Documentation of Inputs to Macroeconomic Assessment of the

Climate Action Team Report to the Governor and Legislature,

January 2006

INTRODUCTION

Staff in the Economic Studies Section of the Air Resources Board performed a preliminary economic assessment of the mitigation strategies identified in the Climate Action Team plan.[1] This document, intended for discussion at a workshop, is a compilation of costs and savings calculations for the economic model inputs. The major tool used for the analysis of the economic impact of the proposed strategies is a model of the California economy developed by the University of California, Berkeley, named the Environmental Dynamic Revenue Analysis Model (E-DRAM). Staff ran E-DRAM to derive the potential impacts of the combined strategies. The pages that follow contain annotated calculations for each of the mitigation strategies evaluated.

The first section shows the energy prices used in all the calculations. The California Energy Commission provided prices in 2005 dollars, which we converted to 2003 dollars, because E-DRAM uses a 2003 price level.

The strategies are bundled by agency:

- Air Resources Board
- California Energy Commission
- California Public Utility Commission
- Department of Food and Agriculture
- Integrated Waste Management Board
- Resources Agency

For each agency, the strategies appear in this order: first, strategies, if any, from Table 5-1; then, strategies, if any, from Table 5-2. The documentation starts with the name of the strategy as it appears in Table 5-1 or 5.2.

All of the strategies had costs associated with them. Many had costs in 2010 as well as in 2020. Some, but not all, of the strategies also had savings due to reduction or displacement of fuel. The results of the calculation, that is, the costs and savings due to the strategy, are highlighted.

In some cases, we received preliminary cost and savings numbers from the agencies themselves. In other cases, we relied on numbers from UC Berkeley or from a previous analysis of information received from the Tellus Institute.

The entire analysis is preliminary. We intend to redo the analysis with refined inputs later this year. The refined analysis will draw on improved cost and savings information provided by the agencies, as well as comments and suggestions offered on the preliminary analysis discussed here.

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[1] **FINAL DRAFT of Chapter 8 on Economic Assessment** of Climate Action Team Report to the Governor and Legislature, Posted: January 12, 2006. At http://www.climatechange.ca.gov/climate_action_team/reports/2006-01-12_CHAPTER_8_DRAFT.PDF

Energy Prices

Energy prices provided by CEC, in 2005 dollars:

Quantity	Value	Units	Source/Comments
Price natural gas 2010	6.14	dollars per Mcf	CEC
Price natural gas 2020	8.62	dollars per Mcf	CEC
Price electricity 2010	116.6	dollars per MWh	CEC
Price electricity 2020	116.6	dollars per MWh	CEC
Price gasoline 2010	2.12	dollars per gallon	CEC
Price gasoline 2020	2.19	dollars per gallon	CEC
Price diesel fuel 2010	2.06	dollars per gallon	CEC
Price diesel fuel 2020	2.13	dollars per gallon	CEC

CEC provided natural gas prices in terms of dollars per Mcf, but we based the calculations on a price in terms of dollars per MMBtu. So we have to convert the units.

Quantity	Value	Units	Source/Comments
Conversion factor	928	Btu/Scf	GREET[2]
	0.928	MMBtu per Mcf	
Price natural gas 2010	5.70	dollars per MMBtu	
Price natural gas 2020	8.00	dollars per MMBtu	

Also we need to convert prices to year 2003 dollars, because E-DRAM requires inputs in 2003 dollars.

Quantity	Value	Source/Comments
CPI June 2003	189.9	CA Department of Industrial Relations
CPI June 2005	201.3	CA Department of Industrial Relations

Energy prices used in the calculation of E-DRAM inputs:

Quantity	Value	Units
Price natural gas 2010	5.38	dollars per MMBtu
Price natural gas 2020	7.55	dollars per MMBtu
Price electricity 2010	110.00	dollars per MWh
Price electricity 2020	110.00	dollars per MWh
Price gasoline 2010	2.00	dollars per gallon
Price gasoline 2020	2.07	dollars per gallon
Price diesel fuel 2010	1.94	dollars per gallon
Price diesel fuel 2020	2.01	dollars per gallon

[2] The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model. http://www.transportation.anl.gov/software/GREET/index.html

Savings Factors

Numerous strategies contain fuel savings. Therefore, we only need to show the calculations for savings factors once. The savings factor relates the dollars saved from reduced fuel consumption to the tons of CO_2 equivalent not released to the atmosphere. Thus, the units are dollars per metric ton CO_2 equivalent (MtCO2e).

Electricity Savings Factor:

Quantity	Value	Units	Source/Comments
Price	$110.00	per MWh	
CO2 per kWh	521	grams per kWh	GREET for natural gas power plant
Electricity factor	$0.21	dollars per kilogram	
	211.13	dollars per Mt	

In other words, if consumers reduce electricity consumption by 1.92 MWh, then CO_2 emissions decrease by 1 metric ton and consumers save $211.

