NATURAL GAS SCENARIO

AB 1007 STATE PLAN TO INCREASE ALTERNATIVE FUELS USE

California Energy Commission and
California Air Resources Board

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NATURAL GAS SCENARIO

PRESENTATION OUTLINE

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STORYLINE

- California will take bold action to increase its motor fuel natural gas use in a cost-effective manner, so that by 2012, 2017, 2022, 2030, and 2050, 0.95 to 2.8 percent of its on-road transportation fuel will be natural gas under a conservative scenario.
- Under a moderate scenario up to 9 percent of California's on-road transportation fuel will be natural gas by 2050.
- Under an aggressive scenario, up to 19 percent of the state's on-road transportation fuel will be natural gas by 2050.
- Achieving NG fuel use goals enhance transportation energy supply by extending petroleum resources in corresponding amounts and reduces emissions proportionately.
- "No Net Material Increase in Emissions" occur from the use of this fuel.
- Natural gas lowers the state Average Fuel Carbon Intensity under the Low Carbon Fuel Standard and helps achieve AB 32 goals.

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IMPORTANT CRITERION

- Based on our analysis, on a full fuel cycle basis, this fuel and the scenarios evaluated result in “No Net Material Increase in Emissions”.

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ESTD. FUEL USE GOALS FOR NATURAL GAS (mm gge/yr)

CASE	2006	2012	2017	2020	2022	2030	2050
Conservative	125	218	294	354	399	589	839
%Total	0.6	1	1.2	1.5	1.7	2.3	2.8
Mod.	125	319	536	736	912	1721	2666
%Total	0.6	1.4	2.3	3.1	3.8	6.8	8.9
Aggr.	125	433	803	1165	1494	3271	5570
%Total	0.6	1.9	3.4	4.9	6.2	13	19
Tot. All Fuels	20981	22981	23661	23819	23969	25289	29853

Source: California Energy Commission

NATURAL GAS SCENARIO

KEY ASSUMPTIONS

Fuel Use Goals	Veh. Pop.	Infrastr./Sta	Cost-Effectvns	Investment
▪Avg. VMT for LD, M/HD CNG and HD LNG Vehicles ▪Fleet Avg. fuel economy for LD, M/HD CNG and HD LNG Vehicles ▪Case Definition -Consr. Lots unk -Mod. Small unk -Aggr. Modest unk ▪Adj. growth rates from 2008-2039. ▪NG fuel use growth stabilize in 2040 to gsl/dsl rates.	▪Mid-size passenger veh as rep LD veh. ▪PDV as rep MD veh. ▪Trash truck & urban bus as rep HD CNG veh. ▪Line Haul truck as rep HD LNG veh.	▪Infrastructure segment-ation by class (HRA, Small, Med., Lrg.) ▪ Vehs. allocation to stations. -40% LD HRA -20% exstg -30% sm/md -10% lg	▪Incentive allocation ▪All veh delta costs covered by incentives ▪Half infra cost from incentives ▪Zero O&M costs between CFV and NGV. O&M Cost negligible. ▪Fleet & Long-term Ckts. dominate fuel sales	▪Veh. RD&D costs ▪Infra RD&D costs ▪Veh. & Infra Incentives applied

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METHODOLOGIES

Fuel Use Goals	Veh. Pop.	Infrastr./Sta	Cost-Effectvns	Investment
▪Det. 5-Yr Historic industry avg. growth ▪Adjust -25:-50% Consr. Case -0% Mod. Case -+25% Aggr. Case ▪Case Definition -Consr. Lots unk -Mod. Small unk -Aggr. Modest unk ▪Apply adj. rate to 2006/7 vol. for proj. ▪Vary rate to 2040 to stable rate.	▪Det veh. Class mpg. ▪Det Class VMT ▪Det veh. Fuel use ▪Det veh. pop	▪Det station thru-put by size. ▪Segment stations by class (HR, Small, Med., Lrg.) ▪Allocate vehs. to stations. ▪Det. no of fueling ctrs by size.	▪Det any incr. veh. cost in ref. yr. ▪Det incentive ▪Det any station cost ▪Det fuel cost savs or loss ▪Sum over veh. pop. ▪Det present value by discounting. ▪Divide cost by fuel vol ovr life.	▪Det veh. RD&D costs ▪Det fueling infra RD&D costs ▪Det incentives applied ▪Sum of RD&D costs plus incentives ▪Det present value by discounting

