CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

School Bus Replacement Program/Clean Transportation Program

FINAL PROJECT REPORT

Hanford Elementary Electric School Bus and Charging Infrastructure Project

Prepared for: California Energy Commission

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance, and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) created the School Bus Replacement Program, appropriating up to $75 million from the California Clean Energy Jobs Act (Proposition 39), an initiative that voters approved in 2012. The statute authorizes the CEC to provide school bus replacement grants to school districts, county offices of education, and joint power authorities operating the oldest school buses in disadvantaged communities.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued GFO-17-607 to provide funding opportunities under both the School Bus Program to fund projects that replace the oldest diesel school buses in California with electric vehicle school buses and the Clean Transportation Program to fund infrastructure projects that support the electric vehicle school buses. In response to GFO-17-607, the recipient submitted an application that was proposed for funding in the CEC's notice of proposed awards November 12, 2019, and the agreement was executed as ARV-19-048 on July 17, 2019.

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ABSTRACT

Hanford Elementary School District (Kings County) submitted an application to receive grant funding under the California Energy Commission (CEC) Solicitation GFO-17-607 to replace five old diesel school buses. Hanford Elementary School District was awarded funding for five vehicle-to-grid ready electric school buses and the supporting electric vehicle charging infrastructure. Hanford Elementary School District purchased five electric school buses, installed five chargers, and installed a 62.7-kilowatt (kW) solar system with a 60kW/130-kilowatt-hour (kWh) battery through the CEC. The buses were placed into service January 12, 2021, and districts were offered workforce training to help support the successful deployment of the new electric fleet. The old, diesel-powered buses were also dismantled and removed from service. This project found that the electric school buses reduced greenhouse gas emissions by 2,443 short tons and that the electric school buses had a lifetime cost savings of $20,295.

Keywords: GFO-17-607, grant funding, electric school bus, diesel, greenhouse gas emissions, cost savings, vehicle-to-grid, electric vehicle charging infrastructure, workforce training.

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EXECUTIVE SUMMARY

The priority of Hanford Elementary School District has always been student health and educational success. The Hanford Elementary School District embraces continuous improvements to its transportation department and fleet to help keep students safe and healthy. This project sought to replace old diesel school buses with zero-emission electric school buses. The replacement buses will improve air quality and reduce school energy and maintenance costs while providing students with necessary school transportation.

The first stage focused on installation of charging infrastructure. This included coordinating with the local utility company, producing engineering and design drawings by subcontractors, purchasing charging equipment, and constructing the charging station. The electric vehicle charging infrastructure is located and maintained at 938 Katie Hammond Lane, Hanford, California, 93230 (Kings County).

The second stage dealt with the procurement of electric school buses. Hanford Elementary School District applied for and was awarded grant funding for the purchase of five new electric school buses. Hanford Elementary School District selected a school bus manufacturer, placed a purchase order for bus procurement, and placed the buses into service January 12, 2021.

The third stage required the Hanford Elementary School District to scrap the old diesel school buses within 12 months from the delivery of the new electric school buses. This disposal is to ensure that the old diesel school buses do not continue to produce emissions.

The final stage involved 12 months of data collection on the electric school buses. These data were used to analyze the economic and environmental impacts that resulted from the electric for diesel school bus replacement.

Hanford Elementary School District's electric school buses have helped save money on fuel and maintenance costs. The new buses have also improved the health of students by reducing their exposure to toxic air contaminants. Hanford Elementary School District recommends school districts across the state to replace their old diesel-polluting school buses with clean, all-electric school buses.

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CHAPTER 1: Introduction

Background

Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) appropriated funds to establish the School Bus Replacement Program at the California Energy Commission (CEC). The CEC provided one-time funding of $75 million from Proposition 39 for the replacement and scrappage of old diesel school buses in disadvantaged and low-income communities throughout California.

To allow wider coverage of the program, the funds were distributed among four regions in California: Northern California, Central California, Southern California, and Los Angeles County. Additional funding of almost $14 million from the CEC's Clean Transportation Program was leveraged to provide the necessary charging infrastructure schools would need to operate the buses. Also, $1 million in Clean Transportation Program funds were set aside for workforce training and development to ensure proper operation and maintenance of the buses in the years to come.

The CEC received more than 200 applications for more than 1,600 diesel school buses requested for replacement, some buses as old as 1978. CEC staff then evaluated the buses based on three factors: age of bus, applicant's percentage of free and reduced-price meals recipients, and applicant's disadvantaged community score according to the CalEnviroScreen 3.0. From the applications received, an initial list of ranked buses was released in November 2018.