Natural Gas Savings Factor (for combustion to CO2):

Quantity	Value	Units	Source/Comments
Price	$7.55	dollars per MMBtu	UCB
C in gas	31.90	lbC/ MMBtu	GREET
CO2/C	3.67		Molecular weights
CO2 from natural gas	116.97	pounds per MMBtu	
Natural gas factor	0.06	dollars per pound	
	141.94	dollars per Mt	

Natural Gas Savings Factor (for escape of methane):

Quantity	Value	Units	Source/Comments
Cost of gas	7.55	dollars per MMBtu	CEC
C in gas	31.90	lbC/ MMBtu	GREET
CH4/C	1.33		Ratio of molecular weights
CH4 in gas	42.53	lbCH4/ MMBtu	Carbon content * ratio of molecular weights
	0.019	Mt CH4 / MMBtu	
CH4 Global warming potential	21		
GHG from escaping gas	0.41	MtCO2e / MMBtu	Multiply global warming potential * CH4 in gas
Natural gas savings factor	18.59	dollars per MtCO2e	Divide price by CO2e from natural gas

This is for strategies capturing CH_4 that otherwise escapes to the atmosphere.

Gasoline Savings Factor:

Quantity	Value	Units	Source/Comments
gasoline density	2,794	grams per gallon	GREET
C ratio	0.84		GREET
CO2/C	3.67		
CO2 from gasoline	8,556	grams per gallon	
Savings factor 2010	0.00023	dollars per gram	
Savings factor 2010	233.74	dollars per Mt	
Savings factor 2020	0.0002	dollars per gram	
Savings factor 2020	241.46	dollars per Mt	

Diesel Fuel Savings Factor:

Quantity	Value	Units	Source/Comments
diesel fuel density	3,240	grams per gallon	GREET
C ratio	0.87		GREET
CO2/C	3.67		
CO2 from diesel fuel	10,336	grams per gallon	
Savings factor 2010	0.00019	dollars per gram	
Savings factor 2010	188.02	dollars per Mt	
Savings factor 2020	0.00019	dollars per gram	
Savings factor 2020	194.41	dollars per Mt	

Air Resources Board
Strategies from Table 5-1
Vehicle Climate Change Standards

Quantity	Value	Units	Source/Comments
			The Board passed this regulation in September 2004. We scale the costs and savings from the staff analysis, adjusting for price levels.
CPI 2004	195.4		CA Department of Industrial Relations
CPI 2003	190.4		CA Department of Industrial Relations
AB1493 Gasoline price	1.74	dollars per gallon	
Cost(2004$) 2010	12.32		AB 1493 calculations
Cost(2004$) 2020	1,235.83		AB 1493 calculations
Savings(2004$) 2010	131.15		AB 1493 calculations
Savings(2004$) 2020	5,277.96		AB 1493 calculations
			For costs, convert from 2004 dollars to 2003 dollars.
Cost(2003$) 2010	12.00	million dollars	Multiply ratio of CPI * AB 1493 calc cost
Cost(2003$) 2020	1,204.21	million dollars	
			For savings, adjust for the price of gasoline.
Savings(2003$) 2010	150.75	million dollars	Multiply ratio of gasoline prices * AB 1493 calc savings
Savings(2003$) 2020	6,266.75	million dollars	

Air Resources Board
Strategies from Table 5-1
Diesel Anti-idling

Quantity	Value	Units	Source/Comments
Cost-effectiveness	-50	dollars per MtCO2e	Calculation based on numbers from staff report
Emission reductions 2010	1.0	MMtCO2e	Table 5-1
Emission reductions 2020	1.2	MMtCO2e	Table 5-1
Diesel saving factor 2010	188.02	dollars per Mt	
Diesel saving factor 2020	194.41	dollars per Mt	
Savings 2010	188.02	million dollars	Multiply saving factor * emission reductions
Savings 2020	233.30	million dollars	
Net cost 2010	-50.00	million dollars	Multiply cost-effectiveness * emission reductions
Net cost 2020	-60.00	million dollars	
Implementation cost 2010	138.02	million dollars	Net cost = savings + implementation cost
Implementation cost 2020	173.30	million dollars	

Air Resources Board
Strategies from Table 5-2
Other New Light Duty Vehicle Technology Improvements

