Electrifying Education: Insights into Charging Electric School Buses in the United States

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BACKGROUND

School buses (SBs) have historically been a source of both greenhouse gas emissions and local air pollutants have negative health impacts for students and others living nearby. Battery electric SBs (ESBs) are a promising emerging technology for decarbonizing student transport, however, ESB adoption in the U.S. remains at an early stage (approximate 1.1%) with many outstanding uncertainties. In this study, **we take inventory of the current SB stock within U.S. states and observe real-world SB operating profiles to better understand the potential battery range requirements, daily charging opportunities, and charging infrastructure needs for ESBs.**

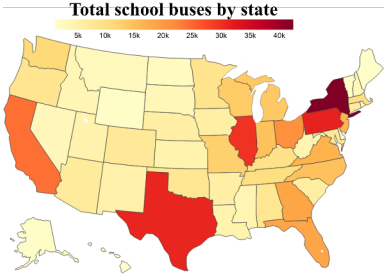

Figure 1: There are currently 480k SBs operating in the U.S; Top states: NY (42k), PA (31k), and TX (31k).

METHODS

State	SB count	Year	Travel day
Thornton, CO	55	2010	5
Redmond, WA	97	2011	5
Torrance, CA	30	2015	12
Napa, CA	8	2015	14
Rialto, CA	21	2017	44

Table 1: Fleet DNA 1-Hz operating data of SB fleets

- Develop **state-level inventory of current school bus stock** in the United States.
- Study the **current geographic distribution of ESBs** in the United States [1].
- Determine the **daily mileage requirements and charging opportunities for ESBs** by analyzing real-world 1-Hz SB operating data (Table 1) [2]

NUMERICAL RESULTS

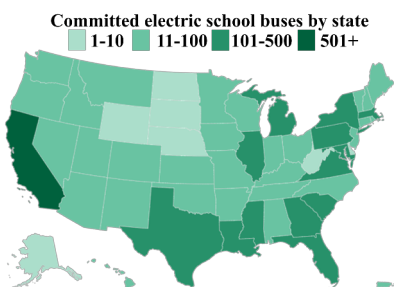

Figure 2: As of Dec. 2022, there are 5.6k committed ESBs; Top states: CA (1.9k), MD (361), and NY (310).

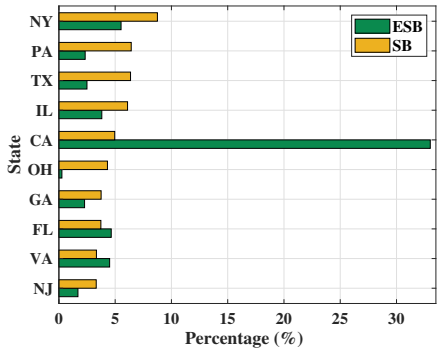

Figure 4: Comparison of % of national SB stock and ESB stock for states with 10 largest SB populations in the U.S

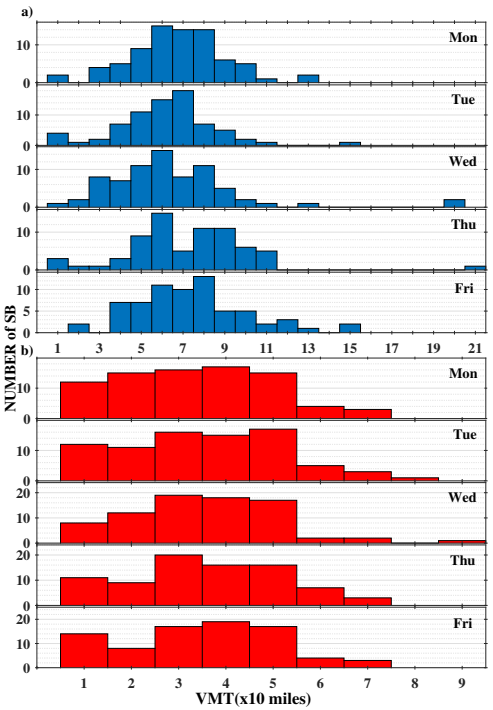

Figure 3: Daily VMT distribution for SBs in a) Fleet 40 (CO) and b) Fleet 41 (WA), respectively.

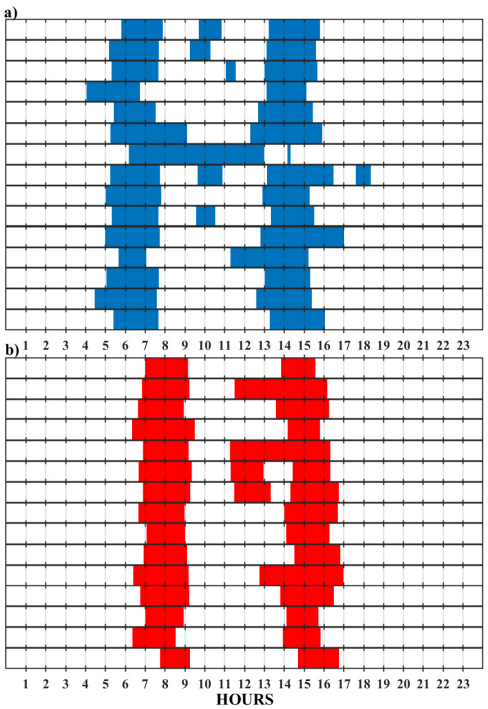

Figure 5: Bus-level operating times (Monday) for a) Fleet 40 (CO) and b) Fleet 41 (WA), respectively.

CONCLUSION

- There are currently **480k SBs in the U.S.** with the most operating in NY (9% of total), PA (6% of total), and TX (6% of total) and the least in DC (0.13% of total), HI (0.17% of total), and VT (0.2% of total).
- There are **5.6k committed ESBs in the U.S.** (1% of the total SB stock), but these are not uniformly distributed (34% in CA).
- The **average daily vehicle miles traveled is 59.92 miles** for the 211 buses in the Fleet DNA data set, **well within the range of ESBs available today** (100-155 miles). Only 1.71% of buses exceeded 155 miles.
- **SBs are parked (and potentially available to charge) for an average of 18 hours per day**, implying that low power charging (e.g., 10 kW AC or less) and/or port sharing may be suitable for ESB depot charging.
- **Most SBs return to their depots after each operating shift**, providing a significant opportunity for depot charging to supply the majority of ESB electricity demands.
- **SB operations tend to be "bimodal" with distinct AM and PM shifts** (typically 2-3 hours long) separated by an extended break during the middle of the day. ESBs could charge during the daytime (following their first shift) and delay charging (or supply electricity back to the grid) upon returning to the depot in the late afternoon.

ACKNOWLEDGEMENT

NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Fleet DNA

REFERENCES

[1] https://www.wri.org/insights/where-electric-school-buses-us

[2] Fleet DNA Project Data (2023). National Renewable Energy Laboratory.
Accessed July 12, 2023: *www.nrel.gov/fleetdna*