California's
Advanced Clean Cars
Midterm Review

Appendix I:
Alternative Credits for Zero Emission Vehicles and Plug-in Hybrid Electric Vehicles

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California Environmental Protection Agency
Air Resources Board

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I. Introduction

In 2012, the California Air Resources Board (ARB or the Board) adopted the Advanced Clean Cars (ACC) program, including increased requirements for the zero emission vehicle (ZEV) regulation), and directed staff in Resolution 12-11 to study "in-use data for range extended battery electric vehicles and plug-in hybrid electric vehicles, and, if warranted, propose appropriate modifications to treatment and credits for these vehicle types".[1] Appendix G describes in detail the in-use trip level vehicle data collected from various plug-in hybrid electric vehicles (PHEV), battery electric vehicles (BEV), and range extended BEVs (BEVx). This appendix will explore various crediting methods for PHEVs and BEVxs using the results from the Appendix G analysis.

I.A. Findings

Staff's alternative credit cases have relatively the same trend line when compared to the credit system in the current regulation. In general, BEVs would continue to earn more credits than PHEVs. In some of the alternative cases, vehicles (both BEV and PHEV) would earn more credits, meaning that, without being coupled with a corresponding increase to the overall stringency of the regulation, manufacturers would be required to produce fewer vehicles to meet the regulatory credit obligation. In general, it is in the best interest of ARB to maintain a stable foundation for crediting these vehicles rather than shift to credit structures based on usage, which is inherently dynamic. Therefore, staff does not recommend to base credits for BEVs and PHEVs on in-use averages from historical vehicles. One alternative that did appeal to staff is Alternative 6, basing vehicle credit on "label" range, as opposed to urban dynamometer drive schedule (UDDS) test electric range. This alternative may help reduce the total number of credits per vehicle, while still crediting vehicles based on what matters to consumers.

II. Credits for PHEVs, BEVs, and BEVxs

II.A. 2009-2017 Model Year Credits: PHEV

Credits for PHEVs prior to 2018 model year are a combination of "allowances". First, a partial zero-emission vehicle (PZEV) allowance of 0.2 is earned for a vehicle meeting super-ultra-low-emission (SULEV) emission standard[2] under the Low-Emission Vehicle (LEV) regulation, and a zero evaporative emissions requirement, and offering a 15-year/150,000 mile emission system warranty, and offering a 10-year/150,000 mile battery warranty.[3] Second, PHEVs qualify for a zero-emission vehicle miles traveled (zero-emission VMT) allowance, calculated from the vehicle's equivalent all electric range (EAER) and utility factor (UF).[4] Lastly, PHEVs qualify for an advanced componentry allowance, which is a list of additional criteria related to the vehicle's

[1] ARB 2012. California Air Resources Board. Resolution 12-11. January 28, 2012. Available: http://www.arb.ca.gov/regact/2012/zev2012/res12-11.pdf, Accessed August 24, 2016
[2] Vehicle can certify to SULEV 20 or 30 exhaust emission standard (CCR 1961.2(a)(a) or 1961(a)(1).
[3] CCR 1962.1(c)(2) "Baseline PZEV Allowance"
[4] CCR 1962.1 (c)(3)(A) "Zero-Emission "VMT PZEV Allowance"

power, performance, and ability to complete either the urban dynamometer drive schedule (UDDS) or US06 drive schedule for 10 miles in all-electric mode.[5,6]

Listed below in Table 1 are the previously and currently certified PHEVs (that qualify as a transitional zero emission vehicle, or TZEV[7]) and the corresponding credits earned by the vehicle for the model year listed. Assuming the vehicles remain unchanged, these PHEVs will continue to earn this same amount of credit through the 2017 model year if delivered for sale in California or the Section 177 ZEV states.[8]

Table 1 - Current credit values for certified TZEVs

Model year	Model	PZEV Allowance	Zero-Emission VMT Allowance	Advanced Componentry Allowance	Total Credit
15	*Toyota Prius PHEV	0.2	0.83	0.35 Type E	1.38
14	*Honda Accord PHEV	0.2	1.052	0.67 (Type $F_{12\text{-}14}$)	1.922
15	Ford C-Max Energi	0.2	1.27	0.57 (Type F)	2.04
15	Ford Fusion Energi	0.2	1.27	0.57 (Type F)	2.04
15	Chevrolet Volt	0.2	1.39	0.8 (Type G)	2.39
15	Mercedes S550E	0.2	1	0.57 (Type F)	1.77
15	Cadillac ELR	0.2	1.39	0.8 (Type G)	2.39

*Models have been discontinued or are being replaced with other models

II.B. 2009-2017 Model Year Credits: BEV

Through 2017 model year, a BEV earns credit according to its certified UDDS all electric range (AER) and its ability to completely charge or exchange the vehicle's battery pack[9] in under 15 minutes. Vehicle credits are binned into "types" according to the vehicle's range and fast refueling capability, as shown in Table 2 below for 2015 through 2017 model years.

[5] CCR 1962.1 (c)(4) "PZEV Allowance for Advanced ZEV Componentry"
[6] Note that PHEVs must have 20 miles all-electric range to receive a rebate from California's Clean Vehicle Rebate Program, beginning November 1, 2016. More information can be found at the following website: https://cleanvehiclerebate.org/eng/eligibility-guidelines
[7] PHEVs are referred to as transitional zero-emission vehicles (TZEV) in the ZEV regulation (California Code of Regulations or CCR 1962.1 and 1962.2). PHEVs do not have to certify as a TZEV to be sold in California, but must certify as a TZEV to earn credit in the ZEV regulation. For this document, PHEVs and TZEVs are one and the same.
[8] Section 177 of the Clean Air Act allows other states to adopt California's regulations. Nine states have adopted California's ZEV regulation: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. These states are referred to as Section 177 ZEV states.
[9] In 2013, the Board approved battery swaps (when accurately demonstrated to the Executive Officer and documented) to qualify under the definition of "fast refueling capable" under Type III, Type IV, and Type V ZEV Credits. Access the following link for documents related to this rulemaking: http://www.arb.ca.gov/regact/2013/zev2013/zev2013.htm

