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Contributions of Zero Emissions Motorcycles for Demand Forecast

Please see the attached documents for inputs on potential contributions of zero emissions motorcycles for the IEPR.
Thank you!

Additional submitted attachment is included below.

Electric Motorcycles, Emissions, and the Low Carbon Fuel Standard (LCFS)

Zero Motorcycles, Inc.

Electric vehicles create a significant opportunity to positively affect the dynamics of petroleum reduction and air pollution. By shifting as many vehicles as possible to electric drive and transferring the vehicle miles traveled (VMT) to electricity, critical GHG and criteria pollution reductions targeted by California can be achieved. Zero Motorcycles, Inc. is committed to developing and supporting programs which directly impact the challenge by replacing gasoline vehicles with electric motorcycles.

Zero has been designing and building electric motorcycles here in California for over 10 years. We have grown from just 8 employees in 2008 to over 145 worldwide today. Zero has shipped thousands of electric motorcycles to customers in California and across the entire world. We are second only to Tesla in terms of volume manufacturing electric vehicles in California. Over 60 police and public safety departments in California including LAPD, cities across the Central Valley, and our California Parks have begun deployment of Zero motorcycles. And these motorcycles emotionally resonate with motorcycle riders, providing high performance and good clean fun.

As a premium brand, Zero designs each motorcycle with the quality and integrity that inspires an exceptional riding experience. The upfront cost of a Zero is not what it appears to be when compared against its traditional internal combustion counterparts. Each mile ridden on a Zero is considerably less expensive, making it even more enjoyable, due to the elimination of routine powertrain maintenance and no gas expenses. When compared to other premium brands, a Zero motorcycle starts saving the owner money on gas and maintenance from day one. In fact, over the life of their motorcycle many Zero owners actually save more than they would have if they had purchased a comparable internal combustion model. And now that Zero has shipped thousands of motorcycles, the benefits of ownership are accelerating and accruing to society in general.

Including electric motorcycles as eligible vehicles in the LCFS program expands the vehicle classes appropriately and helps achieve key program goals. While internal combustion engine (ICE) motorcycles are moderately efficient in terms of fuel consumption, they still show a significant GHG footprint when compared to the alternative of zero emission motorcycles powered by electricity. As indicated in the analysis from Life Cycle Associates in Appendix A, the Zero S from Zero Motorcycles has an energy economy ratio (EER) of 10.1. In addition their report states, “this EER is considerably higher than the 3.5 to 4 estimated for battery electric cars because motorcycle engines must achieve very high power outputs and two or four stroke engines of comparable power are not as efficient as highly developed passenger car engines. “

When it comes to the full emissions profile, the California Air Resources Board (ARB) has conducted significant research on the impact of existing motorcycles and criteria pollutants. According to ARB, when legislation was being considered for motorcycle smog checks in 2009, motorcycles accounted for 3.6% of registered vehicles in the state and made up just 0.8% of vehicle-miles traveled - yet they accounted for ten percent of passenger vehicles' smog-forming emissions. Although fuel-efficient bikes emit significantly less carbon dioxide per mile, the ARB says they are, on average, still 14 times more polluting per mile when it comes to emissions of oxides of nitrogen and hydrocarbons, smog-forming pollutants that have been shown to trigger asthma attacks and worsen respiratory and cardiac illnesses.

Based on emission standards for new vehicles, passenger vehicles are limited to emissions of 0.09 grams of smog-forming pollutants per mile driven, while motorcycles can emit up to 1.29 grams per mile.[1] In February 2009, California State Senator Fran Pavley introduced SB435 which would require biennial smog checks for motorcycles manufactured in the 2000 model year and later[2], making projects to replace aging motorcycle fleets with clean vehicles even more important. This bill did not become law, and California motorcycle regulations have remained the same for over a decade.

In 2017, internal combustion motorcycles have become a major source of emissions – especially criteria pollutants. Based on an analysis of reactive organic gas (ROG) using ARB's EMFAC model, while ICE motorcycles have much smaller volumes and miles traveled (by factors of 27 and 127 respectively), they will combine to pollute 16% more than the total population of 2017 ICE cars. Cars have become so much cleaner over time while motorcycles now represent an ever expanding source of both on and off-road mobile emissions. This gap will continue to expand further according to the modeling. Electric motorcycles are an ideal immediate solution for this problem since they are inherently zero emission vehicles at the local level.

