

November 21, 2025

California Air Resources Board  
1001 I Street  
P.O. Box 2815  
Sacramento, CA 95812

Submitted via Drive Forward Light Duty Vehicle [comment docket](#)

Re: October 21, 2025 workshop on the Drive Forward Light-Duty Vehicle Regulation

Dear Chair Sanchez, members of the Board and Staff:

The Strong Plug-in Hybrid Electric Vehicle (PHEV) Coalition's advocacy team appreciates this opportunity to comment on the Drive Forward Light-duty Vehicle regulation workshop on October 21. Established in July 2019, the Strong PHEV Coalition represents an independent group of over 40 electric transportation experts with many years of collective professional experience. We possess expertise throughout the EV industry including research and academia, vehicle manufacturing and deployment, policymaking, utilities, NGO advocacy, consumer education, EV fleet management, and charging infrastructure development.

The Coalition has provided information to CARB during the last 6 years as we have consistently supported and informed regulations enabling PHEVs with a minimum of 50 miles or greater all-electric range (AER) based on USEPA's label. Please see [www.sphev.org](http://www.sphev.org) for our previous education and advocacy efforts including letters to CARB staff and our April 2023 [overview](#) of strong PHEVs. Today there are about 27 million PHEVs and 91 million BEVs globally<sup>1</sup> and the strong trend is toward longer-range versions for both technologies. Clearly PHEVs have made a difference in enabling a sustainable, equitable and economical transition to electrified transportation.

**Summary:** Our primary goal has always been to advocate for improvements to PHEVs to increase their environmental benefits and attractiveness to consumers, and to educate on the benefits of long-range PHEVs which have additional strong attributes such as further reducing criteria pollutants. Our research has found 84 PHEVs models with over 60-mile range (estimated USEPA label) worldwide but only one model in the US, including 53 PHEV models with over 80-mile AER worldwide but none in the US, and 35 PHEV models with over 100-mile AER worldwide.<sup>2</sup> See Appendix A. To catch up, we believe CARB needs to adjust its incentives and regulations. In 2024, CARB staff projected PHEVs as only making up 5-10% of future vehicle sales (BEVs, FCEVs and PHEVs),<sup>3</sup> but given what is happening with PHEVs in the rest of the world, and the many benefits of strong PHEVs, we believe CARB should seek to have much higher percentages of long and very long-range PHEVs by including new regulatory incentives in the upcoming Drive Forward Light-duty vehicle regulations.

Getting to 100% of sales of new Battery EVs, Fuel Cell EVs and long-range PHEVs and getting the last 40% of the market to be electrified will be much harder than most thought one or two years ago. While more research is needed, at long range AERs a PHEV is equivalent in environmental performance to a long-range BEV (but likely around 70 to 100 miles AER) based on several factors:

- Long range PHEVs achieve 80 – 95% of total miles from off-board electricity. (See appendix B)
- The smaller batteries in a long-range PHEV compared to the greenhouse gases from a long-range BEV equal about one, maybe two years of BEV driving. (See Appendix G.)
- Using E-85 (85% ethanol 15% gasoline) in a long-range PHEV further reduces GHGs and other pollutants. (See Appendix C.)
- Education programs and ZEV assurance regulations will help improve consumers charging of PHEVs as well as emerging technologies such as bidirectional and wireless charging.

Our position regarding the questions in the workshop is evolving because it's unclear the framework that the Drive Forward Light duty vehicle regulation will take. For example, CARB staff may propose a framework that is different than Advanced Clean Cars II, and we'd like to understand the pros and cons of the possible frameworks. Thus, our comments for the framework of the regulation are presented here at high-level. We recommend CARB:

- Design different regulation frameworks for class 1 (~20 million cars in California), class 2a (~ 8 million cars and trucks) and class 2b / 3 vehicles (~one million trucks) in order to recognize the commercialization/ large-scale adoption ramps of ZEVs and long-range PHEVs in these three vehicle classes will be different.
- Keep ACC II's previous minimum floor of a 50-mile all-electric range (USEPA label) for PHEVs but have a sliding scale so that PHEVs with a greater AER are incentivized to earn more incentives in the regulation (e.g., under the previous ACC II framework, the cap should have ratcheted higher for PHEVs with greater AERs). A sliding scale of incentives for PHEVs is used in the Advanced Clean Truck regulation and is appropriate in the Drive Forward Light-duty Vehicle regulation
- Similarly, long-range or very long-range PHEVs should be flexible fuel vehicles (FFVs) capable of using E-85 (to have access to California's 500 E-85 stations). See Appendix C.
- The regulatory framework should incentivize PHEVs with bidirectional charging. See Appendix D.
- Similarly, early action credits for PHEVs sold prior to MY 2031 should, at minimum, reward technologies that do not exist today or that are just emerging such as:
  - PHEVs with long AERs and more for very long AERs
  - PHEVs with bidirectional charging
  - PHEVs with flex fuel vehicle ability so they can use California's many E-85 stations
  - PHEVs with wireless charging .
- Adopt our updated recommendations on ZEV education (e.g., window stickers, QR code labels, dashboard charging reminders/chimes in the car) in a separate regulation in 2026 that does not require a waiver or help the Department of Consumer affairs to do this. (See Appendix E.)
- Adopt our recommendations on conformance testing (See Appendix F.)

The recent press on PHEVs not plugging in is largely based on a European study that does not apply to market and operating conditions in the US. As explained in the Forbes article, this flawed study is based on 70 percent of European PHEVs not plugging in because they are "company cars" given free to employees to take home with a card that provides free gas but not free electricity.<sup>4</sup> This situation does not occur in the US. If the study had looked at the 30 percent of PHEVs in Europe that are personal PHEVs, the results would have been very different. Our prior letters have also criticized CARB and EPA regarding analysis of data from California's Bureau of Automotive Repair regarding their data on PHEVs plugging in. We will provide more analysis in future peer reviewed publication and letters. The focus of industry and regulators should be on improving SAE J2841 which is the standard for the percentage of

a PHEV's miles from plugging in (called the utility factor). To date, the debate has been focused on the critique of shorter-range PHEVs that won't be sold in the next decades, but the focus of utility factor curves should be on long-range PHEVs. See Appendix B for more details and recommendations on PHEVs plugging in.

Regarding the emissions from battery mining and manufacturing, we note that UC Davis, Argonne National Lab and European researchers have separately made a lot of progress on understanding these impacts, based on presentations at the 2025 UC Davis conference at Asilomar. It appears that these and other researchers are close to being able to show how much GHG comes from various types and sizes of batteries and including their mining and manufacturing practices. We strongly recommend that CARB should join in these efforts and use the information to inform policy and education in this rulemaking (e.g., regulations, incentives, window stickers, QR codes for the vehicle). We are not asking for penalties on battery EVs, but for long-range and very long-range PHEVs to receive more PHEV-specific and therefore more accurate treatment in the Drive Forward Light-duty Vehicle regulation. We continue to recommend several near-term studies that should include CARB participations with the National Renewable Energy Lab, SAE International, Argonne National Lab, USEPA, UC Davis, Colorado State University Ft Collins, University of Texas Austin, and automotive manufacturers. The purpose would be to examine the benefits of long-range PHEVs based on a PHEV's percentage of electric mileage driven, use of E-85, and cradle-to-grave greenhouse gas reductions. Details regarding our recommendations and justifications for them are in Appendix G in this letter.

Regarding consumer acceptance of BEVs and PHEVs, we note that there is more skepticism of BEVs according to a new McKinsey study that surveyed consumers in the US, Europe and China.<sup>5</sup> Exhibit 1 in their study showed 32% of US consumers never planning to purchase an EV in 2025 vs 27% in 2024 and another 38% wanting one or more internal combustion engine vehicles (ICEVs) before buying in EV. Further 17% of US consumers wanted their next vehicle to be a PHEVs vs 12% wanting a BEV, and the numbers of PHEV intenders in Europe was 27% and in China, 37%. Exhibit 10 in their study showed a 23% increase in percentage of US purchase intenders (from ICEVs and hybrid EVs) when an extended range EVs (a type of PHEV) was listed as an option (instead of just EVs and PHEVs). A Boston Consulting Group Study has found similar numbers.<sup>6</sup> We believe there is a need for CARB and others to research consumers more, especially the approximately 8 million light-duty truck drivers who are generally late adopters of BEVs and PHEVs (class 2a). See Appendix H.

Regarding cost, we recommend that CARB (likely with EPA, the DOE or the national labs) conduct a comparative analysis regarding PHEV and BEV costs with stakeholder input or a working group and fully explore ways to reduce the costs of PHEVs. This analysis should also consider advances in battery and other technology which reduces the cost of the vehicle and battery, increases fast charging and reduces weight.<sup>7</sup> See Appendix I for more on the PHEV cost and how they can match the cost of BEVs.

Regarding the workshop's question on treating EREVs differently, we do not support this. CARB should clarify that all types of PHEVs that meet the GHG, NOx, ROG, PM, all-electric range and other standards qualify. In other words, CARB should be technology-neutral regarding details such as drivetrain (e.g. parallel, series, power-split), software (e.g. turn-on speed, blending of gasoline and electric operation) or common name (e.g., extended range EVs) if they meet CARB's standards.

EREVs are just a type of PHEV. **PHEV** is a very broad term for a type of dual- or tri-fuel vehicle that includes series, parallel and power split designs with many possible all electric ranges, powertrain energy management schemes, type of transmission (or none), type of liquid or gaseous fuel, charging technology or engine. However, they all must be able to plug into an outlet or charging station. **EREV** (extended range EV) is a marketing term for a type of PHEV that behaves consistently whether the engine is operating or not and typically provides a high AER. EREVs may or may not use a series-hybrid design. The EREV designation is typical for PHEVs with 80–250-mile AERs in China and Europe, and several of these PHEVs will be available in the US in 2026 and 2027. (See Appendix K.) All-electric ranges are measured using different regulatory tests in different regions. In the US, the AER is measured according to a USEPA definition.

**Relationship of battery and engine sizes:** Long-range PHEVs have larger batteries that provide more energy and power, and this allows for smaller engines and more efficient engine designs.

**Type of fuel and engine:** gasoline, blend of 85% ethanol/15% gasoline (E85), or natural gas for spark ignited engines; hydrogen for fuel cells; and diesel for compression ignition engines.

**Type of charging:** Typical is level 1 or 2 AC, but many long-range PHEVs have DC fast charging. Wireless charging could emerge for luxury models.

**Size of vehicle:** Mostly light duty PHEVs today, but medium and heavy-duty PHEVs are in the market and several additional versions will be commercially available soon.

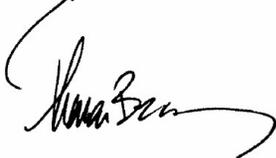
**Powertrain energy management:** Long-range PHEVs provide more electric capability in terms of power and all-electric miles. Many short-range PHEVs have less electric capability so they must engage the engine more often.