Table 2 - 2015-2017 credit values for BEVs

Type	Range Qualification	Credit (2015-2017)	Examples
Type 0	<50 miles	1	n/a
Type I	≥50, <75 miles	2	
Type I.5	≥75, <100 miles	2.5	Mitsubishi i-MiEV
Type II	≥100 miles	3	Fiat 500e, Nissan Leaf, Chevy Spark EV, BMW i3, Ford Focus EV, Kia Soul EV
Type III*	≥100 miles + fast refueling	4	
	≥200 miles		
Type IV	≥200 miles + fast refueling	5	
Type V	≥300 miles + fast refueling	9	Tesla Model X, Model S

*Vehicles can qualify as a Type III through either definition listed

II.C. 2009-2017 Model Year Credits: BEVx

The BEVx was a vehicle category added in the 2012 ACC rulemaking for the ZEV regulation. The following description from the 2011 Initial Statement of Reasons (ISOR) explains the purpose of the vehicle category:

"The proposed vehicle is closer to a BEV than to a PHEV: a vehicle with primarily zero-emission operation equipped with a small non-ZEV fuel auxiliary power unit (APU) for limited range extension. Manufacturers proposing this type of vehicle describe it as having reduced performance while operating in APU mode that allows drivers to find a charging location, and discouraging non-zero-emission driving. Most of these vehicles are expected to have a zero-emission range of 80 miles or greater. This vehicle has substantially more range than currently announced PHEVs, with electric range comparable to full function BEVs and will probably require ground-up BEV design. Manufacturers believe that the APU will be a relatively high-cost option on top of an existing, full function (100+ mile), BEV."[10]

BEVxs are treated similarly to BEVs, in that they earn credit according to the vehicle's UDDS AER per the same schedule as BEVs, but are not allowed to meet more than half of the portion of a manufacturer's requirement that must be met with credits from pure ZEVs. Currently, there is only one certified BEVx, the BMW i3 REX. And like the BMW i3, it earns 3 credits per vehicle.

II.D. 2018 and subsequent model year credits: PHEV

In 2012, the Board adopted a simplified credit system for PHEVs for 2018 and subsequent model years. In general, the simplifications targeted a reduction in per vehicle credits to a level of approximately half of the previous credit levels and much simpler criteria for determining the credits. First, in order to even be eligible for credit under the ZEV regulation, PHEVs must have a minimum of 10 miles AER on the UDDS test cycle, meet the SULEV30 or lower emission standard, meet the zero evaporative emissions standard, and carry the same long-term

[10] ARB 2011. California Air Resources Board. "Initial Statement of Reasons: 2012 Proposed Amendments to the California Zero-Emission Vehicle Regulation", pg. 13. Available: http://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf, Accessed August 28, 2016

emission system and battery warranties that earlier PHEVs were required to have.[11] Second, instead of combining a series of allowances, credits are based on the vehicle's EAER on the UDDS test cycle, and awarded according to the follow calculation:

$$\frac{EAER_{UDDS}}{100} + 0.3$$

For PHEVs that are able to meet the higher speeds and accelerations of the US06 test cycle for at least 10 miles in all electric mode (without the engine turning on), an additional 0.2 credits is given.

$$\frac{EAER_{UDDS}}{100} + 0.3 + 0.2$$

The formulas above resulted in credit levels per PHEV that were approximately half of what they were under the pre-2018 model year formulas and were based on a linear format that did not rely on more complicated non-linear fleet utility fraction calculations. For the US06 capable PHEVs, the additional 0.2 in the calculation was recognition that, while such PHEVs had not yet been produced and studied, there was an expectation that they would be used in a manner more similar to BEVs and thus, credited on the exact same formula as BEVs. However, PHEVs are only allowed to earn up to a maximum of 1.3 credits per vehicle, and therefore are not provided additional credit for ranges greater than 80 miles EAER. Additionally, with the exception of intermediate volume manufacturers, PHEVs are only allowed to be used to fulfill a portion of a manufacturer's annual ZEV credit requirement.

II.E. 2018 and subsequent model year credits: ZEV and BEVx

Also as part of the 2012 ACC amendments, the Board simplified the credit structure for ZEVs and BEVxs. As noted above, simplifications targeted an approximate 50 percent reduction in the credits per ZEV and a linear relationship between an expected minimum 50 mile range ZEV earning 1.0 credits and an expected maximum 350 mile range ZEV earning 4.0 credits. Credits are linearly based on the vehicle's UDDS test range, according to the following equation:

$$\frac{EAER_{UDDS}}{100} + 0.5$$

As adopted, US06 capable PHEVs, BEVxs, and BEVs use the same formula for credits. ZEVs are allowed to earn up to a maximum of 4 credits per vehicle, and therefore are not provided additional credit for ranges greater than 350 miles UDDS test range. Consistent with the pre-2018 requirements, BEVxs are only allowed to fulfill a portion of the manufacturer's annual pure ZEV requirement.

III. Stakeholder requests for review of the current credit structure

Starting with public comments during the 2013 amendments to the Board, manufacturers (notably, Honda, Toyota, Ford, and General Motors) requested (both in front of the Board and during meetings with staff) that staff be directed to study the electric vehicle miles traveled from

[11] CCR 1962.2 (c)(2)(A) through (D) "TZEV Requirements"

PHEVs as compared to BEVs. The United States Departments of Energy (U.S. DOE) sponsored a data collection project on thousands of early plug-in electric vehicle drivers throughout the U.S. from 2012 through 2014, which was called the EV project. For a complete description of the EV Project, see Appendix G. Manufacturer comments asserted that according to EV Project data, "[General Motors] Volt drivers [drove] nearly 40% more zero-emission miles than [Nissan] Leaf drivers" and that staff should review and update credits for TZEVs and ZEVs.[12] In 2014, Idaho National Laboratory (INL) staff presented to the Board an analysis of EV Project data, as well as additional data from Ford, Toyota, and Honda on electric vehicle miles traveled (eVMT). The manufacturers took the INL analysis for their 2014 proposal to make PHEV and BEV credits equivalent (and increase the portion of the requirement that manufacturers could meet with credits from PHEVs). Since 2014, manufacturers have submitted the same trip level data (as well as additional data and data from other manufacturers) for ARB to analyze.[13]

IV. Alternative Credit Structures

Staff analyzed cumulative and trip level data from seven manufacturers for eleven different plug-in electric vehicle (PEV) models. For each vehicle, staff calculated each vehicle's annual vehicle miles travelled (VMT), annual electric VMT (eVMT), and zero-emission VMT (zVMT), which are summarized in Table 3 below.

