

Economic Evaluation Supplement Climate Change Draft Scoping Plan Pursuant to AB 32 The California Global Warming Solutions Act of 2006

Appendix I Modeling Assumptions for Economic Analysis of the Draft Scoping Plan

1 INTRODUCTION

The economic modeling for the Economic Evaluation Supplement was conducted on the measures developed by staff from the California Air Resources Board (ARB) and other State agencies for the Draft Scoping Plan. Staff from ARB and other agencies that proposed the measures estimated the costs and savings of those measures. The costs and savings of each measure were analyzed using a standard ARB methodology to consider costs, savings, and cost-effectiveness of its proposed regulations for the past three decades. The methodology is the annualized discounted cost analysis, further explained below.

The annualized discounted cost analysis methodology is well established and accepted, and has been used for the economic assessment of major regulations developed by ARB in recent years. For example, ARB used the methodology to analyze the costs of the Light-Duty Motor Vehicle Greenhouse Gas Standards of 2006 (AB 1493, Pavley) designed to reduce greenhouse gas emissions. The methodology was also used by the Economic Subcommittee of the Climate Action Team to assess the costs, savings, and cost-effectiveness of the GHG reduction measures in its 2007 *Updated Macroeconomic Analysis of Climate Strategies Report*. Several other regulatory and planning efforts have used the annualized discounted cost analysis.

The level of detail on the costs and saving for the different measures included in the Scoping Plan vary widely. Because some of the measures are in the later stages of regulatory development, their costs and savings estimates were readily available. For other measures the costs and savings were specifically estimated for the Draft Scoping Plan. Many of these estimates are preliminary, and are likely to change during the regulatory process. For example, the costs and savings for some measures were developed, in part, by drawing from cost per ton information compiled to support related measures proposed or adopted by other organizations.

2 COST AND SAVINGS ANALYSIS METHODOLOGY

Applying a consistent methodology for analyzing the costs of measures is a necessary step to prepare inputs into both the E-DRAM and BEAR models.¹ Specifically, the methodology annualizes all costs and savings to calculate the net cost per ton of emissions reduced for each measure.

Many of the measures have up-front costs for equipment or devices that last many years, thus supporting ongoing emission reductions. The costs need to be spread over the years that the equipment operates. For example, an efficient refrigerator that costs more will provide refrigeration with less electricity and cause lower greenhouse gas emissions for 10 to 15 years. The additional cost of purchase would have to be spread over the life of the refrigerator to correspond with the refrigeration benefits to allow comparison with the savings through reduced energy consumption, which also occur over the lifetime of the refrigerator. The up-front costs for many of the measures were reported as the capital expenditures necessary to implement the measure.

Another cost factored into the analysis is the ongoing cost for operations and maintenance after a measure is implemented. In some cases, this cost may be negative, representing a savings when a measure reduces ongoing costs.

Savings are treated similarly to annualized costs if they occur up-front. However, almost all savings from the measures resulted from reduced energy use or operations and maintenance costs, and were reported as an annual amount.

The following items were included in the cost and savings information on the measures and were used in the economic modeling.

- Up-front or Capital Expenditures: investments in equipment or facilities with lifetimes of more than one year.
- Equipment Life: the period of time the equipment provides its benefits.
- Operations and Maintenance Costs: on-going costs that facilitate realization of the benefits from the installed equipment or devices.
- Energy Costs and Savings: were reported in energy units for each year and were valued using a consistent energy price forecast.
- Non-Energy Savings: reported for each year.
- Constant 2007 Dollars: used for all valuations.

¹ E-DRAM and BEAR are described in more detail in Appendices II and III of the Economic Evaluation Supplement.

The analysis of costs and savings involved four steps. The first step is to annualize the up-front or capital expenditures using the following formulas:

$$\text{Annualized Cost of Capital} = \text{Capital Expenditures} \times \text{Capital Recovery Factor}$$

$$\text{Capital Recovery Factor} = i (1+i)^n / (1+i)^n - 1$$

Where, i = discount rate, and n = life of the capital

The capital expenditures developed for the proposed measures were multiplied by a capital recovery factor to give the annualized cost of capital. The capital recovery factor requires selecting a discount rate and equipment lifetime. A uniform real discount rate of five percent was used for all measures, and the equipment lifetime was estimated for each measure. The primary rationale for using a real discount rate of five percent is that it is equivalent to rate of return on an inflation-adjusted 10-year treasury security, (about 2 percent in the past five years)², plus the California Environmental Protection Agency recommended 3 percent risk premium³. The five percent real discount rate has been used for several recent ARB regulations. Additionally, the five percent is the average of what the US Office of Management and Budget recommends (7 percent) and what US Environmental Protection Agency has used historically for regulatory analysis. The result of this first step is a levelized cost that will be incurred for every year the equipment or device operates until the capital expenditure is fully paid. This way, the costs of a measure can be matched with the annual savings and the emission reductions the measure provides.

