Redding Area Bus Authority (RABA) Zero-Emission Bus Rollout Plan

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This plan satisfies the requirements of the California Air Resources Board Innovative Clean Transit (ICT) regulation and the Federal Transit Administration (FTA) I Zero-Emission Fleet Transition Plan for the Grants for Buses and Bus Facilities Competitive Program (49 U.S.C. § 5339(b)) and the Low or No Emission Program (49 U.S.C. § 5339(c).

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Section A: Transit Agency Information

The Redding Area Bus Authority (RABA) provides local fixed routes, commuter express and demand-response bus transit service that operates within the City of Redding, City of Shasta Lake, City of Anderson, and Shasta County and provides countywide public transit services. The service offers transportation for various purposes, including work, medical appointments, school, meetings, senior services, shopping, and more, depending on scheduling. RABA buses are equipped with wheelchair lifts or ramps to accommodate passengers with disabilities in mobility devices. RABA provides the service shown in the figure below. RABA operates 38 buses – eighteen (18) Class 7, seventeen (17) Class 4, and three (3) Class 3 vehicles. All are subject to the Innovative Clean Transit (ICT) regulation. These buses cover 170 miles per day on average. The RABA service area boundary is shown in the figure below:

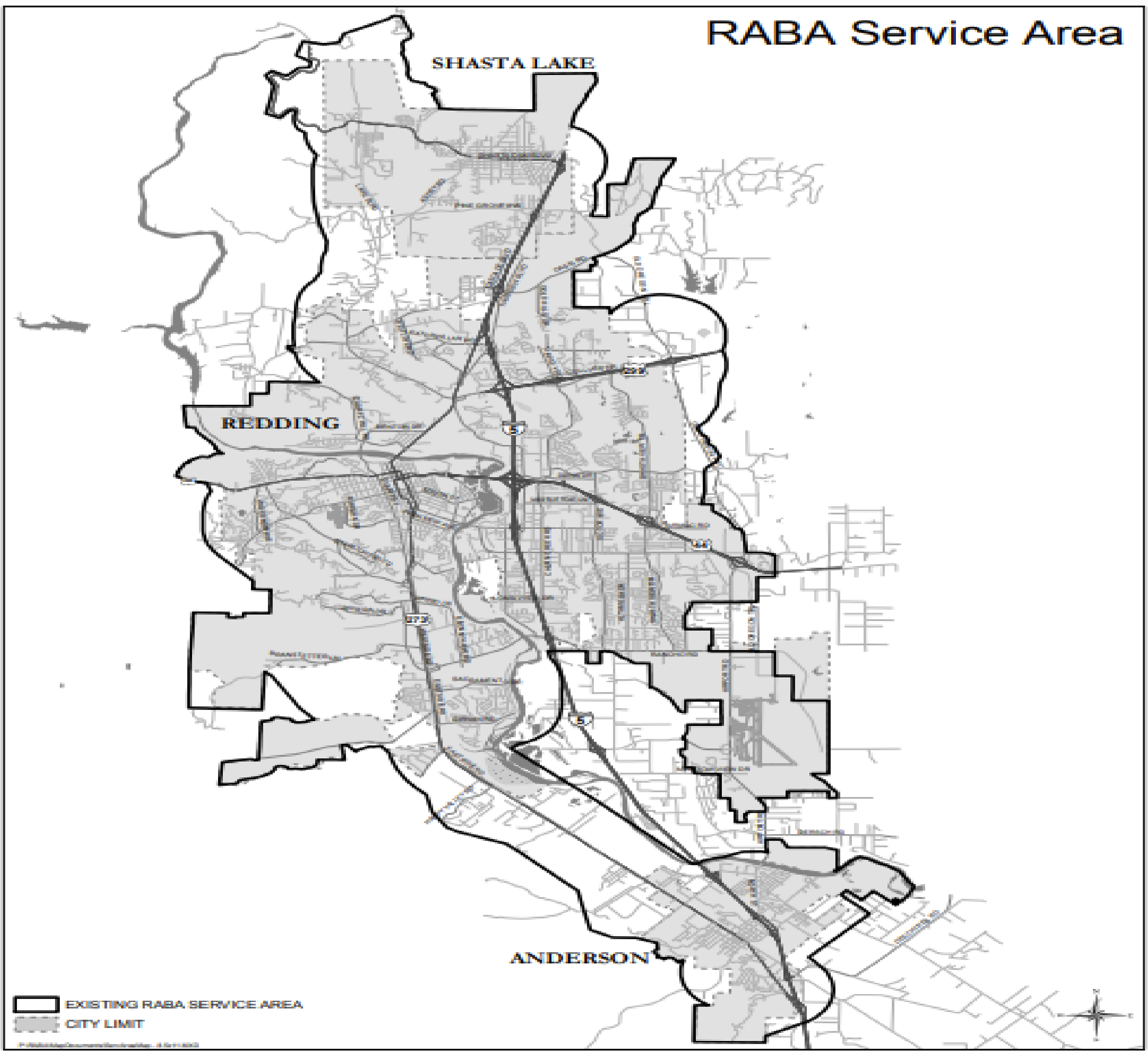


Figure 1 RABA Service area map

General Information

The Redding Area Bus Authority (RABA), based in Redding, CA, is part of the Shasta County Air Quality Management District boundaries. RABA transports approximately 336,000 passenger trips a year. RABA is not currently part of a Joint Zero-Emission Bus Group. They currently have one (1) 2019 Proterra electric bus in service.

RABA is committed to reducing emissions and improving air quality within the community. They have implemented various measures to promote cleaner transportation options, including the use of alternative fuels and exploring the feasibility of transitioning to zero-emission buses in the future.

For additional information on the Rollout Plan and RABA's efforts towards sustainable transportation in Shasta County, please contact John Andoh, Transit General Manager, at 530-338-5091 or jandoh@cityofredding.org.

The ICT regulation allows multiple transit agencies to form a Joint Group. Joint Groups allow the members of the group to comply with the ICT regulation jointly rather than individually. RABA is not currently part of such a joint group.

RABA is committed to transitioning its entire bus fleet to zero-emission in accordance with the ICT regulation.

Section B: Rollout Plan General Information

RABA is dedicated to combatting climate change and enhancing air quality through the adoption of a zero-emission bus fleet. This effort is in line with the ICT regulation issued by the California Air Resources Board (CARB), which mandates all transit agencies in California to transition to zero-emission buses by 2040. To evaluate the feasibility of this transition, the RABA is preparing an ICT Rollout Plan. This ICT rollout plan provides critical information to elected officials and policymakers to support informed decision-making. RABA's Zero Emissions Rollout Plan has a goal of full transition to zero-emission technologies by 2040 that avoids early retirement of conventional transit vehicles.

According to the ICT mandate, all small transit agencies must submit a Zero Emissions Bus (ZEB) Rollout Plan to the Executive Officer of CARB by July 1, 2023, which should include the following items:

1. A goal of full transition to ZEBs by 2040, with a well-planned approach that avoids early retirement of conventional internal combustion engine buses.
2. Identification of the types of ZEB technologies for the transit agency and deployment plans based on techno-economic feasibility for each technology.
3. A schedule for the construction of facilities and infrastructure modifications or upgrades, including charging, fueling, and maintenance facilities, to deploy and maintain ZEBs. The schedule should specify the general location of each facility, the type of infrastructure, the service capacity of infrastructure, and a timeline for construction.

4. A schedule for zero-emission and conventional internal combustion engine bus purchases and lease options. The schedule for bus purchases should identify the bus types, fuel types, and the number of buses.
5. A schedule for conversion of conventional internal combustion engine buses to ZEBs, if any. The schedule for bus conversion should identify the number of buses, bus types, and the propulsion systems being removed and converted.
6. A description of how a transit agency plans to deploy ZEBs in Disadvantaged Communities (DACs) as listed in the latest version of CalEnviroScreen.
7. A training plan and schedule for ZEB operators and maintenance and repair staff.
8. Identification of potential funding sources.

Moreover, the ICT has established a timeline for phasing in ZEB procurements for a small transit agency, which is as follows:

- By 2026: 25% of new bus purchases must be zero-emission.
- By 2029: 100% of new bus purchases must be zero-emission.

The ICT regulation allows multiple transit agencies to form a Joint Group. Joint Groups allow the members of the group to comply with the ICT regulation jointly rather than individually. RABA is not a participant in a joint plan.

CALSTART analyzed the feasibility of replacing the conventional gasoline and diesel fleet with battery-electric buses (BEB)s and fuel cell electric buses (FCEB)s for RABA, including zero-emission bus technology and charging/fueling infrastructure. The project team considered various factors, such as the availability of utility distribution capacity, required infrastructure upgrades, and charging stations, to assess the techno-economic feasibility of transitioning to BEBs and FCEBs.

Additionally, CALSTART developed a conceptual design and outlined a deployment strategy for the vehicles and infrastructure while providing cost estimates based on the ICT regulation timeline. Moreover, CALSTART analyzed the benefits and limitations of replacing the conventional diesel and gasoline powered fleet with ZEBs and provided recommendations to help RABA make an informed decision.

RABA has outlined its plans to gradually replace its conventional diesel and gasoline powered, starting in 2024. RABA intends to replace the vehicles at the end of their useable lifespan, avoiding early retirement. RABA aims for its entire fleet to be zero-emission by 2040.

RABA will pursue all available capital grants from the State of California, Federal Transit Administration, Shasta Regional Transportation Agency (SRTA) and Shasta County Air Quality Management District to cover the costs of a replacement fleet and installation of associated infrastructure to charge the BEBs and fuel the FCEBs.

Additionally, the Federal Transit Administration (FTA) requires that a Zero-Emission Transition Plan must:

- Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions.
- Address the availability of current and future resources to meet costs for the transition and implementation.
- Consider policy and legislation impacting relevant technologies.
- Include an evaluation of existing and future facilities and their relationship to the technology transition.
- Describe the partnership of the applicant with the utility or alternative fuel provider.
- Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.

FTA allows applicants have a similar plan in place that addresses some or all of these components to submit with its grant application to satisfy this requirement. This rollout plan meets the FTA requirements as well.

Section C: Technology Overview

RABA plans to replace their current fleet with ZEBs once funding is secured. BEBs utilize batteries to store electricity and an electrified drivetrain to propel the bus. The bus draws energy from the battery and converts it into torque with the help of a traction motor. During braking, BEBs use regenerative braking to capture the energy that can be used to recharge the battery. Since BEBs and FCEBs do not produce any tailpipe emissions, they are considered environmentally friendly. Additionally, they operate very quietly.

Transit Battery Electric Buses (BEBs)

Classified in the FTA's 12 year/500,000-mile service-life category, transit buses are Class 7 or 8 vehicles, typically used for fixed-route service, and generally range between 30 and 40 feet in length. A transit BEB is a battery-powered bus that has a length of 30 feet or more. Transit BEBs are considered a mature technology: multiple BEB models have passed Altoona testing, and there are several original equipment manufacturers (OEMs) that produce and sell transit BEBs. The Altoona bus testing program is a federal program that evaluates various aspects of buses, including maintainability, reliability, safety, performance, structural integrity, durability, fuel and/or energy economy, noise, and emissions. It serves as a quality control measure to ensure that new bus models are capable of operating safely and reliably in real-world conditions. The testing program is designed to assess and verify the overall quality and performance of buses before they are deployed for public transportation purposes. This is required to purchase buses with federal funds.

Transit BEBs generally have a range of up to 225 miles, depending on the duty cycle. Battery technology is expected to improve over time.

Battery Electric Shuttle Buses

Battery-electric shuttle buses are medium-duty Class 4-6 buses that fall within the FTA 5-year/150,000-mile or 7-year/200,000-mile service-life category. These buses are generally cutaway buses with a length of less than 30 feet and a gross vehicle weight rating (GVWR) greater than 14,000 pounds. They are typically used for demand response service and equipped with a wheelchair lift or ramp to serve persons with disabilities. Most shuttle buses can carry between 12 to 24 passengers. However, OEMs can customize configurations to meet specific transit needs, such as changing the floor plan or adding equipment like fareboxes and wheelchair ramps or lifts. Battery-electric transit vans, classified as Class 1-3 small duty vehicles, smaller than shuttle buses and capable of carrying fewer than 10 passengers, have also been introduced to the market. Currently, the market for electric shuttle buses and vans is limited, with only a few models passing Altoona testing. Battery-electric shuttle buses and vans generally have a range of up to 150 miles.

Transit Fuel Cell Electric Buses (FCEBs)

A transit FCEB is a hydrogen fuel-cell powered bus that has a length of greater than 30 feet and, like transit BEBs, are Class 7 or 8 vehicles, classified in the FTA's 12 year/500,000-mile service-life category, and typically used for fixed-route service. Most current FCEB models have a length of 35 feet or 40 feet. At the time of writing, there is no Altoona tested 30-foot or less FCEB model. Transit FCEBs are considered a mature technology, but to date there are fewer commercial offerings for transit FCEBs than BEBs; however, this is anticipated to change. Transit FCEBs generally have a range of up to 300 miles, depending on the duty cycle. Since transit FCEBs have a longer range, they are generally considered to be a drop-in replacement for a fossil fuel bus.

Fuel Cell Shuttle Buses

A hydrogen fuel cell shuttle bus is defined as a hydrogen fuel-cell powered cutaway bus with a length of less than 30-feet, a GVWR of greater than 14,000 pounds, and is classified in the FTA's 5 year/150,000 mile or 7 year/200,000-mile service-life category. Similar to shuttle type BEBs, fuel cell shuttle buses are generally medium-duty Class 4-6 buses, however, they can be retrofitted within a class 1-3 type vehicle typically used for demand response and deviated fixed route service, have a wheelchair lift or ramp to serve persons with disabilities, and can carry nine (9) to 24 passengers, depending on the floorplan configuration.

