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REPORT

Electrifying US school bus fleets equitably to reduce air pollution exposure in underserved communities

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Electric School Bus INITIATIVE

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SCHOOL BUS

Foreword

New technology can often be beneficial for us if implemented with care. Sometimes, it can be a game changer. Electric school buses are one technology that brings a wide range of benefits and has the potential to transform student transportation.

Electrification is a proven alternative to traditional diesel fuel, which powers approximately 90% of school buses in the country and is linked to serious health and development conditions for children and their communities. In addition, the older these buses are, the dirtier and more dangerous to human health they tend to be. School buses manufactured before 2010—and, in particular, before 2000—produce significantly more exhaust than newer buses—exhaust which infiltrates the cabin and exposes children to pollution during their rides to and from school. Research demonstrates that a 30-year-old diesel bus produces two or three times more onboard pollution than a 3-year-old bus.

However, research also shows that older diesel school buses can be retrofitted with modern pollution-reduction technology, leading to marked improvements in student attendance and test scores. In the face of these challenges, there is also a huge opportunity to transition these dirty buses into newer and cleaner vehicles, such as electric school buses—which have no tailpipes and release no toxic exhaust.

However, new technology is often adopted first by more affluent people and communities. The conventional wisdom is that they can afford to buy new technology, and as the market for the product grows, it will become cheaper and then, and only then can under-served communities benefit as well. What if we rejected this conventional wisdom and asked a different question? What if we asked: is it possible to deploy new technology in a way that will benefit the people most burdened by the old technology first? Never before has research identified where the oldest, most polluting school buses are concentrated—and which communities are most affected. This data is critical in prioritizing an effective and equitable transition to electric school buses across the country.

This report finds that the most polluting buses in the US school bus fleet—those that are older and lack modern emissions reduction technology—inequitably serve students in school districts with larger shares of residents of color and low-income households. Due to a long-standing history of discriminatory policies, these groups are already more likely to be exposed to harmful air pollution from roadways, industrial facilities, and power plants. The research also finds that these buses disproportionately service rural areas, where students often have less access to alternate forms of transportation. This compounded exposure poses additional challenges in already overburdened communities.

But there's good news, too. This report also finds that electric school buses are being deployed most rapidly in many of these school districts that experience the highest levels of air pollution and have higher shares of residents of color and low-income households. Furthermore, this report's findings highlight new opportunities for key stakeholders to further enhance the equitable adoption of electric buses and ensure key funding and finance programs are adapted to best meet the needs of these communities. State legislators, utility regulators, and others can also use this analysis to shape the design of equitable and effective programs to replace aging diesel buses.

With record levels of funding available to procure electric school buses, the electric school bus movement is gaining momentum. Across the country, there is a massive opportunity to accelerate our collaboration and ensure an equitable and effective transition to a cleaner ride to school for kids.

ANI DASGUPTA
President & CEO
World Resources Institute


COUNTY SCHOOLS

Executive summary

This paper is part of the Equity Framework in Action by WRI's Electric School Bus (ESB) Initiative. Its purpose is to provide an equity analysis of the geographic distribution of school buses, their fuel types, and their emissions control technology to understand which school districts and which populations are exposed to emissions from the oldest, most polluting school buses, and, conversely, what the socioeconomic characteristics are of the districts that have been most successful in procuring ESBs. We seek to answer the following question: are older school buses contributing to disparities of transport pollution exposure seen in disadvantaged communities?

HIGHLIGHTS

- It is well established that ambient air pollution in the United States disproportionately impacts low-income communities and communities of color, but data about how the fuel type and age of school bus fleets may be affecting these inequities has only recently become publicly available.
- World Resources Institute (WRI) analyzed its recently published datasets on electric school bus (ESB) adoption and school bus fleets to reveal where the most polluting buses and fleets are located, who is most affected, and which districts have succeeded in procuring ESBs thus far.
- This research finds that the most polluting buses in the US fleet—those that are older and lack modern emissions reduction technology—are disproportionately concentrated in school districts with higher shares of low-income households and residents of color.
- Rural school districts are more likely to have older buses, but they have smaller overall fleets.
- Encouragingly, as of December 2022, most ESB commitments tend to be in districts with lower incomes, more residents of color, and the worst air quality, partly due to federal and state programs that have prioritized support for disadvantaged districts.
- We recommend that state policymakers and agencies, school district officials, and other stakeholders use this analysis to target districts most in need and seize the opportunity of unprecedented federal funding to clean up their fleets and protect their children.

To do this, the report provides new analysis of two recently published WRI datasets on ESB adoption and US school bus fleets, drawing on data from the EJScreen tool of the US Environmental Protection Agency (EPA), the US census, and the American Community Survey. It also provides analyses on emerging trends related to funding opportunities that influence the distribution of ESBs and could be leveraged to enhance equitable adoption.

It offers key stakeholders—such as school district officials, state and federal policymakers, communities, regulatory agencies, and grant-making institutions—clarity into where the most polluting school buses are concentrated around the country and which communities are disproportionately most affected.

The analysis is limited by the availability of data that US states provided in response to Freedom of Information Act requests. Agencies in four states—Colorado, Hawaii, Louisiana, and New Hampshire—responded that they did not have any state-level data on school buses, and four others—Arkansas, Michigan, Mississippi, and Tennessee—provided fleet data that lacked the age of the buses and thus could not be used for the analysis of fleet age (Lazer et al. 2022).

Air pollution inequities, the distribution of diesel school buses, and how and where the transition to ESBs is occurring

The World Health Organization (WHO) estimates that ambient (outdoor) air pollution caused 4.2 million premature deaths worldwide in 2019 (WHO 2022). A 2019 study found that global transport emissions contributed to 11.4 percent of deaths related to fine particulate matter ($PM_{2.5}$) and ozone in 2015, and diesel vehicles contributed to most of these mortalities and other health impacts (Anenberg et al. 2019). It is well established that nonwhite and low-income communities in the United States are disproportionately exposed to—and impacted by—ambient air pollution, including from transport and diesel sources (Jbaily et al. 2022). Diesel exhaust—classified as a carcinogen by WHO—contains $PM_{2.5,}$ cancer-causing air toxics, nitrogen oxides (which help form ground-level ozone), and volatile organic compounds that are precursors to ozone (EPA 2015c). Although the 1990 Clean Air Act has helped to reduce overall air pollution exposure and racial and income disparities to some extent, disparities still persist today (Colmer et al. 2020; Jbaily et al. 2022).

Children are particularly susceptible to the harms of diesel exhaust, including reduced lung function, greater likelihood of asthma, and reduced cognitive function, among other adverse impacts (Liu and Grigg 2018). Specifically, buses manufactured before 2010—and, in particular, before 2000—produce significantly more exhaust, which infiltrates the cabin and exposes children to diesel exhaust pollution during their rides to and from school (Beatty and Shimshack 2011). This is due to changes in emissions standards for buses manufactured in the subsequent years. Other research has shown that retrofitting older diesel school buses with modern pollution-reduction technology improves student test scores and increases attendance (Adar et al. 2015; Austin et al. 2019).

Findings

> *School districts with more students of color and low-income households have more polluting buses but also are at the front of the ESB transition*

WRI's recently published datasets on ESB adoption and school bus fleet data from over 80 percent of US states provided, for the first time, evidence that older, more polluting diesel school buses are disproportionately located in school districts with higher shares of low-income households and residents of color. Analyses from these datasets also revealed that ESBs are being procured most rapidly in school districts with more air pollution and higher shares of low-income households and residents of color.

This analysis can sharpen the focus of school district officials, state agencies, advocates, and other stakeholders on where the transition is needed most urgently, making best use of the unprecedented amount of federal and state funding to support school districts in replacing diesel with electric or alternative fuel buses. Studying these early trends can help stakeholders learn where ESB adoption is taking place and the funding mechanisms that are supporting it. Key findings include the following:

- **The proportion of older, more polluting buses in state fleets can vary widely across states.** In some states, pre-2010 diesel buses compose over half or nearly half of the fleet: Idaho (55 percent), Kansas (45 percent), California (43 percent), South Dakota (43 percent), and Virginia (41 percent). In others, they are less than 5 percent of the total fleet: Delaware (2 percent), New Mexico (2 percent), and Maryland (1 percent).
- **School districts with higher shares of low-income households are more likely to have a higher percentage of older buses in their fleets.** Using the low-income household definition of less than twice the federal poverty level from the EPA's EJScreen tool, we find that 30 percent of pre-2010 diesel school buses are in school districts with the highest shares of low-income households, whereas only 17 percent of pre-2010 diesel school buses are in districts with the lowest shares of low-income households. The disparity increases as buses age. Approximately 36 percent of pre-2000 diesel school buses are in districts with the highest shares of low-income households, and only 12 percent are in districts with the lowest shares of low-income households.
- **The disparity in the age of school buses is even more pronounced for school districts in communities with high percentages of people of color.** Nearly half (43 percent) of the known pre-2010 diesel buses are in school districts with the highest shares of minority residents, whereas only 9 percent are in school districts with the lowest shares of minority residents—in other words, districts with the highest shares of minority residents are **four times more likely** to have older, more polluting buses than districts with the lowest shares of minority residents. When looking at individual races (using American Community Survey data), we find that 75 percent of pre-2010 buses are in districts above the median for the population identifying as Black/African American. Seventy-one percent are in districts above the median for Asian, 68 percent for Hispanic/Latino, 55 percent for American Indian/Alaska Native/Native Hawaiian/other Pacific Islander, and 72 percent for "some other race." Only 22 percent are in districts above the median for population identifying as white.
- **Districts in rural areas are more likely to rely on older school buses for a large share of their fleet.** Rural districts account for 57 percent of the districts where the majority of the fleet predates 2010. It is worth noting that many of these districts tend to have smaller student

populations. More than half of those districts where the fleet comprises predominantly older buses have 10 or fewer buses, and about 200 have 5 or fewer buses.

- **No clear disparities were found between school districts with higher $PM_{2.5}$ levels and the number of older diesel school buses.** Only 20 percent of pre-2010 diesel school buses are in districts with the highest levels of $PM_{2.5}$, and 12 percent are in districts with the lowest levels of $PM_{2.5}$. The majority of pre-2010 diesel school buses are in districts around the median of the distribution, or the middle two quartiles, of exposure. The pattern is similar for school districts with 25 percent or more and 50 percent or more pre-2010 diesel buses in their bus fleets. To be clear, school buses are not a major driver of a region's ambient air quality and are a small portion of a larger overall level of air pollution. Studying these patterns helps reveal whether students in areas with poor air quality from various emissions sources are also exposed to toxic exhaust from their school buses, which may compound negative outcomes.
- **Initial results suggest that those living in communities with higher levels of ozone could be more impacted by concentrated school bus fleets made up of older diesel buses than the absolute number of such buses.** Thirty-two percent of school districts with 50 percent or more of their fleet composed of pre-2010 diesel school buses are in districts with the highest levels of ozone. This is compared to 22 percent of such fleets in districts with the lowest levels of ozone. Looking further, 28 percent of school districts with 25 percent or more of their fleet composed of pre-2010 diesel school buses are in districts with the highest levels of ozone. This is compared to 22 percent of such fleets in districts with the lowest levels of ozone.
- **As of December 31, 2022, there were 5,612 committed ESBs in the United States.** These buses were located in all 50 states, plus the District of Columbia, American Samoa, Guam, Puerto Rico, the US Virgin Islands, and four Tribal Nations, including the Morongo Band of Mission Indians, Mississippi Band of Choctaw Indians, Lower Brule Sioux Tribe, and the Soboba Band of Luiseño Indians. Since September 2022, of all committed ESBs, 2,451 had been awarded from the federal Clean School Bus Program that was established through the Bipartisan Infrastructure Law.
- **ESB adoption is occurring most rapidly in districts that experience the highest levels of air pollution and have higher shares of low-income households and residents of color.** Districts with more low-income households, more students of color, and higher levels of $PM_{2.5}$ and ozone were more likely to have committed ESBs thus far. Forty-three percent of ESBs are concentrated in districts with the highest shares of low-income households, and 68 percent are found in districts with the highest shares of students of color. Forty-three percent and 34 percent of ESB commitments are in districts with the highest shares of $PM_{2.5}$ and ozone levels, respectively.
- **We find that of the 2,102 ESBs in districts with the highest shares of $PM_{2.5}$ levels, 1,651 (78.5 percent) were in California, due in part to state and federal efforts to prioritize areas with poor air quality.** These efforts include California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program and School Bus Replacement Program and the EPA's Clean School Bus Program. California's programs, led by the California Air Resources Board and the Air Quality Management Districts, prioritized "disadvantaged communities" by including criteria on pollution and income levels as well as rates of asthma and cardiovascular disease, which are often in communities with more residents of color. The EPA's 2022 Clean School Bus Program prioritized districts where 20 percent or more of students were living in poverty as well as rural and Tribal school districts.
- **Further analysis shows that without targeted prioritization criteria, ESBs may otherwise be concentrated in higher-income areas.** When ESB commitments that are funded through programs that prioritize income, air quality, or other metrics of inequity are not counted in analysis, the remaining ESB commitments, including those from utilities, are concentrated in school districts with the highest household incomes. Nationally, before the first round of Clean School Bus Program awardees, the concentration of ESBs was highest in districts with the lowest shares of low-income households.

Intended audiences

We hope that all school district officials, state legislators, utility regulators, and other officials will use our analysis in combination with other relevant factors at the school or district level to shape their equity considerations in replacing aging diesel buses. This report, along with the datasets that form the basis of its analysis, is intended to inform and support the following audiences:

- School district officials, including superintendents, transportation directors, and school boards, in their decisions to replace aging, polluting buses in an equitable manner
- Local community groups concerned with the public health of children and environmental quality
- State legislators, regulators, or agencies with authority to prioritize or disburse state funds to support school bus fleets or infrastructure, such as the state governor or state education, environment, or energy agencies
- State legislators working on policies related to transportation, air quality, public health, or equity
- Federal officials directing programs targeting heavy-duty vehicle pollution, such as the EPA Clean School Bus Program

This report builds on previously published datasets to provide new analysis and understanding of the socioeconomic and demographic characteristics of districts that are more likely to be exposed to more polluting buses and have had early success procuring ESBs.

Recommendations

- School districts and state agencies should prioritize the replacement of the oldest school buses to produce the greatest air quality and health benefits for their students.
- State agencies in possession of school bus fleet data should make these datasets publicly available on their websites and update them semiannually or more frequently to enable stakeholders to understand where and at what pace the transition to ESBs is occurring. Given what we know about the health risks and inequitable distribution of older diesel buses, this would fill data gaps on the distribution of older, dirtier fleets across communities in those states.
- The data suggest that federal and state funding programs are dramatically increasing uptake of ESBs in communities that have historically suffered from high levels of air pollution and should be continued as long as disparities in pollution exposure on school buses persist.
- State agencies, nonprofits, and other stakeholders supporting an equitable transition to ESBs should take steps to promote awareness of ESB financing and technical support options as well as to encourage community involvement in and advocacy for the transition to electric fleets. These groups should promote key equity considerations in public funding sources and provide tailored support to school districts based on the number of older buses, fleet compositions, and locale to hasten their replacement.
- Diesel exhaust is closely linked to asthma attacks (EPA 2015a), but childhood asthma data is not available at local levels. Although adult asthma data may work as a proxy for childhood asthma data in certain circumstances, states should work to expand the availability of childhood asthma data and integrate that data, when available, when considering where to prioritize support for bus replacements.

Caveats

One major caveat is our limited access to US school bus fleet data. The fleet dataset includes 80 percent of the US school bus fleet, but 101,000—or roughly 20 percent—of buses are missing or have unusable age data. Four states—Colorado, Hawaii, Louisiana, and New Hampshire—and all US territories did not have data available or were not permitted to disclose the data because the fleet was privately operated (in the case of Hawaii). Additionally, Arkansas, Michigan, Mississippi, and Tennessee either did not provide age data or provided age data that was not detailed enough to be used for this analysis, which excluded their fleet data from being analyzed with age as a proxy for pollution level (Lazer et al. 2022). In this paper, we analyze data from states where we have strong data and explore methodologies that can continue to be applied as more data becomes available.

Besides the age of the bus, other factors may contribute to the duration or degree of exposure to diesel exhaust pollution for children riding the bus. For instance, we do not have data on which routes are assigned older, more polluting buses; the duration of the route and its proximity to high pollution areas, including roads and highways; and other factors that may influence rider exposure, such as ventilation, idling, and use of diesel heaters. We also do not consider pollution from the manufacturing of school buses or from fuel production.


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Introduction: Equity, air pollution, and the school bus

The Electric School Bus (ESB) Initiative defines *equity* as the "guarantee of fair treatment, access, opportunity, and advancement while striving to identify and eliminate barriers that have prevented the full participation of some groups" (Moses and Brown 2023).

In practical terms, this means providing resources and support to low-income communities, communities of color, Tribal and/or Indigenous communities, and others disproportionately impacted by diesel exhaust pollution to ensure they have full access to the assistance they need to electrify their school bus fleets (ESB Initiative n.d.a).

This report uses data from the beginning stages of electric school bus (ESB) adoption in the United States. The numbers of electric and diesel school buses presented here are as of December 31, 2022. The report is intended to serve as a first step in identifying the potential disparities in air pollution exposure that children riding school buses face due to the age of their fleet, alongside an analysis of the states and school districts that had early success procuring ESBs. The report also looks at the state and federal funding mechanisms that were used to adopt the first ESBs and the socioeconomic and demographic characteristics of those districts. We recognize that this is just one piece of the equity puzzle as it relates to student transit, health, and safety.

Utilizing datasets recently published by World Resources Institute (WRI), this paper seeks to shed light on the following questions:

- What are the socioeconomic characteristics of the school districts most negatively impacted by older diesel school bus exhaust pollution, and what are the equity implications given what we know about disparate impacts of air pollution?
- How are ESBs distributed among school districts and regions of differing socioeconomic characteristics?
- What are the emerging trends related to financial, infrastructure, and utility support for ESB adoption, and what insights can be drawn on the potential for equity implications?

During the 2021–22 school year, roughly 20.5 million students, or 51 percent of the total K-12 student population, were transported daily by school buses (*School Bus Fleet Magazine* 2023). An estimated 90 percent of these buses are powered by diesel fuel. However, that percentage is starting to decrease with the recent upswing in ESB procurement that WRI has tracked. This is driven in large part by the Clean School Bus Program of the US Environmental Protection Agency (EPA) and by various state and other funding sources. Diesel exhaust—classified as a carcinogen by the World Health Organization—contains particulate matter ($PM_{2.5)}$ such as soot, cancer-causing air toxics, nitrogen oxides (which help form ground-level ozone), and volatile organic compounds, which are precursors to ozone (EPA 2015c). The polluting levels of school buses are closely tied to the age of the bus fleet. Research has found that a 30-year-old diesel bus produces two or three times more onboard pollution than a 3-year-old bus (Austin et al. 2019). Besides cancer, diesel exhaust can lead to asthma and a host of other respiratory illnesses and health impacts. Children are especially susceptible to these risks due to their developing lungs. Diesel exhaust exposure on school bus rides can lead to reduced lung function, asthma attacks, and impaired cognitive development—observed through reduced test scores (Austin et al. 2019; Beatty and Shimshack 2011).

Individuals who identify as Black, Hispanic/Latino, or Asian or have low incomes are more likely to be exposed to harmful air pollution in the United States than their white and high-income counterparts (Liu et al. 2021). Racial and ethnic minorities and low-income groups face a higher risk of death from $PM_{2.5}$ exposure than other population or income groups (Jbaily et al. 2022) and higher average exposures to nitrogen dioxide (Clark et al. 2017). Although absolute exposures and racial/ethnic disparities have decreased since the enactment of the Clean Air Act, these recent studies show they continue to persist today. The American Lung Association's *State of the*

The polluting levels of school buses are closely tied to the age of the bus fleet. Research has found that a 30-year-old diesel bus produces two or three times more onboard pollution than a 3-year-old bus.