The second step is to determine the on-going costs. These costs were reported as operating and maintenance costs for most of the measures for each year of the equipment life.

The third step is to calculate the value of the energy savings. Many of the measures reduce gasoline, diesel, natural gas, or electricity usage. The savings for each fuel were valued at the prices forecasted by California Energy Commission. The forecast prices for 2020 are displayed in Table I-1.

² http://www.federalreserve.gov/releases/h15/data/Annual/H15_TCMII_Y10.txt

³ Cal/EPA Management Memorandum: Implementation of 1993 Regulatory Reform Legislation.

Table I-1: Forecasted Energy Prices Used in Estimating Measure Costs and Savings

Energy Type	Price	Metric
Electricity avoided cost 2020 ^{*†}	\$86.09	2007 dollars per MWh
Natural gas avoided cost 2020 [†]	\$7.94	2007 dollars per MMBtu
Gasoline price 2020 ^{††}	\$3.673	2007 dollars per gallon
Diesel fuel price 2020 ^{††}	\$3.685	2007 dollars per gallon

* 8,760 average price for avoided generation and T&D costs

† Source: Updated from Climate Action Team (CAT) Report, updated to 2007 dollars

†† Source: California Energy Commission, *Transportation Energy Forecasts for the 2007 Integrated Energy Policy Report*, September, 2007, CEC-600-2007-009-SF (<http://www.energy.ca.gov/2007publications/CEC-600-2007-009/CEC-600-2007-009-SF.PDF>), Table B-3.

The last step is to calculate the net cost for each measure. The net cost was the sum of annualized capital costs, operating and maintenance costs, value of energy savings, and other savings. Some measures, particularly the energy efficiency measures, had negative net costs (i.e. a net savings). Others had positive net costs, meaning that the costs exceeded savings. The costs and savings for the Draft Scoping Plan measures are displayed in Tables I-2 and I-3. Additional details on the derivation of the cost and savings estimates for each measure are provided in the Draft Scoping Plan Measures Documentation Supplement.

3 COST-EFFECTIVENESS

AB 32 requires the Board to consider cost-effectiveness of the measures when adopting the Scoping Plan, and defines cost-effectiveness as, “the cost per unit of reduced emissions of greenhouse gases adjusted for its global warming potential.” (H&S Code 38505 (d)) This definition specifies using a metric of cost per unit of reductions emissions (e.g. dollars per metric ton CO_{2e}) by which the Board must express cost-effectiveness, but it does not specify what should be included in the cost calculation and does not provide criteria to assess if a regulation is or is not cost-effective. In addition to reducing greenhouse gas emissions, some of the measures will provide co-benefits by reducing emissions of criteria pollutants (e.g., particulate matter, ozone precursors). Therefore, when conducting more detailed analyses as part of the regulatory process,

ARB staff plan to account for the value of the co-benefits by reducing the estimated cost of the greenhouse gas emission reduction measures by the average cost of control for the criteria pollutants reduced as a co-benefit. This method is consistent with the approach used in the macroeconomic impact analysis of the Climate Action Team Report. However, this accounting for co-benefits has not been included as part of the analysis conducted for the Scoping Plan.

To achieve the AB 32 2020 emission limit, ARB has estimated that emission reductions from business-as-usual of 169 MMTCO_{2e} will be needed. The Preliminary Recommendation in the Draft Scoping Plan achieves these reductions through a broad spectrum of measures, including performance-based regulations and a California cap-and-trade program linked to a western regional market.

Tables I-2 and I-3 present estimated costs and savings of the recommended greenhouse gas reduction measures as well as other measures under evaluation. The last column in both tables shows the cost-effectiveness (i.e. net annualized cost per ton of CO_{2e} emissions reduced) of each measure as currently estimated. As previously indicated, many of the measures are in the early stages of development. It is anticipated that as the analysis proceeds and the measures move through the regulatory process the costs for some will change; some will increase while others will decrease.

