual measures in the CAT report.

The allowance price estimates from the BEAR and CRA analyses are shown in Exhibit 2. Both the BEAR and CRA analyses show the potential for allowance prices to be higher under certain assumptions. The results particularly underscore the impact that complementary policies could have on allowance prices if the complementary policies are less effective than anticipated.

2.3 2008 WCI Analysis

The Western Climate Initiative (WCI) released an economic analysis of its cap-and-trade program in September 2008.[3] The WCI analysis was performed using ENERGY2020, and covered eight of the 11 WCI Partner jurisdictions.[4]

The cap-and-trade policy cases examined include:

- Broad Scope, with complementary policies and without offsets
- Broad Scope, with complementary policies and with offsets
- Narrow Scope, with complementary policies and with offsets

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[2] "Climate Action Team Report to Governor Schwarzenegger and the Legislature," March 2006. Available at: http://www.climatechange.ca.gov/climate_action_team/reports/index.html.

[3] Appendix B: Economic Modeling Results, "Design Recommendations for the WCI Regional Cap-and-Trade Program," September 23, 2008, available at: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/design-recommendations.

[4] The eight jurisdictions in the analysis were: British Columbia; Washington; Oregon; California; Montana; Utah; Arizona; and New Mexico. Excluded were: Manitoba; Ontario; and Quebec.

The narrow scope included the following:

- Electricity generation, including emissions from electricity imported into WCI jurisdictions from non-WCI jurisdictions;
- Combustion at industrial and commercial facilities above the WCI annual emissions threshold of 25,000 metric tons of CO_2e; and
- Industrial process emission sources, including oil and gas process emissions.

The broad scope included the emissions in the narrow scope plus the following:

- Residential, commercial, and industrial fuel combustion at facilities with emissions below the WCI thresholds; and
- Transportation fuel combustion, including gasoline and diesel fuel.

Three sensitivity cases examined alternative energy prices and generation costs, including:

- High fuel prices and high electricity generation costs;
- Low fuel prices; and
- High natural gas prices due to policy-driven increased demand for natural gas.

The WCI 2020 allowance price estimates are presented in Exhibit 3. As shown in the exhibit, the estimates are in the range of $15 to $70 per metric ton. The analysis demonstrates the impact that offsets could have on allowance prices. Additionally, sensitivity of the estimates to program scope (narrow versus broad) and fuel prices is reported.

The WCI analysis is currently being updated to incorporate all 11 partner jurisdictions and updated assumptions regarding economic growth, complementary policies, and other factors.

2.4 Scoping Plan Analysis

The Air Resource Board (ARB) approved the Scoping Plan in December 2008.[5] The Scoping Plan provides a comprehensive approach for reducing state GHG emissions to the target level defined in AB 32. The Plan proposes a cap-and-trade program, coordinated with the WCI program, along with a broad set of individual measures designed to reduce emissions from specific sources.

Using E-DRAM, ARB estimated the economic impacts of the Scoping Plan as a whole. For the cap-and-trade program, the modeling results reflect a 2020 carbon price of $10 per metric ton (Scoping Plan, p. 75). The analysis did not incorporate the link to the WCI partner jurisdictions.

2.5 2007 Deutsche Bank Analysis.

In September 2008 Deutsche Band released a research report examining the measures proposed by California to achieve the AB 32 2020 emission target.[6] Based on the information in the Scoping Plan, the authors derived a range of allowance prices:

- Best-case scenario: 2020 allowance price of $15 per metric ton based on the expectation that offset credits can be used in sufficient quantity to be the marginal compliance activity, and that offset credits would cost $15 per metric ton.

[5] "Climate Change Scoping Plan, A Framework for Change," California Air Resources Board, December 2008. Available at: http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

[6] "Carbon Emissions: California Gleamin'," Deutsche Bank, September 3, 2008. Available at: http://www.dbcca.com/dbcca/EN/investment-research/additional-investment-research_1444.jsp.

- Base-case scenario: 2020 allowance price of $60 per metric ton based on the expectation that fuel switching in the power-generation sector under the cap-and-trade program will be the back stop technology used, and that this costs $60 per metric ton. The estimated need for fuel switching to achieve the emissions limit is driven by the assumption that only 50% of the direct-control measures for transport and only 66% of the direct-control measures for energy efficiency are achieved.

