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Submitted Via Email: ryan.hart@arb.ca.gov

California Air Resources Board
Sustainable Transportation and Community Division
1001 I Street
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Re: Comments on Advanced Clean Cars (ACC) II Cost Modeling Workbook

CEERT, Center for Biological Diversity, Coalition for Clean Air, Consumer Reports, Earthjustice, EDF, NRDC, Sierra Club California, and UCS appreciate the opportunity to submit comments on the Air Resources Board's (ARB) Zero Emission Vehicle (ZEV) cost modeling workbook, released on July 14, 2021. The workbook follows a Public Workshop held on May 6, 2021 on the development of the Advanced Clean Cars (ACC) II program. It is critical that ARB develop a thorough and timely ZEV cost model that reflects the most recent cost estimates for ZEVs and their ICE counterparts. Indeed, ARB states that the workbook will be used "to generate CARB's draft Zero-Emission Vehicle (ZEV) incremental cost values that will potentially be used in the economic analysis of the Advanced Clean Cars II Regulation." We are concerned that the model is overly conservative in many areas, producing ZEV costs that are potentially thousands of dollars too high. These unduly high-cost estimates lead ARB to the conclusion that no ZEVs will reach cost parity with conventional vehicles by 2035 – a conclusion at odds with other respected studies that project battery electric vehicle (BEV) cost parity by 2024-2028, depending on vehicle size and range.[1] Volkswagen confirms the findings of a UBS teardown study that indicates Volkswagen has BEV models that may attain parity with today's combustion models in terms of costs and profit margins by 2025.[2] ARB's outlier conclusion may improperly undermine the ACC II rulemaking and slow market penetration.

Our organizations provide recommendations below for how ARB staff can improve the accuracy of the cost model in advance of the forthcoming proposed ACC II rulemaking to help ensure that the incremental cost of ZEVs is properly represented.

ARB must provide additional information

The workbook provides data inputs and outputs (e.g., battery size and cost per kW-hr), but does not provide rationale for the assumptions used to develop that data and methodology. The reviewer must essentially perform an original, ground-up analysis of each aspect of ZEV design and use to comment on the appropriateness of both the input values and the resultant costs. This applies to nearly every aspect of the cost estimation methodology, including the credits applied for the removal of internal combustion engine (ICE) components. We urge ARB staff to provide the public with an opportunity to review its rationale for the use of these data inputs before publication of the proposal.

BEV battery costs are too high

The BEV battery costs used in the model are too high and do not reflect the latest projections from recognized experts. The model's BEV battery costs start at $100 per kW-hr in 2026 and decrease to $63 per kW-hr in 2035. BloombergNEF's newest projections show much lower costs of $92 per kW-hr even earlier, in 2024, and $45 per kW-hr in 2035.[3] Use of these more recent battery costs significantly lowers BEV costs by $1,400-$2,900 in 2025 and $1,200-$2,600 in 2035. We urge ARB to update its BEV battery costs to account for more recent projections in this quickly changing field.

Cost model does not reflect all delete costs

Delete costs are a critical aspect of determining the overall cost of BEVs. We are concerned that ARB may be underestimating delete costs by several thousand dollars per vehicle. We ask ARB to publish a thorough rationale for all delete costs prior to the proposed rulemaking. At a minimum, we ask ARB to address these:

- *Engine and transmission delete costs*: ARB assigned engine plus transmission delete costs of $5,000 for all models of small and mid-sized cars and small SUVs and $7,000 for all versions of medium SUVs and pickups. These values appear to be much lower than those estimated by other experts. For example, the International Council on Clean Transportation (ICCT) estimates average engine, transmission and emission control costs for all vehicles between $7,500-$11,500.[4] The cost model also does not appear to reflect an appropriate relationship between ICE vehicle horsepower and engine cost. This is especially problematic when considering premium vehicles. The model should include an increase in costs for premium ICE vehicles, as it does for premium BEV models. We urge ARB to update the cost estimates to reflect the most recent data and assign a delete cost for premium ICE vehicles.
- *Emission standards delete costs*: ARB includes modest delete costs for future emission standards but makes no mention of delete costs related to current emission controls. The model should include the delete costs of complying with the current LEV III greenhouse gas (GHG) standards and exhaust aftertreatment to meet current criteria pollutant standards. The cost of current GHG and criteria emission controls should be estimated for each vehicle segment addressed in the ARB cost model (e.g., premium, towing).
- *Towing delete costs*: ARB assumes a significant cost increase to a BEV vehicle to account for the increase in battery capacity for towing but ignores any effect of towing

capability on ICE vehicle costs, including a larger engine, a transmission designed for greater loads, cooling requirements and enhanced brakes. A brief search shows that this feature costs at least $500-$1,000 without a larger engine and better brakes.[5] The model should account for these additional costs to ICE vehicles capable of towing.

