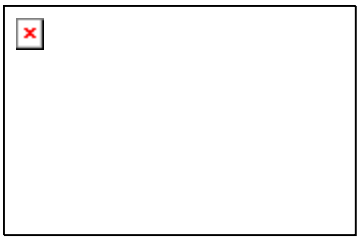

Cost Effective GHG Mitigation Measures for California

Summary Report: An Independent Analysis of Measures to Reduce Greenhouse Gas Emissions in 2010 and 2020 to Meet Executive Order S-3-05

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Executive Summary

To inform the deliberations of the California Energy Commission's Climate Change Advisory Committee and assist in its development of recommendations in its *Integrated Energy Policy Report*, the Center for Clean Air Policy ("the Center" or "CCAP") conducted and compiled multiple "bottom-up" assessments of measures that can reduce GHG gas emissions in California. On June 1, 2005, Governor Schwarzenegger issued Executive Order S-3-05 which calls for a reduction in GHG emissions to 2000 levels by 2010 and to 1990 levels by 2020, with a further reduction to 80% below 1990 levels by 2050. The results of this study have been subsequently applied to the goals set by S-3-05 to analyze the likely feasibility and cost of meeting the targets set for 2010 and 2020.

Specifically, reductions studied by the Center within the agriculture/forestry, cement, methane, transportation and high GWP (HFCs, PFCs and SF_6) sectors combined with measures already underway in California can achieve 88% of the 2010 reduction target and 86% of the 2020 reduction target on their own. The CCAP analysis has not yet examined the potential for cost effective reductions from the electricity and petroleum refining sectors, sectors that were responsible for more than 25% of greenhouse gas emissions in California in 2002. These sectors are expected to help contribute to the ability for the state to reach both its 2010 and 2020 targets cost effectively.

Taking into account the benefits to consumers of the greenhouse gas standards for light duty vehicles and the energy efficiency measures now underway in California, this study finds that carbon reductions sufficient to meet the Governor's targets can be achieved at no net cost to consumers and likely at a net benefit in both 2010 and 2020. The measures identified by the Center have average costs of just $5.25 per ton and $5.77 per ton in 2010 and 2020, respectively. The low cost of CCAP's measures is due to the fact that many measures have a cost of less than zero (i.e., a net benefit) and a significant portion of the measures studied have a cost between zero and $10 per ton.

Since the core CCAP analysis looks solely at costs, separate analyses performed by the California Air Resources Board and by the Natural Resources Defense Council have been reviewed to provide estimates of the annual economic benefits from the proposed Vehicle GHG Standards and the new energy efficiency programs. CARB estimates that the vehicle GHG standards will produce net benefits of $195 million and $2.8 billion in 2010 and 2020, respectively. NRDC estimates the expected savings to consumers from energy efficiency programs in the State of California are expected to result in aggregate savings of nearly $527 million in 2010.

Applying the financial benefits of the vehicle standards and the energy efficiency standards towards the cost of implementing the additional 7 million tons of reductions required to achieve the Governor's target in 2010, it is expected that the 2010 target can be achieved at no cost to consumers. In a similar fashion, applying the benefits of just the enacted Vehicle GHG standards towards the 2020 target, the 2020 target can also be achieved at no cost to consumers, provided that additional reductions to meet the 2020 target cost no more than $123 per ton.

Introduction

To inform the deliberations of the California Energy Commission's Climate Change Advisory Committee and assist in its development of recommendations in its *Integrated Energy Policy Report*, the Center for Clean Air Policy ("the Center" or "CCAP") conducted and compiled multiple "bottom-up" assessments of measures that can reduce GHG gas emissions in California over the last 18 months. Where available, the Center used existing California analyses and supplemented this work with the Center's own independent analysis. The goal of this effort was to identify and quantify a range of GHG emissions reduction and sequestration opportunities in the State, including identifying those activities that might reasonably be implemented and the potential costs of the reductions. It should be noted that in-depth analysis of the power and refining sectors has not been conducted and are planned as the likely next phase of CCAP's analysis.

On June 1, 2005, Governor Schwarzenegger announced greenhouse gas (GHG) emission reduction targets for California and signed Executive Order S-3-05 to codify the reductions and establish an inter-agency task force headed by the Secretary of the California Environmental Protection Agency. Executive Order S-3-05 calls for a reduction in GHG emissions to 2000 levels by 2010 and to 1990 levels by 2020, with a further reduction to 80% below 1990 levels by 2050. The Secretary is required to deliver to the Legislature and Governor an initial report on the progress of implementing the Executive Order by January 2006. The results of this study have been subsequently applied to the goals set by S-3-05 to analyze the likely feasibility and cost of meeting the targets set for 2010 and 2020.

