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U.S. Environmental Protection Agency
EPA Docket Center, OAR
Docket EPA-HQ-OAR-2023-0216
1200 Pennsylvania Avenue NW
Washington, DC 20460
(Filed electronically)

June 5, 2023

Re: Docket No. EPA-HQ-OAR-2023-0216; World Resources Institute's Electric School Bus Initiative, Comments on Request for Information for Development of Guidance for Zero-Emission Clean Heavy-Duty Vehicles, Port Equipment, and Fueling Infrastructure Deployment under the Inflation Reduction Act Funding Programs

To Whom It May Concern:

World Resources Institute's (WRI) Electric School Bus Initiative (ESBI) appreciates the opportunity to comment on the program design and implementation for the U.S. Environmental Protection Agency (EPA) Clean Heavy-Duty Vehicle Program that will invest $1 billion to help replace dirty heavy-duty vehicles with zero-emission alternatives.

WRI is a nonprofit, nonpartisan global think tank dedicated to improving the environment, economic development, and human wellbeing. Our comments for this docket draw upon our electric school bus (ESB) expertise, in particular working with manufacturers and utilities and infrastructure providers and with state and local government entities, including city and county governments and school districts, from across the nation on the implementation of their school bus fleet electrification, clean energy, and equity goals.

Congress stipulated that this program would exclusively fund the electrification of Class 6 and 7 vehicles, which encompasses nearly all types of school buses. This provides a clear indication of Congress' intent for the program to aid in the electrification of the nation's school bus fleet, the largest transportation fleet in the country. ESBs are ready and available: there are ESBs already on the road or on their way in all 50 states and there are more than 22 models available from a total of 8 manufacturers. ESBs provide important air quality, health and climate benefits and can help address non-attainment concerns. ESBs provide substantial operations and maintenance cost savings over their lifetime but because of a higher purchase price, their total cost of ownership is not yet on par with traditional fossil fuel buses in the absence of additional incentives. With these considerations in mind, WRI recommends that EPA prioritize awards for school buses as eligible recipients.

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A. Technology Availability and Market-Readiness:

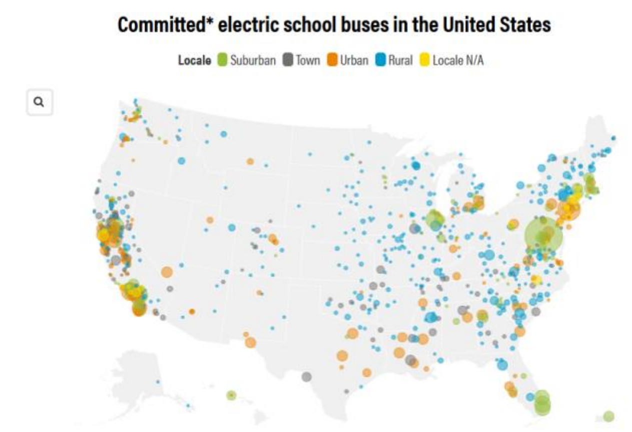
Electric School Bus U.S. Market Study and Buyer's Guide: A Resource for School Bus Operators Pursuing Fleet Electrification | World Resources Institute (wri.org) (Huntington et al.) is the main source for many of our below responses. An update to this guide will be released later in June 2023.

1. **Using the following categories as a guide, please identify specific types of vehicles or equipment that you are providing information about in response to this RFI. For each item you identify, please provide a description, and specify the type of powertrain (*e.g.,* electric [non-battery], battery-electric, hydrogen fuel cell electric, or other zero-emissions technologies).**

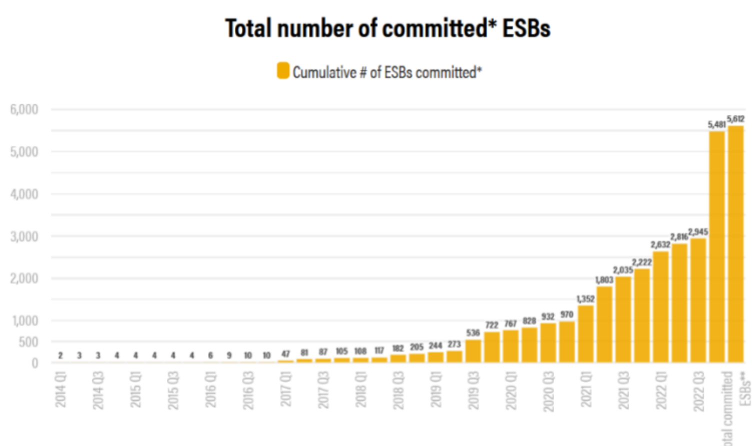
These comments relate to electric school buses and associated charging infrastructure.

