CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Culver City Battery Electric Bus Blueprint

Planning for the Zero-Emission Future in an Urban, Municipal-Owned, Transit Fleet

Prepared for: California Energy Commission

Prepared by: Culver City Transportation Department

Culver CITY
TRANSPORTATION DEPARTMENT

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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.
- 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.

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-20-601, Blueprints for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure to identify actions and milestones needed for implementation of medium- and heavy-duty (MD/HD) zero-emission vehicles (ZEVs) and the related electric charging and/or hydrogen refueling infrastructure in order to accelerate the deployment of MD/HD ZEVs and ZEV infrastructure with a holistic and futuristic view of transportation planning. In response to GFO-20-601, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards April 8, 2021 and the agreement was executed as ARV-21-033 on October 8, 2021.

ABSTRACT

This report details the implementation of the blueprints grant and its outcomes during the Culver City Transportation Department planning and development phase of a zero-emission infrastructure design in 2021. The City used the grant awarded by California Energy Commission to undertake and track activities related to the planning, design, and financing a fleet conversion to draft a written blueprint for other agencies to consider. The blueprint contains reasonable estimates for resource requirements needed to complete full conversion to full zero-emission bus service.

Keywords: Zero Emission Bus, Battery Electric Bus, Culver City, Blueprint, Infrastructure, Design

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EXECUTIVE SUMMARY

The purpose of this report is to present the feasibility and benefits of converting a small urban bus system's fleet to battery electric buses. The report covers the following aspects of the zero-emission bus conversion process: current situation, operational costs, funding sources, and implementation plan. The Culver CityBus system operates 54 compressed natural gas buses that are on average 12 years old and have high maintenance and fuel costs. The buses emit greenhouse gases and air pollutants that contribute to climate change and health problems. This effort was driven by the necessity to move to transition to zero-emission by 2045.

The City of Culver City Transportation Department operates Culver CityBus. CityBus operates seven fixed-route local bus routes and one Bus Rapid Transit line. The Culver CityBus service area encompasses Culver City and the Los Angeles communities of Century City, Marina del Rey, Mar Vista, Palms, Playa Vista, Rancho Park, Venice, West Los Angeles, Westchester, and Westwood. Service runs from the University of California at Los Angeles to the north, to the Metro Green Line Station to the south, and from Fairfax Ave. to the east, to Venice Beach to the west; Culver CityBus service also connects with the Exposition Light Rail Line (E Line). Culver CityBus service area encompasses approximately 43 square miles. The population of this area is approximately 530,000.

The implementation plan for converting to battery electric buses consists of four phases in the planning phase of the zero-emission bus program. Planning involved conducting a detailed feasibility study, securing funding sources, developing a project timeline, and initial design.

The Blueprint produced because of this grant agreement provided Culver City with a roadmap for electrification and proved it is a viable and beneficial option for the bus system that can afford the large capital requirements. That document will be distributed for public use on Culver City Website.

CHAPTER 1: Introduction

This report presents the results of a Blueprints study conducted by the Culver CityBus System to design the conversion from compressed natural gas buses to battery electric buses. The study was funded by a grant from the California Energy Commission, which aims to support the adoption of zero-emission vehicles in public transit. The blueprint is now available to the public for download[1] and covers the following aspects of the conversion:

- The benefits and challenges of switching to battery electric bus (BEB) fleet, such as the environmental impact, the energy efficiency, the infrastructure coordination and availability with utilities, and the regulatory compliance.
- The technical and financial requirements for the conversion, such as the selection and procurement of BEBs, the installation and upgrade of charging stations, the training and education of drivers and technicians, and the budget and funding sources.
- The proposed implementation plan and timeline, which outlines the steps and milestones for the conversion process.
- The design Culver CityBus developed because of the conversion analysis process and resulting procurement.

[1] The Culver CityBus Electrification Transition Plan is available at https://www.culvercitybus.com/News/Culver-CityBus-releases-the-BEB-Transportation-Facility-Electrification-Transition-Plan

CHAPTER 2: Project Objectives

Culver City has been working on a multi-phased project to transition to a zero-emission bus (ZEB) fleet. The project aims to reduce greenhouse gas emissions, improve air quality, and lower operating costs.