Air: 2023 Report finds that people of color are 3.7 times more likely to live in a county with unhealthy levels of either $PM_{2.5}$ or ozone (American Lung Association 2023). Children of color and those from low-income households are more likely to ride the school bus than their white and high-income counterparts (Federal Highway Administration 2022).

These present-day disparities have historical roots in racist housing, transit, zoning, and other land-use policies and practices that concentrated Black and Brown communities near polluting infrastructure such as highways, industrial facilities, power plants, ports, and so on (Lane et al. 2022). Locally, racial covenants and deed restrictions prevented property in cities or within homeowner associations from being sold to, used by, or occupied by either Black people or nonwhites. In 1948 the Supreme Court deemed such restrictions unenforceable, but they were not banned until the 1968 Fair Housing Act. However, the evidence of these laws exists today (Thompson et al. 2021). For instance, the Federal Housing Administration, which was established in 1934, refused to insure the mortgages of Black would-be homebuyers in many neighborhoods, reinforcing segregation and stymying the building of generational wealth through home ownership (Rose et al. 2021).

Climate change is a more recent driver of poor air quality in the United States and cuts across socioeconomic lines. It makes the western United States hotter and drier and increases the prevalence and intensity of wildfires. This shows up in the data as well. From 2004 to 2023, the number of counties located in western states that received failing grades on air quality from the American Lung Association increased from 42 percent of the total to 93 percent (American Lung Association 2023). Although particulate pollution has worsened in western states, it has largely improved in formerly industrialized eastern states due to Clean Air Act implementation.

Further, climate change disproportionately affects those least responsible for it, which is why the equitable transition to ESBs is an environmental justice priority. In the United States, majority-white neighborhoods have the highest per capita greenhouse gas emissions, yet Black Americans are projected to face the greatest risks from climate change out of all American demographic groups (EPA 2021; Goldstein et al. 2022).


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What are the socioeconomic characteristics of the school districts most negatively impacted by older diesel school bus exhaust?

This analysis looks at diesel-powered buses that are from 2009 or earlier, referred to as *pre-2010 diesel buses* and *pre-2000 diesel buses.*

Children riding the bus are particularly at risk from the health harms of older school buses manufactured prior to the 2010 Diesel Emissions Reduction Act (DERA) because they produce more air pollution than newer buses or other fuel types. Although pollution exposure occurs in residential communities near bus stops and on routes, the pollution exposure is highest for students riding the bus (Austin et al. 2019).

Since 1970, the Clean Air Act has required US federal agencies to limit air pollutants and toxics from new stationary and mobile sources. Federal regulations for heavy-duty vehicles, which include school buses, transit buses, and other vehicles used in the trucking industry, started in the early 1970s, with gradually more stringent standards enacted over the following three decades. The EPA launched a voluntary diesel retrofit program in 2000 and the Clean School Bus Program in 2004, which encouraged policies and practices to upgrade pollution control technology, use cleaner fuels, and reduce idling. The DERA program was launched as part of the 2005 Energy Policy Act, providing US$200 million annually from fiscal year 2007 to fiscal year 2011 to retrofit primarily public fleets and support the development of emerging low-pollution technologies. Between 2007 and 2010, a combination of new pollution control technology, such as catalyzed particulate filters and ultralow sulfur diesel, and significantly more stringent standards for $PM_{2.5}$ and nitrogen oxides led to reduced emissions of air pollutants in new school buses manufactured after that point (Adar et al. 2015). A recent study found that student attendance rates in schools that were awarded newer, cleaner buses from the DERA program significantly increased as compared to those at schools that were not selected, reinforcing the positive impact that safe, clean transportation to school has on student performance and attendance (Pedde et al. 2023).

HOW WE DETERMINED THE NUMBER OF OLDEST AND MOST POLLUTING SCHOOL BUSES

WRI's US school bus fleet dataset was utilized to identify areas and communities with the oldest and most polluting school buses (Lazer et al. 2022). This dataset contains detailed information on the composition of school bus fleets in the United States. The dataset contains data from 46 states and the District of Columbia, with information including the school district that the school bus serves and its model year, fuel type, manufacturer, seating capacity, and ownership model.

This dataset has three limitations. The first is missing data from four states (Colorado, Hawaii, Louisiana, and New Hampshire) and all US territories (American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the US Virgin Islands). The second limitation results from methodological and structural differences between a state's original dataset. For example, each state's dataset contained different fields and different sets of allowed values within multiple-choice fields; therefore, some of the data are not directly comparable between states. WRI researchers compiled the dataset by submitting records requests to state governments and harmonized and combined those state-level datasets to the best of their ability. Most original datasets from state governments (40) were structured at the

bus level, but some (7) were structured at the school district level and could not be disaggregated to the bus level. All of those raw state datasets included buses that were owned by school districts, and only some also included buses that were owned by private fleet operators. For states with datasets that only included buses that were owned by school districts, the number and percentage of diesel buses is likely an undercount because private fleet operators probably own additional buses. The extent of this undercount would vary by state because there is a wide range in the percentage of a state's buses owned by school districts versus private fleet operators. For example, Wyoming included only school buses owned by school districts, and Maryland and New York included buses owned by both school districts and contractors (often referred to as "private fleet operators"). Lastly, it is not known which pre-2010 diesel buses were retrofitted with low-pollution technologies. All buses are treated the same in terms of how much pollution they produce, even though that may not always be the case when retrofits are applied.

This analysis includes both known and assumed diesel buses. *Known* refers to buses where the dataset indicates that the bus predates 2010 and the fuel type is diesel. *Assumed* refers to buses where the dataset indicates that the bus predates 2010, but the fuel type is unknown.

We have assumed that buses of unknown fuel type run on diesel because industry sources indicate that diesel buses make up over 90 percent of the US school bus fleet. This is almost certainly a small overestimate of the number of diesel buses because most states have at least a small percentage of other fuel types. However, this assumption is useful because it enabled us to include 14 additional states and gave us a much broader picture of the likely distribution of pre-2010 diesel buses across the United States. For states where we had data about a bus's fuel type but not age, we did not make any assumptions about the bus age to include in the analysis because age distributions of buses vary significantly; therefore, they were excluded from the analysis.

NUMBER AND DISTRIBUTION OF PRE-2010 DIESEL SCHOOL BUSES

At the national level, we identified a total of 69,561 known pre-2010 diesel buses and another 47,081 assumed pre-2010 diesel buses. The known 69,561 diesel-powered school buses from 2009 or earlier were located in 24 states and the District of Columbia. Table 1 contains all states with any known or assumed pre-2010 diesel buses, ranked by the share of pre-2010 diesel buses in the state's total school bus fleet.

Pre-2010 diesel school buses are a significant share of buses transporting students. They make up a quarter of the national school bus fleet. Looking at the share of a state's fleet that consists of pre-2010 diesel buses, the top five states are Oklahoma (75 percent), Idaho (55 percent), Oregon (52 percent), Kansas (45 percent), and South Dakota (43 percent). Nineteen states, or over a third of all US states, have school bus fleets that consist of one-quarter or more pre-2010 diesel buses (Figure 1).

TABLE 1 | Percentage of state fleets that are pre-2010 diesel buses

RANK BY PERCENT	STATE	NUMBER OF PRE-2010 DIESEL SCHOOL BUSES	TOTAL SCHOOL BUSES[a]	PERCENT OF ALL BUSES THAT ARE PRE-2010 DIESEL BUSES	KNOWN OR ASSUMED PRE-2010 DIESEL BUSES?	SOURCE(S) OF SCHOOL BUS DATA
1	Oklahoma	7,344	9,779	75	Assumed	School districts and private fleet operators
2	Idaho	1,567	2,866	55	Known	School districts and private fleet operators
3	Oregon	2,726	5,250	52	Assumed	Unknown
4	Kansas	1,678	3,711	45	Known	School districts and private fleet operators
5	South Dakota	930	2,138	43	Known	School districts and private fleet operators
6	California	6,127	14,241	43	6,126 known, 1 assumed	School districts and private fleet operators
7	Virginia	6,571	15,958	41	Known	School districts
8	Georgia	9,459	23,356	40	Known	Unknown
9	Texas	18,447	51,148	36	Assumed	School districts and private fleet operators
10	North Carolina	3,719	10,917	34	Known	School districts
11	Washington	3,056	9,083	34	3,054 known, 2 assumed	Unknown
12	Kentucky	3,829	11,683	33	Assumed	School districts
13	Florida	7,623	24,648	31	Known	Unknown
14	Montana	795	2,850	28	792 known, 3 assumed	School districts and private fleet operators
15	Utah	1,243	4,716	26	Known	Unknown
16	North Dakota	491	1,867	26	Known	School districts and private fleet operators
17	Arizona	1977	7,796	25	Known	Unknown
18	South Carolina	1,407	5,652	25	Assumed	Unknown
19	Alabama	2,539	10,216	25	Known	School districts and private fleet operators
20	Wyoming	447	1,936	23	Assumed	School districts
21	Iowa	1,561	6,955	22	Known	School districts and private fleet operators
22	West Virginia	997	4,708	21	Known	Unknown
23	Ohio	5,401	26,063	21	5,354 known, 47 assumed	School districts and private fleet operators
24	New Jersey	3,160	15,703	20	Known	School districts and private fleet operators

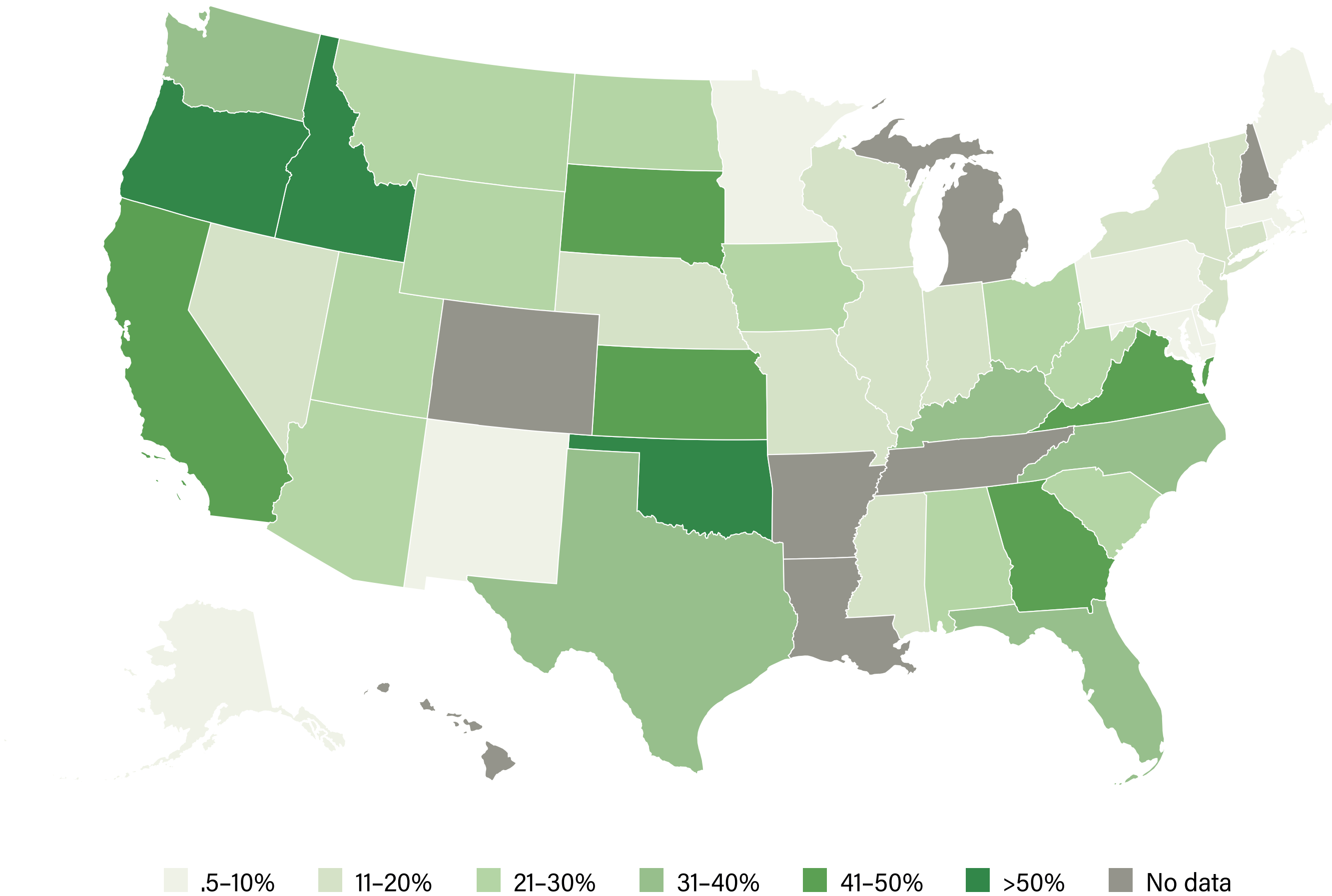
TABLE 1 | Percentage of state fleets that are pre-2010 diesel buses (cont.)

RANK BY PERCENT	STATE	NUMBER OF PRE-2010 DIESEL SCHOOL BUSES	TOTAL SCHOOL BUSES[a]	PERCENT OF ALL BUSES THAT ARE PRE-2010 DIESEL BUSES	KNOWN OR ASSUMED PRE-2010 DIESEL BUSES?	SOURCE(S) OF SCHOOL BUS DATA
25	Missouri	3,011	15,375	20	3,009 known, 2 assumed	School districts and private fleet operators
26	Connecticut	956	5,014	19	Known	School districts and private fleet operators
27	Vermont	327	1,755	19	Known	School districts and private fleet operators
28	Wisconsin	2,664	14,582	18	Assumed	School districts and private fleet operators
29	Nebraska	630	3,599	18	Known	School districts and private fleet operators
30	Indiana	2,718	17,365	16	Assumed	School districts and private fleet operators
31	Nevada	610	3,993	15	Assumed	Unknown
32	New York	4,827	36,885	13	Known	School districts and private fleet operators
33	Illinois	3,177	27,522	12	Assumed	School districts and private fleet operators
34	Mississippi	1,078	10,191	11	Assumed	School districts and private fleet operators
35	Pennsylvania	2,506	25,135	10	Assumed	School districts and private fleet operators
36	Alaska	106	1,361	8	Known	School districts and private fleet operators
37	Maine	224	3,462	6	Known	Unknown
38	Washington, DC	10	230	4.3	Known	Unknown
39	Massachusetts	308	8,049	3.8	Known	School districts and private fleet operators
40	New Mexico	94	4,640	2	Known	School districts and private fleet operators
41	Delaware	45	2,956	1.5	Known	School districts and private fleet operators
42	Maryland	162	12,614	1.3	Known	School districts and private fleet operators
43	Rhode Island	20	2,173	0.8	18 known, 2 assumed	Private fleet operators
44	Minnesota	71	15,432	0.5	Assumed	School districts

Notes: Known refers to buses where the dataset indicates that the bus predates 2010 and the fuel type is diesel. *Assumed* refers to buses where the dataset indicates that the bus predates 2010 but the fuel type is unknown..

Source: a. Atlas EV Hub 2019.

FIGURE 1 | Percentage of state fleets that are pre-2010 diesel buses

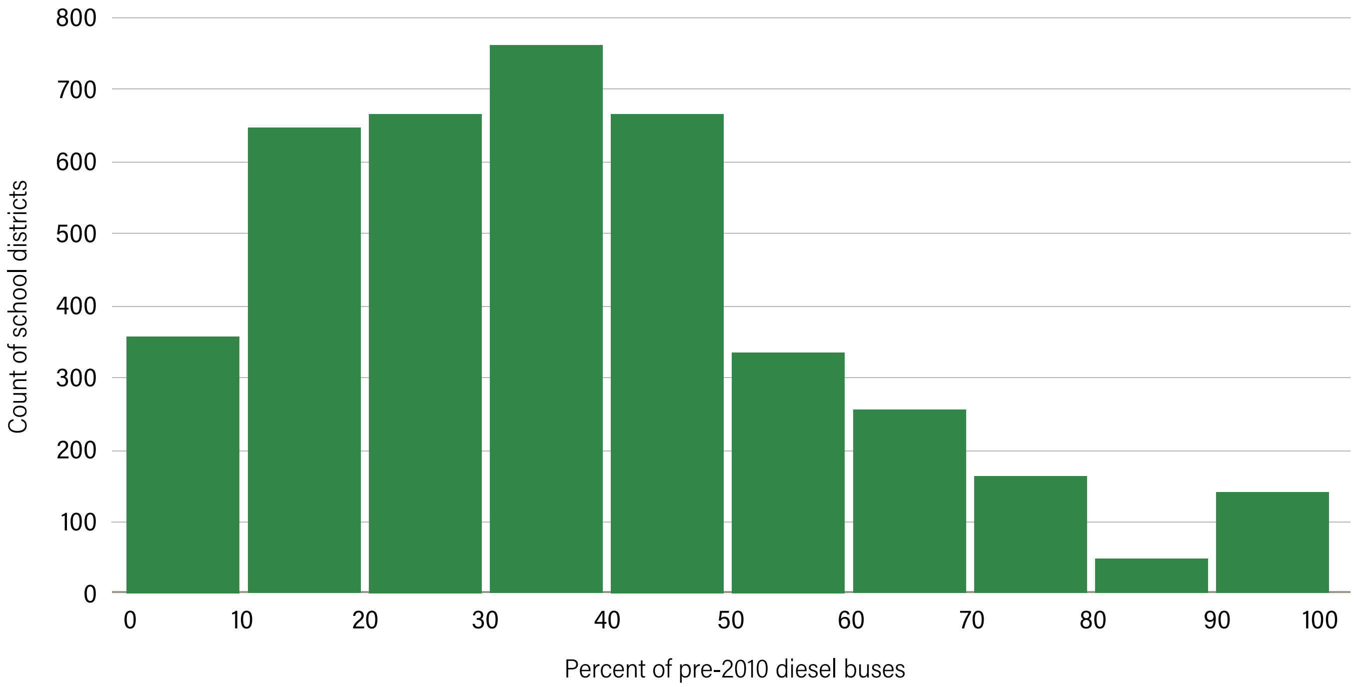


Source: Lazer et al. 2022..

Figure 2 below shows the distribution of pre-2010 diesel buses in terms of their share within school district school bus fleets in our dataset. In over two-thirds of these school districts, the share of pre-2010 diesel buses in school bus fleets ranges from 10 percent to 50 percent, and in 4 percent of these school districts, pre-2010 diesel buses account for 80 percent or more of their bus fleets. This small percentage of school districts with a large share of pre-2010 diesel school buses are rural school districts with only a few buses in their fleets. This is discussed further in this section.

> Pre-2010 diesel school buses are a significant share of buses transporting students. They make up a quarter of the national school bus fleet.

FIGURE 2 | Distribution of pre-2010 diesel buses across school districts



Source: Lazer et al. 2022.

DISTRIBUTION OF PRE-2010 DIESEL BUSES AMONG SCHOOL DISTRICTS OF DIFFERENT INCOME, POVERTY, AND RACE AND ETHNICITY CHARACTERISTICS

Next, we focused our analysis on school districts with local education agency identification (LEAID) numbers. These LEAIDs enabled us to link WRI's US school bus fleet dataset to other datasets with socioeconomic and demographic characteristics of the residents and students. These datasets include WRI's ESB adoption dataset, which includes 13,049 school districts for which we have compiled statistics on population, race, income, and air quality indicators from the EPA's environmental justice screening and mapping tool (EJScreen), the American Community Survey, and PLACES by the Centers for Disease Control and Prevention (CDC).