2. For each of the items you identified in response to Topic 1, please:

> **b. Provide information on the near-term demand outlook for this equipment. For entities that are eligible for funding, please describe how many and what types of zero-emission heavy-duty vehicles and port technologies you anticipate purchasing in the near-term.**



Source: Lazer and Freehafer, 2023, National Center for Education Statistics, 2022 • For locale definitions, see here. Data as of December 2022. *awarded, ordered, delivered, or in operation.
Not shown: American Samoa Department of Education (1 ESB, Town), Guam Department of Education (25 ESBs, Town), and Saint Thomas - Saint John School District (10 ESBs, Town).



Source: Lazer and Freehafer, 2023 • Data as of December 2022
*awarded, ordered, delivered, or in operation **131 ESBs added here due to unknown dates of their commitment stages

There are now 5,612 electric school bus (ESB) commitments across 50 states (plus DC, four territories and four tribal nations) and 895 school districts or private fleet operators, representing around 1.2 percent of the current fleet size; 971 ESBs in 37 states have been delivered or are in operation (Freehafer and Lazer 2023).

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At a national level, the Clean School Bus Rebate opportunity signaled unprecedented demand for ESBs with nearly $4B worth of applications for just the first funding round. Due to overwhelming demand for ESBs, EPA nearly doubled its initial $500 million rebate offering and instead awarded $965 million for low- and zero-emission school buses with 95% of awards going to ESBs based on high demand for this technology.

In addition to the demand of individual school districts, there will be a demand to meet state fleet transition commitments. At the state level, four states enacted legislation setting school bus electrification targets in 2022.

- New York – home to one of the nation's largest school bus fleets of over 10,000 vehicles – passed legislation requiring all new school bus purchases to be zero emission by 2027 and all buses in operation to be zero emission by 2035.
- Connecticut set a fleet electrification date of 2040 for all school buses and 2030 for school buses operating in environmental justice communities (as previously defined in state statute).
- Maryland mandated that all new school bus purchases and contracts statewide will be electric by 2025 (the earliest such date of targets passed this session; contingent on available funding).
- Maine required that 75% of new school bus purchases and contracts must be zero emission by 2035.

In addition to these four legislatively enacted commitments, two other states have set targets in agency-led transportation and climate action planning documents:

- Colorado's Clean Truck Strategy and Michigan's Healthy Climate Plan. Colorado's plan sets a nonbinding goal to "support the adoption of 2,000 electric school buses by 2027 and a longer-term goal to achieve 100% zero-emission buses on the road by 2035.
- Michigan's says the state should aim for 100% of school bus sales in 2030 to be electric. Both suggest prioritization of disproportionately impacted communities.
- In Washington, D.C., the D.C. Council passed the Clean Energy DC Omnibus Amendment Act in 2019, which sets a goal for electric only bus replacement with the goal of 50% ESBs by 2030.

At the local level, Fairfax County Public Schools in Virginia (~1,625 buses), Montgomery County Public Schools in Maryland (~1,400), Boston Public Schools in Massachusetts (~700 buses in fleet), and Austin Independent School District in Texas (~500 buses) are looking to transition their fleets to electric or zero-emission buses between 2030 and 2035 while the Eastern Band of Cherokee Indians set a goal of becoming the first school system in North Carolina to electrify its full fleet.

To respond to growing demand from school districts, existing contractors, who represent around 40 percent of the school bus market, are beginning to explore pathways to electrification to meet customer demand. For example, National Express aims to transition its school bus fleet (Durham School Services) to zero-emission by 2040, while First Student has committed to convert 30,000 diesel buses to electric by

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2035. In addition, Midwest Transit Equipment, the largest bus dealership in the US, has placed an order with SEA Electric to repower 10,000 school buses to electric through 2026.

c. Provide information regarding whether the current and expected near-term manufacturing capacity would be adequate to meet the expected market demand, including anticipated federal funding. Please specify any factors helping or preventing the industry from meeting the expected demand today and in the near-term and provide information on the availability of and materials used in key components such as batteries, electric motors, high-voltage cables, storage tanks, pumps, hoses, nozzles, enclosures, and required safety equipment.