Overview of Measures Considered

For this report the Center evaluated the cost-effectiveness and reduction potential for GHG mitigation options in the transportation and cement sectors, as well as options for sequestering carbon dioxide and methane emissions in the forestry and agriculture sectors. The Center's work was combined with a series of sector-specific GHG mitigation analyses conducted by ICF Consulting ("ICF") for the California Energy Commission's Public Interest Energy Research (PIER) program.[1] In their work for PIER, ICF evaluated measures to reduce methane in the landfill, dairy, and natural gas sectors, and high global warming potential gases (HFCs, PFCs and SF_6) in the semiconductor and other sectors.

Table 1
Total GHG Reduction Potential
($MMTCO_2e$)

Sector	2010	2020
Agricultural/Forestry	5.8	32.1
Cement	2.1	2.2
HFC	0.9	6.2
Methane	15.6	16.7
Oil Refining	TBD	TBD
PFC	3.1	7.1
Power	TBD	TBD
SF6	1.2	1.5
Transportation	8.4	64.6
Total	**36.9**	**130.5**

[1] ICF Consulting, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, July 2005, http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-121.html

In total, the measures analyzed for this report are projected to reduce GHG emissions by nearly 37 million metric tons carbon dioxide equivalent ($MMTCO_2e$) in 2010 and over 130 $MMTCO_2e$ in 2020. Table 1 provides a breakdown of the reductions by sector for each of the target timeframes. Each of the sectors is discussed in the sections that follow.

Agriculture/Forestry, Cement and Other Sector Analysis. CCAP and ICF have estimated the potential GHG emission reductions from key sectors of the California economy, including agriculture/forestry, methane, cement, and high global warming potential (GWP) gases. The latter three sectors accounted for over 8% of total gross GHG emissions statewide in 2002, while land use change and forestry sinks offset about 4% of total state emissions.[2] These sectors thus present important opportunities for achieving significant emission reductions. In addition, available measures and technologies in these sectors can achieve a major portion of the potential reductions at a relatively low cost, with many measures producing a net cost savings.[3] Some of the key measures analyzed in these sectors are discussed below:

- **Agriculture/forestry.** In the forestry sector, CCAP identified measures that could achieve reductions totaling 5.8 $MMTCO_2e$ in 2010 and 32.1 $MMTCO_2e$ in 2020. Significantly, all of the reductions estimated in 2010 would be obtained at less than $20 per metric ton, with 4.7 $MMTCO_2e$ at less than $10 per metric ton. No-till cropping could produce reductions of 1.9 $MMTCO_2e$ in 2010 and 3.8 $MMTCO_2e$ in 2020, while combustion of thinned biomass to displace fossil-fired electricity could reduce emissions by 1.7 $MMTCO_2e$ in 2010 and 3.7 $MMTCO_2e$ in 2020, all at a price of less than $10 per metric ton. The California Climate Action Team has posted a potential reduction value for forestry that is higher than the estimate we present. It is possible that with more research tailored to look at forest carbon opportunities across the state that a greater total reduction can be achieved. CCAP's full report *Activities and Policies to Enhance Forest and Agricultural Carbon Sinks in California* is available at http://www.climatechange.ca.gov/documents/2005-10-14_CCAP_REPORTS/CCAP_REPORT_FORESTRY-AG.PDF

- **Cement.** The CCAP study found that nearly 2 $MMTCO_2e$ could be reduced annually from measures costing less than $30 per metric ton (1.8 $MMTCO_2e$ in 2010 and 1.9 $MMTCO_2e$ in 2020). One-half (over one $MMTCO_2e$) of the annual reductions would be obtained from measures that would produce a net cost savings, including the use of limestone Portland cement (0.6 $MMTCO_2e$ and 0.7 $MMTCO_2e$ in 2010 and 2020, respectively). Blended cements would account for about 0.7 $MMTCO_2e$ in 2010 and 2020, at a cost of less than $5 per metric ton. An additional 0.18 MMTCO2e/year of reductions could be achieved cost-effectively by replacing coal with waste tire as a boiler fuel, but this option is not included because local community opposition makes it an unlikely option. CCAP's full report *Reducing CO2 Emissions from California's Cement Sector is available at* http://www.climatechange.ca.gov/documents/2005-10-14_CCAP_REPORTS/CCAP_REPORT_CEMENT.PDF

[2] *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, California Energy Commission, June 2005. Methane emissions include emissions from landfills, manure management, and natural gas systems only.

