Health Impact of Land Use VMT and In-Use Vehicle Fleets

For the American Lung Association in California

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Vehicles and Scenarios

Hydrogen (H2) vehicles were not analyzed in this study (market share of H2 vehicles, when available, were added to the BEV market share). The following scenarios were examined in this study:

- **CA In-Use**: California in-use fleet in 2035 up to 8,500 lbs.
- **SCAG In-Use**: Southern California Association of Governments (SCAG) region in-use fleet in 2035 up to 8,500 lbs.
- **SJ In-Use**: San Joaquin region in-use fleet in 2035 up to 8,500 lbs.
- **Conv LEVIII**: Car meeting Pavley I and LEVIII (SULEV30) emission standards
- **HEV**: MY2025 Hybrid electric car conforming to Pavley II and LEVIII emission standards
- **PHEV**: MY2025 Plug-in hybrid electric vehicle operating approximately 32% of the time in gasoline engine mode meeting LEVIII and 68% electric mode emission standards
- **BEV**: MY2025 Battery electric car with zero tailpipe (tank-to-wheels) emissions, include upstream well-to-tank emissions. No hydrogen FCVs modeled

Vehicles and Scenarios (continued)

- **6% GHG Reduc (NextGen):** 2025 car fleet mix corresponding to the federal LDV GHG stringency of 6% annual reduction from 2017 to 2025 via Pathway D (electrification focused technology) from EPA, NHTSA, and CARB's LDV GHG emission standards report, September 2010
- **2050 Target 2025 mix (Car of the Future)**: 2025 car fleet mix from Scenario 2 of ARB's ZEV whitepaper (11/25/09) to meet the 2050 goal of 80% GHG reduction below 1990 emission levels. Hydrogen FCV was not analyzed (FCV market share was included with the BEV market share)
- **2050 Target 2035 mix**: 2035 car fleet mix from Scenario 2 of ARB's ZEV whitepaper (11/25/09) to meet the 2050 goal of 80% GHG reduction below 1990 emission levels. Hydrogen FCV was not analyzed (FCV market share was included with the BEV market share)

Geographic Area

The Southern California region is the geographic area of interest. Specifically, the geographic area defined by the Southern California Association of Governments (SCAG) region.

- **SCAG Region (counties of Imperial, Los Angeles, Orange, Riverside, San Bernadino, and Ventura)**
  - Antelope Valley Air Pollution Control District
  - Imperial County Air Pollution Control District
  - Mojave Desert Air Quality Management District
  - South Coast Air Quality Management District
  - Ventura County Air Pollution Control District

Vehicle Assumptions

Individual car technologies (conventional, HEV, PHEV, and BEV) were modeled and used to estimate the vehicle fleet mix scenarios in 2035. Gasoline assumed to have a carbon intensity of 86.27 gCO2/MJ based upon the LCFS

	CA In-Use Fleet	SCAG In-Use Fleet	San Joaquin In-Use Fleet	Pavley I EPA	Proposed Pavley II / Proposed LEV III (similar to EPA LDV Tier 2 Bin 2)[3]					
				Conv LEVIII	HEV	PHEV[4]	BEV	6% GHG Reduc	2050 Target 2025	2050 Target 2035
Typical 2011 Vehicles[1]	In-Use Fleet	In-Use Fleet	In-Use Fleet	Honda Civic, Chevy Malibu	Toyota Prius	Chevy Volt	Nissan Leaf	Fleet Mix: 24%Conv 55%HEV 2%PHEV 19%BEV	2025 Fleet Mix: 25%Conv 34%HEV 16%PHEV 25%BEV	2035 Fleet Mix: 0%Conv 8%HEV 14%PHEV 78%BEV
Criteria Pollutants	In-Use Fleet Average	In-Use Fleet Average	In-Use Fleet Average	LEV III SULEV	LEV III SULEV	68% BEV 32% HEV	WTT Emiss. Only			
Fuel Economy (mi/gal)[2]	27	25	27	38	56	99	119	64	74	111
Petroleum in Fuel (%)	90%	90%	90%	90%	90%	90%	n/a	n/a	n/a	n/a
Well-to-Tank (WTT) GHG (gCO2e/mi)	76	80	74	39	26	56	70	38	45	64
Tank-to-Wheels (TTW) GHG (gCO2e/mi)	298	313	291	225	159	51	0	129	109	66
WTW CO2 (g CO2/mi)	374	393	365	264	185	107	70	167	154	131

[1] Typical 2011 vehicles shown to illustrate examples of the vehicles available in 2011

[2] Conventional, HEV, PHEV, and BEV have a small/midsized car footprint of 45 square feet which corresponds to EPA's fuel economy of 38 miles per gallon in 2016 (or 225 g CO2/mi tailpipe emissions). 2025 and 2035 vehicle fuel economies for conventional, HEV, and BEV were based upon ARB's ZEV whitepaper (11/25/09)

[3] No hydrogen vehicles modeled in this analysis. FCV market share is added to the BEV estimate

[4] PHEV estimate based upon limited range all electric operation and the assumed weighted average of 68% in BEV mode and 32% in HEV mode

In-Use Vehicle Fleet Assumptions

In-use vehicle fleets based upon EMFAC2007 for vehicles up to 8,500 pounds in the year 2035. In-use vehicle fleets assumed GHG emission reduction from Pavley I (fully implemented in 2016) and the Low Carbon Fuel Standard (for 2020 and subsequent years). EMFAC weekday emissions multiplied by 347 days/year to account for reduced vehicle activity on weekends.

	California In-use Fleet	SCAG In-Use Fleet	San Joaquin In-Use Fleet
VMT, miles/year	414,119,863,000	176,976,593,000	52,133,280,000
Vehicle Population	34,822,300	14,905,420	4,013,220
VMT, miles/year/vehicle	11,892	11,873	12,990

Notes: Previous TIAX report "Comparing the Benefits of Clean Car Regulations," for ALAC (May 2011) assumed new vehicle VMT of 15,000 mi/yr.

Criteria Pollutant Emission Factors

Well-to-tank (WTT) criteria emissions (and tank-to-wheel SOx) were estimated from Argonne National Laboratory's GREET model 1.8d.1 (max. year 2020 for California). EMFAC used for CA, SCAG, and San Joaquin TTW criteria emissions.