There are currently more than 22 models of ESBs available from a total of 8 manufacturers.

Industry-wide, manufacturers are anticipated to more than double their existing capacity for Type C and D ESBs by the end of 2024 with longer-term expansion growing five-fold (Lee and Chard 2023).

Announcements pertaining to manufacturer growth include:

- GreenPower Motor Company (new construction): completed construction of its second ESB manufacturing facility, located in West Virginia. It began production of ESBs and conducted a series of pilots to observe performance across the state.
- Lion Electric (new construction): produced its first Made in America certified ESB at their newly constructed facility in Illinois. At its eventual full capacity of 20,000 units, the plant is poised to be the largest electric truck and bus manufacturing facility in the U.S.
- BYD (upcoming new construction): intend to construct a dedicated facility for ESB manufacturing adjacent to their existing manufacturing plant in California.
- Thomas Built Buses (expansion): adding 280 employees in North Carolina in part to ramp-up ESB production.
- Lightning eMotors (expansion): doubling the footprint and production capacity of their Colorado manufacturing facility.
- Pegasus (upcoming expansion): moving to a larger facility in Ohio in 2024.
- Blue Bird Corporation: ramping up of ESB production from 4 to 20 ESBs per day.

New industry partnerships include: Collins Bus and Lightning eMotors (Type A ESB offerings) to include both Ford and GM platforms; Pegasus Specialty Vehicles partnerships with Phoenix Motorcars, VIA Motors and Zeus Electric Chassis; Blue Bird Corporation and Lightning eMotors partnership on repowers; Thomas Built Buses and Optimal EV (Type A ESB)

d. Provide information on whether various duty cycles affect available power levels at the installation site and dwell times needed for charging, whether charging is anticipated to happen on site or en route, and how expected needs for zero-emission heavy-duty vehicles and zero-emission port equipment might differ from what is commercially available today and in the near-term timeframes.

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Charging for electric school buses will occur almost entirely (especially in the near term) at depots where buses are housed. Duty cycles tend to be shorter and dwell times much longer for school buses than for other MHDV use cases. Relatively lower energy requirements and greater flexibility around charging schedules both enable school bus fleets to electrify with relatively lower site-level power requirements than other fleet types. Battery capacities for some portion of the school bus fleet may increase in the future to meet the energy requirements of the longest routes operating under the most severe weather conditions, which could increase site power requirements. Additionally, depending on power needed or charging approach (e.g. 1 DC charger serving 3 ESBs), a site may require three-phase power, which is a higher power electrical service that is typically utilized in commercial and industrial settings.

Charging Station Type	Approximate Power (kW)	3-Phase Power Required?
High-Power Level 2	19.2	No
Medium-Powered DC	24-30	Optional
High-Powered DC	50-150+	Yes

In the long-term, charging outside of depots will need to be considered for 1) field trips – not only the provision of charging infrastructure but also parking spaces that can accommodate the size of school buses and 2) park outs (i.e., buses parked at or near a driver's home), which could include public charging or installing chargers at drivers' homes.

e. Please indicate to what extent it is human-operated equipment and/or a human-maintained technology.

Electric school buses are human-operated and maintained vehicles. Drivers and mechanics (see Section 6a) will need to be trained to adapt to elements such as regenerative breaking and batteries.

f. Provide information on the current and expected near-term average customer delivery time.

Delivery times as provided by manufacturers in WRI's Electric School Bus Buyer's Guide. Note: many school districts are quoting longer delivery timelines.

Type A	6-18 months (outlier: 2 months [dependent on chassis availability]
Type C	6-11 months
Type D	6-12 months

4. For each of the *battery-electric* and *charger* items you identified in response to Topic 1, please describe the standard and optional equipment specifications. Please specify the type of charging included, *e.g.* whether it uses the SAE J1772 connector for AC charging (also known as the Jplug), if it provides DC Fast Charging, if it uses the Combine Charging System (CCS) connector, if it uses the CHAdeMO connector, if it uses the Megawatt Charging System (MCS), and or whether it uses an additional connector technology and what type, whether it uses inductive charging, and other relevant information such as maximum power rating (kW) and standards to which the equipment is certified.

