INTERNATIONAL

Prepared For: Chevron Corporation

The Role of Offsets in Enhancing the Cost-Effectiveness of AB32

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TABLE OF CONTENTS

1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

This report extends a peer-reviewed analysis of a California cap and trade program by looking at five different policy scenarios that vary the quantity and prices of offsets allowed for compliance. The report clearly shows that by limiting availability of offsets, the state could lose more than 300,000 jobs and decrease GSP by almost 1%.

A greenhouse gas (GHG) offset reduces emissions that otherwise would have been emitted into the atmosphere, compensating for an emissions elsewhere. This economic analysis provides a picture of what happens to the California economy based on whether, and to what extent, offset credits are available for compliance with AB 32.

1.2. BACKGROUND

California's current greenhouse gas emission reduction policy, The Global Warming Solutions Act (AB32), is shaped by several important measures that provide the framework in which future policy will develop, but leaves major uncertainties about how the policies will be implemented or modified in response to changing circumstances. One of the large uncertainties is the availability of offsets.

The subject of offsets has become a central part of discussions about greenhouse gas emission reduction policies, and offsets offer the potential to serve as an important cost-containment mechanism for California as it moves forward in implementing AB32. To provide more insight regarding the importance of future decisions relating to the inclusion of offsets, this report analyzes the effect of including offsets on the cost of California's compliance with AB32. To reflect uncertainty about the economic potential for cost-effective offsets, and to highlight the implications of policy decisions about allowable offset use, this report examines the implications of offset use for the cost of California greenhouse gas emission reduction policy under several different scenarios defined by different availabilities of offsets. Additional uncertainty regarding the cost of the program comes from other policy design options including market size, allocations of allowances, point of regulation and the like. Since none of these program elements have been determined by the ARB, this study has selected to use the policy design elements identified in the EPRI base case.[1]

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[1] In particular, the level of the emission cap and the rules for emission permit trading match those of the EPRI scenario 9. See "An Updated Macroeconomic Analysis of Recent California Climate Action Team Strategies," CRA and EPRI (Oct. 2007).

The availability and cost of offsets are quite uncertain. Offsets could come from three geographic designations: California, the rest of the US, and the rest of the world. Offset supply curves for these three regions were developed for this study. In addition to the uncertainty about the supply of offsets from different sources, it is unclear at this time which offsets will qualify under AB32.[2] Therefore, this study considers several different supply curves for offsets in which both the price and availability of offsets vary.

1.3. Organization of the Report

The remainder of the report is organized into four chapters. Chapter 2 describes the different offset curves and their construction. Chapter 3 describes the scenarios run to study the effect of the availability of offsets. Chapter 4 compares the economic impacts on California under different assumptions about the availability of offsets. Chapter 5 summarizes the key insights from this study. The Appendix briefly describes the MRN-NEEM modeling system.

[2] For example, under some regimes, the reductions in methane emissions from flaring of natural gas would count as an offsets, but this is not true under AB32.

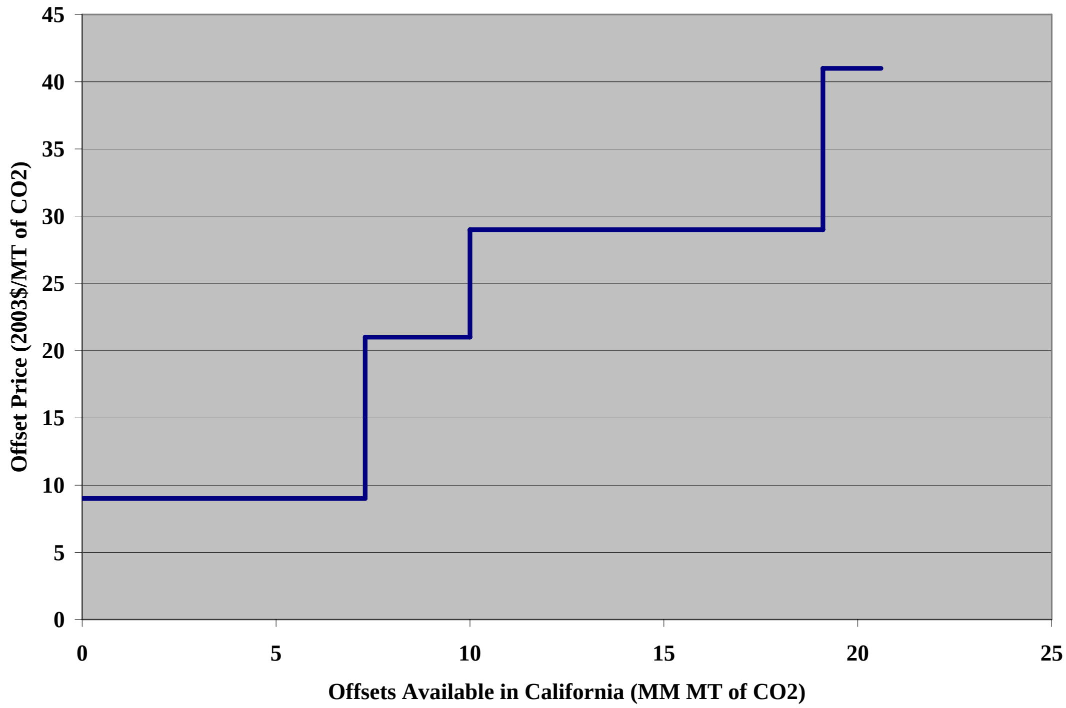
2. OFFSET CURVES

Since the cost and availability of these offsets are highly uncertain, we consider five different offset curves to account for the different geographic availabilities, interpretations about the qualification of offsets, and cost estimates of offsets.