Table 3 - Average Annual VMT, eVMT and zVMT by named model

Type of Vehicle	VMT - Mean	eVMT - Mean	zVMT - Mean
Toyota Prius (PHEV)	15,283	2,304	589
Honda Accord (PHEV)	15,221	3,246	1,471
Ford C-Max Energi (PHEV)	13,920	4,574	2,525
Ford Fusion Energi (PHEV)	15,076	4,776	2,368
Chevrolet Volt (PHEV)	12,403	7,442	5,829
BMW i3 (BEVx)	9,063	8,387	N/A
BMW i3 (BEV)	7,916	7,916	7,916
Ford Focus Electric (BEV)	9,741	9,741	9,741
Honda Fit (BEV)	9,789	9,789	9,789
Nissan Leaf (BEV)	10,294	10,294	10,294
Tesla Model S (BEV)	13,494	13,494	13,494

[12] Honda 2013. Robert Bienenfeld. "Honda's Testimony at the California Air Resources Board's Advanced Clean Car Hearing" October 24, 2013. Available: http://www.arb.ca.gov/lists/com-attach/21-zev2013-UCJVPFc0VWNVIQN3.pdf, accessed August 28, 2016

[13] See Appendix G for complete staff analysis of OEM provided trip level data.

For the Appendix G analyses, General Motors provided data from Volts participating in DOE's EV Project. According to this data, total Volt VMT is ~12,400 on average, eVMT is approximately 9,000 (72%), and zVMT is ~7,300 (59%). However, these EV Project numbers may not be representative of later generation (and current) Volt eVMT and zVMT. According to a General Motor's press release, Volts drive 60% of their miles on grid-powered energy.[14] This could be due to the fact that EV Project participants were early adopters and were given no-cost Level 2 charging.[15] Therefore, for the purposes of this appendix, staff adjusted the Volt eVMT number to 7,442 (60%), and assuming eVMT tracks with zVMT, the adjusted zVMT is 5,829 (47%).

The definition of eVMT is miles attributed to grid energy. For blended PHEVs where, by design, the gasoline-powered engine and the grid energy powered electric drive system can simultaneously be used to propel the vehicle, eVMT includes the portion of these blended miles that are attributed to grid energy. Generally, staff has found that eVMT is a good indicator of a vehicle's greenhouse gas (GHG) benefit. However, eVMT does not appear to accurately represent the criteria pollutant (e.g., hydrocarbons, oxides of nitrogen) benefits. To capture the criteria pollutant benefits of the vehicles, staff analyzed electric only trips (e-trips) which are trips where the internal combustion engine (ICE) did not start at any time during the trip. Additionally, staff looked at zVMT which is the cumulative miles attributed to e-trips.[16] These three metrics will be explored in each of the alternative credit scenarios below.

IV.A. Alternative 1: Electric and Zero-Emission Miles Based

The first alternative would be a simple credit structure, based solely on the average eVMT and zVMT (miles). A scaling factor is proposed to convert the annual miles to a per vehicle credit value that is in the range of approximately +/- 1.0 credits to ensure this credit structure could fit with the existing regulation requirements. Staff created the following credit equation for these alternatives:

Alternative 1 (a)

$$Credit = \frac{(eVMT)}{10{,}000}$$

Alternative 1 (b)

$$Credit = \frac{(zVMT)}{10{,}000}$$

This alternative credit structure would result in all vehicles earning significantly less credits than the current credit structure as depicted in Figure 1 and Figure 2. It is also clear under this credit structure that BEVs with similar test AER would earn different credits based on driving patterns of previous drivers (of possibly different vehicle models). The most negatively impacted by this

[14] GM 2016. General Motors. Press Release. August 1, 2016. http://www.gm.com/mol/m-2016-aug-080116-volt.html
[15] For complete description of United States Department of Energy (U.S. DOE) EV Project, see Appendix G.
[16] For complete description of how each of these metrics were calculated, see Appendix G.

type of credit structure would be longer range BEVs which have an appeal to the growing PEV market, but are only driven so far.