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For Level 2 charging, a single plug standard is used across the industry: SAE J1772. For DCFC, all school buses are equipped with the Combined Charging Standard (CCS). The CHAdeMO plug is not commonly used. As signified in its name, the "Combined" Charging System is designed to accept both the Level 2 SAE J1772 plug and a CCS1 DCFC plug. Most buses come equipped with a single CCS standard port that can facilitate Level 2 and DCFC charging. The only model WRI is aware of that this is not the case for is Thomas Built Buses' Type C Jouley – although it uses a CCS1 port, it can only charge with a DCFC unit.

Note: Some OEMs are indicating that they will move towards **not** offering L2 chargers. We recommend not eliminating L2 chargers as a viable pathway for school districts to charge their electric school buses.

5. For each of the *battery-electric* items you identified in response to Topic 1, please describe whether and how the batteries can be upgraded or replaced.

Over time, the capacity of an EV battery diminishes. Vehicle manufacturers expect electric school bus batteries' capacity to drop to 70% within eight years, after which the battery is no longer deemed fit for the vehicle and must be replaced. (Batteries are replaced by the manufacturer at no cost to the bus owner within the warranty period – see below for more information on warranties.)

B. Performance:

6. For each item you identified in response to Topic 1, please:

> **a. Describe the expected service life and long-term operation and maintenance requirements relative to those operating on conventional petroleum-based liquid fuels.**

With the inclusion of an electric powertrain, ESBs do not contain internal combustion engine components and systems: engine system (engine, radiator, turbocharger, oil filter, coolant hoses); exhaust system (SCR catalyst, DEF tank, DPF canister, muffler, exhaust pipes, exhaust brake); fuel system (tank, pump, hoses, filter, separator, injector).

Electric buses utilize motors comprised of only around 20 parts, compared with 2,000 in a diesel engine; require fewer fluid changes, including elimination of engine oil; and commonly use a direct drive system, eliminating the need for a transmission. Additionally, unlike a diesel bus with weight concentrated in the front, ESB battery weight is more evenly distributed between the front and rear wheels.

With respect to vehicle servicing, technicians have fewer parts to maintain for ESBs when compared with their diesel counterparts. Moreover, many auxiliary systems in ESBs, such as braking and steering, remain similar to those of diesel buses, making them relatively easy to maintain. Additionally, like diesel buses, ESBs also have low-voltage auxiliary systems that use a lead-acid battery to support components like the dashboard, lights and windshield wipers. However, to operate on high-voltage systems, maintenance technicians do need specialized training. For on-site depot maintenance staff, completing this training can be both costly and time consuming.

Additionally, please see the below table from our Total Cost of Ownership Parameters for Electric School Buses Technical Note that lists the compared costs associated with maintenance.

VEHICLE TYPE	TYPE A		TYPE C		TYPE D	
Fuel type	Electric	Diesel	Electric	Diesel	Electric	Diesel
Expected vehicle lifetime (years)	13.5		13.5		13.5	
Annual vehicle mileage (miles/year)	14,084		14,084		14,084	
MSRP 2022 ($/vehicle)	$271,393	$58,484	$352,012	$103,140	$378,459	$127,606
Overall fuel economy (MPGe)	39.46	10.50	22.10	6.59	25.32	6.32
MPGe city	42.00	8.90	24.00	5.50	26.90	4.50
MPGe highway	36.00	12.50	20.40	8.00	35.00	8.50
Overall maintenance and repair costs ($/mile)[a]	$0.24	$0.40	$0.29	$0.57	$0.31	$0.62
Maintenance and repair costs - years 1-5 ($/mile)[a]	$0.22	$0.38	$0.23	$0.40	$0.26	$0.41
Maintenance and repair costs - years 5+ ($/mile)[a]	$0.42	$0.68	$0.43	$0.71	$0.50	$0.74
Diesel exhaust fluid ($/gallon)	n/a	$0.03	n/a	$0.03	n/a	$0.03
Year 8 (2030) Battery replacement cost ($2022)	$9,070	n/a	$15,162	n/a	$14,329	n/a
Liability-only cost to insure ($/year)	$4,786		$6,770		$12,300	
Full coverage cost to insure ($/year)[b]	$14,812	$9,068	$22,548	$12,660	$28,088	$17,575

Notes: n/a = not relevant; MSRP = manufacturer's suggested retail price; MPGe = miles per gallon (or equivalent); NPV = net present value. [a] Battery replacement is listed separately. [b] Full coverage includes liability as well as collision and comprehensive coverage, meaning that fleets select one of the two types, and costs should not be added together.

