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California Air Resources Board
1001 I Street
Sacramento, CA 95814

Attn: Renee Littaua, Staff Air Pollution Specialist

Allison Transmission, Inc. ("Allison") is pleased to comment on the Draft Technology Assessment: Medium- and Heavy-Duty Battery Electric Trucks and Buses. By way of introduction, Allison is the world's largest manufacturer of fully automatic transmissions for medium- and heavy-duty commercial vehicles and is a leader in hybrid propulsion systems for city buses. With a market presence in more than 80 countries, Allison's products are specified by over 250 of the world's leading vehicle manufacturers and are used in a variety of applications including refuse, construction, fire, pick-up and delivery, distribution, bus, motorhomes, defense and energy. Allison, headquartered in Indianapolis, Indiana, has over 1,400 dealer and distributor locations worldwide.

Having sold over 6700 hybrid systems for urban transit buses, Allison has become familiar with the heavy-duty vehicle and electric propulsion requirements. While Allison does not currently offer a battery electric powertrain system, Allison has been investigating the component, vehicle, and infrastructure requirements pertaining to such a system. It is in that spirit that these comments are presented.

1) Component costs

On page V-5 and V-6 the draft report states: "Figure V-3 estimates component costs for a generic BEV truck, with the basic component costs including the battery at $180,000 in 2012, decreasing to $90,000 by 2020 and to approximately $55,000 in 2030.[8]" Footnote 8 states "[8] Table IV-2 is specific to drayage trucks, while this figure reflects anticipated costs for a generic BEV. This is the reason for the observed differences between the Table IV-2 and Figure IV-3."

It would be interesting to understand the volumes and classes of vehicles used to create Figure V-3. Allison does not expect to see a difference in battery electric component costs for drayage trucks compared to other trucks of similar size. This expectation for similar costs is driven by the concept that drayage trucks and similar size trucks (*e.g.* Class 6/7/8 Pickup and Delivery trucks) will use the same battery electric components. Even though drayage trucks have a much higher GCW, they also have lower top speed. The result is similar power and energy requirements compared to large trucks of similar size (regardless of the overall mechanical drive ratio). Based on this perspective and Allison's knowledge and forecasts, Allison believes the drayage truck component costs are realistic and should be applicable to large trucks.

2) Maintenance costs

On page ES-5 the draft report states: "BEVs are expected to cost less to maintain than conventional trucks." Also on page V-6 the draft report states: "BEVs have reduced operating and maintenance (O&M) costs," and on page V-7: "CalHEAT's Report on BEV Parcel Delivery Trucks for the CEC issued in 2013 estimated that vehicle maintenance savings of Class 4 to 5 BEV parcel delivery trucks can be on the order of three to 10 cents per mile driven (CalHEAT, 2013b) when compared to conventionally fueled counterparts, which typically have maintenance costs of 12 to 15 cents per mile driven (a reduction of 20-80 percent). Greater maintenance savings would be expected for heavier trucks and buses."

Allison suggests that more real-world data on maintenance costs, including unscheduled repairs, may be needed before fleets can commit to BEV vehicles beyond a few trial units. Allison agrees that as technologies mature, BEVs do promise to reduce maintenance costs. However, Allison expects that with today's maturity of commercial battery electric vehicle technologies, unscheduled repairs of inverters, motors, and battery pack components, plus replacement of battery cells at vehicle mid-life, could result in higher maintenance costs than ICE vehicles. In addition to the maintenance costs, Allison suggests considering the ramifications of unscheduled downtime as part of the cost assessment.

3) Charging infrastructure costs

On page ES-5, the draft report states: "The cost for a BEV charger must also be considered. These can range from around $1,000 for a basic charger to $350,000 for a specialized Proterra fast charger."

As Allison understands this reference, "Basic charger" refers to "charging station" or EVSE (Electric Vehicle Supply Equipment). For L1 and L2 charging, the EVSE provides AC power to the vehicle, and the actual battery charger is on-vehicle. Allison estimates that basic charging station hardware for overnight charging of commercial BEVs will cost well over $1000 without installation costs. Since installation costs vary by location and can be a significant capital investment, it would be helpful when citing charging station costs to identify if installation costs are included.