[3] All costs in this report are expressed in year 2000 dollars. Costs for all measures were discounted at an annual rate of 4%, except for transportation measures, which were discounted at 5% in the original source (the CEC *Integrated Energy Policy Report* 2005). Costs for 2010 and 2020 are annual costs for most sectors; agriculture/forestry and cement costs are cumulative average costs per cumulative metric ton reduced.

- **Methane.** The emission and cost estimates for methane draws upon a study prepared for the California Energy Commission's PIER program by ICF, which estimated the total emission reduction potential in California for landfills, manure management, and natural gas systems at 15.6 and 16.7 $MMTCO_2e$ in 2010 and 2020, respectively. CCAP also performed its own additional in-depth analysis of the potential for methane in arriving at the results presented.

  The ICF study found that landfills have the largest methane reduction potential, totaling 9 $MMTCO_2e$ in 2010 and 9.7 $MMTCO_2e$ in 2020 from direct gas use and electricity generation projects. All of the emission reduction measures would cost less than $20 per metric ton, while one-fourth (about 2.3-2.4 $MMTCO_2e$) of the total reduction potential can be achieved in both years through measures that produce a net cost savings.

  The methane reduction potential from manure management at dairy farms is also significant (5.8 $MMTCO_2e$ in 2010 and 6.2 $MMTCO_2e$ in 2020). The measures considered included coverage of lagoons and installation of methane digesters. While all manure management measures evaluated cost less than $20 per metric ton, nearly 3 $MMTCO_2e$ annually could be achieved with a net cost savings.

  CCAP's analysis of potential savings from methane reductions is summarized in its report *Prospects for Participation of Methane Sectors in Emissions Trading Programs in California* available at http://www.climatechange.ca.gov/documents/2005-10-14_CCAP_REPORTS/CCAP_REPORT_METHANE.PDF

- **High GWP Gases (HFCs, PFCs & SF_6).** The ICF study estimates that measures targeting emissions of HFCs, PFCs and SF_6 could reduce over 5 $MMTCO_2e$ in 2010 and nearly 15 $MMTCO_2$ in 2020. Measures to reduce HFC emissions in motor vehicle air conditioning and refrigeration could reduce nearly 3 $MMTCO_2e$ in 2020 with a net cost savings, while other measures (reduction of leaks and recovery of SF_6 in electric power systems, plasma abatement to reduce PFC emissions, and other HFC reduction measures) costing less than $30 per metric ton could reduce emissions by an additional 4.8 $MMTCO_2e$ in 2010 and 12 $MMTCO_2e$ in 2020.

Transportation Sector. In order to adequately address GHG emissions, California must reduce the growth of emissions from the biggest source - the transportation sector. Emissions from the state's cars, buses, trucks, trains, planes, and other vehicles account for almost 40 percent of statewide GHGs. In fact, passenger vehicles emit more than the electricity sector, and freight and aviation emissions are both greater than the state's residential sector emissions. Importantly, transportation emissions are growing at almost 2% per year, driven primarily by increasing travel demand (VMT).

Analysis guided by the Transportation Advisory Committee (TAC) of the Climate Advisory Committee includes a comprehensive set of strategies covering all areas of the transportation sector along with policy recommendations.[4] The goal of the TAC was to contribute to a

[4] This included a review pertinent data on transportation emissions and costs, including information provided by CEC and CARB as well as from industry, non-profit organizations and other U.S. states.

statewide goal of achieving 2000 emissions levels by 2020. Several priority strategies, quantified by the Center, include:

- **Freight.** Shifting 10 percent of 2020 truck traffic to rail would reduce emissions by 3.3 $MMTCO_2$ in 2020 and reduce fuel costs by $713 million in 2020. A *national* study conducted by the nonpartisan American Association of State Highway and Transportation Officials (AASHTO) calculates that increased rail infrastructure costs would be offset by reduced highway costs and user cost savings, with net benefits from a 10 percent shift from truck to rail of $35 billion per year.[5] Further GHG and cost savings can be achieved by replacing older truck engines, electrifying cranes or converting other high-use diesel port equipment