The second phase of the program included selecting a manufacturer or dealer that could design, construct, and deliver electric school buses. In November 2018, the CEC released a solicitation to establish a bulk purchase price for replacement buses. Applications were evaluated and scored for the technical evaluation portion based on the following criteria:

- Relevant experience and qualifications
- Project readiness and implementation
- Client references
- Battery and fuel range
- Warranty, service, and support
- Innovation
- Economic benefits to California
- Ability to leverage funding

Applications passing the technical evaluation advanced to the next screen, where the lowest-cost bid was selected for each school bus type (Type A[1], Type C[2], Type D[3], and each type with or without chair lifts). The bus bid forms were ranked in order from lowest to highest cost per bus by type. Table 1 shows the manufacturer's awarded bids, which did not include an awarded Type B bus.

[1] A Type "A" school bus is a van conversion or bus constructed utilizing a cutaway front section vehicle with a left-side driver's door. This definition includes two classifications: Type A-I, with a Gross Vehicle Weight Rating (GVWR) less than or equal to 14,500 pounds; and Type A II, with a GVWR greater than 14,500 pounds and less than or equal to 21,500 pounds.

[2] A Type "C" school bus is constructed utilizing a chassis with a hood and front fender assembly. The entrance door is behind the front wheels. A "type C school bus" also includes a cutaway truck chassis or truck chassis with cab, with or without a left side door, and with a GVWR greater than 21,500 pounds.

[3] A "type D school bus" is a body installed upon a chassis, with the engine mounted in the front, midship or rear, with a gross vehicle weight rating of more than 10,000, designed for carrying more than ten persons. The engine may be behind the windshield and beside the driver's seat; it may be at the rear of the bus, behind the rear wheels, or midship between the front and rear axles. The entrance door is ahead of the front wheels. A type D school bus has a maximum length of 45 feet.

Table 1: School Bus Replacement Program Awarded Bids

Applicant	Bus Type	Bid Amount
The Lion Electric Co.	Type A Without Chair Lift	$271,389
A-Z Bus Sales, Inc. – California (Micro Bird)	Type A With Chair Lift	$293,424
The Lion Electric Co.	Type C Without Chair Lift	$321,184
The Lion Electric Co.	Type C With Chair Lift	$329,627
The Lion Electric Co.	Type D Without Chair Lift	$332,009
The Lion Electric Co.	Type D With Chair Lift	$339,370

Source: CEC

Once the manufacturers were selected, CEC staff was able to allocate funding based on bid price, using the rank list to determine which applicants would be awarded buses. From the initial rank list of buses, the CEC was able to fund 228 electric school buses, with an additional $60,000 in infrastructure funding per bus.

Recipients also had the option to procure their bus(es) outside the CEC awarded manufacturer bid, as long as the recipients used their own established procurement procedures while adhering to all applicable state and local laws and terms and conditions of the grant agreement.

School Bus Replacement Program Objectives

The School Bus Replacement Program is helping schools throughout the state transition from old, polluting diesel school buses to electric school buses, reducing exposure to harmful emissions and helping the state reach its climate and air quality goals. This program also supports the state's overall energy goals such as the Low Carbon Fuel Standard target for 2030 and the Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) target goal to reduce greenhouse gas (GHG) emissions 40 percent below the 1990 level by 2030. The agreement objective is to purchase electric school buses to replace diesel buses that will be removed from service and scrapped and install or upgrade electric bus charging infrastructure at grant recipient transportation sites.

CHAPTER 2:
Project Details

Electric School Bus Funding

Hanford Elementary School District was awarded $1,957,663 to replace five old diesel school buses with five all-electric school buses, as well as purchase and install the associated charging infrastructure. The district selected one Type C bus with wheelchair lift and four Type D buses without wheelchair lift, based on the following needs:

- Total cost of bus (CEC share)
- Quoted bus range and battery capacity (kWh)
- Bus route profiles
- Upgrade options available
- Air conditioning

Hanford Elementary School District is responsible for transporting 830 children per year, with an average route distance of 40 miles. Hanford Elementary School District has a fleet composed of 16 school buses featuring a total of five electric school buses and 11 diesel buses.