Quantity	Value	Units	Source/Comments
C02 reduction from 2017 baseline	16.5%		CCAP - Center for Clean Air Policy [3]
Cost per vehicle	1,450	dollars	CCAP
Baseline 2017 F.E.	39.9	miles / gallon	CCAP
Price of gasoline	2.07	dollars / gallon	CEC
Gasoline factor	8,556.35	grams CO2 / gallon	
Annual VMT	13,000	miles / year	
CO2 emissions	214.44	grams / mile	Divide gasoline factor by baseline 2017 F.E.
			Calculation of CO2 reductions
Annual CO2 reduction per vehicle	459,984.15	grams CO2 / year	Multiply percent reduction CO2 emissions * annual VMT
	0.46	MtCO2 / year	Convert grams to metric tons
			Calculation of compliance cost
Capital recovery factor	0.0855		CRF corresponding to 5% and 18 years.
Annualized cost per vehicle	124.04	dollars / year	Multiply CRF * cost per vehicle
			Calculation of savings
Gasoline consumed	325.81	gallons / year	Divide annual VMT by F.E.
Gasoline reduction	53.76	gallons / year	Multiply percent reduction by gasoline consumption
Annual savings	111.07	dollars / vehicle	Multiply by price of gasoline
			Calculation of net cost
Net cost per vehicle	12.98	dollars / vehicle	Subtract savings from compliance cost
			Calculation of cost-effectiveness, total savings, total compliance cost
Cost-effectiveness	28.21	dollars / MtCO2	Divide cost by emission reduction
Gasoline savings factor	241.46	dollars / Mt	
Emission reduction	5.4	MMtCO2e	Table 5-2
Net cost	152.34	million dollars	Multiply cost-effectiveness * emission reduction
Savings	1,303.86	million dollars	Multiply gasoline savings factor * emission reduction
Compliance cost	1,456.20	million dollars	Net cost = savings + implementation cost

[3] http://www.climatechange.ca.gov/documents/2005-10-14_CCAP_REPORTS/CCAP_REPORT_TRANSPORTATION.PDF

Air Resources Board
Strategies from Table 5-2
HFC Reduction Strategy

Quantity	Value	Units	Source/Comments
			We base the calculation on cost-effectiveness provided by Department of Agricultural and Resource Economics at UC Berkeley
Cost-effectiveness	1.46	dollars per Mt	UCB
Emission reduction 2010	3.4	MMtCO2e	Table 5-2
Emission reduction 2020	8.5	MMtCO2e	Table 5-2
Cost 2010	4.97	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	12.42	million dollars	

Air Resources Board
Strategies from Table 5-2
Transport Refrigeration Units, Off-Road Electrification, Port Electrification

Quantity	Value	Units	Source/Comments
TRU reductions 2020	0.14	MMtCO2e	ARB
TRU cost by 2020	105	million dollars	ARB
Ship reductions 2020	0.18	MMtCO2e	ARB
Ship cost by 2020	180	million dollars	ARB
Lifetime	20	years	
Discount rate	5%	per year	
Capital recovery factor	0.08		CRF for 20 years @ 5%
Annualized cost	22.8	million dollars	Multiply CRF times capital costs

Air Resources Board
Strategies from Table 5-2
Manure Management

Quantity	Value	Units	Source/Comments
			We base the calculation on cost-effectiveness provided by Department of Agricultural and Resource Economics at UC Berkeley
Net cost-effectiveness	25.90	dollars per MtCO2e	UCB
Emission reduction	1	MMtCO2e	Table 5-2
Natural gas saving factor	18.59	dollars per MtCO2e	*Takes into account GWP of escaped methane*
Recovery factor	50%		*Not all captured gas is good enough to use as fuel*
Net cost	25.90	million dollars	Multiply cost-effectiveness * emission reduction
Savings	9.29	million dollars	Multiply factors * emission reduction
Compliance cost	35.20	million dollars	Net cost = savings + implementation cost

Air Resources Board
Strategies from Table 5-2
Semi Conductor Industry Targets (PFC Emissions)

Quantity	Value	Units	Source/Comments
			We base the calculation on cost-effectiveness provided by Department of Agricultural and Resource Economics at UC Berkeley
Cost-effectiveness	34.66	dollars per MtCO2e	UCB
Emission reductions	2	MMtCO2e	Table 5-2
Cost	69.32	million dollars	Multiply cost-effectiveness * emission reduction

Air Resources Board
Strategies from Table 5-2
Alternative Fuels: Biodiesel Blends

This calculation relies on the Tellus analysis. For years when biodiesel is more expensive than conventional diesel fuel, we report the incremental cost. For years when biodiesel is less expensive, we assume that its price will be the same as for conventional diesel.

Quantity	Value	Units	Source/Comments
Tellus incremental cost	0.23	dollars per gallon	Tellus
Tellus gasoline cost	1.73	dollars per gallon	Tellus
Biodiesel cost	1.96	dollars per gallon	Add the two cost components together.
Emission reduction 2010	0.40	MMtCO2e	Table 5-1
Emission reduction 2020	0.80	MMtCO2e	Table 5-1
CO2 from diesel fuel	10,336	grams per gallon	
	1.03E-08	MMt per gallon	
Biodiesel GHG reduction	78%		Tellus. Biodiesel produces 78% less GHG than conventional diesel
Biodiesel quantity 2010	49,616,908	gallons	Emission reduction / (GHG reduction * CO2 from diesel)
Biodiesel quantity 2020	99,233,816	gallons	
Price diesel fuel 2010	1.94	dollars per gallon	CEC
Price diesel fuel 2020	2.01	dollars per gallon	CEC
Price difference 2010	0.02	dollars per gallon	Subtract price of conventional diesel from price of biodiesel
Price difference 2020	(0.05)	dollars per gallon	
Additional cost 2010	826,702	dollars	If price diff is positive, multiply by fuel quantity
Additional cost 2020	-	dollars	
Implementation cost 2010	0.83	million dollars	
Implementation cost 2020	-	million dollars	

Air Resources Board
Strategies from Table 5-2
Alternative Fuels: Ethanol

ARB follows the Tellus analysis. We have to revise the Tellus cost-effectiveness result to take into account a different gasoline price.