Replacing conventional fuel motorcycles with electric motorcycles will also result in significant particular matter (PM) emission reductions. The USEPA's Motor Vehicle Emission Simulator (MOVES) estimates PM emissions from cars, trucks & motorcycles. A recent study at UC Berkeley indicated that the average on-road motorcycle still has PM_{10} emissions of 39 mg/mi, approximately one-third that of most modern cars.[3] Replacing a conventional motorcycle or vehicle with an electric motorcycle will eliminate these PM emissions.

Commuting and VMT estimates

California census data from 2005 reveals that most citizens have a commute within range for riding a motorcycle, with over 16.3M commuters in California. With the shifting transportation landscape, many consumers are considering motorcycles as a commuting alternative. According to American Community Survey (ACS) data released by the US Census Bureau in March 2005, "Americans spend in excess of 100 hours commuting to work each year. For the nation as one, the average daily commute to work lasted about 24.3 minutes in 2003. A motorcycle or a scooter does not offer a lot of passenger room or storage space, but most get far better mileage than even a hybrid car and at a far cheaper price. Moreover, two wheelers have the added advantage of maneuverability to beat the rush hour traffic. With fuel prices skyrocketing, motorcycles and scooters can be a practical fuel-economy transportation option for the typical half hour drive to work."[4] Even with current lower gasoline prices, ever-growing traffic congestion and future gasoline price uncertainty continue to be key drivers for the market.

[1] CA Senate Committee Analysis, April 14, 2009, http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0401-

[2] http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0401-0450/sb_435_bill_20090226_introduced.html

[3] Chester, M, and Horvath, A. "Life-cycle Energy and Emissions Inventories for Motorcycles, Diesel Automobiles, School Buses, Electric Buses, Chicago Rail, and New York City Rail." Pages 27 and 29. Accessed June 20, 2013. http://www.its.berkeley.edu/publications/UCB/2009/VWP/UCB-ITS-VWP-2009-2.pdf

[4] http://www.census.gov/Press-Release/www/releases/archives/american_community_survey_acs/004489.html

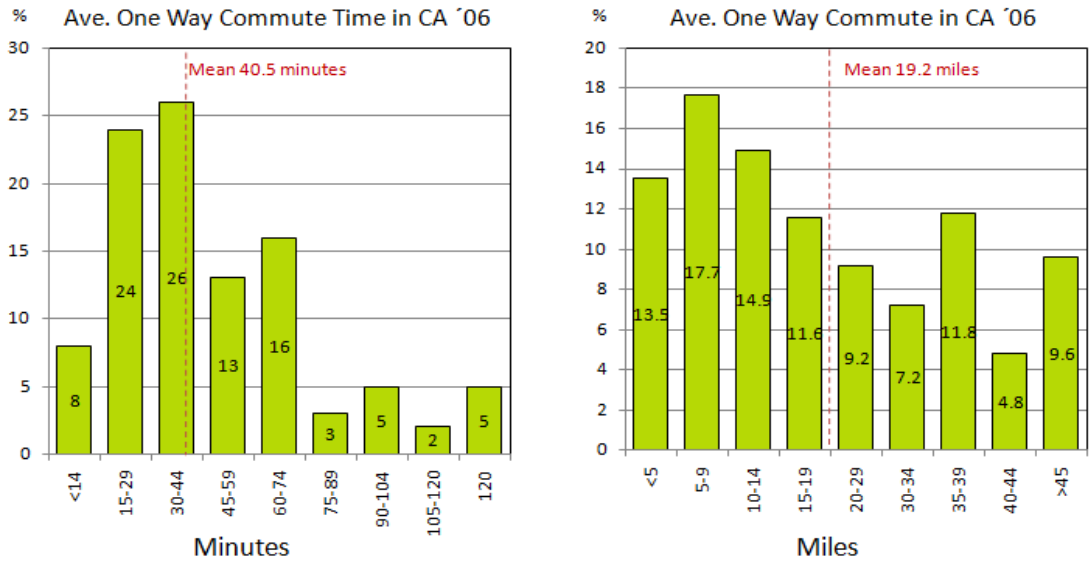

Figure 1: California Commute Information - Time and Distances[5]

Source: Southern California Association of Governments

A Consumer Reports Auto Pulse survey found that 26% of people would consider switching to either a motorcycle or motor scooter[6]. California is the largest market in the United States for motorcycles. Thus, more benefits from electric motorcycles can be realized in California than anywhere else in the US.