Hanford Elementary School District decided to procure electric school buses from BlueBird because of the brand awareness and perceived reputability of the company within the district's transportation department. The Type C buses had the following upgrades: wheelchair lift. These upgrades were necessary due to the mobility needs of the district's students. The total cost for the new electric school buses was $1,927,805. Of that total, 86 percent was covered by the CEC. Figure 1 below shows the district's new electric school buses funded by the CEC.

Figure 1: Hanford Elementary School District Electric School Buses

Source: Hanford Elementary School District

The replaced diesel buses must be scrapped and removed from service within 12 months from delivery of the new bus. Each district was required to show proof of scrappage, which included photographs of bus/engine destruction, vehicle identification number, engine serial number, and method used to dismantle the engine and non-engine components. As of December 18, 2020, all five of the Hanford Elementary School District buses have been scrapped.

Infrastructure Funding

The CEC's Clean Transportation Program allocated $14 million to the School Bus Replacement Program to fund electric school bus charging infrastructure. The CEC provided up to $60,000 per awarded bus for purchase and installation of associated infrastructure. This allocation enabled Hanford Elementary School District to install five Level 2 Blink chargers and a 62.7-kW solar system with a 60-kW/130-kWh battery. The infrastructure was completed July 8, 2021, and began operating that same day.

The CEC worked with electric utilities, both public and private, to assist in upgrading electrical infrastructure required to charge the awarded buses while emphasizing the need to plan for future electrical capacity needs. Electric vehicle supply equipment was required to be, at a minimum, a Level 2[4] ENERGY STAR®-certified, networked charger capable of charging a vehicle at a minimum of 6.2 kW; however, the CEC recommended electric vehicle supply equipment capable of charging at 19.2 kW. These high-capacity 19.2-kW chargers require only 6–8 hours of charging time to power a school bus battery from 0 to 100 percent, as indicated by the school bus manufacturers selected for the School Bus Replacement Program. Networked electric vehicle supply equipment provides recipients with the ability to set charging for buses to off-peak-demand hours, provide remote diagnostics, and allow remote start of connected vehicles.

Obstacles, Delays, and Lessons Learned

Hanford Elementary School District's biggest obstacle were delays caused by ere the COVID-19 pandemic. The pandemic caused a global shutdown that led to supply chain disruptions and labor shortages. The project was completed on time but took longer than expected because of limited resources.

Another obstacle that the project team faced was selecting a solar structure and contractor that best fit the district's energy needs. In response, the Energy Commission had to develop a memo to its management team to determine what the standards and requirements would be for a school district that wishes to use its infrastructure funds for solar and storage. This approval process took a few months and delayed the solar and battery storage installation.

Hanford Elementary School District also noted that coordination with the local utility and equipment manufacturers on infrastructure management was challenging. Although the local utility provided the infrastructure for the chargers, the utility's lack of invoicing for more than a year made it difficult for the district to modify its charging patterns to be more cost-efficiently. Scheduling issues with the bus manufacturer and charger manufacturer also affected infrastructure maintenance and management. By working towards more effective charging management in the future, the Hanford Elementary School District believes it can save a substantial amount.

[4] Level 2 Chargers operate between 208 and 240 Volts with output of anywhere between 3 kW and 19 kW of alternating current power.

CHAPTER 3:
Workforce Training Funding

In anticipation of the CEC's School Bus Replacement Program, in 2018 the CEC began to work with California school districts, county offices of education, and joint power authorities to understand the importance and role of school bus training for zero-emission school bus technology. Many school districts expressed the need for training of school bus maintenance and service technicians, as well as training for bus operators for battery-electric technology.

In 2019, the CEC approved a $1 million contract with Cerritos Community College to develop and implement the "Electric School Bus Training Project." Cerritos Community College developed the curriculum with the Southern California Regional Transit Training Consortium and college faculty throughout the state. Faculty from the colleges provided training in the school bus regions through a hybrid of in-person and online training.

The training project included automotive instructor-led training to maintenance and service technicians for 96 hours. It also included 12 hours of school bus operator training. The training content consisted of:

- Electric Vehicle School Bus and Charging Infrastructure Familiarization.
- Circuit Diagnostic With Digital Volt Ohm Meter.
- Computerized Engine Management Systems.
- Complexity of the Harness and Computer Functions in the Modern Chassis.
- Programmable Logic Controller Input/Output Systems Diagnostics.
- Network Systems Electronics Diagnosis and Repair
- Electric Bus Driver Training Familiarization.

The district is scheduling training for its mechanics.