The market for fuel cell shuttle buses is less developed than battery electric shuttle buses, with fewer models of fuel cell shuttle buses available. Fuel cell shuttle buses are also at an earlier stage of commercialization and have a lower technology readiness level than battery electric shuttle buses. Hawai'i County has demonstrated in partnership Hawai'i Natural Energy Institute and US Hybrid has retrofitted three shuttle type cutaway buses that can travel up to about 150 miles. Details on this effort is available here: https://www.hnei.hawaii.edu/wp-content/uploads/NELHA-MTA-Hydrogen-Stations-and-FCEBs.pdf

Fuel cell shuttle buses generally have a range of 150-230 miles and cost around $275,000. Data on the cost of a fuel cell shuttle bus is scarce. However, cost data from pilot/demo fuel cell shuttle buses indicates that the price is approximately equal to a battery electric shuttle bus. Fossil-fueled powered counterparts have a range of 350 miles and cost around $75,000. Since fuel cell buses have a longer range than BEBs, they are closer to serving as a drop-in replacement. Both full-sized and shuttle FCEB refuel at 350 bar, but the filling speed may have to be adjusted for the shuttle buses to maintain hydrogen tank integrity.

Charging Infrastructure

Plug-in depot charging is one of the most prominent methods for BEB charging. The dispenser used in charging most electric buses consists of a plug and a hose that connects to the bus to provide energy for battery charging. The dispenser is then connected to a charging cabinet containing the power electronics and communication equipment necessary for controlling charging and communicating with the charging provider's network. Buses can be charged using Level 2 chargers, which provide AC power at up to 240 volts and can deliver up to 19.2 kilowatts (kW).

Figure 2. BEB Plug-in Charger Source: CALSTART [1]

On the other hand, DC fast chargers deliver DC power at up to 600 volts and are typically used to charge transit buses but can also be used for shuttle buses. Plug-in charging systems require concrete pads and bollards for protection and have a significant physical footprint. The charging cabinets are responsible for most of the footprint and must be located within a few hundred feet of the dispenser. Charging cabinets can be placed in areas of the yard with more space, and most depots are designed with dispensers and charging cabinets adjacent to parked buses to minimize cost.

Presently, RABA buses are parked at the RABA maintenance facility, located at 3333 South Market Street, Redding, CA 96001. There is currently one charger for an electric bus in use. The facility is expandable for additional charging infrastructure. RABA will look at inductive charging at its transfer centers in Downtown Redding, Canby, and Masonic.

Hydrogen Fueling Infrastructure Overview

FCEBs consume hydrogen to power the vehicle. To fuel a fleet of FCEBs, a transit agency needs to obtain and dispense hydrogen to the buses. Currently, FCEBs have a hydrogen tank that receives hydrogen at a pressure of 350 bar. Most FCEBs store 35-50 kg of hydrogen in the tank. Transit agencies have several options for obtaining hydrogen. A transit agency can either produce the hydrogen on-site or buy hydrogen from a fuel provider and have it delivered to the fueling site. Since the transportation of hydrogen is expensive, on-site hydrogen production is usually the less expensive option. However, on-site hydrogen production requires installing infrastructure, which can present challenges depending on the space available.

Hydrogen is a flammable gas, and as a result, hydrogen infrastructure, as with other types of propulsion infrastructure, must comply with fire safety standards, especially the prominent National Fire Protection Association (NFPA) codes. Hydrogen infrastructure installations often have a lead time of ten months to two years, including the permitting process.

On-site Steam Methane Reforming (SMR)

Hydrogen can be produced using SMR. SMR requires a reformer that combines natural gas and steam at high temperatures to produce hydrogen. SMR uses little electricity, instead using a catalyst to produce hydrogen. However, SMR does require the use of natural gas and water.

An on-site SMR system would need a minimum of 60 feet by 60 feet, or 3,600 square feet. The system can also be split into two 60-foot by 30-foot rectangles, if the two areas can be placed near each other. Typically, the SMR comes in two parts. One part is a container that houses the SMR modules, the electronics, and hydrogen compression equipment. The second part is the fueling station and storage. An on-site SMR system also requires a compressor to compress the hydrogen to dispense at a pressure of 350 bar.

Since this process produces GHGs, the State of California requires that 33 percent of the natural gas comes from renewable sources. SMR also consumes about 4.6 gallons of water per kg of hydrogen produced (Webber, 2007). Still, SMR can produce hydrogen in a less expensive manner, but SMR production does require investment in production equipment.

On-site Electrolysis

Hydrogen can also be produced via on-site electrolysis. Electrolysis produces hydrogen by running an electrical current through pure water to split the water into hydrogen and oxygen. The hydrogen is then captured, compressed, and stored until it is dispensed into the bus. Electrolysis uses approximately 2.4 gallons of water per kg of hydrogen (Webber, 2007). An electrolyzer has a similar footprint as an SMR system and comes in two containers, with one container housing the electrolyzer and compression equipment and the second container housing storage and fueling equipment. An on-site electrolyzer system also requires a compressor to compress the hydrogen to dispense at a pressure of 350 bar.

Electrolysis is considered the cleanest method of producing hydrogen, as it does not produce any direct GHG emissions. In using electricity, indirect GHG emissions are generated when producing the electricity. However, these emissions can be mitigated if the electricity is produced from renewable sources. Electrolysis is currently an expensive method of producing hydrogen and is energy intensive.

Delivered Gaseous Hydrogen

Hydrogen can be produced offsite at a centralized location and then delivered to the bus fueling location. Gaseous hydrogen is typically produced at a central production facility at low pressures of 20-30 bar, then compressed to a higher pressure. The hydrogen is stored in long cylindrical tubes that are then loaded onto a truck trailer and transported to the bus fueling location. Once the tube trailer arrives at the location, the hydrogen is delivered to the fueling station. A compressor is used to increase the pressure of the hydrogen in the tube trailer. This compressed hydrogen is then delivered to storage tanks where it can be dispensed to the buses.

These tube trailers can carry only a limited amount of hydrogen, however. U.S. Department of Transportation regulations limit compression pressures to 250 bar. Furthermore, truck payload weight restrictions effectively limit a tube trailer to delivering a maximum of 280 kg of hydrogen [2]. As a result, this option is more advantageous for fleets that require relatively low volumes of hydrogen. See page 24 for more information on hydrogen delivery cost considerations.

Delivered Liquid Hydrogen

To be delivered in liquid form, hydrogen is produced at a centralized production facility and then liquified by reducing its temperature to -253 degrees Celsius. The liquid hydrogen is then put onto a truck for delivery. Once the truck reaches the depot, it will pump the liquid hydrogen into a liquid hydrogen storage tank. The hydrogen from the storage tank is processed by liquid compression pumps, which delivers the hydrogen to a vaporizer. The vaporizer converts the liquid hydrogen to gaseous hydrogen, which is then delivered to gaseous storage tanks. The hydrogen is subsequently dispensed to the buses.

Liquid hydrogen has the economic advantage as compared to gaseous hydrogen but some drawbacks exist. Mainly, liquid hydrogen is lost if it is left in storage for a long time. As liquid hydrogen warms up, it evaporates and turns into a gas. Hydrogen systems are designed to release this gas, known as off-gassing. Off-gassing can result in losses of 1 percent per day, but off-gassing can be reduced if hydrogen is dispensed to vehicles on a daily basis. A system that captures off-gassed hydrogen and compresses it into the gaseous storage tanks can also be employed.

Offsite Retail Fueling

If a transit agency is unable to invest in hydrogen fueling infrastructure, they could theoretically fuel buses at offsite retail fueling stations. A retail fueling station is a privately-owned station that sells hydrogen to customers and would be analogous to a gas station.

The market for retail hydrogen fueling is in the early stages of development. As the fuel cell vehicle market has matured, more retail stations have been built. While there are multiple retail stations, light-duty and heavy-duty retail fueling are distinct markets. Light-duty stations typically have 700 bar dispensers and lower levels of storage. Heavy-duty stations typically have 350 bar dispensers and require large storage capacity.

The use of retail hydrogen stations as the primary source of hydrogen entails some operational risks. Retail hydrogen stations can be inoperable if they run out of hydrogen or are undergoing planned or unplanned maintenance. To lower this risk, it would be prudent to have access to multiple fueling stations.

RABA in partnership with SRTA and the California Department of Transportation (Caltrans) is studying constructing a hydrogen fueling station at the RABA Maintenance Facility, 3333 South Market Street, Redding, CA 96001. Initially, the hydrogen station will have a dispenser to allow for the delivery of hydrogen fuel with the potential for future electrolyzer.

Section D: Current Bus Fleet & Replacement

RABA is planning to replace their current and future conventional fleet with battery electric vehicles (BEVs) and hydrogen powered vehicles (FCEVs). The details about RABA’s current and future fleet are discussed in the following section. Information about current ZEVs that may suit RABA’s needs are located in ***Appendix A: Shuttle Bus Vehicle Options*** and ***Appendix B: Full-Sized Transit Bus Options***.

Current Bus Fleet

Currently, RABA operates 38 buses – eighteen (18) Class 7, seventeen (17) Class 4, and three (3) Class 3 vehicles. All are subject to the Innovative Clean Transit (ICT) regulation.

Once the transition plan is fully executed, RABA's fleet network will have a battery-electric and hydrogen powered fleet made up of direct replacements of their current internal combustion engine (ICE) classes. For RABA's planned transition to battery electric and hydrogen vehicles with 1:1 ration, and CALSTART used its Route Energy Model (REM) Analysis tool to evaluate power and energy demand for the buses and estimate the energy consumption of the RABA fleet. The average distance covered by each vehicle, assumptions and results of REM analysis are discussed below.

Performance Analysis

All vehicle replacement fuel types were estimated from RABA's replacement plan and are summarized in Table 1. CALSTART assumed RABA will transition to battery electric vehicles first, followed by hydrogen vehicles next. Additionally, CALSTART considered that all paratransit buses would be replaced with battery electric cutaway shuttle buses. Fixed routes will be replaced with a mixed fleet of battery electric, and hydrogen powered 30-35-foot transit buses and cutaway shuttle buses as defined by RABA.

Table 1: RABA's Vehicle Replacement Plan

Number Of Buses*	Engine Model Year	Fuel Type	Replacement Year	Bus Type	Replacement Fuel Type
5	2010-2011	Gasoline	2023	Paratransit – Cutaway/shuttle bus (5)	Battery Electric
1	2009	Diesel	2026	Fixed Route -Cutaway/shuttle bus (1)	Battery Electric
2	2010	Diesel	2027	Fixed Route -Cutaway/shuttle bus (1) & 30-35-ft Transit Bus (1)	Battery Electric
4	2017	Gasoline	2028	Paratransit – Cutaway/shuttle bus (4)	Battery Electric
4	2012	Diesel	2028	Fixed Route – 30-35-ft Transit Bus (4)	Battery Electric
2	2013	Diesel	2030	Fixed Route – Cutaway/shuttle bus (1) & 30-35-ft Transit Bus (1)	Battery Electric
1	2013	Diesel	2030	Fixed Route – 30-35-ft Transit Bus (1)	Hydrogen
2	2019	Gasoline	2031	Paratransit – Cutaway/Shuttle bus (2)	Battery Electric
2	2019	Gasoline	2031	Commuter – Cutaway/Shuttle bus (2)	Hydrogen
2	2015	Diesel	2032	Fixed Route –	Hydrogen

Number Of Buses*	Engine Model Year	Fuel Type	Replacement Year	Bus Type	Replacement Fuel Type
				Cutaway/Shuttle bus (1) & 30-35-ft Transit Bus (1)	
6	2021	Gasoline	2033	Paratransit – Cutaway/Shuttle bus/van (6)	Battery Electric
3	2017	Diesel	2034	Fixed Route – Cutaway/shuttle bus (1) & 30-35-ft Transit Bus (2)	Hydrogen
1	2019	Electric	2037	Fixed Route –30-35-ft Transit Bus (1)	Electric
2	2020	Diesel	2037	Fixed Route – Cutaway/shuttle bus (1) & 30-35-ft Transit Bus (1)	Hydrogen

*RABA may purchase additional paratransit buses in the future; however, this analysis was limited to the replacement of a total of 38 buses which comprising of eighteen (18) buses on the fixed route, eighteen (18) buses for paratransit services, and two (2) buses for commuter purposes.

RABA has various options to switch to battery electric and hydrogen vehicles given the required energy consumption and daily mileage calculations and assumptions listed below. To determine whether the available battery size is sufficient for RABA's existing paratransit, fixed, and commuter services, each vehicle's range was estimated using the REM, considering the topography and Heating, Ventilation, & Air Conditioning (HVAC) efficiency based on the Redding area 's ambient temperature. In addition, passenger weight, and route characteristics to estimate energy consumption per mile and per trip is taken into consideration.

Energy Consumption Estimate Assumptions

- The charging load profiles for the 19.2 kW, 50 kW, 100 kW, and 200 kW were developed from NREL's "Heavy-Duty Electric Fleet Depot Charging Load Profiles & Substation Load Integration Assessment Results" study for depot and on-route charging. These load profiles account for charger efficiency losses and assume that each charger reaches a maximum of 80 to 85% efficiency [3].
- Additionally, the energy requirements for each bus are estimated based on the route information provided by RABA. Since the buses are not dedicated to specific routes, a charging profile is created based on the average energy needed for each route.
- Daily mileage is used to estimate energy consumption as defined by RABA.
- Redding's elevation changes are considered for energy calculations.
- To meet the daily demand, only 80% of the total vehicle battery capacity is considered as useful energy.

The REM analysis was performed based on a set of assumptions to determine the average energy consumed per mile by the cutaway shuttle buses and 30-35-ft transit buses. The results (Table 2) of the REM analysis revealed that paratransit cutaway shuttle buses consumed an average of 1.56 kWh/mile, with a total daily energy requirement of approximately 65 kilowatts per hour (kWh) per bus for a distance traveled of 42 miles per bus. Fixed route and commuter cutaway shuttle buses consumed an average of 1.55 kWh/mile, with a total daily energy requirement of approximately 290 kWh/bus for a distance traveled of 185 miles/bus. Fixed route 30-35-ft transit buses consumed an average of 4.13 kWh per mile, with a total daily energy requirement of approximately 600 kWh/bus for a distance traveled of 145 miles per bus. These findings are vital for understanding the energy demands of the buses and for appropriately sizing the required infrastructure equipment and are summarized in Table 2.