Schools and other users without LEAIDs were excluded from the analysis. This included private and specialty school users, such as religious schools or early learning centers. The socioeconomic and demographic variables in the ESB adoption dataset were based on data from the EPA's EJScreen tool, which collects data from various sources, including the US census. Census block groups were associated with a school district (LEAID) based on the Geographic Relationship Files published by the National Center for Education Statistics. All variables were calculated as the population-weighted average of the values for all census block groups within the school district's geographic boundaries for which data were available. If a census block group was included in multiple school districts, it was included in the averages for all of those school districts.

The final sample contains 4,042 school districts that have LEAIDs and one or more pre-2010 diesel buses, with a total of 58,637 pre-2010 diesel buses. Of those, a total of 6,322 were pre-2000 diesel buses.

Our analysis revealed that pre-2010 diesel buses, which produce more air pollution than newer buses or other fuel types, are disproportionately concentrated in school districts with lower income levels and higher shares of minority residents.

This finding holds true whether looking at various income measurements—such as low-income households, poverty level, and median household income—or an aggregated percentage of minority residents or disaggregated racial and ethnic groups.

This trend is magnified for school bus fleets with the highest shares of pre-2010 diesel buses. Fleets with the highest shares of these older school buses are present in districts with the lowest income levels and the highest shares of racial minority residents. This means that under-served communities are more likely to be exposed to dangerous air pollution from older diesel school buses, exemplifying environmental injustices that have been documented across issue areas and underscoring the need for an equitable transition to ESBs. The following section presents these trends.

For our analysis, we first divided school district distributions on each indicator of interest into four equal parts, or quartiles. Specifically, we looked at the school district distributions of households below the poverty line, low-income households, the median household income, the percentage of minority residents, $PM_{2.5}$ and ozone exposure levels, and whether the school district is above or below the median for the presence of a specific racial or ethnic group. These indicators are featured in the EPA's EJScreen tool to identify a community's potential susceptibility to environmental burdens.

When discussing these results throughout this section, the "highest shares" represent the top, or fourth, quartile, and the "lowest shares" represent the first quartile. Using the low-income household metric as an example for interpretation, school districts in the first quartile of the distribution have the lowest shares of households classified as being low income, and school districts in the fourth quartile have the highest shares of low-income households. The same can be said for the share of minority residents within school districts. School districts in the first quartile of the distribution have the lowest shares of minority residents, and school districts in the fourth quartile have the highest shares of minority residents.

We then looked at the number and share of pre-2000 and pre-2010 diesel school buses within each quartile of each EJScreen indicator distribution. We analyzed school bus fleets consisting of at least 10 percent, 25 percent, or 50 percent or more pre-2010 diesel buses, and we studied their distribution among school districts based on similar income and race characteristics.

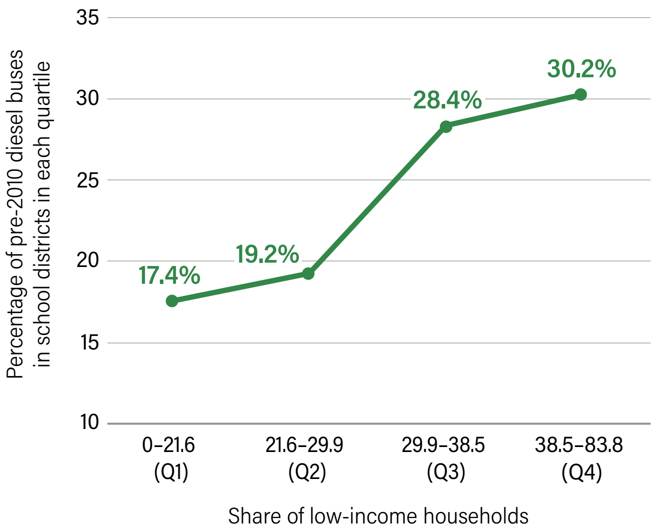
Low-income households

The share of low-income households was the first of three income inequality measurements included in our analysis, with the other two being poverty and median household income, both discussed later in this section. These various measurements of income inequality can often result in different national statistics used to illustrate poverty in the United States. We included each measurement to investigate the strength of the relationship between older diesel buses and communities with more overall income inequality. The EPA's EJScreen defines a low-income household as having a household income less than twice the federal poverty level.

Pre-2010 diesel school buses are disproportionately concentrated in school districts with more low-income households.

As you can see in Figure 3, pre-2010 diesel school buses are mostly concentrated in districts with more low-income households. Thirty percent of pre-2010 diesel school buses are located in districts with the highest shares of low-income households (Figure 3). Only 17 percent of pre-2010 diesel school buses are in districts with the lowest share of low-income households.

FIGURE 3 | Distribution of pre-2010 diesel school buses across districts by their share of low-income households



Note: Data missing for 4.8 percent of districts.
Source: WRI authors.

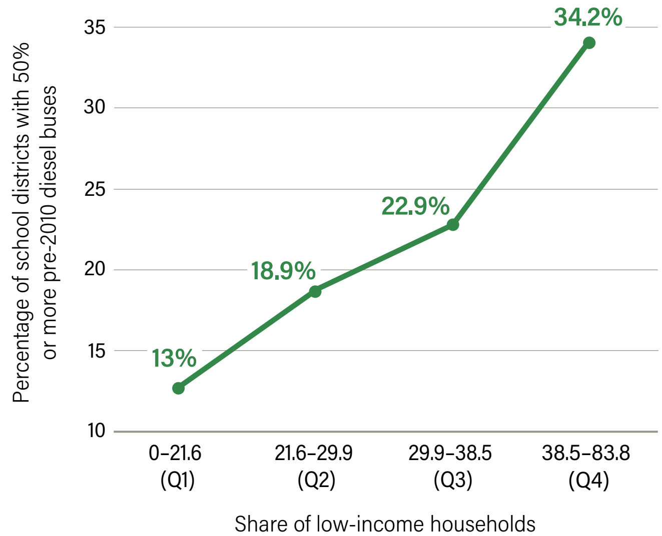
This share increases as we look at older buses. Thirty-six percent of pre-2000 diesel school buses are in districts with the highest shares of low-income households, and only 12 percent are in districts with the lowest shares of low-income households.

The pattern of pre-2010 diesel buses being concentrated in areas with relatively larger shares of low-income households also exists when we look at the composition of school bus fleets.

> *School bus fleets consisting of 50 percent or more pre-2010 diesel school buses are disproportionately located in districts with more low-income households.*

For example, as you can see in Figure 4, 34 percent of school districts with half or more of their school bus fleets composed of pre-2010 diesel school buses are districts with the highest shares of low-income households. Only 13 percent of districts in which 50 percent or more of their fleets are composed of pre-2010 diesel school buses are districts with the lowest shares of low-income households (Figure 4).

FIGURE 4 | Distribution of districts with 50 percent or more pre-2010 diesel school buses in their fleets by their share of low-income households



Note: Data missing for 11 percent of districts.
Source: WRI authors.

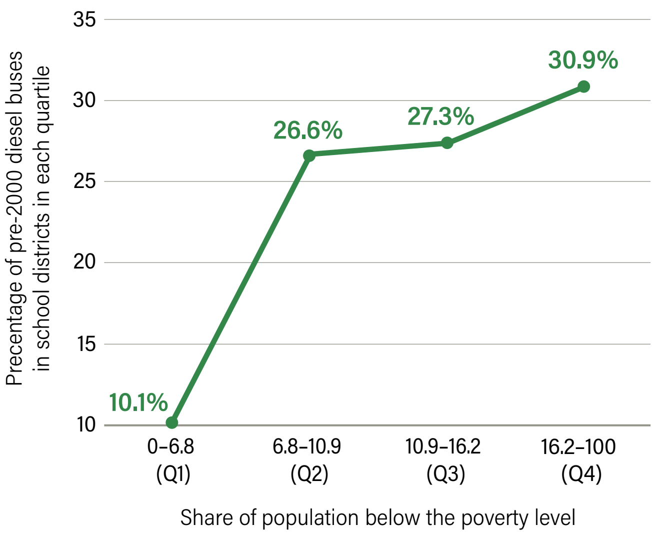
Poverty

The federal poverty level is the amount of annual income earned by a household, below which they would be eligible to receive certain programs and benefits. The poverty level varies by size of household members but does not vary geographically across the 48 contiguous states and the District of Columbia. For example, in 2022, people were considered to live below the poverty level if their individual income was below $13,590 or their household income was below $27,750 for a family of four.

> *Pre-2010 diesel school buses are disproportionately concentrated in school districts with higher shares of the population living below the poverty level.*

Twenty-four percent of pre-2010 diesel buses are located in school districts with the highest shares of residents living below the poverty level. This is compared to only 15 percent of pre-2010 diesel buses located in school districts with the lowest shares of residents living below the poverty level.

FIGURE 5 | Distribution of pre-2000 diesel school buses across districts by the population living below the poverty level



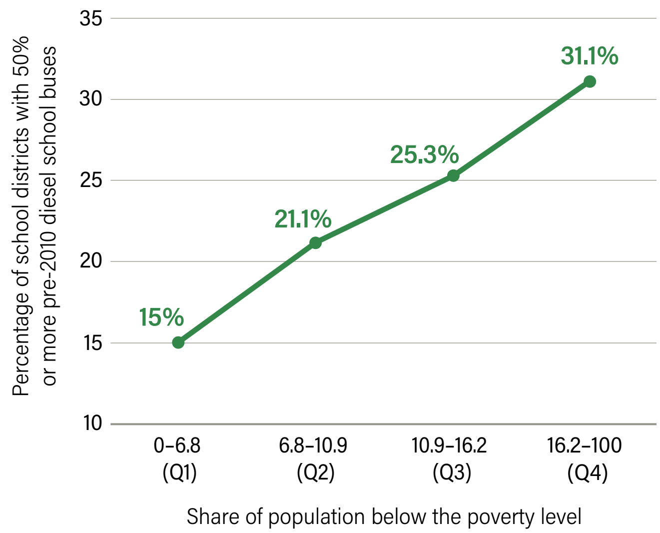
Note: Data missing for 5.1 percent of districts.

Source: WRI authors.

This trend becomes more pronounced as we look at older buses. As you can see in Figure 5, 31 percent of pre-2000 diesel buses are located in school districts with the highest shares of residents living below the poverty level. Only 10 percent of pre-2000 diesel buses are in school districts with the lowest shares of residents living below the poverty level (Figure 5).

The pattern of pre-2010 diesel buses being concentrated in school districts with larger shares of residents living below the poverty level also exists when we look at the composition of school bus fleets. For example, 31 percent of school districts with half or more of their school bus fleets composed of pre-2010 diesel school buses are districts with the highest shares of residents living below the poverty level. Only 15 percent of such school bus fleets are in districts with the lowest shares of residents living below the poverty level (Figure 6).

FIGURE 6 | Distribution of districts with 50 percent or more pre-2010 diesel school buses in their fleets by their share of the population living below the poverty level



Note: Data missing for 7.5 percent of districts.

Source: WRI authors.

Median household income

For households, the median household income is based on the income distributions of all households, including those with no income. The median divides the income distribution into two equal parts, with half of the cases falling below the median income and the other half above the median. The median US household income in 2022 was $74,580.

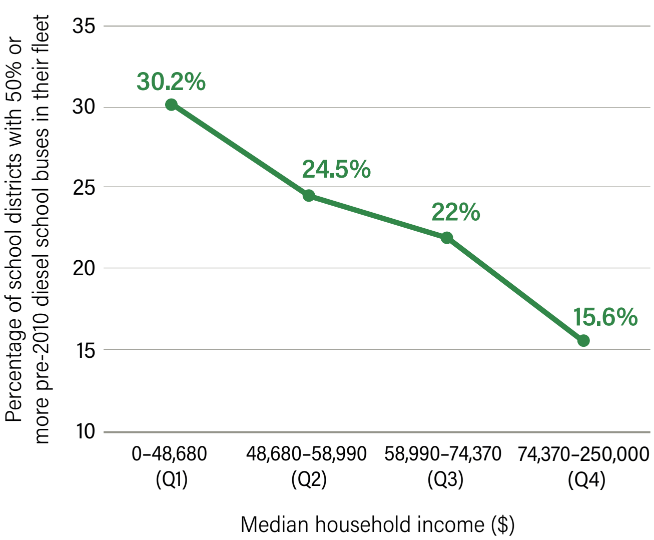
The numbers of pre-2000 and pre-2010 diesel school buses were evenly spread across school districts in terms of median household income. However, it should be noted that school districts with higher median household incomes can still have a relatively large share of low-income households and/or residents living below the poverty level. For example, a household in the San Francisco Bay Area can have a household income well above the national median but still meet federal definitions for poverty level and/or consideration as a low-income household. Equity implications are clearer when we look at the composition of school bus fleets.

> *School bus fleets with half or more pre-2010 diesel school buses are disproportionately concentrated in districts with the lowest median household incomes.*

In Figure 7, 30 percent of school districts in which pre-2010 diesel buses compose half or more of their bus fleets are districts with the lowest median household incomes, compared to 16 percent in school districts with the highest median household incomes (Figure 7). This trend continues when lowering the threshold to school districts that have bus fleets consisting of 25 percent or more pre-2010 diesel school buses. Twenty-eight percent of these bus fleets are in areas with the lowest median household incomes, compared to 17 percent in districts with the highest median household incomes.

This finding is in line with discussions above, where school districts with bus fleets composed of a higher share of pre-2010 diesel buses are overrepresented in areas with more low-income households and residents below the poverty level.

FIGURE 7 | Distribution of districts with 50 percent or more pre-2010 diesel school buses in their fleets by median household income



Note: Data missing for 7.7 percent of districts.

Source: WRI authors.

Despite the differences in the levels of these income measurements, the trends from our three analyses are consistent, indicating a strong relationship between the use of older diesel school buses and a community's socioeconomic status, meaning low-income students are more likely to be exposed to dangerous diesel exhaust pollution from older school buses compared to non-low-income students.

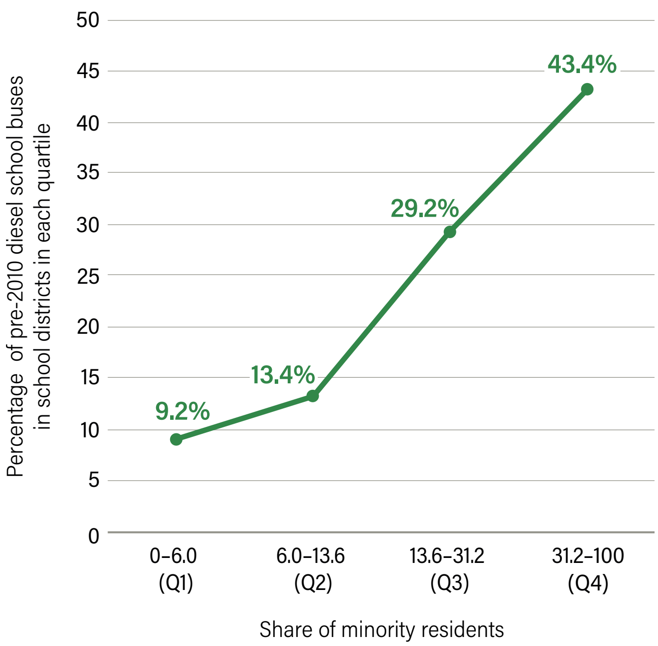
Racial composition

According to the US census, a person identifying as anything other than non-Hispanic white is considered a racial minority. We looked at the distribution of school districts with pre-2010 diesel buses in terms of their racial composition by the percentage of racial minority residents.

> *Pre-2010 diesel school buses are disproportionately concentrated in school districts with the highest shares of minority residents.*

In Figure 8, 43 percent of pre-2010 diesel school buses are in school districts with the highest shares of minority residents. This is compared to only 9.2 percent of pre-2010 diesel school buses operating in districts with the lowest shares of minority residents. This trend continues as buses age. Forty-nine percent of pre-2000 diesel buses are in school districts with the highest shares of minority residents compared to only 8 percent of such buses in districts with the lowest shares of minority residents.

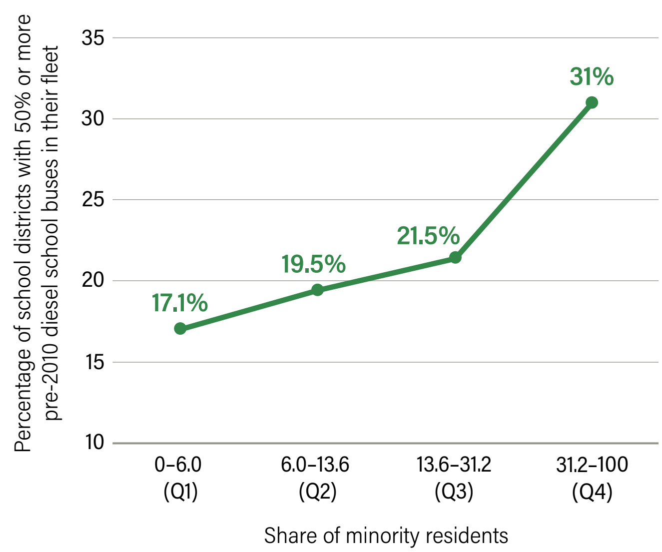
FIGURE 8 | Distribution of pre-2010 diesel school buses across districts by their share of minority residents



Note: Data missing for 4.8 percent of districts.

Source: WRI authors.

FIGURE 9 | Distribution of districts with 50 percent or more pre-2010 diesel school buses in their fleets by their share of minority residents



Note: Data missing for 10.9 percent of districts.

Source: WRI authors.

This pattern continues when we look at the composition of school bus fleets. Thirty-one percent of school districts with 50 percent or more of their fleets consisting of pre-2010 diesel school buses are districts with the highest shares of minority residents. Only 17 percent of such bus fleets are in districts with the lowest shares of minority residents (Figure 9).

> Low-income students are more likely to be exposed to dangerous diesel exhaust pollution from older school buses compared to non-low income students.

To further investigate these trends, our analysis examined the distribution of pre-2010 diesel school buses across school districts in terms of their share of disaggregated race and ethnicity categories within school district populations. Race and ethnicity categories from the American Community Survey were used for this analysis because EJScreen data do not disaggregate by race and ethnicity categories. This disaggregation is important to uncover further inequities that different racial or ethnic groups face; research demonstrates that race is the strongest predictor of environmental pollution exposure in the United States (Liu et al. 2021). Understanding the specific disparities and needs of racial and ethnic groups can also support the design of tailored assistance to meet community needs.

We looked at how the concentration of pre-2010 diesel school buses varies between school districts where the share of different race and/or ethnicity groups is above or below the national median. We took this approach instead of dividing school district distributions into quartiles because some racial and ethnic groups made up a very small share of the population distribution of many school districts. Because of this, there would be very small differences between the quartile distributions and therefore difficulty in deriving meaningful findings or disproportionalities.

A higher share of pre-2010 diesel school buses are in school districts that are above the median in terms of their percentage of residents who identify as nonwhite (Table 2). Seventy-five percent of pre-2010 diesel school buses are in school districts that are above the median for the percentage of the population identifying as Black or African American. Seventy-two percent of pre-2010 diesel school buses are in school districts that are above the median for the percentage of the population identifying as some other race. Seventy-one percent of pre-2010 diesel school buses are in school districts that are above the median for the percentage of the population identifying as Asian. This trend continues for those identifying as Hispanic or Latino (68 percent), two or more races (65 percent), and American Indian/Alaska Native/Native Hawaiian/other Pacific Islander (55 percent).

TABLE 2 | Distribution of pre-2010 diesel buses across school districts disaggregated by race and ethnicity

RACE/ETHNICITY	PERCENTAGE OF PRE-2010 DIESEL BUSES IN SCHOOL DISTRICTS ABOVE THE MEDIAN FOR EACH RACIAL AND ETHNIC CATEGORY
Black or African American	75
Some other race	72
Asian	71
Hispanic or Latino (of any race)	68
Two or more races	65
American Indian/Alaska Native/Native Hawaiian/other Pacific Islander	55
White	22

Source: WRI authors.