See Appendix J for more on the many benefits of strong, long-range PHEVs and why they are needed. At minimum, given that long-range PHEVs have substantial advantages over BEVs and given slide 32 in the June 2024 presentation which shows only 5-10 percent PHEVs in ACC II, CARB should be sure to not discourage PHEVs in this rulemaking. California needs more than 20% PHEVs especially in the near term as there are not enough chargers being placed in the remote and underserved areas of California and Section 177 states or in workplaces, streets, shopping areas and apartments.

While there are many announcements of upcoming long-range PHEVs for the US (see appendix K), we recommend that a Drive Forward Light duty Vehicle regulation reward those long-range PHEVs with regulatory incentives (e.g., a sliding scale where greater AER receives a larger incentive). Given today's marketplace environment and cancellation of announced ZEVs, long range PHEVs need to be supported and encouraged. As an example of the perhaps unintentional impact of revisions of regulation, one automotive CEO admitted that their change regarding PHEVs was due to the ACC II provisions on PHEVs.<sup>8</sup> Clearly, CARB has the experience to lead and should encourage these PHEVs with long and very long AERs in this rulemaking.

In this letter and our previous conversations with CARB and EPA staff, the Strong PHEV Coalition sought to share our data- driven approach to understanding the future of PHEVs. We seek to be a resource to CARB and to EPA to connect policy making to the resources and expertise that we have available in our diverse team. We look forward to more dialogue with staff so that we might collectively improve the sustainability, justice, and economy of transportation for all stakeholders.

Sincerely,

A handwritten signature in black ink, appearing to read "Anna Ben", written in a cursive style.

Thomas Bradley, PhD  
 Co-Chair Strong PHEV Coalition, and  
 Woodward Professor and  
 Department Head of Systems Engineering Department of Systems Engineering  
 Colorado State University , Engineering Building A202B  
[Thomas.Bradley@colostate.edu](mailto:Thomas.Bradley@colostate.edu) and <https://www.engr.colostate.edu/se/>

***Robert L. Graham***

Robert L. Graham

Co-Chair, Strong PHEV Coalition, and Retired (EPRI, Southern California Edison, US Dept of Energy)

## Appendix A

**Long Range PHEV Table 1 Not available in US** Black font = sold in China. **Blue font = sold in Europe & China, Green font = sold in China and other countries.**

Note that Chinese PHEVs exports are increasing and the media reports a tidal wave of new models for EU, UK, Australia, South Asia and Latin America. Shorter range PHEVs not included

	<b>Make</b>	<b>Model</b>	<b>price (Sept 2025) converted to \$</b>	<b>pack size (gross)</b>	<b>Est Miles AER USEPA label<sup>9</sup></b>
1	AITO	M9 <sup>10</sup> EREV	\$65,250	52	<b>87</b>
2	AITO	M7 <sup>11</sup> EREV	\$34,695	42	<b>81</b>
3	AITO	M8 <sup>12</sup> EREV	\$63,200	53.4	<b>143</b>
4	AITO	M8 base <sup>13</sup> EREV	\$50,800	37	<b>93</b>
5	AITO	M5 <sup>14</sup> EREV	\$34,500 to \$38,600	42	<b>107</b>
6	Arcfox (part of BAIC group)	Alpha T5 <sup>15</sup>			<b>100</b>
7	Audi	A3 sport back TFSIe <sup>16</sup>	\$51,700		73
8	<b>Audi</b>	Q3 e-hybrid <sup>17</sup>	\$57,000	25.7	61
9	Buick	Electra L7 <sup>18</sup> EREV	\$41,800	40.2	<b>139</b>
10	<b>BYD</b>	Seal 06 DM i <sup>19</sup>	\$15,232	18.7	71
11	BYD	Sealion 6 ER <sup>20</sup>	\$31,013	26.6	62
12	BYD	Sealion 07 <sup>21</sup>	\$31,800		<b>256</b>
13	BYD	Song DM <sup>22</sup>	\$18,500	26.6	66

14	BYD	Tang <sup>23</sup>	\$24,600 to \$27,400		<b>99</b>
15	BYD	Seal U <sup>24</sup>	\$20,600		64
16	BYD	SongPlus DM	\$25,600	26.6	71
17	Changan	deepal S07 <sup>25</sup> EREV	\$20,820	31.7 or 39	<b>106 or 138</b>
18	Changan	Deepal G318 <sup>26</sup> EREV	\$24,431	35	63
19	Changan	Hunter pickup <sup>27</sup> EREV	\$19,500 to \$31,100	31.8	<b>83</b>
20	Changan	Deepal S09 <sup>28</sup> EREV	\$48,000	40	<b>83</b>
21	Changan	Nevo AO6 <sup>29</sup> EREV	less than \$20,000	28.4	<b>92</b>
22	Chery	Fulwin A9L <sup>30</sup>	\$20,700 to \$27,600.	33.7	<b>124</b>
23	Chery	Fulwin A8 <sup>31</sup>	\$16,700 to \$19,000		67
24	Chery Exceed	Exlantix ET5 <sup>32</sup>		32.7	<b>94</b>
25	Chery	Fulwin 11 <sup>33</sup>		40	<b>101</b>
26	Chery	Tiggo 9 <sup>34</sup>	\$56,470	34.5	74
27	Cupra (part of VW)	Formentor <sup>35</sup>	\$33,800 to \$44,200	25.8	60
28	Cupra (part of VW)	TerraMar <sup>36</sup>	\$50,700	25.8	61
29	Cupra (part of VW)	Leon <sup>37</sup>	\$52,300 to \$56,300	25.8	63
30	DENZA (part of BYD)	Z9 <sup>38</sup>	\$46,300	38.5	<b>93</b>
31	DENZA (part of BYD)	N9 <sup>39</sup>	\$54,000 and \$62,000	47	<b>93</b>
32	Dongfeng	Aeolus L8 <sup>40</sup> EREV	\$21,000	30.3	<b>114</b>
33	Ford (China)	Bronco <sup>41</sup> EREV	not yet on sale	44	<b>111</b>
34	GAC	Hyptec HL <sup>42</sup> EREV	\$37,500 to \$42,000	60.3	<b>161</b>
35	GAC	M8 <sup>43</sup>		44.5	76
36	GAC	Trumpchi S7 PHEV <sup>44</sup>	\$34,500	36.3	<b>94</b>
37	Geely	Starshine 8 <sup>45</sup>	\$23,600	18.4	60
38	Geely	Galaxy M9 <sup>46</sup>	\$29,000	41.5	<b>106</b>
39	GWM	WEY 05 <sup>47</sup>	not available	39.7	74
40	GWM	WEY 03 <sup>48</sup>	not available	34	70
41	GWM	Haval H6 GT <sup>49</sup>	\$36,600	35.4	<b>92</b>
42	Hozon Auto	Neta S EREV <sup>50</sup>	\$29,600	44	<b>116</b>

43	IM Motors	LS6 Pro EREV <sup>51</sup>	\$34,200	52	<b>170</b>
44	IM Motors	LS6 Ultra EREV <sup>52</sup>	\$41,000	66	<b>207</b>
<b>45</b>	<b>Jaecoo (part of Chery)</b>	9 <sup>53</sup>	pending		78
46	Jetour (part of Chery)	Shanghai L7 Plus <sup>54</sup>	\$19,500 to \$25,400	32.7	<b>101</b>
47	Leapmotor	C11 EREV <sup>55</sup>	\$20,900	43.7	<b>138</b>
<b>48</b>	<b>Leapmotor</b>	C10 EREV <sup>56</sup>	\$47,817	28.4	74
49	Li	L9 EREV <sup>57</sup>	\$56,917	44.5	<b>96</b>
50	Li	L8 EREV <sup>58</sup>	\$50,500	52.3	<b>143</b>
51	Li	L7 EREV <sup>59</sup>	\$47,700	52.3	<b>143</b>
52	Li	L6 EREV <sup>60</sup>	\$34,695	36.8	<b>93</b>
<b>53</b>	<b>Lynk &amp; Co (part of Geely)</b>	O8 <sup>61</sup>	\$60,000 to 65,000	39.6	<b>98</b>
55	Lynk & Co (part of Geely)	900 <sup>62</sup>	\$42,500	44.9	<b>129</b>
55	Maextro (part of Huawei and JAC)	S800 EREV dual <sup>63</sup>	\$141,600		<b>184</b>
56	Maextro (part of Huawei and JAC)	S800 EREV tri <sup>64</sup>	\$98,700		<b>168</b>
57	Mazda	EZ 60 <sup>65</sup>	\$17,000 to \$22,600	31.4	73
58	Mazda	Vision X-coupe <sup>66</sup>	Pending		<b>61</b>
<b>59</b>	<b>Mercedes</b>	GLC 300de <sup>67</sup>			64
<b>60</b>	<b>MG (part of SAIC)</b>	eHS <sup>68</sup>	\$ 43,400		61
61	Nissan (China)	N6	About \$15,000	21.1	<b>83</b>
<b>62</b>	<b>Omoda (part of Chery)</b>	9 <sup>69</sup>	\$58,952	34.5	76
<b>63</b>	<b>Renault</b>	EREV <sup>70</sup>	not yet on sale		<b>102</b>
64	SAIC	Roewe M7 <sup>71</sup>	\$13,700 to \$16,100	19.7	73
65	Smart (part of Mercedes / Geely)	#5 EHD <sup>72</sup>	\$32,000	41.5	<b>116</b>
<b>66</b>	<b>Skoda (part of VW)</b>	Superb iV <sup>73</sup>	\$55,600 to \$65,000		69
<b>67</b>	<b>Skoda (part of VW)</b>	Kodiatq iV <sup>74</sup>	\$56,300 to \$60,000+		61
68	Volvo (part of Geely)	XC 70 EREV <sup>75</sup>	\$57,300 to \$68,400	39.6	<b>98</b>
69	Volvo (part of Geely)	XC 90 EREV <sup>76</sup>	not yet on sale		<b>about 100</b>
70	Voyah (part of Dongfeng)	FREE EREV <sup>77</sup>	\$31,792	43	<b>119</b>

71	Voyah (part of Dongfeng)	Passion EREV <sup>78</sup>	not clear	43	<b>121</b>
72	Voyah (part of Dongfeng)	Passion L EREV <sup>79</sup>	not yet on sale		<b>138</b>
73	Voyah	Dream	\$63,700	62.5	<b>161</b>
74	Voyah	Dream – base <sup>80</sup>	\$46,700	43.5	<b>104</b>
<b>75</b>	<b>VW</b>	eGolf PHEV <sup>81</sup>	\$ 51,700	19.7	72
<b>76</b>	<b>VW</b>	Passat eHybrid <sup>82</sup>	\$59,000 to \$68,600		66
<b>77</b>	<b>VW</b>	Tiguan eHybrid <sup>83</sup>	\$56,900	19.7	63
78	Xpeng	G7 EREV <sup>84</sup>	about \$30,000	55.8	<b>150</b>
79	Xpeng	X9 MPV EREV <sup>85</sup>	not yet on sale		<b>207</b>
80	Xpeng	P7+ EREV <sup>86</sup>	\$29,600		<b>184</b>
81	Yangwang (part of BYD)	U8L Dingshi EREV <sup>87</sup>	\$179,000		<b>92</b>
82	Zeeker (part of Geely)	9X EREV <sup>88</sup>	\$68,000 to \$136,000 est		<b>174</b>
83	Zhengzhou Nissan	GE PHEV pickup <sup>89</sup>	\$ 30,500	33	63