Table 2 Zero Emission Vehicles Performance – Electricity Demand

Bus Type	Paratransit Shuttle Bus	Fixed & Commuter Shuttle Bus	Fixed 30-35-Ft Transit Bus
Average Miles travelled per day	42	185	145
Average Energy consumed per mile (kWh/mile)	1.56	1.55	4.13
Average Energy required per vehicle (kWh/day/bus)	65	290	600

A preliminary assessment of the energy needed for the routes with electric vehicles has revealed that depot charging will not be sufficient to meet the energy demands for the vehicles servicing the fixed routes. On-route charging will be needed to supplement depot charging. These battery electric vehicles that require more energy than can be provided with depot charging were modeled to charge to full battery capacity overnight in depot charging. CALSTART conducted an initial estimate of the on-route energy requirements and estimated that approximately 60 minutes per bus of on-route charging are needed on average to supplement depot charging for all seven (7) transit and three (3) cutaway buses on fixed routes each day, assuming the use of a 200-kW inductive charger. Three potential locations for on-route charging have been identified by RABA and are summarized in Table 6.

A detailed assessment of the on-route charging energy demand, infrastructure needs, and total costs are not included in this analysis. RABA's fleet of fixed route vehicles changes dynamically based on availability and can be reassigned to different routes on the same day. Due to the dynamic nature of RABA's fixed route fleet, the detailed operational schedule of each bus is needed to determine the specific time and location each bus will be available for on-route charging.

In the case of the demand response fleet, depot electric charging should be sufficient as these vehicles can be rotated in and out of service throughout the day.

In addition to electric energy demand, the route energy results were also utilized to estimate hydrogen demand. An average of 84 kg of hydrogen is estimated to be consumed per day for all planned hydrogen powered vehicles. Since RABA does not have a dedicated fuel cell bus per route, an average of 8 kg per bus per day is determined based on the route energy analysis.

In summary, the REM enables a detailed analysis of the energy consumption patterns of the paratransit shuttle buses, fixed route shuttle buses, fixed route 30-35-ft transit buses, and the commuter shuttle buses. This information is indispensable in determining the energy needs of the buses, sizing the necessary infrastructure equipment, and ensuring their reliable and efficient operation throughout the year.

Table 3 Projected service requirements by route and vehicles needs based on RABA service as of May 2023

Routes	Total Route Mileage	Number Of Weekday Round Trips	Number Of Saturday Round Trips	Total Weekday Route Miles	Total Saturday Route Miles	Projected Fuel Type	Projected Fleet Size
1	20.40	14	11	285.6	224.4	Hydrogen	Cutaway
2	12.20	13	10	158.6	122	Battery Electric	30 foot
3	16.11	13	10	209.43	161.1	Hydrogen	35 foot
4	14.30	13	10	185.9	143	Battery Electric	30 foot
5	12.40	13	10	161.2	124	Battery Electric	Cutaway
6	17.90	13	10	232.7	179	Hydrogen	30 foot
7	15.20	12	9	182.4	136.8	Battery Electric	Cutaway
9	18.76	12	9	225.12	168.84	Hydrogen	Cutaway
11	10.60	13	10	137.8	106	Battery Electric	35 foot
12 Anderson Commuter	22.90	1	0	22.9	0	See 9	See 9
14	11.10	13	10	144.3	111	Battery Electric	35 foot
17 School Express	18.43	1	0	18.43	0	See 6	See 6
18 Crosstown Express	7.48	16	0	119.68	0	Battery Electric	30 foot
19 Beach Bus	25.80	4	4	103.2	103.2	Battery Electric	Cutaway
299 Burney Express	**108.06**	3	0	324.18	0	Hydrogen	Cutaway
Total Fixed Route	**331.64**						

*Route mileages provided by COR GIS

Table 4 Fixed Route Projected Fleet Size Summary

Fixed Route Projected Fleet Size	Quantity	30 Foot	35 Foot	Cutaway
Battery Electric	10	4	3	3
Hydrogen	10	3	2	5
Total	20	7	5	8

Table 5 Paratransit Projected Fleet Size Summary

Paratransit Projected Fleet Size	Quantity	Van	Cutaway
Battery Electric	18	3	15
Hydrogen	0	0	0
Total	18	3	15

Paratransit service operates with 12-13 vehicles at peak, transport approximately 150 passenger trips and travel on average 12,500 miles annually.

Section E. Facility and Infrastructure Modifications

RABA currently operates a transit facility that houses all 37 of their paratransit cutaway buses and fixed route transit and cutaway buses. The current facility is located at the maintenance facility at 3333 S. Market Street in Redding. The maintenance facility is located within the City of Redding Electric Utility (REU) service territory. It has been confirmed by REU that the power supply at the facility exceeds its power demand at the substation level, even with the fleet expansion. This means that the substation is capable of meeting energy requirements. Upgrades to the transformer or other infrastructure may be necessary and cannot be confirmed until closer to the service request upgrade. Based on the load analysis, the peak energy required for charging the replacement buses at the depot is approximately 940 kW. In addition to that, RABA is also considering having a backup on route charging at the Masonic Transfer Center which is shown in Table 7 below.

There is no need to relocate the facility or upgrade the substation as confirmed by REU.

Table 6 Facility and Infrastructure Modifications

Division/ Facility Name	Address	Main Function(S)	Structure Type	Utility Service Capacity	Utility Upgrade (Yes/No)	Infrastructure Need		
						Type	Port Type	Qty
Maintenance Facility	3333 S. Market St., Redding, CA 96001	Vehicle Maintenance/ Storage Bus Parking	Bus Shelter Depot Charging Facility	TBD	No	19.2 kW	Dual-Port	9
					No	50 kW	Single- Port	3
					No	100 kW	Single-Port	6

Division/ Facility Name	Address	Main Function(S)	Structure Type	Utility Service Capacity	Utility Upgrade (Yes/No)	Infrastructure Need		
						Type	Port Type	Qty
Hydrogen Facility	Ellis Street side of the RABA Maint. Facility	Vacant Land	Potential Fueling Site	TBD	Yes	Hydrogen Fuel Dispenser and Tank		
RABA Downtown Passenger Terminal	1530 Yuba Street, Redding, CA 96001	Passenger Terminal	Potential Inductive Charging Site	TBD	No	200 kW	Inductive Charger(s)	4
RABA Masonic Transfer Center	135 Masonic Ave, Redding, CA 96003	Bus Transfer Center	Potential Inductive Charging Site	TBD	No	200 kW	Inductive Charger(s)	1
RABA Canby Transfer Center	Canby Road, Redding, CA 96003	Bus Transfer Center	Potential Inductive Charging Site	TBD	No	200 kW	Inductive Charger(s)	2

To meet the electricity needs required for the 10 planned battery electric vehicles, three different chargers were considered for depot charging: 19.2 kW, 50 kW, and 100 kW chargers. Nine (9) dual port 19.2 kW chargers are sufficient to charge all 17 paratransit cutaway shuttle buses at the depot. Three (3) 50-kW and six 100-kW chargers are required to charge the three (3) cutaway shuttle buses and seven (7) 30-35-ft transit buses used for the fixed and commuter routes.

The energy analysis of the demand requirements for the fixed route buses has determined that depot charging is not adequate to meet the daily demand for the buses. RABA has identified three (3) locations viable for on-route charging which are summarized in Table 6 and Table 7. A total of eight (8) 200-kW inductive chargers have been determined to meet RABA's on-route charging needs.

The total number of on-route chargers were estimated based on the following assumptions:

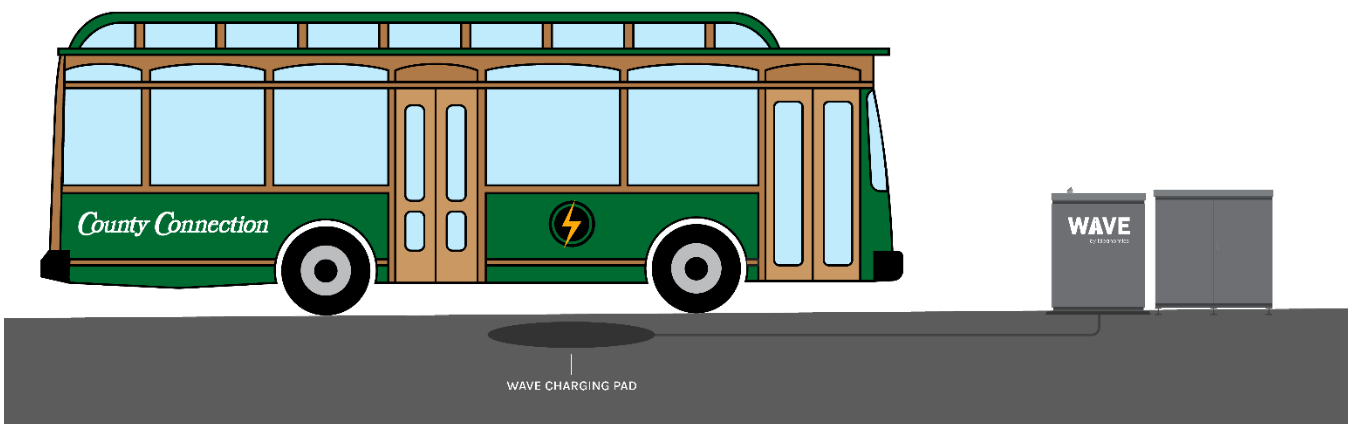
- A minimum of 15-minute charging intervals were assumed for on-route charging.
- All on-route chargers were assumed to be 200 kW.
- Only capital costs for on-route chargers were estimated and no electricity, installation, or maintenance costs were included in this analysis.

In addition, inductive charging will be required at RABA's Downtown Transit Center, Canby Transfer Center, and Masonic Transfer Center to recharge BEBs operating in service. It is projected the total number of inductive charging units are required for each facility:

Table 7 On-Route Charging Quantity and Capital Cost Summary

On-Route Charging Variables	RABA Downtown Transit Center	Canby Transfer Center	Masonic Transfer Center (Backup on-route Charger)	Total
Number Of Inductive Charging Units	5	2	1	8
Projected Capital Cost for Inductive Charging Units	$718,750	$287,500	$143,750	$1,150,000
Peak Power Demand from On-Route charging (kW)	800	320	160	1,280

*Inductive charging costs are not included in the TCO calculations.



Inductive Charging Example

To meet the hydrogen needs required for the 10 planned hydrogen vehicles, 84 kg of hydrogen is estimated to be needed per day. RABA does not have a plan for onsite hydrogen generation at this time. However, SRTA received $ 9,058,500 from Caltrans to support the development of hydrogen fueling infrastructure in the Redding area by September 30, 2028. This funding was recently awarded in February 2023, so details are still forthcoming with regards to timeline, project partners, and production capacity and specific location. RABA, Caltrans and SRTA are continuing to work together to develop a scope for this project.

Details on the award is below:

- SRTA was awarded $9,058,500 in state Carbon Reduction Program funds.
- These funds were for planning, design, engineering, environmental, station construction, and fuel purchases for a station.

- Focus must be on intercity bus service, but may have mutual benefit to RABA and DHCL for regional transit and local government agencies needing to test hydrogen medium/heavy-duty vehicles.

Next steps:

- Identify an implementation agency – Very likely this could be RABA.
- Setup meeting with RABA, SRTA, and Caltrans to explore how the agreements could work.
- Receive SRTA and RABA board approval to work together.
- SRTA programs funds and project efforts can start.

Key dates:

- Funds must be obligated by September 30, 2024. In order to obligate, the following are needed:
    - Federal Transportation Improvement Program (FTIP) amendment (SRTA)
    - Completion of a Project Management Plan, Real Estate Acquisition Plan (if needed), and environmental clearance
- Funds must be spent by September 30, 2028.

Figure 3 Conceptual Hydrogen Station and Bus Fueling

Construction Timeline

Division/ Facility Name	Address	Structure Type	Anticipated Construction Date	Infrastructure Need		
				Type	Port Type	Qty
Maintenance Facility	3333 S. Market St., Redding, CA 96001	Bus Shelter Depot Charging Facility	2026, 2027, 2028, 2037	19.2 kW	Dual-Port	9
				50 kW	Single- Port	3
				100 kW	Single-Port	6
Hydrogen Facility	Ellis Street side of the RABA Maint. Facility	Potential Fueling Site	2027, 2028	Hydrogen Fuel Dispenser and Tank		
RABA Downtown Passenger Terminal	1530 Yuba Street, Redding, CA 96001	Potential Inductive Charging Site	2030, 2031, 2033	200 kW Inductive Charger(s)		
RABA Masonic Transfer Center	135 Masonic Ave, Redding, CA 96003	Potential Inductive Charging Site	2030, 2031, 2033	200 kW Inductive Charger(s)		
RABA Canby Transfer Center	Canby Road, Redding, CA 96003	Potential Inductive Charging Site	2030, 2031, 2033	200 kW Inductive Charger(s)		

Overall, RABA is taking a proactive approach to ensuring that its transit operations are energy-efficient and sustainable. By carefully analyzing its energy needs and exploring the most efficient charging options, RABA can reduce its carbon footprint and provide reliable transportation services to its residents and visitors in Shasta County.

Section F: Estimated Costs

Transitioning to a ZEB fleet from an ICE fleet requires high upfront capital investments. However, the ZEB implementation makes up for this cost due to their low operations costs including energy/fuel charges and maintenance cost. CALSTART has calculated the capital cost associated with this transition based on the ICT rollout mandate and RABA's proposed plans for transitioning their fleet to zero emission vehicles. In addition to the initial investment, CALSTART has also calculated the levelized cost of converting RABA's fleet to battery electric and hydrogen powered vehicles until 2040, considering the lifetime of the vehicles. Capital costs for all vehicles, equipment, and hydrogen are listed in Table 8 and Table 9 and later summarized with references in Table 13.