Only 22 percent of pre-2010 diesel school buses are in school districts that are above the median for the percentage of the population identifying as white. This analysis demonstrates that the disparity among pre-2010 diesel school buses between white and minority school districts persists across all racial minority and ethnic groups.

DISTRIBUTION OF PRE-2010 DIESEL BUSES AMONG SCHOOL DISTRICTS OF DIFFERENT AIR QUALITY AND ASTHMA RATES

In addition to the above demographic characteristics, we assessed how the distribution of older diesel buses varies according to air quality and asthma indicators for school districts. These included $PM_{2.5}$ and ozone levels as well as the share of the adult population with asthma. We used adult asthma data as a proxy because childhood asthma rates at the census tract level were not available for most districts.

We assessed how the distribution of older diesel school buses varies according to air quality and asthma indicators for school districts to understand whether students in districts with worse ambient air quality are also more likely to be exposed to a polluted bus ride to and from school. Exposure to air pollution can greatly increase asthma symptoms and worsen health outcomes for adults and children living with asthma. Traffic-related air pollution is also a significant risk factor for asthma development in children (Tiotiu et al. 2020). More than half of children who have asthma will have symptoms persisting through adulthood.

School buses are only a small contributor to a region's overall air quality, but understanding these patterns helps reveal if students in areas with poor air quality from various emissions sources are also exposed to toxic exhaust from their school bus.

Minority residents and those with low incomes are more likely to live in communities with unhealthy levels of $PM_{2.5}$ and ozone and to face a higher risk of death from $PM_{2.5}$ exposure (Jbaily et al. 2022). Historically, these communities also receive less investment in sustainable infrastructure and low- to zero-emissions technological interventions (Tessum et al. 2021). Therefore, exposure to emissions from the transportation sector, industrial facilities, and other sources is compounded, putting student academic achievement at risk and creating additional health challenges in already overburdened communities.

$PM_{2.5}$

The EPA's EJScreen defines the $PM_{2.5}$ indicator as the annual average $PM_{2.5}$ levels in the air. This is measured in terms of annual average concentration in air measured in micrograms per cubic meter. Particulate matter contains microscopic solids or liquid droplets that can be inhaled and cause health harms. Particles less than 2.5 micrometers in diameter, or $PM_{2.5,}$ pose the greatest health risks (EPA 2016). The $PM_{2.5}$ indicator in EJScreen is a measure of potential exposure but not a measure of risk.

In general, there were no clear disparities found between school districts with higher $PM_{2.5}$ levels and the number of older diesel school buses. Only 20 percent of pre-2010 diesel school buses are in districts with the highest levels of $PM_{2.5,}$ and 12 percent are in districts with the lowest levels of $PM_{2.5}$. The majority of pre-2010 diesel school buses are in districts around the median of the distribution, or the middle two quartiles, of exposure. The pattern is similar for school districts consisting of 25 percent or more and 50 percent or more pre-2010 diesel buses in their bus fleets, which show relatively similar values across exposure levels.

Ozone

The EPA's EJScreen defines the ozone indicator as the average of the annual top 10 daily maximum eight-hour ozone concentrations in air. The ozone indicator in EJScreen is a measure of potential exposure but not a measure of risk.

Ground-level ozone is not directly emitted into the air from school buses but is created by chemical reactions in the presence of heat and sunlight between nitrogen oxides and volatile organic compounds. Breathing ozone can harm the health of students riding the bus, especially those with asthma. It can also travel long distances through the air and put wider communities at risk (EPA 2015b).

We found a greater concentration of pre-2010 diesel buses in school districts with relatively lower levels of ozone pollution. Nineteen percent of pre-2010 diesel school buses are in school districts with the highest levels of ozone pollution, whereas 38 percent are in districts with the lowest levels of ozone pollution.

The trends were a bit different when looking at the composition of school bus fleets. Thirty-two percent of school districts with 50 percent or more of their fleet composed of pre-2010 diesel school buses are districts with the highest levels of ozone pollution. This is compared to 22 percent of such fleets in districts with the lowest levels of ozone pollution.

When narrowing the criteria, 28 percent of school districts with 25 percent or more of their fleet composed of pre-2010 diesel school buses are in districts with the highest levels of ozone pollution. This is compared to 22 percent of such fleets in districts with the lowest levels of ozone pollution.

These initial results from the analysis suggest that those living in districts with higher levels of ozone pollution could be more impacted by concentrated school bus fleets made up of older diesel buses than the absolute number of such buses.

Asthma

In terms of adult asthma rates, we see that pre-2010 diesel buses are quite evenly distributed across school districts with different levels of the adult population with asthma. However, the trend changes slightly when looking at the composition of bus fleets. The highest concentration of school districts with fleets consisting of 25 percent or more pre-2010 diesel buses and 50 percent or more pre-2010 diesel buses are districts with higher levels of the adult population with asthma.

Similar to our findings between ozone and the distribution of pre-2010 diesel school buses, these initial results suggest that those living in communities with higher levels of asthma burdens could be more impacted by concentrated school bus fleets made up of older diesel buses than the absolute number of such buses.

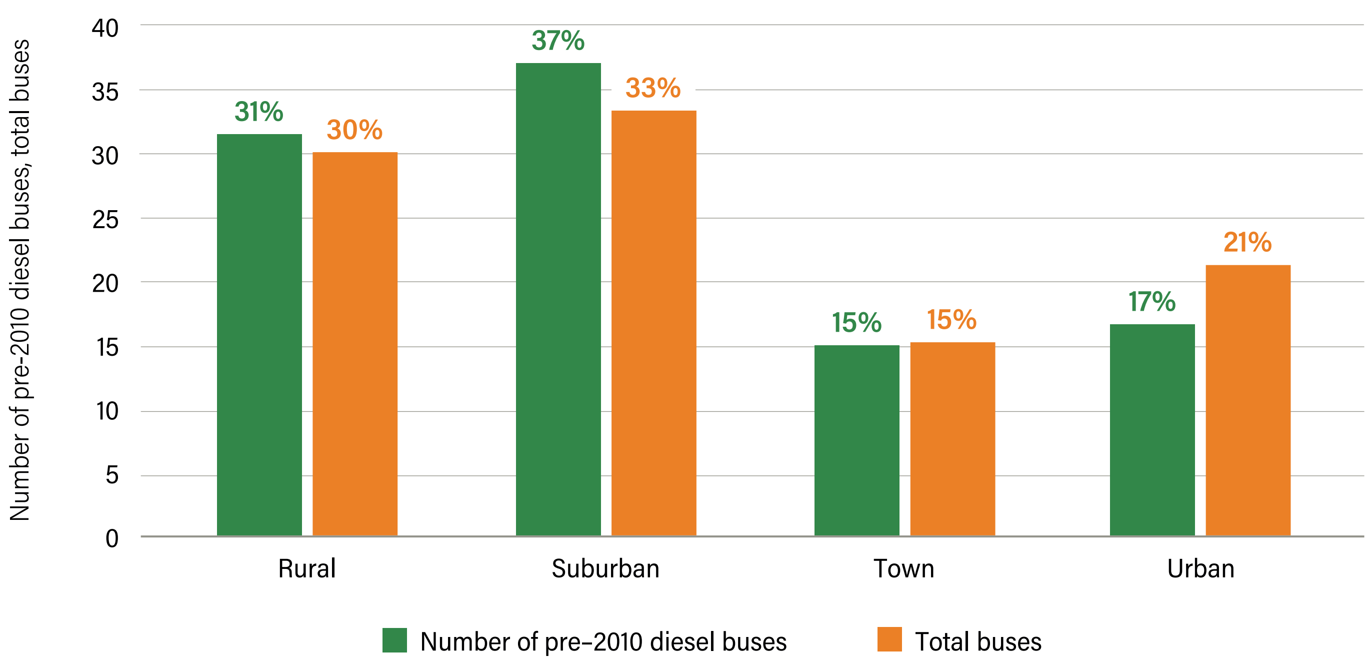
DISTRIBUTION OF PRE-2010 DIESEL BUSES AMONG URBAN, SUBURBAN, TOWN, AND RURAL SCHOOL DISTRICTS

Lastly, in this section we looked at the distribution of pre-2010 diesel buses among urban, suburban, town, and rural school districts. Locale is important to consider when studying the distribution of pre-2010 diesel buses because it reveals additional equity intersections between a child's exposure to air pollution and their academic and health outcomes.

For example, research shows that rural students are more likely to ride the school bus due to limited transportation options and have the longest commute times to school (Lidbe et al. 2020). In urban school districts, where longer commutes are less common, those with the longest school bus rides are disproportionately Black (Cordes et al. 2022). These long commutes extend the length of the school day for many rural and urban students and are associated with increased absenteeism, which affects the ability of a student to perform well in school and participate in extracurriculars and other activities (Pedde et al. 2023). Riding on a pre-2010 diesel bus with high levels of harmful tailpipe emissions may increase these disparities, and many children in rural areas lack access to other transportation options. Distribution by locale can also provide insights into areas that have a disproportionate number of older buses and areas where bus fleets have been upgraded, raising equity considerations and highlighting future topics of study.

Looking at the distribution of pre-2010 diesel school buses by locale, rural (31 percent) and suburban (37 percent) areas each accounted for about one-third of the total, and urban (17 percent) areas and towns (15 percent) each accounted for roughly one-sixth. This very closely mirrors the national distribution of all school buses among locales: suburban districts have the most school buses (34 percent), followed by rural areas (30 percent), whereas 21 percent and 15 percent of school buses are in urban areas and towns, respectively (Figure 10).

FIGURE 10 | Distribution of pre-2010 diesel buses by locale



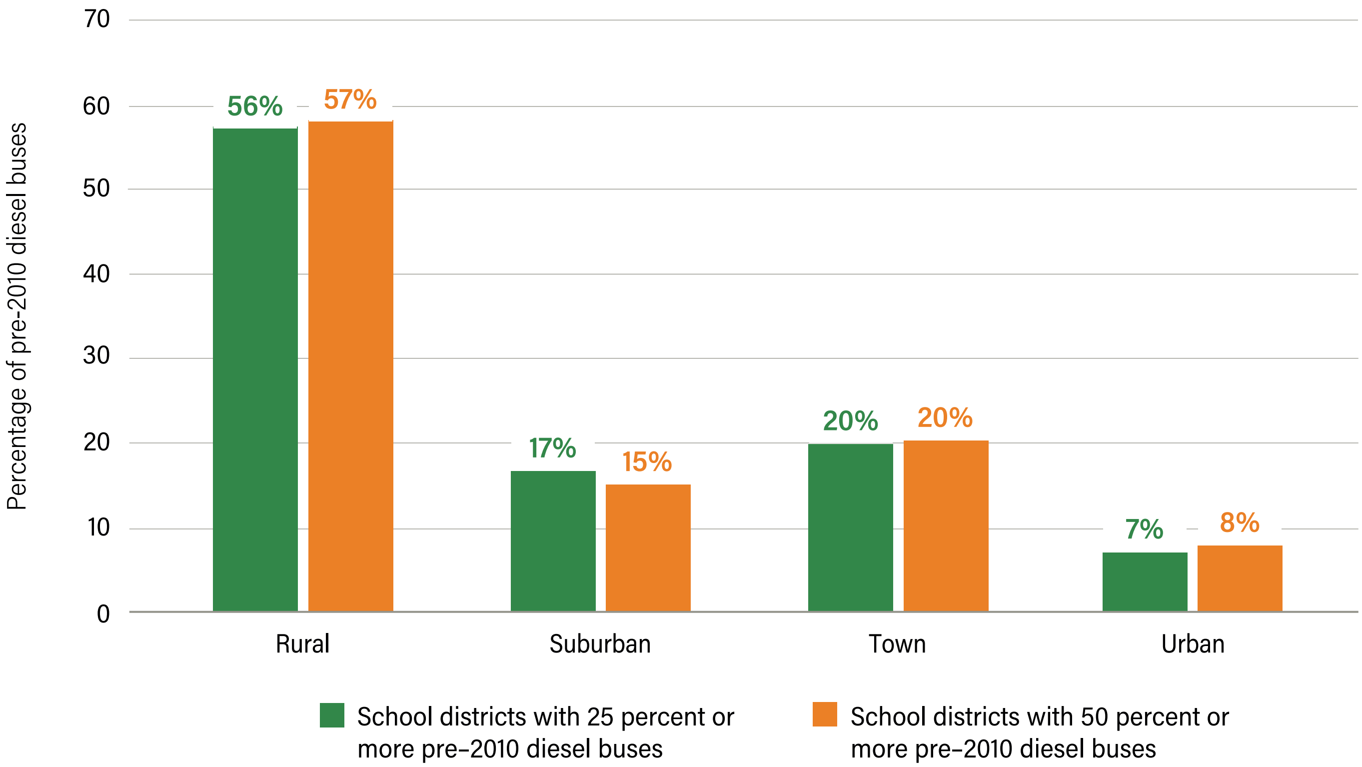
Source: WRI authors

However, pre-2010 diesel buses become disproportionately concentrated in rural areas when looking at the locale of districts that have a high share of pre-2010 diesel buses in their fleets (Figure 11).

> *School bus fleets comprising more pre-2010 diesel school buses are disproportionately concentrated in rural school districts.*

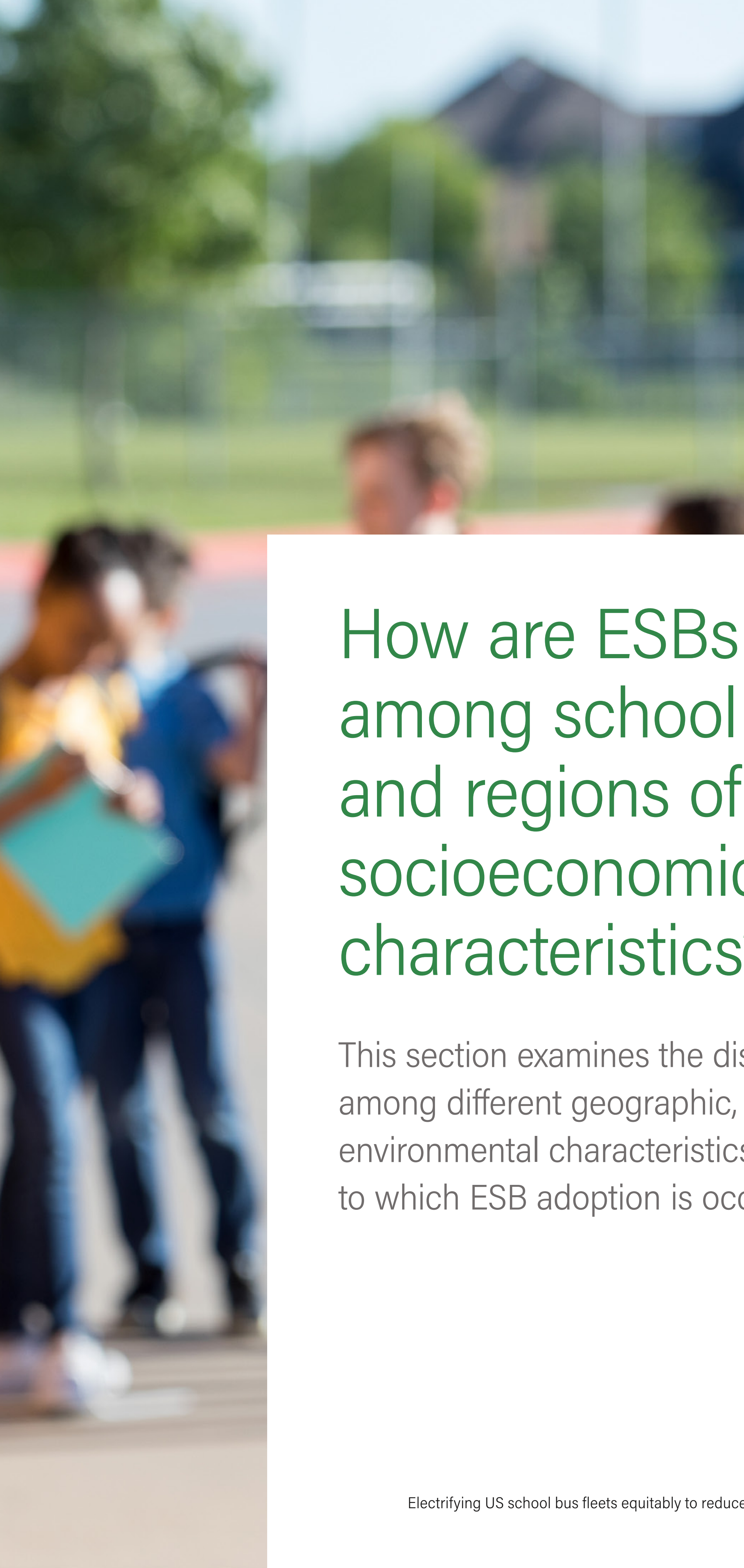
More than half of all school districts (57 percent) with pre-2010 diesel buses making up 50 percent or more of their bus fleets are rural school districts. This high share may be partly explained by the small fleet sizes in rural districts due to smaller student populations. More than half of the approximately 680 rural districts with bus fleets composed of 50 percent or more pre-2010 diesel buses have only 10 total buses or fewer, and over 200 school districts have 5 buses or fewer.

FIGURE 11 | Distribution of pre-2010 diesel buses by locale and size of fleet



Source: WRI authors


STOP



How are ESBs distributed among school districts and regions of differing socioeconomic characteristics?

This section examines the distribution of ESB adoption among different geographic, demographic, and environmental characteristics to determine the extent to which ESB adoption is occurring equitably.

We analyzed the distribution of ESBs across demographic and environmental indicators from the EPA's EJScreen (EPA 2023a), among school districts with different racial compositions based on the American Community Survey (US Census Bureau 2021), and among school districts with different levels of adult asthma levels from CDC PLACES (CDC 2022).

We used "committed" ESBs as our unit of analysis. An ESB is considered to be committed once a school district or other fleet operator is awarded funding for the bus and includes subsequent stages—namely, when the operator places an order for the bus, takes delivery of the bus, or is currently using the bus on regular routes. As of December 31, 2022, there were 5,612 committed ESBs across all 50 states, plus the District of Columbia, American Samoa, Guam, Puerto Rico, and the US Virgin Islands (Table 4). This count includes 21 ESBs in five Tribal schools (schools funded by the Bureau of Indian Education) and one private school operated by a Tribal Nation.

TABLE 4 | Number of committed ESBs by US state and territory

STATE OR US TERRITORY	NUMBER OF COMMITTED ELECTRIC SCHOOL BUSES (AS OF DECEMBER 31, 2022)	PERCENTAGE OF TOTAL FLEET THAT IS COMMITTED ELECTRIC SCHOOL BUSES
Alabama	54	0.5
Alaska	2	0.2
American Samoa	1	Not available
Arizona	37	0.6
Arkansas	11	0.2
California	1,852	9.3
Colorado	52	0.8*
Connecticut	73	0.8
Delaware	4	0.3
District of Columbia	25	3.7
Florida	261	1.5
Georgia	128	0.6
Guam	25	Not available
Hawaii	21	2.9*
Idaho	13	0.4
Illinois	214	1.0
Indiana	35	0.2
Iowa	31	0.5
Kansas	17	0.4
Kentucky	68	0.7
Louisiana	111	0.9*
Maine	45	3.0
Maryland	361	4.0
Massachusetts	123	1.5
Michigan	157	0.9
Minnesota	13	0.6
Mississippi	109	3.0
Missouri	66	0.5

TABLE 4 | Number of committed ESBs by US state and territory (cont.)