	CA In-Use Fleet	SCAG In-Use Fleet	San Joaquin In-Use Fleet	Pavley I	Pavley II / Proposed LEV III					
				Conv LEVIII	HEV	PHEV	BEV	6% GHG Reduc	2050 Target (2025mix)	2050 Target (2035mix)
WTT NOx (g/mi)	0.033	0.035	0.032	0.023	0.016	0.010	0.0101	0.016	0.015	0.011
WTT VOC (g/mi)	0.067	0.071	0.066	0.047	0.032	0.013	0.0006	0.029	0.025	0.005
WTT CO (g/mi)	0.016	0.017	0.015	0.011	0.008	0.005	0.0053	0.008	0.007	0.005
WTT PM (g/mi)	0.004	0.005	0.004	0.003	0.002	0.001	0.0005	0.002	0.002	0.001
WTT SOx (g/mi)	0.026	0.027	0.025	0.018	0.012	0.009	0.0118	0.013	0.013	0.011
TTW NOx (g/mi)	0.068	0.070	0.064	0.020	0.020	0.006	0.000	0.016	0.013	0.003
TTW VOC (g/mi)	0.111	0.115	0.099	0.010	0.010	0.003	0.000	0.008	0.006	0.001
TTW CO (g/mi)	0.944	1.003	0.904	1.000	1.000	0.324	0.000	0.796	0.642	0.125
TTW PM (g/mi)	0.020	0.022	0.019	0.001	0.001	0.0003	0.000	0.001	0.001	0.0001
TTW SOx (g/mi)	0.004	0.005	0.004	0.001	0.001	0.001	0.000	0.001	0.001	0.0002
WTW NOx (g/mi)	0.101	0.105	0.096	0.043	0.036	0.016	0.010	0.032	0.028	0.013
WTW VOC (g/mi)	0.178	0.185	0.165	0.057	0.042	0.017	0.001	0.037	0.031	0.006
WTW CO (g/mi)	0.960	1.020	0.920	1.011	1.008	0.329	0.005	0.804	0.649	0.131
WTW PM (g/mi)	0.024	0.027	0.023	0.004	0.003	0.001	0.001	0.003	0.002	0.001
WTW SOx (g/mi)	0.030	0.032	0.029	0.019	0.014	0.010	0.012	0.015	0.014	0.012

GREET g/MJ and the fuel economy (mi/gal) were used to estimate the g/mi values

Criteria Pollutant Emission Factors (continued)

- HEV TTW emissions were assumed to have the same TTW emissions as the conventional LEVIII (SULEV30)
- PHEV TTW emissions were estimated based upon the assumed 68% operation in HEV mode and 32% BEV mode
- The mixed fleet scenarios are based upon the weighted market share averages applied to the single car scenarios of conventional LEVIII, HEV, PHEV, and BEV
- All vehicles assumed to be using the same low carbon gasoline in 2035 (86.27 gCO_2/MJ)

Cost to Society Valuations

The cost to society was estimated for the year 2035 in 2010 dollars. PM-related valuations (Neal Fann of EPA) used average of American Cancer Society (ACS) study (Pope et al. 2002) and Six-Cities study (Laden et al., 2006). The Six-Cities study is about 145% larger than the ACS study. Ozone and visibility valuations calculated based upon national results presented in the latest EPA report "The Benefits and Costs of the Clean Air Act from 1990 to 2020" (March 2011)[1]

	Value	Units
GHG[2]	37.9	2010$/tonne CO2e
PM2.5	756,413	2010$/ton Direct PM2.5
Indirect PM: NOx	58,841	2010$/ton NOx
Indirect PM: SOx	61,386	2010$/ton SOx
Indirect PM: VOC	7,778	2010$/ton VOC
Ozone: Health	1,648	2010$/ton (NOx+VOC)
Ozone: Agriculture & Forests	318	2010$/ton (NOx+VOC)
Visibility	1,270	2010$/ton (PM+NOx+SOx+VOC)
Energy Security Premium[3]	0.468	2010$/gal petroleum

[1]Ozone emissions are approximated by summing the ozone precursors NOx and VOC with visibility based upon the PM, NOx, SOx, and VOC emissions presented for 2020 in the EPA report. Valuations based upon the discount rate of 3%

[2]GHG emissions from the US Government's Regulatory Impact Analysis on the Social Cost of Carbon (February 2010)

[3]Energy security premium includes the macroeconomic and the monopsony effects (excludes other costs such as military costs to secure stable oil supply from potentially vulnerable regions of the world). Gasoline assumed to be 90% petroleum

PM-Related Health Cases-per-ton

PM-related cases-per-ton estimate refers to the number of health effects associated with reducing one ton of PM2.5 or PM2.5 precursors (VOC, NOx, and SOx). Estimates based upon calendar year 2035

Health Endpoint, cases/ton	PM2.5	VOC	NOx	SOx
Premature Mortality (Pope & Laden)	0.07631	0.00078	0.00594	0.00619
Chronic Bronchitis	0.03417	0.00035	0.00264	0.00276
Acute Myocardial Infarction	0.07272	0.00076	0.00565	0.00609
Hospitalization: Respiratory	0.00882	0.00009	0.00069	0.00072
Hospitalization: Cardiovascular	0.01982	0.00021	0.00154	0.00165
ER visits (respiratory related)	0.01754	0.00018	0.00135	0.00142
Acute Bronchitis	0.08750	0.00089	0.00671	0.00709
Work Loss Days	6.48295	0.06564	0.50044	0.51187
Asthma Exacerbation	0.95418	0.00969	0.07339	0.07681
Acute Respiratory Symptoms	38.23382	0.38744	2.95034	3.02214
Lower Respiratory Symptoms	1.04022	0.01060	0.07988	0.08416
Upper Respiratory Symptoms	0.78766	0.00801	0.06068	0.06357

Notes: Cases-per-ton estimates from Neal Fann of US EPA for the San Joaquin Region (previous analysis used national data). Premature mortality is the average of the American Cancer Society study (Pope et al. 2002) and the Six-Cities study (Laden et al., 2006). The rounded Six-Cities benefits per ton results are presented in the EPA's Environmental Benefits Mapping and Analysis Program website: http://www.epa.gov/oaqps001/benmap/bpt.html