Table 8 Infrastructure and Hydrogen Unit Costs

Equipment	Amount	Unit Cost ($)
19.2 kW Charger (Port-2)	9	$5,068
50 kW Charger (Port-1)	3	$30,000
100 kW Charger (Port-1)	6	$58,366
200 kW Inductive Charger	8	$143,750
Hydrogen (kgs/day)	84*	$18/kg
Hydrogen Station	1	$300,000

*Considering10% loss from evaporating and other losses

Table 9 Vehicle Capital Costs

Vehicle Type	Number of Vehicles	Unit Cost ($)*
Battery Electric Cutaway Bus	17**	$240,000
Battery Electric Transit Bus (30-35 feet)	7	$580,000
Hydrogen Cutaway Bus* **	5	$350,000
Hydrogen Transit Bus (30-35 feet)	5	$900,000

*The capital cost of the buses including the HVIP incentive

**RABA may continue to purchase additional cutaway buses in the future; however, no additional buses were considered in this analysis

*** Cost of retrofit gasoline to fuel cell shuttle bus

RABA has plans to transition its existing fleet to zero emission vehicles that are both battery electric and hydrogen powered. To determine the overall cost of this transition, CALSTART has taken a systematic approach by first analyzing the expenses involved in transitioning to battery electric vehicles, followed by evaluating the costs associated with adoption hydrogen powered vehicles. Both scenarios incorporate the replacement of the fleet based on the replacement schedule in Table 1, previously.

Table 11 and Table 12 outline the initial capital costs associated with the replacement schedule of RABA's fleet, which involves transitioning to 37 ZEVs, including 27 battery electric and 10 hydrogen vehicles. These cost calculations are based on the following assumptions:

- The Downtown Redding Passenger Terminal and the RABA Maintenance Facility falls under the REU territory. The current electric utility costs for were provided by RABA and are presented in Table 10.

Table 10 Utility Rate Structure (Source: REU)

Fee Type	Fee
Demand Charges	$20/kW
Energy Charges	$0.1044/kWh

- RABA already owns one (1) electric transit bus, which is scheduled to be replaced in 2037. The maintenance and utility costs for operating this existing electric bus are accounted for in all years of the financial calculations. RABA already owns the associated charging infrastructure for this electric transit bus; therefore, no additional capital expenditures for charging infrastructure are included for the existing electric transit bus.
- Utility charges for on-route energy needs were estimated using the electric utility costs presented in Table 10.
- Information on energy requirements, charging location, and timing for the on-route energy and financial analysis are summarized in Appendix C.
- Based on information from RABA, it was assumed the running cost to purchase hydrogen is $18/kg.
- RABA is not planning for onsite hydrogen generation at this time, so it is assumed that fuel will be transported to the RABA maintenance facility for buses to refuel.
- The analysis includes an average of 10% losses, which include evaporation and leaking losses during refueling and delivery.
- This analysis assumes a vehicle charging efficiency of 95%.
- All capital costs associated with vehicle charging/fueling infrastructure and vehicle purchasing are industry averages obtained from various OEM catalogs.
- Maintenance costs for electric vehicles are estimated from Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation tool. [4].
- Maintenance costs for hydrogen vehicles are estimated from REL's "SunLine Transit Agency Fuel Cell Electric Bus Progress Report" [5].
- Hydrogen station capital costs were estimated from CALSTART's study on the Roadmap to Fuel Cell Electric Truck Commercialization [6].
- Levelized costs were calculated using a 5% discount rate and costs were calculated from 2023 to 2040.

Table 11 Annual Cost Breakdown for Replacement Vehicles and Required Chargers

Annual	Battery Electric			Hydrogen		
	Capital Expenditures	Operational Expenditures	Total	Capital Expenditures	Operational Expenditures	Total
2023	$1,358,954	$85,392	$1,444,356	$0	$0	$0
2024	$0	$85,392	$85,397	$300,000	$6,000	$306,000
2025	$0	$85,392	$85,397	$0	$6,000	$6,000
2026	$413,750	$150,011	$563,768	$0	$6,000	$6,000
2027	$1,052,116	$321,482	$1,373,608	$0	$6,000	$6,000
2028	$3,954,850	$720,472	$4,675,346	$0	$6,000	$6,000
2029	$0	$720,472	$720,488	$0	$6,000	$6,000
2030	$1,195,866	$865,624	$2,061,510	$900,000	$86,604	$986,606

Annual	Battery Electric			Hydrogen		
	Capital Expenditures	Operational Expenditures	Total	Capital Expenditures	Operational Expenditures	Total
2031	$485,068	$880,126	$1,365,216	$700,000	$220,522	$920,527
2032	$0	$880,126	$880,146	$1,250,000	$341,478	$1,591,485
2033	$1,455,204	$929,535	$2,384,771	$0	$341,478	$341,483
2034	$0	$929,535	$929,561	$2,150,000	$522,911	$2,672,922
2035	$0	$929,535	$929,561	$0	$522,911	$522,919
2036	$0	$929,535	$929,561	$0	$522,911	$522,919
2037	$580,000	$951,195	$1,531,223	$1,250,000	$656,863	$1,906,875
2038	$0	$951,195	$951,222	$0	$656,863	$656,873
2039	$0	$951,195	$951,222	$0	$656,863	$656,873
2040	$0	$951,195	$951,222	$0	$656,863	$656,873
Total	$10,495,808	$12,317,409	$22,813,575	$6,550,000	$5,222,265	$11,772,353
Levelized Cost	$0.63/kWh			$31.5/kg		

Table 12 Total Cost Summary

Vehicle Type	Capital Expenditures	Operational Expenditures	Total
Battery Electric	$10,495,808	$12,317,409	$22,813,575
Hydrogen	$6,550,000	$5,222,265	$11,772,353
Total	$15,895,808	$12,703,197	**$34,585,929**

Using the capital, operational, and utility costs presented in Table 10 and Table 11, the levelized cost of ownership was estimated separately for the battery electric and hydrogen fleet conversions. The approximate levelized cost for the fleet transition to battery electric vehicles is $0.63/kWh and the levelized cost for the fleet transition to hydrogen vehicles is $31.5/kg. However, it is important to note that the financial calculations are only for transitioning of ICE vehicles to zero emission vehicles and the cost of replacing vehicles at the end of their useful life (after the initial purchase is made) is not considered in the calculation. The capital and operational expenditures considered in the financial calculations are shown in Table 13.

Table 13 Capital and Operation Expenditures Breakdown

Capital Expenditures (One Time Costs)	Type	Details	Category	Cost
	Vehicle Cost	The upfront cost of purchasing the battery electric or hydrogen powered vehicles, including	Cutaway - Electric	$240,000
			Transit Bus - Electric	$580,000
			Cutaway - Hydrogen	$350,000

		approximate incentives.	Transit Bus - Hydrogen	$900,000
	Charger Cost	The upfront cost of purchasing the electric chargers.	19.2 kW (Dual Port)	$5,068
			50 kW (Single Port)	$30,000
			100 kW (Single Port)	$58,366
			200 kW (Inductive)	$143,736
	Hydrogen Station Cost	The upfront cost share of purchasing the hydrogen refueling station.	Hydrogen Station	$300,000
Operational Expenditures (Reoccurring Costs)	Bus Maintenance Cost	The average maintenance cost per mile.	Cutaway - Electric	$0.13/ [4]
			Transit Bus - Electric	$0.60/ [4]
			Cutaway & Transit Bus - Hydrogen	$0.36/ [5]
	Infrastructure Maintenance Cost	2% of the capital cost of charger or fueling equipment.	19.2 kW	$101/Charger/Year
			50 kW	$600/Charger/Year
			100 kW	$1,167.32/Charger/Year
			Hydrogen Station	$6,000/Year
	Running/Charging Cost	Includes utility costs and the cost of purchasing the required amount of hydrogen annually. Cost of hydrogen was assumed to be $18/kg.	Paratransit - Electric	$6,388 /Bus/Year
			Cutaway Bus - Electric	$12,899/Bus/Year
			Transit Bus - Electric	$32,116/Bus/Year
			Cutaway & Transit Bus - Hydrogen	$2,638/Bus/Year

Section G: Providing Service in Disadvantaged Communities

RABA's service area does not include disadvantaged communities (DAC) as identified in the CalEnviroScreen 4.0 tool. The CalEnviroScreen tool assigns a score to each California census tract based on pollution levels and population vulnerability to pollution. This score is used to rank each census tract, where higher scores indicate worse pollution. Census tracts with worse scores typically have higher levels of pollution. They also tend to have a higher proportion of children or elderly who are more vulnerable to the health effects of pollution. As a result, DACs are at higher risk of adverse health effects from pollution, including elevated levels of asthma, respiratory disease, and cardiovascular disease.

RABA is the only public transit provider in the region and has a service that connects Redding Rancheria. Redding Rancheria is a federally recognized tribe with a reservation in Shasta County.

Section H: Workforce Training

Many similarities exist between ZEBs and traditional buses, but ZEBs have unique systems such as electric drivetrains and batteries that require specific operational and maintenance needs. These systems have particular needs and require specialized training to service. In addition, BEBs must be operated and driven differently than a traditional bus to obtain the maximum performance from the buses. RABA's fleet is maintained by a third-party contractor at a RABA owned facility. These staff members will need training to effectively maintain and operate the ZEBs.

RABA contracts out its operations and maintenance to a third-party provider and as part of the transition to BEB and FCEBs, RABA will incorporate contractual language into future contracts regarding training, operations and maintenance of BEB and FCEBs. This includes the implementation of a comprehensive training program to understand BEB and FCEBs and its associated chargers and fueling.

Additionally, RABA will coordinate with OEMs and/or contractors early on to create and align workforce training schedules with the purchasing of zero-emission vehicles and infrastructure deployment. Training can occur early and throughout deployment as needed. Such coordination can help RABA meet its goal of full transition to zero-emission technologies by 2040.

As RABA transitions to ZEBs operation, one of the most efficient ways to develop a skilled workforce is by upskilling the existing contracted bus operators and maintenance staff. Bus operators will need training to drive and operate ZEBs. ZEBs need to be driven in a certain manner to optimize performance and bus range. Typically, electric buses maximize their range when accelerated slowly. Poor operator behavior, such as rapidly accelerating from a stop, can reduce bus energy efficiency by up to 25%. As a result, ensuring the bus operators drive the buses in the correct manner is vital to maximizing the benefits of ZEBs. Range anxiety, where the operator fears that they do not have enough charge to complete their route, has also been widely documented. This fear has resulted in operators prematurely ending their route and returning to the maintenance facility to charge the bus. To avoid this problem, bus operators need to understand the range and capabilities of the bus. Bus operators also need to learn how to correctly use technologies such as regenerative braking.

ZEBs have different maintenance needs and operation best practices than traditional buses. ZEBs replace the ICE with an electric drivetrain, which changes the maintenance needs of the bus. While maintaining a traditional bus, a maintenance technician needs to have expertise in maintaining and repairing ICEs and moving parts like belts, alternators, and pumps. In addition, expertise in mechanical systems such as steering, HVAC, and suspension is vital. However, with ZEBs, the vast majority of the moving parts are replaced with electric components, such as batteries, DC-to-DC converters, and electric motors. Since there are few moving parts on a ZEB, the majority of the maintenance tasks relate to preventative maintenance. As a result, the most vital skills for mechanics to become proficient in are high voltage safety and proper use of personal protective equipment to minimize the risk of electrical shocks and arc flashes. Mechanics should consider obtaining the NFPA 70E: Standards for Electrical Safety in the Workplace and High Voltage OSHA 1910.269 8 Hour Qualified Training Course certificates. Maintenance technicians will also need to become proficient in bus inspection, preventative maintenance, and how to handle removed battery systems to effectively maintain the buses. Knowledge of standard bus mechanical systems is also important. Local first responders need to receive training in EV and hydrogen safety so they can effectively respond in the event of an accident.

RABA will need to work with its contractor to upskill their current maintenance staff so they can maintain ZEBs. CALSTART recommends the following training sequence for their maintenance staff. It is recommended that mechanics complete training in this order:

1. High Voltage Electrical Safety: The prerequisite knowledge required to begin ZEB maintenance training is a firm understanding of high voltage electrical systems and safety. During this training, maintenance staff learn how to use multimeters, how to identify high voltage components and cables, how to use personal protective equipment, and safety procedures for working with high voltage equipment. OEMs view high voltage electrical training as a prerequisite for OEM-provided maintenance training. As a result, maintenance staff need to receive high voltage safety training before they receive any instruction on bus maintenance. There are several options for obtaining this training:
    a. The California Transit Training Consortium (CTTC) provides high voltage safety training. The prerequisite for their high voltage safety training course is a course in using a digital volt-ohm meter. CTTC provides three levels of high voltage safety training. Awareness training is a four-hour course that is offered to any employee who is on the floor of the vehicle repair workshop. Certification training is a 16-hour course that teaches workers how to use personal protective equipment, tools, and arc flash rescue equipment and procedures. Lastly, the advanced class is offered to any technicians who will physically be working on the vehicle. This training aligns with NFPA 70E and OSHA 1910.269 certification.
    b. OEM-provided training: Bus OEMs provide training to teach maintenance staff to repair their specific system. RABA will purchase training packages from the OEM to support the training efforts of its contracted staff. The OEM-provided training teaches maintenance staff how to operate and maintain a zero-emission drivetrain system. Generally, the OEM-provided training begins about a week before the delivery of the buses and will send a field service representative to provide bus operator training to the operators and maintenance staff. Since there are few moving parts on a ZEB, the most of the maintenance tasks relate to preventative maintenance. Bus OEMs also provide training on their diagnostic tools and how their bus systems function. Maintenance staff learn how to use the diagnostic tool to identify and resolve faults.
    c. SunLine Transit Agency's West Coast Center of Excellence has a ZEB Maintenance course that includes instruction on high voltage safety.

d. Warranty Period: The field service representative is also vital for training mechanics on more advanced maintenance tasks. During the warranty period, if repairs or troubleshooting beyond preventative maintenance are needed, the field service representative can be called to teach the mechanics how to fix the issue. It is important to use the warranty period to provide further training for its mechanics. If there are problems with any of the non-drivetrain components on the bus (e.g., the HVAC system), many component manufacturers offer similar services. Overtime the maintenance staff will accrue enough knowledge to work independently from the field service representative. This knowledge can be institutionalized by pairing more experienced maintenance staff with junior staff and new hires to teach them maintenance best practices.
e. Supplemental Training: RABA can obtain additional training from SunLine Transit Agency's West Coast Center of Excellence and CTTC. CTTC provides specialized training on topics like electronic brakes and electrical system diagnosis. Other organizations like the California Transit Association, American Public Transportation Association, CALACT, and the National Transit Institute (NTI) also provide supplementary training.