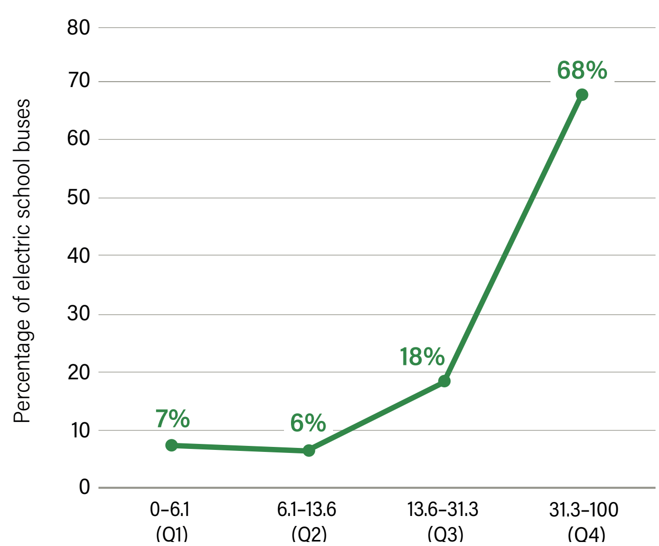
STATE OR US TERRITORY	NUMBER OF COMMITTED ELECTRIC SCHOOL BUSES (AS OF DECEMBER 31, 2022)	PERCENTAGE OF TOTAL FLEET THAT IS COMMITTED ELECTRIC SCHOOL BUSES
Montana	19	0.7*
Nebraska	6	0.2
Nevada	30	1.0
New Hampshire	11	0.3*
New Jersey	95	0.5
New Mexico	16	0.8
New York	310	0.7
North Carolina	85	0.7
North Dakota	7	0.3
Ohio	15	0.1
Oklahoma	76	0.8*
Oregon	34	0.5
Pennsylvania	131	0.9
Puerto Rico	25	Not available
Rhode Island	34	1.6*
South Carolina	172	3.0
South Dakota	9	0.3
Tennessee	45	0.5
Texas	140	0.3
US Virgin Islands	10	Not available
Utah	20	0.6
Vermont	21	1.2
Virginia	253	1.5
Washington	66	0.5
West Virginia	5	0.2
Wisconsin	65	0.6
Wyoming	3	0.2

Sources: Lazer et al. (2022), unless marked with an asterisk (*), in which case the source is Atlas EV Hub (2019).

DISTRIBUTION OF ESBS AMONG SCHOOL DISTRICTS WITH DIFFERENT RACE, ETHNICITY, AND POVERTY CHARACTERISTICS

Using EJScreen's "percent people of color" and "percent low-income" indicators, we found that many ESBs are committed in areas that have historically suffered environmental injustices (EPA 2023b). People of color are defined as individuals who identify as a race other than white alone and/or identify as Hispanic or Latino. Low-income households have an income that is less than or equal to twice the federal poverty level (EPA 2023c). Sixty-eight percent of committed ESBs are in districts with the highest shares of people of color (Figure 12), where more than 31 percent identified as people of color. Out of all school districts with ESBs, almost 50 percent are districts with the highest shares of people of color (Figure 13). Similarly, the highest concentration of ESBs (41 percent) (Figure 14) and school districts with ESBs (34 percent) are in areas with the most low-income residents (Figure 15).

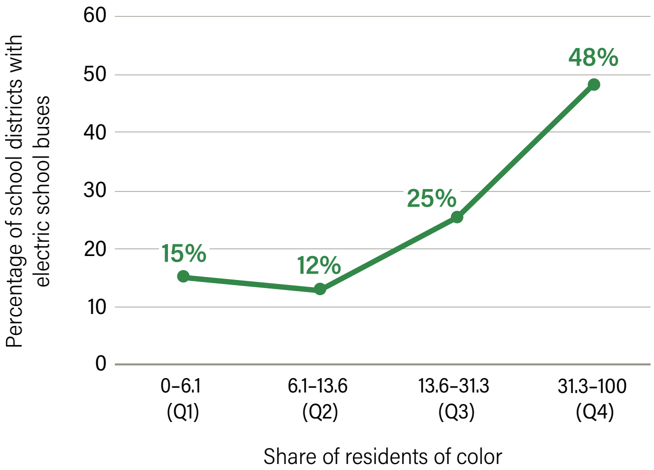
FIGURE 12 | Percentage of overall ESBs by share of residents of color



Note: Data missing for 12.3 percent of districts.

Source: WRI authors.

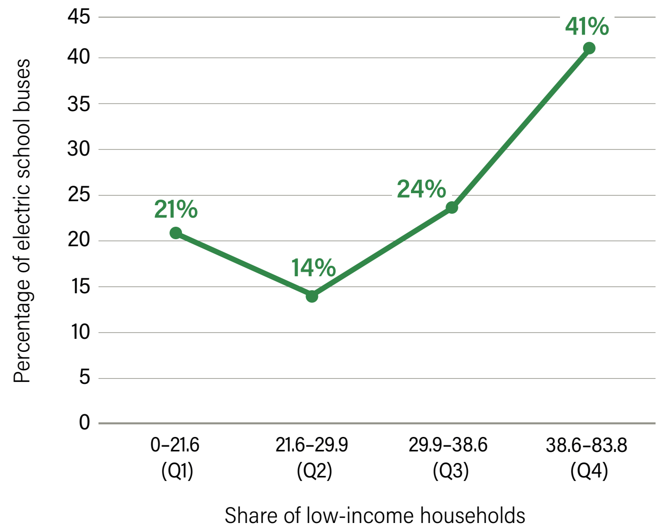
FIGURE 13 | Percentage of school districts with ESBs by share of residents of color



Note: Data missing for 13.8 percent of districts.

Source: WRI authors.

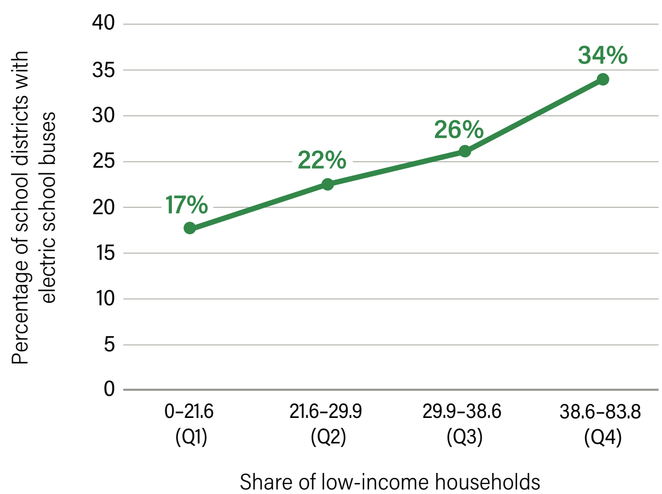
FIGURE 14 | Percentage of overall ESBs by share of low-income households



Note: Data missing for 12.3 percent of districts.

Source: WRI authors.

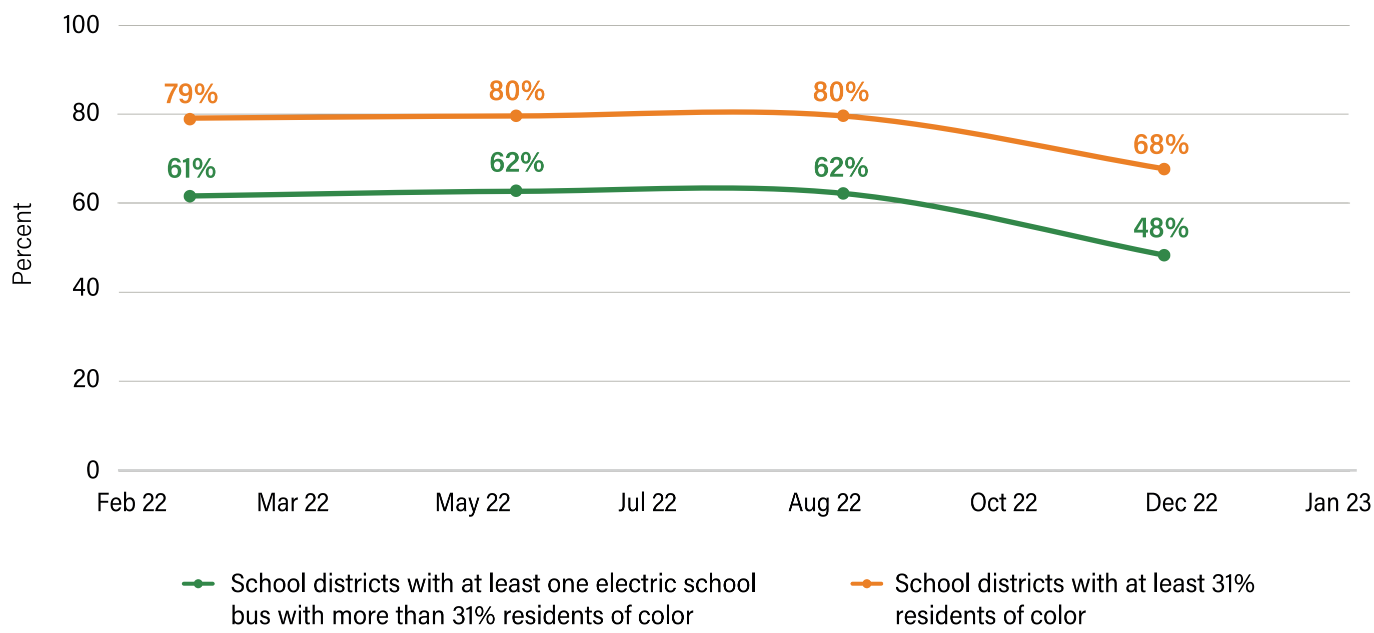
FIGURE 15 | Percentage of school districts with ESBs by share of low-income households



Note: Data missing for 13.8 percent of districts.

Source: WRI authors.

FIGURE 16 | Committed ESBs in districts with highest share of residents of color over time

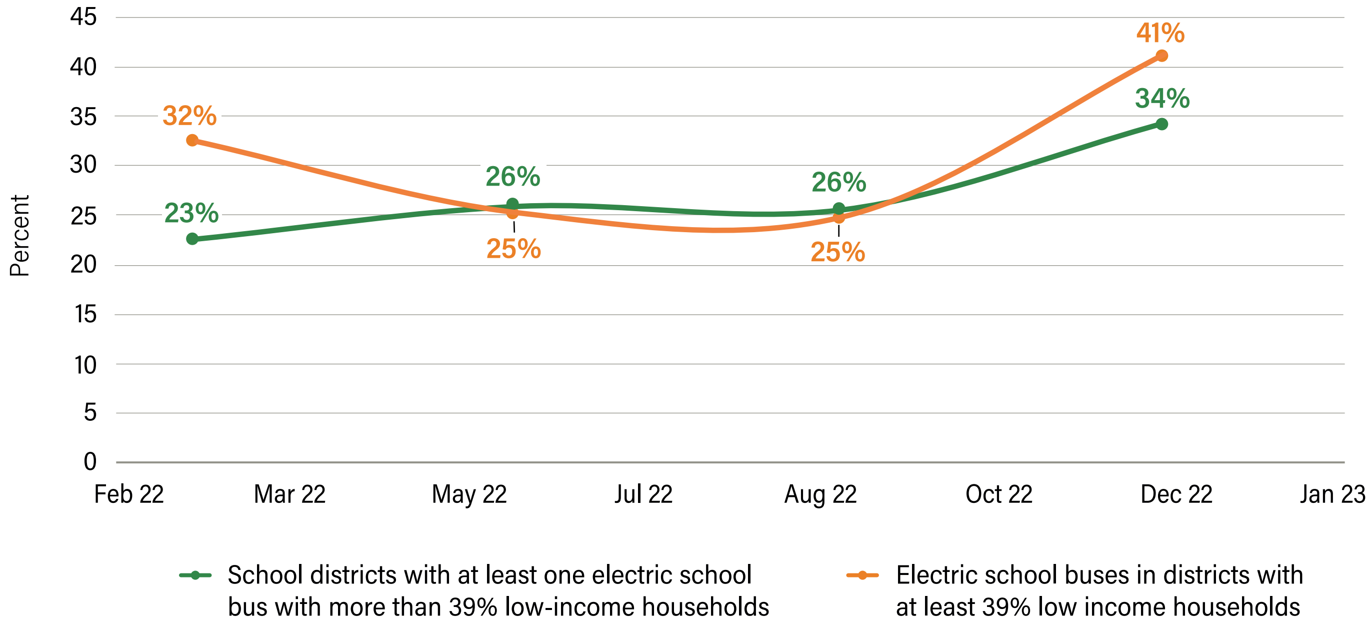


Note: Thirty-one percent is the threshold for the fourth quartile of residents of color for all school districts nationwide.
Source: WRI authors.

The share of ESBs—and districts with ESBs—in areas with the highest shares of people of color has actually decreased slightly since September 2022, largely due to the introduction of the EPA's Clean School Bus Program (Figure 16). This program prioritized school districts using criteria other than race, including income levels, rurality, and Tribal status.

The EPA's Clean School Bus Program funded 2,451 ESBs in 389 school districts, 374 of which had no ESBs previously. Thirty-two percent of Clean School Bus Program districts were districts with the highest shares of people of color, compared to 62 percent of districts in September 2022, before these awards were released (Figure 17). Although 54 percent of the total number of ESBs awarded through the program are in districts with the highest shares of people of color, this is still lower than before the program, when 80 percent of electric buses were in the top 25 percent of this distribution (Figure 17).

FIGURE 17 | Committed ESBs in districts with highest share of low-income households over time

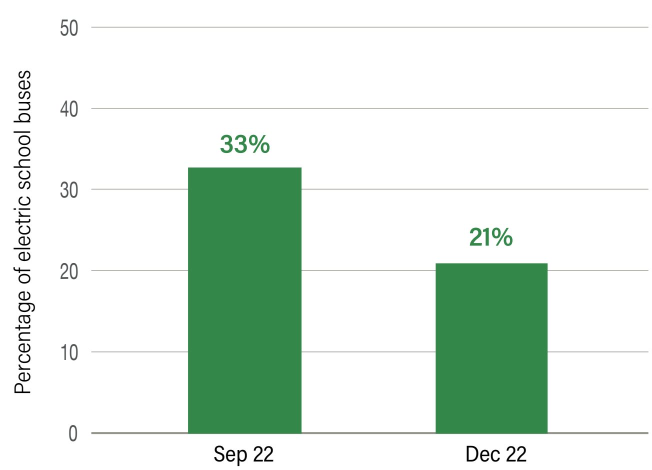


Note: Thirty-nine percent is the threshold for the fourth quartile of low-income households for all school districts nationwide.
Source: WRI authors.

California's share of nationwide ESBs heavily influenced this larger percentage. This state held 59 percent of ESBs and 64 percent of school districts with ESBs in the fourth quartile of people of color prior to October 2022. This may be because some of the largest California-specific funding sources, such as the Hybrid and Zero-Emission Truck and Bus Voucher Program (HVIP) and the School Bus Replacement Program, prioritize "disadvantaged communities," which includes indicators such as pollution burden, asthma and cardiovascular disease rates, and income levels (CEC n.d.; HVIP n.d.; OEHHA n.d.). Although race and ethnicity are not specifically named as prioritization criteria, an analysis conducted by the California Environmental Protection Agency found that people of color tended to live in these most disadvantaged communities (CalEPA 2018). Thus, California's prioritization of disadvantaged communities could explain the state's large number of ESBs in the quartile with the highest share of residents of color.

Since the Clean School Bus Program's selection process ensured priority districts from each US state and territory were chosen, ESBs are now spread more evenly across the country (EPA 2022a). Thus, the concentration of buses

FIGURE 18 | Percentage of ESBs in lowest quartile of low-income households (wealthiest households)



Source: WRI authors.

in districts with the highest shares of people of color decreased slightly by late 2022 (Figure 16). The Clean School Bus Program contributed to the concentration of ESBs increasing in areas with the highest share of low-income residents (Figure 17) and decreasing in areas with a high share of wealthy households (Figure 18) because the program prioritized areas that had 20 percent or more students living in poverty (EPA 2022a). Sixty-two percent of ESBs and 46 percent of districts awarded support for ESBs through the Clean School Bus Program are in areas with the highest shares of low-income residents.

> *Before October 2022, most ESBs belonged to districts of the* **lowest** *quartile of low-income residents; one-third of all ESBs were in districts where the fewest residents identified as low-income residents.*

Overall, low-income areas and communities of color represent a large share of ESB recipients, and these are where most older diesel buses are operated. This suggests that the disproportionate concentration of older diesel buses in these districts may soon be changing, and that children who tend to live in areas with worse air quality will have a cleaner ride to school. The share of ESBs and districts with ESBs in regions with the largest share of low-income households is rising; this pattern is likely to continue with the second round of Clean School Bus Program funding, which again prioritizes low-income districts (EPA 2023d). Although most ESBs currently belong to districts with the highest percentage of people of color, the share of buses in this quartile decreased slightly and may continue to fall due to the Clean School Bus Program's absence of race or ethnicity as prioritization criteria.

Our analysis also examined ESB adoption trends among disaggregated racial categories from the American Community Survey (Table 4). This is in line with much of the literature on air pollution exposure, which disaggregates racial groups to better understand impact disparities (Jbaily et al. 2022). Areas with a relatively high number of people of color represent a large share of current ESB commitments. We found that between 62 percent and 69 percent of school districts with ESBs are in areas that are above the median percentage of residents for six racial and ethnic categories, including Black or African American, Asian, American Indian/Alaska Native/Native Hawaiian/other Pacific Islander, some other race, two or more races, and Hispanic or Latino of any race.

TABLE 4 | Committed ESBs disaggregated by race

RACE/ETHNICITY	MEDIAN PERCENTAGE (ALL SCHOOL DISTRICTS)	SCHOOL DISTRICTS WITH AT LEAST ONE ESB (SHARE OF WHICH ARE ABOVE THE MEDIAN FOR THE RACE)	SHARE OF TOTAL ESBS IN SCHOOL DISTRICTS ABOVE THE MEDIAN FOR THE RACE
White	90.1	27	13
Hispanic or Latino (of any race)	4.4	65	76
Two or more races	3.0	66	76
Black or African American	1.2	64	81
Some other race	0.8	69	81
Asian	0.6	66	80
American Indian/Alaska Native/Native Hawaiian/other Pacific Islander	0.3	62	61

Notes: ESB = electric school bus. The categories "white," "Black or African American," "Asian," "American Indian/Alaska Native/Native Hawaiian/other Pacific Islander," and "some other race" each reflect the percentage of the population, within the geographic boundaries of the school district, who identified as that race or ethnicity alone. For example, for all districts for which we have data (n = 13,049), the median percentage of the population that identified as Black or African American alone is 1.2 percent. "Two or more races" covers residents who identified as more than one of the above racial categories. "American Indian/Alaska Native" and "Native Hawaiian/other Pacific Islander" are separate categories in the American Community Survey that we have combined here because these groups are often both considered Indigenous (AIANNH Caucus n.d.). For more information, see US Census Bureau (2021).

This trend is even more pronounced looking across the percentage of ESBs in districts above the median percentages of these race composition categories. Between 61 percent and 81 percent of ESBs belong to districts above the median for these six categories. This is in contrast with the share of ESBs and school districts with ESBs that are in areas above the median percentage of white residents (13 percent and 27 percent, respectively). These patterns suggest that historically disadvantaged racial and ethnic groups are receiving most of the benefits that come from school bus electrification.

Although the percentages of school districts with ESBs that are above the median for the six aforementioned racial and ethnic categories are relatively similar, the pattern is slightly different when considering the distribution of ESBs among these categories. Districts above the median percentages for Black or African American, Asian, some other race, two or more races, and Hispanic or Latino are within five percentage points of one another (76–81 percent), but the percentage of ESBs in areas above the median percentage for American Indian/Alaska Native/Native Hawaiian/other Pacific Islander is notably lower at 61 percent. This difference could be explained in part by Montgomery County Public Schools in Maryland, which is an outlier in terms of its large ESB commitment size of 326. This school district is above the median for residents who identify as Black or African American, Asian, some other race, two or more races, and Hispanic or Latino, but it is not above the median for American Indian/Alaska Native/Native Hawaiian/other Pacific Islander, thus excluding a sizable number of ESBs from that category.