The project had six objectives, as described in the Scope of Work:

- Objective 1: ZEB Transition Plan. This objective involved developing a comprehensive plan for transitioning the entire bus fleet to ZEBs, including identifying the optimal bus technology, assessing the infrastructure needs and costs, and creating a timeline and budget for the transition.
- Objective 2: Pilot BEB Deployment, Phase 1. This objective involved procuring and deploying ten BEBs and installing four depot chargers at the Culver City Transportation Facility. This objective tested the performance, reliability, and efficiency of the BEBs and the chargers in real-world conditions. Figure 1 shows a BEB for one of Culver City's four pilot buses charging at the City of Culver City bus facility.
- Objective 3: BEB Infrastructure Detail Planning & Design. This objective involved evaluating and selecting the best charging infrastructure option based on the conceptual designs developed in Objective 1. The Center for Transportation and the Environment and AECOM created a detailed infrastructure deployment plan, site plan for complete with infrastructure design capacity, and configuration of the chargers and other related equipment.
- Objective 4: BEB Infrastructure Construction and Installation. This objective involved constructing and installing the charging infrastructure according to the design plans developed in Objective 3. This objective ensured that the charging infrastructure was ready to support the full fleet conversion by 2028.

Figure 1: BEB at Temporary Charger

Source: Culver CityBus

CHAPTER 3: Finance and Budget

Cost Estimating

The total cost of ownership assessment done in the ZEB transition plan compiled the results from the fleet, fuel, facilities, and maintenance assessments to show cumulative and annual costs throughout the transition period for each scenario. It includes selected capital and operating costs of each fleet scenario over the transition timeline. Other costs may be incurred (e.g., incremental operator and maintenance training) during a fleet transition; however, these four assessment categories are the key drivers in ZEB transition decision-making.

Initial Estimate

The total combined cost for the conversion of Culver City's bus fleet is estimated at $172 million for depending on infrastructure scenario selected. Only one alternative, a design with a parking garage and gantry charging platform over the existing bus yard were deemed feasible. The total cost of ownership assessment assumes a total of 54 total BEBs in service by 2028.

The project phasing recommended infrastructure costs be incurred toward the beginning of the project as a possibility to excess scaled purchasing capacity considering ongoing inflation for major capital investment. Maintenance and fueling costs remained relatively stable from year to year. Fleet costs are the main source of variability in costs from year to year, depending on the agency's bus procurement schedule. Figure 2 is one of the circulator minibuses currently in operating in service for Culver City.

Figure 2: Circulator Minibus

Culver CityBus Circulator Vehicle fully electric and currently in service

Source: Culver CityBus

The total cost of ownership assessment summarizes the main findings and recommendations from the four assessments conducted for the ZEB transition project. The document provided a clear and comprehensive overview of the total and annual costs of each fleet scenario and infrastructure option over the transition period (2021-2040). The document used consistent assumptions and data sources across the four assessments to ensure comparability and reliability of the results. The document highlighted the key drivers and trade-offs in ZEB transition decision-making, such as capital costs, operating costs, environmental benefits, and social impacts.

The document could have included more sensitivity analysis to account for uncertainty and variability in key parameters, such as fuel prices, inflation rates, and maintenance costs. The document could have addressed some of the limitations and challenges of ZEB transition, such as availability of charging infrastructure, grid capacity, and technology maturity. The document could have incorporated more stakeholder feedback and input from potential ZEB operators and users to enhance the relevance and applicability of the findings.

Construction Estimates

The project team used a variety of methods and tools to estimate the construction costs, such as historical data, parametric estimation, bottom-up estimation, and contingency analysis. They also updated the estimates regularly throughout the project life cycle, considering the changes in scope, schedule, quality, and risks. As a result, the final construction cost of Phase 1 was only 2-percent higher to provide infrastructure for 36 BEBs.

CHAPTER 4: Design

In September 2022, the City Council approved the civil, structural, and electrical plans for Phase 1 of the project and authorized staff to issue a bid for the construction of the electrification infrastructure. In October 2022, the City Council approved the complete plans for Phase 1.