Ozone-Related Health Cases-per-ton

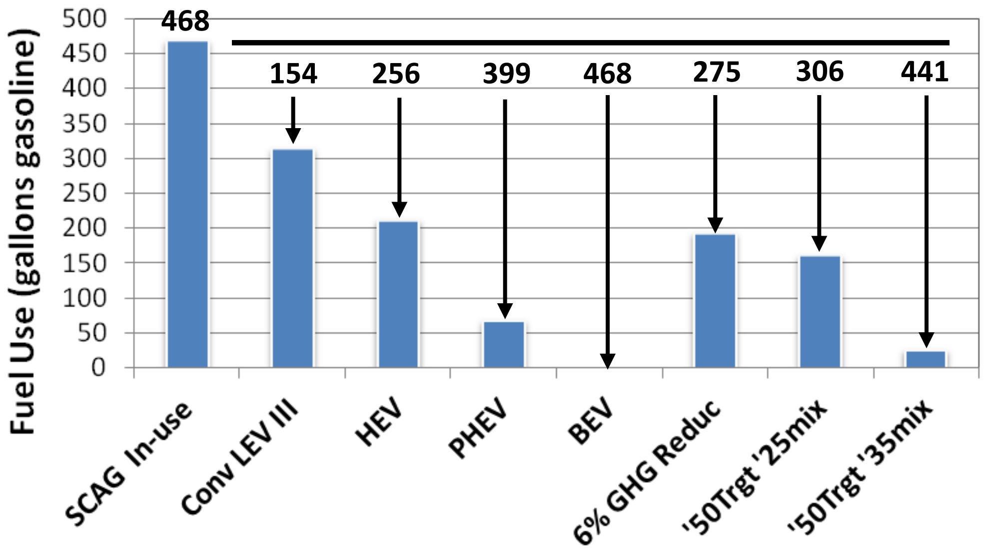
Ozone-related cases-per-ton estimate refers to the number of health effects associated with reducing one ton of ozone which is approximated by adding NOx and VOC precursors. Estimates based upon calendar year 2020 in EPA's "The Benefits and Costs of the Clean Air Act from 1990 to 2020," Final Report, March 2011. Premature mortality valuations are the average of the American Cancer Society study (Pope et al. 2002) and the Six-Cities study (Laden et al., 2006)

Health Endpoint, cases/ton	Ozone (NOx+VOC)
Premature Mortality (Pope & Laden)	0.00018
Hospitalization: Respiratory	0.00087
ER visits (respiratory related)	0.00027
Asthma Exacerbation	0.19102
School Loss Days	0.13765

SCAG Fuel Consumption

Advanced technology vehicles substantially reduce gasoline use.

Annual Single SCAG Vehicle Fuel Consumption in 2035

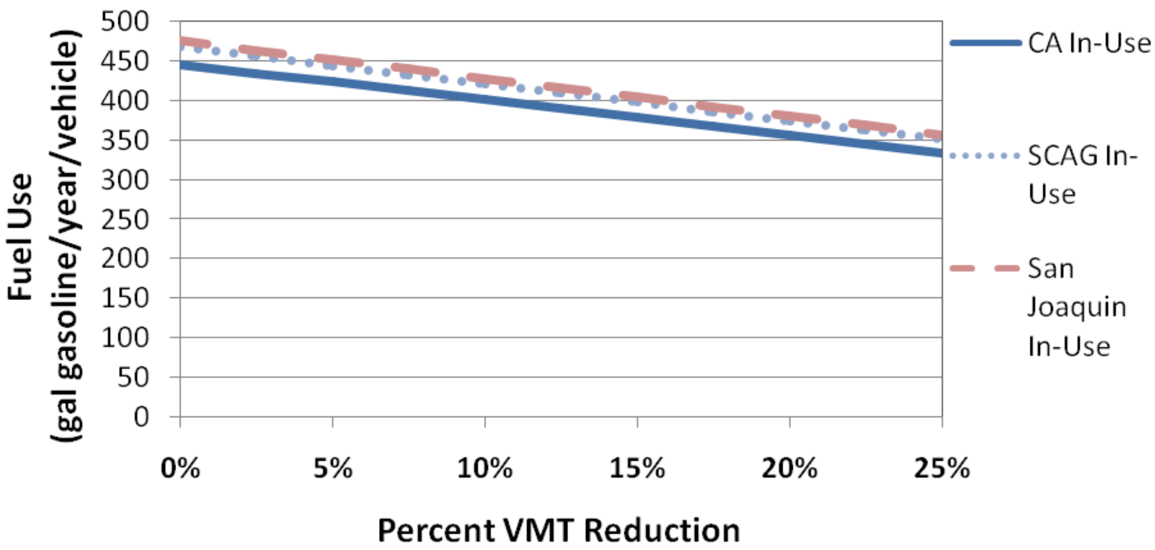


Fuel consumption of model year 2035 vehicles (except for SCAG In-Use)

Fuel Consumption

Reduction in vehicle miles traveled directly proportional to reduction in fuel use.

In-Use Fleet Average Annual Fuel Consumption per vehicle (2035)