- **Travel Demand.** Existing transportation and land use planning forums provide important opportunities to consider the impact of future infrastructure and development patterns on climate change. A review of metropolitan planning organization (MPO) regional plans for San Diego, Los Angeles, San Francisco, Sacramento and others indicated potential GHG savings of 7.7 $MMTCO_2$ in 2020, with fuel costs reductions of over $1.5 billion in 2020. A *national* study conducted by The Research Institute for Housing America estimated potential public and private savings of up to $10 billion a year from the types of "smart growth" measures contained in the MPOs' plans.[6]

  Reducing transportation sector's contribution to GHG emissions in California can provide significant energy, cost and fuel savings to residents. It also represents an opportunity to show national leadership on a challenge sector, comprised of fast-growing emission sources. CCAP's full report *Analysis of Measures for Reducing Transportation Emissions in* California is available at http://www.climatechange.ca.gov/documents/2005-10-14_CCAP_REPORTS/CCAP_REPORT_TRANSPORTATION.PDF

Oil Refining and Power Sectors. The Center has not yet completed a "bottom up" analysis of reductions from the power and oil refining sectors. According to the most recent state inventory, in-state power plants emitted about 44 $MMTCO_2e$ in 2002 and imported power accounted for about 52 MMTCO2e in 2002. Refining emissions accounted for over 32 $MMTCO_2e$ in 2002.[7] Additional analysis is needed on the technical viability and cost-effectiveness of specific control measures in these sectors.

Comparison of CCAP Estimates to Estimates Released by the Climate Action Team

On December 8, 2005 the Climate Action Team released its draft *Climate Action Team Report to the Governor and Legislature*. The report by the Climate Action Team estimates emission

[5] American Association of State Highway Transportation Officials (AASHTO), 2003. *Freight-Rail Bottom Line Report*, Table 17. http://freight.transportation.org/doc/FreightRailReport.pdf

[6] Research Institute for Housing America. 2001. *Linking Vision with Capital –Challenges and Opportunities in Financing Smart Growth*. www.housingamerica.org/docs/RIHA01-01.pdf.

[7] Refining emissions includes emissions from the following categories: refining, transformation at refinery, refinery still gas, oil refinery use, and petroleum coke oil refinery use. Values taken from *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, California Energy Commission, June 2005

reductions from many of the same sectors studied by CCAP. The major differences between CCAP's estimates and the Climate Action Team's estimates appear below.

Sectors where CCAP estimates that more cost effective reductions are available include (in MMTCO2e in 2010 and 2020):

- Manure management +5.8 and + 5.24
- Landfill gas +5.84 and +5.43
- Shifting truck freight to rail +3.25 in 2020 only

Sectors where CCAP estimates less potential for cost effective reductions than the Climate Action Team include (in MMTCO2e in 2010 and 2020):

- Afforestation - 7.3 in 2020
- Smart growth - 4.8 and – 10.3

Measures with no CCAP estimates:

- Tightened tailpipe standards post 2017
- Carbon reduction strategies from private and public power facilities serving California

These differences point up the fact that there is potential for additional cost effective reductions to help meet the Governor's targets if a more aggressive approach is taken in key sectors. In addition, neither the CCAP analysis nor the Climate Action Team analysis examine the potential for cost effective reductions in the petroleum refining sector. Given the reported success of the BP, Shell and PEMEX internal company greenhouse gas trading initiatives in recent years in identifying low and net benefit reduction measures in oil industry operations, this sector deserves in-depth analysis in the coming year.

Cost Effectiveness of Measures

As discussed above, within each sector individual measures can be implemented across a wide-range of prices. By aggregating the reduction measures from all sectors studied by the Center at various prices a sense of the total cost-effectiveness of the package of measures can be determined.

As illustrated in Table 2 the measures analyzed by the Center provide a total reduction of 29.4 $MMTCO_2e$ in 2010 and 58.0 $MMTCO_2e$ in 2020 *at a price of less than $30 per metric ton.*

In addition, Charts 1 and 2 provide a breakdown of the cost effectiveness of the measures plotted against the tons of reductions achieved for the 2010 and 2020 timeframes, respectively.