Quantity	Value	Units	Source/Comments
Tellus cost-effectiveness	278	dollars per Mt	Tellus, for corn-based ethanol
Tellus gasoline price	1.73	dollars per gallon	Tellus
Price gasoline	2.07	dollars per gallon	
Diff gasoline price	0.34	dollars per gallon	Subtract Tellus price from price used here
CO2 from gasoline	8,556	grams per gallon	
	0.0086	Mt per gallon	
Diff cost-effectiveness	39	dollars per Mt	Divide difference in gasoline price by CO2 from gasoline
Cost-effectiveness	239	dollars per Mt	Adjust by subtracting diff C/E from Tellus C/E
Emission reduction 2010	0.2	MMtCO2e	Table 5-2
Emission reduction 2020	2.7	MMtCO2e	Table 5-2
Cost 2010	47.75	million dollars	
Cost 2020	644.58	million dollars	

Air Resources Board
Strategies from Table 5-2
Heavy Duty Vehicle Emission Reduction Measures

Quantity	Value	Units	Source/Comments
Net cost-effectiveness	-113	dollars per Mt	Tellus
Emission reduction 2020	3	MMtCO2e	Table 5-2
Savings factor 2020	194.41	dollars per Mt	
Net cost	-339.00	million dollars	Multiply cost-effectiveness * emission reduction
Savings	583.24	million dollars	Multiply savings factor * emission reduction
Compliance cost	244.24	million dollars	Net cost = savings + compliance cost

Air Resources Board
Strategies from Table 5-2
Reduced Venting and Leaks in Oil and Gas Systems

Quantity	Value	Units	Source/Comments
			We base the calculation on cost-effectiveness provided by Department of Agricultural and Resource Economics at UC Berkeley
Net cost-effectiveness	0.33	dollars per MtCO2e	UCB
Emission reduction	1	MMtCO2e	Table 5-2
Natural gas saving factor	18.59	dollars per MtCO2e	*Takes into account GWP of escaped methane*
Recovery factor	50%		*Not all captured gas is good enough to use as fuel*
Net cost	0.33	million dollars	Multiply cost-effectiveness * emission reduction
Savings	9.29	million dollars	Multiply factors * emission reduction
Compliance cost	9.62	million dollars	Net cost = savings + implementation cost

California Energy Commission
Strategies from Table 5-1
Building Energy Efficiency Standards

The CEC notes that there are savings due to both electricity and natural gas. However, the electricity savings alone is the amount needed to achieve the emission reductions. Therefore, for the preliminary analysis we used only electricity savings.

Quantity	Value	Units	Source/Comments
			CEC provides the annualized cost.
Cost of reduction 2010	60.45	million dollars	CEC
Cost of reduction 2020	175.59	million dollars	CEC
			We calculate the savings due to electricity.
Electricity savings rate	211.13	dollars per Mt	
Emission reduction 2010	1	MMtCO2e	Table 5-1
Emission reduction 2020	2	MMtCO2e	Table 5-1
Savings 2010	211.13	million dollars	Multiply savings rate * emission reduction
Savings 2020	422.25	million dollars	

California Energy Commission
Strategies from Table 5-1
Building Energy Efficiency Standards

The CEC notes that there are savings due to both electricity and natural gas. It reports savings such that the electricity savings alone is the amount needed to achieve the emission reductions. Therefore, for the preliminary analysis, we use electricity only.

Quantity	Value	Units	Source/Comments
			CEC provides the annualized cost.
Cost of reduction 2010	61.69	million dollars	CEC
Cost of reduction 2020	152.43	million dollars	CEC
			We calculate savings for electricity.
Electricity savings rate	211.13	dollars per Mt	
			We apply these rates to emissions to get costs, savings.
Emission reduction 2010	3	MMtCO2e	Table 5-1
Emission reduction 2020	5	MMtCO2e	Table 5-1
Savings 2010	633.38	million dollars	Multiply savings rate * emission reduction
Savings 2020	1,055.63	million dollars	

California Energy Commission
Strategies from Table 5-1
Fuel-efficient Replacement Tires & Inflation Programs

We relied on Tellus for the cost assumptions of this strategy. We had to update the cost-effectiveness because we use a different price of gasoline than Tellus.