Including electric motorcycles in the LCFS takes advantage of consumer interest and desire for an alternative means of transportation at a price point significantly lower than other electric vehicles. It also targets a market segment that has been traditionally more polluting and has generated more GHG due to lower standards for the engines in this class. The advanced electric powertrains have zero tailpipe emissions and represent at least an 89% reduction in carbon intensity as compared to similar gasoline engines.

GHG reductions

In order to estimate the annual GHG reductions resulting from electric motorcycles manufactured by Zero, we are using the Life Cycle Associates' calculations (See Appendix A: Life Cycle Associates Analysis) for carbon intensity factors of 257g CO_2 emitted per mile on a standard gasoline motorcycle using California reformulated gasoline and their calculation of 28g CO_2 emitted per mile for a Zero S Motorcycle. We are also using Zero Motorcycles 2016 survey data showing our average consumer rides 5,169 miles/year with an average life span of 5 years per vehicle. Using the projected sales volume we estimate annual GHG reductions per vehicle of 1.18 metric tons (MT) CO_2. This results in yearly total GHG reductions of 1,776 MT in 2017, 4,380 MT in 2018, and 9,588 MT in 2019, 17,756 MT in 2020, and 29,356 MT in 2021 for a total of 62,855 metric tons GHG reductions over the five

[5] "2006 State of the Commute", Southern California Association of Governments, http://www.scag.ca.gov/publications/pdf/2007/2006_StateoftheCommute_Report.pdf

[6] Consumer Reports, 7/1/2008, http://blogs.consumerreports.org/cars/2008/07/downsizing-to-t.html

year period from 2017-2021. The detailed calculations have been summarized in Figure 2 below.

GHG Reduction Overview			
	Zero Motorcycle	Gasoline Motorcycle	GHG Reduction
GHG g/mile	28	257	-229
g GHG/year/vehicle	144732	1328433	-1183701
2017 MT GHG	217	1,993	-1,776
2018 MT GHG	536	4,915	-4,380
2019 MT GHG	1,172	10,760	-9,588
2020 MT GHG	2,171	19,926	-17756
2021 MT GHG	3,589	32,945	-29356
Cum. MT GHG over 5 years	7,685	70,540	-62,855

Figure 2: GHG Reductions calculation and assumptions

Petroleum Displacement

Using the same assumptions as above (see Figure 2) and using an average fuel consumption of 44.4 miles per gallon for gas motorcycles and 462 miles per gallon equivalent for a Zero, we calculate the estimated reduction in volume of petroleum transportation fuels displaced as 105 gallons per year per vehicle. This number may appear small as gasoline motorcycles are moderately efficient and their gallons per 100 miles have already climbed much of the curve. However, by getting more electric motorcycles on the road there is a multiplicative effect of every mile ridden reducing more petroleum usage.

Using projected volumes, it is estimated that the total amount of reduction in petroleum transportation fuels would be 5.59 million gallons over the five year period from 2017-2021. The detailed calculations can be found in Figure 3 below.