Workforce training is an important consideration when incorporating zero-emission school buses into a fleet. As with most new technologies, there is a learning curve and operational adjustments the fleet must make to maximize the benefits of the technology. Compared to conventional-fueled school buses, there are differences in zero-emission school bus maintenance and operation. For example, zero-emission school buses have fewer moving parts, do not have an exhaust system, or require oil changes, and the braking systems of these buses last longer. For these reasons, along with many more, electric school buses have proven to be a cost-effective solution.

CHAPTER 4:
Data Collection

12-Month Data Collection

A requirement of the School Bus Replacement Program was to collect 12 months of data and metrics on the usage of the new buses. These data points will be used to determine the financial, environmental, and health benefits of replacement school buses funded by the CEC. Listed below are the specific data points for the five electric school buses funded by the School Bus Replacement Program.

Hanford Elementary School District Bus Number 7

When placed into service over a 12-month period, the Hanford Elementary School District's Bus 7, shown in Figure 3, traveled 3,855 miles. The replaced diesel fuel bus had a miles-per-diesel-gallon average of 5. The miles traveled over the reporting period equate to a total reduction of 771 gallons of diesel.

The average cost of a gallon of diesel fuel was $4.17 during the reporting period. This equals a diesel cost savings of $3,215. The total replaced diesel maintenance cost of the scrapped bus was $2,313. Over the 12-month period, the new electric school bus used 8,847 kWh. The total cost for this electricity usage was $2,886. Total maintenance cost for the new electric school bus amounted to $0.00. During this 12-month period alone, the Hanford Elementary School District was able to save $2,642 with the new electric school bus.

Hanford Elementary School District Bus Number 8

When placed into service over a 12-month period, the Hanford Elementary School District's Bus 8, shown in Figure 3B, traveled 6,046 miles. The replaced diesel fuel bus had a miles-per-diesel-gallon average of 5. The miles traveled over the reporting period equate to a total reduction of 1,209 gallons of diesel.

The average cost of a gallon of diesel fuel was $4.17 during the reporting period. This equals a diesel cost savings of $5,042. The total replaced diesel maintenance cost of the scrapped bus was $3,628. Over the 12-month period, the new electric school bus used 13,875 kWh. The total cost for this electricity usage was $4,526. Total maintenance cost for the new electric school bus amounted to $0.00. During this 12-month period alone, the Hanford Elementary School District was able to save $4,144 with the new electric school bus.

Hanford Elementary School District Bus Number 9

When placed into service over a 12-month period, the Hanford Elementary School District's Bus 9, shown in Figure 3C, traveled 8,501 miles. The replaced diesel fuel bus had a miles-per-diesel-gallon average of 5. The miles traveled over the reporting period equate to a total reduction of 1,700 gallons of diesel.

The average cost of a gallon of diesel fuel was $4.17 during the reporting period. This equals a diesel cost savings of $7,090. The total replaced diesel maintenance cost of the scrapped bus was $5,101. Over the 12-month period, the new electric school bus used 19,509 kWh. The total cost for this electricity usage was 6,363. Total maintenance cost for the new electric

school bus amounted to $0.00. During this 12-month period alone, the Hanford Elementary School District was able to save $5,828 with the new electric school bus.

Hanford Elementary School District Bus Number 15

When placed into service over a 12-month period, the Hanford Elementary School District's Bus 15, shown in Figure 3D, traveled 6,608 miles. The replaced diesel fuel bus had a miles-per-diesel-gallon average of 5. The miles traveled over the reporting period equate to a total reduction of 1,322 gallons of diesel.

The average cost of a gallon of diesel fuel was $4.17 during the reporting period. This equals a diesel cost savings of $5,511. The total replaced diesel maintenance cost of the scrapped bus was $3,965. Over the 12-month period, the new electric school bus used 15,165 kWh. The total cost for this electricity usage was $4,946. Total maintenance cost for the new electric school bus amounted to $0.00. During this 12-month period alone, the Hanford Elementary School District was able to save $4,530 with the new electric school bus.