Quantity	Value	Units	Source/Comments
NPV implementation cost	$1,242	million dollars	Tellus
NPV Tellus fuel savings	(3,339)	million dollars	Tellus
Tellus gasoline price	1.11	dollar per gallon	Tellus
Price gasoline 2010	2.00	dollars per gallon	
Price gasoline 2020	2.07	dollars per gallon	
Average price gasoline	2.03	dollars per gallon	Take average of 2010 and 2020 forecasts
Scaled NPV fuel savings	(6,017)	million dollars	Scale NPV fuel savings by gasoline prices
Net cost Tellus strategy	($4,774)	million dollars	NPV implementation cost plus NPV Tellus savings
Proportion	79%		Net savings divided by scaled fuel savings.
			We need to calculate the gasoline savings factor.
gasoline density	2,794	grams per gallon	GREET
C ratio	0.84		GREET
CO2/C	3.67		Ratio of atomic weights.
CO2 from gasoline	8,556	grams per gallon	Multiply density * C ratio * CO2/C
Gasoline savings factor	(0.0002)	dollars per gram	Divide average price gasoline by CO2 from gasoline
	(237.60)	dollars per Mt	
			Now we calculate the cost factors
Net cost factor	(188.54)	dollars per Mt	Multiply proportion * gasoline savings factor
Implementation cost factor	49.06	dollars per Mt	Net cost factor - gasoline savings factor
			Now we can calculate dollar amounts
Annual emission reduction	1.5	MMtCO2e	Same for both 2010 and 2020
Implementation cost	73.59	million dollars	Multiply implementation cost factor * emission reduction
Savings	356.39	million dollars	Multiply gasoline savings factor * emission reduction

California Energy Commission
Strategies from Table 5-2
Cement Manufacturing

Quantity	Value	Units	Source/Comments
			We base the calculation on cost-effectiveness provided by Department of Agricultural and Resource Economics at UC Berkeley
Savings factor	7.34	dollars per Mt	UCB
Cost factor	2.37	dollars per Mt	UCB
Emission reduction	1	MMtCO2e	Table 5-2
Savings	7.34	million dollars	Multiply factors * emission reduction
Compliance cost	2.37	million dollars	

California Energy Commission
Strategies from Table 5-2
Municipal Utility Energy Efficiency Programs/Demand Response

Quantity	Value	Units	Source/Comments
Electricity Savings Factor	211.13	dollars per Mt	
Cost factor	0.04	dollars per kilogram	Divide cost of saved electricity / CO2 per kWh
	44.15	dollars per Mt	
			Emission reductions
Emission reduction 2010	1	MMtCO2e	Table 5-2
Emission reduction 2020	5.9	MMtCO2e	Table 5-2
			We calculate savings and costs
Savings 2010	211.13	million dollars	Multiply savings rate * emission reduction
Savings 2020	1,245.64	million dollars	
Implementation cost 2010	44.15	million dollars	Multiply cost factor * emission reduction
Implementation cost 2020	260.46	million dollars	

California Energy Commission
Strategies from Table 5-2
Municipal Utility Renewable Portfolio Standard

Quantity	Value	Units	Source/Comments
Cost-effectiveness	8.73	dollars per Mt	Same as for CPUC strategy in Table 5-1 on Accelerated Renewable Portfolio Standard
Emission reduction 2020	3.2	MMtCO2e	Table 5-2
Cost 2020	27.93	million dollars	Multiply cost-effectiveness * emission reduction

California Energy Commission
Strategies from Table 5-2
Municipal Utility Combined Heat and Power

Quantity	Value	Units	Source/Comments
Net cost-effectiveness	(113.89)	dollars per Mt	Same as for CPUC strategy in Table 5-2 on IOW Combined Heat and Power Initiative
Emission reduction 2020	0.3	MMtCO2e	CEC
Natural gas savings:			
Price natural gas 2020	7.55	dollars per MMBtu	-
C in gas	31.90	lbC/ MMBtu	GREET
CO2/C	3.67		
CO2 from natural gas	116.97	pounds per MMBtu	Multiply by ratio of molecular weight
Natural gas factor	0.06	dollars per pound	Price divided by CO2 from natural gas
	141.94	dollars per Mt	
Natural gas savings 2020	42.58	million dollars	Multiply natural gas factor * emission reduction
Net cost 2020	(34.17)	million dollars	Multiply cost-effectiveness * emission reduction
Implementation cost 2020	8.42	million dollars	Net cost = savings + implementation cost

California Energy Commission
Strategies from Table 5-2
Municipal Utility Electricity Sector Carbon Policy

Quantity	Value	Units	Source/Comments
Cost-effectiveness	10	dollars per Mt	Tellus
Emission reduction 2010	3	MMtCO2e	Table 5-2
Emission reduction 2020	9	MMtCO2e	Table 5-2
Cost 2010	30	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	90	million dollars	Multiply cost-effectiveness * emission reduction

California Public Utility Commission
Strategies from Table 5-1
Accelerated Renewable Portfolio Std (33% by 2020)