## Appendix B

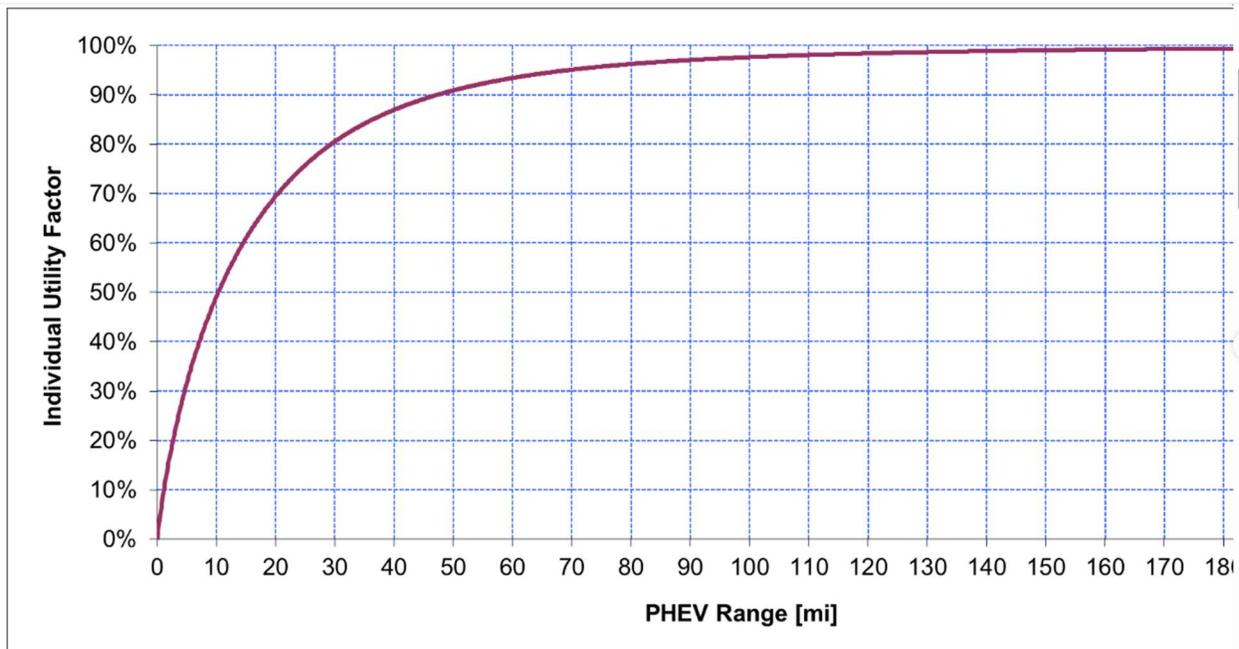
As shown in USEPA’s Final light- and medium-duty vehicle GHG rulemaking (Figure 11 and Figure 12), a PHEV with 120 AER counts as 83-90 percent of total miles electric, and recent studies show PHEVs driving substantially more annual miles than BEVs in 2022.<sup>90</sup> These two factors result in similar annual electric miles for the BEVs and the PHEVs with very long AERs.

A UC Davis study using data loggers found that PHEVs with longer AERs are plugged in more often compared to PHEVs with short AERs.<sup>91</sup> The SAE J2841 fleet utility factor analysis and USEPA analysis in their final federal GHG standards (2024) also shows that PHEVs with longer AERs are plugged in more often. Based on this and other data, we believe long range PHEVs are a major part of ensuring the benefits of PHEVs and more electric miles. Incentivizing PHEV 60s, 90s and 120s in the Drive Forward regulation is a unique opportunity to address concerns about PHEVs delivering long-term benefits and more annual electric miles. Further, our proposal is a simple way to accelerate innovation by individual automakers, a unique opportunity to get better PHEVs that address concerns about plugging in and achieve environmental benefits if the light duty Drive Forward regulation has a cap on the number of PHEV 50s that can earn one credit. For example, the cap can be much higher for longer range PHEVs and removed for very long-range PHEVs. .

We further request that staff’s analysis of PHEV’s electric versus gasoline range and related statistics from the Bureau of Automotive Repair data, similar data from other states or any supplemental data from automakers be done as part of a working group that includes universities mentioned above, national labs and USEPA and specifically includes the Department of Systems Engineering at Colorado State University, Fort Collins, the Plug in Hybrid and EV Center at University of California, Davis. USEPA in their final federal GHG standards for vehicles essentially made the same recommendation.<sup>92</sup>

Further, we recommend that CARB somehow involve SAE International committee on SAE J2841 in this effort as they are in the process of updating the PHEV fleet utility factor. CARB together with the above stakeholders should research the PHEV fleet utility factor issue in depth not just for existing PHEVs but also look at sensitivities, data from other countries and states, and model PHEVs with very long range AERs (70, 90, 110, 130, 150s). CARB and the stakeholders should especially analyze electric miles driven by PHEVs in urban stop and go environments and the resulting GHG reduction.

The Figure below from SAE International shows the percent of Electric vs non-electric miles (Y-Axis or UF) for PHEVs with different all-electric ranges (X-axis or miles). The red line (Ind UF) shows the electric miles from plugging in as percentage of total miles from individuals who typically plug in.



**We oppose EPA and CARB changing the fleet utility factor for PHEVs at this time or using a new utility factor in this rulemaking,** but support seeking new data sources, considering other sources of GHG and new ways to verify PHEV use of electric miles that potentially could be used in a future rulemaking. Regarding staff’s proposal and questions on November 2023 workshop slide 21, we repeat our comments we provide in July 2023 to USEPA on this topic and make the same recommendations to CARB staff. Regarding the Fleet Utility Factor (FUF or UF) and the issue of PHEVs plugging in we have many recommendations. We recognize this is an important and a complicated issue. We share CARB and EPA’s desire to have PHEVs plug-in frequently in order to achieve needed emission reductions and make the averaging, banking and trading system work. We believe that a combination of regulatory requirements, incentives and disincentives discussed in our letter will address the issues that CARB and EPA have raised and improve the FUF.

In addition, several things have changed since our June 2023 letter to EPA that strengthen our request to keep J2841 as the basis for the FUF in CARB and EPA regulations and work to improve the FUF for a follow-on rulemaking using improved data sources.

- Several studies are saying that light duty EVs are not driving as much as ICEVs: as low as 61 percent of annual miles from ICEVs.<sup>93</sup> This makes SAE J2841 a conservative approach to the FUF.

- The big sales increase in China of PHEVs (including EREVs) compared to BEVs which points to consumers having concerns about BEVs in a more mature market such as China.<sup>94</sup> This further points to the potential (likelihood) for this need for PHEVs to occur in US in a future more mature market especially given the increased polarization and realization of real-world drive cycle applications that may be problematic for BEVs among drivers. Obviously, the press is full of articles about concern about the BEV market adoption slowing. Also achieving 100 percent adoption of ZEVs and Strong PHEVs will be very challenging.
- The RamCharger pickup with anticipated 145-mile AER and 690 total miles and others including Scout, Jeep, Ford, BMW, and Volvo. See Appendix K.
- Finally, there is the cost of fuel. When the cost of fuel rises, owners are far more likely to drive their BEV or plug-in their PHEV.

**Fleet Utility Factors for PHEVs** The Technical Committee of the Strong PHEV Coalition includes researchers who have been engaged with development and evaluation of UF calculations for more than 20 years. We are very familiar with the set of datasets that are available in the public and private domain for UF evaluation and have researched the datasets and authored many of the studies referenced in the DRIA by EPA. Our assessment and recommendations in response to the request for input on UF data in the DRIA is that the proposed changes to UF are based on a very poor dataset, poor analysis, and statistically indefensible methods. These datasets and methods are inadequate to inform policy of the importance and impact of CARB or EPA’s emissions standards. See our recommendations section above for what should be done instead.

***Critiques of the methods that are used in the EPA UF calculations.*** We assert that the methods used to derive the proposed fleet utility factors (FUFs) from transportation datasets are not statistically defensible, and that the process of “averaging” FUF curves is inappropriate and does not improve predictive ability. Apart from the inconsistencies described in the section above, policy makers and researchers must take caution in deriving findings from transportation data.

Figure 1 below illustrates the set of individual vehicle-level UFs that are derived from an updated data pull from BAR. Of course, the data are extremely scattered and do not illustrate the validity of the UF curves for either the SAE J2841 FUF or the proposed FUF. When EPA or ICCT perform least-squares regression to derive a particular UF curve, they must calculate the confidence interval around the parameter estimates. When we perform that regression with vehicle models’ pooled averages, we find that this dataset provides no evidence that the EPA FUF model is more representative than the SAEJ2841 model. To illustrate this point more visually, Figure 2 provides additional statistical detail for some selected vehicle models. Figure 2 illustrates the wide dispersion of measured individual UFs and shows that the 95 percent confidence intervals on the mean value may or may not encompass any particular pre-derived response curve.

Finally, EPA’s method of “averaging” of FUEly/BAR/J2841 UF curves does not have any statistical/theoretical/practical power in achieving UF prediction and is inappropriate given the varied and disperse nature of these data. A more data-driven approach that incorporates a number of driver and vehicle operating factors is needed to better characterize the real-world utility factors that are likely to arise over time. As the BAR database expands and becomes cleaner and more regularized, it can form the basis of a statistically relevant and more acceptable data-driven model.

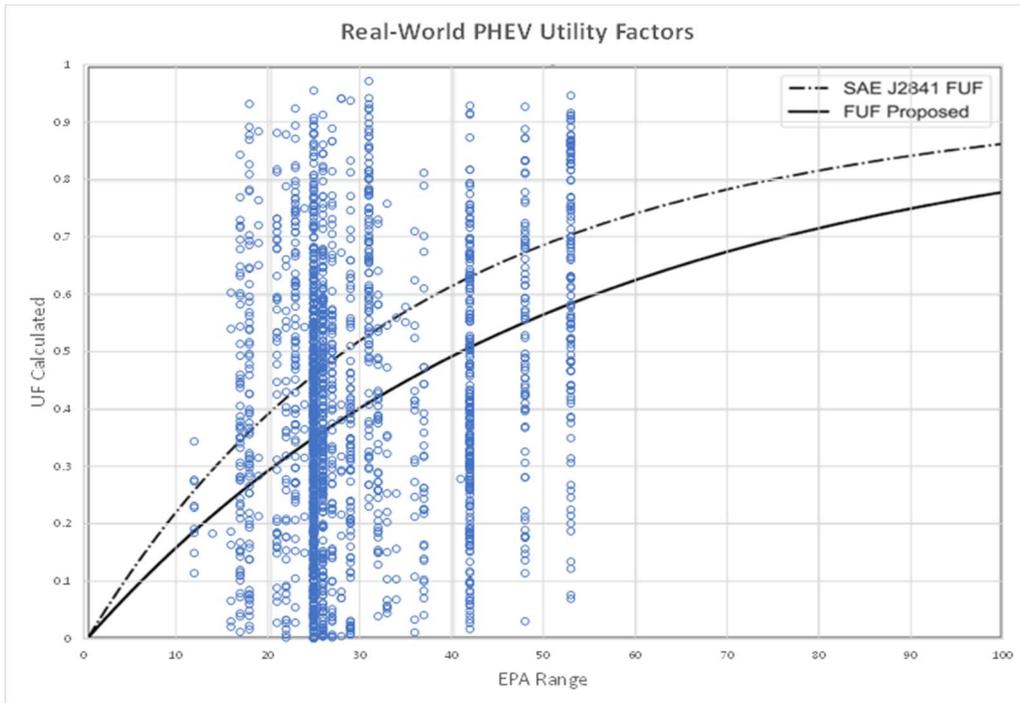


Figure 1. Calculated real-world PHEV utility factors for all vehicle models in the data set compared to the SAE J2841 FUF and the proposed FUF. Values are displayed as a function of EPA range irrespective of vehicle model and model year (e.g., EPA CD range of 31 encompasses two versions of the 2022 Hyundai Santa Fe and three model years of the BMW X5 XDrive45E). Note the wide variation in calculated utility factors compared to the two FUF curves for all EPA ranges.

