

PresidiGo Capital Plan

A Technical Analysis of Alternative Transit Fleet Fuels and Transition Strategy



Final Report — February 2019

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Prepared for:

Presidio Trust

San Francisco, California

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List of Abbreviations

Abbreviation	Term
BAAQMD	Bay Area Air Quality Management District
BEB	Battery Electric Bus
CARB	California Air Resources Board
CMP	Carl Moyer Program
CNG	Compressed Natural Gas
CO	Carbon Monoxide
ESS	Energy Storage System
EV	Electric Vehicle
GVWR	Gross Vehicle Weight Rating
HVIP	Hybrid Vehicle Incentive Program
ICT	Innovative Clean Transit
kW	Kilowatt
kWh	Kilowatt hour
NOx	Nitrogen Oxides
NOx	Nitrogen Oxides
PG&E	Pacific Gas and Electric
RA	Reimbursable Agreement
RFP	Request for Proposals
RNG	Renewable Natural Gas, or Bio-CNG
SFCTA	San Francisco County Transportation Authority
SFMTA	San Francisco Municipal Transportation Agency
SGIP	Self-Generation Incentive Program
SOW	Statement of Work
TFCA	Transportation Fund for Clean Air
VOC	Volatile Organic Compounds

Executive Summary

The PresidiGo Capital Plan presents a technical analysis and conclusions regarding the management of the future transit fleet for the PresidiGo shuttle system. This system provides transit access to and through the Presidio of San Francisco in support of the Presidio Trust's mission.

The Presidio of San Francisco is an approximately 1,500-acre park at the northern tip of San Francisco that is a part of the Golden Gate National Recreation Area. A former military base, the Presidio is managed by the Presidio Trust and the National Park Service. The Presidio Trust (Trust) is a federal agency charged with operating the Presidio without taxpayer support by raising revenue from leasing homes and commercial space throughout the Presidio. The Presidio currently has approximately 4,000 employees and 3,200 residents, and the Presidio Trust Management Plan (PTMP)¹ Environmental Impact Statement (EIS) forecast approximately 6,900 employees and 3,800 residents at build-out. The PresidiGo transit service supports the Trust's mission by providing sustainable transportation for the Presidio's residents, workers, and recreational visitors.

This PresidiGo Capital Plan began with a directive to evaluate potential long-term fuel sources for the PresidiGo transit fleet. The Presidio owns a fleet of Compressed Natural Gas (CNG) buses and a CNG fueling station, while a contractor performs the system's operations and maintenance. The fleet provides an alternative to private vehicle commute trips and therefore qualifies for California grant funding based on offsetting local air quality emissions.

The PresidiGo's transit vehicles have projected life spans between 5 and 15 years, and they rely on a recently repaired CNG fueling station that can provide at least another decade of service. However, the Trust is currently reviewing proposals for the redevelopment of the Fort Scott area, which includes the existing fueling station and bus storage area. This project may require the relocation and redevelopment of the bus fueling and storage area within the next five years.

Given the varied lifespans of these assets and the interdependencies between the PresidiGo's vehicles and charging infrastructure, the Trust decided to study the feasibility and potential benefits of transitioning the fleet to alternative fuel technologies. The Trust was particularly interested in evaluating the benefits and costs of the following fuel options for future:

- New Compressed Natural Gas (CNG) vehicles to replace their existing fleet;
- Using Renewable Natural Gas (RNG) across the current & future (new CNG-based) fleet; and
- Converting to a battery-electric bus (BEB) fleet.

This final report builds on the initial findings and recommendations of an Interim Memo delivered to the Trust in October 2018, which found that CNG, RNG, and BEB buses are all feasible for the PresidiGo

¹ Presidio Trust Management Plan, available online at: <https://www.presidio.gov/presidio-trust/planning-internal/Shared%20Documents/Planning%20Documents/PLN-301-PTMP02-Plan.pdf>.

service, but that transitioning to a BEB fleet would best meet the Trust’s sustainability goals and maintain competitiveness for state and local grant funding programs. The planned redevelopment of Fort Scott over the next three to five years provides an important opportunity to transition the fleet’s charging infrastructure, while spending the time preceding the redevelopment piloting a BEB shuttle bus and planning for a coordinated fleet transition.