In the discussion of this range of estimates, the authors emphasize the role of offsets in producing allowance prices toward the low end of the range. They suggest that limits on the use of offsets could cause allowance prices to be toward the high end of the range, particularly if complementary policies do not deliver the emission reductions anticipated in the Scoping Plan.

2.6 2008 CRA Offsets Study

In April 2008, CRA International released a study examining the impact of offset policies on the costs of achieving the emission limit adopted in AB 32.[7] The study considered offset policies ranging from restricting offsets to California only, to allowing California and international offsets, to allowing offsets from the entire U.S. The options examined included:

- No offsets from sources outside California (CA_Only)
- Offsets from California and a small fraction of available offsets in rest of US (Restricted US Offsets)
- Offsets from California and the rest of US (All US Offsets)
- Offsets from California and unlimited international offsets with a 1%/yr cost escalator (International-1%)
- Offsets from California and unlimited international offsets with a 5%/yr cost escalator (International-5%)

The impact on the estimated 2020 allowance price was examined, as shown in Exhibit 4. As shown in the exhibit, the study concluded that restrictions on the geographic source of offsets could have a substantial impact on allowance prices, ranging from $8 to $81 per metric ton in 2020.

3. Allowance Prices in a National Program

A variety of studies have been published evaluating the potential allowance prices in a national cap-and-trade program. In May 2008 the Pew Center on Global Climate Change released a summary of economic analyses of the Lieberman-Warner legislation.[8] Estimates from six studies using a range of models and assumptions reported 2020 allowance prices from $22 to $61 per metric ton.

In June 2009 the U.S. EPA released its analysis of the Waxman-Markey legislation (HR 2454).[9] U.S. EPA estimated that 2020 allowance prices would be in the range of $16 to $19 per metric

[7] "The Role of Offsets in Enhancing the Cost-Effectiveness of AB32," CRA International, April 23, 2008. Available at: http://www.crai.com/NorthAmerica/ProfessionalStaff/AuxListingDetails.aspx?id=7708&fID=34.

[8] "Insights from Modeling Analyses of the Lieberman-Warner Climate Security Act (S. 2191)," Pew Center and Global Climate Change, May 2008. Available at: http://www.pewclimate.org/in-brief/l-w-modeling.

[9] "EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress," U.S. Environmental Protection Agency, June 23, 2009. Available at: http://www.epa.gov/climatechange/economics/economicanalyses.html.

ton if no limits were put on the use of offsets. Using a range of assumptions about restrictions on the use of offsets, their estimate of 2020 allowance prices increased to a range of $16 to $30 per ton. The U.S. EPA underscored that assumptions regarding offsets have a "strong impact on cost containment" (page 3).

4. Price Trajectory

The studies summarized above use a variety of methods to estimate allowance prices both prior to and after 2020. Some studies examine individual years independently, estimating the allowance price necessary in that year to achieve the emission reductions to comply with the cap-and-trade program in that year. Under these circumstances, the rate of decline of the emission allowance budget has a strong influence on the allowance price trajectory. Some studies explicitly consider the opportunity to bank emission allowances across years, minimizing compliance costs by "over complying" early and using banked emission allowances later in the program.

Given that proposed program designs typically allow banking of allowances (including recent federal proposals and the California and WCI program recommendations), the estimate of the price trajectory of allowances must consider what rate of return would motivate allowance holders to bank allowances for future use. In its analysis of this question, the Congressional Budget Office (CBO) concluded that the rate of return of typical investments in the U.S. nonfinancial corporate sector is most appropriate to use as the expected rate of return for banking of allowances.[10] CBO estimated that an annual real return of about 6% would motivate banking, consistent with CBO's long-run economic forecast.

Using CBO's 6% figure, the price trajectories for a range of 2020 allowance prices are shown in Exhibit 5. Also shown in the exhibit is an illustrative estimate of the cap-and-trade allowance budget that was presented in the October 5, 2009 memo provided to the Committee ("Factors Affecting Allowance Value"). Multiplying the allowance prices by the allowance budget provides an illustration of the potential allowance value using these price and quantity assumptions.