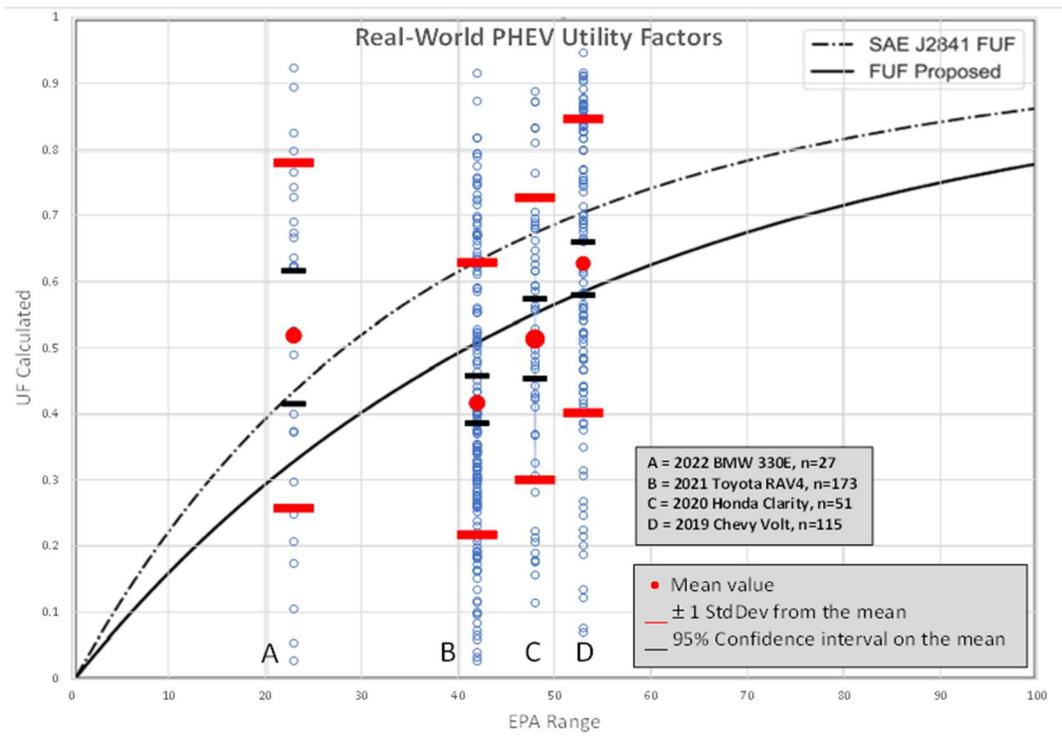


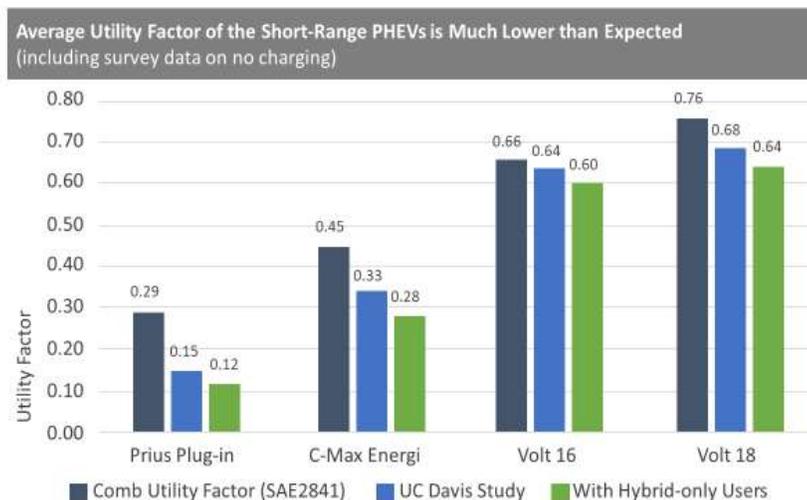
Figure 2. Statistics of calculated real-world utility factors for four selected PHEV models compared to SAE J2841 FUF and proposed FUF. Model variations (e.g., Volt and Volt Premier) do not exhibit significantly different utility factors, on average, and are combined in this figure. Model year is constant for each model to minimize potential year-to-year differences.

**There are better data sets that support EPA using SAE J2741 for now.** Regarding PHEVs not plugging in, there are many factors that impact plugging in and it is a complicated subject that needs more research.<sup>95</sup> This August 2020 paper<sup>96</sup> from UC Davis is one of the best analyses and uses data loggers from actual drivers and shows that PHEVs with longer AERs do not have a substantial issue with not plugging in (e.g., about 3-5 percent).<sup>97</sup> See Table 2 below. Also, there are many factors that could see this decrease in the future. We make the case above that better data in the future will allow a new rulemaking on the FUF issue.

**Table 2**

<u>For short range PHEVs</u>	<u>AER EPA label</u>	<u>Percent not plugging in</u>
Toyota Prius Gen 1	11 miles	17.6%
Ford Cmax and Ford Fusion	20 miles	12%
Audi e-tron	17 miles	9%
Toyota Prius Prime Gen 2	25 miles	9%
<u>For longer-range PHEVs</u>		
Chrysler Pacifica	33 miles	4%
Chevy Volt Gen 2-	53 miles	5%
Chevy Volt Gen 1-	38 miles	3%
Honda Clarity	48 miles	4%
<u>For very long-range PHEVs</u>		
BMW i3 rex	128 miles	no data
Karma Revero	60 miles	no data

## Real-World Range



# Volt – E-Miles vs. Gasoline Miles<sup>1</sup>

**PHEV Miles Driven in Charge-Sustaining Mode (Using Gasoline) or Charge-Depleting Mode (Using Battery)**

Note: There was only one Ford C-MAX Energi and one Fusion Energi used in this analysis

Vehicle Model	Total Miles Driven	Charge Depleting Miles	% of Total Miles Charge Depleting	Charge Sustaining Miles	% of Total Miles Charge Sustaining	Fuel Consumed (Gallons)
C-MAX Energi	15,414.0	6,155.9	40%	9,258.2	60%	197.4
Fusion Energi	18,721.1	12,685.1	68%	6,036.4	32%	142.5
Volt	309,878.2	258,127.3	83%	51,751.5	17%	1,508.0

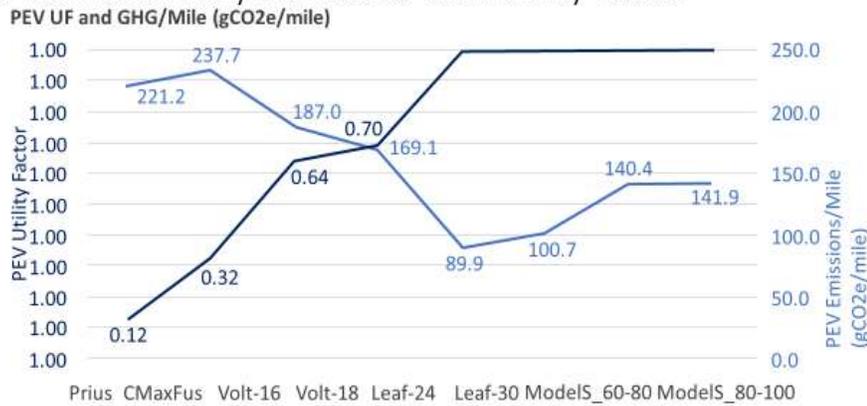
Electric Vehicle Driving, Charging, and Load Shape Analysis: A Deep Dive into Where, When, and How Much Salt River Project (SRP) Electric Vehicle Customers Charge. EPRI, Palo Alto, CA: 2018. 3002013754.

## Strong PHEV vs long-range BEV GHG emissions

CARB-funded research by UC Davis,<sup>98</sup> shows a PHEV 60 has the same life cycle GHG emissions as a Tesla model S because of the weight of the Tesla and it has fewer GHG life cycle emissions than a heavier BEV with 400- or 500-mile AER. See the first chart below. Toyota’s publicly available tool also correctly shows this result.<sup>99</sup> Furthermore, the UC Davis analysis does not include battery manufacturing GHG emissions. Using data from the USDOE cradle to grave analysis,<sup>100</sup> we estimate that adding 350 miles more of AER adds about 10 grams per mile of GHG emissions to the above analysis for a light duty EV. See the next three charts below. Further, a flex fuel vehicle requirement to enable low carbon fuels for these stronger PHEVs would further lower their life cycle GHG. Also see Appendix G for more on emissions from battery mining and manufacturing.