Summaries of the interim report conclusions begin below.

Transit Fuel Evaluation

The project team’s analysis indicates that CNG, RNG, and BEB transit buses are feasible for the existing PresidiGo service based on current routes and schedules. Purchasing new CNG buses or BEB buses would both increase the energy efficiency of the PresidiGo transit fleet and would lead to reduced local air pollutant emissions. However, BEB buses are the only solution that can facilitate zero local emissions, and they would better support the Trust’s sustainability goals. In addition, BEB buses typically provide maintenance savings of approximately \$0.25 per mile compared to CNG buses, or approximately \$45,000 per year for the full PresidiGo fleet. “Next-generation” batteries, projected to be available in the next few years, are also expected to provide greater range potential and contribute to lower purchasing costs.

As an interim strategy to reduce emissions while planning for a transition to BEBs, the Trust can purchase RNG credits from the Trust’s CNG provider, Clean Energy. By purchasing RNG credits, the Presidio could reduce the equivalent of the CO₂e emissions from the PresidiGo fleet by 75 percent at no cost.

Transition Strategy

While the Trust could conceivably wait several years for performance and cost of BEBs to improve further, they must make decisions regarding the redevelopment of the Fort Scott area today. The infrastructure needs for BEBs, like many alternative energy sources, are unique. Significant costs associated with electric vehicle (EV) charging infrastructure relate to site work, including: trenching and laying of conduit for new power lines; construction of pads, pedestals or other structures to mount hardware; and construction of potential shade structures featuring solar photo voltaic (PV) panels to supply renewable energy for charging the buses (if desired). With a new bus storage location in development, the costs associated with delaying a transition to BEBs outweigh the potential benefits of preserving a CNG fleet when coupled with the anticipated life of future bus acquisitions. Any new heavy-duty CNG bus purchased now relies upon preserving the existing fueling station for decades to come, or construction of a new CNG fueling facility at the new bus storage and operations location. Both of these would prove costly, particularly if a later transition toward BEBs required additional infrastructure

construction, on top of the prior investments into the Fort Scott Area redevelopment, including any new CNG-related infrastructure.

One of the most difficult things to manage in transit is a dual-fueled fleet, requiring duplicative infrastructure, parts inventories, and operational knowledge. The difficulty is compounded when sites planned around the needs of a particular vehicle or fuel source are retrofitted to accommodate new technologies. The Trust is in a unique position to carry out operations of its legacy fleet from the current bus storage and fueling location while a new storage and operations location is being constructed. This approach will minimize infrastructure costs and reduce operational impacts of operating a dual-fueled fleet.

This timeframe also provides the Trust with an opportunity to explore a pilot program with a BEB to gain first-hand knowledge, exposure, and experience with EVs well ahead of a full-fleet transition. The lessons learned through piloting a vehicle can dynamically inform the new site development requirements, and can help inform the future fleet's makeup. The project team recommends piloting a BEB shuttle bus on one of the Around-the-Park (ATP) loops for the following reasons:

- The ATP routes run smaller capacity, cutaway-style shuttles that have shorter lifespans and will need to be replaced in the next few years, whereas the 35' to 40' heavy-duty transit buses on the Downtown route will not need to be replaced as soon.
- The San Francisco Metropolitan Transportation Agency (SFMTA) is currently conducting a pilot study evaluating a range of potential heavy-duty BEB transit vehicles for their suitability for San Francisco's unique operating conditions. The Presidio can benefit from the SFMTA's findings and may realize future maintenance and service benefits by selecting a similar platform. Therefore, it makes sense for the Trust to wait for the results of the SFMTA pilot.

Funding Opportunities

The project team researched and summarized a variety of state and local funding programs for which the PresidiGo service would be eligible. These funding programs, summarized in Table 1 below, can help the Trust defray some of the costs associated with vehicle replacement, transit operations, EV charging infrastructure, and on-site renewable energy storage. Several of these funding sources evaluate eligibility based on the effectiveness of the transit fleet in reducing local emissions, so lower-emissions vehicle options – such as BEBs – are more competitive for grant funds.