Source: WRI Authors.

c. Describe the original manufacturer's warranty. Please include all applicable parameters, such as years, hours or miles of operation, and number of charging cycles and as well as whether the warranty covers the damage from any potential charger malfunction.

See WRI's Buyer's Guide for full list – offerings provided below, vary by manufacturer

Battery	
Type A	• 5 years // 60,000 miles or 100,000 miles • 6 years // 157,000 kWh of gross discharge throughput per battery pack • 8 years // 100,000 miles or 150,000 miles • 12 years
Type C	• 8 years // 125,000 miles/160,000 kWh discharge or 175,000 miles/200,000 kWh discharge • 12 years
Type D	• 8 years // 125,000 miles/160,000 kWh discharge or 200,000 miles

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	• 12 years
Drivetrain	
Type A	• 3 years // 50,000 miles or 150,000 miles • 4 years // 80,000 miles • 5 years // 60,000 miles or 100,000 miles or150,000 miles or 160,000 miles • 8 years // 150,000 miles
Type C	• 4 years // 80,000 miles • 5 years // 100,000 miles
Type D	• 4 years // 80,000 miles • 5 years // 100,000 miles
Chassis	
Type A	• 3 years // 36,000 miles or 250,000 miles • 5 years // 60,000 miles • Body (1 year/12,000 miles) and structure (5 years)
Type C	• 3 years // 50,000 miles • 5 years // 100,000 miles
Type D	• 3 years • 5 years // 100,000 miles
Key: // = whichever comes first Of the models on the market, rows have been combined across manufacturers – for example, “5 years // 60,000 miles or 100,000 miles” means one manufacture offers 5 years // 60,000 miles while another offers 5 years // 100,000 miles	
Some offer bumper to bumper, extended, and other warranties as well	

d. Describe differences in performance and operational characteristics between the zero-emission HDV or port equipment and the comparable conventionally fueled counterpart. Please fully explain all differences in capacity, speed, operating range, impacts on operation due to ambient conditions or limitations in capabilities.

Range: When considering the battery range, it is important to distinguish the “nameplate” battery capacity from its “usable” capacity. Many manufacturers will cite the actual battery size (kWh) or nameplate capacity of a bus, but in reality around 80-90% of that capacity will be “usable.” Manufacturers reserve about 10-20% of the battery capacity to maintain the battery state of health over the long run. Reserving some battery power also ensures that the vehicle will maintain critical functionality and not suddenly shut off. The usable range can be impacted by various factors. Managing the battery’s temperature and heating or cooling the cabin in very high or low external temperatures will expend the usable range more quickly, while effective use of regenerative braking will recapture energy to add range back en route. Over the lifetime of an ESB, the battery will naturally degrade by around 20% after several years of use.

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Cold weather operations: Unlike a diesel bus with weight concentrated in the front, ESBs' battery weight is more evenly distributed between the front and rear wheels, improving driving in the snow. Three Rivers Community Schools outside of Kalamazoo, Michigan, has found that their ESBs have "outperformed [their internal combustion engine] buses in cold weather." While Three Rivers utilizes an auxiliary diesel heater, Salt Lake City School District in Utah has opted for electric heaters. Electric heaters do draw from the battery responsible for propulsion (<30°F an electric heater use draws around 18% of range). Pre-heating the buses and adjusting routes can help address colder weather impacts.

Hot weather operations: Cartwright School District 83 outside of Phoenix, Arizona, received the state's first ESB in July 2021. The bus has an upgraded air conditioning system that is appropriate for the Arizona heat and has successfully operated in summer temperatures without major battery impacts (Hannon 2021).

Mountainous terrain: ESBs are also navigating the mountainous terrain of Cherokee, North Carolina, as well as the snow-covered ski mountains for field trips and local canyons for regular routes outside of Salt Lake City (16-17% in-route battery gain when driving down a mountain pass at 55-57 miles per hour). Many districts have sited stronger horsepower.

7. For each of the *battery-electric* items you identified in response to Topic 1, please:

> **a. Identify all charger manufacturers or charger models with which this item has been verified to have full technology compatibility or other EV charging standards and how compliance was demonstrated. Please provide information on how the technology compatibility was verified.**

See WRI Buyer's Guide to see the extent to which this information is available. We anticipate releasing an updated version of this report in the coming weeks. Some OEMs provide this on their website (e.g., Lion Electric). Individual OEMs will need to provide information on certification.