Section I: Start-up and Scale-up Challenges

The transition to ZEBs will require substantial funding, which presents a challenge for RABA. While the benefits of transitioning to ZEBs are straightforward, such as improved air quality and reduced Greenhouse gasses (GHG) emissions, the increased capital associated with purchasing and operating these buses must be addressed. Therefore, RABA will need to find creative ways to secure the necessary funding to complete the transition to ZEBs.

RABA will need to rely on financial support from various sources, including federal, state, and local governments as well as funding programs from the CARB and/or the Shasta County Air Quality Management District, to make the transition to ZEBs a reality. This will require coordination and collaboration with government agencies and other stakeholders. It will be essential to develop a comprehensive funding strategy that leverages all available funding sources, including grants, and ensures that the transition to ZEBs is financially sustainable and beneficial for the community.

RABA recognizes that securing funding for the ZEB transition is crucial to the long-term sustainability of the RABA transit system considering the ICT rule.

Section J: Potential Funding Sources

Below are additional funding sources to consider in addition to currently planned funding sources.

California Funding Sources and Incentives

California State Budget Allocations

The California State Budget has allocated $2.7 billion for the 2021-2022 fiscal year and a total of $3.9 billion over the next three (3) years. Millions of dollars of funding are specifically being earmarked for ZEB and associated refueling/charging infrastructure:

- $1.3 billion over three (3) years to deploy over 3,000 ZEV such as drayage trucks, transit buses, and school buses;
- $500 million for zero emission clean truck, buses, and off-road equipment;
- $200 million for medium-and heavy-duty ZEV fueling and charging infrastructure;
- $407 million to demonstrate and purchase or lease clean bus and rail equipment and infrastructure that increase intercity rail and intercity bus frequencies.

California Air Resources Board

Carl Moyer Program

The Carl Moyer Program provides grant funding for engines, equipment, and other sources of air pollution that exceed CARB's regulations for on-road heavy-duty vehicles. The Carl Moyer Program is managed by CARB in collaboration with local air pollution control districts and air quality management districts. ZEBs with a GVWR of greater than 14,000 pounds are eligible for funding under the Carl Moyer Program. The air pollution control districts and air quality management districts are the entities that issue the grants and determine funding for the program.

Volkswagen (VW) Mitigation Trust

The purpose of the VW Environmental Mitigation Trust is to fully mitigate the excess NOx emissions released during the Volkswagen emission scandal. This program was established as a part of the settlement that VW reached with the Environmental Protection Agency (EPA). The VW Mitigation Trust has allocated $423 million to the State of California to fund the deployment of clean transportation vehicles. $130 million of these funds is devoted to replacing older, high emission buses with BEBs or FCEBs. Transit, school, and shuttle buses are eligible for funding.

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)

HVIP is a CARB-funded program administered by CALSTART since 2009. The HVIP program is different than traditional grant programs in that it does not involve a grant application or a rebate. As a voucher program, HVIP provides point-of-sale vouchers through approved dealers that apply savings at time of purchase. HVIP accelerates the deployment of zero-emission and other eligible trucks and buses, including plug-in hybrids, vehicles using engines certified to the optional Low NOx standard of 0.01 g/bhp-hr as of the publication of this document, and trucks equipped with electric power take-off (ePTO) systems in California. HVIP is implemented through a partnership between CARB and CALSTART. HVIP provides vouchers on a first-come, first-served basis. In addition, HVIP provides increased incentives for fleets domiciled in disadvantaged communities.

CARB is implementing $587.7 million of funding allocated to the HVIP in the Fiscal Year (FY) 2022-2023 Funding Plan.

Table 14 HVIP Voucher Funding Amounts

Vehicle Weight Class	Base Vehicle Incentive
Class 3	$45,000
Class 4-5	$60,000
Class 6-7	$85,000
Class 8	$120,000

Medium- and Heavy-Duty Zero-Emission Vehicle Fleet Purchasing Assistance Program

Under existing California law, CARB administers an Air Quality Improvement Program which promotes the use of zero-emissions vehicles by providing rebates for their purchase. There is a bill in the state legislature, SB-372, which established a Medium- and Heavy-Duty Zero-Emission Vehicle Fleet Purchasing Assistance Program within the Air Quality Improvement Program, making financing tools and nonfinancial support available for the operators of medium and heavy-duty vehicle fleets to help them transition to zero-emissions vehicles. This bill was approved by the Governor in late 2021. The bill requires that the financial tools offered by this program be available to fleets by January 1, 2023.

California Energy Commission

Clean Transportation Program

The Clean Transportation Program was created to fund projects that help transition California's fuels and vehicle types to achieve California's climate policies. The Clean Transportation Program is funded from fees levied on vehicle and vessel registrations, vehicle identification plates, and smog abatement. The Clean Transportation Program was created by Assembly Bill 118 and was extended to January 1, 2024 by Assembly Bill 8. The Clean Transportation Program funds multiple classes of vehicles. Every year the California Energy Commission (CEC) develops an Investment Plan Update to identify how the program's funds will be allocated. For FY 2021-22, the CEC proposed that $30.1 million in Clean Transportation Program funding and $208 million in general funds would be used to fund medium- and heavy-duty vehicle charging and hydrogen fueling infrastructure. For FY 2022-23, the CEC is allocating $30.1 million of Clean Transportation Program funding for zero emission medium- and heavy-duty vehicles and infrastructure.

Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE)

EnergIIZE Commercial Vehicles (Energy Infrastructure Incentives for Zero- Emission Commercial Vehicles) is the nation's first commercial vehicle fleet infrastructure incentive project. Funded by the California Energy Commission's Clean Transportation Program and implemented by CALSTART, EnergIIZE provides incentives for zero-emission vehicle (ZEV) infrastructure equipment for medium- and heavy-duty (MD/HD) battery electric and hydrogen fuel cell vehicles operated and domiciled in California. EnergIIZE Commercial Vehicles was created to address the needs of MD/HD zero-emission vehicles in California through financial incentives towards the purchase of infrastructure equipment and software. EnergIIZE provides funding across four (4) unique funding lanes, each catered to a specific stakeholder group (Figure 7).

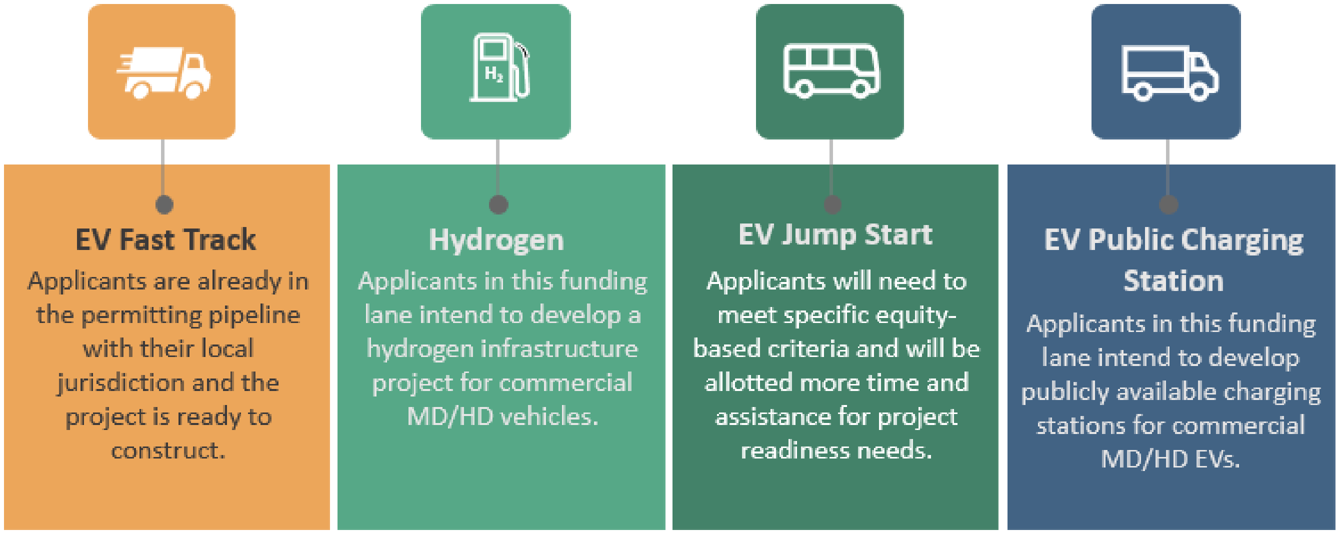


Figure 4 EnergIIZE Funding Lanes

With some or all recharging infrastructure lying within a Disadvantaged Community (according to CalEnviroScreen 4.0[1]) or Low-Income Community (according to AB 1550[2]), the RABA may be eligible to participate in the EV Jump Start funding lane. This funding lane is competitive (i.e. scored) and has a cap of $750 thousand per infrastructure project (compared to $500 thousand for EV Fast Track), and provides additional time for documents to be submitted by applicants.

California Infrastructure and Economic Development Bank (IBank)

The IBank was created in 1994 to fund infrastructure and economic development projects in California. The IBank was started by the Bergeson-Peace Infrastructure and Economic Development Bank Act and is operated by GO-Biz. IBank can issue low-interest bonds that can be used to finance projects for public agencies or nonprofits. The IBank has programs that can be used to finance the transition to a zero-emission fleet. The Infrastructure State Revolving Fund (ISRF) program provides low-Interest financing for infrastructure projects. ISRF provides loans of $50,000 to $25 million over a term of up to 30 years at a fixed interest rate. These loans are funded through the sale of Infrastructure State Revolving Fund Revenue Bonds. Public transit projects, which includes but is not limited to, vehicles and maintenance and storage yards, are eligible for funding through ISRF. ISRF applicants must be a public agency, joint power authority, or nonprofit corporation formed by an eligible entity. ISRF accepts applications on an ongoing basis (California Infrastructure and Economic Development Bank, 2016).

The IBank also offers the California Lending for Energy and Environmental Needs (CLEEN) program. CLEEN provides loans from $500,000 to $30 million over a team of up to 30 years. These loans can

[1] https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40
[2] https://webmaps.arb.ca.gov/PriorityPopulations/

be used to fund projects that use a commercially proven technology to reduce greenhouse gas emissions or pursue other environmental objectives. Eligible projects include energy storage, renewable energy generation assets, stationary fuel cells, electric vehicles, alternative fuel vehicles, and alternative fuel vehicles refueling stations (California Infrastructure and Economic Development Bank, n.d.).

Clean Mobility Options Vouchers Program

The Clean Mobility Options (CMO) Voucher Pilot Program is a statewide initiative that provides zero-emission shared mobility options to under-resourced communities in California. The CMO Voucher Pilot is available throughout California to eligible disadvantaged communities, as well as low-income communities and eligible tribal governments, to increase access to safe, reliable, convenient, and affordable transportation options.

Clean Mobility Options is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment — particularly in under-served communities, and California Energy Commission's Clean Transportation Program, which is investing more than $1 billion to accelerate the deployment of zero-emission transportation infrastructure and support in-state manufacturing and workforce training and development.

Caltrans

Transit and Intercity Rail Capital Program (TIRCP)

TIRCP provides grants to fund capital improvements that will modernize California's rail, bus, and ferry public transit facilities. The objective of the program is to reduce GHG emissions, expand transit service, increase transit ridership, and improve transit safety. Funded projects are expected to reduce GHG emissions, vehicle miles traveled, and congestion. TIRCP is funded through the Greenhouse Gas Reduction Fund (GGRF) and the Cap and Trade program. TIRCP funds can be used to finance site upgrades and the deployment of zero-emission infrastructure at bus depots and facilities.

Low Carbon Transit Operations Program (LCTOP)

The Low Carbon Transit Operations Program (LCTOP) is one of several programs that are part of the Transit, Affordable Housing, and Sustainable Communities Program established by the California Legislature in 2014 by Senate Bill 862. LCTOP was created to provide operating and capital assistance for transit agencies to reduce greenhouse gas emission and improve mobility, with a priority on serving disadvantaged communities. Approved projects in LCTOP will support new or expanded bus or rail services, expand intermodal transit facilities, and may include equipment acquisition, fueling, maintenance and other costs to operate those services or facilities, with each project reducing greenhouse gas emissions. For agencies whose service area includes disadvantaged communities, at least 50 percent of the total moneys received shall be expended on projects that will benefit disadvantaged communities. Senate Bill 862 continuously appropriates five percent of the annual auction proceeds in the Greenhouse Gas Reduction Fund (Fund) for LCTOP, beginning in 2015-16.

State of Good Repair

The Road Repair and Accountability Act of 2017, Senate Bill (SB) 1 (Chapter 5, Statues of 2017), signed by the Governor on April 28, 2017, includes a program that will provide additional revenues for transit infrastructure repair and service improvements. This investment in public transit will be referred to as the State of Good Repair (SGR) Program. This program receives funding of approximately $105 million annually. SGR funds are to be made available for eligible transit maintenance, rehabilitation and capital projects. SB 1 emphasizes the importance of accountability and transparency in the delivery of California's transportation programs.

Transportation Development Act (TDA)

The Mills-Alquist-Deddeh Act (SB 325) was enacted by the California Legislature to improve existing public transportation services and encourage regional transportation coordination. Known as the Transportation Development Act (TDA) of 1971, this law provides funding to be allocated to transit and non-transit related purposes that comply with regional transportation plans. TDA established two funding sources; the Local Transportation Fund (LTF), and the State Transit Assistance (STA) fund. Providing certain conditions are met, counties with a population under 500,000 (according to the 1970 federal census) may also use the LTF for local streets and roads, construction and maintenance. The STA funding can only be used for transportation planning and mass transportation purposes.

LTF- Local Transportation Fund (LTF), is derived from a ¼ cent of the general sales tax collected statewide. The State Board of Equalization, based on sales tax collected in each county, returns the general sales tax revenues to each county's LTF. Each county then apportions the LTF funds within the country based on population.