Table 1: Summary of Relevant Funding and Technical Assistance Opportunities

Assistance Program	Funding Amount	Applicability to Presidio Trust Fleet	Eligibility Notes
TFCA – Regional Fund	\$100,000/year (current funding)	Currently funds Downtown Route operations.	Eligibility is determined by a cost-effectiveness ratio calculated by the BAAQMD.
TFCA – County Program Manager Funds	Funding awarded based on project cost effectiveness.	Could be used to fund Downtown Route operations, but PresidiGo has not been successful in securing funding in the past.	Eligibility is determined by a cost-effectiveness ratio calculated by the SFCTA.
HVIP	Up to \$95,000 per vehicle purchased.	Could fund purchase or lease of new battery-electric buses for the Downtown Route or Around-the-Park routes.	Eligibility is determined on a vehicle basis. (Motiv, currently only medium-duty BEB supplier, is eligible). The bus vendor submits a voucher request, which is applied to purchase. Can be combined with the CMP.
CMP	Up to \$200,000 per vehicle replacement or 95% of all costs	Could fund replacement of the Trust’s oldest vehicles (those with a model year of 2009 or older, with consideration of 2010 model year buses on a case-by-case basis. Can also fund charging infrastructure.	Eligibility is based on meeting minimum calculated emissions reduction and cost-effectiveness requirements under the current CMP Guidelines, and zero-emission projects are highly encouraged.
DOE Federal Energy Management Program (FEMP)	N/A; technical assistance and financing program to support solar projects	FEMP can provide technical assistance, guidance, and training to help the Trust finance solar energy development.	Technical assistance available to Federal agencies. The Trust’s energy provider, WAPA, works with FEMP.

Introduction

Project background

The Presidio of San Francisco is an approximately 1,500-acre park on a former U.S. military base that includes recreational and open space as well as commercial space, and residential dwellings. It is a part of the Golden Gate National Recreation Area, and its management consists of a partnership between two federal agencies: the National Park Service manages 300 acres along the coast, and the Presidio Trust (Trust) manages the remaining 1,191 acres of the Presidio. Figure 1 is a map of the Presidio, highlighting its size and prominence situated south of the Golden Gate Bridge.

Figure 1: Presidio of San Francisco overview map (Source: Presidio Trust)



The Trust is a unique agency founded by bipartisan legislation, charged with operating the Presidio sustainably without taxpayer support and with an eye toward long-term financial health. Funds generated on-site through leasing residential and commercial space help fund park operations and maintenance, including the park-owned transit system.

The PresidiGo Shuttle system offers transportation throughout the park with two Around-the-Park (ATP) loops – the “Presidio Hills” and “Crissy Field” routes – and a commuter service that runs between the Presidio and downtown San Francisco, referred to as the “Downtown” route. The ATP routes utilize two

“cutaway” style² shuttle buses built from production truck chassis with one held in reserve. The shuttle buses typically require replacement approximately every 5 years. The Downtown service utilizes half a dozen heavy-duty (HD) transit buses.³ These buses typically require replacement after 15 years of use, and most of these buses will reach this milestone in the next six years.

Currently, all of the PresidiGo buses run on Compressed Natural Gas (CNG) and rely on a CNG fueling station that the Trust maintains within the park. The Trust has recently acquired new shuttle buses and anticipates further acquisitions over the next 10 years. Because of the long-term nature of the HD transit buses, the Trust has decided to study the feasibility of transitioning the fleet to battery-electric buses (BEBs) to inform future bus purchases and infrastructure decisions. With an eye towards a more sustainable transportation fleet and local emissions goals, the Trust decided to pursue a fleet and energy analysis to help inform pending investments for their transportation fleet and infrastructure.

Project Objectives

The Trust entered into a Reimbursable Agreement (RA) with the U.S. Department of Transportation’s Volpe National Transportation Systems Center (Volpe) in May of 2018, to provide technical transportation assistance to the Trust to develop this PresidiGo Capital Plan. The purpose of this plan is to evaluate a range of potential transit fuel sources for the Presidio’s future transit fleet and to provide recommendations for future fleet transition.

The RA provided baseline information on the current PresidiGo transit fleet, including an inventory of vehicles, overview of the existing on-site bus storage⁴ and fueling facility, as well as route and schedule information. The Trust also included prior internal analyses undertaken with regard to consideration of battery-electric buses (BEB), including their thoughts on potential barriers to adoption.