Table 2
Cumulative GHG Reductions
By Cost, < $50/metric ton
(excludes oil and power sectors)

Step ($/ton CO_2e)	**Reductions** ($MMTCO_2e$)	
	2010	**2020**
< $0	8.11	20.84
< $10	22.66	42.52
< $20	26.73	51.31
< $30	29.40	58.01
< $50	30.25	68.06

Uncertainties in the Cost-Effectiveness. Importantly, while some of the measures do not appear cost-effective when evaluated just for their GHG emissions benefits, they may be cost-competitive when considering co-benefits. For example, many transportation measures will reduce criteria pollutants in addition to emissions of GHGs. In nonattainment areas, these GHG mitigation actions will also defray the cost of state and local control measures. Other co-benefits may be less quantifiable, such as improvements in livability from measures that reduce sprawl.

In addition, some of the measures may not include the full costs. In particular, ICF's analysis of emissions reductions in the dairy industry may not include the full costs of NO_x control technologies that would be needed to meet more stringent air quality requirements in the San Joaquin Valley. Moreover, ICF's most recent assessment of methane reduction opportunities in the landfill sector has changed significantly from their earlier version with use of a different methodology. These numbers may be more uncertain than cost estimates for other sectors.

Chart 1
Emissions Reductions in 2010 by Sector and Cost (<$50/MTCO$_2$e)

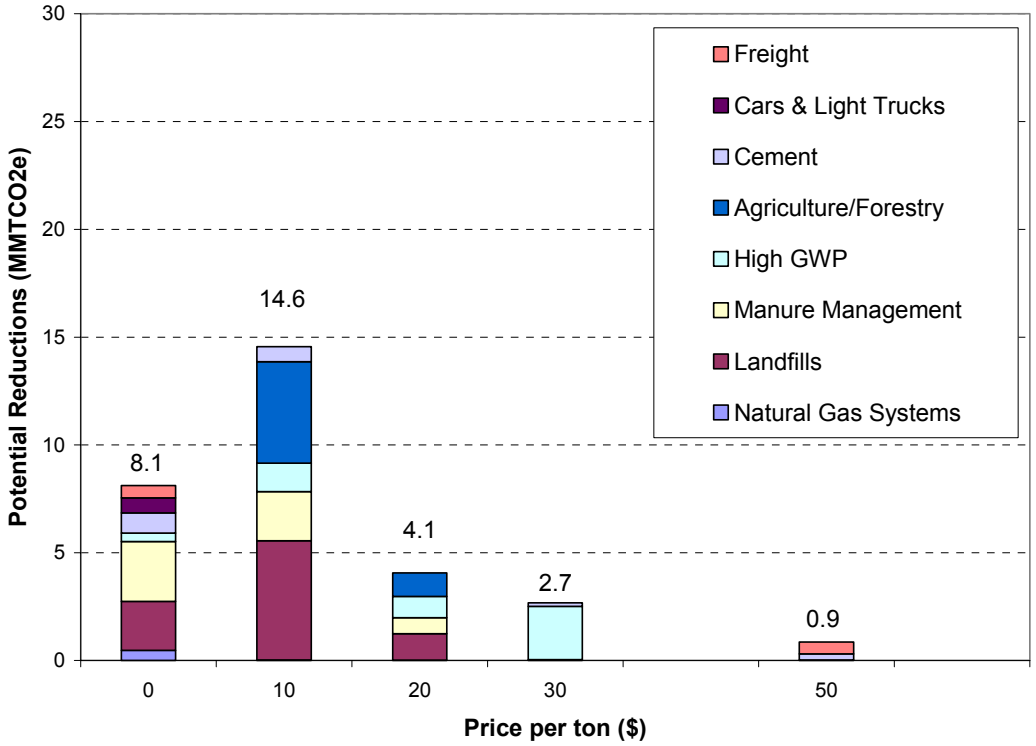
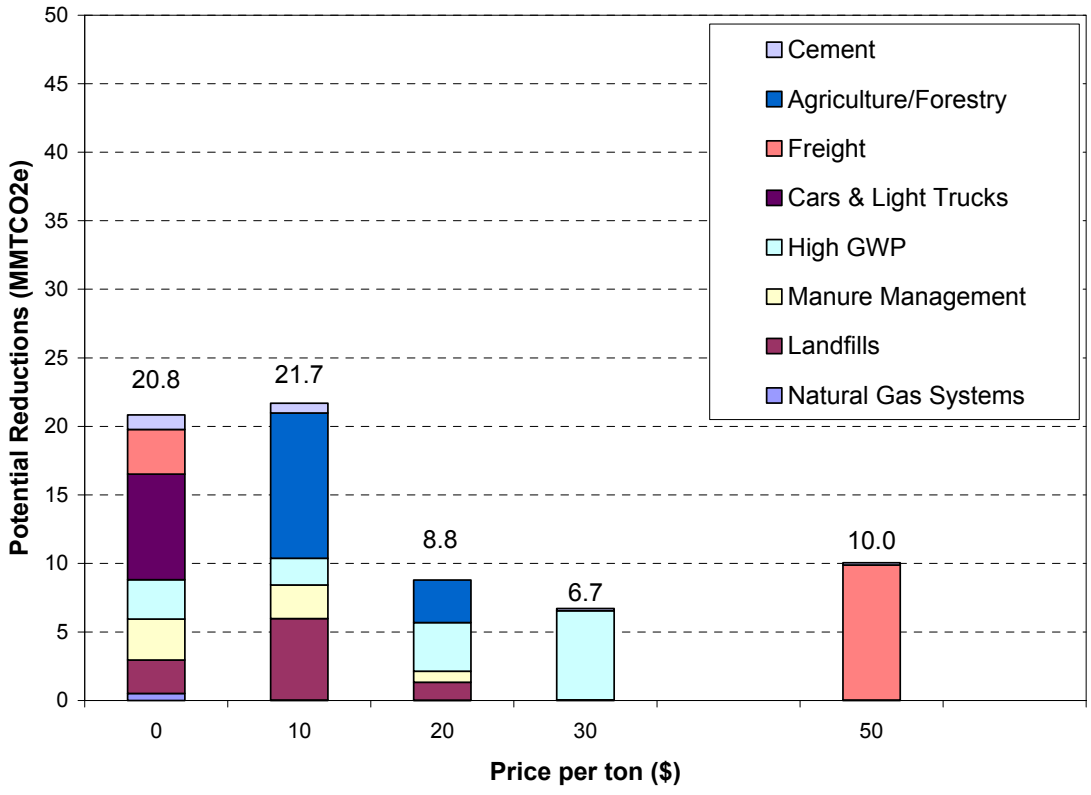