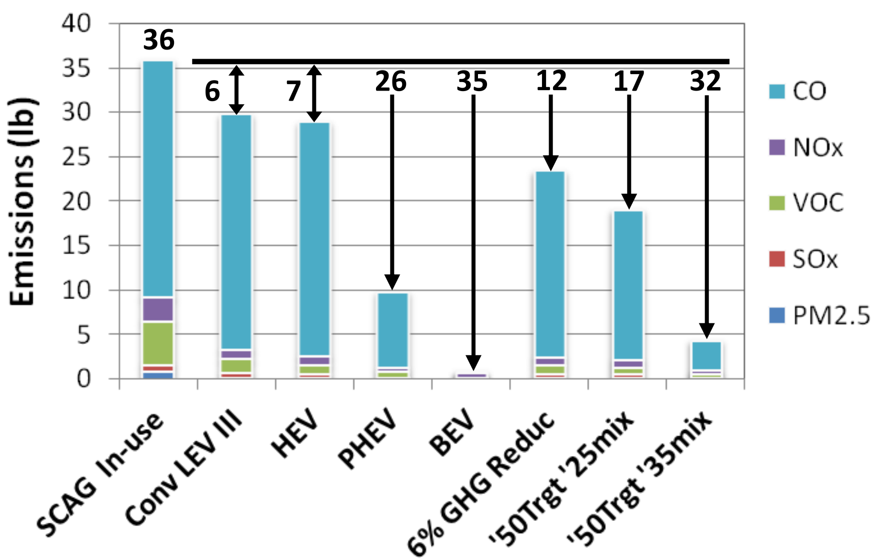


Fuel consumption of calendar year 2035

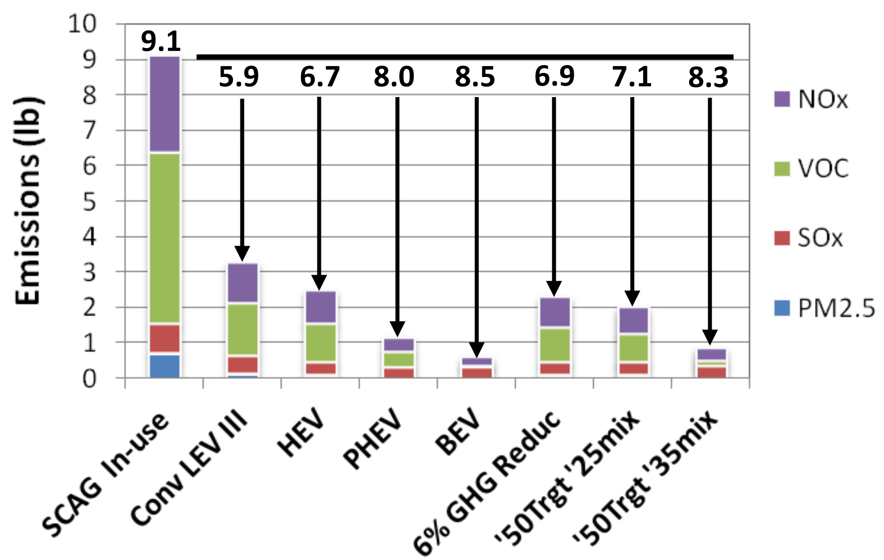
SCAG Criteria Pollutant Emissions

Full fuel cycle (well-to-wheel) emissions are dominated by CO followed by VOC, NOx and then PM2.5. Advanced technology vehicles reduce emissions even further than the ultra clean gasoline technology

Well-To-Wheel Criteria Pollutant Emissions per Vehicle



Well-To-Wheel Criteria Pollutants without CO per Vehicle



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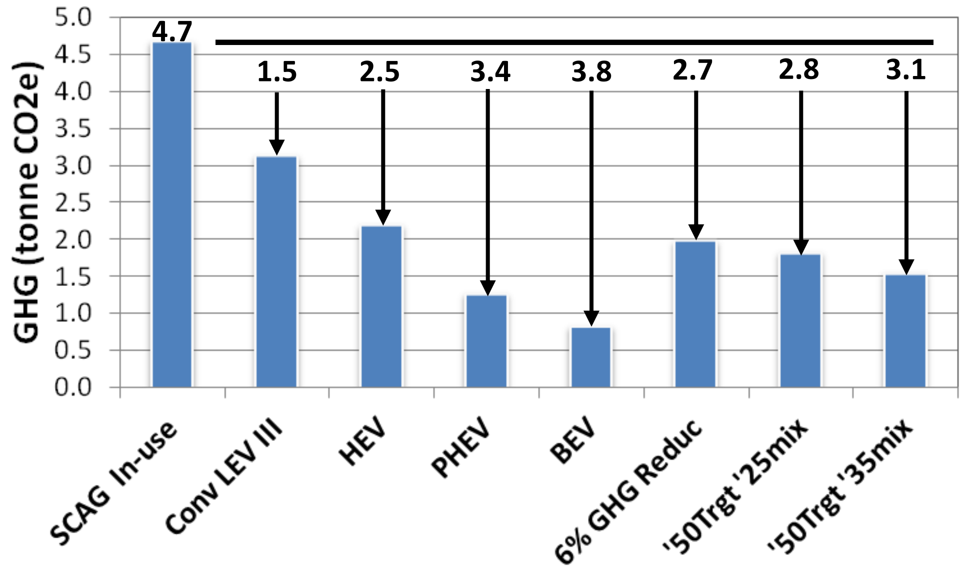
SCAG Greenhouse Gas Emissions

Advanced technology vehicles substantially reduced GHG emissions over the vehicle lifetime

Annual Well-To-Wheel GHG Emissions per vehicle

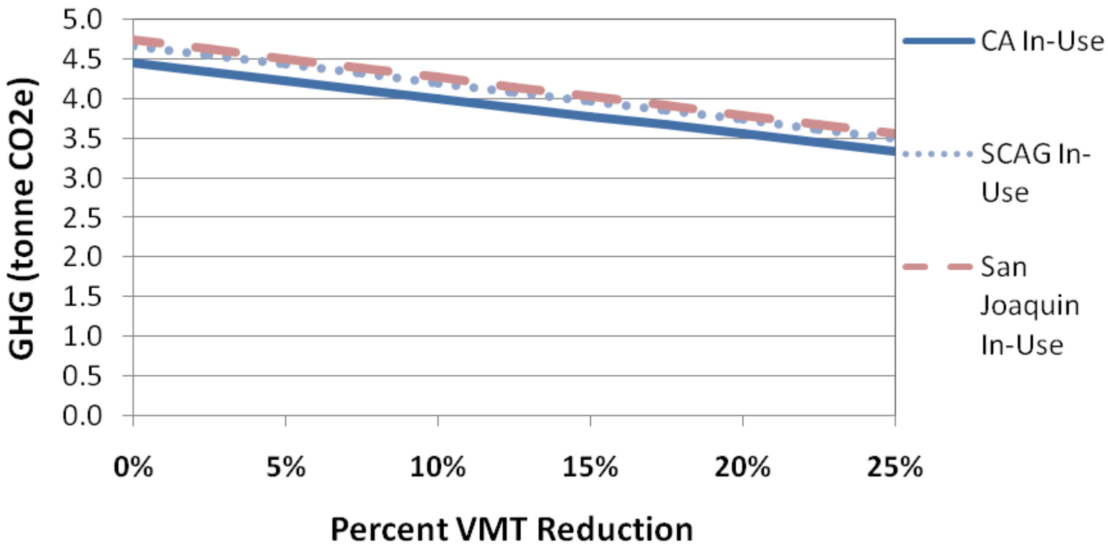


Upstream emissions for electricity are from electricity produced from natural gas fired combined cycle power plants combined with the renewable portfolio standard goals of 33 percent by 2020