Figure 1 - Alternative 1(a): Simple eVMT

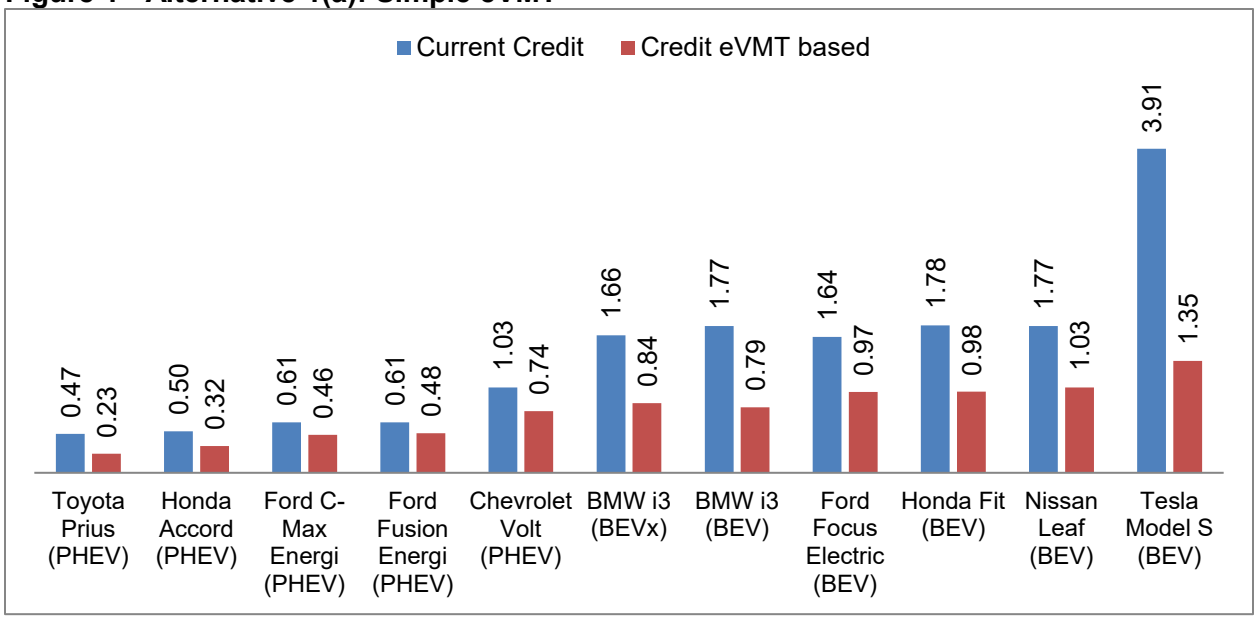
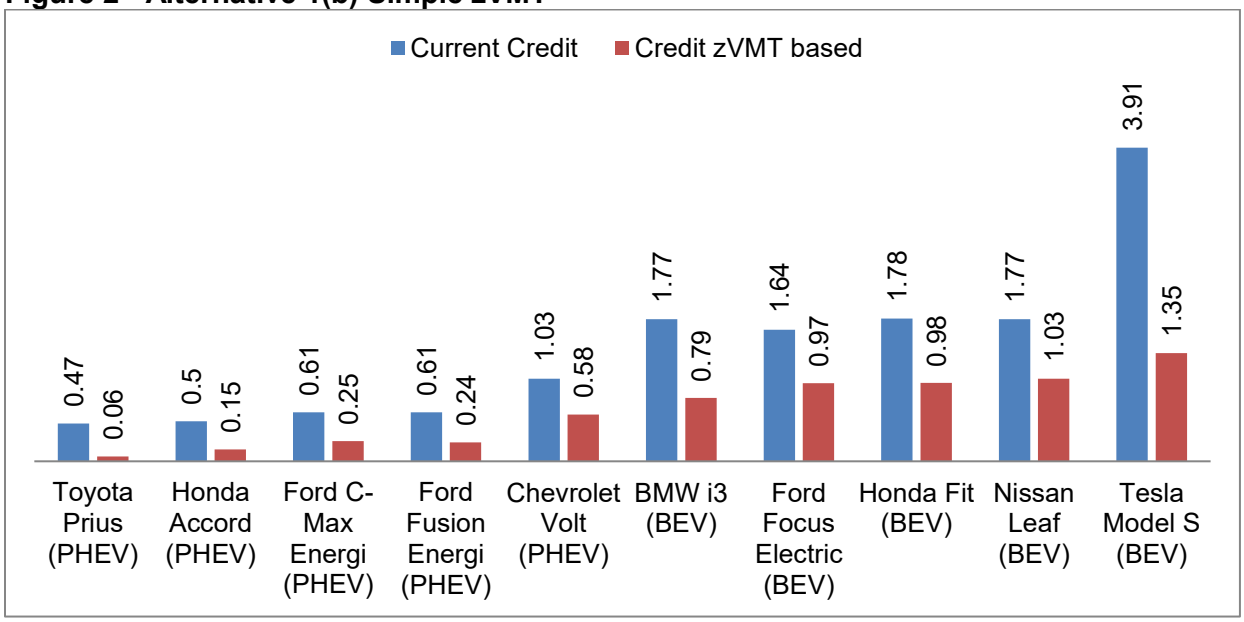


Figure 2 - Alternative 1(b) Simple zVMT



VI.B. Alternative 2: Credit normalized to Nissan Leaf eVMT vs. PHEV eVMT (miles)

The first alternative scenario looks at PHEV eVMT (in terms of actual or absolute miles) compared to annual average Nissan Leaf eVMT (which is in every case equal to its VMT). The

Leaf was chosen as a comparison vehicles since it is a representative 100-mile (certified UDDS range) BEV with the highest sales volume, and was the largest set of trip data for BEVs that staff was able to analyze. Additionally, as stated above, manufacturers have made similar comparisons between their PHEVs and Leafs.

The following equation was used to calculate this alternative scenario:

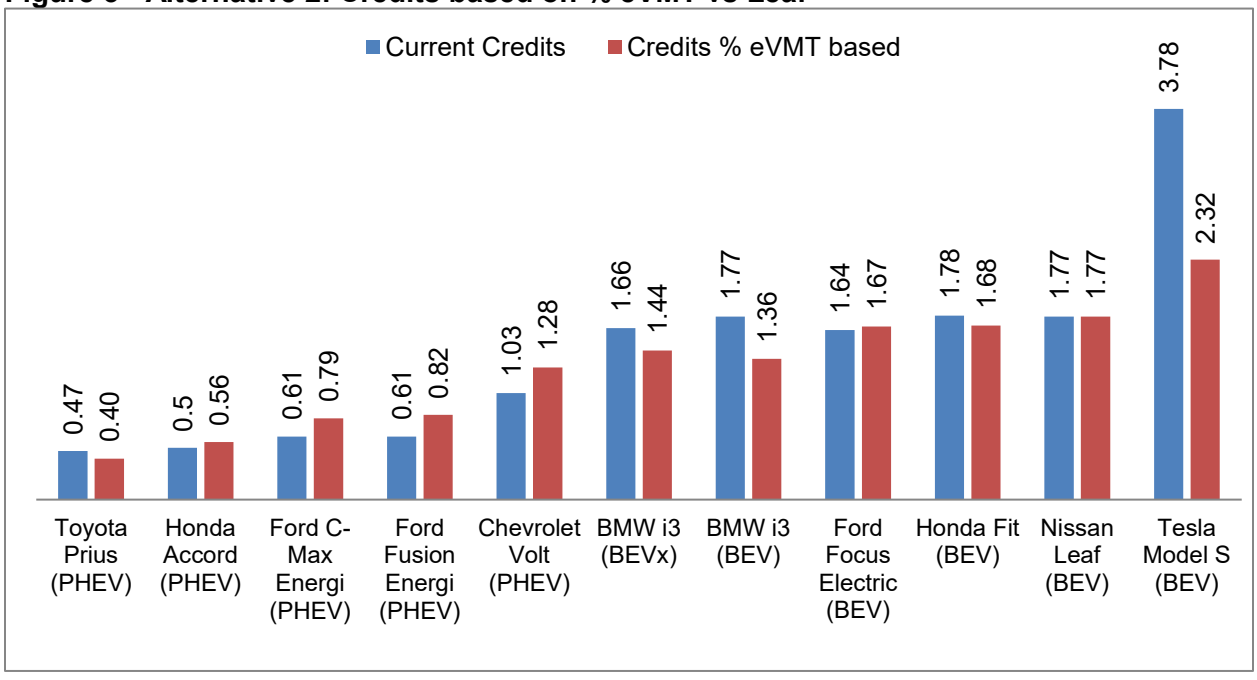
$$Credit = 1.77 \times \frac{eVMT}{Leaf\ eVMT}$$

Where, 1.77 is equal to what the 2015 model year Leaf would earn for credits according to the adopted 2018 and subsequent model year regulation, and based on its certified UDDS range for 2015 model year,[17] and where Leaf eVMT is equal to 10,294 miles.