L2 EVSEs for passenger cars are available for $1000 or less. These EVSEs only provide 6-10 kW (30-40 Amps at 208 or 240 V). Commercial BEVs, such as transit buses, typically require 3-phase AC power, or DC power, up to 50 kW, even for overnight charging. Also, the cost cited for a bus fast charging station does not appear to include installation costs, which can significantly impact total cost.

4) Transfer of light-duty BEV components to medium and heavy duty commercial vehicles

On page ES-10, the draft report states: "Battery technology, the learning curve, and economies of scale found in the light-duty sector will readily transfer to the medium- and heavy-duty vehicle segment." Allison believes that, to the extent "battery technology" intends to include battery pack technology, challenges exist that battery pack technology will "readily transfer to the medium and heavy duty vehicle segment." Cells, battery management system, and contactors will readily transfer to medium and heavy duty vehicles. However, pack designs for commercial vehicles will have to be more rugged, which would require different structure and thermal management designs. High and low voltage harnesses and connectors also must be significantly more rugged, which would result in specialized, lower volume packs with higher pricing than light-duty automotive battery packs. The draft report on page ES-10, 11 does note that "ruggedization of battery packs and systems may be required." In Allison's opinion, ruggedization will be required, and it will drive different battery pack designs and tooling.

5) Payback time period

On page ES-12 the draft report states "the West Coast Collaborative has found a three to five year payback period for medium-duty BEVs." Allison believes the study uses optimistic assumptions for the input data used for the payback calculation and that the three to five year payback may be unrealizable with 2015 BEV component and vehicle costs. Allison suggests a new study with updated fleet and end user collected costs for vehicles, maintenance, and recharging. Fleet and end user costs for charging station installation would also be informative to understand the cost of converting commercial fleets to BEVs.

6) Minor technical corrections

On page ES-4 the draft report states: "The primary issues are battery cost and power density" and "increasing the amount of power that can be supplied by those batteries would bring overall BEV cost down considerably". Allison believes the authors meant to use "energy" instead of "power" in these statements. Today's BEV battery packs generally do not have difficulty delivering the power (rate of energy delivery) required to match ICE vehicle performance, including medium and heavy duty commercial vehicles. However, the cost and weight required to achieve the energy storage capacity to provide ICE equivalent range is more challenging with today's battery technology.

On page II-2 the draft report states: "Specific power, which reflects the amount of current that can be provided (W/kg)". Allison suggests the measurement of current is not enough to provide power. Power delivery can be increased by increasing either voltage or current. Additionally, "specific power" refers to the power to weight ratio. Accordingly, Allison suggests the following alternative language:

> "Specific Power, which reflects the rate of energy delivery per unit of mass (W/kg)".

On page III-5, the draft report states: "In DC fast charging systems, the charging functions are split between the charging station and the vehicle's on-board charger." It is Allison's understanding that DC fast charging systems do not utilize on-board chargers. Rather, for DC fast charging, the battery charger is completely off-vehicle, and it provides DC power to the vehicle. The vehicle routes this DC power directly to the battery pack, bypassing the on-board charger if the vehicle is so equipped.

7) Additional vehicles required with converting commercial fleets to 100% BEVs

Finally, the draft report does not mention the necessity to run additional vehicles to maintain existing routes and schedules while vehicles are charging. Allison requests guidance on this issue and, in particular, requests that ARB quantify the number of extra vehicles needed. The following is an example specific to urban transit buses. While some buses are scheduled for less than 100-150 miles per day operation, others need to be scheduled to run up to 20 hours per day with up to 300 miles operation, to service existing bus schedules and routes. Today's battery technology cannot provide a 40' transit bus with 300 mile range. DC Fast Charging stations in route could potentially solve the range problem, but fast charging stations can cost $500-750k including installation. Also, permitting can be a problem, especially in historic downtown areas. These factors could require transit authorities to purchase additional battery electric buses to allow one bus to charge while another bus is in service.

Allison commends ARB for investing in this technology assessment and its associated follow-on work to further gauge the technology maturity and projected costs prior to taking further actions. I can be reached at (317) 242-3501 or debbie.gordon@allisontransmission.com if you would like to discuss Allison's comments.

Respectfully submitted,

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