In-Use Fleet Greenhouse Gas Emissions

Reduction in GHG is directly proportional to reduction in vehicle miles traveled

Annual Well-To-Wheel GHG Emissions per vehicle

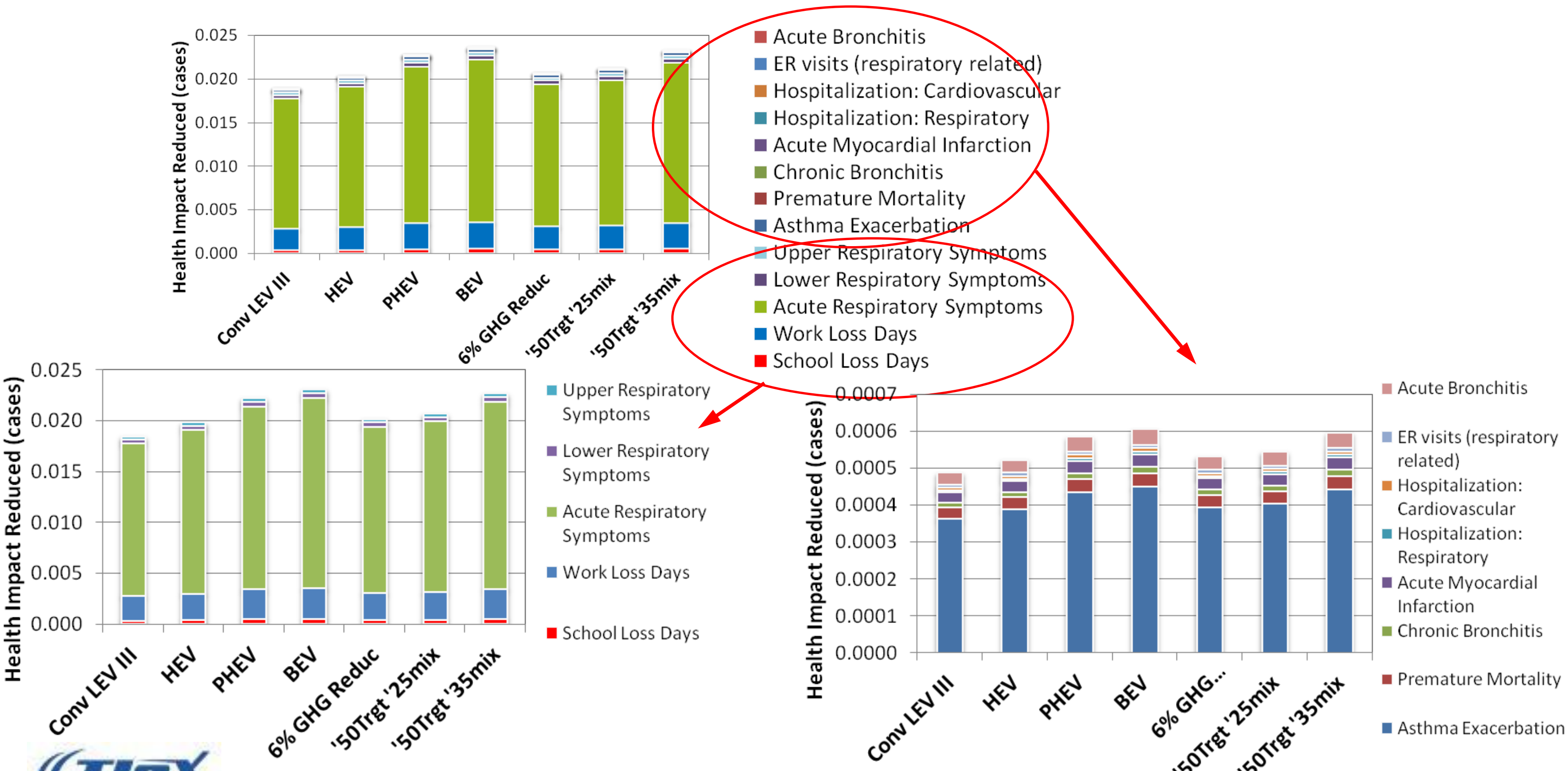


Upstream emissions for electricity are from electricity produced from natural gas fired combined cycle power plants combined with the renewable portfolio standard goals of 33 percent by 2020

SCAG PM2.5 & Ozone Related Health Damage Avoided

Model year 2035 PM2.5 and ozone related health impacts (incidences) avoided per vehicle compared to the average SCAG in-use vehicle fleet.

PM & Ozone Related Health Impact Avoided per Vehicle



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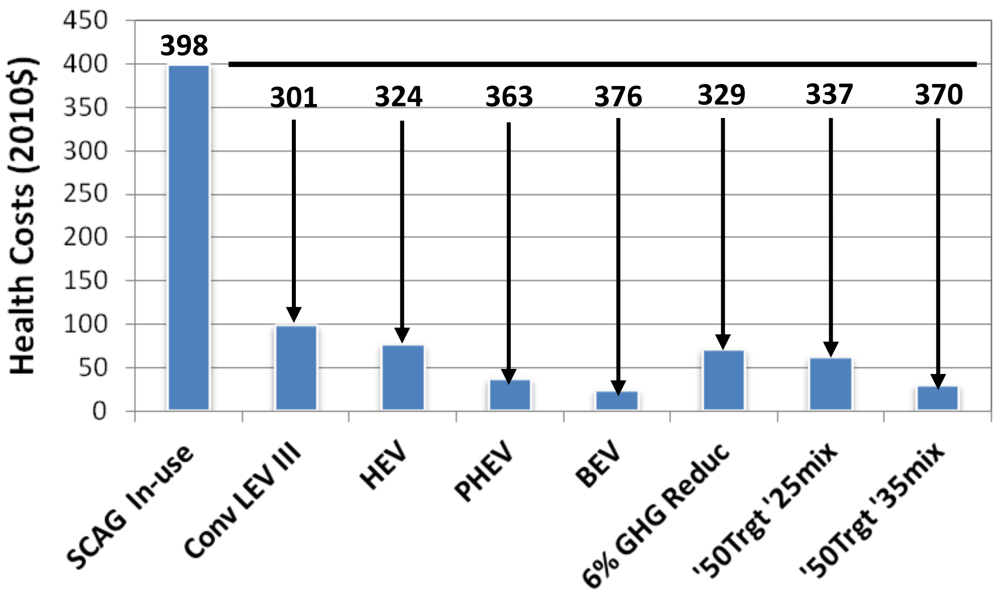
SCAG PM2.5 and Ozone Health Costs

Monetizing health related damages per vehicle shows PM2.5 (direct and indirect PM summed together) contributes to most of the savings associated with advanced gasoline vehicles and electricification further reduces criteria pollutant damages