- No offsets from sources outside California (CA_Only)
- Offsets from California and 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%)

Figure 2-1 reports the offsets used in the scenario that assume only California offsets are available. The offsets, all of which cost less than $50/metric ton of CO2, are based on California's Climate Action Team's updated 2007 measures. These reduction opportunities are from policies aimed at reducing non-CO2 GHGs as well as sequestration, forestry and land use management to address CO2 emissions.

Figure 2-1 Offsets from California sources from 2020 onward[3]

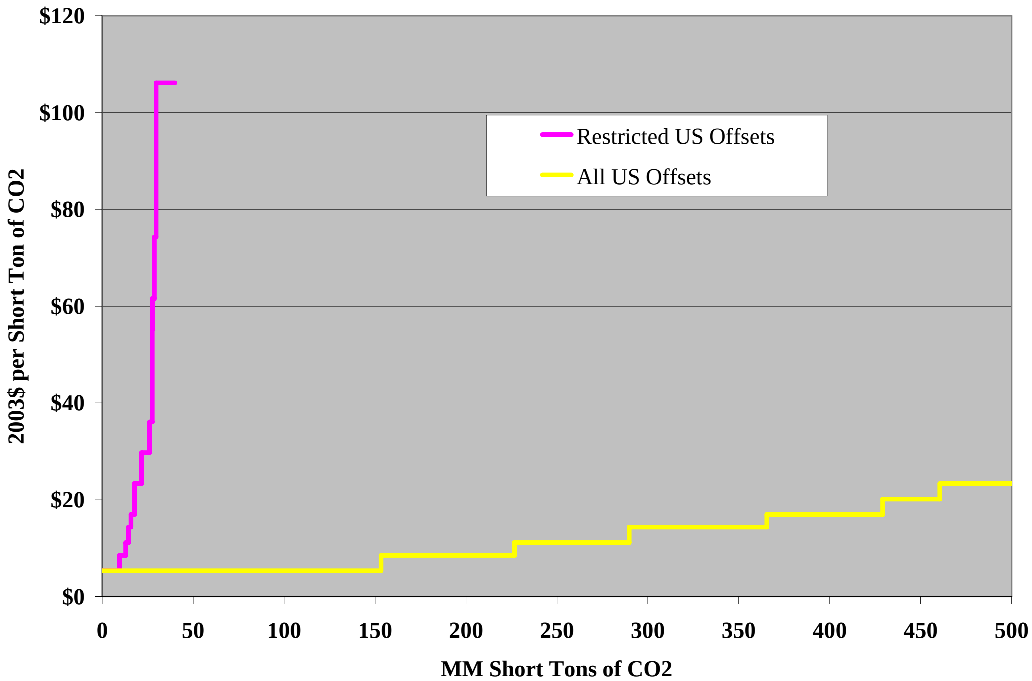


The US offset curves are based on an analysis released by the U.S. EPA as part of its analysis of S.843 in October 2005. The spreadsheet with the offsets information is available at http://www.epa.gov/airmarkt/progsregs/cair/docs/CO2OffsetMarginalCost.xls and there is a supporting memo available at http://www.epa.gov/airmarkt/progsregs/cair/docs/OffsetMethodology.pdf. CRA has made adjustments to these marginal abatement curves to account for transaction costs and adjust for the availability of some of these reductions over time.[4]

[3] Sources include HFC Reduction Strategies, Manure Management, PFC Emission Reduction for Semiconductor Manufacturers, Reduced Venting and Leaks in Oil and Gas Systems, Landfill Methane Capture, Conservation Forest Management, Forest Conservation, Afforestation/Reforestation, Cement Manufacturing, and Enteric Fermentation.

[4] No similar adjustments were made to the CAT curves.

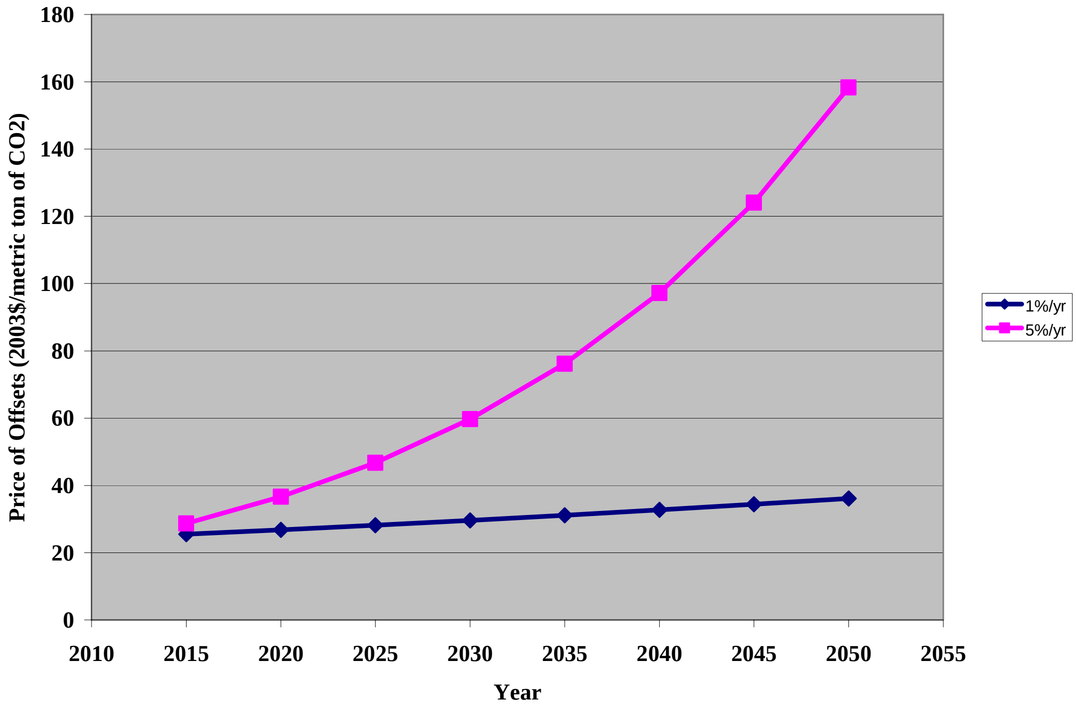
Figure 2-2 Availability of Offsets from the rest of the US in 2020.