The Trust’s purpose for conducting this study is to consider how to make long-term vehicle and infrastructure decisions for the PresidiGo fleet that will serve riders’ needs, meet Trust emissions reduction goals, and be financially sustainable. In addition, the Trust aims to leverage local transit vehicle pilots and grant funding based on reducing local vehicle emissions. The RA highlights the anticipated growth in demand for transportation: “The Presidio currently has approximately 4,000 employees and 3,200 residents, and the Presidio Trust Management Plan (PTMP)⁵ Environmental Impact Statement (EIS) forecast approximately 6,900 employees and 3,800 residents at build-out. Visitation is

² “Cutaway” style shuttle buses feature a passenger compartment built onto a domestic work truck chassis. A primary manufacturer, such as Ford or GM, produces a truck chassis, which a secondary manufacturer will build out into one of many custom configurations for commercial use. The primary manufacturer’s warranty covers the chassis and drivetrain of the vehicle, while the secondary manufacturer provides a warranty on body or various systems and components installed by them.

³ The PresidiGo Downtown route fleet consists of five 35’ El Dorado XHF buses purchased between 2008 and 2010 and one 40’ New Flyer bus purchased in 2017.

⁴ The existing on-site bus parking location facilitates storage and fueling of the buses. There are no maintenance structures, but the transit operator performs light maintenance in the parking lot.

⁵ Presidio Trust Management Plan, available online at: <https://www.presidio.gov/presidio-trust/planning-internal/Shared%20Documents/Planning%20Documents/PLN-301-PTMP02-Plan.pdf>.

also expected to grow as the Tunnel Tops site is developed and more lodging is added to the park. Current PresidiGo operation is described at <http://www.presidio.gov/transportation/presidigo>. PresidiGo ridership is currently at or near capacity during peak commute periods on the Downtown route and the Presidio Hills route, which serves most of the residential areas of the park, and acts as a feeder route to the Downtown route.”

The Trust is also in the planning stage for the redevelopment of the Fort Scott area, where the current CNG fueling station and bus yard are located. As part of this project, the bus storage and operations station may be relocated to a nearby site, which would provide an important opportunity for redeveloping this infrastructure to meet the fleet’s long-term needs.

Report Organization

This report includes the following sections, which correspond to the tasks specified in the RA’s Statement of Work (SOW):

- 1. Introduction:** This section provides report objectives and context on the PresidiGo transit system.
- 2. Transit Fuel Evaluation:** This section evaluates the feasibility, opportunities, and constraints associated with three transit fuel alternatives: CNG, RNB, and BEB.
- 3. Transition Strategy:** Analyzes considerations for future fleet transitions, considering the timeframes of projected vehicle and fuel infrastructure replacement needs.
- 4. Funding Opportunities:** Summarizes information about applicable federal, state, and local grant funding opportunities for transit bus and fuel infrastructure costs and considers the relative competitiveness of the PresidiGo service under different fuel sources.
- 5. Implementation Plan:** Presents a series of implementation actions and their timeframe.
- 6. Conclusion:** Summary of the report findings and next steps.