This alternative shows how PHEVs (and other BEVs) stack up against the Leaf in terms of eVMT derived from staff's analysis. Each PHEV (and BEV) is earning a percentage of what a Leaf earns, based on the vehicle's eVMT.

This credit alternative would slightly bring PHEV credit values closer to ZEV credit values. As shown in Figure 3 below, this credit scenario raises the number of credits for most PHEVs. The exception to this would be the Toyota Prius which loses 0.07 credits. BEVs, dependent on their VMT would lose credit value, though many of the BEV models analyzed have similar AER. The Model S would lose the most from the current credit calculation (40% loss), but would still earn ~30% more than the Leaf.

Figure 3 - Alternative 2: Credits based on % eVMT vs Leaf



[17] 2015 model year Nissan Leaf: 127 certified UDDS AER

VI.C. Alternative 3: Credit normalized to Leaf zVMT vs. PHEV zVMT (miles)

Sticking with the Leaf as the credit baseline, the next alternative shows PHEVs compared in terms of each vehicle's zVMT, which is a better indicator of its criteria pollutant benefit rather than its GHG benefit (i.e., eVMT). As with Alternative 2, the eVMT, zVMT, and VMT are all equal for BEVs, and therefore are not shown in this alternative.

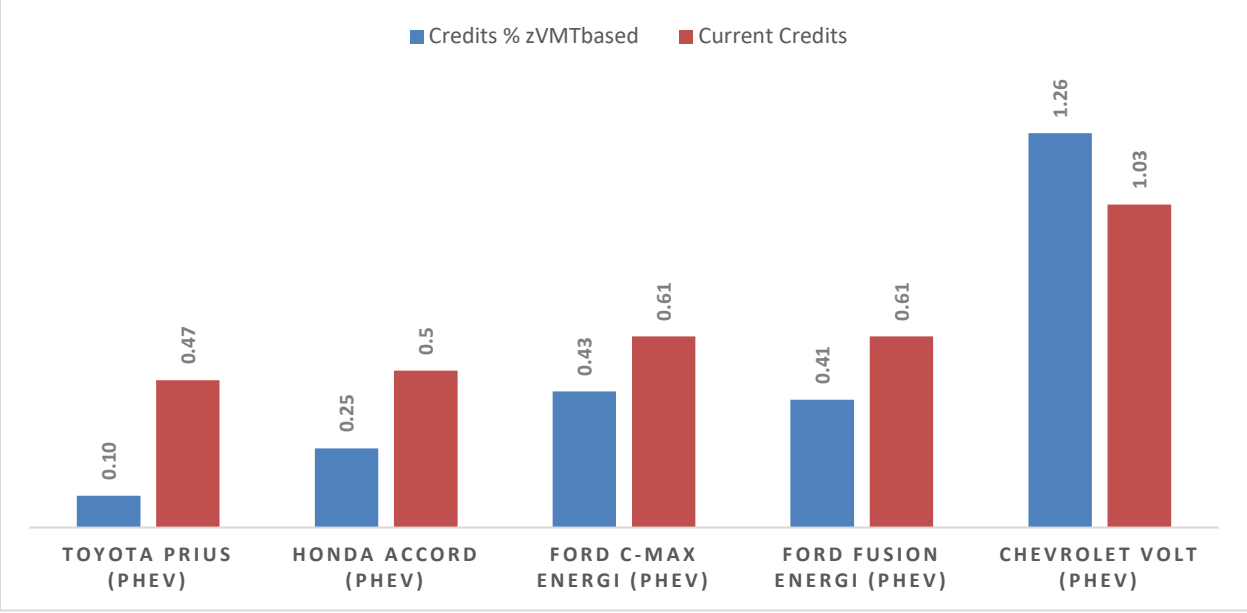
The equation used for this alternative is the same as the Alternative 2, but replaces eVMT with zVMT, as shown below:

$$Credit = 1.77 \times \frac{zVMT}{Leaf\ zVMT}$$

Where 1.77 is equal to the current Leaf credit, calculated according to the 2018 and subsequent model year currently written in the regulation, based on its certified UDDS range for 2015 model year. The Leaf zVMT is equal to 10,294 miles.

This credit alternative shows how PHEVs measure up against the Leaf in terms of zVMT. Each PHEV is earning a percentage of what a Leaf earns, based on the vehicle's zVMT. As shown in Figure 4 below, this credit scenario reduces the number of credits for almost all of the PHEVs. The Toyota Prius would lose the greatest amount of credits (~80%). However, the Chevrolet Volt would earn more credits than the current credit structure.

Figure 4 - Alternative 3: Credits based on % of zVMT vs Leaf



VI.D. Alternative 4: Credit normalized to Tesla eVMT and zVMT vs. PHEV eVMT (miles)

Given the analysis is intended to look at credit alternatives for future model years (2018 or later), Alternative 4 (a) uses a BEV that is more representative of the electric range of BEVs staff expects to see emerging over the next several model years: the greater than 200 mile Tesla Model S. The same general equation was used; however, the credit used in the equation is equal to what Tesla would earn in 2018 and subsequent model years, and the denominator for the equation changes to Tesla's annual average VMT. The equation for this alternative is shown below:

$$Credit = 3.91 \times \frac{eVMT}{Model\ S\ VMT}$$

Where, 3.91 is equal to Tesla Model S credit, calculated according to the 2018 and subsequent model year currently written in the regulation, and based on its certified UDDS range for 2015 model year,[18] and where Tesla Model S eVMT is equal to 13,494 miles.

All PHEVs would see a significant increase in credit under this alternative. BEVs would also earn more credit, since certified range does not necessarily correlate with VMT. In particular, the Leaf would earn 2.98 credits under this case, which is almost double what it would earn under the current credit structure for BEVs. Doubling credits for a shorter range vehicle creates less incentive to make a longer range vehicle. This also means that manufacturers can meet their current credit requirement with fewer cars.