STA- The STA funds are appropriated by the legislature to the State Controller's Office (SCO). The SCO then allocates the tax revenue, by formula, to planning agencies and other selected agencies. Statue requires that 50% of STA funds be allocated according to population and 50% be allocated according to transit operator revenues from the prior fiscal year.

These funding programs can support the RABA's efforts in purchasing ZEBs.

Federal Funding Sources and Incentives

Low or No Emissions Program (Low-No) – United States Department of Transportation (USDOT)-FTA/Caltrans – Section 5339(c)

Low-No provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses. Low-No funding can also be used to acquire charging or fueling infrastructure for the buses, pay for construction costs, or obtain or lease facilities to house a fleet. In FY2021, $182 million was allocated for the Low-No program. However, the enactment of Infrastructure Investment and Jobs Act (IIJA) will expand funding for the Low-No program. IIJA allocates an additional $5.25 billion for the Low-No program over five years. To be eligible for this funding, a transit agency will need to submit a plan for transitioning to zero emission buses. This plan must demonstrate a long-term fleet management plan that addresses how the transit agency will meet the costs of transitioning to zero emission, the facilities and infrastructure that will be needed to be deployed to serve a zero-emission fleet, the transit agency's relationship with their utility or fuel provider, and the impact that the transition will have on the transit agency's current workforce. Under IIJA, transit agencies may apply for Low-No funding with other entities, such as an OEM, which will participate in the implementation of the project. IIJA also requires that 5% of grant funds awarded be used to fund workforce training to prepare their current workforce to maintain and operate the buses.

USDOT-FTA/Caltrans – Bus & Bus Facilities - Section 5339 (a) and (b)

Congress created the FTA Section 5339 Bus and Bus Facilities program under Moving Ahead for Progress in the 21st Century (MAP 21). Section 5339 is a grant program authorized by 49 United States Code (U.S.C) Section 5339. The program was continued, with some modifications in the recently authorized Fixing America's Surface Transportation (FAST) Act. The 5339 Program provides capital funding to replace, rehabilitate and purchase buses, vans, and related equipment, and to construct bus-related facilities. FTA apportions a discretionary component and a small urban (population 50,000 to 200,000) formula component to governors of each State annually. The California State Department of Transportation, Division of Rail and Mass Transportation (DRMT) has been delegated the designated recipient responsibilities by the Governor and is the direct recipient for these funds. DRMT administers these funding components to eligible sub-recipients which include public agencies and private nonprofit organizations engaged in public transportation.

Section 5307 (FTA/Caltrans)

The Urbanized Area Formula Funding program (49 U.S.C. 5307) makes federal resources available to urbanized areas and to governors for transit capital and operating assistance in urbanized areas and for transportation-related planning. An urbanized area is an incorporated area with a population of 50,000 or more that is designated as such by the U.S. Department of Commerce, Bureau of the Census.

Funding is made available to designated recipients that are public bodies with the legal authority to receive and dispense federal funds. Governors, responsible local officials and publicly owned operators of transit services shall designate a recipient to apply for, receive, and dispense funds for urbanized areas pursuant to 49 USC A5307(a)(2). The governor or governor's designee acts as the designated recipient for urbanized areas between 50,000 and 200,000.

For urbanized areas with 200,000 in population and over, funds are apportioned and flow directly to a designated recipient selected locally to apply for and receive Federal funds. For urbanized areas under 200,000 in population, the funds are apportioned to the governor of each state for distribution.

Eligible activities include: planning, engineering, design and evaluation of transit projects and other technical transportation-related studies; capital investments in bus and bus-related activities such as replacement, overhaul and rebuilding of buses, crime prevention and security equipment and construction of maintenance and passenger facilities; and capital investments in new and existing fixed guideway systems including rolling stock, overhaul and rebuilding of vehicles, track, signals, communications, and computer hardware and software. In addition, associated transit improvements and certain expenses associated with mobility management programs are eligible under the program. All preventive maintenance and some Americans with Disabilities Act complementary paratransit service costs are considered capital costs.

Section 5311 (FTA/Caltrans)

The Formula Grants for Rural Areas program provides capital, planning, and operating assistance to states to support public transportation in rural areas with populations of less than 50,000, where many residents often rely on public transit to reach their destinations. The program also provides funding for state and national training and technical assistance through the Rural Transportation Assistance Program. Eligible activities include planning, capital, operating, job access and reverse commute projects, and the acquisition of public transportation services. The federal share is 80 percent for capital projects. Section 5311 funds are available to the States during the fiscal year of apportionment plus two additional years (total of three years). Funds are apportioned to States based on a formula that includes land area, population, revenue vehicle miles, and low-income individuals in rural areas.

Rural Surface Transportation Grant Program – Federal Highways Administration (FHWA).

The Rural Surface Transportation Grant Program supports projects that improve and expand the surface transportation infrastructure in rural areas to increase connectivity, improve the safety and reliability of the movement of people and freight, and generate regional economic growth and improve quality of life. Rural Surface Transportation grant program funding will be made available under the MPDG combined Notice of Funding Opportunity (NOFO). Eligible projects:

- A highway, bridge, or tunnel project eligible under National Highway Performance Program
- A highway, bridge, or tunnel project eligible under Surface Transportation Block Grant
- A highway, bridge, or tunnel project eligible under Tribal Transportation Program
- A highway freight project eligible under National Highway Freight Program
- A highway safety improvement project, including a project to improve a high-risk rural road as defined by the Highway Safety Improvement Program
- A project on a publicly owned highway or bridge that provides or increases access to an agricultural, commercial, energy, or intermodal facility that supports the economy of a rural area
- A project to develop, establish, or maintain an integrated mobility management system, a transportation demand management system, or on-demand mobility services.

Carbon Reduction Program (FHWA)

The IIJA establishes the Carbon Reduction Program (CRP), which provides funds for projects designed to reduce transportation emissions, defined as carbon dioxide (CO_2) emissions from on-road highway sources .A State may transfer up to 50% of CRP funds made available each fiscal year to any other apportionment of the State, including the National Highway Performance Program, Surface Transportation Block Grant Program, Highway Safety Improvement Program, Congestion Mitigation and Air Quality Improvement (CMAQ) Program, National Highway Freight Program, and Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) Formula Program. CRP funds may be obligated for projects that support the reduction of transportation emissions, including, but not limited to– [except as noted, § 11403; 23 U.S.C. 175(c)(1)]

- a project described in 23 U.S.C. 149(b)(4) to establish or operate a traffic monitoring, management, and control facility or program, including advanced truck stop electrification systems;
- a public transportation project eligible under 23 U.S.C. 142;
- a transportation alternative (as defined under the Moving Ahead for Progress under the 21st Century Act [23 U.S.C. 101(a)(29), as in effect on July 5, 2012]), including, but not limited to, the construction, planning, and design of on-road and off-road trail facilities for pedestrians, bicyclists, and other nonmotorized forms of transportation;
- a project described in 23 U.S.C. 503(c)(4)(E) for advanced transportation and congestion management technologies;
- deployment of infrastructure-based intelligent transportation systems capital improvements and the installation of vehicle-to-infrastructure communications equipment;
- a project to replace street lighting and traffic control devices with energy-efficient alternatives;
- development of a carbon reduction strategy developed by a State per requirements in 23 U.S.C. 175(d);
- a project or strategy designed to support congestion pricing, shifting transportation demand to nonpeak hours or other transportation modes, increasing vehicle occupancy rates, or otherwise reducing demand for roads, including electronic toll collection, and travel demand management strategies and programs;
- efforts to reduce the environmental and community impacts of freight movement;
- a project that supports deployment of alternative fuel vehicles, including–
  - acquisition, installation, or operation of publicly accessible electric vehicle charging infrastructure or hydrogen, natural gas, or propane vehicle fueling infrastructure; and
  - purchase or lease of zero-emission construction equipment and vehicles, including the acquisition, construction, or leasing of required supporting facilities;
- a project described in 23 U.S.C. 149(b)(8) for a diesel engine retrofit;
- certain types of projects to improve traffic flow that are eligible under the CMAQ program, and that do not involve construction of new capacity; [§ 11403; 23 U.S.C. 149(b)(5); and 175(c)(1)(L)]
- a project that reduces transportation emissions at port facilities, including through the advancement of port electrification; and
- any other STBG-eligible project, if the Secretary certifies that the State has demonstrated a reduction in transportation emissions, as estimated on a per capita and per unit of economic output basis. (Note: FHWA will issue guidance on how the Secretary will make such certifications.) [§ 11403; 23 U.S.C. 133(b) and 175(c)(2)]

Section 5310 (FTA/Caltrans)

FTA Section 5310 – Enhanced Mobility of Seniors and Individuals with Disabilities Program is authorized by 49 United States Code (U.S.C.) 5310. The goal of the FTA 5310 Program is to improve the mobility of seniors and individuals with disabilities by removing barriers to transportation services and expanding the transportation mobility options available. This program provides grant funds for capital, mobility management, and operating expenses for:

- Public transportation projects planned, designed, and carried out to meet the special needs of seniors and individuals with disabilities when public transportation is insufficient, inappropriate, or unavailable;
- Public transportation projects that exceed the requirements of the Americans with Disabilities Act (ADA);
- Public transportation projects that improve access to fixed-route service and decrease reliance on complementary paratransit; and
- Alternatives to public transportation projects that assist seniors and individuals with disabilities and with transportation.

USDOT Congestion Mitigation and Air Quality (CMAQ) Improvement Program

The Congestion Mitigation and Air Quality (CMAQ) Improvement Program was created in 1991 under the Intermodal Surface Transportation Efficiency Act (ISTEA) to support surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. Eligible projects for CMAQ include but are not limited to:

- Transit Vehicle Engine Retrofits and Vehicle Replacements
- Street Sweeper and School Bus Engine Retrofits and Vehicle Replacements
- Transit Service Improvements
- Traffic Flow Improvements
- Bicycle and Pedestrian Improvements

Credits for New Clean Vehicles Purchased in 2023 or After

If you take possession of a new clean vehicle on or after April 18, 2023, it must meet critical mineral and battery component requirements to qualify for the credit. This applies even if you bought the vehicle before April 18. If you place in service a new plug-in electric vehicle (EV) or fuel cell vehicle (FCV) in 2023 or after, you may qualify for a clean vehicle tax credit.

Credits up to $7,500 under Internal Revenue Code Section 30D if you buy a new, qualified plug-in EV or FCV. The Inflation Reduction Act of 2022 changed the rules for this credit for vehicles purchased from 2023 to 2032. The credit is available to individuals and their businesses.

To qualify, you must:

- Buy it for your own use, not for resale
- Use it primarily in the U.S.

The credit is nonrefundable, so you can't get back more on the credit than you owe in taxes. You can't apply any excess credit to future tax years. The amount of the credit depends on when you placed the vehicle in service (took delivery), regardless of purchase date.

For vehicles placed in service January 1 to April 17, 2023:

- $2,500 base amount
- Plus $417 for a vehicle with at least 7 kilowatt hours of battery capacity
- Plus $417 for each kilowatt hour of battery capacity beyond 5 kilowatt hours
- Up to $7,500 total

In general, the minimum credit will be $3,751 ($2,500 + 3 times $417), the credit amount for a vehicle with the minimum 7-kilowatt hours of battery capacity.

For vehicles placed in service April 18, 2023, and after:
Vehicles will have to meet all the same criteria listed above, plus meet new critical mineral and battery component requirements for a credit up to:

- $3,750 if the vehicle meets the critical minerals requirement only
- $3,750 if the vehicle meets the battery components requirement only
- $7,500 if the vehicle meets both

A vehicle that doesn't meet either requirement will not be eligible for a credit.
To qualify, a vehicle must:

- Have a battery capacity of at least 7 kilowatt hours
- Have a gross vehicle weight rating of less than 14,000 pounds
- Be made by a qualified manufacturer.
- FCVs do not need to be made by a qualified manufacturer to be eligible. See Rev. Proc. 2022-42 for more detailed guidance.
- Undergo final assembly in North America
- Meet critical mineral and battery component requirements (as of April 18, 2023).

The sale qualifies only if:

- You buy the vehicle new
- The seller reports required information to you at the time of sale and to the IRS.
- Sellers are required to report your name and taxpayer identification number to the IRS for you to be eligible to claim the credit.

In addition, the vehicle's manufacturer suggested retail price (MSRP) can't exceed:

- $80,000 for vans, sport utility vehicles and pickup trucks
- $55,000 for other vehicles

MSRP is the retail price of the automobile suggested by the manufacturer, including manufacturer installed options, accessories and trim but excluding destination fees. It isn't necessarily the price you pay.

You can find your vehicle's weight, battery capacity, final assembly location (listed as “final assembly point”) and vehicle identification number (VIN) on the vehicle's window sticker.

To claim the credit, file Form 8936, Qualified Plug-in Electric Drive Motor Vehicle Credit (Including Qualified Two-Wheeled Plug-in Electric Vehicles) with your tax return. You will need to provide your vehicle's VIN.

Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants – USDOT

The RAISE grant is the latest iteration of the BUILD and TIGER grant program. This program is intended to invest in road, rail, transit, and port projects. The objective of this program is to fund projects that are difficult to support through traditional USDOT programs. Public entities, such as municipalities, are eligible to apply for this program. RAISE is a competitive grant program.

Prospective Financing Mechanisms

IBank Climate Catalyst Fund

The state's IBank is poised to create a new low-interest loan program for public fleets. The Climate Catalyst Fund was created in June 2020 and received its first funds in September 2021. The objective of this fund is to provide a financing mechanism to support the State of California's climate and sustainability infrastructure. The Climate Catalyst Fund's goal is to provide low-interest loans for projects that support the state's climate objectives. The IBank is in the process of developing the criteria that will be used to award projects. The Climate Catalyst Fund will initially prioritize projects that advance forest biomass management. However, the Climate Catalyst Fund's scope is expected to increase over time. From discussions with the Governor's Office of Business Development as well as the Director of the IBank, Scott Wu, CALSTART understands that the Fund's scope will eventually encompass zero emission fleets. These low interest loans could be used to fund vehicle purchases, as well as charging infrastructure projects.

