NC STATE UNIVERSITY

MEMORANDUM

NC CLEAN ENERGY TECHNOLOGY CENTER

From: John Bonitz, Clean Transportation Specialist, jhbonitz@ncsu.edu

To: Interested parties

Re: Student health and academic improvements with clean school buses

Date: June 16, 2023

Some citations for research and study literature show considerable improvements in student respiratory health, academic performance, and student attendance when old diesel school buses are replaced with cleaner engines or electric school buses. They emphasize the benefits of transitioning to cleaner and more environmentally-friendly school buses.

The main points of these six studies are that

- Diesel exhaust causes cancer,
- Exhaust from diesel engine school buses can be higher inside than outside the bus,
- Retrofitting diesel school buses is not only beneficial for students' health but also improves their academic outcomes,
- Reducing school bus emissions is clearly associated with better academic performance, and
- Increasing the pace at which older, highly polluting buses are replaced positively impacts student attendance.

1) Diesel Engine Exhaust Carcinogenic. International Agency for Research on Cancer (IARC), World Health Organization (WHO), (2012).
https://www.iarc.who.int/news-events/iarc-diesel-engine-exhaust-carcinogenic/

Summary: After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

2) Diesel Emissions from School Buses Increase Pollution Levels inside the Bus: Summary of studies of air pollution inside school buses, Environmental Defense Fund (2006).
https://www.edf.org/sites/default/files/5342_School_bus_pollution_studies.pdf

Summary:
Recent studies show that air pollutant levels inside school buses can be greater than the ambient levels outside the bus. The elevated levels are attributed to emissions from the bus itself that intrude into the bus cabin, a process sometimes called "self-pollution." Factors that affect the amount of these emissions entering the bus include wind speed and direction, whether windows are opened or closed,

and the age and condition of the bus. A smaller number of studies question whether school bus self-pollution actually occurs to any significant extent, typically attributing pollution inside a school bus to other vehicles on the road. The existing evidence is summarized in the attached review.

On balance, there is strong evidence that school bus self-pollution is a real phenomenon. Five independent research teams using different methods have documented the effect for many buses in numerous locations. By comparison, the studies with negative results examined fewer components of the engine's emissions and consequently failed to fully characterize the problem.

3) Do Electric School Buses Have an Impact in the Classroom? Handel-Meyer, Samantha. Chicago Policy Review (Online); Chicago (Jan 8, 2020).
https://www.proquest.com/docview/2334202497

Abstract: Policy experts have studied the many social determinants of health for years. Most researchers agree that a person's health is dependent on his or her social and physical environment. Many studies have examined how repeated exposure to air pollution increases the risk of developing asthma and pneumonia. School buses, which about 25 million children in the United States ride to school every morning, are a major source of this pollution. A recently published study suggests that these buses are negatively impacting not only students' health but also their academic achievement.

Excerpt: The researchers' analysis reveals two notable trends. **First, districts that retrofitted more buses see a significant increase in respiratory health.** This finding is especially strong among elementary-age students. Perhaps more surprisingly, those districts also demonstrate **a significant increase in English test scores**. This increase in test scores is so dramatic that the authors compare it to the impact of an experienced teacher (another study found similar shifts in test scores when comparing the outcomes of first-year teachers and fifth-year teachers). **In other words, these results suggest that retrofitting diesel school buses is not only beneficial for students' health but also improves their academic outcomes.**

4) School Bus Diesel Retrofits, Air Quality, and Academic Performance: National Evidence Using Satellite Data. Austin, Wes. Georgia State University, gaustin4@gsu.edu, October 25, 2019
http://wes-austin.com/files/Bus_Retrofits_National_102119.pdf

Abstract: **Prior work shows that air pollution affects cognitive performance.** School bus diesel emissions meaningfully contribute to this exposure for school-age children. I exploit variation in the timing and location of 17,901 school bus diesel engine retrofits or replacements across the US from 2008 to 2016 to test how these bus fleet investments affect air quality and student test scores. I use satellite-based fine particulate matter (PM 2.5) measurements from the Atmospheric Composition Analysis Group to provide the first evidence that these engine retrofits significantly improve surface-level ambient air quality, suggesting potentially large spillover benefits. Retrofitting school buses is also associated with a 0.05-0.06 standard deviation increase in standardized test scores. Moreover, each additional μg/m3 of fine particulate matter is associated with a precisely-estimated decrease in English and math test scores of 0.0056 standard deviations. **Finally, I calculate the benefit of these test score and air quality improvements, finding that $170 million spent in**

grants by the EPA led to approximately $4.75 billion in external benefits. Whether considered from a mortality and clinic cost or test score perspective, the retrofits pass a benefit-cost test.

5) Randomized design evidence of the attendance benefits of the EPA School Bus Rebate Program. Pedde, M., Szpiro, A., Hirth, R. et al. Nature Sustainability (2023).
https://doi.org/10.1038/s41893-023-01088-7
https://www.nature.com/articles/s41893-023-01088-7

Abstract: Approximately 25 million children ride buses to school in the United States. While school buses are the safest school transport from an accident perspective, older buses often expose students to high levels of diesel exhaust. Because these exposures can adversely impact health, which may lead to more missed school, the US Environmental Protection Agency (EPA) has spent millions of dollars to hasten the transition of school bus fleets to cleaner vehicles. Here, we leveraged the randomized allocation of the EPA's 2012–2017 School Bus Rebate Program funding to causally assess the district attendance impacts of upgrading buses. Districts randomly selected for funding had greater attendance improvements after the lottery than unselected districts, resulting in over 350,000 estimated additional student days of attendance each year (95% confidence interval = −70,678 to 772,865) due to the use of EPA funds. **Attendance improvements were greatest when the oldest buses were replaced and for districts with high ridership on applicant buses.** Extrapolating our results nationwide, we expect that the replacement of all pre-2000 model year school buses would lead to more than 1.3 million additional student days of attendance per year (95% confidence interval = 247,443 to 2,406,511). **Given the importance of attendance to educational success, we conclude that increasing the pace at which older, highly polluting buses are replaced positively impacts student attendance.**

6) School buses, diesel emissions, and respiratory health. Timothy K.M. Beatty et al, Department of Applied Economics, University of Minnesota, Journal of Health Economics (2011).
https://www.sciencedirect.com/science/article/pii/S0167629611000701#bib0190

Abstract: School buses contribute disproportionately to ambient air quality, pollute near schools and residential areas, and their emissions collect within passenger cabins. This paper examines the impact of school bus emissions reduction programs on health outcomes. A key contribution relative to the broader literature is that we examine localized pollution reduction programs at a fine level of aggregation. We find that school bus retrofits induced reductions in bronchitis, asthma, and pneumonia incidence for at-risk populations. Back-of-the-envelope calculations suggest conservative benefit–cost ratios between 7:1 and 16:1.