Hanford Elementary School District Bus Number 16

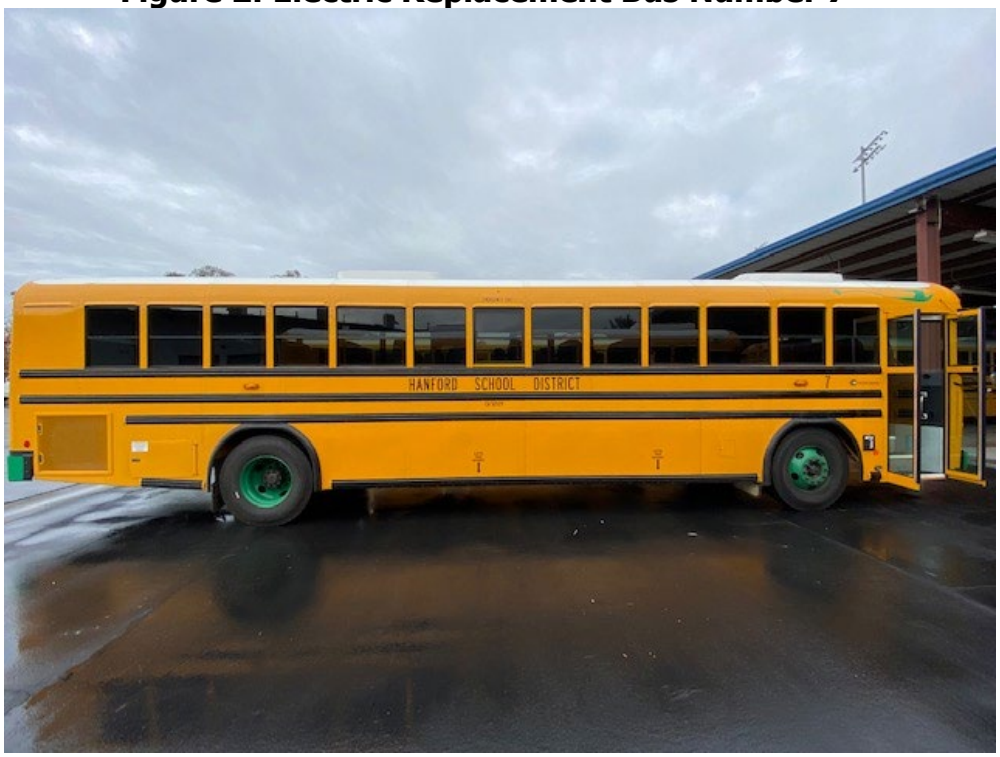
When placed into service over a 12-month period, the Hanford Elementary School District's Bus 16, shown in Figure 3E, traveled 4,233 miles. The replaced diesel fuel bus had a miles-per-diesel-gallon average of 7.6. The miles traveled over the reporting period equate to a total reduction of 557 gallons of diesel.

The average cost of a gallon of diesel fuel was $4.17 during the reporting period. This equals a diesel cost savings of $2,323. The total replaced diesel maintenance cost of the scrapped bus was $ 2,540. Over the 12-month period, the new electric school bus used 9,714 kWh. The total cost for this electricity usage was $3,168. Total maintenance cost for the new electric school bus amounted to $0.00. During this 12-month period alone, the Hanford Elementary School District was able to save $3,151 with the new electric school bus.

The reduction in total gallons of diesel equates to a lifetime reduction of 2,443.40 short tons of GHGs, 5,582.48 lbs. of oxides of nitrogen (NO_x), and 43.74 lbs. of PM2.5 for all five electric school buses. Cost savings analysis of electric school buses over the diesel counterparts indicates a lifetime fuel savings cost of about $28,000, or about 27 percent savings per bus.