Low Carbon Fuel Standard (LCFS)

The California Air Resources Board approved the Low Carbon Fuel Standard in 2009 to reduce the carbon intensity of California's transportation pool fuel by incentivizing the use of alternative/renewable fuels. The program establishes an annual carbon intensity score for each fuel that reflects the emissions from each fuel's life cycle assessment. Low carbon fuels below the annual CI benchmark can generate credits. As a zero-emission fuel, the power associated with charging electric vehicles and equipment generates LCFS credits.

REU Electric Vehicle DC Fast Charger Rebate and Demand Fee Credit

REU will provide up to $6,000 per electric charging station for the installation. Additionally, Qualifying charging stations may be eligible for a Demand Fee credit on their utility bill, lowering utility costs and creating more predictable bills. If eligible, a Demand Fee credit will be applied to your bill for five years, ramping down 20% each year until the credit sunsets from the bill. Details available here: https://www.cityofredding.org/departments/redding-electric-utility/reu-pages/energy-efficiency-rebate-program-commercial.

Shasta County Air Quality Management District

AB 617 Community Air Protection Program Grant Projects

The Community Air Protection Program (CAPP) is a multi-faceted program that provides funds for air districts to operate community outreach and incentive-based programs to reduce air pollution in local communities. The grants help owners of older high-polluting vehicles and equipment, make replacements with newer models that have much lower emissions -- or zero emissions. Grant funds may also be used for changes at local industrial facilities that reduce emissions of toxic or smog-forming pollutants, to build zero-emission charging stations, or to support local measures that air districts and communities identify through AB 617 Community Emissions Reduction Programs. The Shasta County Air Quality Management District is currently participating in implementation of AB 617 through development of a Best Available Retrofit Control Technology (BARCT) implementation plan.

Shasta County Air Quality Management District has obtained California Climate Investments grant funds that will be used as implementation incentives for emission reductions. Eligible projects include: Mobile Equipment Emissions Reductions through the Carl Moyer Diesel Exhaust Reduction Program, Air Filtration Systems for Schools or other Community Environments, Zero Emission Vehicle Charging Stations, and Zero Emission Commercial and Residential Landscaping Equipment Replacements.

Section K: Summary

RABA's current fleet will be replaced with ZEBs through 2040. Considering the RABA's service area topography and climate conditions, the fuel economy of these buses is estimated to be around 1.5 kWh/mi for shuttle cutaway buses and 4.13 kWh/mi for 30-35-ft transit buses. Based on the average daily miles traveled for each planned battery electric bus, the paratransit shuttle buses require an average of 65 kWh, fixed and commuter shuttle buses require an average of 290 kWh, and the 30-35-ft transit buses require an average energy of 600 kWh per bus to complete their daily trips. Hydrogen buses require an average of 8 kg of hydrogen per bus per day.

To address charging infrastructure needs, four types of chargers are needed: 19.2 kW, 50 kW,100 kW, and 200-kW chargers. A total of nine (9) 19.2 kW dual port chargers are needed to charge all paratransit shuttle buses overnight that the main depot. A total of three (3) 50 kW and seven (7) 100 kW chargers are needed to charge all commuter and fixed route transit and shuttle buses overnight at the RABA Maintenance Facility. A total of eight (8) on route 200-kW inductive chargers are needed to supplement charging for all fixed route electric vehicles. Depot charger quantities were determined assuming no manual unplugging of the chargers from buses after working hours and are summarized below.

Table 15 Installation Schedule

Clean Fuel Type	Vehicle Type	Number of Vehicles	Chargers Type	Chargers Qty	Daily used kWh/kg	Utility Upgrade	Capital Expenditure	Operational Expenditure	Total
Battery Electric	Paratransit - Shuttle Cutaway	17	19.2 kW	9	65	TBD	$10,495,808	$12,317,409	$22,813,575
	Commuter and Fixed Route - Shuttle Cutaway Bus	3	50 kW	3	290				
			200 kW	2					
	Fixed Route - 30-35-ft Transit Bus	7	100 kW	6	600				
			200 kW	6					
Hydrogen	Commuter and Fixed Route - Shuttle Cutaway Bus	5	N/A		8	TBD	$6,550,000	$5,222,265	$11,772,353
	Fixed Route - 30-35-ft Transit Bus	5			8				

In addition, inductive charging will be required at RABA's Downtown Transit Center, Canby Transfer Center, and Masonic Transfer Center to recharge BEBs operating in service. It is projected the total number of inductive charging units are required for each facility:

Table 16 On-Route Charging Summary

On-Route Charging Variables	Raba Downtown Transit Center	Canby Transfer Center	Masonic Transfer Center (Backup on-route Charger)	Total
Number Of Inductive Charging Units	5	2	1	8
Projected Capital Cost for Inductive Charging Units	$718,750	$287,500	$143,750	$1,150,000
Peak Power Demand from On-Route charging (kW)	800	320	160	1,280

All relevant costs, such as capital expenditures, installation expenses, operating costs, and incentives like HVIP were included in the total cost of ownership analysis. RABA can successfully transition their bus fleet to ZEBs, accommodate future growth, and effectively manage their charging requirements by considering the operators for ZEBs and the selection of appropriate charging and/or fuel cell fueling infrastructure. This will contribute to RABA's sustainable transportation goals while optimizing operational and economic efficiency.

Additionally, this plan is prepared to meet the requirements of the ICT regulation as well as FTA's Zero Emission Bus Transition Plan requirements for pursuing Lo-No funding.

Table 17 FTA ZEB Transition Plan Requirements

FTA Criteria	Location In ZEB Bus Rollout Plan
Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions.	Section D
Address the availability of current and future resources to meet costs for the transition and implementation.	Section I
Consider policy and legislation impacting relevant technologies.	Section B
Include an evaluation of existing and future facilities and their relationship to the technology transition.	Section E
Describe the partnership of the applicant with the utility or alternative fuel provider.	Section E
Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.	Section H

Appendix A: Shuttle Bus Vehicle Options

GreenPower

Green Power EV Star

Category	Specification
Passenger Capacity	19 FF / 21 Perimeter
Lift Capable	Yes
Battery Size	118 kWh
Length	25 ft

GreenPower – EV Star+ is a cutaway bus with a broader body to utilize the interior space. It is designed for paratransit fleet operations—a larger seating capacity and wheelchair position options are available. The bus is ideal for hospitals, carpooling services, airport shuttles, and campus transportation.

Green Power EV Star+

Category	Specification
Passenger Capacity	24 passengers
Lift Capable	Yes
Battery Size	118 kWh
Length	25 ft

Lightning eMotors

Lightning ZEV3

Category	Specification
Passenger Capacity	15 passengers
Lift Capable	Yes
Battery Size	80 kWh/120 kWh
Length	18 ft

Lightning ZEV4

Category	Specification
Passenger Capacity	18 passengers
Lift Capable	Yes
Battery Size	120 kWh
Length	18 ft

Phoenix Motorcars

ZEUS 400 Shuttle Bus

Category	Specification
Passenger Capacity	Up to 23 passengers forward seating, 12/2, 14/2, 16/2 ADA
Lift Capable	Yes
Battery Size	140 kWh
Length	22 ft

US Hybrid – H2 Ride offers the H2 Ride Fuel Cell Shuttle Bus, a 22-foot vehicle, and carries up to 12 passengers (two wheelchairs) plus an Operator.

Category	Specification
Passenger Capacity	12
Lift Capable	Yes
Length	22'
Passenger Capacity	12

Additionally, there are low-floor battery electric buses now entering this market:

- Optimal S1LF Low-Floor Shuttle Bus: https://www.optimal-ev.com/press/optimal-electric-vehicles-introduces-first-low-floor-shuttle-bus

- Arboc Freedom: https://arbocsv.com/models/freedom-gm-chassis/ https://www.nfigroup.com/news-releases/news-release-details/nfi-subsidiary-arboc-partners-xl-fleet-offer-hybrid-electric-bus

- RAM Promaster Van: https://robussales.com/inventory/2023-low-floor-rp-mini-bus/

Appendix B: Full-Sized Transit Bus Options

Battery Electric Transit Buses (BEBs)

This is a non-exhaustive list of BEB options that may be appropriate for RABA's fleet transition.

Proterra – ZX5

Features faster acceleration, industry-leading gradeability, and a range of more than 300 miles per charge. The ZX5 has a capacity of up to 29 passengers.

PROTERRA

Proterra ZX5	
Category	**Specification**
Passenger Capacity	29
Ramp Capable	Yes
Battery Size	225 kWh
Approximate nameplate single-charge range	95-125 miles
Length	35 Ft
Source	https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-35-Foot-Bus-U.S..pdf

Proterra – ZX5 MAX

Approximately 5' longer than the standard Proterra ZX5 bus model, which can accommodate 40 passengers and run up to 329 miles on a single charge.

PROTERRA

Proterra ZX5 MAX	
Category	**Specification**
Passenger Capacity	40
Ramp Capable	Yes
Battery Size	675 kWh
Approximate nameplate single-	221-329 miles

charge range	
Length	40 Ft
Source	https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-40-Foot-Bus-U.S..pdf

Proterra – ZX5+

A 35' bus that can run up to 240 miles on a single charge and has a capacity of up to 29 passengers.

Proterra ZX5+	
Category	**Specification**
Passenger Capacity	29
Ramp Capable	Yes
Battery Size	450 kWh
Approximate nameplate single-charge range	172-240 miles
Length	35 Ft
Source	https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-35-Foot-Bus-U.S..pdf

New Flyer – XCELSIOR XE

A 35-foot bus that can be configured to carry up to 35 passengers standing and 32 seating. The XCELSIOR has two battery options at 350 kWh and 440 kWh.

New Flyer XCELSIOR XE 35' All-Electric Transit Bus	
Category	**Specification**
Passenger Capacity	Up to 32 seats, up to 35 standees
Ramp Capable	Yes
Battery Size	350 kWh, 440 kWh
Approximate nameplate single-charge range	179, 220 miles
Length	35 Ft
Source	https://www.newflyer.com/site-content/uploads/2021/03/Xcelsior-CHARGE-NG-Brochure-1.pdf

New Flyer – XCELSIOR XE

A more extended version of its 35-foot counterpart, is capable of operating with three different battery sizes (350 kWh, 440 kWh, and 525 kWh). Each battery size gives varies in range, going up to 251 miles on a single charge.

NEW FLYER

New Flyer XCELSIOR XE 40' All-Electric Transit Bus	
Category	**Specification**
Passenger Capacity	Up to 40 seats, up to 44 standees
Ramp Capable	Yes
Battery Size	350 kWh, 440 kWh, 525 kWh
Approximate nameplate single-charge range	174, 213, 251 miles
Length	40 Ft
Source	*https://www.newflyer.com/site-content/uploads/2021/03/Xcelsior-CHARGE-NG-Brochure-1.pdf*

Additional buses that RABA could consider include:

Gillig 29. 35 and 40 foot – details here: https://www.gillig.com/battery-electric

Novabus LFSe+ 40 foot – details here: https://novabus.com/transit-solutions/electromobility/ through 2025.

Section 7613 of the National Defense Authorization Act for Fiscal Year 2020 (NDAA 2020), Pub. L. No. 116-92 (Dec. 20, 2019), added new subsection 49 U.S.C. § 5323(u) to federal public transportation law. Section 5323(u) limits the use of FTA funds, and in some circumstances local funds, to procure rolling stock from certain transit vehicle manufacturers.

Section 5323(u)(1) generally prohibits FTA funding of procurements of rolling stock from any manufacturer that is "owned or controlled by, is a subsidiary of, or is otherwise related legally or financially to a corporation based in" certain foreign countries. A country is covered by the restriction if it—

- "(i) is identified as a nonmarket economy country (as defined in section 771(18) of the Tariff Act of 1930 (19 U.S.C. 1677(18))) as of [December 20, 2019];
- "(ii) was identified by the United States Trade Representative in the most recent report required by section 182 of the Trade Act of 1974 (19 U.S.C. 2242) as a foreign country included on the priority watch list defined in subsection (g)(3) of that section; and
- "(iii) is subject to monitoring by the Trade Representative under section 306 of the Trade Act

of 1974 (19 U.S.C. 2416).”

- For criterion (i), recipients should consult the U.S. International Trade Administration’s list of designated nonmarket economy countries, available at https://www.trade.gov/nme-countries-list. For criteria (ii) and (iii), recipients should consult the latest version of the U.S. Trade Representative’s Special 301 Report for a list of countries included on the priority watch list and whether such countries are subject to monitoring under Section 306 of the Trade Act of 1974.

Recipients should apply general corporate law principles to determine whether a particular transit vehicle manufacturer is “owned or controlled by, is a subsidiary of, or is otherwise related legally or financially to a corporation based in” a country that meets the statutory criteria. For purposes of this requirement, “otherwise related legally or financially” does not include a minority relationship or investment; it also does not include a relationship with or investment in a subsidiary, joint venture, or other entity based in a covered country that does not export rolling stock or components of rolling stock for use in the United States.

Until this law changes, if Federal funds are used, the following BYD buses could not be purchased:

BYD – K7M

30 feet bus
Details here: https://en.byd.com/bus/k7m/
Extended range: https://en.byd.com/bus/k7mer/

BYD – K9S

A 35.8-foot bus with a maximum load of 33 passengers, including the driver. The K9S can travel up to 157 miles on a single charge.

BYD K9S 35’ All-Electric Transit Bus	
SPECIFICATIONS	**SPECIFICTION VALUE(S)**
Passenger Capacity	32 + 1
Ramp Capable	Yes
Battery Size	266 kWh
Approximate nameplate single-charge range	Up to 157 miles
Length	35.8 ft
Source	*https://en.byd.com/bus/35-electric-transit-bus/*

BYD – K9M

A 40-foot plus bus with two battery sizes, 313 kWh and 352 kWh. The passenger load varies on configuration and can comfortably sit between 38 and 43 passengers depending on the battery size. This Altoona-tested model can run up to 160 miles contingent on the battery size selected.