Petroleum Reduction Overview			
	Zero Motorcycle	Gasoline Motorcycle	Gallon Reduction
MPG (MPGe for electric vehicle)	462	44.4	-417.6
Petroleum equiv./year/vehicle	11.19	116.42	-105.23
2017 gallon petroleum equiv. (in millions)	0.017	0.175	-0.158
2018 gallon petroleum equiv. (in millions)	0.041	0.431	-0.389
2019 gallon petroleum equiv. (in millions)	0.091	0.943	-0.852
2020 gallon petroleum equiv. (in millions)	0.168	1.746	-1.578
2021 gallon petroleum equiv. (in millions)	0.277	2.887	-2.610
Cum. gallon petroleum equiv. (in millions)	0.594	6.182	-5.59

Figure 3: Petroleum reduction calculation and assumptions

Criteria Pollutant Reductions

When considering the impact of electric motorcycles on criteria pollutants, the most simple method to look at motorcycle vs. automobile (LDV) emissions is using current regulations from ARB for motorcycles and LDVs. Motorcycles after 2008 are currently regulated to 0.8 g/km of HC+NOx (corp. average w/ 2.5g/km max) and 12 g/km of CO, no regulation of

Formaldehyde or PM. For the purposes of this discussion the ratios need to be converted so that the motorcycle numbers go from g/km to g/mi and assume that HC=NOx is functionally equivalent to NMOG+NOx in LDV. For LDV the limits under LEV III (now in force as of 2015, LEV160 is the maximum allowed) are 0.16 g/mi of NMOG+NOx, 4.2 g/mi of CO, 4 mg/mi of Formaldehyde, and 0.01 g/mi of PM. This yields the data in Figure 4 for a comparison of motorcycle to automobile emissions.

Criteria Pollutant Standards		
	Motorcycle	Automobile
HC+NOx	1.28 g/mi*	0.16g/mi (NMOG+NOx)
CO	19.2 g/mi	4.2 g/mi
Formaldehyde	NR	4 mg/mi
PM	NR	0.01 g/mi

* Corporate average, 4 g/mi under the maximum scenario.

Figure 4: Criteria Pollutant Comparison between Motorcycles and Automobiles.

It is quite clear that ICE motorcycles are subject to dramatically lower regulatory requirements than automobiles, anywhere from a factor of 8x to 25x when measuring only basic hydrocarbon and NOx emissions. Electric motorcycles reduce the tailpipe emissions to zero and therefore create a major benefit with respect to criteria pollutants. ARB is considering additional regulations to close this gap and Zero Motorcycles anticipates that electric motorcycles will play a major role.

In summary, including electric motorcycles in the LCFS program as an eligible vehicle type would further incentivize development of both the technology and market. Adding a vehicle type with an EER in excess of 10 allows these benefits to accrue to the LCFS program, to manufacturers, and to consumers. The air pollution benefits are even more significant and can help ARB achieve additional critical emission goals. Electric motorcycles are an excellent fit with the stated goals of the program to reduce carbon intensity of California's transportation fuels over time, and to incentivize the shift to more efficient and less polluting vehicles.

For questions or further information about this document please contact:
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Appendix A: Life Cycle Associates Analysis

Life Cycle Associates, LLC

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May 11, 2010

Jay Friedland
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Dear Jay,

Life Cycle Associates (LCA) completed a life cycle assessment of the Zero Motorcycles' battery electric powered motorcycle compared to a comparable vehicle powered by conventional California reformulated gasoline (RFG). This assessment used the California Air Resources Board (ARB) default carbon intensity (CI) values for electricity and RFG fuel, combined with the fuel efficiency of a ZEV based on the Zero Motorcycles electric propulsion system and a comparable gasoline vehicle.

The life cycle Well to Wheel (WTW) GHG emissions include the emissions from fuel production and vehicle operation. The WTW results are based on the CI of the fuel combined with vehicle energy consumption such that:

> WTW GHG = CI (WTT + TTW[1]) × Energy Consumption
> Where CI represents the carbon intensity of the upstream fuel cycle, vehicle fuel, and methane and N_2O emissions from the gasoline vehicle.
> Energy Consumption is represented in MJ/mi

The WTW results are consistent with the approach used by ARB for the Low Carbon Fuel Standard. ARB reports an adjusted CI for electric transportation taking into account improvements in EV fuel efficiency, which is expressed as an energy economy ratio (EER), or the ratio of the fuel consumption (MJ/mi) of an alternative fueled vehicle compared to a comparable gasoline vehicle[2].