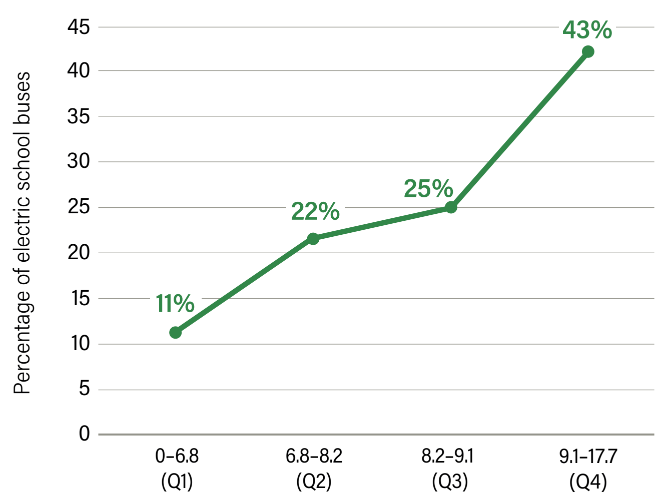
DISTRIBUTION OF ESBS AMONG SCHOOL DISTRICTS OF DIFFERENT AIR QUALITY AND ASTHMA RATES

We analyzed ESB adoption across different concentrations of ambient $PM_{2.5}$ and ozone in the district because of the pollutants' close linkage to diesel exhaust and harmful health effects, including the exacerbation of asthma.

In areas with the highest concentration of $PM_{2.5}$, the share of ESBs and the share of districts with ESBs hovered around 50 percent before September 2022, slightly increasing with time. These highly polluted areas also hold the largest share of students nationwide (CCD 2022; EPA 2023a). However, as of December 2022, these areas reported decreases in the percentage of ESBs (43 percent) and districts with these buses (34 percent) (Figures 19 and 20).

This trend may be due to a large influx of buses from the Clean School Bus Program, which did not include air quality as a prioritization criterion. After September 2022, areas with the highest ozone levels also saw a slight decrease in the share of ESBs and districts with ESBs. However, as seen in Figures 15 and 16, the highest shares of ESBs (34 percent) and districts with ESBs (32 percent) are still in areas with the highest levels of $PM_{2.5}$ and ozone pollution, despite the overall share in the top quartile decreasing for both pollutants (Figures 21 and 22).

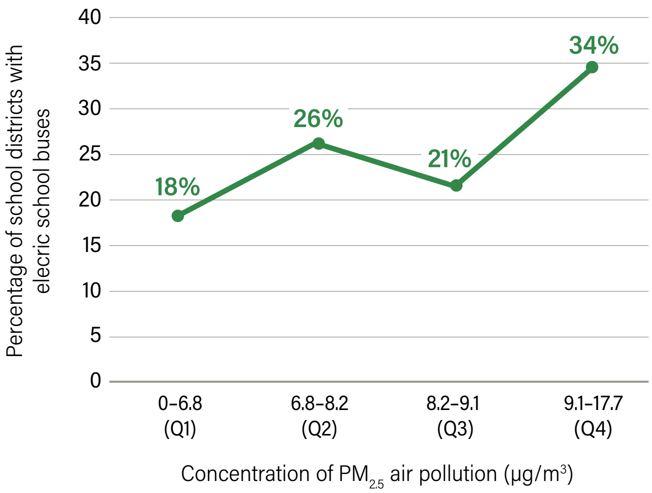
FIGURE 19 | Percentage of overall ESBs by $PM_{2.5}$ level (December 2022)



Note: Data missing for 12.3 percent of districts.

Source: WRI authors.

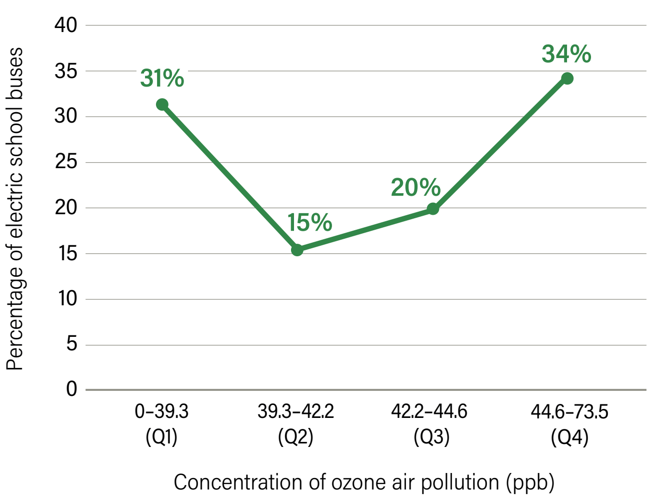
FIGURE 20 | Percentage of school districts with ESBs by $PM_{2.5}$ level (December 2022)



Note: Data missing for 13.8 percent of districts.

Source: WRI authors.

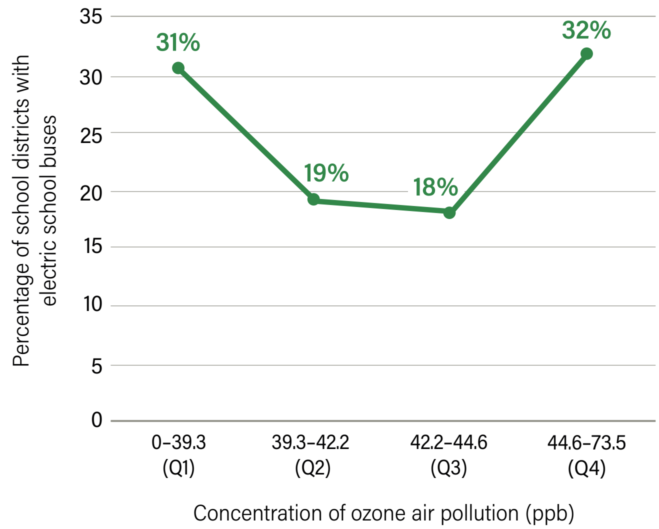
FIGURE 21 | Percentage of overall ESBs by ozone levels (December 2022)



Note: Data missing for 12.3 percent of districts.

Source: WRI authors.

FIGURE 22 | Percentage of school districts with ESBs by ozone levels (December 2022)

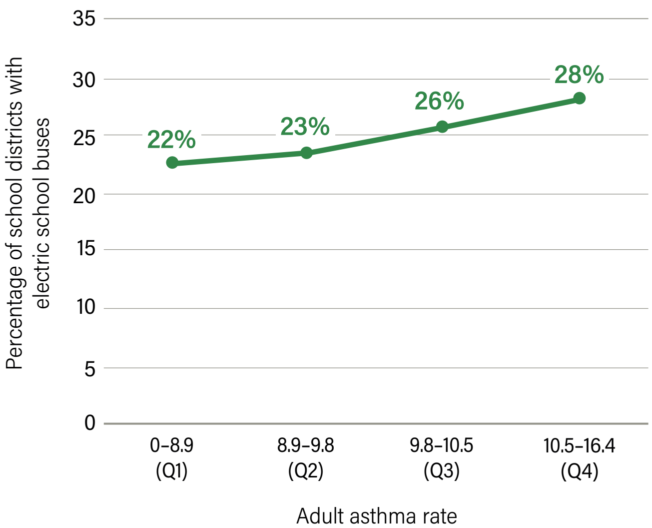


Note: Data missing for 13.8 percent of districts.

Source: WRI authors.

Since childhood asthma rates at the census tract level were not available for most districts, we used CDC PLACES data on adult asthma rates to examine ESB adoption among communities where asthma was prevalent. We began collecting and analyzing this metric during the second half of 2022; thus, at the time of writing, we were unable to look at trends across all of 2022. We found that school districts with ESBs are generally evenly spread across different levels of adult asthma rates (Figure 23). Although most ESBs are in districts with the lowest shares of adults with asthma, the percentage is only slightly more than the share of electric buses in districts with the highest shares of adults with asthma (Figure 24).

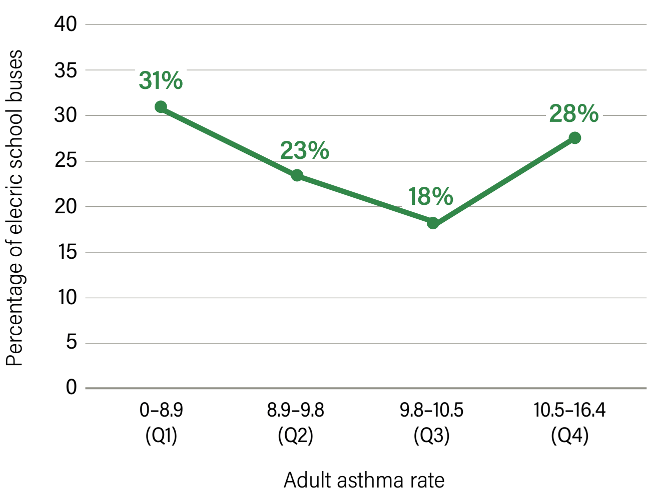
FIGURE 23 | Percentage of school districts with ESBs by asthma levels (December 2022)



Note: Data missing for 13.8 percent of districts.

Source: WRI authors.

FIGURE 24 | Percentage of overall ESBs by asthma levels (December 2022)



Note: Data missing for 12.3 percent of districts.

Source: WRI authors.

The data we have collected on ESB adoption in areas of different air quality rates suggest an equitable distribution. Most buses are committed in areas with the poorest air quality as measured by $PM_{2.5}$ and ozone levels. The share of ESBs in districts with the highest levels of these pollutants has decreased since September 2022, but this downward trend is recent, and we cannot say with confidence if this pattern will persist.

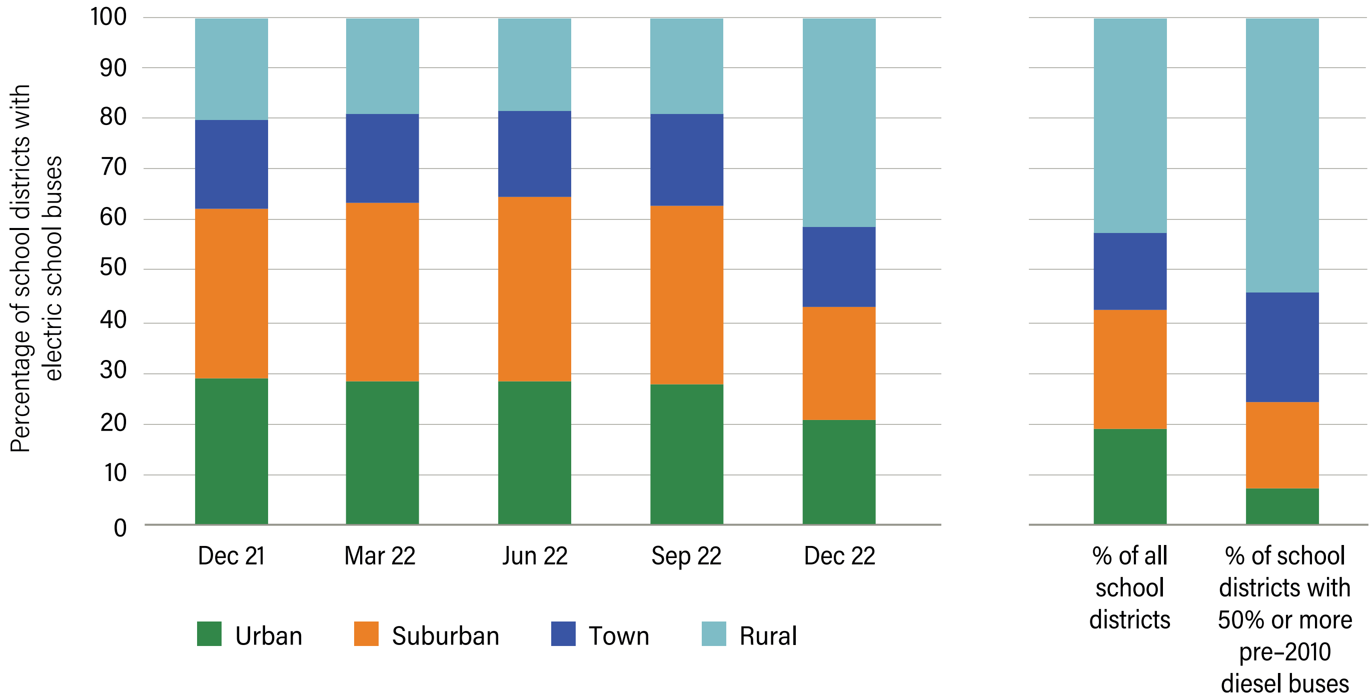
ESB adoption among districts with different rates of adult asthma tells a slightly different story. Although many ESBs are in districts with the highest rates of adult asthma, districts with the lowest rates of asthma still have the majority of electric bus commitments. The rate of asthma is not always a criterion used to prioritize ESB funding, which may explain this pattern. However, more research is necessary to understand how the rate of asthma changes with funding patterns.

DISTRIBUTION OF ESBS AMONG URBAN, SUBURBAN, TOWN, AND RURAL SCHOOL DISTRICTS

The share of ESBs and districts with ESBs in each locale remained consistent between December 2021 and September 2022, with suburban areas holding the greatest share of both total districts and ESBs. This trend shifted during the fourth quarter of 2022 with the introduction of the EPA's Clean School Bus Program, which prioritized rural districts among other criteria (EPA 2022b).

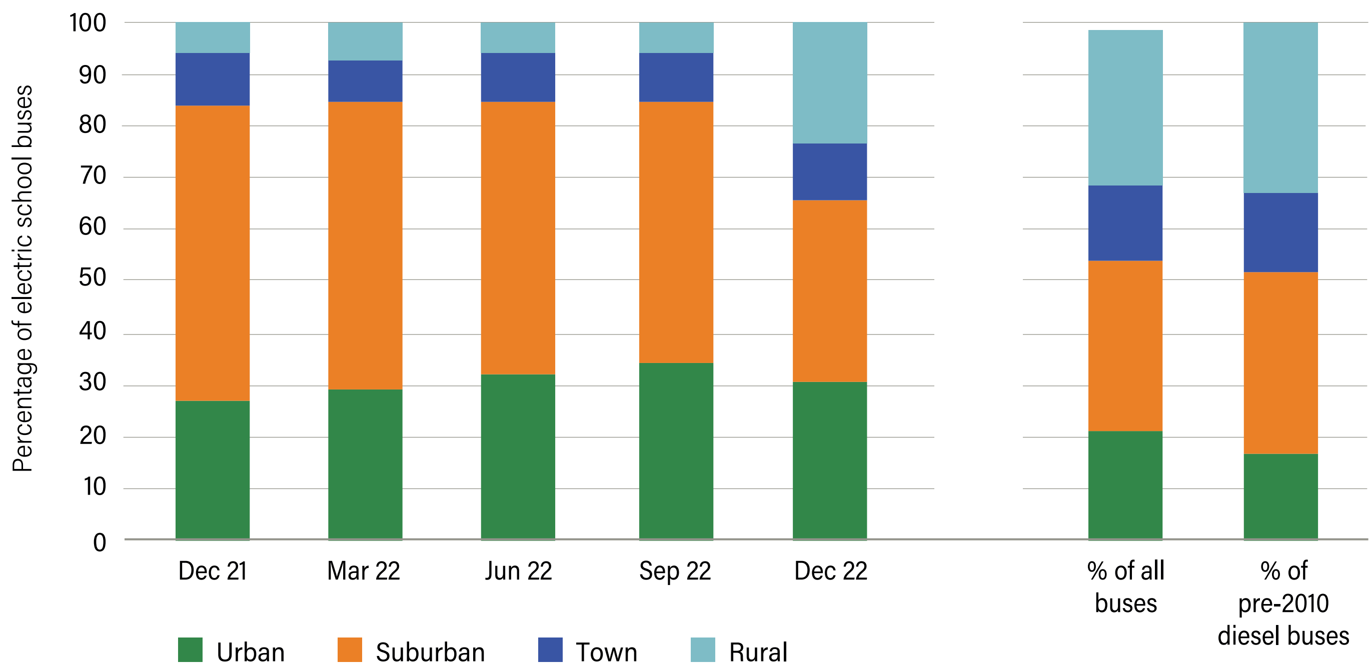
Overall, two-thirds of school districts (261) that were awarded Clean School Bus funds are located in rural regions, amassing a total of 1,034 ESBs, which is 42 percent of the program's funded ESBs. As Figure 25 shows, the percentage of school districts with ESBs in each of the four locales (rural, town, suburban, and urban) matches almost exactly the share of all districts in each locale as of December 2022. This distribution also more closely aligns with the percentage of school districts with 50 percent or more of their fleet consisting of pre-2010 diesel buses than it did before December 2022. The share of ESBs in each locale during the fourth quarter of 2022 was also more closely aligned with the distribution of all school buses and pre-2010 diesel buses among each locale than before this time (Figure 26). This indicates that the introduction of Clean School Bus Program funds allowed more ESBs to go to the types of areas that have the oldest, and therefore most polluting, diesel school buses.

FIGURE 25 | Percentage of school districts with ESBs by locale (December 2021–December 2022)



Source: WRI authors.

FIGURE 26 | Percentage of ESBs by locale (December 2021–December 2022)



Source: WRI authors.


SCHOOL BUS
SCHOOL BUS
POIGNÉE DE SECOURS

What are the emerging trends related to financial, infrastructure, and utility support for ESB adoption?

The high costs of ESBs and infrastructure upgrades are cited as the main barriers to ESB adoption, presenting a higher barrier for under-served communities.

In this section, we analyze emerging trends related to the funding of ESBs and related infrastructure, considering program characteristics, funders, and environmental considerations. These trends show how public funding has shaped the adoption of ESBs, especially among environmentally burdened communities. These findings can highlight new opportunities for key stakeholders to enhance the equitable adoption of electric buses and ensure key programs are adapted to best meet the needs of communities most negatively impacted by older diesel buses.

FUNDING

Most ESBs acquired by December 2022 have utilized some form of grant or public funding for ESB procurement to supplement school district budgets (Figure 27). The price of an ESB is estimated to be three to four times as expensive as its diesel counterpart. The Clean School Bus Program is the funding program most widely known. In 2022, the Clean School Bus Program funded 46.8 percent of all ESBs awarded to school districts to date. However, earlier efforts to combat carbon emissions and improve air quality helped to pave the way for the adoption of ESBs.

The first ESBs were funded in 2016 in Massachusetts by the Regional Greenhouse Gas Initiative (RGGI), an initiative established in 2009 among 11 northeastern states to reduce greenhouse gas emissions (RGGI n.d.). Participating states use the RGGI platform to auction carbon dioxide allowances, and the proceeds are used to invest in clean energy and greenhouse gas reduction programs. New Jersey also used the proceeds to invest in building decarbonization, clean transportation, and protecting coastal habitats. Between 2019 and 2020, 62 ESBs were funded by New Jersey's proceeds from the RGGI.

California was an early adopter with strong efforts to establish programs that combat air pollution and reduce greenhouse gases. Its HVIP, established in 2009, is the second program that has funded more ESBs after the Clean School Bus Program. It was not until 2017 that the vouchers were used for ESBs (HVIP 2023). Previous school buses were either hybrid or fueled by natural gas. The program is funded by California Climate Investments, an entity that invests California's cap-and-trade proceeds into more than 20 state agencies (California Climate Investments n.d.). Other programs funded have included the Rural School Bus Pilot Project, Community Air Protection Incentive Program, and Carl Moyer Program, to name a few. As a result, ESBs in California make up 35.6 percent of the total ESBs awarded in the country. Yet this percentage is disproportionate because California's school bus fleet is approximately 3.9 percent of the US school bus fleet.