Two versions of these offset curves were used. In both cases, the California offsets from Figure 2-1 were subtracted out so that Figure 2-2 reports the remaining offsets available from the rest of the US. The “All US Offsets” assumes offsets from all sources are available to California. The “Restricted US Offsets” case assumes only biosequestration related offsets qualify under California’s rules. Furthermore, only 10% of these offsets are assumed to be available to California. These cases represent a range of possibilities regarding offsets from the rest of the U.S. Figure 2-2 reports the offsets available in 2020. The quantity of offsets available in the All US Offsets case increases over time as the sequestration opportunities are assumed to increase over time: for example the total number of offsets available at a price of $20/ST of CO2 or less increases from about 460 million short tons of CO2 in 2020 to about 645 million short tons of CO2 in 2050.

This report considers two different supply curves for international offsets. In both cases, it is assumed that an infinite number of offsets are available at each price for a given year. The price of international permits is based off of the average 2012 Carbon Emission Reduction credit’s forward price during 2007 from the European Climate Exchange (ECX).

Figure 2-3 Price of International Offsets by Year ($/metric ton of CO2)



We extend the 2012 price by assuming an annual escalation rate. Because of the great uncertainty in future international permit prices, we consider both a low and high price trajectory from the 2012 price. For simplicity, we consider constant escalation rates of 1% and 5% per year. Therefore, under the 5%/yr. case, the 2020 permit price equals the 2012 permit price ($20/ton of CO2) multiplied by the escalation rate from 2012 to 2020 (1.05 to the eighth power) or $30. As an aside, the No Offsets case captures the extreme high end of the price range in that it assumes the international permit prices exceed those of California and hence no international offsets would be available.

The ranking of the offset curves by availability of offsets at the lowest price is as follows: All US Offsets, International-1%, International-5%, Restricted US Offsets, and CA_Only.

3. SCENARIO DESIGN

The five offset supply curves lead naturally to five scenarios. These five scenarios span a wide range of possibilities regarding the availability of offsets and the effect of including or excluding emissions from vehicles. The scenarios are identical in all respects except in the availability of offsets. Table 3-1 gives the scenario names and a brief description of the assumed offset availability for each scenario.

Table 3-1 Definition of scenarios

Scenario Name	Availability of Offsets
CA_Only	California only
US_All	California + Rest of US
US_Restricted	California + Limited Offsets from rest of US
International-1%	California + International 1% rise
International-5%	California + International 5% rise

Baseline:

Our baseline scenario will be consistent with the one we used in the EPRI Report[5] (September 2007) when we modeled California's AB 32. This baseline assumes pre-2007 Energy Policy Act's levels of fuel economy standards.

Scenarios:

For all scenarios, we assume California complies with AB 32 through 2020 by implementing a cap and trade program to control emissions. We assume that the statewide emissions cap descends in a linear fashion from the business-as-usual emissions level in 2012 to the 1990 level in 2020. Since AB 32 is silent about the emission caps after 2020, we assume that the cap is maintained at this same level through the end of the model horizon - 2050. If we were to follow the Executive Order's reductions, this analysis would provide different long-term results. We are more confident in the short term results of this study.

For the CA_Only scenario, all assumptions are the same as they were in our work for EPRI.[6] Scenarios US_All and US_Restricted differ from CA_Only in only the level of offsets available. These scenarios assume the availability of US offsets. The supply of US offsets is reported in Figure 2-2. Scenarios International-1% and International-5% assume the

[5] "An Updated Macroeconomic Analysis of Recent California Climate Action Team Strategies," CRA and EPRI (Oct. 2007).

[6] "An Updated Macroeconomic Analysis of Recent California Climate Action Team Strategies," CRA and EPRI (Oct. 2007).

availability of California and international offsets. Offsets from the US are assumed to be unavailable. Both International scenarios assume an unlimited amount of international offsets, but the price of these offsets differs between the scenarios (see Figure 2-3).

4. MODEL RESULTS AND CONCLUSIONS

This chapter reports the economic impacts of the different scenarios. For each economic metric with the exception of investment, California fares best under the US_All scenario, which has the greatest availability of offsets, and California fares worst under the CA_Only scenario, which has the fewest offsets available.