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UNCERTAINTIES

Fuel Use Goals	Veh. Pop.	Infrastr./Stations	Cost-Effectiveness	Investment
▪Adjustments to historic fuel growth ▪Modulating adjusted fuel growth over time to the equilibrium rate ▪Other -Govt policy consistency -Oil prices -Investor response -Product availability	▪Distillation of vehicle classes from bulk fuel vol. ▪Using avg. veh. Mpg ▪Using avg. veh. vmt	▪Distillation of veh. pop from bulk fuel vol.	▪Distillation of vehicle classes from bulk fuel vol. ▪Allocating fueling infra. amongst station sizes	▪Estimating the veh. RD&D data ▪Estimating the fueling infra. RD&D data

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SENSITIVITIES

Fuel Use Goals	Veh. Pop.	Infrastr./Stations	Cost-Effectiveness	Investment
▪Equilibrium rate year introduced changes 2050 result by up to 20% ▪Magnitude of equilibrium rate affects growth rate modulation and milestone yr results by 10% or more	▪Change of 5 to 10% in avg. mpg can change veh pop result by 10% ▪Change of 5 to 10% in avg veh vmt can change result by 20%	▪Infra-structure distribution	▪Fuel price difference ▪ 25-cent change causes big CE change	▪No investment, no fuel use growth. ▪Small investment, no fuel use growth.

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Market Conditions

Market Drivers	Market Barriers	Barrier Resolution
▪Oil supply constraints ▪High crude oil prices ▪Resource nationalism ▪Renewed interest in alternative fuels ▪Competitive fuel supply ▪NG price advantage ▪Policy Initiatives -AB 1007 -AB 32 -LCFS, SIP -New Fed. initiatives	▪Product availability ▪Persistent but changing veh. incr. cost ▪On-board storage technology ▪On-board storage cost ▪Limited fueling network ▪Consumer acceptance ▪Lack of consumer awareness	▪Expand product offerings ▪Stabilize thru consumer-oriented pricing ▪Long-term, consistent support to deploy ANG ▪Develop new materials; achieve scale economies ▪Implement long-term growth plan, including support for HRAs ▪Consumer education ▪Marketing and promotion by auto cos, fuel cos, NPOs, govt