Chart 2:
Emissions Reductions in 2020 by Sector and Cost (<$50/MTCO$_2$e)



Strategies Already Underway In California

The measures evaluated by the Center are additional to a set of strategies already underway in California. As compiled by the California Climate Action Team, such strategies are estimated to reduce GHG emissions in the state by 22 $MMTCO_2e$ in 2010 and 67 $MMTCO_2e$ in 2020 as shown in Table 3.

Table 3
Strategies Already Underway in California[8]

Lead Agency *Strategy*	*GHG Savings (Million Metric Tons CO_2 Equivalent)*	
	2010	**2020**
Air Resources Board		
Vehicle Climate Change Standards	1	30
Diesel Anti-Idling	1	1.2
Energy Commission/Public Utilities Commission		
Accelerated Renewables Portfolio Std (33% by 2020)	5	11
California Solar Initiative	0.4	3
Investor Owned Utility Energy Efficiency Programs	4	8.8
Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Energy Commission		
Building Energy Efficiency Standards	1	2
Appliance Efficiency Standards	3	5
Fuel-efficient Replacement Tires & Inflation Programs	1.5	1.5
State and Consumer Services/CalEPA		
Green Building Initiative	0.5	1.8
Air Resources Board/Cal EPA		
Hydrogen Vehicles	Not yet estimated	
Total Potential Emission Reductions	**22**	**67**

Reductions from Additional Sectors

Finally, as noted earlier, there may be additional cost-effective opportunities in the power and refining sectors, and in other sectors not included in these analyses. For example, while emissions from the residential and commercial building heating sectors were not evaluated, measures undertaken in these sectors could play an important role in mitigating GHG emissions in California

[8] From Table ES-3 in the Climate Action Team's December 8, 2005 draft report to the Governor and Legisltaure.

Attainment of the Emission Reduction Targets

As described in Table 5, based on updated emission baseline estimates for 2010 and 2020 developed by CEC[9], the emission reduction opportunities identified in this report meet the aggressive GHG reduction targets established by Governor Schwarzenegger for 2010 when combined with reductions already underway and with reductions expected from the power and refining sectors. Specifically, when measures below $30 per metric ton CO_2e are combined with measures already underway in California a total reduction of 51 $MMTCO_2e$ is achieved, which is 91% of the targeted amount. This is 5 $MMTCO_2e$ short of the Governor's 2010 reduction target.

For 2020, when measures below $30 per metric ton CO_2e are combined with measures already underway in California a total reduction of 126 $MMTCO_2e$ is achieved, which is 73% of the target. This is 19 $MMTCO_2e$ short of the 2020 reduction target.