As the availability of offsets increases, the permit price (see Table 4-1) for California's cap and trade program falls because more offsets are purchased, which slows or halts the increase in permits prices. The purchase of offsets means that California reduces fewer of its in-state emissions while other regions (either the rest of the US or other countries) emit less. But global emissions essentially remain the same. Table 4-2 and Table 4-3 show this relationship between in-state emissions and offsets purchased. Hence the CA_Only policy has the highest permit prices, least amount of in-state emissions, and fewest offsets purchased; whereas the US All scenario has the lowest permit prices, highest in-state emissions, and the most offsets purchased. In-state emissions are still reduced even under the more generous offset policies. It is clear that allowing offsets would not entirely undermine efforts to reduce in-state emissions. Unlike a safety-valve where total emissions can increase, California emissions minus offsets are the same for all scenarios; hence global emissions remain essentially the same in all scenarios.[7] For example, in 2030, total California in-state emissions are at about 600 million tonnes, which is about 100 million tonnes below the baseline levels.

Table 4-1 Market price for CO2 permits under all scenarios (2003$/metric ton of CO2)

	2015	2020	2025	2030	2035	2040	2045	2050
CA_Only	19	81	86	101	107	109	109	102
US Restricted	12	48	62	91	100	104	106	106
International-5%	19	37	47	60	76	97	124	116
International-1%	18	27	28	30	31	33	34	36
US All	5	8	9	14	17	23	27	30

Table 4-2 California GHG emissions for each scenario (million metric tons of CO2)

	2015	2020	2025	2030	2035	2040	2045	2050
Baseline	580	622	656	701	741	783	818	850
CA_Only	516	456	456	456	456	456	456	456
US Restricted	528	484	485	486	494	496	501	500
International-5%	516	509	504	520	511	491	470	466
International-1%	516	528	535	567	591	615	645	674
US All	531	547	571	594	620	641	662	683

[7] Differences in leakage across the scenarios will lead to some small differences in total U.S. emissions across scenarios.

Table 4-3 Offsets purchased by California (million metric tons of CO2)

	2015	2020	2025	2030	2035	2040	2045	2050
CA_Only	6	21	21	21	21	21	21	21
US Restricted	18	48	49	50	58	60	65	64
International-5%	6	74	68	85	75	55	34	31
International-1%	6	92	100	131	155	180	210	238
US All	20	112	135	158	184	206	226	247

An important consideration with any GHG abatement policy is leakage or the effect of reducing emissions in the region controlled by the policy on the change in emissions in the uncontrolled regions. Since we assume that California regulators can control emissions from electricity imports, no leakage of emissions occurs in the electric sector. However, emissions in the non-electric sectors increase outside California (see Figure 4-1).

Figure 4-1 Change in Emissions for the Rest of the US (millions of metric tons of CO2)

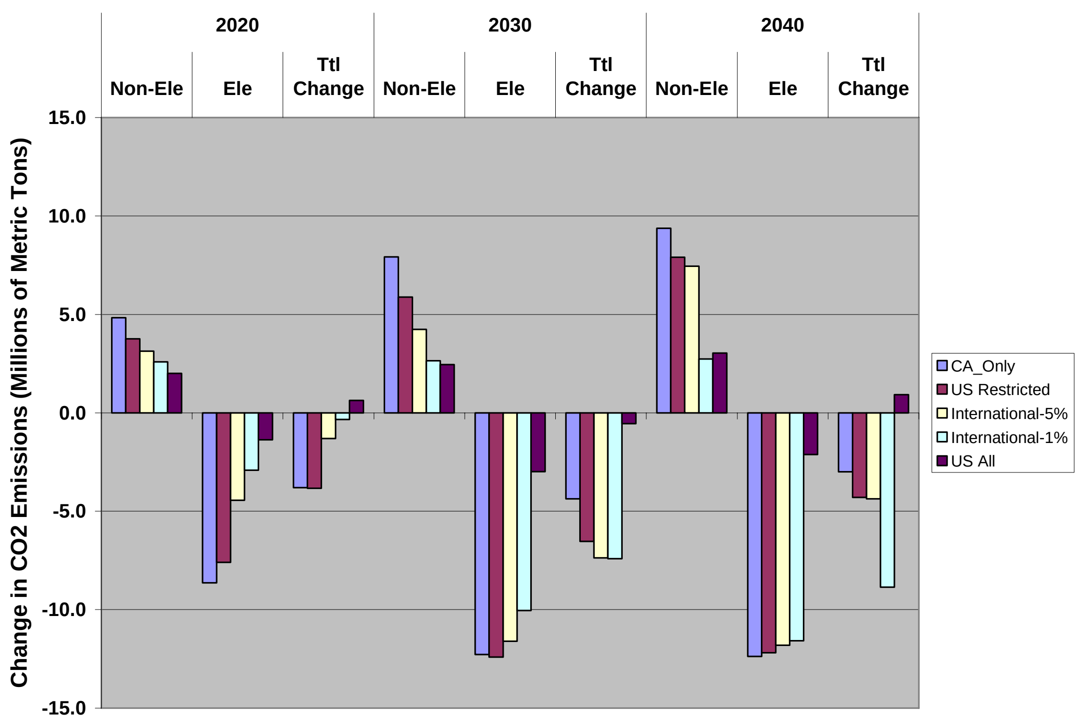
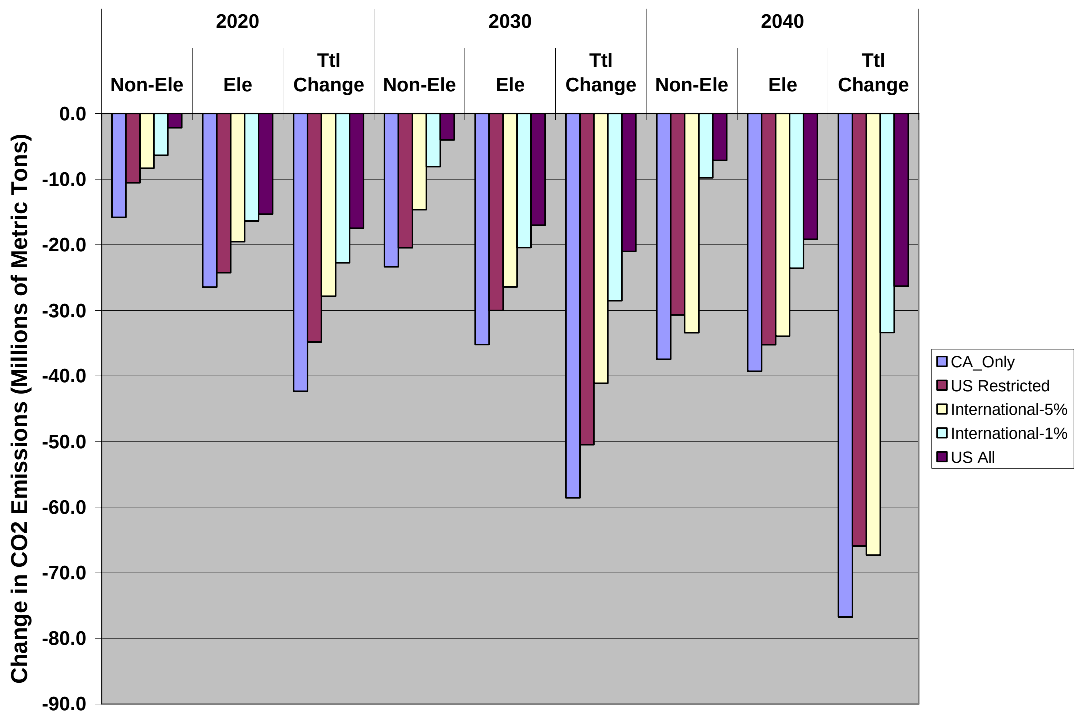