Quantity	Value	Units	Source/Comments
Capital cost	1.2	billion dollars	CPUC. This budget amount in the preliminary estimate of the incremental costs to the IOUs for years 2011-2020 and does not include potential infrastructure costs or municipal utility investment that will be needed to meet the 33% goal.
Project lifetime	20	years	CPUC
CO2 per kWh	521	grams per kWh	GREET for natural gas power plant
Price electricity	110.00	dollars per MWh	CEC
Capital Recovery Factor, 20 years @ 5%	0.08		
Annualized cost 2020	96	million dollars per year	Multiply Capital Recovery Factor * Capital cost.
Emission reduction 2010	5	MMtCO2e	Table 5-1
Emission reduction 2020	11	MMtCO2e	Table 5-1
Annualized cost 2010	43.64	million dollars per year	Scale 2020 cost by emission reductions.
Cost-effectiveness	8.73	dollars per Mt	Divide cost by emission reduction
To summarize and put the results all in one place:			
Annualized cost 2010	44	million dollars per year	
Annualized cost 2020	96	million dollars per year	
Annualized savings 2020+			Using the CEC's long-term forecast of natural gas prices, IOU ratepayers would likely realize a net benefit over a 20 year period.

California Public Utility Commission
Strategies from Table 5-1
California Solar Initiative

Quantity	Value	Units	Source/Comments
Capacity	3000	MW	CPUC
Cost per watt	6	dollars per watt	Tellus
Capital cost	18000	million dollars	Multiply cost per watt * power capacity
	18	billion dollars	
Incentives	2.9	billion dollars	OK. The incentives are less than the capital cost.
Capital Recovery Factor	0.08	CRF for 20 years @ 5%	
Annualized cost 2020	1440	million dollars per year	Multiply Capital Recovery Factor * Capital cost.
Emission reduction 2010	0.4	MMtCO2e	Table 5-1
Emission reduction 2020	3	MMtCO2e	Table 5-1
Annualized cost 2010	192	million dollars per year	Scale 2020 cost by emission reductions
Implementation cost	480.00	dollars per Mt	Divide 2020 cost by 2020 emission reduction
Electricity Savings Factor	211.13	dollars per Mt	
Savings 2010	84	million dollars	Multiply savings factor times emission reduction
Savings 2020	633	million dollars	
Net Cost-effectiveness	269	dollars per Mt	Difference between implementation cost per Mt and savings factor
To summarize and put all the results in one place:			
Annualized cost 2010	192	million dollars per year	
Annualized cost 2020	1,440	million dollars per year	
Savings 2010	84	million dollars	
Savings 2020	633	million dollars	

California Public Utility Commission
Strategies from Table 5-1
Investor Owned Utility Energy Efficiency Programs

Quantity	Value	Units	Source/Comments
Electricity savings	23000	GWh	*CPUC. Savings through 2013.*
Natural gas savings	453	MMth	*CPUC. Savings through 2013.*
Electricity cost factor	3	cents / kWh	CPUC
Nat gas cost factor	21	cents / therm	CPUC
Electricity price	$110.00	dollars / MWh	CEC
Price natural gas 2010	5.38	dollars / MMBtu	CEC
Price natural gas 2020	7.55	dollars / MMBtu	CEC
			First the fraction of reductions due to electricity and to nat gas.
CO2 per GWh	521	tons / GWh	
Elec CO2 reduction	11,983,000	MtCO2e	CO2 per GWh * electricity savings
	12.0	MMtCO2e	
Natural gas savings	45,300,000	MMBtu	1 therm = 0.1 MMBtu
Nat gat CO2 reduction	2.7	MMtCO2e	CO2 per MMBtu * nat gas savings
Electricity fraction, Natural gas fraction	82%, 18%		Electricity CO2 reduction / total CO2 reduction
			Next, calculate costs and savings for electricity
Emission red 2010	4.00	MMtCO2e	Table 5-1
Emission red 2020	8.80	MMtCO2e	Table 5-1
Electricity cost factor	30	dollars / MWh	
Elec reduction 2010	3,261,836	MtCO2e	Multiply electricity fraction * emission reduction
Elec reduction 2020	7,176,040	MtCO2e	
Elec reduction 2010	6,261	GWh	emission red. / CO2 per GWh
Elec reduction 2020	13,774	GWh	
Cost to save elec 2010	$187.82	million dollars	electricity cost factor * energy
Cost to save elec 2020	$413.21	million dollars	
Electricity savings 2010	$688.66	million dollars	Multiply electricity price * energy
Electricity savings 2020	$1,515.05	million dollars	
			Next, calculate costs and savings for natural gas
Nat gas reduction 2010	0.74	MMtCO2e	nat gas fraction * emission red
Nat gas reduction 2020	1.62	MMtCO2e	
CO2 per MMBtu	0.06	MtCO2e / MMBtu	
Nat gas reduction 2010	12,330,901	MMBtu	emission red / CO2 per MMBtu
Nat gas reduction 2020	27,127,982	MMBtu	
Cost to save gas 2010	25.89	million dollars	natural gas cost factor * energy
Cost to save gas 2020	56.97	million dollars	
Nat gas savings 2010	66.28	million dollars	Multiply natural gas price * energy
Nat gas savings 2020	204.72	million dollars	
Imp cost 2010	$213.72	million dollars	electricity and natural gas
Imp cost 2020	$470.18	million dollars	
Savings 2010	$754.94	million dollars	electricity and natural gas
Savings 2020	$1,719.77	million dollars	