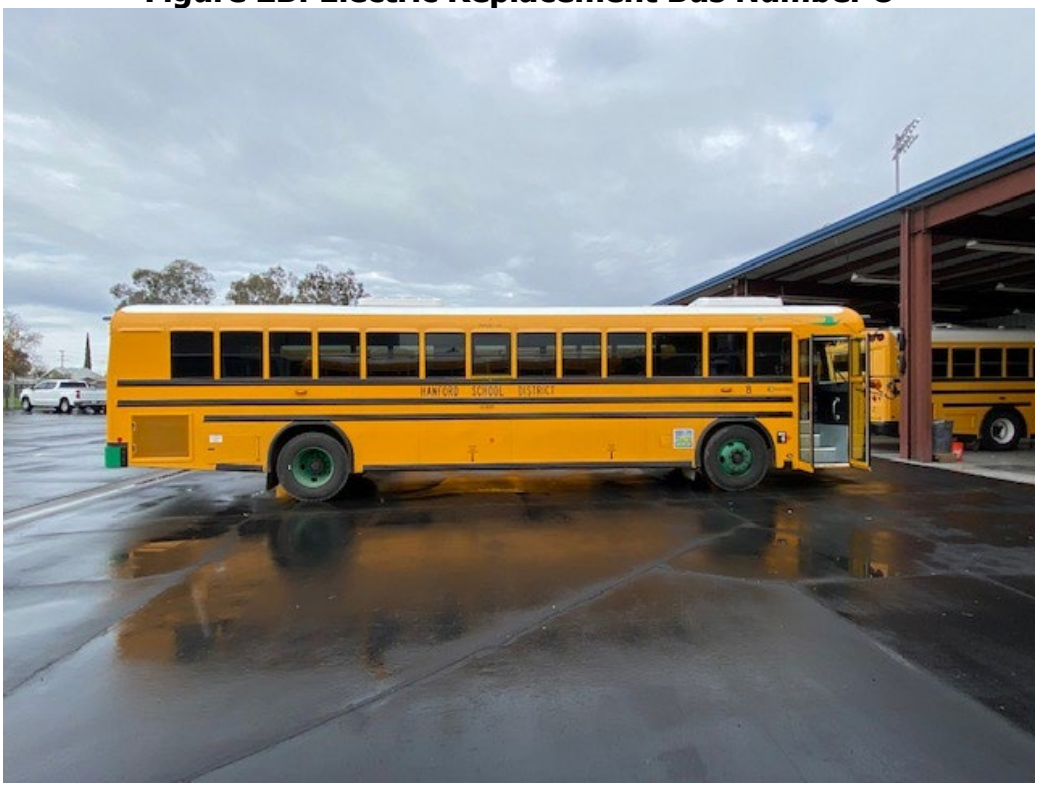
The CEC's School Bus Replacement Program will help reduce tailpipe emissions of smog-forming nitrogen oxides by 98,000 lbs. and toxic diesel soot by more than 2,500 lbs. Minimizing exposure to hazardous emissions reduces the risk to adolescent bus riders of developing respiratory diseases such as asthma and helps the state achieve emissions reductions goals.

Figure 2: Electric Replacement Bus Number 7



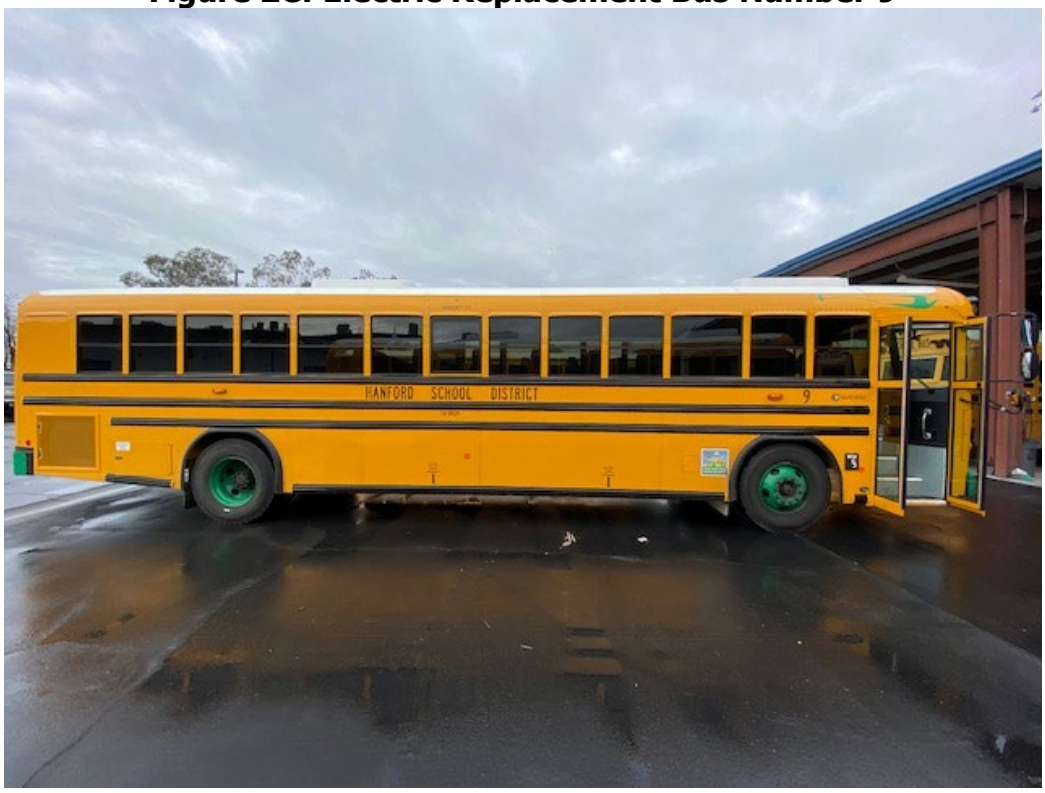
Source: Hanford Elementary School District