5. Observed Allowance Prices

The Regional Greenhouse Gas Initiative (RGGI) has held five auctions of emission allowances. The first auction was held in September 2008, and subsequent auctions have been held quarterly. The program covers electricity generation in 10 states, and its compliance requirements started January 1, 2009. Exhibit 6 lists the clearing prices from the five auctions. Prices declined in the most recent auction, reportedly in response to reduced electricity generation and consumption. RGGI's market monitor reports that recent prices in the secondary market are consistent with the observed auction results.[11]

Of note is that the annual quantity of emission allowances available in the RGGI program is currently estimated to exceed annual emissions covered by the program. Consequently, the emissions cap is not constraining current emissions. The potential ability to convert RGGI emission allowances into allowances usable under a future federal program may be contributing to the observed prices.

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[10] "How CBO Estimates the Costs of Reducing Greenhouse Gas Emissions," Congressional Budget Office, April 2009, pp. 22-23. Available at: http://www.cbo.gov/ftpdocs/99xx/doc9923/04-24-Greenhouse.pdf.

[11] "Report on the Secondary Market for RGGI CO_2 Allowances," prepared for RGGI Inc., Potomac Economics, September 2009. Available at: http://www.rggi.org/docs/Secondary_Market_Report_September_2009.pdf.

Carbon prices have also been observed in the EU Emissions Trading Scheme (ETS). A summary of the EU ETS experience through 2007 was provided to the Committee previously.[12] That summary showed Phase II carbon prices briefly exceeding €30 in 2006 before declining into the €15 to €25 range in 2007. More recently EU ETS prices have been in the range of €11 to €16, as reported by the European Climate Exchange.[13] The economic downturn has been suggested as a factor contributing to lower carbon prices in 2009.

[12] "The European Union's Emissions Trading System in Perspective," A. Denny Ellerman and Paul L. Joskow, Massachusetts Institute of Technology, prepared for The Pew Center on Global Climate Change, May 2008. Available at: http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf.

[13] Recent carbon prices on the European Climate Exchange are available at: http://www.ecx.eu/EUA-CER-Daily-Futures.

Exhibit 1: Scenarios Analyzed in the 2007 CAT Analysis

Analysis Cases	Climate Strategies[1]	Cap-and-Trade Program[2]	Offsets[3]	Energy Prices[4]
Baseline	None	None	None	IEPR Forecast
Scenario 1	Reference Case	Program A: All Sectors	None	IEPR Forecast
Scenarios 2-4: The Impact of Allowing Offsets				
Scenario 2	Reference Case	Program A: All Sectors	$10/ton	IEPR Forecast
Scenario 3	Reference Case	Program A: All Sectors	$30/ton	IEPR Forecast
Scenario 4	Reference Case	Program A: All Sectors	$50/ton	IEPR Forecast
Scenarios 5-6: The Impact of Narrowing the Scope of the Cap-and-Trade Program				
Scenario 5	Reference Case	Program B: Major Sectors Only	None	IEPR Forecast
Scenario 6	Reference Case	Program B: Major Sectors Only	$30/ton	IEPR Forecast
Scenarios 7-8: Sensitivity Case Examining What if the Climate Strategies Produce only 50% of Their Expected Reductions				
Scenario 7	Sensitivity Case: 50% Effective	Program A: All Sectors	$30/ton	IEPR Forecast
Scenario 8	Sensitivity Case: 50% Effective	Program B: Major Sectors Only	$30/ton	IEPR Forecast
Scenario 3*: Energy Price Sensitivity Case				
Baseline	None	None	None	CPUC MPR Forecast
Scenario 3*	Reference Case	Program A: All Sectors	$30/ton	CPUC MPR Forecast

1. The sensitivity case uses 50% of the emission reductions, costs, and savings.

2. Program A sets the cap across the entire California economy. Program B sets the cap across the energy intensive sectors, including the electric sector (including electricity imports), the cement sector, and the refining sector.

3. Offsets can account for up to 10% of the required emission reduction. In 2020, offsets can account for up to 10% of the 174 $MMTCO_2e$ emission reduction required, or 17.4 $MMTCO_2e$.

4. The energy prices are based on the 2005 Integrated Energy Policy Report (IEPR) forecast. The Sensitivity Case is based on the CPUC Market Price Referent (MPR) natural gas price forecast.

Source: "Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report: Final Report," Economics Subgroup, Climate Action Team, October 15, 2007, page 38.

