OPTION 2B
ELECTRIC BATTERY TECHNOLOGIES

Description

In 1990, the California Air Resources Board (CARB) adopted low-emission vehicle standards that required automobile manufacturers to offer a minimum percentage of zero-emission vehicles for sale. The most recent amendments to those standards, the Zero Emission Vehicle (ZEV) Regulation, require that certain automobile manufacturers make ZEVs available in California. [1] The ZEV program encouraged the development of advanced technologies, but the ZEV market did not develop as fast as was anticipated. As a result, automakers signed Memoranda of Agreement that resulted in about 2,000 electric vehicles being demonstrated in California fleets.

In 2000 and 2003, the ZEV regulations were modified to provide automakers additional flexibility by allowing credits for low-speed electric vehicles and partial ZEVs (PZEVs). The minimum percentage has been reduced since the ZEV program inception, and although other types of vehicles have been granted partial credit toward meeting the ZEV requirements, manufacturers must still produce, and offer for sale, a “pure” zero-emission vehicle.[2]

At this time, it is not clear what types of electric vehicles will be used to meet ZEV requirements. It appears there will be significant flexibility allowed the automakers to achieve ZEV compliance strategies. Currently, chemical-battery (where the electricity or fuel for the vehicle is stored) electric vehicles are the zero-emission vehicle technology closest to commercialization. However, the ZEV requirements may be fulfilled by a combination of grid- and non-grid-connected hybrids, fuel cell vehicles, and any vehicles certified as PZEVs, as well as chemical-battery electric vehicles. Within this context, the markets for chemical-battery electric vehicles will be created by regulations requiring vehicle emissions to be zero. These vehicles are already included in the base case forecast at the levels required by California’s low-emission vehicle standards.

The definition of electric vehicle has evolved since the start of the low-emission vehicle program. Electric vehicles used to be defined in relation to the internal combustion engine light-duty vehicle as a full-function electric car. Since then, both on-road (e.g. low-speed vehicles and electric buses) and non-road equipment (e.g. forklifts and airport ground support) have entered the market.[3] Some vehicles, such as low-speed vehicles, can perform well in both on-road and non-road niche markets, but are usually given credit only for the petroleum displacement within one niche. If a CARB proposal for requiring electric golf carts in non-attainment areas is factored in, an electric low-speed vehicle would replace not only a portion of internal combustion vehicle use, but gasoline golf cart use as well. The non-attainment areas

in Table 1 were evaluated for potential electric golf cart and low-speed vehicle populations. The fuel displaced is evaluated in the non-road section.

Table 1. Golf Cart and Specialty Vehicles/Carts Population in Non-Attainment Counties[4]

Non-attainment County	Year Required for Attainment	Golf Cart Population 2006 Estimate	Low-Speed Type Vehicle Population 2006 Estimate	Fuel Consumption (gallons/year)
Sacramento	2013	371	356	Diesel 25,387 Gasoline 229,234 LPG 2,613
San Diego	2009-2014	708	1,300	Diesel 93,085 Gasoline 484,960 LPG 9,582
San Joaquin	2013	240	236	Diesel 16,925 Gasoline 165,083 LPG 1,742
San Francisco	2007	101	142	Diesel 10,155 Gasoline 65,946 LPG 1,045
Imperial	2007	34	213	Diesel 15,232 Gasoline 34,549 LPG 1,568
Los Angeles	2021	2,159	1,585	Diesel 113,395 Gasoline 1,297,327 LPG 11,673
Ventura	2010	371	165	Diesel 11,847 Gasoline 214,871 LPG 1,220
Totals		3,984	3,997	Diesel 286,026 Gasoline 2,491,970 LPG 29,443

Two classes of low speed electric vehicles will be the focus of this analysis – Neighborhood Electric Vehicles (NEVs) and City Electric Vehicles (CEVs).

NEVs are defined by the National Highway Traffic Safety Administration as low speed vehicles. NEVs typically have a top speed of about 25 miles per hour. The NEV is designed for short-distance travel in confined residential and city areas. NEVs are approved for city streets with speed zones up to 45 miles per hour.

A CEV is designed for higher speeds of 35 to 40 miles per hour. The CEV can accommodate up to four passengers.

Previous studies found that these chemical-battery electric vehicles may have only a marginal impact on gasoline consumption when measured against a light-duty highway-capable gasoline vehicle. However, those studies assumed battery replacements expensive and short lived. Further, the "equivalent" gasoline vehicle had poor fuel economy in the low-speed operating conditions of the NEV or CEV.

The Energy Commission staff analysis made different assumptions. Both the NEV and CEV are in a niche use for which they are well designed and the gasoline vehicle is poorly suited. NEVs have great popularity in retirement communities, military bases, and commercial and government fleets. They have been used with great success for several years and have been virtually maintenance free with strong performance records. Gasoline vehicle efficiencies and performance drops significantly at the speeds of the NEV and CEV. NEVs and CEVs are highly maneuverable in tight conditions and produce no tailpipe emissions. Over 30,000 NEVs have been sold in the U.S. and Europe. For the 2005 model year, over 3,000 CEVs have been ordered in the U.S. and Europe.[5]

User studies have found the NEV is used as a daily replacement for more than two-thirds of the short-distance trips formerly taken with an internal combustion engine vehicle.[6] Even when the NEV trips may be on the golf course, the vehicle is a replacement for a gasoline-powered cart. NEVs are more likely to be carrying more than one person.