Figure 4-2 Change in Emissions for California (millions of metric tons of CO2)



Therefore, leakage exists in these sectors. For some sectors, leakage reaches close to 100% in the short-run and as high as 70% in the long-run. Though the low offset prices result in fewer emission reductions from California's non-electric sectors, they do compensate for the flow of emissions from non-electric sectors inside to outside of the state.

Under a pure economy wide cap and trade program, higher permit prices imply greater compliance costs. The following tables and figures provide a snapshot of the economic impacts on California's economy under different assumptions about the availability of offsets. These snapshots clearly show that increasing the availability and reducing the cost of offsets lowers the cost of complying with AB 32. Most reductions occur in the electricity sector in this model, since it assumes that California regulators are able to perfectly track the source of all emissions associated with imported power.

Table 4-4 Percentage change in California's welfare under the different scenarios

	Welfare
CA_Only	-0.52%
US Restricted	-0.39%
International-5%	-0.41%
International-1%	-0.16%
US All	-0.10%

Table 4-4 reports the percentage change in overall economic welfare for California over the model horizon (2010 to 2050) under the different scenarios. The welfare impacts under the US-All scenario are less than one-fifth of those of under the CA_Only scenario. This implies that for California, the cost-effectiveness of AB32 increases by a factor of five as the availability of offsets moves from a limited set of in-state options to a full set of options available in the rest of the US. That is, the cost shrinks by a factor of five while total global emissions remain roughly the same.

Figure 4-3 (below) further shows that having a large supply of low cost offsets available in the near term can greatly mitigate losses in consumption. Comparing the consumption losses under the CA_Only to the US_All scenario, one can see that offsets could cut the losses by 50% in 2015 and by as much as 80% in 2020.