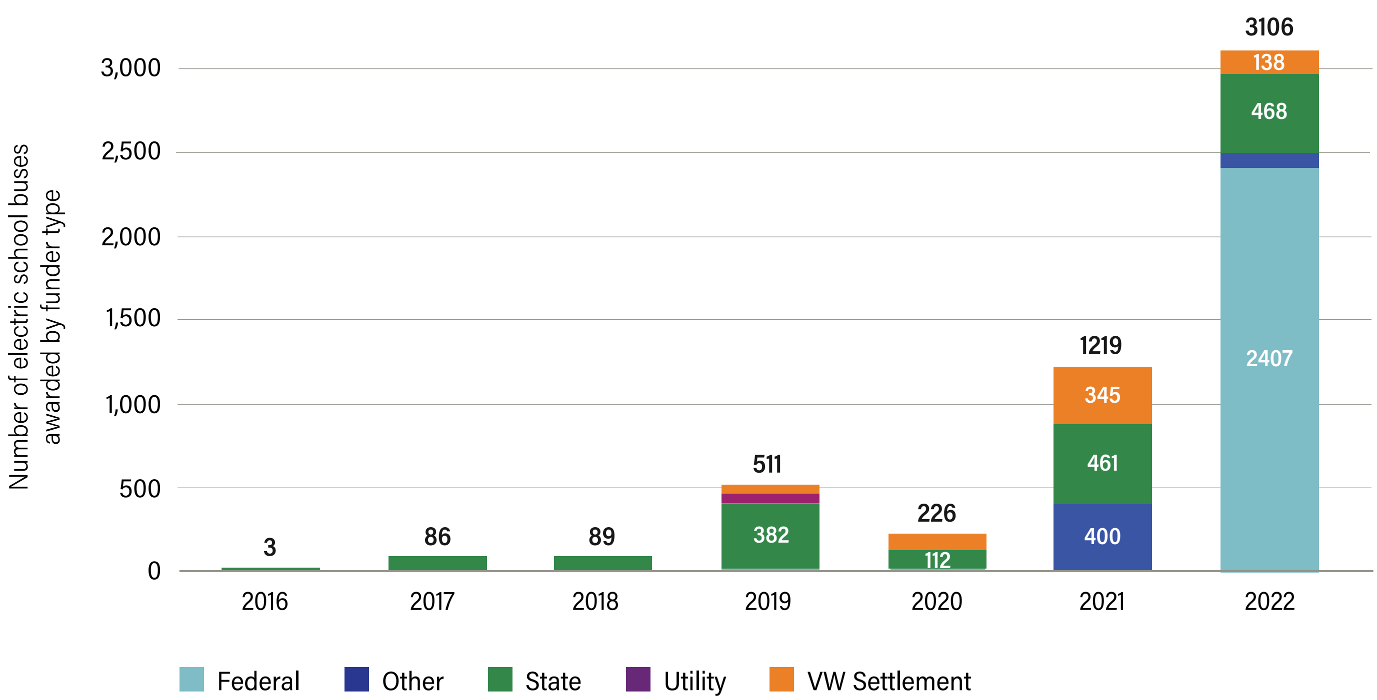
The Volkswagen Settlement was an inflection point that allowed states to receive funding to develop and implement projects that reduce carbon emissions and supported the adoption of clean transportation. These funds came from the settlement between the US government and Volkswagen to resolve allegations of violations of the Clean Air Act. The state's allocation was based on the number of damaged vehicles sold within state lines (EPA 2023d). The first ESBs funded by Volkswagen Settlement funds were awarded in 2018. The following year, it funded all the ESBs in Illinois, Maryland, and Michigan. Volkswagen Settlement funds were the second most frequently used funding source for ESBs between 2019 and 2021, with 345 ESBs funded.

By 2019, approximately 17 states had school districts with committed ESBs. Aside from California, these states included Virginia, with 54 ESBs, followed by Michigan (17), Massachusetts (7), New Jersey (7), Illinois (6), and Maryland (6). Although this uptake correlated with the Volkswagen Settlement and DERA grants, some utilities began to establish rebate programs for ESBs. Dominion Energy's ESB program funded 59 buses between 2019 and 2020. PG&E in California also provided funds for 5 ESBs. Overall, utilities provided funds for 82 ESBs in California, Nevada, Minnesota, Oregon, and Virginia. Nonetheless, it is important to note that these were often pilot programs to support the broad adoption of electric vehicles that lasted for one or two rounds of applications due to limited funding.

Between 2020 and 2021, states followed in California's footsteps and increased funding for clean transportation programs. These programs included the Oregon Clean Fuels Program, the New York Truck Voucher Incentive Program (NYTVIP), and Colorado's ALT Fuels Program. Their early developments resulted in an increase in the number of ESBs funded by state programs. At the same time, school districts were creative in their searches for funding using philanthropic grants, bonds, and funds from local settlements.

Through the Bipartisan Infrastructure Law, signed in 2021, the federal government is providing $5 billion over five years for the replacement of existing school buses with electric or other alternative fuel school buses through the development of the Clean School Bus Program. In 2022, the Clean School Bus Program funded 2,358 ESBs, more than any other single program. In contrast, California's HVIP and the Volkswagen Settlement were responsible for funding 833 and 654 ESBs, respectively. Prior to this, federal funding only accounted for 3 percent of ESBs awarded (Figure 27).

FIGURE 27 | Number of ESBs funded by funder and year



Source: WRI authors.

PROGRAM CHARACTERISTICS

Public funding is distributed through different mechanisms depending on the design of the program. The application process and disbursement mechanisms can affect the accessibility of funding for school districts with limited resources and capacity. The most common funding mechanisms identified for ESBs are rebates (2,451), followed by grants (1,512) and vouchers (848) (Figure 28).

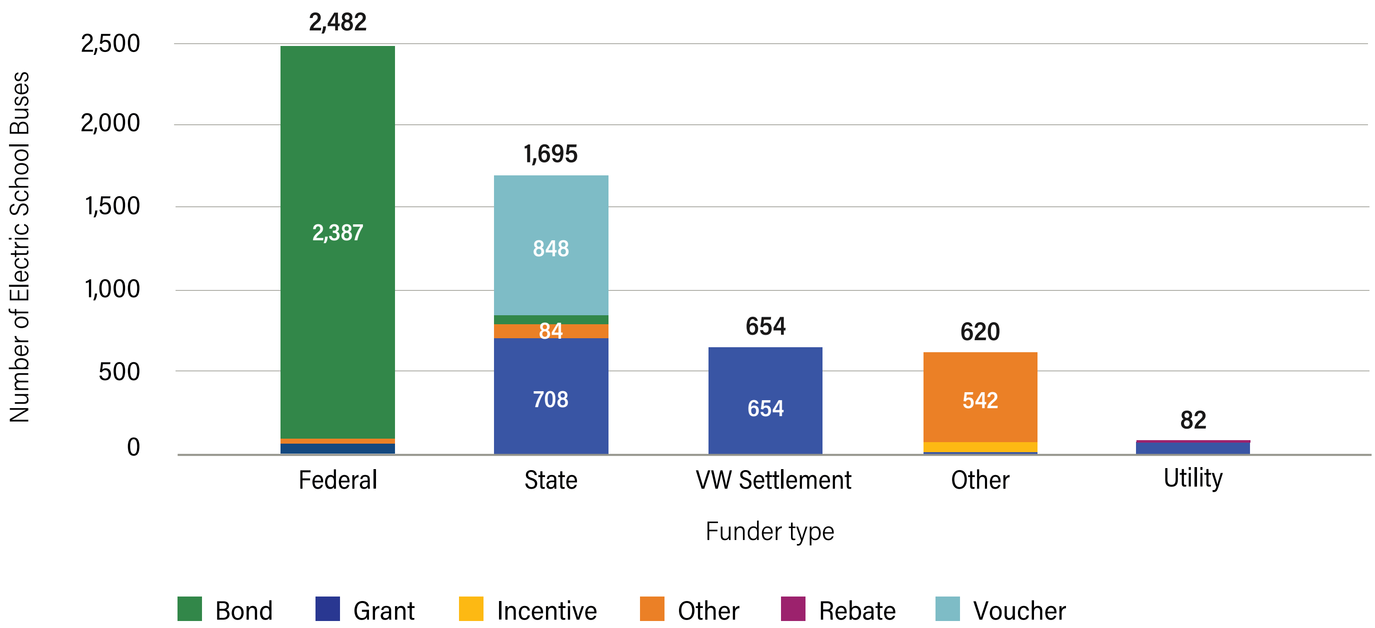
Rebates are reimbursements for eligible and preapproved equipment purchases. Although rebates offer limited paperwork, they create a barrier for schools with limited financial capacity to provide up-front payment of the equipment and then wait for reimbursement. Rebates are commonly used among utility programs to cover costs related to charging infrastructure. Their high use can be explained by the scale of the 2022 round of the Clean School Bus Program. However, it is important to note that schools were not required to pay up front for the bus—only a purchase order was required. Future rounds of the Clean School Bus Program will also use competitive grants to provide awards for ESBs.

> Most ESBs acquired by December 2022 have utilized some form of grant or public funding for ESB procurement to supplement school district budgets.

Grants are awards made to qualifying applicants, and the grantee is given the funding prior to the purchase of the equipment. Grants were frequently used by state programs and Volkswagen Settlement awards. Grants may allow for awards to be more competitive, considering project planning and prioritization of districts. However, the time and staff capacity needed to submit an application and reporting documents can present a barrier for schools in disadvantaged communities. These schools may choose to pass up a funding opportunity if they do not have staff experienced in application writing.

Vouchers are point-of-sale discounts. This means the funding is provided directly to a vendor on behalf of the awarded organization. Dealers may have to submit an application beforehand to be an eligible vendor under the program. This mechanism reduces the burden for schools in disadvantaged communities, which may have neither the capacity to manage the administrative processes to apply for grants nor the liquidity to pay up front and be reimbursed later. Nonetheless, it is important to conduct proper tracking to disincentivize changes on pricing structures. California and New York provided the greatest number of vouchers through the HVIP and NYTVIP, respectively.

FIGURE 28 | Number of ESBs by funding type



Source: WRI authors.

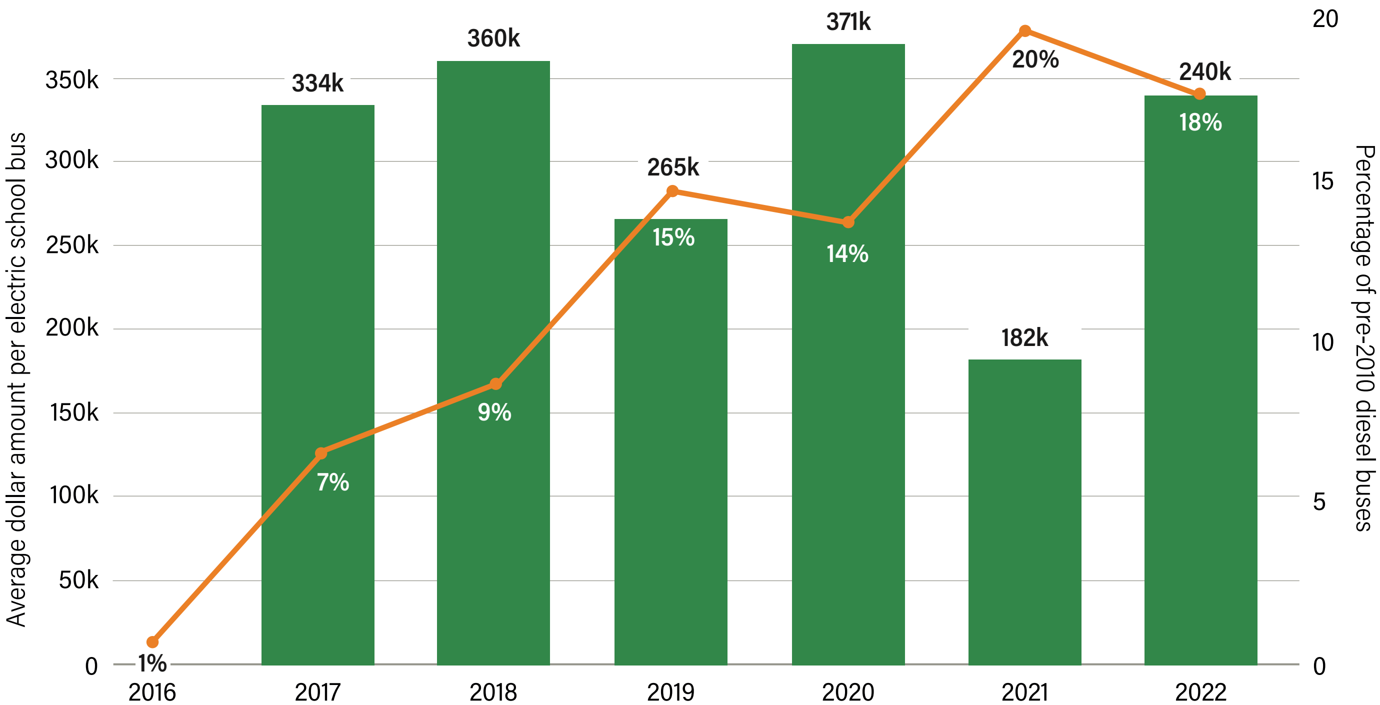
AVERAGE FUNDING AWARDED

The amount of public funding awarded to school districts can be a decisive factor, especially for under-served school districts. The average funding awarded per ESB between 2017 and 2022 was $318,157 (Figure 29). Although this average would cover 90 percent of the up-front cost of an ESB, the amount of funding ranged from $70,000 by Colorado's ALT Fuels Program to $515,000 by the Rural School Bus Pilot Project. Many under-served school districts may not have the financial capacity to cover the gap needed to buy an ESB. Furthermore, under-served school districts may need additional funds for infrastructure upgrades because of underinvestment.

The Clean School Bus Program prioritized school districts that served low-income, rural, and Tribal communities, awarding them up to $125,000 more compared to nonpriority school districts. In comparison, California's HVIP and the DERA rebates were on the lower end of the average award at $168,685 and $184,375, respectively. It should be noted that funding amounts were reported for 30 percent of ESBs awarded.

The amount of funding per bus has varied as the number of funding programs available has consistently increased each year. In 2021, the average amount awarded decreased to $182,000 as the number of funding programs peaked. This variation can be explained by the availability of funding. The rebound in 2022 can be explained by the first round of the EPA's Clean School Bus Program. It should be noted that the averages were not controlled by bus type because 86 percent of ESBs reported did not have a bus type.

FIGURE 29 | Average dollar amount per ESB



Source: WRI authors.

The average award amount per ESB mentioned above is 10 percent lower than the average price of an ESB ($350,000). The data shows that school districts mostly use one source of funding for each ESB. Only 6.6 percent of awarded ESBs were linked to multiple sources of funding. Out of these, school districts used more commonly known funding programs as secondary sources. For instance, a school might have used the Carl Moyer Program and Volkswagen Settlement funds to pay for an ESB. Other commonly used sources include California's HVIP and the DERA rebate. Many of these programs have matching requirements within their application process and allow for stacking funding from other sources.

Whereas most school districts used public funding to acquire their first ESB, there were schools that reapplied to get additional ESBs. Approximately, 28 percent of school buses awarded were part of the second, third, or fourth round of bus procurement processes. Most of these ESBs were awarded to schools within the bottom or top 25 percent of low-income populations. This outcome can be explained by the availability of funding opportunities, familiarity with the application process, and prioritization given to under-served school districts. Out of the 121 ESBs that were part of a fourth batch, 113 buses went to schools within the top 25 percent of low-income populations.

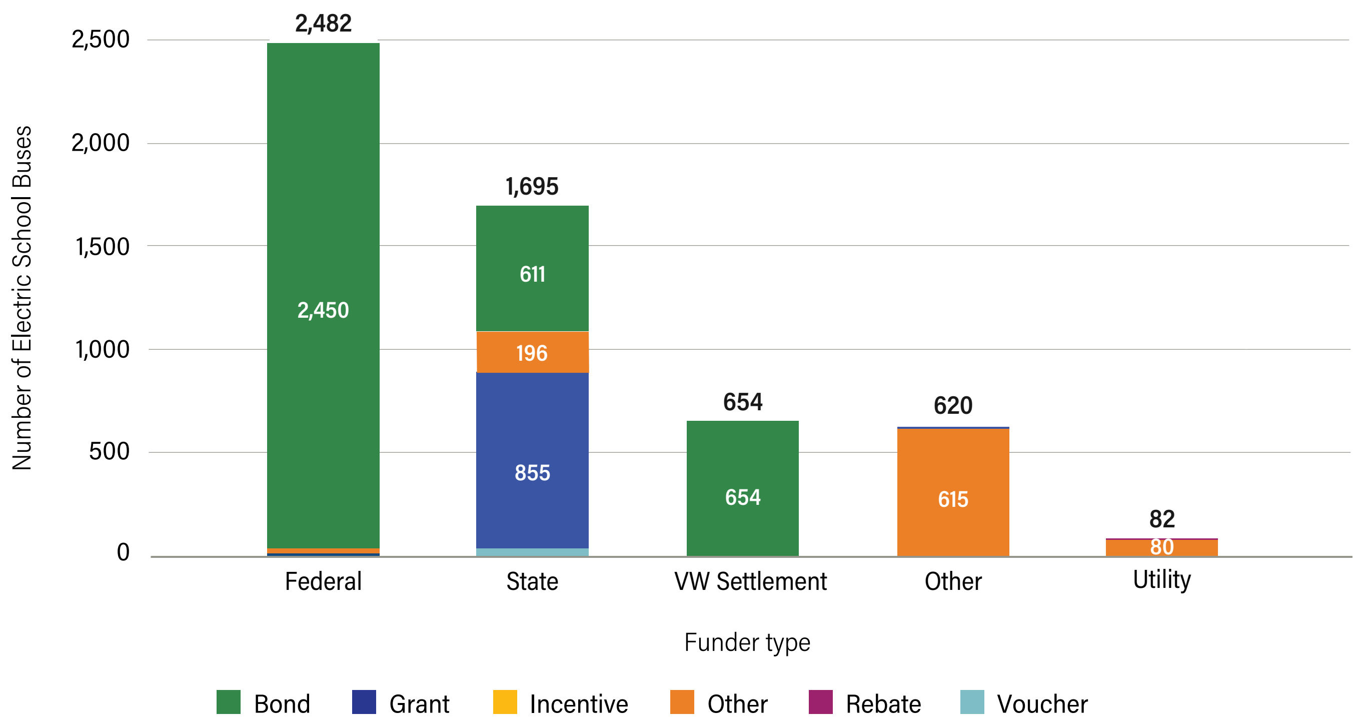
ENVIRONMENTAL JUSTICE CONSIDERATIONS

Across all funding sources reviewed, 32 programs out of 57 stated environmental justice (EJ) considerations. These programs were either exclusive to EJ communities, provided extra funding, or prioritized their applications. Most of the programs stated prioritization within the application process. This means that administrative agencies considered the socioeconomic demographics of school districts to determine their *qualifications* to obtain an ESB. Only seven programs were exclusive to EJ communities or provided extra funding. The definition and criteria to classify EJ communities or disadvantaged communities differed by agency and state. Some states developed their own EJ tools and used them to determine eligibility. For instance, California developed CalEnviroScreen, a tool used to identify census tracts that are most affected by pollution using socioeconomic, environmental, and health indicators. Other agencies had predetermined priority areas/counties or specific income and pollution indicators. If data on funding sources was unavailable or there was not enough information about the funding program, funding sources were classified as having no EJ considerations.