Annual PM2.5 and Ozone Costs to Society per Vehicle

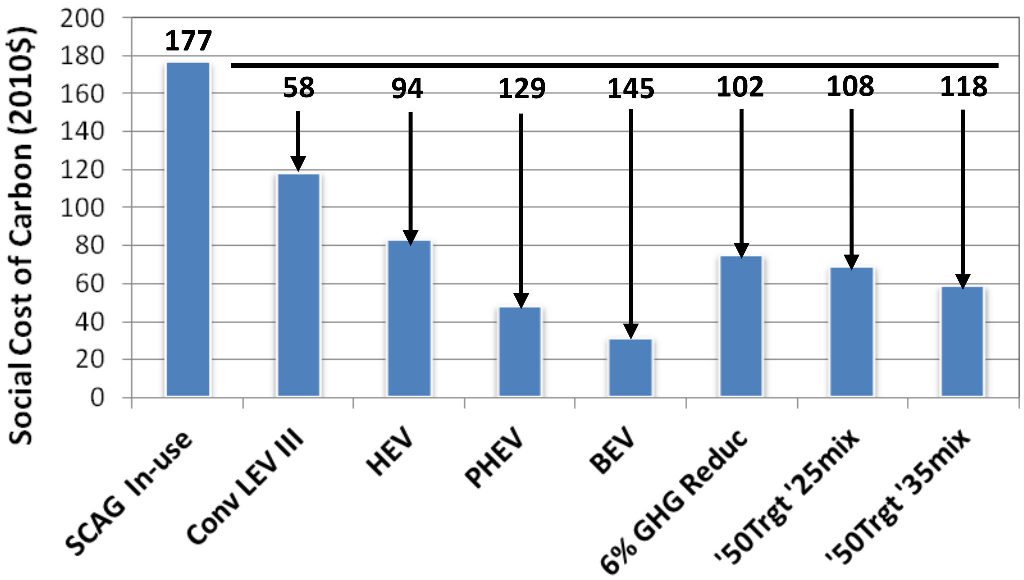


The cost of illness for morbidity measures the direct (value of goods and services used to diagnose and treat individuals) and indirect (lost productivity/wages) costs resulting from a health effect. These estimated costs do not account for the full costs associated with an illness/injury (pain and suffering, for example, are not included). Health effects include hospitalization (including emergency room visits) for effects such as acute/chronic bronchitis, acute myocardial infarction, reduced lung function, premature mortality, and other cardiovascular/respiratory effects including asthma

SCAG Greenhouse Gas Costs to Society

Monetized greenhouse gas emissions per vehicle are substantially reduced with advanced technology vehicles

Annual GHG Emission Costs to Society per Vehicle

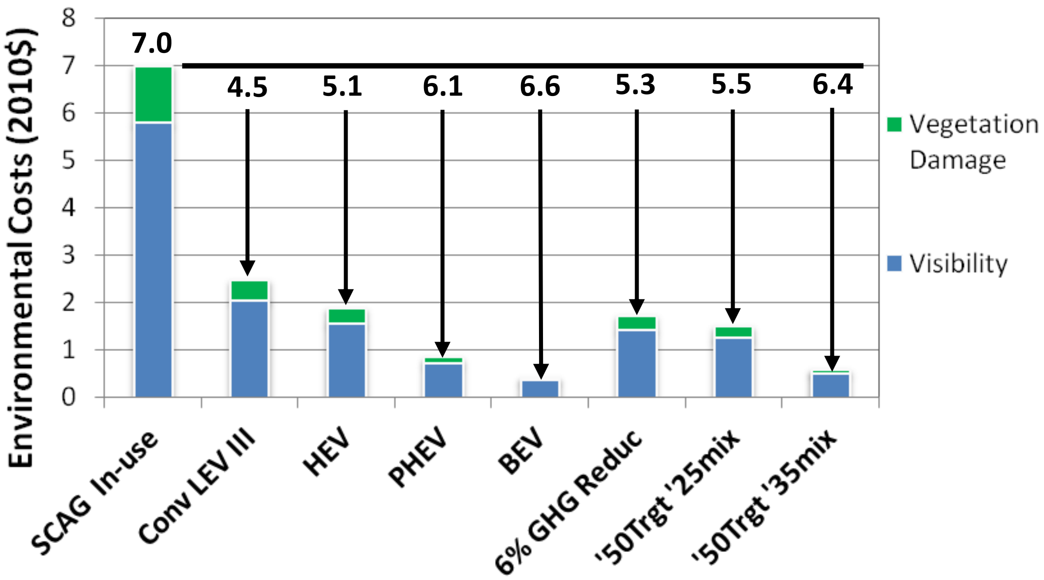


Social cost of carbon includes changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change

SCAG Environmental Costs

Damage costs to vegetation (agricultural crops and forest) caused by ground level ozone is not as large as the visibility impairment in both residential and recreational settings. Reduction of petroleum fuels would significantly reduce the environmental damage costs

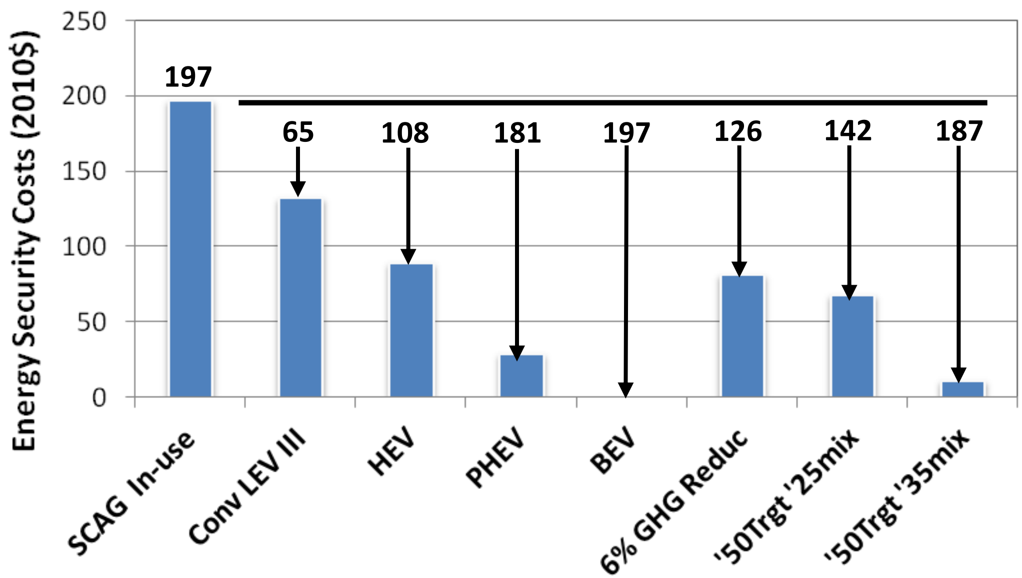
Annual Environmental Damage Costs per Vehicle



SCAG Energy Security Costs to Society

U.S. energy security is defined as protecting the U.S. economy against circumstances that threaten significant increases in energy costs. Energy security premium costs are proportional to the quantity of petroleum fuel used. Advanced technology vehicles minimizes petroleum fuel consumption

Annual Energy Security Premium Costs (per Vehicle)