Note that conducting interoperability testing can be challenging and costly, so not all interconnections are known but testing efforts are ongoing. More information on charger offerings can be found at https://www.energiize.org/infrastructure?section=infrastructure.more-details.technology or Charged EVs | EPRI's Vetted Product List helps utilities and agencies approve EV charging projects faster - Charged EVs. Please also look for results of ongoing EV-EVSE interoperability testing activities in North America through CharIN (the Charging Interface Initiative) at www.charin.global. An example of CharIN testing efforts can be found at https://www.youtube.com/watch?v=zGDGZ5gHleA&t=11s.

> **b. Please describe what type of safety mechanisms are used to protect battery packs from water intrusion, corrosion due to flooding and salt, thermal runaway events, and/or other hazards.**

From https://electricschoolbusinitiative.org/all-about-electric-school-bus-battery-safety:

While the batteries in electric vehicles are inherently less likely to cause fires than internal combustion engines, there are also a number of additional aspects that make electric school bus batteries safe for use:

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1. **Solid battery protection:** The structural placement of the electric school bus battery is designed with safety in mind. Battery packs are typically enclosed in a weather-durable metal casing and laid in between the guard rails of the bus chassis for maximum protection. This area is often referred to as the vehicle's safe zone as it is separated from passengers by a structural barrier and away from the front of the bus where collisions are more common. This is intended to protect against adverse physical impacts to the battery – including dislocation and disfiguration, impacts from weatherization, and theft. EV batteries are designed with seals to protect against water intrusion and corrosion.
2. **Automatic Electrical Disconnects:** ESBs are designed with automatic electrical disconnects that activate in a moderate or severe crash event or if the electrical system short circuits. This mechanism breaks the conductive connection between the battery and electric motor to prevent thermal runaway. Further, if the automatic disconnect fails, ESBs have manual cutoff switches to isolate the battery and disable the electrical system. This helps protect the battery from internal damage.
3. **Battery management system and Passive Propagation Resistance:** The battery management system provides an added layer of safety by controlling the temperature of the battery pack to remain in its most optimal state of performance. ESBs have specific protection to maintain the battery temperature – an active cooling system in electric school buses helps maintain an optimal temperature around the battery, and a secondary safety system automatically shuts off the battery before major issues can arise. ESB batteries are equipped with Passive Propagation Resistance (PPR). This safety system is designed to detect and isolate single battery cells experiencing a rare thermal incident. PPR prevents the issue from spreading to neighboring battery cells and triggers a slower release of energy to allow for more efficient heat venting.
4. **Roll Over Resistance**: The stability of an electric school bus provides roll over mitigation. Most vehicle fire deaths result from fires caused by collisions or roll overs. According to the National Fire Protection Association, roll overs occur in only 1-3% of all motor vehicle crashes but account for nearly one third of all passenger fatalities. Electric school buses are less likely to roll over because the location of the battery in the base of an electric school bus lowers the vehicle's center of gravity and reduces its roll over risk during a crash.

A few additional notes on safety mechanisms that help protect batteries and the people that work on them from adverse events:

5. **Extensive battery testing:** Battery testing is essential in identifying and developing solutions for problems before they occur. ESB batteries follow globally-recognized automotive safety standards, so batteries are subject to very high safety standards. These include safety-specific standards for the batteries (SAE J2929) and the systems in the vehicle that monitor and control the batteries (ISO 26262). Additionally, there are UL and UN safety certifications for lithium-ion batteries that need to be completed by the cell manufacturer before it is sold. These tests are industry standards and must be passed for the vehicle to be certified for sale.
6. **Typical ESB battery chemistry offers additional stability**: Battery safety starts with battery chemistry. LFP (Lithium-iron-phosphate) batteries used in almost all electric school buses have better thermal stability compared to NMC (nickel-manganese-cobalt) batteries commonly used in

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electric cars. This thermal stability ensures that the battery structure remains intact for longer even during high temperatures and decreases the risk of a widespread thermal event.