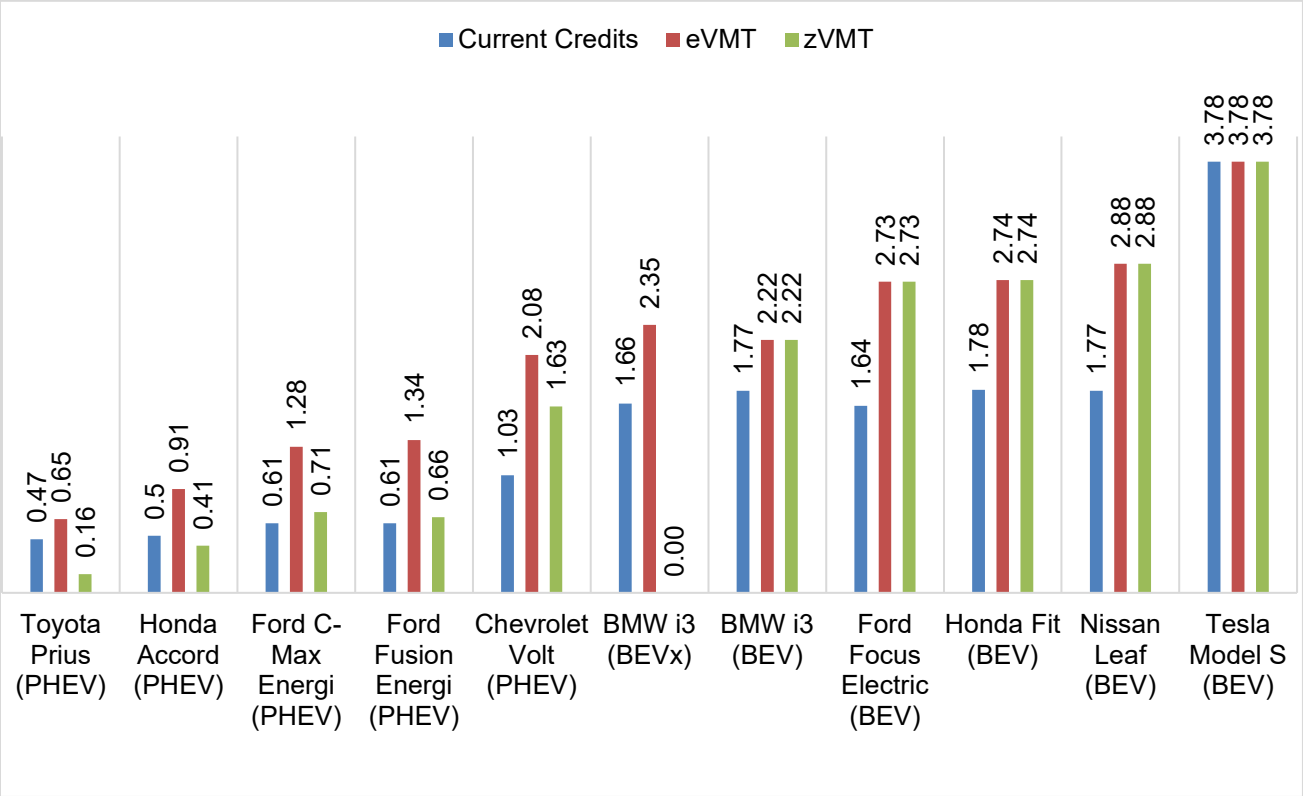
Staff also compared vehicles on the basis of zVMT with the Model S. The equation for this slight variation is shown below:

$$Credit = 3.91 \times \frac{zVMT}{Model\ S\ VMT}$$

As expected, credits are higher for BEVs and PHEVs when credits are based on zVMT and compared to the Model S because the number the percent zVMT is being multiplied by is higher. However, raising the amount of credit for all vehicles does not necessarily change the relationship between the technologies. BEVs (particularly 100 mile range BEVs) are earning more than PHEVs, though some of the gap is filled. But fewer vehicles could be expected without a subsequent raising of the entire ZEV requirement if all vehicles earn more credit.

[18] 2015 model year Model S: 328 certified UDDS AER

Figure 5 - Alternative 4: Credits based on eVMT and zVMT vs Tesla



VI.E. Alternative 5: Credits based on eVMT and zVMT normalized to ICE VMT

Instead of comparing to a BEV, another way to credit both BEVs and PHEVs would be to compare to typical conventional ICE car VMT. This could be a way to credit vehicles based on their ability to be a full replacement for an ICE vehicle. As VMT also decreases with each year a vehicle gets older, the average VMT for the first five years of age is used for the ICE VMT data, because this compares well with the average age of vehicle data given to ARB to analyze for various PEVs. The five year average for ICE VMT is 14,598 miles. The following equations were developed for this alternative credit structure:

$$Credit = 4 \times \frac{eVMT}{ICE\ VMT}$$

$$Credit = 4 \times \frac{zVMT}{ICE\ VMT}$$

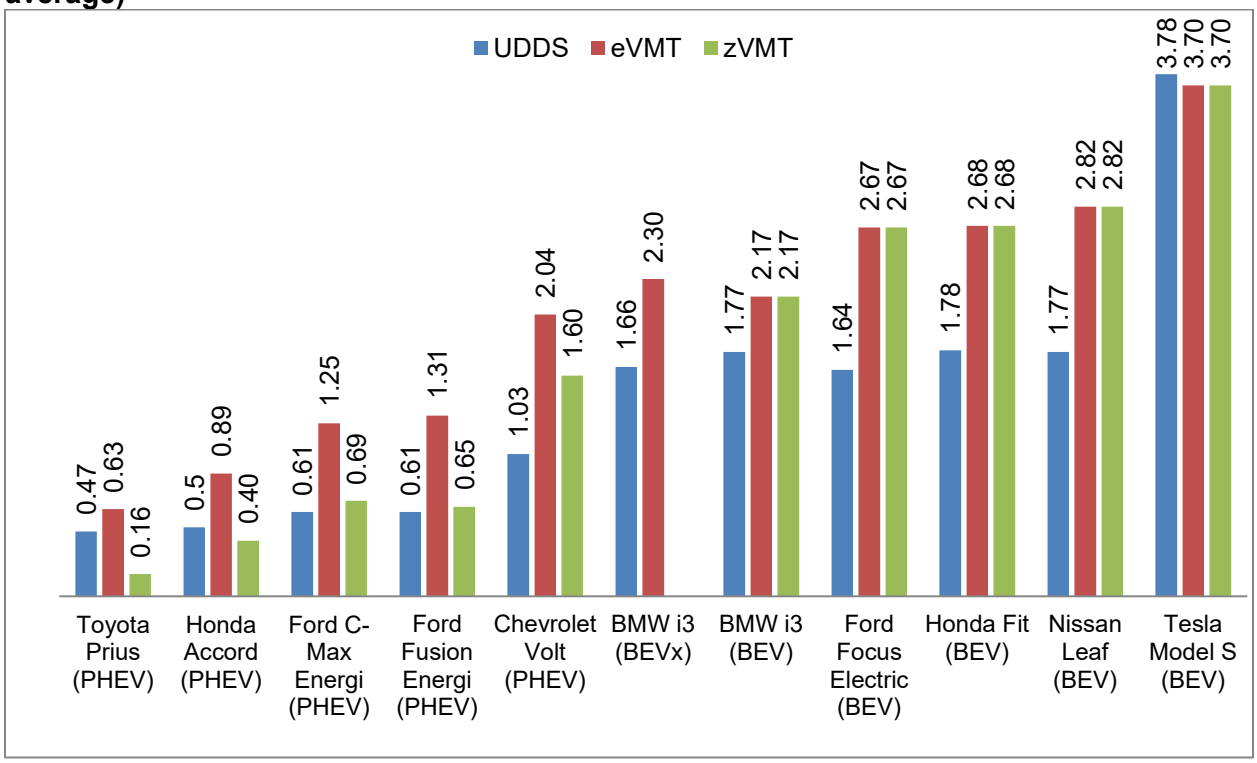
Where, 4 is equal to maximum number of credit earned by any vehicle,

Where, ICE VMT is equal to 14,598 miles.

All BEVs would see a credit boost except the Tesla Model S, which would earn slightly less credit. What is interesting about this credit structure is that it results in lower range BEVs becoming much closer in credits to long range BEVs than the current structure based on the

vehicle's all electric range. All PHEVs would also see increased credits when using eVMT. However, when considering PHEV zVMT, longer range PHEVs would receive more credit, but lower range PHEVs would receive less credit.

Figure 6 - Alternative 5: Credits based on eVMT and zVMT normalized to ICE VMT (5 year average)



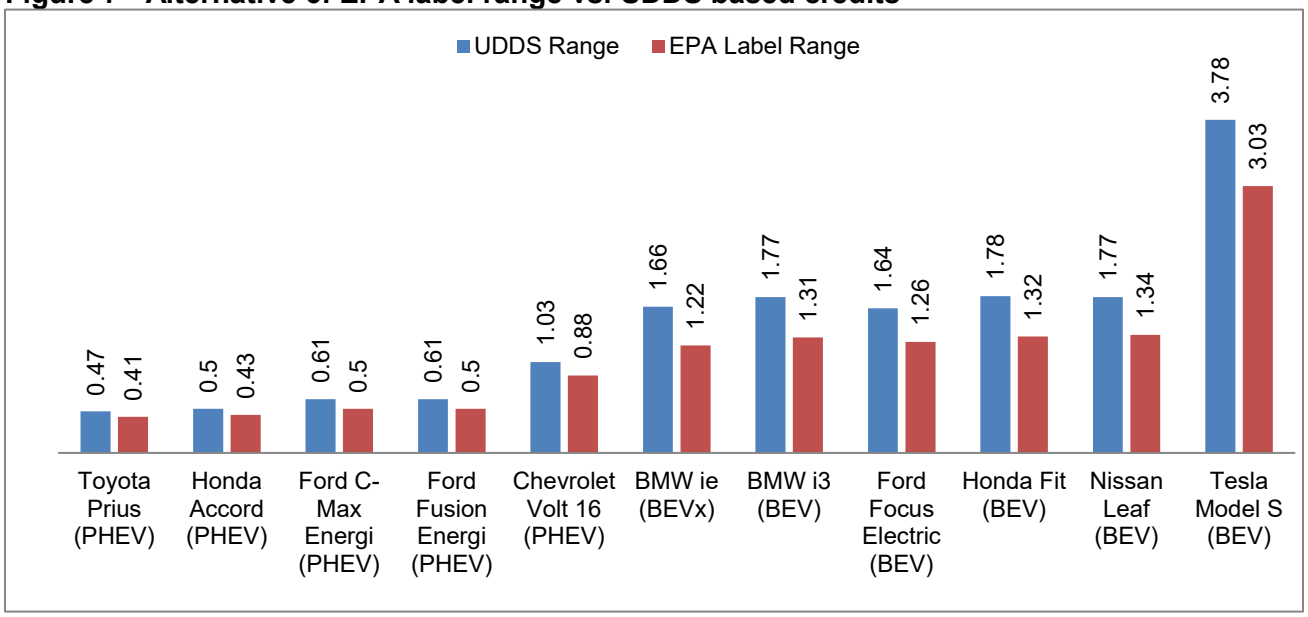
VI.F. Alternative 6: Current ZEV credit scheme using EPA label range

The last alternative credit structure considered was using EPA label range instead of UDDS range. UDDS is a drive cycle that only represents city (urban) driving and is the primary cycle used for criteria pollutant emission testing. EPA label range represents the approximate number of miles that can be travelled in combined city and highway driving.[19] EPA label range is based on the UDDS cycle plus several others that incorporate higher speeds and accelerations as well as colder and hotter weather conditions. While conventional cars use 5-cycle testing to determine their label values, electric vehicles determine their label values slightly differently. PEVs are able to do 2-cycle testing (also known as the UDDS and highway cycles) and multiply it by 0.7 to determine their label range (instead of the additional three cycles to determine their full 5-cycle weighted range). A direct substitution of the EPA label range for the UDDS certification number could utilize the same credit equation as what is currently in the regulation for PHEVs and BEVs but would directionally lower the credits for all cars (as the EPA label range is always shorter than the UDDS cycle range). This approach would also have the benefit of using a range value that is more commonly available in the public

[19] DOE, 2016. United States Department of Energy. Electric Vehicles Learn More About the New Label. https://www.fueleconomy.gov/feg/label/learn-more-electric-label.shtml Accessed 11/1/2016

domain as the label ranges are widely disclosed while UDDS ranges are typically only reported in certification documentation submitted to ARB and U.S. EPA.