Figure 2B: Electric Replacement Bus Number 8



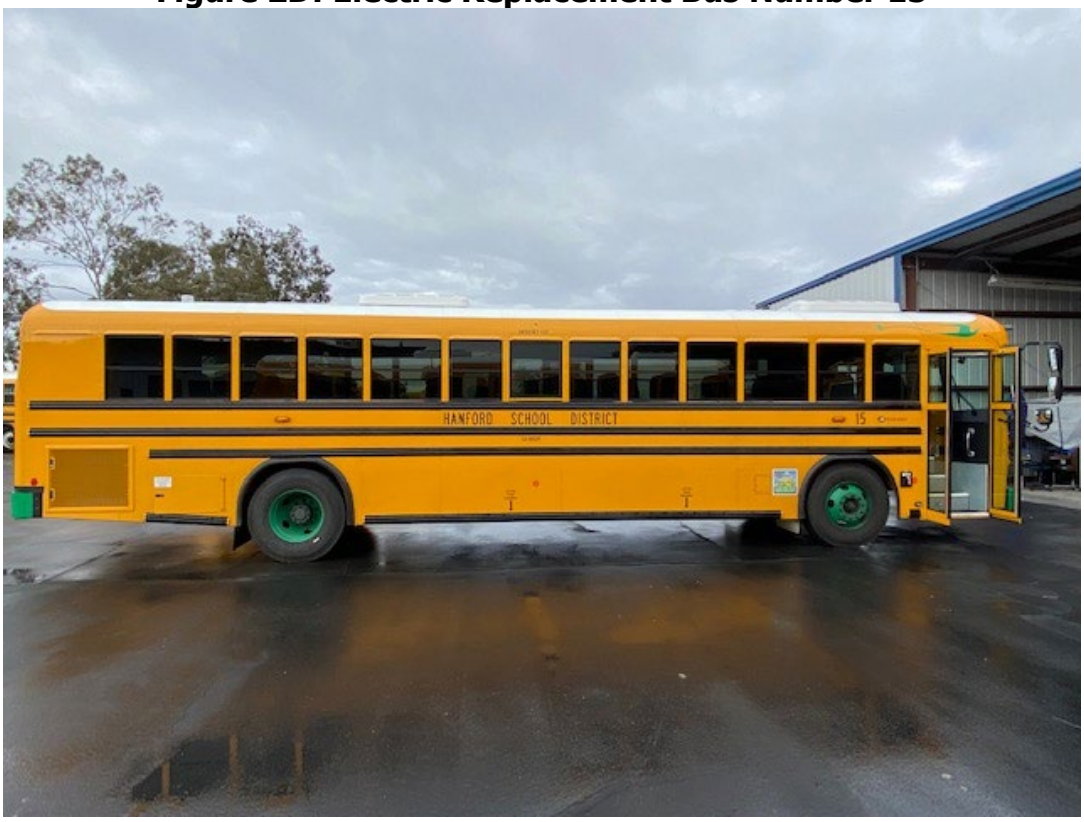
Source: Hanford Elementary School District