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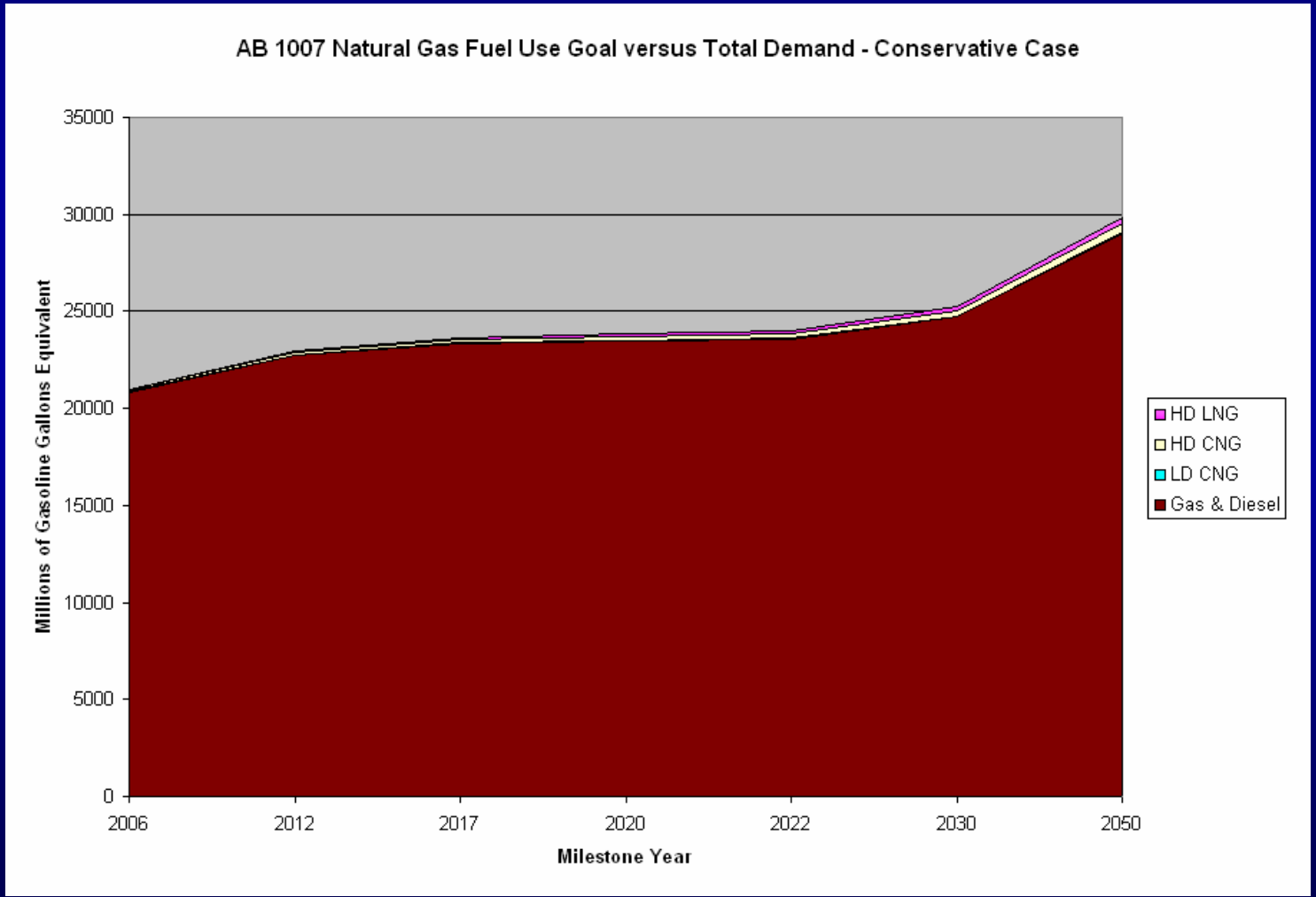
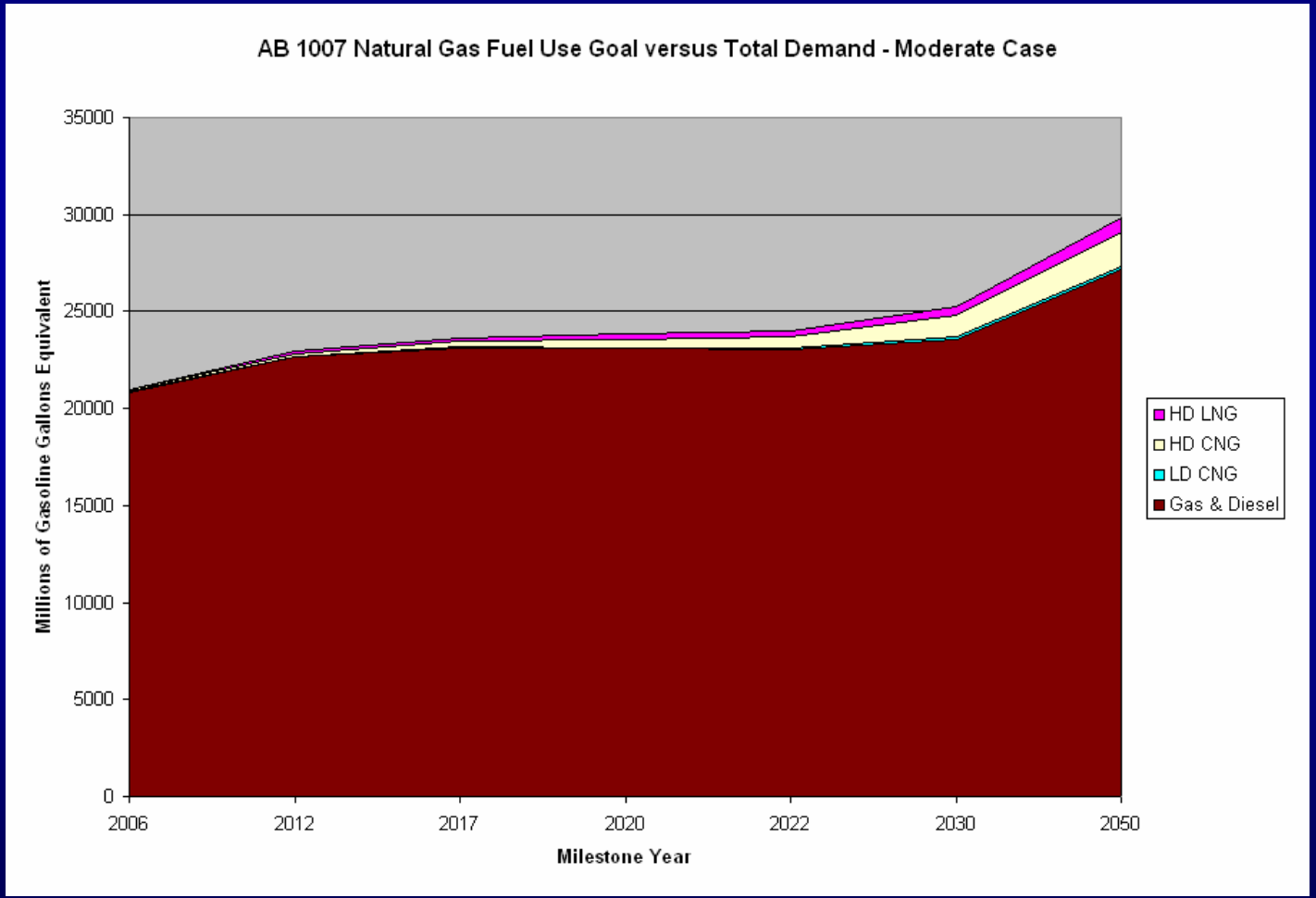
ESTIMATED FUEL USE OUTCOMES