Figure 4-3 Change in California's consumption for all scenarios

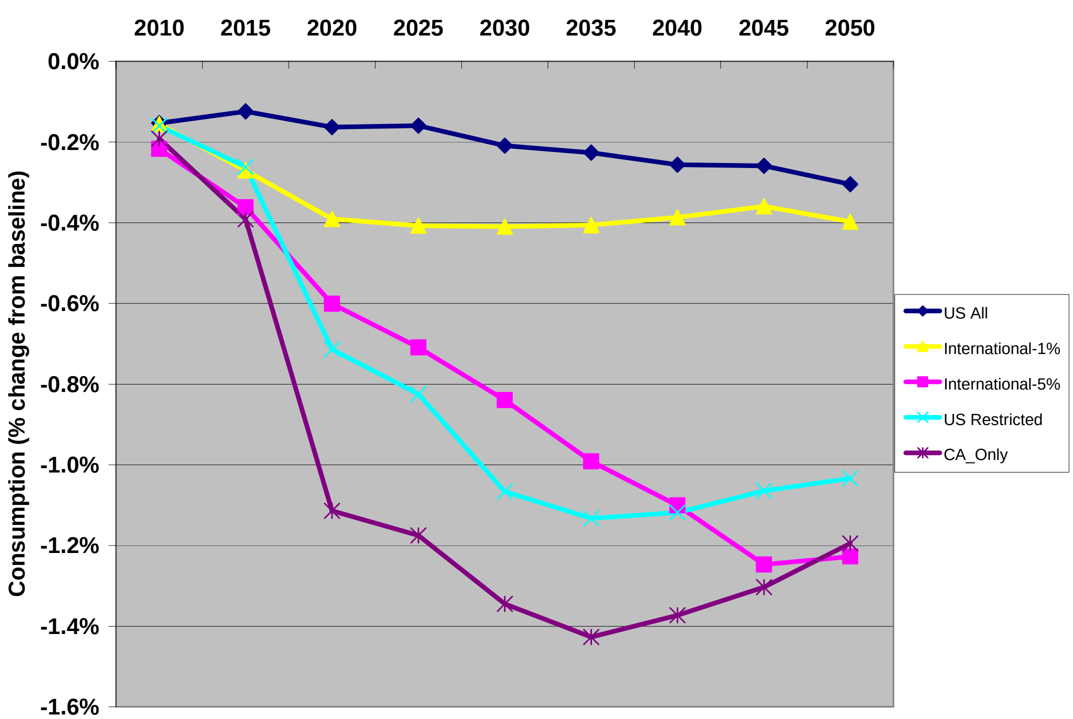
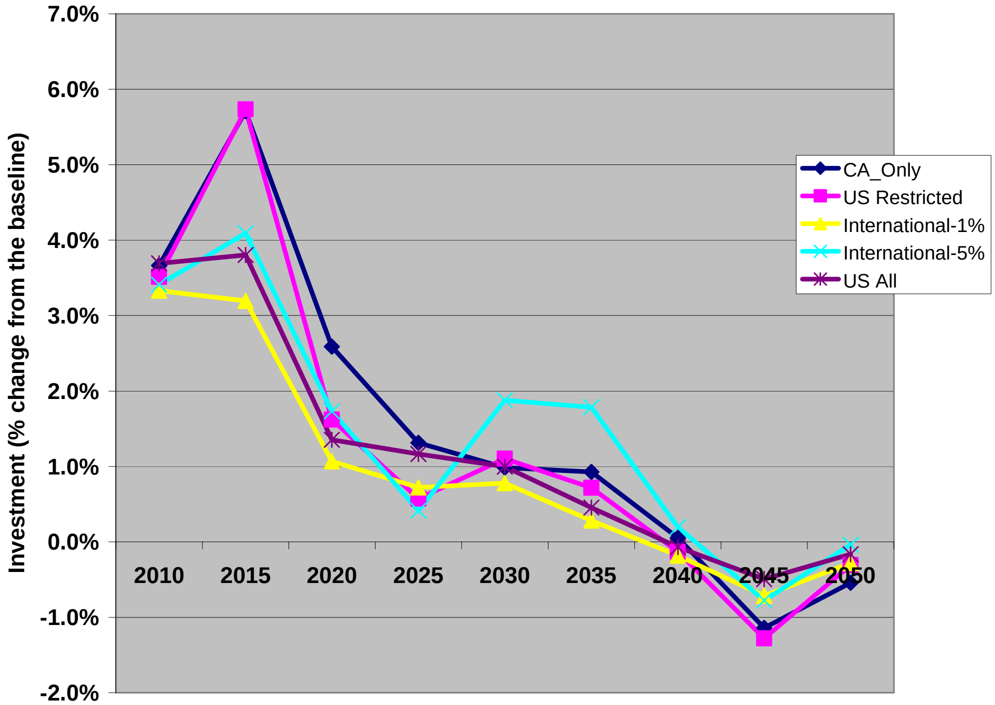
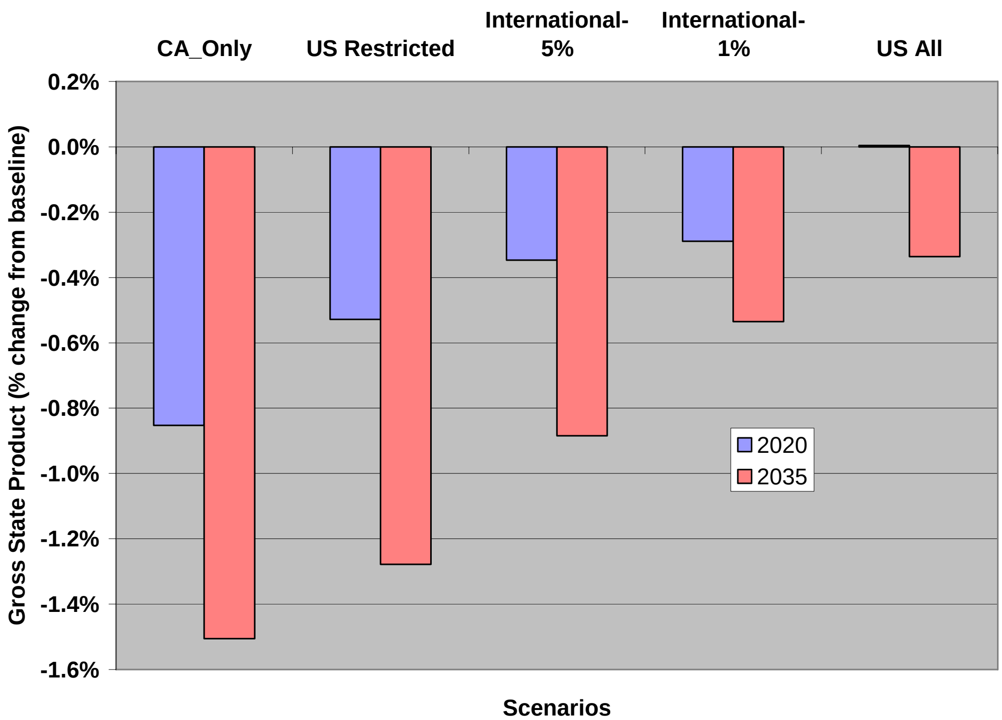