# BEV Households Have a Lower Average GHG Per Mile

But It's Not Directly Correlated with Utility Factor



# GHG Reductions of Strong PHEVs Compared to Large BEVs

Without Battery Manufacturing

Strong PHEV Coalition made a spreadsheet model to represent GHG emissions of BEVs and PHEVs, including considerations of:

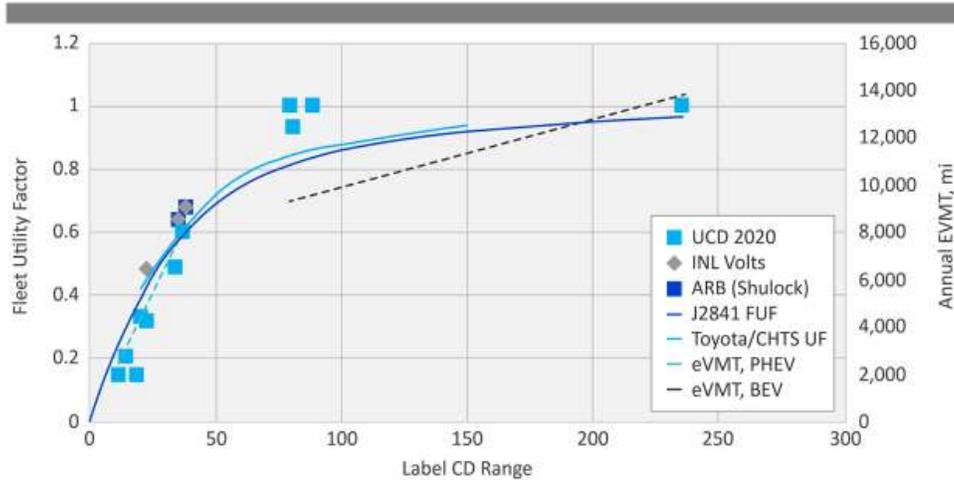
- Drivers' use of replacement ICEVs for trips of max range or greater
- Varying vehicle efficiency, grid emissions, etc.
- Operable XLS and references ([here](#))

**Strong PHEVs at ~50mi of R<sub>CD</sub> have similar GHG emissions as BEVs of ~150mi**



## PHEVs Can Match BEVs on GHGs

PHEVs with 60–150-mile AER can match the annual EVMT of BEVs; and their GHG emissions. Long-range PHEVs have UF between 0.8 and 0.95. Chart can be used as surrogate to show GHG emitted for BEVs and PHEVs



T.H. Bradley, et. al, Colorado State University

## Appendix C

**In this rulemaking, CARB should require PHEVs to have flex fuel vehicle (FFV) technology** so they can use E85, renewable gasoline, and other renewable fuels. PHEVs should be allowed post 2035 based on the logic in ACC II. As a result, California and section 177 states will need fueling stations and infrastructure for PHEVs long term and a signal today that these stations are needed. Unless new FFV models are available to consumers, the number of FFVs on the road in California will gradually decline, as will E85 sales. While gasoline stations will go extinct, we need E85 stations for PHEVs. Today, there are 500 stations in California that sell E85. Requiring FFVs for PHEVs will help bring FFVs and E-85 back and support the existing E85 stations in CA and other ZEV states. In addition, the cost of E85 today is about \$2 to \$2.50 less than gasoline and has substantial GHG benefits and some benefits for other air pollutants.<sup>101</sup> Making PHEVs an FFV increases their overall environmental benefit as many PHEVs will use E85. Finally, today FFVs are not priced more than non-FFVs, and GM says they cost \$70 more.<sup>102</sup> In addition, we understand the slightly poorer fuel economy of E85 makes a very small impact on the substantial GHG benefits of E85 compared to gasoline.

We believe there is enough feedstock to support a FFV requirement for long range or very long-range PHEVs, but welcome new studies to verify this. Some biomass feedstocks used in gasoline can't or won't be used in diesel or jet fuel powered transportation. This should result in large amounts of unused feedstocks because biomass feedstocks for spark-ignited engines may not be needed in the long run (e.g., 2050) for transportation or industrial uses. CARB staff should also use data from the many low carbon liquid biofuels that can be blended with gasoline and are certified in the Low Carbon Fuel Standard on a well-to-wheels basis.

## Appendix D

**We recommend that CARB should consider adding a small bonus credit in the Drive Forward light duty Vehicle regulation for vehicles that have on-board AC bidirectional chargers or are integrated with multiple DC off-board chargers.** Alternatively, at minimum, CARB should conduct an analysis on how it can advance bi-directional charging in the future. *Justification:* The promise of bi-directional charging (AC or DC) to address air pollution, GHG and electric grid issues is very significant with BEVs and PHEVs in light-, medium- and heavy-duty vehicles, or off-road equipment. For example, a recent May 2022 presentation by the World Resources Institute using Bloomberg NEF and Energy Information Administration data found the power capacity in 2030 for EVs to be 10 to 20 times more than the 2030 power capacity of stationary storage.<sup>103</sup> CARB can and should play a role in helping to unlock this potential.

- For example, the internal combustion engine in a PHEV has a much lower emission signature than a stand-alone, backup generator. A PHEV backup generator function can be extremely valuable in emergency response scenarios or with increasing grid failures.
- Bidirectional charging, like battery stationary energy storage, can reduce GHG and traditional pollutants from fossil fueled power plants by shifting electricity use to renewable energy in the cleanest hours of the day and reducing the need for high-emitting plants (such as traditional peaker power plants).
- Bidirectional charging can also provide many types of grid services including ancillary services, providing resource adequacy, and helping with the evening transition from renewables to other generation resources. Because the batteries are already paid for by car and truck owners, utilities can gain a low-cost resource compared to battery stationary storage.
- The potential value is significant and can contribute to lower operating costs for BEVs and PHEVs.<sup>104</sup>

While we understand the desire by CARB to simplify the regulation and reduce the use of bonus multiplier credits, we believe a small bonus credit in the final regulation for a few years is justified and needed to unlock this technology because of the large emission reduction benefits and other benefits enabled by bidirectional charging.

## Appendix E

### ***Recommendations on the ZEV Assurance Portion of This Rulemaking***

We support your proposal on November 2023 workshop slides 46-47 regarding consumer-facing vehicle labels but request that GHG emissions from battery mining and battery manufacturing be included as part of well to wheels GHG emissions in the California environmental performance label using best available estimates. As shown in Appendix G to our letter, these emissions are very significant for a battery EV and can equal the GHG from gasoline miles in a Strong, long-range PHEV (e.g. with 0-30 percent of total miles on gasoline). Further, due to this reason, there is a big difference in GHG emissions a battery EV with 150 miles vs 600 miles of range, and consumers should know about this. Education is critical today and we urge CARB to assume this role. See additional recommendations regarding the label below.

Additional ZEV assurance measures are needed such as those on November 2023 workshop slide 47. We are very pleased that you are considering more ZEV assurance measures and would like to recommend several more assurance measures to help accelerate adoption of BEVs and PHEVs.

1. We recommend a window sticker for all cars and trucks (ICEVs, HEVs, BEVs, PHEVs, FCEVs) that shows bar from 0 to 700 grams per mile and where the vehicle for sale falls on that bar. At minimum the calculation for each model sold should show well to wheel GHG including California average powerplant emissions. Ideally the calculation should include battery mining and manufacturing emissions and asterisk that shows the number if solar power or 100% green electricity is used. This approach will begin to educate consumers on the advantage of smaller and/or more efficient vehicles, the use of batteries with fewer emissions, and the benefits of 100% green electricity.
2. We recommend adding an additional window label for BEVs and PHEVs to help the consumer understand:
  - a. The type of battery (where CARB comes up with shorthand names of each chemistry)
  - b. The size of the battery (kWh)
  - c. Battery passport and recycled content information
  - d. How to access battery state of health information required by ACC II (section 1962.6)
  - e. Improved driving range information (including gasoline miles) for both city and highway driving and other major factors that impact range (e.g. HVAC, payload)
  - f. The type of charging the vehicle can do (e.g. level 1, level 2, DCFC) including range of kW levels
  - g. How quickly the vehicle can charge at different charging levels that is more sophisticated than the current federal window label or the proposal from the June workshop (e.g., level 1, low-power level 2, high power level 2, and different levels of DC fast charging).
  - h. If the vehicle can do bidirectional charging: vehicle to load, vehicle to home, or vehicle to grid
  - i. If the vehicle is a flex fuel vehicle (e.g., capable of using low-carbon E85).
  - j. A QR code on window glass or window label, similar to the QR code found on the Federal window sticker, be provided so the consumer can obtain more detailed information on the above and potentially more detailed information on other subjects (e.g. the vehicle's connectors, battery warranty, results from conformance tests, details on potential savings by using electricity, vehicle range under different conditions, battery passport, recycled content, bi-directional charging ability, charging speed options, etc).
3. We recommend CARB create a website that has the same information as above in #1 and #2 because window stickers are not used enough and are temporary. *Justification:* Moving from early adopters to mainstream and late adopters will require more education on basic information. A website URL is also needed in order to reach a broader audience who can't or won't use QR codes. In addition, media attention has resulted in consumers needing to be more informed about basic battery information. Ideally well-educated consumers can push the market for BEVs and PHEVs to batteries with less environmental impact.
4. We recommend CARB require automakers to provide several reminders or displays on dashboard of PHEVs and BEVs to improve the consumer experience.

- a. CARB should require a graphic, voice, or word reminder from the dashboard to plug in the vehicle when they park (for PHEVs and BEVs). In other words, it would be similar to the seat belt reminder or window is down reminder, but at the end of a journey. This requirement will be especially helpful for second and third owners of a PHEV or BEV. As someone who has forgotten to plug in a BEV and a PHEV, this reminder will be helpful. In general, we support more education on the issue of plugging in from the vehicle's human-vehicle interface.
  - b. CARB should require diagnostic trouble codes on the vehicle's screen or dashboard. The basic idea is to reduce the perceived and/or real risk of buying either a new or used BEVs and PHEVs, as well as reduce the hassle/cost of maintaining BEVs/PHEVs. ICE vehicles have an On-Board Diagnostics (OBD-2) port. The owner can obtain the code and look up the cause. Having trouble codes and battery condition available on the vehicle's screen or dashboard would build confidence, especially for those buying a used BEV or PHEV. In case the display is non-functional, it would be a good idea to also have the DTCs available through an OBD2 port or USB-C port for PHEVs or some other common port for BEVs. Over the years, there have been "Right to Repair" concerns with ever more sophisticated cars. The auto manufacturers have made it very difficult to diagnose the vehicle. Owners may feel forced to have their cars repaired only at the dealer or by the manufacturer. Enabling independent shops or vehicle owners to diagnose and repair EVs would real help consumers. If CARB requires this, more independent repair shops will be capable of repairing BEVs and PHEVs. This should reduce repair costs, increase convenience, reduce perceived "risk" of owning both new and used BEVs and PHEVs. Given that the used car market is about 2.5 times the size of new car market, our proposal would eventually help the millions of 2<sup>nd</sup> and 3<sup>rd</sup> owners and many low- and moderate-income buyers/owners.
  - c. Further, CARB should consider requiring automakers and charging providers to use the new standard error codes developed by the Charge X consortium.
5. We recommend CARB require a sticker on the inside of charge port door for BEVs and PHEVs, and on the inside of the gasoline port door too. As stated above, the reason for our recommendation is basic education of the consumer to explain that PHEVs are dual fuel vehicles which can run on either electricity or a second fuel (e.g., gasoline or hydrogen or perhaps another fuel). The sticker on the charge port door would identify the different charging levels and types the vehicle is capable of and contain a QR code and website to obtain all the other information mentioned above. This approach would further reinforce our similar recommendations for window labels and dashboard communications. CARB should hold a workshop on this and potentially other ZEV assurance measures.

We also recommend that, in order to have more data on PHEVs using gasoline and electric miles, CARB require automakers to provide more data than CARB receives from the Bureau of Automotive Repair (e.g., data from new PHEVs). Alternatively, this requirement could be only for automakers who do not make and sell PHEV with an AER of 90 or more miles. In other words, make this an incentive to encourage PHEVs with an AER of 90 or more.