California Public Utility Commission
Strategies from Table 5-2
IOU Additional Energy Efficiency Prog/Dem Response

Quantity	Value	Units	Source/Comments
			We calculate dollar per Mt factors
Cost of Saved Energy	23.00	dollars per MWh	Tellus
CO2 per kWh	521	grams per kWh	GREET for natural gas power plant
Cost factor	0.04	dollars per kilogram	Divide cost of saved electricity / CO2 per kWh
	44.15	dollars per Mt	
Electricity savings factor	211.13	dollars per Mt	
Cost-effectiveness	(166.98)	dollars per Mt	
			Emission reductions
Emission reduction 2020	6.3	MMtCO2e	Table 5-2
			We calculate savings and costs
Savings 2020	1,330.09	million dollars	Multiply savings rate * emission reduction
Implementation cost 2020	278.12	million dollars	Multiply cost factor * emission reduction

California Public Utility Commission
Strategies from Table 5-2
IOU Combined Heat and Power Initiative

For the preliminary costs associated with this strategy, we used an emission-weighted average of the two other Table 5-2 CPUC strategies.

Quantity	Value	Units	Source/Comments
Reduction PUC1 2020	6.3	MMtCO2e	IOU Additional Energy Efficiency Prog/Dem Response
Cost-effectiveness PUC1	(166.98)	dollars per Mt	
Reduction PUC3 2020	2.7	MMtCO2e	IOU Electricity Sector Carbon Policy
Cost-effectiveness PUC3	10.00	dollars per Mt	
Cost PUC1	(1,051.98)	$ million	Multiply cost-effectiveness * emission reduction
Cost PUC3	27.00	$ million	
Total reductions	9	MMtCO2e	Add reductions together
Total costs	(1,024.98)	$ million	Add costs together
Cost-effectiveness	(113.89)	dollars per Mt	Divide costs by reductions
			We assume that the emission reduction occurs because users do not have to burn natural gas to create heat, so they spend less on natural gas.
Natural gas factor	141.94	dollars per Mt	
			Now we can look at this strategy.
Emission reduction 2010	1.10	MMtCO2e	Table 5-2
Emission reduction 2020	4.40	MMtCO2e	Table 5-2
Net cost 2010	(125.27)	dollars per Mt	cost-effectiveness * emission reduction
Net cost 2020	(501.10)	dollars per Mt	
Savings 2010	156.13	$ million	natural gas factor * emission reduction
Savings 2020	624.52	$ million	
Implementation cost 2010	30.86	$ million	Net cost = savings + implementation cost
Implementation cost 2020	123.43	$ million	

California Public Utility Commission
Strategies from Table 5-2
IOU Electricity Sector Carbon Policy

Quantity	Value	Units	Source/Comments
Cost-effectiveness	10	dollars per Mt	Tellus
Emission reduction 2010	1.6	MMtCO2e	Table 5-2
Emission reduction 2020	2.7	MMtCO2e	Table 5-2
Cost 2010	16	millions of dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	27	millions of dollars	

Department of Food and Agriculture
Strategies from Table 5-2
Enteric Fermentation

Quantity	Value	Units	Source/Comments
Cost-effectiveness	3	dollars per MtCO2e	Tellus
Emission reductions 2010	1	MMtCO2e	Table 5-2
Emission reductions 2020	1	MMtCO2e	Table 5-2
Cost 2010	3	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	3	million dollars	

Integrated Waste Management Board
Strategies from Table 5-1
Achieve 50% Statewide Recycling Goal

Quantity	Value	Units	Source/Comments
Cost of waste diversion	50	dollars per ton solid waste	IWMB
GHG production	1.82	MtCO2e per ton solid waste	IWMB
C/E	27.47	dollars per Mt	Divide Cost by GHG production
Emission reduction 2010	3	MMtCO2e	Table 5-1
Emission reduction 2020	3	MMtCO2e	Table 5-1
Cost 2010	82.42	million dollars	Multiply C/E * emission reduction
Cost 2020	82.42	million dollars	

Integrated Waste Management Board
Strategies from Table 5-2
Landfill Methane Capture