The first phase of the project involves the installation of five heavy vehicle chargers along a newly constructed concrete island. These chargers, which have a total capacity of 750kW and a maximum demand of 150kW each, will be used to charge the first ten battery electric buses.

Each charging cabinet will have two space frame-mounted dispensers. The existing transformer will be upgraded to handle the increased load, and trenching and boring will be carried out to install a conduit from the distribution panel to the charging island. The charger stub outs will also be completed during this phase. Figure 3 shows the completed spaceframe structure from bird's eye perspective.

Figure 3: Rendering of Phase 1 and 2

This is a completed rendering for the design activities undertaken during the Grant.

Source: Culver CityBus

In addition, half of a new space frame structure will be constructed over the western half of the yard. This structure will include an advanced pulley system that will allow the dispensers to be pulled from overhead and plugged into the vehicles to charge them.

Phase 1:

- Construction of a new central island with underground infrastructure for future connections.
- Installation of a new space frame canopy over the northern bus lanes.
- Installation of a new 4000A switchboard with breakers for phase 1 and space for future phases.
- Installation of underground conduit infrastructure.
- Installation of charging infrastructure for 10 bus positions.
- Installation of a new distribution panelboard for lighting and power at the canopy.
- Connection to the Southern California Edison service, including conduit from the overhead point of connection to the transformer pad and from the transformer to the switchboard.

Phase 2:

- Installation of charging infrastructure for an additional 10 bus positions.
- Installation of breakers for phase 2 in the switchboard.
- Installation of a new space frame canopy over the southern bus lanes.
- Installation of a new 4000A switchboard with breakers for phase 4 and space for future phases.
- Installation of charging infrastructure for 7 bus positions.
- Installation of charging infrastructure for 18 bus positions.
- Installation of breakers for phase 5 in the switchboard.
- The work in the initial design also included the following items:
- Demolition of existing yard paving, fueling pumps, concrete-filled steel bollards, underground fuel lines, high mast light poles, and yard striping.
- Construction of three new service islands on a raised curb for new charging equipment.
- Construction of new electrical switchgear, panels, and an underground duct bank to new charging cabinets on service islands.
- Construction of a new steel space frame with supporting steel columns and foundations, dispenser boxes and charging cables/reels, new lighting, and a steel purlin framework on top grid of the space frame to allow attachment of a future solar photovoltaic (PV) system. See Figure 4 for ground level view of spaceframe with PV panels mounted on top.
- The space frame is designed to support live and dead loads, including the frame itself, all attached charging equipment, lighting, a future solar PV system, and service worker fall protection.

The resulting design lead the Culver City Transportation Department to issue an invitation for bids and awarded a construction contract for Phase 1 of the Transportation Facility Electrification Project. This contract was authorized on December 12, 2022, and was valued at $4,055,000.

However, after the contract was awarded, the Transportation Department canceled the bid. Cost considerations and the ability to manage such an intense work program amidst changes in leadership has seen a pause on construction for further research into potential hydrogen solutions and possible facility expansion. In February 2023, the Transportation Department recommend that the City Council cancel the contract award and issue a new invitation for bids (IFB) in the future based on additional research done in the intermediary period.

Figure 4: Rendering of Spaceframe With PV Panels

Source: Culver CityBus

Glossary

BATTERY ELECTRIC BUS (BEB): A bus that runs on electricity stored in batteries and does not emit any tailpipe emissions.

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 Energy Commission's five major areas of responsibilities are:

1. Forecasting future statewide energy needs
2. Licensing power plants sufficient to meet those needs
3. Promoting energy conservation and efficiency measures
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
5. Planning for and directing state response to energy emergencies.

CULVER CITYBUS (CityBus): Municipal bus transit service operated by Culver City Transportation Department for the City of Culver City.

PHOTOVOLTAIC (PV): A technology that converts sunlight into electricity using solar cells. PV systems can be installed on rooftops, ground mounted, or integrated into building materials.

ZERO EMISSION BUS (ZEB): A bus that does not produce any harmful emissions from its propulsion system. This can include battery electric buses, fuel cell buses, or buses that use renewable fuels.