Table 4
Mitigation Strategies Compared with Targets[10]

	2010	2020
Projected Future Baseline Emissions	542	591
2000 Actual Emissions (Net CA emissions including imported electricity)	483	N/A
Required Reductions in 2010 (Projected 2010 less 2000 Actual)	58	N/A
1990 Actual Emissions (Net CA emissions including imported electricity)	N/A	446
Required Reductions in 2020 (Projected 2020 less 1990 Actual)	N/A	145
Strategies Already Underway (from Table 3)	22	67
CCAP Mitigation Measures Less Than $30 per metric ton CO_2e (from Table 2)	29	58
Total Mitigation (CCAP <$30 + Strategies Underway)	51	125
Difference From Target (MMTCO2e)*	-7	-20
Percentage of Target Achieved (CCAP <$30 + Strategies Underway)	88%	86%

* Positive values indicate that the target is exceeded; negatives indicate that the target has not been reached.

[9] Baseline values were derived from data released by the California Climate Action Team on December 8, 2005.
[10] Emissions for 1990, 2000, 2010 and 2020 shown in Table 3 were derived from data released by the California Climate Action Team on December 8, 2005

Program Cost Perspectives

While $30 per metric ton was used as a cutoff for determining which measures were most attractive, the weighted average cost of the reductions identified by the Center is significantly lower than cutoff. As shown in Table 5, the average cost of all reductions identified by the Center below $30 per metric ton CO_2e is $5.25 per ton and $5.77 per ton in 2010 and 2020, respectively.

The low average cost is a result of two factors which combined produce the very low average cost:

1. A significant portion of the measures have a *negative* cost (e.g., the economic benefits of implementing the measure exceed the economic costs.). In 2010, 8.1 MMTCO2e of the reduction measures (27.5% of the 29.4 $MMTCO_2e$ total) and in 2020, 20.8 $MMTCO_2e$ (35.9% of the 58.01 $MMTCO_2e$ total), result in an economic benefit.

2. An even larger portion of the measures identified have a cost between zero and $10 per metric ton CO_2e. For 2010, 14.6 $MMTCO_2$ (49.7% of the 29.4 $MMTCO_2e$ total) and in 2020, 21.7 $MMTCO_{2e}$ (37.4% of the 58.01 $MMTCO_2e$ total fall in the zero to $10 range.

Table 5
Average Cost of Reductions Below $30 per metric ton CO_2e

Sector	2010			2020		
	MMT CO_2e	Cost (2000$)	Avg Cost	MMT CO_2e	Cost (2000$)	Avg Cost
Agricultural/ Forestry	5.8	$62,628,000	$10.80	13.7	$153,807,000	$11.23
Cement	1.79	-$11,803,237	-$6.59	1.93	-$15,131,759	-$7.83
HFC	0.88	$3,131,500	$3.56	6.22	$9,088,500	$1.46
Methane	15.38	$36,173,940	$2.35	16.55	$39,100,530	$2.36
Oil Refining	TBD	TBD	TBD	TBD	TBD	TBD
PFC	3.1	$60,558,200	$19.53	7.14	$139,625,500	$19.56
Power	TBD	TBD	TBD	TBD	TBD	TBD
SF6	1.18	$3,728,800	$3.16	1.51	$8,199,300	$5.43
Transportation	1.27	$0	$0.00	10.96	$0	$0.00
Total	**29.40**	**$154,417,203**	**$5.25**	**58.01**	**$334,689,071**	**$5.77**

While not explicitly studied by CCAP, similar savings are expected for certain of the strategies already underway in California. For example, analysis by the California Air Resources Board (CARB) of the Vehicle GHG Standards (from Table 3) when adjusted to account for current

gasoline prices ($2.30 per gallon) indicate net economic savings of $190 million per year by 2010 and $2.8 billion per year in 2020.[11]

In a similar fashion, the energy efficiency standards already underway in the State of California identified in Table 3 are expected to save consumers $572 million in 2010.[12]

As a simplified analysis, the total cost of the reductions from CCAP's package, approximately $154.4 million in 2010 as identified in Table 5, can be subtracted from the savings cited from the two programs noted above of $762 million. For 2010, this results in a remaining net benefit of $608 million ($762 million in expected savings less $154 million in expected costs). This net benefit could be applied to the cost of implementing the 7 $MMTCO_2e$ that CCAP determined that the measures would fall short of the target in 2010 (from Table 4). Thus, even if the 7 million MMTCO2e in additional reductions were to cost as much as $108 per ton – which is highly unlikely -- the net cost to consumers would still be zero. A review of cost per ton in the European Union Emissions Trading System (EUETS) and in the nascent Clean Development Mechanism (CDM) market suggests that reduction opportunities with costs below $30 per ton should be readily available.