Quantity	Value	Units	Source/Comments
			We base the calculation on cost-effectiveness provided by Department of Agricultural and Resource Economics at UC Berkeley
Net cost-effectiveness	1.69	dollars per MtCO2e	UCB
Emission reduction 2010	2	MMtCO2e	Table 5-2
Emission reduction 2020	3	MMtCO2e	Table 5-2
Net cost 2010	3.38	million dollars	Multiply cost-effectiveness * emission reduction
Net cost 2020	5.07	million dollars	
			We calculate the savings due to captured methane.
Natural gas savings factor	18.6	dollars per MtCO2e	natural gas
Recovery factor	50%		*Not all captured gas is good enough for fuel*
Savings 2010	18.59	million dollars	Multiply factors times emission reduction
Savings 2020	27.88	million dollars	
Compliance cost 2010	21.97	million dollars	Net cost = savings + implementation cost
Compliance cost 2020	32.95	million dollars	

Integrated Waste Management Board
Strategies from Table 5-2
Zero Waste – High Recycling

Quantity	Value	Units	Source/Comments
Cost of waste diversion	50	dollars per ton solid waste	IWMB
GHG production	1.82	MtCO2e per ton solid waste	IWMB
C/E	27.47	dollars per Mt	Divide Cost by GHG production
Emission reduction 2010	0	MMtCO2e	Table 5-2
Emission reduction 2020	3	MMtCO2e	Table 5-2
Cost 2010	-	million dollars	Multiply C/E * emission reduction
Cost 2020	82.42	million dollars	

Resources Agency
Strategies from Table 5-2
Forest Management

Quantity	Value	Units	Source/Comments
Cost-effectiveness	23	dollars per MtCO2e	Resources Agency
Emission reductions 2010	1	MMtCO2e	Table 5-2
Emission reductions 2020	2	MMtCO2e	Table 5-2
Cost 2010	23	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	46	million dollars	

Resources Agency
Strategies from Table 5-2
Forest Conservation

Quantity	Value	Units	Source/Comments
Cost-effectiveness	15	dollars per MtCO2e	Resources Agency
Emission reductions 2010	4.2	MMtCO2e	Table 5-2
Emission reductions 2020	8.4	MMtCO2e	Table 5-2
Cost 2010	63	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	126	million dollars	

Resources Agency
Strategies from Table 5-2
Fuels Management/Biomass

Quantity	Value	Units	Source/Comments
Cost-effectiveness	20	dollars per MtCO2e	Resources Agency
Emission reductions 2010	3.4	MMtCO2e	Table 5-2
Emission reductions 2020	6.8	MMtCO2e	Table 5-2
Cost 2010	68	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	136	million dollars	

Resources Agency
Strategies from Table 5-2
Urban Forestry

This strategy has both costs and savings. The costs have to do with planting trees. The savings come from reduced use of air conditioning, as the trees provide shade.

Quantity	Value	Units	Source/Comments
			We calculate the cost for 2020.
Cumulative cost	500	million dollars	Resources Agency
Capital recovery factor	0.08		For 20 years @ 5%
Annualized cost	40	million dollars	Multiply CRF * cumulative cost
			We note the emission reductions.
Emission reductions	3.5	MMtCO2e	Table 5-2
			We calculate how much electricity is saved.
CO2 per kWh	521	grams per kWh	GREET for natural gas power plant
CO2 per GWh	521	Mt per GWh	
CO2 per MWh	0.52	Mt per MWh	
CO2 per MWh	0.00000052	MMtCO2e per MWh	
Electricity reduction	6,717,850	MWh	Divide emission reduction by CO2 per MWh
			We calculate the savings.
Price electricity 2020	110.00	dollars per MWh	
Savings	738,941,506	dollars	Multiply price * electricity reduction
Savings	738.94	million dollars	

Resources Agency
Strategies from Table 5-2
Afforestation/Reforestation

Quantity	Value	Units	Source/Comments
Cost-effectiveness	20	dollars per MtCO2e	Resources Agency
Emission reductions 2010		MMtCO2e	Table 5-2
Emission reductions 2020	12.5	MMtCO2e	Table 5-2
Cost 2010	0	million dollars	Multiply cost-effectiveness * emission reduction
Cost 2020	250	million dollars	

Resources Agency
Strategies from Table 5-2
Water Use Efficiency

Quantity	Value	Units	Source/Comments
Emission reduction 2010	0.4	MMtCO2e	Table 5-2
Emission reduction 2020	1.2	MMtCO2e	Table 5-2
			We calculate the cost.
Annual cost of strategy	30	million dollars per year	RA
Start year, end year	2008, 2020		
Cumulative cost	360	million dollars	(End year - start year) * annual cost
Capital recovery factor	0.08	For 20 years @ 5%	
Annualized cost 2020	28.8	million dollars	Multiply CRF * cumulative cost
Cost factor	24	dollars per Mt	Divide 2020 annualized cost by 2020 emission reduction
Annualized cost 2010	9.6	million dollars	Multiply cost factor * 2010 emission reduction
Electricity savings factor	211.13	dollars per Mt	
Savings 2010	84.45	million dollars	Multiply electricity savings factor * emission reduction
Savings 2020	253.35	million dollars	
Summary of costs, to put it all in one place:			
Annualized cost 2010	9.6	million dollars	
Annualized cost 2020	28.8	million dollars	