We recommend that CARB should in this rulemaking, like the European Union, require automakers to have battery passports (digital battery identifier). We recommend that CARB work with the federal government to include in the battery passport battery sourcing information needed to comply with

the Internal Revenue Service 30 D tax credit but have this sourcing data apply to all batteries in ACC II. Further, batteries should have a unique digital identifier accessible via QR code that includes data on as much information as possible (e.g., battery chemistry, recycled and PFAS content, manufacturing history and origin of each battery's materials, battery state of health, environmental analysis, and safe handling and end-of-life management).<sup>105</sup> The list can be refined or expanded in later rulemakings. This data will not only help consumers but also is needed for reuse, repurposing and recycling. This approach is consistent with the European Union's Battery law which includes a battery passport, and CARB potentially could reference this law.

Other possible assurance measures that could help EV adoption:

- Adopt safety standards for adapters used for charging. The concern is that unsafe adapters are flooding the market
- Standardize the charge port location on BEVs and PHEVs in order to improve the public charging experience, and
- Adopt standards for charging to require a longer authentication window to avoid the driver having to restart the process to initiate a charge (e.g. longer than the sixty seconds typical today).

## Appendix F

### Recommendations on conformance testing

Regarding slides 55 and 56 in the June 2024 workshop:

- We support the new testing method
- We support the proposed AC and DC charge rate metric but are also supportive of alternative metrics such as time needed for 50 miles of range.

We support staff's proposal in the November 2023 workshop slides 43-45 regarding CARB doing conformance testing on EV-EVSE performance of communications using SAE 1772, ISO-15118-2, ISO-15118-20, and DIN 70121, but respectfully request that you also look into end-to-end conformance testing of communications for level 1, level 2 and DC fast charging from the EV to the grid. It is important to recognize that almost all light-duty OEMs will be transitioning to the SAE 3400 connector (formerly Tesla connector) The Tesla connectors have their own communications protocol, similar to ISO 15118.20. Conformance testing should also include the J3400 connector as well. These standards should be required to communicate with the grid in one-way charging and problems may occur in de-encryption, translation to another communications protocol and re-encryption in order to communicate with the grid. We also recommend CARB hold a workshop to see if other standards should be included for testing (e.g., safety standards, cybersecurity, etc.).

Further we respectfully request that CARB identify whether or not a vehicle is capable of bi-directional charging, and if so, conduct conformance testing of bi-directional charging for DC fast charging as well as AC charging and compliance with specific communication protocols. For AC charging, that means testing SAE J3072 for EV to EVSE and other standards from the EVSE to grid. As bi-directional charging emerges, assurance, and identification of the appropriate standard(s) involved will become increasingly important to the consumer. See Appendix A.

In addition, we respectfully request that CARB conduct conformance testing to determine if BEVs and PHEVs can charge as fast as claimed by the vehicle manufacturer for both level 2 and DCFC. Not all cars can charge as fast as claimed by the vehicle manufacturer, and having an independent test would be valuable (e.g., charging speed is influenced by temperature, typically decreases over time, etc.). It has not been uncommon that vehicles capable of charging at higher rates (both L2 and DCFC) are unable to do so. This may be because software is throttling the power to the L2 or the DCFC, or there is/are other software issues between the device and the vehicle.

## Appendix G

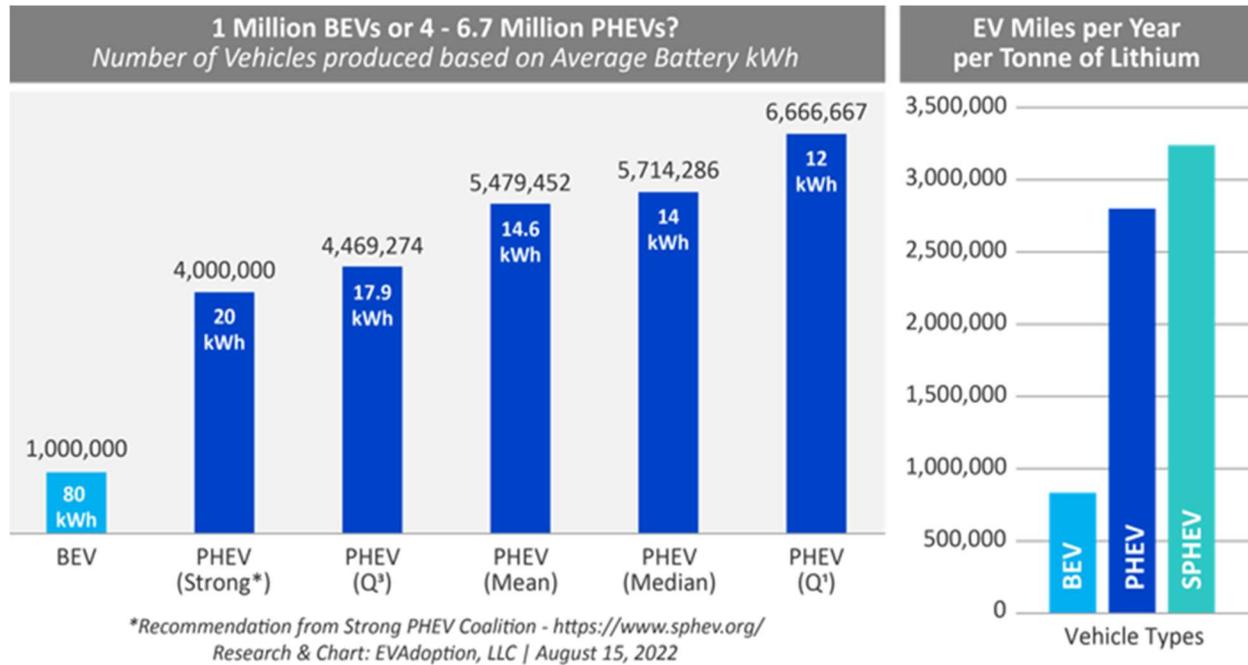
**Emissions from battery mining and manufacturing:** The Drive Forward Light duty Vehicle regulation needs to consider issues that traditionally have not received enough attention in order to avoid unintended consequences. Specifically, concerns regarding supply of critical minerals, supply chain ramp-up and the GHG and other emissions from mining and battery manufacturing need to factor into policy making. While PHEVs have gasoline miles, they have substantial benefits regarding these issues which essentially mitigate the GHG from the gasoline miles (including refinery emissions) and reduce reliance on critical minerals – especially from outside the US. This is especially true for PHEV 60s, 90s and 120s. Using regulatory incentives in this rulemaking to encourage automakers to make PHEV 60s, 90s and 120s is a small no-regrets action that should be adopted in this rulemaking.

CARB needs to take the issue of mineral for batteries much more seriously including environmental impacts, supply chain impacts, vulnerabilities due to disruption. While it may be too hard to design a regulation based on well-to-wheel impacts, these factors should be considered in design of the PHEV part of the Drive Forward regulation. We believe it is possible to include this issue without making these emissions part of BEV and fuel cell EV parts of the regulation. For example, the percentage cap on the number of PHEVs an automaker can make could be different for a PHEV 50, 70, 90, 110, 130, 150 and so on.

CARB should work with the UC Davis, Argonne National Lab<sup>106</sup> and European researchers that presented at the 2025 UC Davis conference at Asilomar as was as other experts such as the University of Michigan, Massachusetts Institute of Technology, Yale University, McKinsey and Company and the International Energy Agency to study this issue in order to determine how many years worth of driving a each type of long-range PHEV can save in GHG emissions from battery mining and manufacturing compared to a long range BEV. It appears to be about one or one and half years of benefit which is significant because it offsets the very low amount of gasoline used in a long range PHEV using E85. (see Appendix B and C.) Recently the University of Michigan has published a study on this topic.<sup>107</sup> and the Massachusetts Institute of Technology,<sup>108</sup> Yale University,<sup>109</sup> USEPA<sup>110</sup> and McKinsey & Company<sup>111</sup> have also researched it. To give an example, the chart below shows an International Energy Agency analysis on well-to-wheel GHG of conventional vehicles, hybrid EVs, PHEVs, BEVs and fuel cell EVs that is close to a cradle-to-grave analysis as it includes mining, battery manufacturing and refinery emissions and shows very favorable results for long-range PHEVs compared to BEVs.

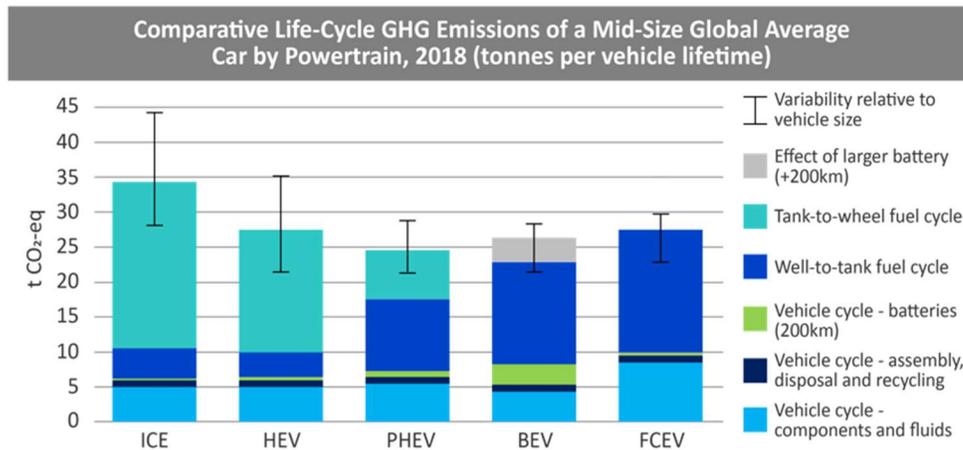
Because of this IEA analysis and the other studies, we do not believe that long-range, strong PHEVs come at the expense of BEVs, but support a more in-depth analysis by CARB, USEPA and the stakeholder community in order to determine how to treat long-range and very long-range PHEVs in

this rulemaking and also to design a window sticker (see Appendix E) that includes a bar from zero to 700 grams per mile GHG (cradle-to-grave) and the position on that bar for the vehicle being sold. Ideally, this research should include power plant, battery manufacturing, mining, oil extraction, and refinery emissions.