For 2020, the same analysis results in a net benefit of $2.466 billion ($2.8 billion in expected savings less $334 million in costs).[13] Applying this savings to the additional 20 MMTCO2e in reductions needed to achieve the target results in a cost per ton of $123.30. Thus, if the 20 MMTCO2e required to meet the 2020 target could be achieved at a cost of $123 or less per ton, the net cost to consumers in 2020 would be zero or a net benefit.

It should be noted that the threshold cost-effectiveness level for CCAP's analysis (see Table 4) was set at $30 per ton CO_2e for both the 2010 and 2020 targets. For 2020 there is additional 10 MMTCO2e of reductions in the range of $40-50 range that were not used to demonstrate compliance. But, as the analysis above shows, these additional tons could be used in 2020 since the tons are well below the $123 per ton price threshold calculated as still providing a net economic benefit.

While these measures could provide additional tons in a cost-effective manner, as noted earlier, there are additional measures such as the emissions from the commercial and residential heating sectors that have yet to be studied, and additional work that needs to be done to quantify the costs of potential reductions in the power and refining sectors.

Prior to using the additional measures above the $30 threshold from the measures studied in this report, it is recommended that additional work be done to determine if there are more cost

[11] California Environmental Protection Agency and Air Resources Board addendum presenting and describing revisions to: initial statement of reasons for proposed rulemaking, public hearing to consider adoption of regulations to control greenhouse gas emissions from motor vehicles, August 2004.

[12] Estimates of net savings provided Devra Wang, Staff Scientist at the Natural Resources Defense Council. The benefit reported to CCAP by NRDC assumes that 2009 and 2010 programs maintain the same savings-to-cost ratio as the 2006-2008 programs already approved by the California Public Utility Commission, and the same ratio of net benefits to cost. NRDC's estimate of the 2010 savings was $1,027 million (in 2010 nominal dollars). For comparability to CCAP's analysis this values was discounted to 2000 real dollars using actual GDP-IPD as reported by Congressional Budget Office and a 4% social discount factor.

[13] This benefit is only for the Vehicle GHG standards: estimates of the annual savings from energy efficiency programs are not readily available for 2020.

effective measures in the additional sectors identified (power, refining and combustion emissions from the commercial and residential heating sectors.) However, regardless of what measure or sector the remaining reductions come from, given the high break-even prices estimated for achieving the 2020 target there is ample reason to believe that reductions can be found at or below the break-even levels to support achieving the 2020 target.

Conclusions & Recommendations

Executive Order S-3-05 set rigorous targets for GHG emission reductions in the 2010 and 2020 timeframes. Based on a "bottom up" analysis by the Center for Clean Air Policy which utilized analyses conducted by the Center and studies from the California Energy Commission's PIER program, there are sufficient cost-effective measures available to meet the reduction targets.

Specifically, reductions studied by the Center within the agriculture/forestry, cement, methane, transportation and high GWP (HFCs, PFCs and SF_6) sectors combined with measures already underway can nearly achieve 88% of the 2010 reduction target and 86% of the 2020 reduction target on their own. The measures identified by the Center have average costs of just $5.25 per ton and $5.77 per ton in 2010 and 2020, respectively. CCAP's analysis priced available options in each of the sectors it studied, however, only those reductions below $30 per ton CO2e reduced were considered viable options and included in the calculations for meeting the target and for the average cost per ton.

Given the low average cost of measures studied by CCAP and the high net benefit that measures such as the Vehicle GHG Standards and energy efficiency measures are estimated to have, there is ample room, in both 2010 and 2020, for additional measures to be implemented that allow the total cost to consumers to still be zero. As reported, if the additional 7 $MMTCO_2$ e in 2010 and the 47 MMTCO2e required in 2020 to meet the target can be achieved at a cost below of $108 and $123 per ton, respectively, consumers will see no net cost for achieving the targets.

CCAP recommends studying additional reduction strategies, particularly the potential measures that can be implemented for reductions in the power and refining sectors, in order to identify cost-effective options for meeting the shortfalls identified in meeting the 2010 and 2020 targets.