Source: California Energy Commission

NATURAL GAS SCENARIO

ESTIMATED FUEL USE OUTCOMES



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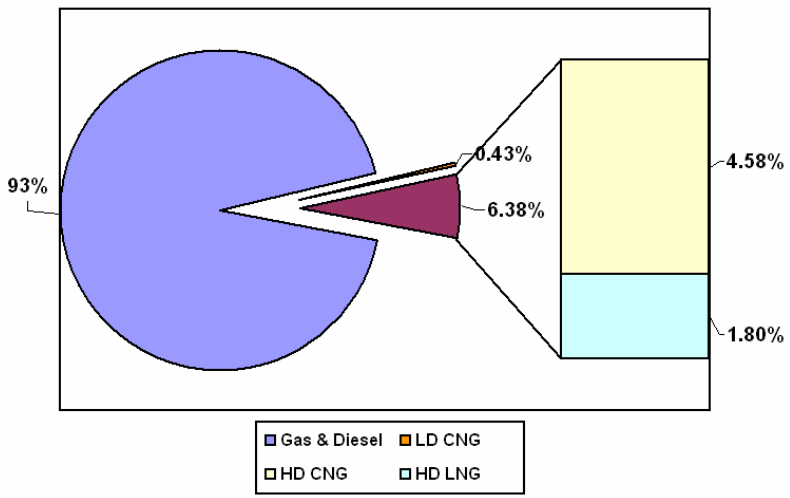
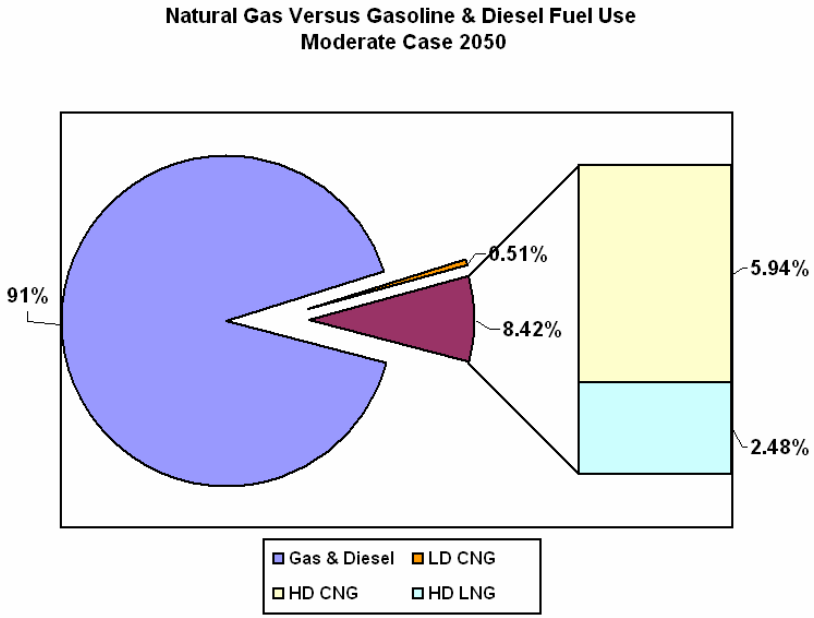
FUEL USE OUTCOMES – MODERATE CASE