## GHG Reductions of Strong PHEVs Compared to Large BEVs With Battery Manufacturing

- Strong PHEVs (PHEVs with 35 mi range) are indistinguishable from BEVs in lifecycle GHG emissions
- Significant difference between BEV 100 and BEV 500 in GHG emissions



Source: IEA (2019), "Global EV Outlook 2019", IEA, Paris  
T.H. Bradley, et. al, Colorado State University

The chart above for light-duty PHEVs and BEVs shows the benefit of PHEVs in reducing the use of critical minerals and accounts for the difference in electric miles between BEVs and different types of PHEVs. Strong PHEV battery utilization maximizes the value of battery manufacturing and materials

capacities and helps address the need for fast scale up of battery manufacturing and mineral extraction by better utilizing resources. PHEV cars and trucks, especially, Strong PHEV cars and trucks, can electrify most daily commuting miles while occasionally using some gasoline, while BEVs have a lot of battery capacity that only gets "used" on very long trips. We assert that this could be considered wasted or underutilized lithium and other battery minerals. Thus, because PHEVs use their batteries more, the USA gets more EV miles per tonne of lithium by driving PHEVs and Strong PHEVs as shown in the chart above. PHEV's smaller batteries reduce the lifecycle environmental burdens associated with battery materials, production, and end-of-life.<sup>112</sup>

## Appendix H

**We recommend that CARB conduct an analysis and use different adoption curves for class 1, class 2a and class 2b/ 3 vehicles when designing the Drive Forward Light duty Vehicle regulation.**

*Justification:* As mentioned above, several market drivers are changing fast which will likely impact willingness to pay and interest in ZEV and PHEV adoption. We believe the staff review should examine future adoption rates by the various market segments (e.g., type and mass of vehicles, type of consumer), consumer's willingness to pay and reasons why some market segments might be lagging in adopting ZEVs and PHEVs. Reaching 100 percent sales of ZEVs and PHEVs will be hard for late adopters and other challenging market segments. Some examples of difficult market segments that need to be better understood in a future technology and progress review:

- The needs of frontline and other priority communities need to be better understood.
- The needs of approximately eight million vehicles in class 2a vehicles (about 27 percent of all vehicles in California) to be ZEVs or PHEVs as this market often has the most difficult use cases such as 4WD and towing.
- Many of those surveyed recently were not interested in purchasing a ZEV according to JD Power<sup>113</sup> and those who bought a ZEV and then returned to a traditional gasoline vehicle for their next car.<sup>114</sup>

The fleet utility factor issue needs be fully researched as we discuss above.

## Appendix I

**We recommend that CARB (likely with EPA, the DOE or the national labs) conduct a comparative analysis on PHEV and BEV costs** with a stakeholder input or working group). PHEVs can be made in a less costly manner than shown in most analyses. Technical maturity, engineering advances, supply chain issues, changes in mineral prices, war and scale-up issues are impacting the costs of BEV and PHEV up-front and operating costs. Today, costs are rapidly changing, especially for batteries. In addition, Argonne National Lab's recent report<sup>115</sup> shows that PHEVs are less expensive than BEVs for cars. Technical experts at the Strong PHEV coalition assert that several additional modifications can lower the cost of PHEVs that most analyses do not consider. We think this likely applies to plug-in hybrid cars and trucks but recognize that more analysis is needed.

**A common mistake we find in reports is not understanding the difference between a strong PHEV and other PHEVs because a strong PHEV can use the same batteries as a BEV which results in significant cost savings.** See the chart below.

## Cost of PHEVs, BEVs, & ICEVs

**PHEV Battery Costs are the same per kWh as BEV Battery Costs**, because they have the same Power to Energy Ratio as modern BEVs, and are scalable by kWh

**BEVs have a low battery P/E ratios**

- 2021 Tesla M3 SR+P/E = 3.9
- 2016 Leaf P/E = 3.6

**HEVs have a high battery P/E ratios**

- 2010 Prius P/E = 18

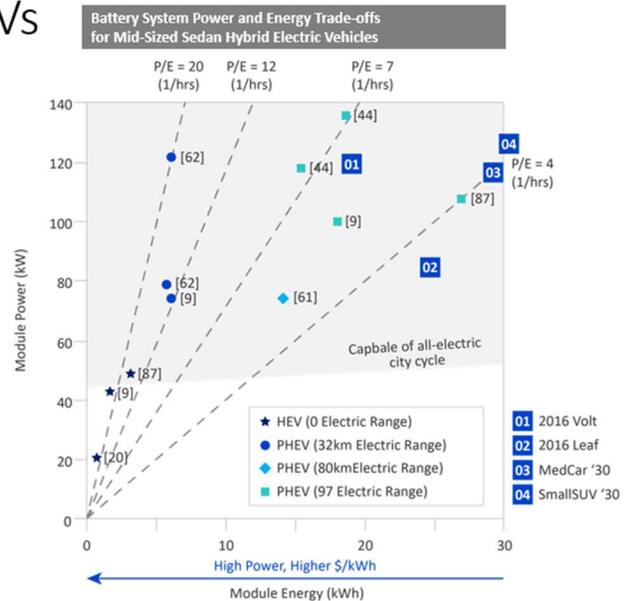
**PHEVs are in-between**

- 2016 Volt P/E = 6.6

**CARB ACCII PHEVs have BEV-like packs**

- CARB PHEV MedCar '30 P/E = 4
- CARB PHEV SmallSUV '30 P/E = 4.2

**Strong PHEV Batteries have the same P/E Ratio (and therefore chemistry, systems, and costs) as BEV batteries**



T.H. Bradley, et. al, Colorado State University

In order to show additional ways that costs can be reduced and that hard-to-reach markets are served, we respectfully request that CARB develop a scenario in this rulemaking that reduces the total costs. Specifically, this new scenario should include a modest number of PHEV cars and trucks as that will impact the cost analysis by reducing the cost of charging infrastructure, the amount of critical minerals and by using BEV batteries in strong PHEVs. This scenario could reduce the number of BEVs and FCEVs by a small amount (say 20 percent collectively) and be instead served by a mix of Strong PHEV cars and trucks and other PHEV cars and trucks. The PHEV battery costs should be based on using BEV batteries as explained in our prior letters to CARB. The use of away-from-home DC fast chargers should be modestly reduced, and the cost of the PHEV including total cost of ownership should be based on work by Argonne national lab for light-duty PHEVs.<sup>116</sup> Finally, bidirectional charging using DC off-board chargers should be assumed in our recommended alternative cost analysis for a reasonable percentage of BEVs and PHEVs in order to further reduce the total cost of ownership.

We applaud EPA for commissioning a tear down analysis of BEV costs and request that EPA or CARB conduct a similar tear-down analysis be done for a Strong PHEV. Most importantly, In any cost analysis, scenario or tear-down study for PHEVs, special PHEV batteries should not be used, but rather medium and long-range PHEVs should use less expensive BEV batteries and the benefits of PHEVs not needing as strong of chassis as BEVs should be included in the cost. These are the two largest cost savings with mid- to long-range PHEVs compared to BEVs

**We have not been able to validate CARB staff’s PHEV transmission costs and internal combustion engine vehicle “delete” costs in the 2022 ACC II and recommend further work in a technology and progress review by staff in two or three years.** CARB staff’s cost modeling in ACC II included an assessment of transmission removal costs, which serve to represent the cost saving/increment that accrues to advanced technology vehicles (PHEVs, BEVs, and FCEVs) relative to conventional ICEVs.

CARB’s estimates are based on 2017 NHTSA CAFE<sup>186,188</sup> and 2018 NHTSA<sup>187</sup> (references refer to the References section of CARB’s Appendix G). Notable is that the references 186 and 188 contains no transmission removal costs and are perhaps referenced in error or in lieu of other more authoritative sources. CARB assumes that PHEV transmission costs are the same as ICEV transmission costs, referencing primarily the NHTSA reference.<sup>187</sup> Islam (ANL) uses the same source for ICE transmission costs \$2483 as CARB (Reference 187), but finds that PHEV transmissions are \$793, ~\$1600 less expensive than is in the CARB model. Because the ANL modeling is treated as an authoritative reference throughout the CARB cost modeling document, we recommend that CARB adopt Islam’s (2021) same incremental cost of transmission removal for PHEVs. A plot from Islam, 2021 is included here for reference, highlights that PHEV transmissions (even for long range PHEVs) are lower cost than those of ICEVs.

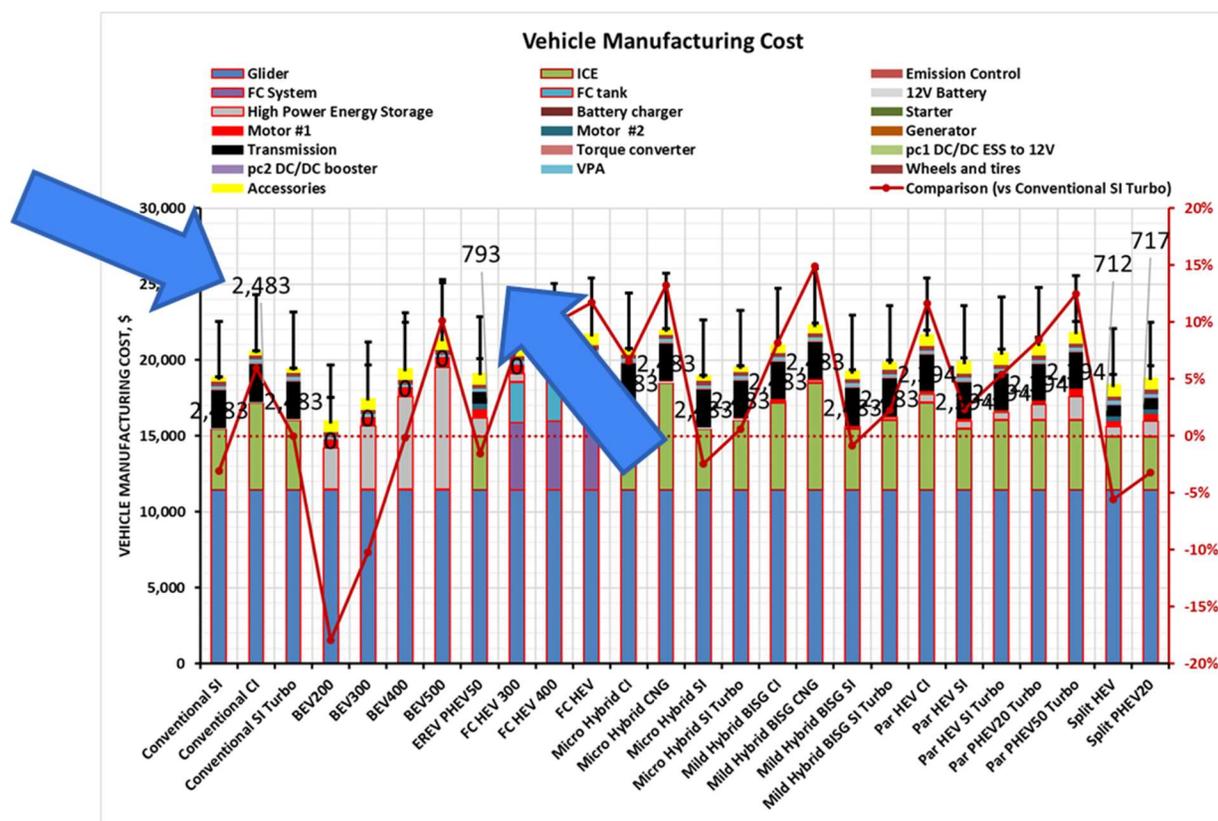


Figure 1. Transmission Manufacturing Costs modeling from Islam, et al., 2021

As transmission cost credits are the subject of considerable disagreement within the key references used by CARB, The Strong PHEV Coalition requests that a technology and progress review in two or three years that as part of its purview should seek to improve BEV and PHEV cost modeling.