Exhibit 2: Estimated 2020 Allowance Prices in the 2007 CAT Analysis and Companion Analyses

Scenarios	E-DRAM	BEAR	CRA
Scenario 1	$21	$22	$42
Offset Scenarios:			
Scenario 2	$13	$7	$35
Scenario 3	$21	$22	$35
Scenario 4	$21	$22	$45
Scope Scenarios:			
Scenario 5	NA	$80	$45
Scenario 6	NA	$17	$39
Climate Strategy Scenarios:			
Scenario 7	$45	$206	$86
Scenario 8	NA	$442	$190
Energy Price Sensitivity Scenario:			
Scenario 3*	$17	$9	--
NA: E-DRAM was not able to analyze these scenarios. CRA did not analyze Scenario 3*. Scenarios are defined in Exhibit 1.			

Sources:

"Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report: Final Report," Economics Subgroup, Climate Action Team, October 15, 2007, page 42.

EPRI-CRA Analysis provided to California Environmental Protection Agency, September 24, 2007, page 1.

Exhibit 3: Estimated 2020 Allowance Prices in the WCI 2008 Analysis

Case	2020 Allowance Price (2007 $)
Cap-and-Trade Policy Cases	
Broad Scope, No Offsets	$63
Broad Scope, With Offsets	$24
Narrow Scope, With Offsets	$71
Sensitivity Cases	
High Fuel Prices and Electricity Costs	$18
Low Fuel Price	$56
High Natural Gas Price (driven by policy)	$20
Sensitivities are applied to the "Broad Scope, With Offsets" case. Note: Analysis includes eight of the 11 WCI Partner jurisdictions.	

Source: Appendix B: Economic Modeling Results, "Design Recommendations for the WCI Regional Cap-and-Trade Program," September 23, 2008.

Exhibit 4: Estimated 2020 Allowance Prices in the CRA Offset Analysis

Scenario Name	Availability of Offsets	2020 Allowance Price
CA_Only	California only	$81
US_Restricted	California + Limited Offsets from rest of US	$48
International-5%	California + International 5% rise	$37
International-1%	California + International 1% rise	$28
US_All	California + Rest of US	$8

Source: "The Role of Offsets in Enhancing the Cost-Effectiveness of AB32," CRA International, April 23, 2008, page 10.

Exhibit 5: Illustrative Estimates of Allowance Prices and Allowance Value

Year	Illustrative Budget ($MMTCO_2e$)	Illustrative 2020 Allowance Price							
		$20.00		$35.00		$45.00		$60.00	
		Price ($/ton)	Value (mill.)	Price ($/ton)	Value (mill.)	Price ($/ton)	Value (mill.)	Price ($/ton)	Value (mill.)
2012	200	$12.54	$2,508	$21.96	$4,392	$28.23	$5,646	$37.65	$7,530
2013	195	$13.29	$2,592	$23.28	$4,540	$29.92	$5,834	$39.91	$7,782
2014	190	$14.09	$2,677	$24.68	$4,689	$31.72	$6,027	$42.30	$8,037
2015	405	$14.94	$6,051	$26.16	$10,595	$33.62	$13,616	$44.84	$18,160
2016	397	$15.84	$6,288	$27.73	$11,009	$35.64	$14,149	$47.53	$18,869
2017	389	$16.79	$6,531	$29.39	$11,433	$37.78	$14,696	$50.38	$19,598
2018	381	$17.80	$6,782	$31.15	$11,868	$40.05	$15,259	$53.40	$20,345
2019	373	$18.87	$7,039	$33.02	$12,316	$42.45	$15,834	$56.60	$21,112
2020	365	$20.00	$7,300	$35.00	$12,775	$45.00	$16,425	$60.00	$21,900

Budget: Illustrative California cap-and-trade program emission allowance budget in millions of metric tons of carbon dioxide equivalent ($MMTCO_2e$).

Price: Illustrative emission allowance price in each year in dollars per metric ton. The price trajectory is computed assuming a 6% annual price increase, resulting in the 2020 price noted in the table.

Value: Illustrative allowance value in millions of dollars, equal to the allowance price times the allowance budget.

Exhibit 6: RGGI Auction Prices to Date

Allowance Prices in RGGI Auctions: $ Per Short Ton			
Auction	Auction Date	Allowance Vintage	
		2009	2012
1	September 25, 2008	$3.07	
2	December 17, 2009	$3.38	
3	March 18, 2009	$3.51	$3.05
4	June 17, 2009	$3.23	$2.06
5	September 9, 2009	$2.19	$1.87

Auction reserve price is $1.86 per short ton.

Source: RGGI market monitor reports, available at: http://www.rggi.org/co2-auctions/market_monitor.