For 2005, four models of NEVs and two models of CEVs are listed for sale in California as zero-emission vehicles. The specifications are shown in Table 2.[7]

Table 2. California NEV and CEV Prices and Specifications

	NEV	CEV
Price	$7,000 to $9,000	$15,500
Batteries	Six 12-volt, lead acid	Fourteen 12-volt, lead acid
Top Speed	25 mph	25 mph to over 35 mph
Range	30 miles per charge	50 miles per charge

The Massachusetts Division of Energy Resources accumulated more than 200,000 miles on a variety of fleet electric vehicles.[8] The U.S. military has also conducted extensive tests on electric vehicles over several years. The results for NEVs and small electric vehicles such as the Honda EV Plus and the Solectria Force (Geo Metro body) show long battery durability for these small vehicles.[9] Therefore, we assume the battery will last the life of the vehicle or 15 years.

The scenario for number of vehicles follows the CARB projections of ZEVs. The current population of California's low-speed vehicles is approximately 15,000. The scenario assumes the majority of the ZEV requirement will be met by PZEVs and Advanced Technology PZEVS (ATPZEVs) in the short-term and new zero-emission technologies from 2015 to 2025. However, low-speed vehicles will continue in popularity within their niche.

Incremental cost per vehicle ranges from $15,500 (CEV is purchased in addition to a conventional vehicle) to -$6,500 (NEV replaces a small conventional vehicle). The vehicle fuel economy for both types of vehicle is 5.8 miles/kWh. Electricity rates range from $0.10/kWh to $0.12/kWh.[10]

The conventional fuel vehicle's fuel economy is estimated based on low-speed, stop-and-go driving conditions.[11] Both conventional and low-speed electric vehicles have a 15-year life. The chemical batteries do not require replacement during the life of the vehicle. In the scenario where a conventional vehicle is replaced by the low-speed vehicle, there is a positive consumer savings, but total gasoline displacement remains small because of the limited number of vehicles and limited use (miles per year).[12]

Using these assumptions, the staff developed the values shown in Tables 3 and 4.

Table 3. Average Petroleum Reduction and Direct Benefits for NEVs and CEVs

	Average Conventional Fuel Displaced (billions gallons)	Average Consumer Savings 12%-5% discount rate	Average Change in Government Revenue 12%-5% discount rate
2005 to 2010	0.024	$3 to $4	($5) to ($7)
2005 to 2020	0.284	$8 to $19	($25) to ($55)
2005 to 2025	0.698	$16 to $50	($42) to ($114)

Table 4. Petroleum Reduction and Benefits for NGVs and CEVs

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon/year gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Net Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
NEVs and CEVs	0.1	0.48	1.11	(0.11)	0.06	0.03	1.09

Uncertainties

- Since niche market electric vehicles are driven by regulations requiring zero vehicle emissions, any change to the regulations will impact the number of vehicles produced.

- Incremental vehicle costs depend on vehicle production volumes and sales.

Endnotes

[1] California Air Resources Board, Final Regulation Order, The 2003 Amendments to the Zero Emission Vehicle Regulations, March 2004, http://www.arb.ca.gov/regact/zev2003/zev2003.htm

[2] California Environmental Protection Agency, Air Resources Board, *California Exhaust Emission Standards and Test Procedures for 2005 and Subsequent Model Zero-Emission Vehicles, and 2001 and Subsequent Model Hybrid Electric Vehicles, in the Passenger Car, Light-Duty Truck and Medium-Duty Vehicle Classes*, (August 5, 1999).

[3] California Electric Transportation Coalition, *Report on the Electric Vehicle Markets, Education, RD&D and the California Utilities' LEV Programs*, Final Report FR-02-109 (March 22, 2002).

[4] NONROAD2004 model runs conducted for specified non-attainment counties and year 2006, by equipment description and engine type.

[5] www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/06-20-2003/00019690

[6] Green Car Institute, *Study of NEV User Behavior in California*, July 2003.

[7] www.driveclean.ca.gov/en/gv/vsearch/cleansearch_result_des.asp?vehicleid=163

[8] Massachusetts Division of Energy Resources, *EV Progress Report: Summer 1998*, (March 1998).

[9] Energy Efficiency and Renewable Energy, Federal Energy Management Program, *Federal Technology Alert*, Department of Energy, Publication DOE/EE-0280.

[10] Electricity rates based on an average of 2004 to 2016 Energy Commission forecasts from IOU data. The lower rate ($0.10/kWhr) was adjusted down by $0.02 to reflect potential savings from off-peak charging rates.

[11] Bluewater Network, October 28, 2002, *Fuel Economy Falsehoods.*

[12] Numbers used in assumptions based on conservative values produced through surveys for the Electric Vehicle Consumer Awareness Program, prepared for the U.S. Department of Energy and the California Energy Commission (April 2001) and PRNewswire, *DaimlerChrysler's GEM Neighborhood Electric Vehicle Sales in California Top 10,000 Mark*, June 20, 2004.