A number of measures included in the Draft Scoping Plan provide greenhouse gas reduction benefits, but are being pursued for other policy reasons. For example, the ship electrification (T-4) and goods movement measures (T-5) are being pursued to achieve reductions in criteria air pollutants and toxic air contaminant emissions. While the greenhouse gas emission reductions that result will help California achieve the 2020 target, ARB is not attributing the costs or savings that result from these measures to implementation of AB 32. For this reason, these measures, along with the high speed rail measure (T-10), the California solar programs measure (E-4), and the solar hot water heater measure (CR-2) all show zero costs and zero savings in the tables below.

**Table I-2: Costs, Savings, and Dollars Per Metric Ton of CO₂e Reduced
Recommended Greenhouse Gas Reduction Measures**

	Measures	Reductions (MMTCO₂e in 2020)	Costs (\$Millions)	Savings (\$Millions)	Net Cost or Savings Per MTCO₂e (\$)
Transportation					
T-1	Pavley I Light-Duty Vehicle GHG Standards	27.7	1,372	11,371	-361
	Pavley II - Light-Duty Vehicle GHG Standards	4.0	594	1642	-262
T-2	Low Carbon Fuel Standard	16.5	11,000	11,000	0
T-3	Low Friction Oil	2.8	520	1,149	-225
	Tire Pressure Program	0.82	95	337	-295
	Tire Tread Program (Low resistance)	0.3	0.6	123	-439
	Other Efficiency (Cool Paints)	0.89	360	365	-6
T-4	Ship Electrification at Ports	0.2	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾
T-5	Goods Movement Efficiency Measures	3.5	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾
	Vessel Speed Reduction				
	Other Efficiency Measures				
T-6	Heavy-Duty Vehicle GHG Emission Reduction (Aerodynamic Efficiency)	1.4	1,136 ⁽²⁾	496 ⁽²⁾	⁽²⁾
T-7	Medium and Heavy-duty Vehicle Hybridization	0.5	93	177	-168
T-8	Heavy-Duty Engine Efficiency	0.6	26	213	-312
T-9	Local Government Actions and Targets	2	200	821	-311
T-10	High Speed Rail	1	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾
	Subtotal	62.2			
Building and Appliance Energy Efficiency and Conservation					
E-1	Electricity Reduction Program 32,000 GWh reduced	15.2	3,294	4,904	-106
	Utility Energy Efficiency Programs				
	Building and Appliance Standards				
	Additional Efficiency and Conservation				
E-2	Increase Combined Heat and Power Use by 30,000 GWh	6.8	362	1,673	-193
CR-1	Natural Gas Reduction Programs (800 Million Therms saved)	4.2	910	1,355	-106
	Utility Energy Efficiency Programs				
	Building and Appliance Standards				
	Additional Efficiency and Conservation				
	Subtotal	26.3			

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**Table I-2 (cont.): Costs, Savings, and Dollars Per Metric Ton of CO₂e Reduced
Recommended Greenhouse Gas Reduction Measures**

	Measures	Reductions (MMTCO₂e in 2020)	Costs (\$Millions)	Savings (\$Millions)	Net Cost or Savings Per MTCO₂e (\$)
Renewable Energy					
E-3	RPS (33%)	21.2	3,671	1,889	84
E-4	California Solar Programs (3000 MW Installation)	2.1	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾
CR-2	Solar Water Heaters (AB 1470 goal)	0.1	0 ⁽¹⁾	0 ⁽¹⁾	0 ⁽¹⁾
	Subtotal	23.4			
High GWP Measures					
H-1	MVACS: Reduction of Refrigerant from Non-Professional Servicing	0.5	60	0	120
H-2	SF6 Limits in Non-Utility and Non-Semiconductor Applications	0.3	0.22	0.14	0.3
H-3	High GWP Reduction in Semiconductor Manufacturing	0.15	2.6	0	17
H-4	Limit High GWP Use in Consumer Products	0.25	0.06	0.23	-0.7
H-5	High GWP Reductions from Mobile Sources	3.3	20.86	0	6.32
H-6	Specifications for Commercial and Industrial Refrigeration	4	1.24	0.66	0.15
	Foam Recovery and Destruction Program	1	94.83	0	95
	SF6 Leak Reduction and Recycling in Electrical Applications	0.1	0.3	0.4	-1
	Alternative Suppressants in Fire Protection Systems	0.1	1.96	0.2	18
	Gas Management for Stationary Sources--Tracking/Recovery/Deposit Programs	6.3	1.02	3.6	-0.41
	Residential Refrigeration Early Retirement Program	0.2	18.9	24.79	-29
	Subtotal	16.2			