Figure 4-4 Change in California's aggregate investment for all scenarios



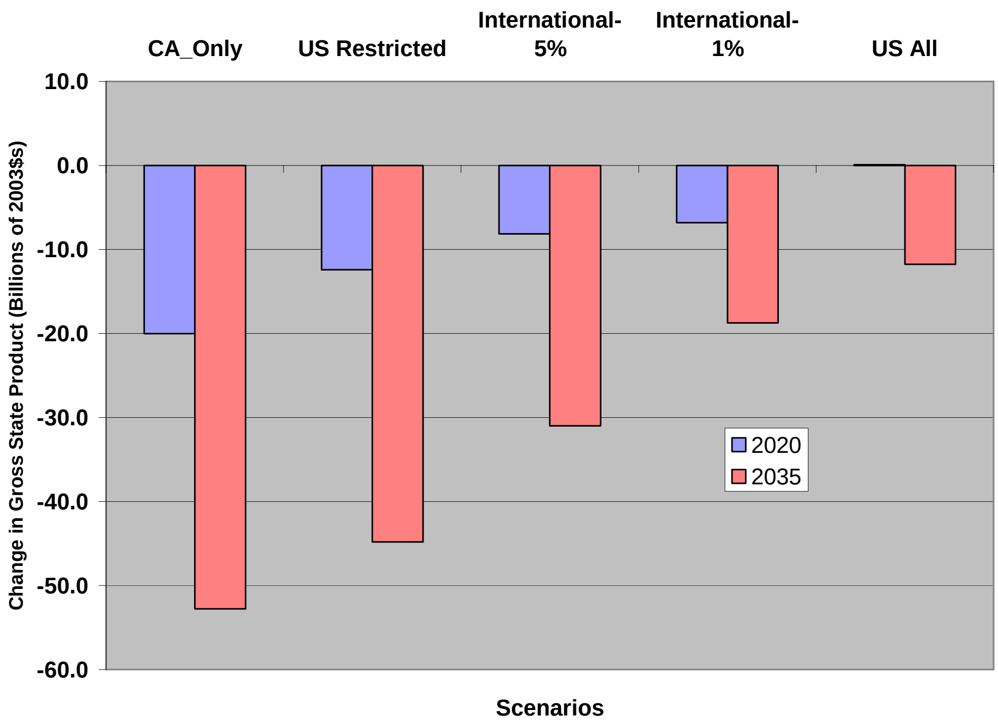
All scenarios induce an increase in investment toward lower emitting technologies (see Figure 4-4). Therefore, even with a generous offset scenario, the resulting carbon price will stimulate important in-state investment in low-carbon technologies. However, the larger increases in investment under the CA_Only and US_Restricted scenarios signal a greater shock to the California economy and hence a greater need to change technologies. These large near-term changes suggest the importance of having offsets available in the near-term so that costs can be moderated to allow time for the needed higher efficiency or lower emission intensity technologies to be developed.

Figure 4-5 Change in California's gross state product in 2020 and 2035



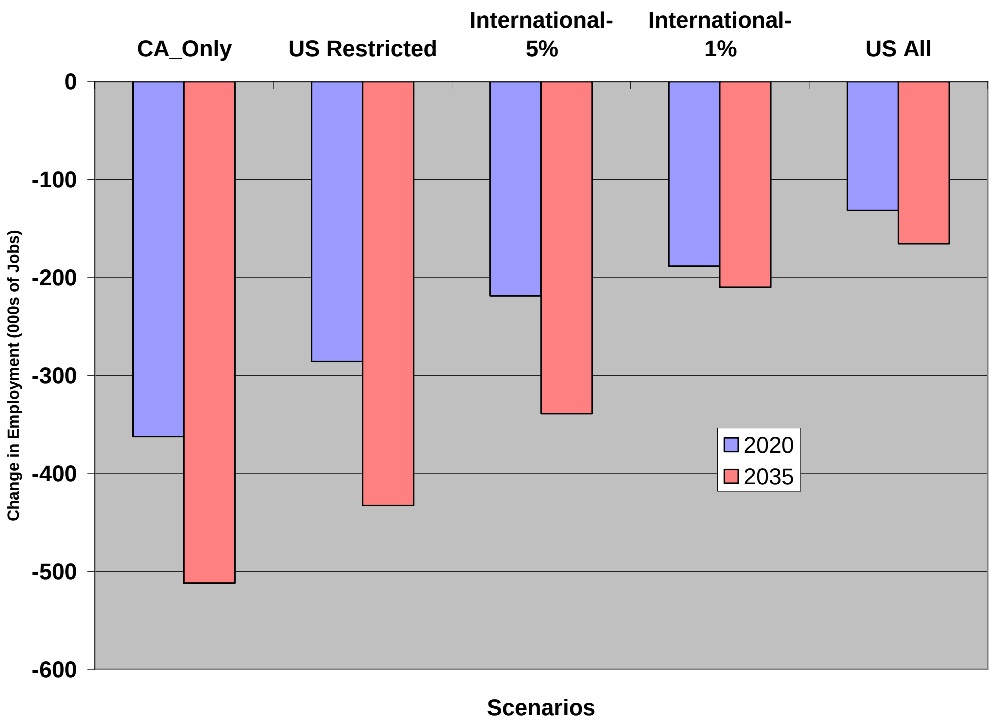
The loss in GSP across scenarios and years follows a similar pattern to that of consumption. For both measures, the decline increases over time and with the reduction in offsets. That is, the result matches one's intuition in that as the cap becomes more binding the macroeconomic losses increase.