2050, NG 8.9% of on-road transportation fuel



2006, NG < 1% of on-road transportation fuel

2030, NG 6.8% of on-road transportation fuel

Source: California Energy Commission

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FUEL USE OUTCOMES – Vehicles, Fueling Network

Conservative Case	2006	2012	2017	2020	2022	2030	2050
(mmgge)	125	218	294	354	399	589	839
% On-Road TFuel	0.6	1	1.2	1.5	1.7	2.3	2.8
LD CNG Vehs.	6800	7050	9600	11600	13150	19500	26350
HD CNG Vehs.	7080	10851	14805	17931	20322	30069	40644
HD LNG Vehs.	2345	5931	7862	9379	10483	15379	23724
HRA Units	2040	2115	2880	3480	3945	5850	7905
One Dspsr 2 pmps	132	34	47	56	64	95	128
Small Stations	66	17	23	28	32	47	64
Med. Stations	33	9	12	14	16	24	32
Lrg Stations -CNG	295	113	154	187	212	313	423
Lrg Stations LNG	49	31	41	49	55	80	124

Source: California Energy Commission

NATURAL GAS SCENARIO

FUEL USE OUTCOMES – Vehicles, Fueling Network

Moderate Case	2006	2012	2017	2020	2022	2030	2050
(mmgge)	125	319	536	736	912	1721	2666
% On-Road TFuel	0.6	1.4	2.3	3.1	3.8	6.8	8.9
LD CNG Vehs.	6800	7550	13500	19500	25000	54000	76000
HD CNG Vehs.	7080	15908	29241	42023	53609	106391	163126
HD LNG Vehs.	2334	9034	13172	16552	19241	31448	51034
HRA Units	2040	2265	4050	5850	7500	16200	22800
One Dspsr 2 pmps	132	37	66	95	122	263	369
Small Stations	66	18	33	47	61	131	185
Med. Stations	33	9	16	24	30	66	92
Lrg Stations -CNG	295	166	305	438	558	1108	1699
Lrg Stations LNG	49	47	69	86	100	164	266

Source: California Energy Commission

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ESTIMATED ENVIRONMENTAL BENEFITS

Moderate Case	2006	2012	2017	2020	2022	2030	2050
(mmgge)	125	319	536	736	912	1721	2666
GHG Red. LD	N/A	-21%	-21%	-20%	-20%	?	?
HD		-5%	-5%	-10%	-10%	?	?
PM	N/A	Negl.	Negl.	Negl.	Negl.	?	?
NOx	N/A	Negl.	Negl.	Negl.	Negl.	?	?
HC	N/A	-72%	-72%	-38%	-38%	?	?
Toxics – LD	N/A	-80%	-80%	-80%	-80%	?	?
HD – CNG		-40%	-40%	-20%	-20%	?	?
HD - LNG		-40%	-40%	-20%	-20%	?	?
Water Impacts	N/A	None	None	None	None	?	?

Source: Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions & Water Impacts, CEC, March 2007

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ESTIMATED ENVIRONMENTAL BENEFITS – AB 32 NEXUS

Case (mm gge)	2006	2012	2017	2020	2022	2030	2050
Conservative	125	218	294	354	399	589	839
GHG Red. (m-tons)	N/A	1	TBD	TBD	TBD	?	?
%Trans. Total AB 32	N/A	Negl.	TBD	TBD	TBD	?	?
Moderate	125	319	536	736	912	1721	2666
GHG Red (m-tons)	N/A	1.4	TBD	TBD	TBD	?	?
%Trans. Total AB 32	N/A	Negl.	TBD	TBD	TBD	?	?
Aggressive	125	433	803	1165	1494	3271	5570
GHG Red (m-tons)		1.8	TBD	TBD	TBD	?	?
%Trans. Total AB32	N/A	Negl.	TBD	TBD	TBD	?	TBD
TTotal AB 32 mm tons	N/A	10	35	25	TBD	?	?