BYD K9M 40' All-Electric Transit Bus	
Category	**Specification**
Passenger Capacity	Up to 37+1 / Up to 42+1 MD
Ramp Capable	Yes
Battery Size	313 kWh / 352 kWh MD
Approximate nameplate single-charge range	Up to 156 miles / Up to 160 miles MD
Length	40.2 ft / 40.9 ft MD
Source	https://en.byd.com/bus/40-foot-electric-transit-bus/#specs

Fuel Cell Electric Buses (FCEBs)

New Flyer – Xcelsior Charge H2

A battery-electric vehicle that uses compressed hydrogen as an energy source. Fuel cell-electric technology is an innovative way to obtain extended-range operation similar to existing transit vehicles with a fully zero-emission solution.

New Flyer Xcelsior Charge H2	
Category	**Specification**
Passenger Capacity	Up to 40 seats / Up to 42 standees
Ramp Capable	Yes
Fuel Tank Size	37.5 kg
Approximate nameplate single-charge range	Up to 350 miles on a single charge
Length	40’
Source	*https://www.newflyer.com/site-content/uploads/2021/01/Xccelsior-CHARGE-H2-Brochure_2021.pdf*

EL Dorado – AXESS FC

The only hydrogen bus in the federally certified industry for 3-point seat belts. It features a heavy-duty low floor adapted for applications such as airport shuttles and college transit. The Axess-FC offers optional ADA-compliant wheelchair ramps, has completed Altoona testing, and passed numerous side-impact and roof crush tests to ensure passenger safety.

El Dorado AXESS FC	
Category	**Specification**
Passenger Capacity	43 Max
Ramp Capable	Yes
Fuel Tank Size	50 kg at 350 bar
Approximate nameplate single-charge range	Up to 260 miles
Length	40’
Source	*https://www.eldorado-ca.com/hydrogen-hybrid-bus* https://www.nrel.gov/docs/fy20osti/71312.pdf

RABA could take advantage of cooperative procurements as allowable by FTA, the State of California and the RABA's procurement policies to procure these vehicles from CALACT, California Department of General Services, Washington State Department of Enterprise Services as examples.

Appendix C: On-Route Energy and Infrastructure Needs

Table 18 Route 2 – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	337	85%	58	-15%	0%	0	85%	---	Downtown
2	279	71%	58	-15%	0%	0	71%	---	
3	221	56%	58	-15%	10%	40	66%	8:05 - 8:20 am	
4	163	41%	58	-15%	10%	40	62%	9:05 - 9:20 am	
5	105	27%	58	-15%	10%	40	57%	10:05 - 10:20 am	
6	47	12%	58	-15%	10%	40	53%	11:05 - 11:20 am	
7	-11	-3%	58	-15%	10%	40	48%	12:05 - 12:20 pm	
8	-69	-17%	58	-15%	10%	40	44%	1:05 - 1:20 pm	
9	-127	-32%	58	-15%	10%	40	39%	2:05 - 2:20 pm	
10	-185	-47%	58	-15%	10%	40	34%	3:05 - 3:20 pm	
11	-243	-61%	58	-15%	7%	26	26%	4:05 - 4:20 pm	
12	-301	-76%	58	-15%	5%	21	17%	5:05 - 5:20 pm	
13	-359	-91%	58	-15%	0%	0	3%	---	

Table 19 Route 2 – Weekend On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	337	85%	58	-15%	0%	0	85%	---	Downtown
2	279	71%	58	-15%	0%	0	71%	---	
3	221	56%	58	-15%	10%	40	66%	11:05 - 11:20 am	
4	163	41%	58	-15%	10%	40	62%	12:05 - 12:20 pm	
5	105	27%	58	-15%	10%	40	57%	1:05 - 1:20 pm	
6	47	12%	58	-15%	10%	40	53%	2:05 - 2:20 pm	
7	-11	-3%	58	-15%	10%	40	48%	3:05 - 3:20 pm	
8	-69	-17%	58	-15%	0%	0	33%	---	
9	-127	-32%	58	-15%	0%	0	19%	---	
10	-185	-47%	58	-15%	0%	0	4%	---	

Table 20 Route 4 – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	340	86%	55	-14%	0%	0	86%	---	Canby
2	285	72%	55	-14%	0%	0	72%	---	
3	230	58%	55	-14%	10%	40	68%	8:05 - 8:20 am	
4	175	44%	55	-14%	10%	40	65%	9:05 - 9:20 am	
5	120	30%	55	-14%	10%	40	61%	10:05 - 10:20 am	
6	65	17%	55	-14%	10%	40	57%	11:05 - 11:20 am	
7	10	3%	55	-14%	10%	40	53%	12:05 - 12:20 pm	
8	-45	-11%	55	-14%	10%	40	49%	1:05 - 1:20 pm	
9	-100	-25%	55	-14%	10%	40	46%	2:05 - 2:20 pm	
10	-155	-39%	55	-14%	10%	40	42%	3:05 - 3:20 pm	
11	-210	-53%	55	-14%	10%	40	38%	4:05 - 4:20 pm	
12	-265	-67%	55	-14%	0%	0	24%	---	
13	-320	-81%	55	-14%	0%	0	10%	---	

Table 21 Route 4 – Weekend On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	340	86%	55	-14%	0%	0	86%	---	Canby
2	285	72%	55	-14%	0%	0	72%	---	
3	230	58%	55	-14%	0%	0	58%	---	
4	175	44%	55	-14%	10%	40	54%	12:05 - 12:20 pm	
5	120	30%	55	-14%	10%	40	51%	1:05 - 1:20 pm	
6	65	17%	55	-14%	10%	40	47%	2:05 - 2:20 pm	
7	10	3%	55	-14%	10%	40	43%	3:05 - 3:20 pm	
8	-45	-11%	55	-14%	10%	40	39%	4:05 - 4:20 pm	
9	-100	-25%	55	-14%	0%	0	26%	---	
10	-155	-39%	55	-14%	0%	0	12%	---	

Table 22 Route 5 – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	82	81%	19	-19%	0%	0	81%	---	Downtown
2	63	62%	19	-19%	0%	0	62%	---	

3	44	44%	19	-19%	0%	0	44%	---	
4	25	25%	19	-19%	40%	40	65%	9:05 - 9:20 am	
5	6	6%	19	-19%	40%	40	85%	10:05 - 10:20 am	
6	-13	-13%	19	-19%	0%	0	67%	---	
7	-32	-31%	19	-19%	0%	0	48%	---	
8	-51	-50%	19	-19%	40%	40	69%	1:05 - 1:20 pm	
9	-70	-69%	19	-19%	0%	0	50%	---	
10	-89	-88%	19	-19%	40%	40	71%	3:05 - 3:20 pm	
11	-108	-106%	19	-19%	0%	0	52%	---	
12	-127	-125%	19	-19%	0%	0	33%	---	
13	-146	-144%	19	-19%	0%	0	15%	---	

Table 23 Route 5 – Weekend On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	82	81%	19	-19%	0%	0	81%	---	Downtown
2	63	62%	19	-19%	0%	0	62%	---	
3	44	44%	19	-19%	0%	0	44%	---	
4	25	25%	19	-19%	40%	40	65%	12:05 - 12:20 pm	
5	6	6%	19	-19%	40%	40	85%	1:05 - 1:20 pm	
6	-13	-13%	19	-19%	0%	0	67%	---	
7	-32	-31%	19	-19%	0%	0	48%	---	
8	-51	-50%	19	-19%	40%	40	69%	4:05 - 4:20 pm	
9	-70	-69%	19	-19%	0%	0	50%	---	
10	-89	-88%	19	-19%	0%	0	31%	---	

Table 24 Route 7 – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	76	75%	25	-25%	0%	0	75%	---	Downtown
2	51	51%	25	-25%	0%	0	51%	---	
3	26	26%	25	-25%	40%	40	66%	8:05-8:20 am	
4	1	1%	25	-25%	40%	40	81%	9:05 - 9:20 am	
5	-24	-23%	25	-25%	0%	0	56%	---	
6	-49	-48%	25	-25%	40%	40	71%	11:05 - 11:20 am	
7	-74	-73%	25	-25%	40%	40	86%	12:05 - 12:20 pm	
8	-99	-98%	25	-25%	35%	35	96%	1:05 - 1:20 pm	
9	-124	-122%	25	-25%	0%	0	71%	---	
10	-149	-147%	25	-25%	40%	40	86%	3:05 - 3:20 pm	

11	-174	-172%	25	-25%	0%	0	61%	---	
12	-199	-196%	25	-25%	0%	0	36%	---	

Table 25 Route 7 – Weekend On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	76	75%	25	-25%	0%	0	75%	---	Downtown
2	51	51%	25	-25%	0%	0	51%	---	
3	26	26%	25	-25%	40%	40	66%	11:05 - 11:20 am	
4	1	1%	25	-25%	40%	40	81%	12:05 - 12:20 pm	
5	-24	-23%	25	-25%	40%	40	95%	1:05 - 1:20 pm	
6	-49	-48%	25	-25%	0%	0	71%	---	
7	-74	-73%	25	-25%	40%	40	86%	3:05 - 3:20 pm	
8	-99	-98%	25	-25%	0%	0	61%	---	
9	-124	-122%	25	-25%	0%	0	36%	---	

Table 26 Route 11 – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	350	89%	45	-11%	0%	0	89%	---	Downtown
2	305	77%	45	-11%	0%	0	77%	---	
3	260	66%	45	-11%	0%	0	66%	---	
4	215	54%	45	-11%	0%	0	54%	---	
5	170	43%	45	-11%	10%	40	53%	10:35 - 10:50 am	
6	125	32%	45	-11%	10%	40	52%	11:35 - 11:50 am	
7	80	20%	45	-11%	10%	40	51%	12:35 - 12:50 pm	
8	35	9%	45	-11%	10%	40	50%	1:35 - 1:50 pm	
9	-10	-2%	45	-11%	10%	40	48%	2:35 - 2:50 pm	
10	-55	-14%	45	-11%	0%	0	37%	---	
11	-100	-25%	45	-11%	0%	0	26%	---	
12	-145	-37%	45	-11%	0%	0	14%	---	
13	-190	-48%	45	-11%	0%	0	3%	---	

Table 27 Route 11 – Weekend On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location

1	350	89%	45	-11%	0%	0	89%	---	Downtown
2	305	77%	45	-11%	0%	0	77%	---	
3	260	66%	45	-11%	0%	0	66%	---	
4	215	54%	45	-11%	0%	0	54%	---	
5	170	43%	45	-11%	10%	40	53%	1:35 - 1:50 pm	
6	125	32%	45	-11%	10%	40	52%	2:35 - 2:50 pm	
7	80	20%	45	-11%	0%	0	41%	---	
8	35	9%	45	-11%	0%	0	29%	---	
9	-10	-2%	45	-11%	0%	0	18%	---	
10	-55	-14%	45	-11%	0%	0	6%	---	

Table 28 Route 14 – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	345	87%	50	-13%	0%	0	87%	---	Downtown
2	295	75%	50	-13%	0%	0	75%	---	
3	245	62%	50	-13%	0%	0	62%	---	
4	195	49%	50	-13%	10%	40	60%	9:05 - 9:20 am	
5	145	37%	50	-13%	10%	40	57%	10:05 - 10:20 am	
6	95	24%	50	-13%	10%	40	55%	11:05 - 11:20 am	
7	45	11%	50	-13%	10%	40	52%	12:05 - 12:20 pm	
8	-5	-1%	50	-13%	10%	40	50%	1:05 - 1:20 pm	
9	-55	-14%	50	-13%	10%	40	47%	2:05 - 2:20 pm	
10	-105	-26%	50	-13%	10%	40	45%	3:05 - 3:20 pm	
11	-155	-39%	50	-13%	0%	0	32%	---	
12	-205	-52%	50	-13%	0%	0	19%	---	
13	-255	-64%	50	-13%	0%	0	7%	---	

Table 29 Route 14 – Weekend On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	345	87%	50	-13%	0%	0	87%	---	Downtown
2	295	75%	50	-13%	0%	0	75%	---	
3	245	62%	50	-13%	0%	0	62%	---	
4	195	49%	50	-13%	10%	40	60%	12:05 - 12:20 pm	
5	145	37%	50	-13%	10%	40	57%	1:05 - 1:20 pm	
6	95	24%	50	-13%	10%	40	55%	2:05 - 2:20 pm	
7	45	11%	50	-13%	0%	0	42%	---	
8	-5	-1%	50	-13%	0%	0	29%	---	

9	-55	-14%	50	-13%	0%	0	17%	---	
10	-105	-26%	50	-13%	0%	0	4%	---	

Table 30 Route 18 (Crosstown Express) – Weekday On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	363	92%	32	-8%	0%	0	92%	---	Canby
2	331	84%	32	-8%	0%	0	84%	---	
3	299	76%	32	-8%	0%	0	76%	---	
4	267	68%	32	-8%	0%	0	68%	---	
5	235	60%	32	-8%	0%	0	60%	---	
6	203	51%	32	-8%	0%	0	51%	---	
7	171	43%	32	-8%	10%	40	53%	12:05 - 12:20 pm	
8	139	35%	32	-8%	10%	40	56%	1:05 - 1:20 pm	
9	107	27%	32	-8%	10%	40	58%	2:05 - 2:20 pm	
10	75	19%	32	-8%	0%	0	50%	---	
11	43	11%	32	-8%	0%	0	41%	---	
12	11	3%	32	-8%	0%	0	33%	---	
13	-21	-5%	32	-8%	0%	0	25%	---	
14	-53	-13%	32	-8%	0%	0	17%	---	
15	-85	-21%	32	-8%	0%	0	9%	---	
16	-117	-30%	32	-8%	0%	0	1%	---	

Table 31 Beach Bus –On-Route Charging

End of lap	Energy without on-route charging	SOC without on-route charging	Energy Consumed in Lap	SOC Lost During Lap	Added SOC with on-route charging	Energy transferred from on-route charging	Final SOC	Charging Time	Charging Location
1	49	49%	52	-51%	40%	40	88%	11:05-11:20 am	Downtown
2	-3	-3%	52	-51%	40%	40	77%	1:05 - 1:20 pm	
3	-55	-54%	52	-51%	40%	40	65%	4:05 - 4:20 pm	
4	-107	-105%	52	-51%	0%	0	13%	---	

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