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**Table I-2 (cont.): Costs, Savings, and Dollars Per Metric Ton of CO₂e Reduced
Recommended Greenhouse Gas Reduction Measures**

	Measures	Reductions (MMTCO₂E in 2020)	Costs (\$Millions)	Savings (\$Millions)	Net Cost or Savings Per MTCO₂e (\$)
	Others				
RW-1	Landfill Methane Capture	1.0	1	0	1
A-1	Methane Capture at Large Dairies ⁽³⁾	1.0	0	0	0
F-1	Sustainable Forest Target	5.0	50	0	10
W-1	Water Use Efficiency ⁽⁴⁾	1.4	-	-	
W-2	Water Recycling ⁽⁴⁾	0.3	-	-	
W-3	Pumping and Treatment Efficiency ⁽⁴⁾	2.0	-	-	
W-4	Reuse Urban Runoff ⁽⁴⁾	0.2	-	-	
W-5	Increase Renewable Energy Production [†]	0.9	-	-	
	Subtotal⁽⁵⁾	6.0			
Recommended Measures Totals		134	23,835	37,553	

Notes for Table I-2:

- ¹ These measures are being pursued to achieve other policy goals, including renewable energy development and air quality/public health goals, so their costs and savings have not been attributed to implementation of AB 32.
- ² The costs for this measure include the full equipment cost, while the savings only reflect fuel savings in California. Therefore, no net cost number is presented here.
- ³ Because the emission reductions from this measure are not required, they are not counted in the total.
- ⁴ GHG reductions from the water sector may already be incorporated into the 2020 forecast. Therefore, they are not currently counted toward the 2020 goal. ARB will work with the appropriate agencies to determine whether these reductions are additional.
- ⁵ Subtotal is for Landfill Methane Capture and Sustainable Forest Target measures only.

Table I-3: Costs, Savings, and Dollars Per Metric Ton of CO₂e Reduced Measures Under Evaluation

Measures	Reduction (MMTCO₂e)	Costs (\$Millions)	Savings (\$Millions)	Net Cost or Savings Per TON (\$)
Transportation				
Feebates for New Vehicles	4	594	1,642	-262
<i>Incentives to Reduce VMT⁽¹⁾</i>	2	200	821	-310
Electricity				
<i>Energy Efficiency (8000 additional to 32,000 GWh Reduced Demand)⁽¹⁾</i>	3.8	1,235	1,226	2.4
Calif. Solar Initiative (including New Solar Homes Partnership) Additional 2000MW	1.4	1,348	339	721
Reduce Coal Generation by 12,800 GWh	8	850	0	106
Natural Gas				
<i>Energy Efficiency (200 million Therms Reduced)⁽¹⁾</i>	1.1	358	385	-25
Residential Solar Water Heater Installation (beyond AB 1470 goal) 2 million Therms	1	452	160	292
Industrial				
Energy Efficiency and Co-benefits Audits	TBD			
<i>Carbon Intensity Standard for Calif. Cement Manufacturers⁽¹⁾</i>	1.1-2.5	19.4	22.8	-1.9
<i>Carbon Intensity Standard for Concrete Batch Plants⁽¹⁾</i>	2.5-3.5	0	0	0
<i>Waste Reduction in Concrete Use⁽¹⁾</i>	0.5-1	55	83	-37
<i>Refinery Energy Efficiency Process Improvement⁽¹⁾</i>	2-5	71.1	460.7	-111
Removal of Methane Exemption from Existing Refinery Regulations	0.01-0.05	5	2.7	77
<i>Oil and Gas Extraction GHG Emission Reduction⁽¹⁾</i>	1-3	106.9	274.0	-84
<i>GHG Leak Reduction from Oil and Gas Transmission⁽¹⁾</i>	0.5-1.5	19	34.2	-15
<i>Industrial Boiler Efficiency⁽¹⁾</i>	0.5-1.5	22.9	150	-127
<i>Stationary Internal Combustion Engine Electrification⁽¹⁾</i>	0.1-1	17.9	25	-13
Glass Manufacturing Efficiency	0.1-0.2	36.9	23.6	89
Off-Road Equipment	Up to 0.5			0

Note for Table I-3:

- ¹ Measures in italics are low-cost measures that were included in the economic modeling of the Preliminary Recommendation, as discussed in the Economic Analysis Supplement.