The major funders of ESBs have incorporated EJ considerations into their application and allocation processes. These programs include the EPA's Clean School Bus Program, California's state grants, and the Volkswagen Settlement. Approximately 4,580 ESBs were funded through agencies or programs that prioritized or provided extra funding to EJ communities, out of 5,529 total awards (Figure 30). This does not mean all 4,580 ESBs funded were awarded to schools with high levels of low-income populations or pollution. As seen in Figure 31, 353 and 199 ESBs awarded by programs that prioritized or provided extra funding to EJ communities, respectively, went to school districts with the lowest levels of low-income populations.

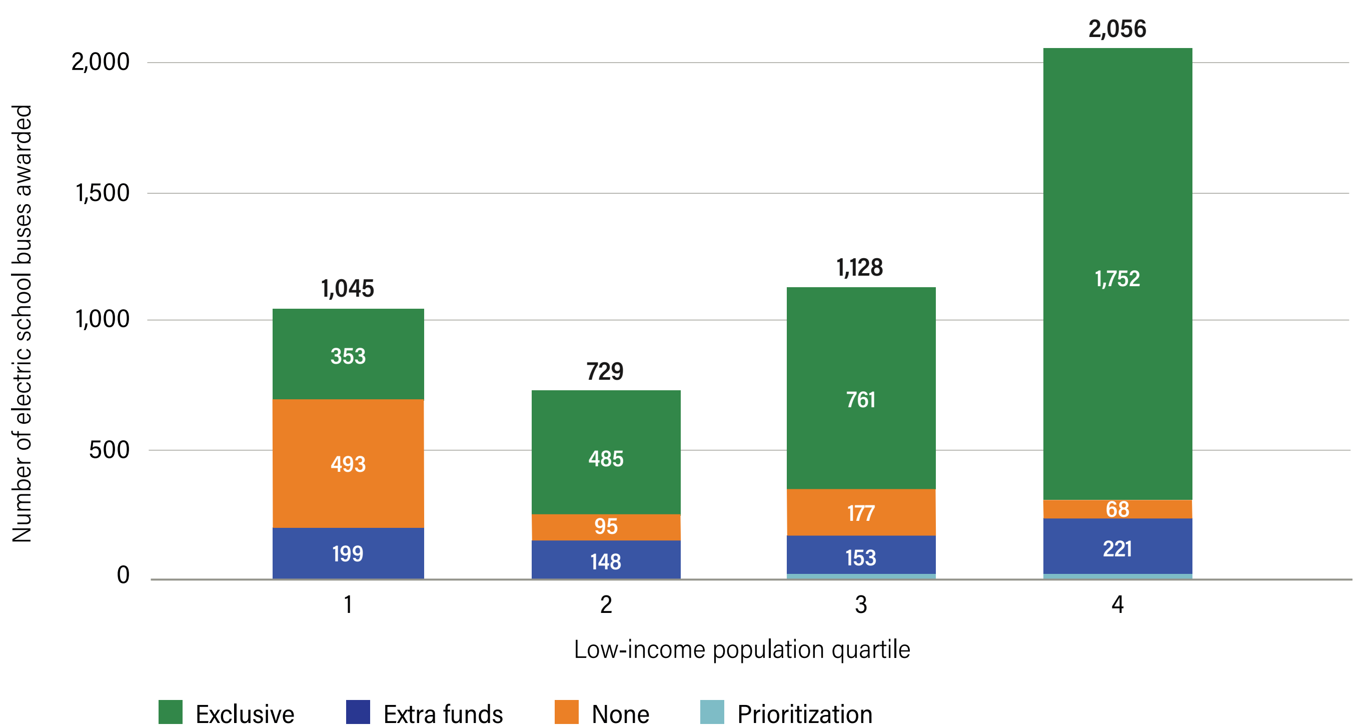
The development of new funding programs presents an opportunity to design programs that prioritize under-served communities.

FIGURE 30 | Number of ESBs by funder type and EJ considerations



Source: WRI authors.

FIGURE 31 | EJ considerations by type of funder



Source: WRI authors.

Nonetheless, the criteria for environmental considerations among different government programs can be linked to the socioeconomic demographics of the school districts awarded. For schools awarded by programs that prioritize EJ communities, their average low-income population was 38 percent. This average is 15 percentage points higher compared to school districts awarded by programs with no EJ considerations. The average amount awarded to schools within the lowest 20th percentile of average household income was $140,000 more than schools within the top 20th percentile.

The Clean School Bus Program funded more than half of the ESBs in schools within the top 25 percent of the low-income population. Due to the relationship between low-income households and high asthma rates, the Clean School Bus Program can explain the increase of buses in school districts with the highest asthma rates, as described in the previous section.

California has focused its state grants on schools within higher pollution areas. A large portion of grants were managed by the California Air Resources Board or California's Air Quality Management Districts. Nationally, out of 2,102 ESBs awarded to schools within the 75th percentile of $PM_{2.5}$, 1,651 ESBs are in California, where a variety of funding mechanisms were used, including grants, vouchers, and rebates.

Although Volkswagen Settlement funds used EJ considerations to prioritize school districts in low-income and high-pollution areas, the different implementation criteria among states show school buses awarded across different socioeconomic demographics. Most ESBs were awarded to districts within the 50th and 75th percentile (third quartile) of low-income populations. In contrast, most school buses were awarded to schools within the 25th and 50th percentile (second quartile) of pollution levels and the 25th percentile of asthma rates (first quartile).

UTILITIES, INFRASTRUCTURE, AND MAKE-READY PROGRAMS

Utilities have also provided funding for infrastructure and charging costs, which tend to be an additional capital investment required for broader adoption and may not be covered by funding programs. Out of the 57 programs reported, 32 explicitly stated that chargers were eligible for purchasing. These costs disproportionally affect low-income populations and communities of color, who have also experienced a history of underinvestment. Thus, the implementation of utility-rebate and make-ready programs will have a key role on the success of an equitable adoption of ESBs.

The dataset used for this analysis includes little detail on costs and funding sources utilized for charging infrastructure. To address this question, the research team reviewed the charger eligibility under commonly used programs. Across ESBs in the adoption dataset, 73 percent were funded by programs that could have been used to acquire charging infrastructure.

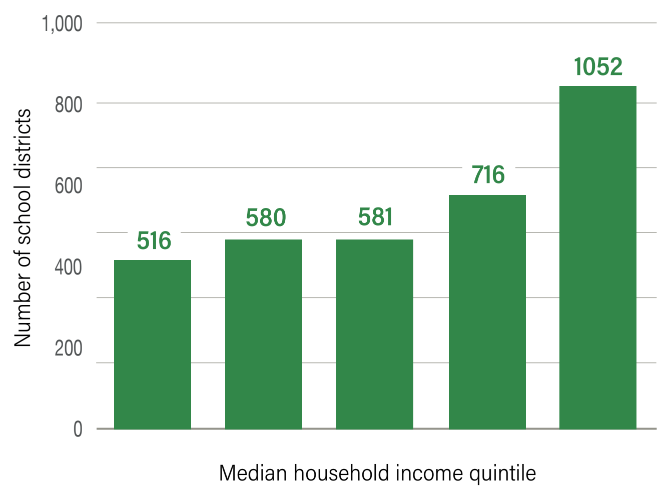
Make-ready programs are utility programs designed to reduce the cost of infrastructure upgrades for customers and developers by covering all or some of the costs for which they would otherwise be responsible (ESB Initiative n.d.b). School district access to make-ready programs for ESB charging infrastructure funding that covers charging infrastructure and/or utility and site electrical work are key to deploying charging infrastructure necessary to power ESBs. Utilities across the country have created incentives to support the adoption of electric vehicles, especially through make-ready programs. As of November 2022, a total of 138 make-ready programs pertinent to ESBs were available from 38 investor-owned utilities. California and New York have more utilities with make-ready programs than other states, with five and six utilities, respectively.

Based on analysis of the service areas of utilities with make-ready programs, it was found that up to 43 percent of school districts may have had potential access to make-ready programs. This may be an approximation because some school districts intersect with multiple utility territories, but a particular charging location may not be served by the utility that offers the make-ready program. On the other hand, some rural electric cooperatives and municipal utilities may offer make-ready programs that were missed in this analysis. Access to a make-ready program is not evenly distributed throughout the nation. California school districts account for over 25 percent of the districts with make-ready program access, followed by Michigan districts (15.3 percent) and New Jersey districts (14.2 percent).

Make-ready programs are more accessible to schools in high-income communities (Figure 32). Districts with high median household incomes (top quintile) represent 30 percent of the districts with access to make-ready programs. In comparison, districts with low median household incomes (lowest quintile) represent 15 percent of districts with access to make-ready programs. This finding, combined with the small number of utility programs that have EJ considerations, can increase barriers for low-income and disadvantaged communities to electrify their fleet. An exception is Georgia, where the vast majority of school districts with access to make-ready programs are among the lowest-income quartile.

At a national level, at first glance there is no substantial difference in ambient $PM_{2.5}$ levels between districts with and without access to make-ready programs. It is important to note that California districts make up the preponderance (70 percent) of districts with the highest pollution levels and access to make-ready programs. Communities with larger minority populations appear to have greater access to make-ready programs (30 percent more). However, excluding California brings down this percentage, suggesting that outside of California, communities with larger minority populations are slightly underrepresented among those districts with access to make-ready programs.

FIGURE 32 | School districts with access to make-ready programs by median household income



Source: WRI authors.

FUTURE FUNDING TRENDS

The Clean School Bus Program, California's state grants, and Volkswagen Settlement funds have been key in the early electrification of school buses across the country, especially prioritizing awards to under-served communities that might otherwise be left behind.

As schools nationwide decide to adopt more ESBs, we can likely expect more funding options. At the same time, the development of new funding programs presents an opportunity to design funding programs that prioritize under-served communities and scale the adoption of ESBs. States such as Hawaii, Illinois, Massachusetts, and Washington have proposed legislation to electrify their fleets within the next two decades. Last year, the state of New York committed $500 million for ESBs in its 2023 budget. More recently, Michigan's legislature approved $125 million in the state budget to support an ESB program. The federal government has made tax credits available until 2032 to reduce the up-front price of ESBs.

Current funding of Volkswagen Settlement funds is expected to be fully allocated within the next couple of years. In many states, the amount allocated for clean transportation has been exhausted, and the remaining funds will be used for other categories, such as air or maritime freight and public transport, among others.

As battery prices continue to decline and manufacturers achieve economies of scale, the up-front costs of ESBs are expected to decline. Long-term operational savings from fuel and maintenance costs of ESBs can considerably reduce the lifetime costs of an ESB compared to the lifetime cost of a diesel school bus. Current grant programs also promise to move up the timeline to achieve total ownership cost parity between electric and diesel school buses. With an average 5 percent price decrease over the next 10 years, along with government funding such as the Tax Credit for Qualified Commercial Clean Vehicles (Section 45W), total cost of ownership parity between electric and diesel school buses is expected to be achieved by the second half of the decade.

To ensure an equitable transition where public funding is maximized, it is important to analyze different mixes of funding and financing mechanisms. This could mean adjusting grant programs where the up-front or lifetime premium of an ESB is covered, instead of the total cost of the bus, while providing a low-interest financing mechanism. Furthermore, ensuring that disadvantaged communities obtain greater funding allocation is key for an equitable transition. Other considerations could ensure more streamlined processes to reduce the burden on school districts with limited resources. For instance, compared to a rebate program, point-of-sale vouchers can lower the cost burden for school districts that do not have the capital to cover up-front costs and charging infrastructure. Technical assistance can also support school districts with limited capacity and staff to plan and procure ESBs. Targeted outreach during open application periods can help school districts to prepare their applications and plan the implementation of the project. These considerations can extend to the design of utility programs and incentives that support charging infrastructure and ensure school districts are ready to make the transition to ESBs.

Implications and recommendations

Overall, our research shows that pre-2010 diesel buses that emit harmful exhaust are more likely to be in school districts with a larger share of the population exposed to socioeconomic burdens.

DIESEL BUS DISTRIBUTION

These buses disproportionately serve students in communities with larger shares of low-income households, residents living below the poverty level, minority residents, and, in some cases, communities with poor ambient air quality. They are also disproportionately located in rural areas where students are more dependent on older diesel buses due to less access to alternate forms of transportation.

Specifically, school districts with the largest shares of older, pre-2010 diesel buses are in communities that have been historically disadvantaged due to the long-term impact of discriminatory policies. These communities already have disproportionately higher exposures to air toxics, and the presence of older diesel buses exacerbates these disparities.

School districts and state agencies should prioritize the replacement of the oldest school buses to produce the greatest air quality and health benefits for their students.

Targeting these local sources of emissions within the communities identified in this report can address disproportionate student risks by reducing exposure to toxic bus exhaust, reducing costs of health care from associated health impacts, and strengthening educational opportunities. Replacing older, diesel-burning school buses with ESBs could also help improve the environmental health of communities with poor air quality.

This transition must be equitable and ensure that the communities most impacted by pre-2010 diesel buses, and their associated harmful exhaust, continue to have priority access to the benefits of ESBs. This includes acknowledging the ongoing disparities associated with school transportation discussed here and proactively working to include the identified districts with the most pre-2010 diesel buses in outreach and technical assistance approaches. State agencies in possession of school bus fleet data should make these datasets publicly available on their websites and update them semiannually or more frequently. This would enable stakeholders to understand and fill data gaps on the distribution of older, dirtier fleets across communities in those states as well as learn how they change over time. Such approaches must not only share information and resources but also equip disparate districts with meaningful investments, funding, training, and capacity-building exercises to ensure success. Children of color and from low-income families ride the bus more frequently, often in poorly resourced school districts with less funds for procurement (Federal Highway Administration 2022). Under-resourced school districts may also have challenges investing in ESBs and charging infrastructure when other expenditures at the school district level take precedent.

Without adequate support, the transition to new electric buses has the potential to worsen existing disparities because predominately white and higher-income communities with smaller shares of pre-2010 diesel buses have the capacity and funds to realize a faster and easier transition to ESBs.

ESB ADOPTION

Our research found that a large share of ESBs are in low-income school districts (43 percent), school districts with the highest populations of residents of color (68 percent), and in areas with high $PM_{2.5}$ and ozone levels (43 percent and 34 percent, respectively). This is likely caused by funding programs that target one or more of these criteria. Additionally, the most ESBs and school districts with ESBs are in regions that are above the national median for six distinct nonwhite racial and ethnic categories.

Taken together, this data on the distribution of ESBs among districts with different racial compositions, income levels, air quality, asthma rates, and locales supports the idea that the transition to ESBs is happening equitably because these are often considered under-served communities.

To reiterate, the ESB Initiative defines *equity* as the guarantee of fair treatment, access, opportunity, and advancement while striving to identify and eliminate barriers that have prevented the full participation of some groups. An equitable transition to ESBs would be one where under-served communities—including school districts where a significant share of the population is considered to be low income (and whereby schools have fewer resources), people of color, or exposed to environmental health hazards like air pollution—are the first to experience the health and societal benefits of ESBs.

However, the rate of ESB adoption fell slightly in communities of color and in school districts with high air pollution between September and December 2022, largely due to the EPA's Clean School Bus Program, which did not include these characteristics as funding criteria. Whenever possible, prioritizing low-income districts should not come at the expense of communities of color and those with poor air quality. To ensure these areas continue to benefit from ESB adoption, funding opportunities and policies should explicitly prioritize regions that have a relatively high percentage of people of color and high air pollution levels. These resources should also prioritize areas with high asthma rates since most ESBs are currently in areas with the lowest levels of adult asthma rates. More research is needed on childhood asthma rates and diesel exhaust exposure from school buses.

We also found that in areas that are above the median for the percentage of residents who are American Indian/Alaska Native/Native Hawaiian/other Pacific Islander, the share of ESBs is around 20 percent less than the share in other nonwhite racial and ethnic categories. Although this can partly be explained by an outlier in terms of ESB commitment size, it is still important to note that American Indian and Alaska Native populations experience higher rates of asthma than the general population (AAFA 2020). Funders and policymakers should commit to supporting these groups with the transition to ESBs.

The percentage of ESBs adopted in rural areas has increased since September 2022. This pattern addresses equity concerns because rural areas have an outsized proportion of older, and more polluting, diesel buses that may now be taken off the road. Additionally, one might consider the current distribution of school districts with committed ESBs equitable since it matches closely to the distribution of all school districts among different locales. The design of funding programs and policies should account for the unique challenges that different locales face when pursuing vehicle electrification projects so that a school district's geography does not preclude it from transitioning to ESBs. Technical assistance providers should also tailor their support based on the district's locale.

An equitable transition to ESBs would be one where under-served communities are the first to experience the health and societal benefits of ESBs.

More research is needed on equitable ESB adoption because no single scale is most relevant from an equity perspective. Different trends appear at different geographic scales, such as at the state level, school district level, bus level, or student level. For example, 34 percent of school districts with ESBs are in the country's top quartile for $PM_{2.5}$ levels, compared to 25 percent of districts with ESBs overall. This initial result is seen as equitable because districts with the worst air quality are benefiting from ESBs at a higher rate. However, at the same time, it is possible that the ridership on these buses is comparatively lower than in areas with better air quality, meaning fewer students are getting the benefits than if the electric buses were otherwise distributed.

There are also other relevant equity considerations at the intradistrict level that we do not currently have the data to assess. For instance, we lack data on which schools within a district are benefiting from ESBs and the socioeconomic characteristics of those schools, as well as the ambient air quality, which may vary considerably, especially in larger districts. Although it is likely that ESBs are replacing districts' oldest buses, we do not know which routes they are being placed on; longer routes may reduce overall exposure to diesel exhaust.

POLICY TRENDS AND FUTURE DIRECTIONS

Policymakers in federal and state governments have made efforts to prioritize funding for school districts in areas with higher shares of low-income populations and pollution levels. Overall, the aggregated data shows that environmental considerations have channeled most resources to low-income and environmentally burdened communities. Without this targeted prioritization criteria, the transition to new electric buses has the potential to worsen existing disparities because predominately white and higher-income communities with smaller shares of pre-2010 diesel buses have the funds—and the capacity to navigate funding applications—to realize a faster and easier transition to ESBs.

However, it is important to disaggregate the data because major federal or state funding programs can potentially mask inequitable outcomes. Excluding the Clean School Bus Program, Volkswagen Settlement funds, Rural School Bus Pilot Project, and California's HVIP, most ESBs were awarded to schools in districts with lower shares of low-income populations. For example, out of 65 ESBs funded by utilities, 33 were awarded to school districts with the lowest shares of low-income populations. Schools that did not report a funding source, which represented more than 500 ESBs, were more likely to serve students in higher income brackets. This finding highlights the importance of embedded equity considerations throughout all public funding sources, federal and local, to ensure an equitable distribution of ESBs.

In contrast, when looking at disaggregated pollution levels, more ESBs were awarded to schools with the highest levels of ambient $PM_{2.5}$ pollution. This is driven by ESBs in California or buses whose funding sources were not reported. This finding demonstrates that as states increase their adoption of ESBs, it is important to include environmental considerations in all funding to ensure an equitable distribution of ESBs and their benefits.

The transition to ESBs is helping to reverse trends that place larger shares of older diesel buses in districts with more low-income households, residents of color, and worse ambient air quality. This is partly due to inclusive federal and state funding programs that have prioritized disadvantaged districts with worse air quality. State policymakers and agencies supportive of ESBs should use this analysis to target resources toward districts that are most impacted by older diesel buses and encourage community involvement in and advocacy for the transition to electric fleets. Local stakeholders and school district officials, particularly those with older buses, can seize the opportunity of unprecedented federal funding and investments in utility infrastructure to provide all their children with a clean ride to and from school.

ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
EJ	environmental justice
EPA	US Environmental Protection Agency
ESB	electric school bus
DERA	Diesel Emissions Reduction Act
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Program
LEAID	local education agency identification
NYTVIP	New York Truck Voucher Incentive Program
PM	particulate matter
RGGI	Regional Greenhouse Gas Initiative
WHO	World Health Organization

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