Energy Consumption

Energy consumption for both gasoline and battery electric motorcycles are based on range estimates or estimated driving range divided by fuel tank capacity. The baseline gasoline fuel consumption is based on a Suzuki DRZ400SM, which is comparable in size and performance to the Zero-S battery electric model with an estimated city/highway fuel economy of 44.4 mpg. The energy consumption for the battery electric motor cycle is 74 Wh/mi. Table 1 shows the energy consumption for both vehicles in MJ/mi with the ratio indicating an EER of 10.1. This EER is considerably higher than the 3.5 to 4 estimated for battery electric cars because motorcycle engines must achieve very high power outputs and two or four stroke engines of comparable power are not as efficient as highly developed passenger car engines.

[1] WTT: Well to Tank, the fuel production CI including all life cycle components leading to a fuel in a vehicle tank; TTW, Tank to Wheel, the CI of the vehicle emissions comprised of the carbon in the fuel (as CO_2) plus the combustion generated N_2O and CH_4. For the Zero Motorcycles motorcycle, the TTW CI is 0.

[2] Thus, the EER for a gasoline vehicle is 1.0; more efficient vehicles fueled with an alternative fuel have EERs greater than 1.0.

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Fuel Carbon Intensity

The carbon intensity for the baseline gasoline and electric power cases are also shown in Table 1. These carbon intensity values are based on the LCFS and reflect fuel production in California (ARB 2009). The CI for gasoline includes both the WTT plus vehicle emissions. Electric power reflects new or marginal generation for California. This resource mix would primarily be based on natural gas production. However, in order to meet the renewable portfolio standard requirements, additional load growth would also need to include renewable power. Therefore, the marginal resource mix for the LCFS reflects a combination of natural gas and renewable power.

Life Cycle GHG Emissions

Table 1 outlines the WTW GHG calculations for each vehicle giving the final results in g CO_2e/mi. The percent reductions for the Zero Motorcycles ZEV cases are also given in the table. Figure 1 illustrates these reductions. As shown, Zero Motorcycles' ZEVs achieve an 89% reduction using the electricity resource mix for the LCFS. An all renewable resource mix is also examined here. Of course the GHG emissions from this option will be zero and the lower power consumption from the electric motor cycle can enable operation on resources such as home solar power.

Table 1. Zero Motorcycle Carbon Intensity Reduction

Vehicle	MJ/mi	Fuel Use		EER	CI (g CO_2e/MJ)	GHG (g/mi)	Reduction
Zero Motorcycle, Renewable Power	0.27	0.074	kWh/mi	10.1	0.0	0	100%
Zero Motorcycle, NG/RPS	0.27	0.074	kWh/mi	10.1	104.7	28	89%
Gasoline Motorcycle, RFG	2.68	44.4	Mpg	1.0	95.9	257	0%

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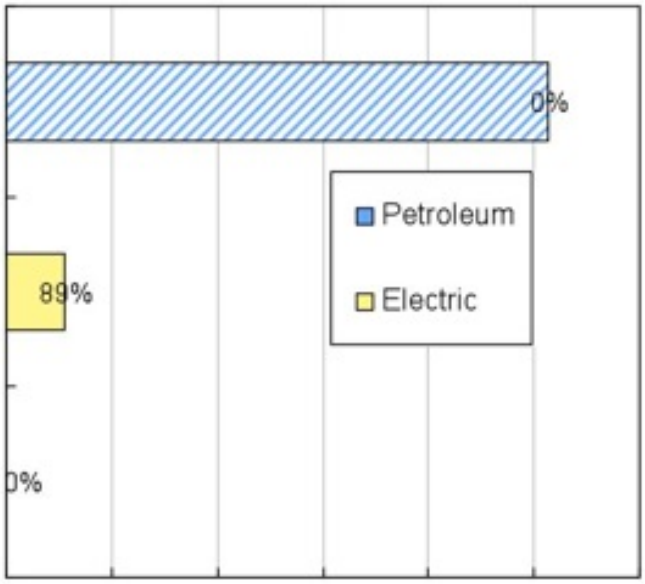

Figure 1. Motorcycle Carbon Intensity Reduction

Best Regards,

Stefan Unnasch
Managing Director

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