Figure 7 - Alternative 6: EPA label range vs. UDDS based credits



Overall, the credits would decrease per vehicle because a vehicle's EPA label EAER range is lower than its UDDS EAER. BEVs would see the most significant reduction in credit losing proportionally more credit than PHEVs. However, this could increase the number of vehicles to be delivered from each OEM because each vehicle would be generating less credit.

VI.G. Alternative 7: Other Credit Structures

Staff has been asked to also consider crediting vehicles based on various other factors such as total battery pack kilowatt hours (kWh), footprint, utility, etc. Staff has not developed a specific proposal to evaluate the effect of any of these factors on the overall credit structure. Directionally, however, these factors are not based on any analysis of how the vehicle performs or is used, but rather rewards attributes of the vehicle such as technical content or perceived consumer utility.

For instance, basing credit on battery size rewards the volume of a particular component (like battery cells) which could, theoretically, help promote high volumes to bring down cost. And such structures have been considered and even utilized in past ZEV credit structures (e.g., advanced technology partial zero-emission vehicles (AT PZEV) earned additional ZEV credits based on defined technical components being included on the vehicle). However, such metrics generally ignore how efficiently those components are being used in each vehicle (e.g., two similar sized cars with similar electric range but with one being much less energy efficient and thus, requiring a larger battery pack, would be rewarded with additional credits for its inefficiency). Further, the current credit process based on electric range largely achieves much of the same effect in that manufacturers are adding battery capacity to increase the range and thus, earn more credits. Lastly, the current and projected sales volumes for ZEVs in CA (and

the Section 177 ZEV states) represent only a portion of the global sales volumes for ZEVs. Accordingly, an adjustment to the ZEV credit structure would likely have less effect on helping push volumes to appreciably higher levels than the global market is already demanding.

Regarding credit structures that would base credits on vehicle attributes such as size of the vehicle, footprint of the vehicle, market segment of the vehicle, or other measures of vehicle utility such as seating capacity, interior volume, or cargo capacity, there is even less nexus connecting these attributes to the performance of the ZEV. Supporters suggest that such an approach would better ensure a wider range of product offerings that would appeal to a larger segment of the new car buyers. Directionally, staff agrees that broader offerings could help build the ZEV market. However, even under the current credit structure, manufacturers have created and announced upcoming product offerings within the next five years in nearly every vehicle segment with a variety of vehicle configurations. While it is true that a larger share of these offerings are in the small and midsize car and small sport utility vehicle segments, these three segments make up over 75% of all new vehicle sales in California and is exactly the market segments ZEV need to be in to achieve significantly higher volumes. Given the 300 to 400 or more models (and over 1,300 unique variants within those models) offered for sale every year in California, it does not appear feasible to define a few key vehicle attributes for the credit structure that correctly identify the utility or features that ensure broad appeal of the vehicle.

VII. Conclusion and summary

Each of these alternative credit cases has relatively the same trend line when compared to the current credit structure. In general, a 100 mile (UDDS) BEVs would continue to earn more than PHEVs. In some of the alternatives, all vehicles (both BEV and PHEV) would earn more credits, meaning that, without being coupled with a corresponding increase to the overall stringency of the regulation, manufacturers would be required to produce fewer vehicles to meet the regulatory credit obligation. This would be the opposite direction the Board has indicated it wants the regulation to go in. The Board has stated its interest in providing more certainty to vehicle volumes, rather than more credits per vehicle.[20]

All of these cases are based on analyses of different metrics quantifying how current PHEVs are being operated. Unfortunately, these metrics are ever-changing numbers, based on consumer's charging and usage patterns. These numbers are dynamic and will change over time because vehicle offerings and technology are rapidly changing, which means vehicle credits could go up or down based on consumer driving habits, energy prices, vehicle range, infrastructure availability, etc. It is in the best interest of the OEMs and ARB to maintain a stable foundation for crediting these vehicles rather than propose a credit structure based on usage, which is inherently dynamic.

Lastly, consumers value range. In a 2015 survey of PEV drivers, among those responding they would replace their PEV with a PHEV, current PHEV drivers indicate an average desired all-electric range of 40-50 miles while almost all current BEV drivers indicate a range of around 80

[20] ARB 2016. California Air Resources Board. July 2016 Board Transcript. July 21, 2016 http://www.arb.ca.gov/board/mt/2016/mt072116.pdf

miles.[21,22] For a mandate structure, ZEV regulation credits being based on range is appropriate since that structure values what the consumer values. Other ARB and EPA fleet average regulations appropriately credit PHEVs on their environmental benefits.

It is important to point out that the list of above alternative is not all inclusive, nor have these alternative structures been evaluated for economic or environmental impacts. In any future rulemaking process, staff will continue to meet with stakeholders to discuss various credit alternatives, and receive input on improving the regulation in future years.

[21] See Appendix B, Section VII for a description of the CVRP Consumer survey results.
[22] See Appendix B for complete description and analysis of consumer attitudes towards ZEVs and PHEVs.

VIII. References

ARB 2011. California Air Resources Board. “Initial Statement of Reasons: 2012 Proposed Amendments to the California Zero-Emission Vehicle Regulation”, pg. 13. Available: http://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf

ARB 2012. California Air Resources Board. Resolution 12-11. January 28, 2012. Available: http://www.arb.ca.gov/regact/2012/zev2012/res12-11.pdf

ARB 2016. California Air Resources Board. July 2016 Board Transcript. July 21, 2016 http://www.arb.ca.gov/board/mt/2016/mt072116.pdf

CADOT, 2013. California Department of Transportation. 2010-2012 California Household Travel Survery Final Report. June 2013. http://www.dot.ca.gov/hq/tpp/offices/omsp/statewide_travel_analysis/Files/CHTS_Final_Report_June_2013.pdf

DOE, 2016. United States Department of Energy. Electric Vehicles Learn More About the New Label. https://www.fueleconomy.gov/feg/label/learn-more-electric-label.shtml Accessed 11/1/2016

GM 2016. General Motors. Press Release. August 1, 2016. http://www.gm.com/mol/m-2016-aug-080116-volt.html

Honda 2013. Robert Bienenfeld. “Honda’s Testimony at the California Air Resources Board’s Advanced Clean Car Hearing” October 24, 2013. Available: http://www.arb.ca.gov/lists/com-attach/21-zev2013-UCJVPFc0VWNVIQN3.pdf, accessed August 28, 2016