Notes: The cost (in addition to the petroleum purchase price) of importing petroleum into the U.S. consists of macroeconomic adjustments and monopsony costs (other costs such as military costs to secure stable oil supply from vulnerable regions of the world were not included). Macroeconomic adjustments account for sudden disruptions in the supply of imported oil to the U.S. which can result in reduction in U.S. economic output and disruption of the U.S. economy. Monopsony costs are the effect of U.S. import demand on the world oil price and on OPEC market power

1. Introduction
2. Assumptions and Emission Factors
3. Fuel Use and Pollutant Emissions
4. Cost to Society
5. **Summary**
6. Sources

SCAG Light Duty Vehicle Fleet Emissions (per day)

SCAG Emissions in 2035 (per day)

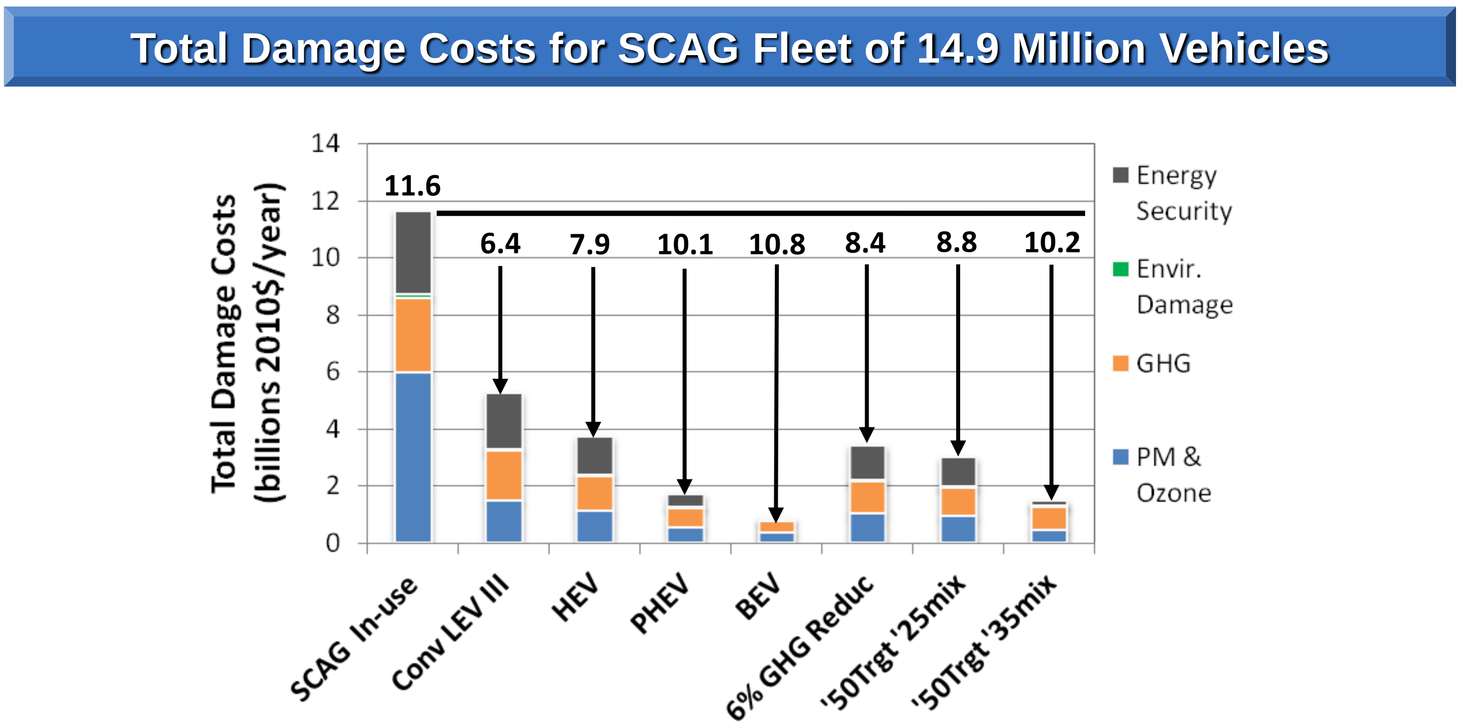
	CA In-Use Fleet	Pavley I	Pavley II / Proposed LEV III					
		Conv LEVIII	HEV	PHEV	BEV	6% GHG Reduc	2050 Target 2025mix	2050 Target 2035mix
PM2.5 (ton/day)	14.4	2.2	1.7	0.7	0.3	1.5	1.3	0.4
SOx (ton/day)	16.9	10.4	7.3	5.1	6.3	7.8	7.5	6.2
VOC (ton/day)	99.1	30.7	22.4	8.9	0.3	19.9	16.8	3.3
NOx (ton/day)	56.3	23.2	19.1	8.7	5.4	17.3	15.1	7.0
CO (ton/day)	545	540	538	176	3	430	347	70
Total (ton/day)	732	607	589	199	15	476	388	87
Total w/o CO (ton/day)	186.6	66.5	50.5	23.4	12.3	46.5	40.6	16.9
GHG (tonne/day)	190,660	127,956	89,678	51,969	33,922	81,026	74,626	63,310
Fuel Use (million gal/day)	19.11	12.83	8.66	2.80	0.00	7.90	6.60	1.09

SCAG Light Duty Vehicle Fleet Emissions Reduced (per day)

SCAG Emissions Reduced in 2035 (per day)

	CA In-Use Fleet	Pavley I	Pavley II / Proposed LEV III					
		Conv LEVIII	HEV	PHEV	BEV	6% GHG Reduc	2050 Target 2025mix	2050 Target 2035mix
PM2.5 (ton/day)	Baseline	12.2	12.8	13.7	14.1	12.9	13.1	14.0
SOx (ton/day)	Baseline	6.5	9.6	11.8	10.6	9.1	9.4	10.7
VOC (ton/day)	Baseline	68.4	76.6	90.2	98.8	79.1	82.3	95.8
NOx (ton/day)	Baseline	33.0	37.1	47.5	50.8	38.9	41.2	49.3
CO (ton/day)	Baseline	4	6	369	542	115	198	475
Total (ton/day)	Baseline	125	142	532	716	255	344	645
Total w/o CO (ton/day)	Baseline	120.1	136.1	163.2	174.3	140.1	146.0	169.7
GHG (tonne/day)	Baseline	62,703	100,982	138,691	156,738	109,633	116,033	127,350
Fuel Use (million gal/day)	Baseline	6.29	10.45	16.31	19.11	11.22	12.51	18.03

SCAG Vehicle Fleet Damages: Costs per Year



The expected California population of light duty vehicles (up to 8,500 lbs.) in 2035 is 14.9 million vehicles based upon EMFAC2007.