Source: California Energy Commission

Note: Estimated environmental benefits from representative LD NGV, MD NGV, HD CNGV and HD LNGV on a full fuel cycle basis. Ref. AB 1007 Full Fuel Cycle Analysis. AB 32 mm tons, illustrative only.

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ECONOMIC BENEFITS & COST-EFFECTIVENESS

- Evaluated several natural gas fuel production pathways and vehicle combinations
- Production costs optimized around production pathways
- Determined the most cost-effective production pathway and vehicles combination that satisfied the environmental criteria, economic criteria
- Range: $-0.54/gge to $0.71/gge

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ECONOMIC BENEFITS & COST-EFFECTIVENESS

- CE determined as a function of time
- CE is ratio of net sum of life cycle costs to sum of fuel used over vehicle useful life.
- Represents cost to get one gge of NG to market.
- Negative cost-effectiveness means an overall benefit to market actors under the assumptions made.
- Positive cost effectiveness means cost to market actors including government.
- No monetized environmental benefits included in calculations.

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ECONOMIC BENEFITS & COST-EFFECTIVENESS

Selected Cost Assumptions							
		Near-Term (2008-2017)		Medium Term (2018-2030)		Matured Market (2030-2050)	
		Low	High	Low	High	Low	High
LD CNG Vehs.		$1000	$6800	$1000	$3900	$500	$2500
HD CNG Vehs.		$2000	$28000	$2000	$14000	0	$4700
HD LNG Vehs.		$28000	$35000	$14,000	$22,000	0	$4700
HRA Units		$4000	$5500	$3200	$4400	$2560	$3520
One Dspsr 2 pmps		$100K	$150K	$80K	$120K	$64K	$96K
Small Stations		$200K	$300K	$160K	$240K	$120K	$192K
Med. Stations		$300K	$500K	$240K	$400K	$192K	$380K
Lrg Stations -CNG		$700K	$1000K	$560K	$800K	$448K	$640K
Lrg Stations LNG		$700K	$1500K	$560K	$1200K	$448K	$960K

Source: California Energy Commission

Note: Veh. Costs incremental. Infrastructure, capital.

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ESTIMATED COST EFFECTIVENESS (2007$/GGE)

Case (mm gge)	2006	2012	2017	2020	2022	2030	2050
Conservative	125	218	294	354	399	589	839
2007$/GGE	N/A	-0.11	0.71	0.69	0.64	-0.08	-0.10
Moderate	125	319	536	736	912	1721	2666
2007$/GGE	N/A	-0.22	0.38	0.33	0.33	-0.20	-0.16
Aggressive	125	433	803	1165	1494	3271	5570
2007$/GGE	N/A	-0.54	0.09	0.12	0.16	-0.29	-0.21

Source: California Energy Commission

Note: $2007 at 5% discount rate. CE includes fuel savings and tax revenue impacts to government. Negative CE means overall savings to consumer/end user.

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CAPITAL INVESTMENT (MM Nominal & MM $2007)

Investment Required 1 = (LD, MD, HD) Vehicle R&D + Infrastructure R&D

Investment Required 2 = (LD, MD, HD) Vehicle R&D + Infrastructure R&D + Vehicle Incentives + Infrastructure Incentives

Investment Required to support 3 vehicle product offerings in LD, MD, HD classes and flexible fueling infrastructure.

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ESTIMATED CAPITAL INVESTMENT – VEH. & INFRA.

Case (mm gge)	2006	2012	2017	2020	2022	2030	2050	Total
Conservative	125	218	294	354	399	589	839	N/A
MM Nom$	N/A	840	840	840	840	840	N/A	4200
MM $2007	N/A	658	516	445	404	273	N/A	2300
Moderate	125	319	536	736	912	1721	2666	2666
MM Nom$	N/A	1620	1620	1620	1620	420	N/A	6900
MM $2007	N/A	1270	995	860	780	137	N/A	4040
Aggressive	125	433	803	1165	1494	3271	5570	5570
MM Nom$	N/A	1620	1620	1620	1620	420	N/A	6900
MM $2007	N/A	1270	995	860	780	137	N/A	4040

Source: California Energy Commission

Note: $2007 at 5% discount rate.

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ESTD. INVESTMENT – VEH. & INFRA R&D + INCENT.