CARB staff’s cost modeling in ACC II also includes a model of “assembly cost” for advanced vehicles. The result of this model of assembly cost as published is that BEVs are represented (in the costing worksheet) as having an assembly cost credit of \$1600, due to “less complex assembly process.” However, not many quantitative references for this benefit of EVs exist. McKinsey quantifies this benefit at \$600, long-term (for native EV design), without any reference to primary sources, datasets or other literature.<sup>117</sup> ICCT is the primary reference for this assembly cost credit in the CARB Appendix, but the ICCT report referenced uses “vehicle assembly” to represent the entirety of components and

process, scaled-up from a reference to the UBS report ***wherein this \$1600 value and ICEV values are not present*** (UBS, 2017).<sup>118</sup> In our assessment, there is some confusion in interpretation of the ICCT publication in that ICCT uses the term “vehicle assembly” to mean what the experts in this field have traditionally called “glider cost”. Further evidence is that the CARB cost model assumes that there is a \$1600 cost savings available in vehicle assembly process costs, when the total vehicle assembly costs are asserted to be \$2600 by the UBS report referenced. It is implausible that BEV’s “less complex assembly process” reduces processing/labor costs by 62 percent. In our opinion, without a more definitive reference for this \$1600 incremental benefit to BEVs (and FCEVs, which have even higher levels of advanced materials and precision assembled components), the Strong PHEV Coalition requests that a technology and progress review in two or three years seek to assess assembly cost credit issue we have identified along with other issues that we’ve identified above.

## Appendix J

***Summary of why PHEV cars and trucks are needed.*** We believe that regulations and incentives have not tried hard enough to encourage Strong plug-in hybrid cars and trucks, especially those that can achieve 80 percent to nearly 100 percent of their annual miles using electricity. We believe that Strong PHEV in combination with battery electric vehicles (BEVs) and fuel cell EVs (FCEVs) are better in the near- and long-term than a scenario with FCEVs and BEVs with no Strong PHEVs or other PHEVs.

Advantages of including Strong PHEV (and other PHEVs) in the rule include:

- A combined strategy (strong PHEVs + PHEVs + BEVs + fuel cell EVs) is a faster path for the world to adopt vehicles with zero greenhouse gasses<sup>119</sup> As mentioned above, the 27 million PHEVs and 91 million BEVs today in the world, illustrate this.
- Strong PHEV cars and trucks are a better solution (because they are dual fuel) to survive long-term catastrophes and daily emergencies (e.g., wildfires, earthquakes, windstorms, hurricanes, tsunamis, power outages, riots, vandalism, tornadoes, and floods) and can provide power export using the engine
- Strong PHEV cars and trucks are a better solution for personal EV drivers and commercial fleets that are renters and change residences or business locations relatively often
- Strong PHEV cars and trucks are a better solution for owners of used cars and trucks who are often low-income residents or are low-income independent contractors
- Strong PHEV cars and trucks have much less cost impact to the grid and have a lower demand charge part of their electricity bill and help mitigate scale-up concerns of building a network of away-from-home heavy-duty vehicle DC fast chargers and heavy-duty hydrogen infrastructure in a timely manner
- Drivers in rural areas often drive longer distances than others and in areas with little access to charging. As a result strong PHEV cars and trucks are a better option for the portion of the world that covers small and mid-size towns where trip distances (when needed) exceed those in urban megacity regions. Strong PHEVs are a better option in regions with extreme cold weather for the same reason
- Strong PHEV cars and trucks are particularly useful in cold weather regions and for fleets that need to tow trailers, boats and campers for work

- Strong PHEVs are attractive to drivers who are skeptical of or opposed to battery EVs or fuel cell EVs
- Strong PHEVs can equal the GHG reduction benefits of a comparable long-range BEV when battery manufacturing emissions and other factors are considered (See Appendices C and G) and thus are a long-term solution
- Strong PHEV cars and trucks use substantially less critical minerals (due to their smaller batteries compared to battery EVs), and thus reduce pressure on the need to rapidly scale supply chains for these minerals and hedge against supply chain disruptions<sup>120</sup>
- Strong PHEV cars and trucks compared to BEV cars and trucks can weigh less resulting in fleets not having to purchase larger BEVs (e.g., Class 4 instead of Class 3) in order to have the same payload
- Strong PHEV cars and trucks will have important long-term adopters globally regardless of their cost and many car and/or truck makers will want to serve this market
- Strong PHEV cars and trucks offer air quality benefits.

Note our May 31 2022 letter to CARB on Advanced Clean Cars II regulation goes into more detail on the above bullet points.

## Appendix K

**Table 3 - US available and proposed long range PHEVs (over 50-mile AER)<sup>121</sup>**

Make	Model	price	Est Mi AER on USEPA test cycle	launch year
BMW	X5 Range Extender			<b>2026</b>
Ford	F-250 Super Duty Range Extender			<b>2027-2028</b>
Genesis (owned by Hyundai)	GV70 EREV	About \$70,000		<b>2027</b>
Genesis (owned by Hyundai)	GV90 EREV			<b>2028</b>
Genesis (owned by Hyundai)	GV80 EREV	about 75,000		<b>2028</b>
Hyundai	Santa Fe PHEV	About \$55,000	<b>100</b>	<b>2027</b>
Hyundai	EREV pick-up truck			<b>2027</b>
Jeep	Grand Wagoneer 4xe REPB			<b>2026</b>
Jeep	Wagoneer 4xe REPB <sup>122</sup>			<b>2026</b>
Karma	Amaris <sup>123</sup>		<b>100</b>	<b>late 2026</b>
Karma	Revero <sup>124</sup>		<b>80</b>	<b>now</b>
Kia	EREV Sorrento or Telluride			<b>2027</b>

<b>Land Rover</b>	Range Rover <sup>125</sup>		51	<b>now</b>
<b>Land Rover</b>	Ranger Rover sport <sup>126</sup>		51	<b>now</b>
Mazda	Rotary Rex			<b>around 2028</b>
Mercedes	AMG E53 Wagon			<b>Late 2025</b>
Mercedes	GLC 350e PHEV <sup>127</sup>	\$72,000	54	<b>now</b>
Nissan	Rogue e-Power		<b>0</b>	<b>2027</b>
Nissan	Next gen XTerra EREV		<b>~75</b>	<b>2028</b>
Nissan	GT-R Sport <sup>128</sup>			<b>3 to 5 years</b>
Ram	1500 REV pick-up		<b>145</b>	<b>2026</b>
Ram	EREV SUV		<b>50</b>	<b>2028</b>
Scout (owned by VW)	Traveler Harvester		<b>150</b>	<b>2027</b>
Scout (owned by VW)	Terra pick-up Harvester		<b>150</b>	<b>2028</b>
Toyota	RAV4 Prime next gen <sup>129</sup>	\$33,350	52	<b>Spring 2026</b>
Volvo (part of Geely)	XC90 EREV			<b>2028</b>

<sup>1</sup> Global electric car sales, 2014-2024, *International Energy Agency*, <https://www.iea.org/data-and-statistics/charts/global-electric-car-sales-2014-2024>, accessed 2025-10-07. 2025 estimate based on Global EV sales over 9 million in first half of 2025, growing by 28%, Rho Motion, <https://rhomotion.com/news/global-ev-sales-up-28-in-2025-2/>, accessed 2025-10-07.

<sup>2</sup> For PHEVs with 50 to 59 mile all-electric range we found 19 PHEVs worldwide but only 3 in the US. For example, outside the US we found models such as Renault’s Rafale e-Tech, Mercedes GLE 400e and C3002, Land Rover’s Range Rover, Geely’s Galaxy L7 and A7 Emi, Chery’s Tiggo 8, Changan’s Nevo AO5 and CS 55plus, BYD’s Qin L DMi and Seal 05 DMi, BMW’s X5, 3 series 330e, and 5 series PHEV, and Audi’s A5, A6 and Q5

<sup>3</sup> See Slide 32 in the June 26 2024 workshop by CARB on amendments to ACC II.

<sup>4</sup> <https://www.forbes.com/sites/neilwinton/2025/10/26/plug-in-hybrids-a-practical-bridge-to-electrification-despite-critics/>

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<sup>9</sup> <https://insideevs.com/features/343231/heres-how-to-calculate-conflicting-ev-range-test-cycles-epa-wltp-nedc/>

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<sup>15</sup> <https://interestingengineering.com/transportation/chinas-new-extended-range-ev>

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- <sup>99</sup> [GitHub - khamza075/PVC: A software for assessing the efficacy of various vehicle powertrains at mitigation of greenhouse gas emissions](https://github.com/khamza075/PVC) . Also see <https://app.carghg.org/>
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- <sup>110</sup> See <https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-multi-pollutant-emissions-standards-model> published April 18, 2024. This rule package mentions the critical minerals issue over 190 times.
- <sup>111</sup> <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-race-to-decarbonize-electric-vehicle-batteries>
- <sup>112</sup> Two studies. 1) Dunn, J.B., Gaines, L., Kelly, J.C., Gallagher, K.G. (2016). Life cycle analysis summary for automotive lithium-ion battery production and recycling. In: *REWAS 2016: Towards Materials Resource Sustainability*, R.E. Kirchain, B. Blanpain, C. Meskers, E. Olivetti, D. Apelian, J. Howarter, A. Kvithyld, B. Mishra, N.R. Neelamegham, and J. Spangenberg, eds. (Springer) pp. 73-79, [https://doi.org/10.1007/978-3-319-48768-7\\_11](https://doi.org/10.1007/978-3-319-48768-7_11)
- <sup>113</sup> <https://www.newsweek.com/most-americans-wont-consider-buying-electric-car-jd-power-study-finds-1710444> and <https://www.thetruthaboutcars.com/2022/05/survey-suggests-americans-still-doubt-evs/>
- <sup>114</sup> For example, see <https://www.musclecarsandtrucks.com/50-of-ev-owners-are-switching-back-to-ice-vehicles-excluding-tesla/>
- <sup>115</sup> <https://www.anl.gov/argonne-scientific-publications/pub/167396>
- <sup>116</sup> Ibid
- <sup>117</sup> <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/making-electric-vehicles-profitable>
- <sup>118</sup> [https://theicct.org/sites/default/files/publications/EV\\_cost\\_2020\\_2030\\_20190401.pdf](https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf)
- <sup>119</sup> Long-range PHEV cars and trucks with 80-90 percent of annual miles electric and 10-20 percent existing miles on biofuels are likely a long-term solution.
- <sup>120</sup> For example, see <https://insideevs.com/news/589228/stellantis-plans-combat-battery-shortage-recession/>
- <sup>121</sup> <https://topelectricsuv.com/hybrid-trucks/range-extender-models-upcoming/>
- <sup>122</sup> <https://insideevs.com/news/775742/jeep-wagoneer-range-extender-announced/>
- <sup>123</sup> <https://www.caranddriver.com/news/a64234195/karma-amaris-plug-in-hybrid-coupe-revealed/>
- <sup>124</sup> <https://karmaautomotive.com/revero/>
- <sup>125</sup> <https://www.rangerover.com/en-us/range-rover/index.html>
- <sup>126</sup> Ibid
- <sup>127</sup> <https://www.autoblog.com/reviews/2025-mercedes-benz-glc-phev-review>
- <sup>128</sup> <https://www.theverge.com/news/653822/nissan-r36-gt-r-plug-in-hybrid>
- <sup>129</sup> <https://www.cars.com/articles/how-much-is-the-2026-toyota-rav4-518884/>