SCAG: PM2.5 and Ozone Health Impact (cases per year)

The health impact (cases/year) for the 2035 light duty vehicle fleet (14.9 million) is presented below.

Health Endpoint (cases/year)	SCAG In-Use Fleet	Pavley I	Pavley II / Proposed LEV III					
		Conv LEVIII	HEV	PHEV	BEV	6% GHG Reduc	2050 Target 2025mix	2050 Target 2035mix
Asthma Exacerbation	7,099	1,707	1,315	638	416	1,225	1,080	519
Premature Mortality	600	147	113	54	34	105	92	43
Chronic Bronchitis	255	61	47	23	15	44	39	19
Acute Myocardial Infarction	546	132	102	49	32	95	84	40
Hospitalization: Respiratory	116	33	26	12	6	23	20	8
Hospitalization: Cardiovascular	149	36	28	14	9	26	23	11
ER visits (respiratory related)	148	37	29	14	8	27	23	11
Acute Bronchitis	651	157	121	58	38	112	99	48
Work Loss Days	48,250	11,590	8,927	4,324	2,809	8,312	7,327	3,510
Acute Respiratory Symptoms	295,397	72,116	55,552	26,731	16,968	51,620	45,436	21,422
Lower Respiratory Symptoms	7,739	1,862	1,433	696	454	1,335	1,178	567
Upper Respiratory Symptoms	5,863	1,411	1,086	527	344	1,012	892	429
School Loss Days	7,803	2,707	2,089	884	287	1,871	1,600	515

SCAG: PM2.5 and Ozone Health Damage Avoided (cases per year)

The health impact reduced (cases/year) for the 2035 light duty vehicle fleet (14.9 million) from the SCAG in-use fleet is presented below.

Health Endpoint (cases/year)	SCAG In-Use Fleet	Pavley I	Pavley II / Proposed LEV III					
		Conv LEVIII	HEV	PHEV	BEV	6% GHG Reduc	2050 Target 2025mix	2050 Target 2035mix
Asthma Exacerbation	Baseline	5,392	5,784	6,461	6,683	5,874	6,019	6,580
Premature Mortality	baseline	453	487	546	566	495	508	557
Chronic Bronchitis	baseline	193	208	232	240	211	216	236
Acute Myocardial Infarction	baseline	414	444	497	514	451	463	506
Hospitalization: Respiratory	baseline	83	90	104	110	92	95	108
Hospitalization: Cardiovascular	baseline	113	121	136	140	123	126	138
ER visits (respiratory related)	baseline	110	119	134	140	121	124	137
Acute Bronchitis	baseline	494	530	592	613	539	552	603
Work Loss Days	baseline	36,660	39,323	43,926	45,441	39,938	40,923	44,740
Acute Respiratory Symptoms	baseline	223,281	239,845	268,666	278,429	243,777	249,961	273,976
Lower Respiratory Symptoms	baseline	5,877	6,305	7,043	7,284	6,403	6,561	7,172
Upper Respiratory Symptoms	baseline	4,452	4,776	5,336	5,518	4,851	4,970	5,434
School Loss Days	baseline	5,096	5,714	6,919	7,516	5,932	6,203	7,288

- ARB, "Detailed California-Modified GREET Pathway for California Reformulated Gasoline (CaRFG)," Version: 2.1, Release Date: February 27, 2009
- ARB, "Pavley I and Low Carbon Fuel Standard Postprocessor Version 1.0, User's Guide"
- ARB, "Preliminary Discussion Paper – Amendments to California's Low-Emission Vehicle Regulations for Criteria Pollutants – LEV III," ARB Workshop: March 2, 2010
- ARB, "Proposed Regulation to Implement the Low Carbon Fuel Standard: Volume I: Staff Report: Initial Statement of Reasons," March 5, 2009
- ARB, "Public Workshop on Proposed Revisions to the Low-Emission Vehicle Program," Presentation to ARB Workshop: March 2, 2010
- ARB, "White Paper: Summary of Staff's Preliminary Assessment of the Need for Revisions to the Zero Emission Vehicle Regulation," November 25, 2009
- California Code of Regulations, Title 17, Subchapter 10, Subarticle 7 Section 95480-95490
- CEC, "Full Fuel Cycle Assessment: Well To Tank Energy Inputs, Emissions and Water Impacts," AB1007's CEC Report # CEC-600-2007-002-D, February 2007
- CEC, "Full Fuel Cycle Assessment: Well To Wheels Energy Inputs, Emissions, And Water Impacts," AB1007's CEC Report # CEC-600-2007-004-D, February 2007
- CEC, "State Alternative Fuels Plan," AB1007's Report #CEC-600-2007-011-CMF, December 2007
- DOE, Argonne National Laboratory, The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model, Version 1.8d.1
- EPA and NHTSA, "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis," Report #EPA-420-R-10-009, April 2010

Benefits of VMT Reduction from In-Use Fleets *Sources*

- EPA, "The Benefits and Costs of the Clean Air Act from 1990 to 2020," Final Report, March 2011
- EPA, NHTSA, and ARB, "Interim Joint Technical Assessment Report: Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2017-2025," September 2010
- McCubbin, D., Delucchi, M., “The Social Cost of the Health Effects of Motor-Vehicle Air Pollution,“ UC Davis, Report # UCD-ITS-RR-96-3 (11), August 1996
- National Highway Traffic Safety Administration’s Fatality Analysis Reporting System website November 19, 2010 http://www-fars.nhtsa.dot.gov/States/StatesFatalitiesFatalityRates.aspx
- Personal communication with Neal Fann, USEPA, Office of Air Quality Planning & Standards, Air Benefit and Cost Group (July 2011). Using the same model that also produced the benefits per ton results for the EPA’s Environmental Benefits Mapping and Analysis Program website : http://www.epa.gov/oaqps001/benmap/bpt.html
- TIAX, “Appendix A: Benefits of Reducing Demand for Gasoline and Diesel (Task 1),” TIAX report for CARB and CEC’s AB2076 “Reducing California's Petroleum Dependence,” Report #P600-03-005A1, September 2003
- US Government, "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis, Under Executive Order 12866," Interagency Working Group which includes DOE, DOT, and EPA, February 2010
- US Federal Register, Volume 75, No. 58, March 26, 2010, pg 1476-14818
- US Federal Register, Volume 75, No. 88, [40 CFR Parts 85, 86, and 600], "Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule," May 7, 2010