Case (mm gge)	2006	2012	2017	2020	2022	2030	2050	Total
Conservative	125	218	294	354	399	589	839	N/A
MM Nom$	N/A	1270	990	1260	880	1070	120	5600
MM $2007	N/A	1000	608	670	422	350	15	3070
Moderate	125	319	536	736	912	1721	2666	N/A
MM Nom$	N/A	2260	2030	2040	2230	1350	290	10200
MM $2007	N/A	1770	1250	1080	1070	440	36	5600
Aggressive	125	433	803	1165	1494	3271	5570	N/A
MM Nom$	N/A	2520	2380	2270	2760	2250	560	12700
MM $2007	N/A	1980	1460	1200	1330	730	69	6800

Source: California Energy Commission

Note: $2007 at 5% discount rate. Does not include fuel savings or tax revenue impacts.

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ESTIMATED LCFS NEXUS & IMPLICATIONS

CASE (mm gge)	2006	2012	2017	2020	2022	2030	2050
Conservative	125	218	294	354	399	589	839
AFCI Effect	N/A	-2%	-1%	-1%	-1%	-2%	-2%
Moderate	125	319	536	736	912	1721	2666
AFCI Effect	N/A	-3%	-1%	-2%	-1%	-3%	-3%
Aggressive	125	433	803	1165	1494	3271	5570
AFCI Effect	N/A	-4%	-2%	-4%	-3%	-6%	-9%
AFCI	1	0.99	0.95	0.90	0.90	0.90	0.90

Sources: California Energy Commission, University of California, Davis

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ACTIONS & ACTORS TO REALIZE OUTCOMES

STATE/LOCAL GO	FEDERAL	INDUSTRY	INVESTMENT	CONSUMERS
▪Shape fuel excise tax by C content ▪Reshape program funds by C content ▪Sliding scale veh. incentives to red delta cost by 50% to 100% ▪ Incentive to red station cost by 50% ▪Rate shape for HRAs ▪Consistent R&D ▪Req. alt fuel at new stations ▪Buy NGVs	▪Extend vehicle tax credits to 2040 ▪Extend station tax credits to 2040 ▪Consistent, predictable R&D support to 2040	▪Auto Cos -Expd veh. offerings. -Price veh. Right -Targeted ad and mktg. ▪Fuel Producers -Targeted ad & mktg. ▪Fuel Retailers -Targeted ad & mktg. -Expand stns. -Rate shape for HRAs	▪ Become aware of alt. fuel investment opportunities ▪ Include carbon benefits in ROI det. ▪Seek out and add alternative fuel elements to portfolio	▪Learn about NGVs. ▪Buy NGVs ▪Learn about HRAs ▪Learn station locations ▪Learn about HOV access ▪USE alt fuels

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ACTIONS & ACTORS TO REALIZE OUTCOMES

Auto Cos	Fuel Providers	Non-Profits	INVESTORS	CONSUMERS
▪Honda ▪Baytech ▪Bachman ▪Volvo ▪Cummins Westport ▪Westport ▪John Deere ▪Ford ▪GM ▪Toyota	▪Clean Energy ▪Trillium ▪PG&E ▪SCG ▪SDG&E ▪SEMPRA ▪Lincoln Composite ▪Fuel Maker ▪Quantum	▪CNGVC ▪NGV America ▪Environmental Coalition ▪CALSTART	▪ Boone Pickens ▪ Include carbon benefits in ROI det. ▪CALPERS ▪CALSTRS ▪Others	▪ALL OF US

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RECOMMENDATIONS

- ADOPT PLAN

NATURAL GAS SCENARIO

PRIMARY REFERENCES & DATA SOURCES

- 2002 Vehicle Inventory and Use Survey, U.S. Census Bureau
- 1997 Truck Inventory Use Survey, U.S. Census Bureau
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- Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, U.S. Environmental Protection Agency, December 2000, EPA420-R-00-026
- Profile and Segmentation of Medium and Heavy Vehicle Purchase Patterns and Current and Projected Populations, Gas Research Institute, February 1995
- AB 1007 Stakeholder Survey and Focus Group Meetings, CEC Consultant Report, April 2007
- One-on-One Interviews with stakeholders and industry representatives, February-May 2007
- Other selected publications (Heavy-Duty Truck Magazine, Light & Medium Truck Magazine, current newspaper articles)