Figure 4-6 Change in California's gross state product in 2020 and 2035 (Billions of 2003$s)



The higher losses in employment under the scenarios with fewer offsets reflect higher GDP and economic losses seen in the previous figures and tables. The employment losses increase with the increasing required emission reductions over time.

Figure 4-7 Change in employment for 2020 and 2035 (thousands of jobs)



5. CONCLUSION

This study makes no attempt to determine the actual carbon price or availability of true offsets but shows clearly that offsets could significantly lower the economic costs of complying with AB 32. Therefore, it would be prudent to research all possible sources of offsets to determine which ones are viable.

Unlike a safety-valve where total emissions can increase, California emissions less offsets are the same for all scenarios; hence global emissions remain the same in all scenarios. However, offsets must assure that emission reductions are permanent and would not have occurred if not for an outside investment. Regulators should focus on developing rules on allowing permanent offsets.

The importance of offsets depends greatly on the availability of low emitting technologies. If R&D programs prove successful at developing low emitting technologies such as IGCC with carbon capture, then the need for offsets will be less than if these technologies prove difficult to develop. Since these technologies likely will not come on-line for the next ten to twenty years, the availability of offsets in the near-term is quite critical.

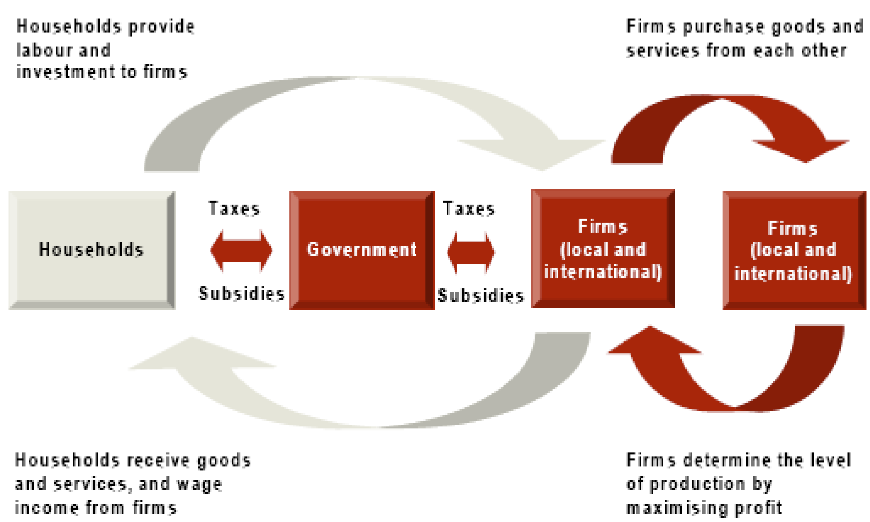
6. APPENDIX: MRN-NEEM MODELING SYSTEM

In conducting this analysis for Chevron, CRA International combined two widely accepted state-of-the-art economic models: the Multi-Region National (MRN) model and the North American Electricity and Environment Model (NEEM). The linked model approach made it possible to understand the economy-wide impacts of specific climate policies.

6.1. OVERVIEW OF THE MRN SUBMODEL

The top-down component of the integrated MRN-NEEM model is tailored from CRA International's Multi-Region National (MRN) model. MRN is a forward-looking, dynamic computable general equilibrium (CGE) model of the United States. It is based on the theoretical concept of an equilibrium in which macro-level outcomes are driven by the decisions of self-interested consumers and producers. The basic structure of CGE models, such as MRN, is built around a circular flow of goods and payments between households, firms, and the government, as illustrated in Figure 6-1.

Figure 6-1 Circular Flow of Goods and Services and Payment



6.2. OVERVIEW OF THE NEEM SUBMODEL

The North American Electricity and Environment Model (NEEM) fills the need for a flexible, partial equilibrium model of the North American electricity market that can simultaneously model both system expansion and environmental compliance over a 30- to 50-year time frame.

The model employs detailed unit-level information on all of the generating units in the United States and large portions of Canada. In general, coal units over 100 MW are represented individually in the model, and other unit types are aggregated. NEEM models the evolution of the North American power system, taking account of demand growth, available generation, and environmental technologies, and environmental regulations both present and future. The North American interconnected power system is modeled as a set of regions that are connected by a network of transmission paths.

6.3. MRN-NEEM INTEGRATION METHODOLOGY

The MRN-NEEM integration methodology follows an iterative procedure to link top-down and bottom-up models. The method utilizes an iterative process where the MRN and NEEM models are solved in succession, reconciling the equilibrium prices and quantities between the two. The solution procedure, in general, involves an iterative solution of the top-down general equilibrium model given the net supplies from the bottom-up energy sector sub-model followed by the solution of the energy sector model based on a locally calibrated set of linear demand functions for the energy sector outputs. The two models are solved independently using different solution techniques but linked through iterative solutions points (see Figure 6-2).

Figure 6-2 Integration of MRN-NEEM