C. Pricing:

9. EPA is interested in better understanding the current lifetime costs/Total Cost of Ownership (TCO) gap between electric and diesel school buses as well as how that gap is expected to change over time. For each of the TCO cost categories (a–c) listed here, please provide cost estimates using the following parameters: a period of analysis of 10 years; a fleet size of 50 buses; and a 5-year straight line depreciation schedule (please clearly state what alternative assumptions have been made). Also, please clearly state what assumptions have been made on geographic region of analysis and/or specific districts; average vehicle life expectancy; sales tax; and annual days of operation. To the extent other HD vehicle types, such as dray trucks, can address the TCO in this fashion, please provide a similar description for those vehicle types.

Using assumptions listed in our Recommended Total Cost of Ownership Parameters for Electric School Buses Technical Note, and using this TCO tool developed by Atlas Public Policy in collaboration with WRI's Electric School Bus Initiative, we find the following cost estimates for a fleet size of 50 Type C school buses over the next ten years, using national averages. We find that, on a total cost of ownership basis, 50 electric school buses will achieve parity with 50 comparable diesel school buses by 2032.

Type C - Generic School Bus		number of buses	50		
National level - 00000		number of L2s	23		
ESB MSRP	$ 352,012	number of DCs	2		
Annual miles	14,084				
		Scenario 1		Scenario 2	
Diesel		**ESB + 45W**		**ESB + CSBP Priority Rebate**	
Years operating	14	Years operating	14	Years operating	14
		45W tax refund	$ 2,000,000		
				CSBP Priority Rebate	$ 17,994,745
Bus capital value	$ 5,157,000	Remaining bus capital value	$ 15,600,600	Remaining bus capital value	$ -
		EVSE (L2) capital value	$ 260,797	EVSE (L2) capital value	$ -
		EVSE (DC) capital value	$ 133,348	EVSE (DC) capital value	$ -
Fuel NPV	$ 5,045,314	Fuel NPV	$ 1,544,064	Fuel NPV	$ 1,544,064
Insurance, taxes and	$ 4,701,826	Taxes and fees NPV	$ 4,701,826	Taxes and fees NPV	$ 4,701,826
Maintenance NPV	$ 5,792,390	Maintenance NPV	$ 3,465,769	Maintenance NPV	$ 3,465,769
		EVSE (L2) Maintenance NPV	$ 312,845	EVSE (L2) Maintenance NPV	$ 312,845
		EVSE (DC) Maintenance NPV	$ 61,106	EVSE (DC) Maintenance NPV	$ 61,106
Total O&M (NPVs)	$ 15,539,530	Total O&M (NPVs)	$ 10,085,610	Total O&M (NPVs)	$ 10,085,610
TCO	$ 20,696,530	TCO	$ 26,080,355	TCO	$ 10,085,610
TCO per bus	$ 413,930.61	TCO per bus	$ 521,607.10	TCO per bus	$ 201,712.20
TCO per mile per bu	$ 2.10	TCO per mile per bus	$ 2.65	TCO per mile per bus	$ 1.02
Other assumptions:					
No battery replacement					
2 DC and 23 L2 dual ports (assumptions from tech note)					
For CSBP, up to $1m to cover charging (up to $20,000 per bus pooled, only need $394,145)					

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TCO results	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Diesel bus price (50 Type C school buses)	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000	$5,157,000
ESB price (50 Type C school buses)	$15,600,600	$14,820,570	$14,079,542	$13,375,564	$12,706,786	$12,071,447	$11,467,875	$10,894,481	$10,349,757	$9,832,269	$9,340,655
annual ESB price reduction	5%										
Upfront premium	$10,443,600	$9,663,570	$8,922,542	$8,218,564	$7,549,786	$6,914,447	$6,310,875	$5,737,481	$5,192,757	$4,675,269	$4,183,655
Diesel TCO (50 Type C school buses)	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530	$20,696,530
ESB TCO (50 Type C school buses)	$26,080,355	$25,300,325	$24,559,297	$23,855,320	$23,186,541	$22,551,202	$21,947,630	$21,374,236	$20,829,512	$20,312,024	$19,820,411
lifetime premium	$5,383,825	$4,603,795	$3,862,766	$3,158,789	$2,490,011	$1,854,672	$1,251,099	$677,706	$132,982	($384,506)	($876,120)
financeable savings	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775	$5,059,775

Diesel Sum total NPV Fuel + O&M	$15,539,530
Electric Sum total NPV Fuel + O&M	$10,085,610
Charging and infrastructure	$394,145

Thank you for your time and consideration.