- *All-wheel drive delete costs*: The model does not appear to include delete costs associated with all-wheel drive (AWD). Manufacturers currently charge several thousand dollars more for AWD and 4WD ICE vehicles than their 2WD counterparts. A brief search of the sticker cost of AWD for Ford vehicles, for example, is at least $2,000.[6] The ZEV cost model increases the cost of a ZEV with AWD capability by $1,000-$1,400 (direct manufacturing cost) and should similarly account for the additional cost of AWD in ICE vehicles.

Assumptions on energy efficiency improvements should be examined

Automakers have a large incentive to improve the energy efficiency of their EV products, as doing so allows for a reduced battery capacity size to achieve a given range. The default assumptions used in ARB's model however, reflects a very marginal, 0.5% annual improvement rate over a period of ten years. A recent study evaluating the potential for energy efficiency of electric vehicles found improvements of 15-20% are possible using a variety of optimization techniques.[7] Other researchers found that the "large variability in the energy consumption of passenger cars with a similar mass suggests there is scope for further efficiency improvements, e.g., through purpose design, wheel-hub motors, improved energy recuperation, decreased coasting resistance, and the application of light-weight chassis components."[8] Evaluation of EV efficiency improvements over time show that Tesla has improved at a rate of 3% *annually* over the past decade, while other automakers like Nissan have achieved even higher rates of improvement.[9] We ask ARB to re-examine its default assumptions.

Cost model should account for indirect costs

The costs presented in ARB's model only describe direct manufacturing costs. To better represent the true cost of a ZEV, ARB must account for indirect costs. The ICCT study cited above projects indirect costs to be significantly lower for BEVs than ICE vehicles.[10] BEV manufacturers are expected to purchase electric motors, inverters, and batteries in ready-to-install condition. The direct manufacturing costs of these components already include many of the indirect costs currently being assigned to vehicle manufacturers. Indeed, battery costs being projected for the future include full costing (including warranties) and little indirect cost for the auto manufacturer purchasing or utilizing them. These readymade components will eliminate much of the overhead associated with auto manufacturing today, including powertrain calibration and emission certification. Due to the longevity of these electric components, warranty costs at the automaker level will also decrease. Battery packs are provided in such a complete state that there should be almost no indirect costs associated with them. We ask ARB to provide its methodology for estimating these costs for public comment prior to the regulatory proposal.

Cost model should include lower vehicle range BEVs

The minimum BEV range considered in the cost model is 300 miles. This is above the range of some of today's popular BEVs, which have been shown to provide their owners with sufficient range. A recent analysis, based on data loggers, found current longer-range BEVs (above 200-mile range but below 400 miles) have average annual miles higher than gasoline vehicles.[11] In

other words, longer range BEVs are not necessary to match the driving patterns of current ICE vehicles, especially as charging speeds increase and infrastructure becomes ubiquitous.

While there will undoubtedly be 400-mile range BEVs on the market in the future, it is unclear if they will be the "average" BEV range. Assuming such a high average range is likely artificially inflating the overall BEV costs. In a recent evaluation of BEV costs, the National Academy of Sciences included ranges of 150-300 miles and recommended against "over-crediting" higher range, warning that it will increase cost and could slow down market penetration.[12] We ask ARB to consider including more BEV ranges in the analysis, including:

- Base - 250 miles
- Mainstream - 300 miles
- Premium - 400 miles

This is likely to better reflect the market choices made by consumers. At the low end many consumers may want affordable and reliable transportation for their daily driving, while others are likely to be willing to pay a premium for more range. At 250 miles a typical BEV driver with a place to charge at home overnight will only require an average of 6 public charging sessions a year compared to over 40 stops at the gas station for a similar ICE vehicle, resulting in a similar level of time spent fueling annually. Moving to 300 miles reduces the number of charging stops required per year by 2 but increases battery cost by 20%.[13] We urge ARB to consider lower range BEVs in the cost model to better represent customer preference and overall BEV costs.

Towing assumptions must be reexamined

ARB has developed specific costs for medium/large SUV and pickup BEVs capable of towing. ARB has not disclosed what level of towing this entails (e.g., total weight, hitch weight, etc.), or how it determined the fraction of vehicle sales that have this towing capacity. We are concerned that the towing assumptions used in the cost model are driving up the overall costs of BEVs.[14]

The cost model increases battery capacity of the premium medium SUVs by 54% and that of the high towing pickups by 70% to maintain vehicle range while towing. For the base SUVs and pickups, the increase in battery size exceeds 100%. ARB is projecting that these SUVs will be designed to provide 400 miles of range even while towing a trailer. When these BEVs are not towing a large load most of the time, they will then have a range of 600-700 miles, likely far greater than customer preference or need.[15]

ARB's workshop presentation shows that 25% of medium SUVs will have this 400-mile range towing capability without offering a rationale for this assumption. Given that these increases in battery capacity will cost many thousands of dollars, we believe this estimate is too high. If ARB designed the model to require a 400-mile range for these vehicles because of current ICE driving habits, ARB should consider the fact that some consumers may currently purchase ICE vehicle towing packages and not use them because they can get the extra power and the possibility of towing for a moderate cost. But when faced with paying thousands of dollars more for a towing package on a BEV, many consumers may decide against it or find a lower range for towing sufficient. We urge ARB to conduct a thorough analysis examining the demand for such towing capabilities on BEVs.