Figure 2C: Electric Replacement Bus Number 9



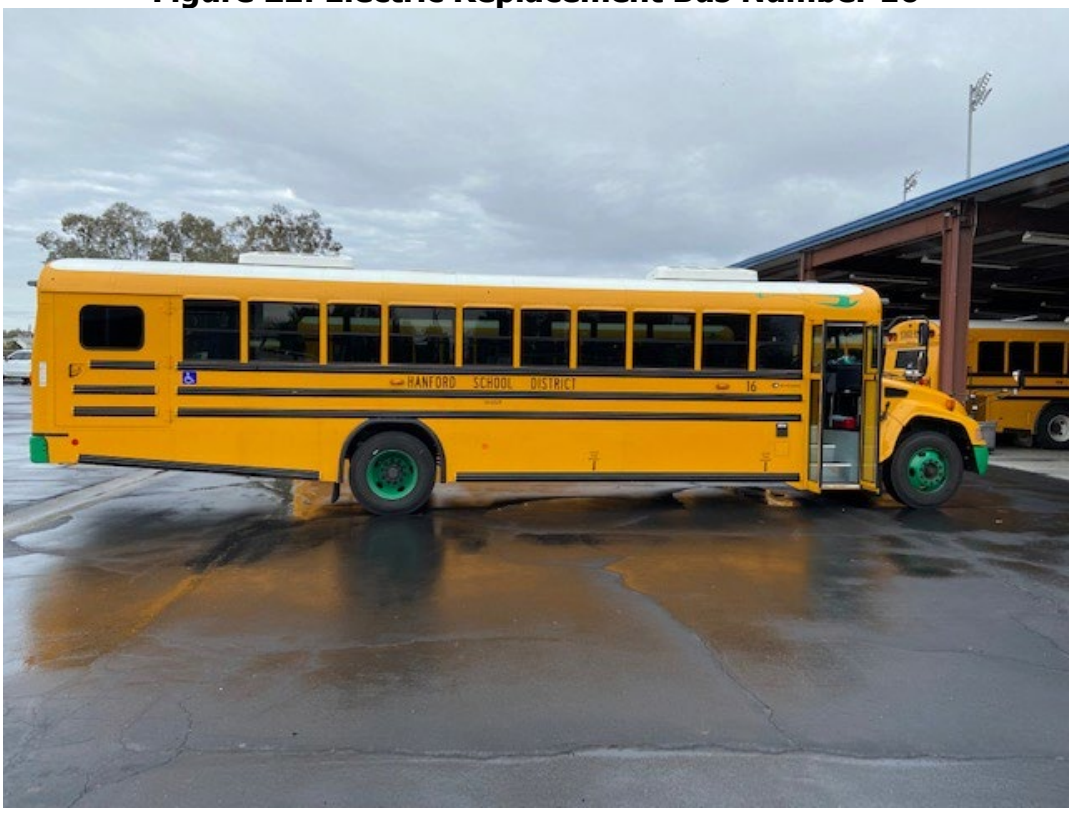
Source: Hanford Elementary School District

Figure 2D: Electric Replacement Bus Number 15



Source: Hanford Elementary School District

Figure 2E: Electric Replacement Bus Number 16



Source: Hanford Elementary School District

CHAPTER 5:
Conclusion

The School Bus Replacement Program was vital to the long-term success of transporting students to and from school. Not only is the program saving districts time and money, it is also helping reduce the total amount of emissions released into the environment. Hanford Elementary School District is dedicated to contributing to California's overall goals of decreasing greenhouse gas emissions and improving overall air quality. Hanford Elementary School District's next steps are to continue to apply for electric school bus grants with the hope of eventually attaining a fully electric school bus fleet for its daily routes.

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC) — The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, sections 25000 et seq.) responsible for energy policy. The CEC's seven major areas of responsibilities are:

1. Planning and Policy Development
2. Renewable Energy Growth
3. Energy Efficiency
4. Energy Innovation
5. Cleaner Transportation
6. Responsible Electricity Infrastructure
7. Emergency Response

KILOWATT (kW) — One thousand watts. A unit of measure of the amount of electricity needed to operate given equipment. On a hot summer afternoon, a typical home — with central air conditioning and other equipment in use — might have a demand of 4 kW each hour.

KILOWATT-HOUR (kWh) — The most commonly used unit of measure telling the amount of electricity consumed over time, means 1 kilowatt of electricity supplied for 1 hour. In 1989, a typical California household consumed 534 kWh in an average month.

LOW CARBON FUEL STANDARD (LCFS)—A set of standards designed to encourage the use of cleaner low-carbon fuels in California, encourage the production of those fuels, and therefore reduce greenhouse gas emissions. The LCFS standards are expressed in terms of the carbon intensity of gasoline and diesel fuel and their respective substitutes. The LCFS is a key part of a comprehensive set of programs in California that aim cut greenhouse gas emissions and other smog-forming and toxic air pollutants by improving vehicle technology, reducing fuel consumption, and increasing transportation mobility options.

NITROGEN OXIDES (OXIDES OF NITROGEN, NOx)—A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes and are major contributors to smog formation and acid deposition. NO2 is a criteria air pollutant and may result in numerous adverse health effects.

PARTICULATE MATTER (PM)—Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

SHORT TON—An imperial unit of mass equal to 2,000 pounds.