Conclusion

The concerns that we have outlined above have a very substantial impact on the estimated cost of electrification, potentially increasing the projected cost of a non-towing BEV by $5,000-$11,000, and a BEV with towing capacity by another $4,000-$6,000. It is impossible to project the fleetwide impact of these concerns as ARB has not provided the mix of base, premium, cold temperature, AWD and towing vehicle sales. Taking the available mix of sales for medium/large SUVs as indicative, in the 2035 timeframe, addressing our concerns could reduce the estimated cost of a BEV by:

- $1,200 to $2,600 due to more up-to-date battery cost estimates;
- $3,000 to $6,000+ due to more accurate ICE powertrain and emission control delete costs;
- $1,000 to $2,000 in lower battery cost by assuming a lower, 300-mile average BEV range for non-towing vehicles (using a lower estimated cost of the battery); and
- $4,000 to $6,000 in towing packages by reducing the extra amount of battery ARB assumed.

We strongly urge ARB to update the cost model in advance of the forthcoming proposed ACC II rulemaking to help ensure that the incremental cost of ZEVs is properly represented.

Respectfully submitted,

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[1] Nic Lutsey and Michael Nicholas (April 2019). Update on Electric Vehicle Costs in the United States through 2030, *The International Council on Clean Transportation*. See https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost; Goldman School of Public Policy (April 2021). 2035 Report: Plummeting costs and dramatic improvements in batteries can accelerate our clean transportation future, *UC Berkeley*.

http://www.2035report.com/transportation/wp-content/uploads/2020/05/2035Report2.0-1.pdf?utm_referrer=https%3A%2F%2Fwww.2035report.com%2F; National Academies of Sciences, Engineering, and Medicine 2021. Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025-2035. *The National Academies Press*. https://doi.org/10.17226/26092.

[2] https://www.volkswagenag.com/en/news/stories/2021/03/ubs-study.html

[3] BloombergNEF (May 2021). Hitting the EV Inflection Point – Electric vehicle price parity and phasing out combustion vehicle sales in Europe, *Transport and Environment*. https://www.transportenvironment.org/sites/te/files/publications/2021_05_05_Electric_vehicle_price_parity_and_adoption_in_Europe_Final.pdf.

[4] Nic Lutsey, Michael Nicholas (March 2019). Electric Vehicle Costs and Consumer Benefits in Colorado in the 2020-2030 Time Frame, *ICCT*. Figures 2 and 3. https://theicct.org/sites/default/files/publications/ev_Colorado_cost_2020_20190613.pdf.

[5] See www.ford.com, pricing for Explorer and F-150. More powerful brakes required the addition of several other "packages".

[6] See www.ford.com, pricing for Escape and Explorer.

[7] Pareek, D. 2019. *Performance & Efficiency Improvement of Electric Vehicle Power Train*, SAE Technical Paper 2019-28-2483. https://doi.org/10.4271/2019-28-2483

[8] Weiss, M., Cloos, K.C. & Helmers, E. 2020. Energy efficiency trade-offs in small to large electric vehicles. *Environ Sci Eur* 32, 46. https://doi.org/10.1186/s12302-020-00307-8

[9] See https://electrek.co/2019/11/18/tesla-efficiency-increasing-3-year/.

[10] Nic Lutsey, Michael Nicholas (March 2019). Electric Vehicle Costs and Consumer Benefits in Colorado in the 2020-2030 Time Frame, *ICCT*. Figures 2 and 3. https://theicct.org/sites/default/files/publications/ev_Colorado_cost_2020_20190613.pdf

[11] UC Davis, Institute of Transportation Studies (2020). Advanced Plug-in Electric Vehicle Travel and Charging Behavior Final Report, prepared for California Air Resources Board. https://csiflabs.cs.ucdavis.edu/~cjnitta/pubs/2020_03.pdf See also https://its.ucdavis.edu/blog-post/no-electric-vehicles-arent-driven-less-than-gas-cars/

[12] National Academies of Sciences, Engineering, and Medicine 2021. Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025-2035. *The National Academies Press*. https://doi.org/10.17226/26092.

[13] Chris Harto (2020). *Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers*, Consumer Reports. https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

[14] We limit our comments to the cost of premium BEVs with towing, as ARB's workshop presentation indicated that all SUV towing packages fell into the premium category.

[15] This range was determined by dividing the total battery capacity of medium/large SUVs and pickups with ARB's towing package by the electricity consumption per mile for these vehicles provided in the spreadsheet model.