PresidiGo operational profile

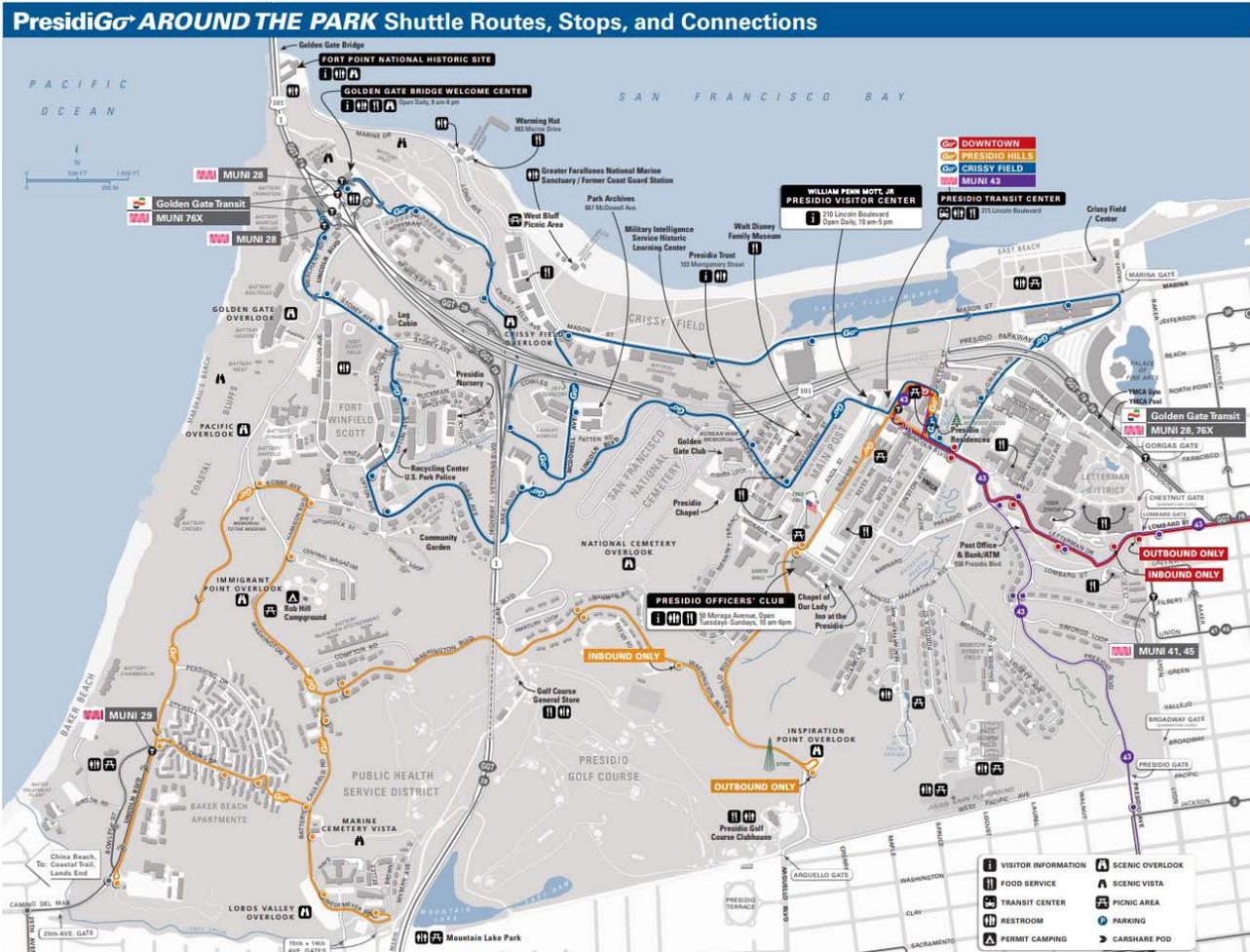
As outlined above, the PresidiGo service operates both a downtown, transit-style service as well as a continuous all-day circulator shuttle service. The PresidiGo downtown route is roughly 9 miles per round trip and provides service between the Presidio and downtown San Francisco, where it connects to the region’s transportation network. The Downtown route is visible in Red in Figure 2 below and represents a somewhat typical urban transit duty cycle with modest grade considerations. The buses are operating on urban corridors with frequent stop and go traffic, a low average speed, and frequent traffic or signal-related delays. The transit operator, MV Transportation, indicated to the project team that their drivers are in constant communication with each other, as well as with the dispatcher, in order to identify potential traffic delays and re-route when possible. Semi-regularly deviating from the planned route can assist drivers in remaining on time and on-schedule.

Figure 2: PresidiGo Downtown Bus Route (source: Presidio Trust)



Figure 3 provides a detailed view of the ATP routes. The ATP shuttle service includes two distinct routes: the Presidio Hills route (highlighted in gold) is roughly 6.4 miles round-trip, and the Crissy Field route (highlighted in blue) is roughly 4.2 miles round trip. The Presidio Hills route covers several moderate grades as it winds through the Presidio to provide service to its residential base, and experiences typical commute time peaks in demand. The Crissy Field route also covers a few modest grades and experiences rush hour crowding, but unlike the Presidio Hills route, it serves recreational attractions and visitors throughout the day. Both routes operate continuously throughout the service day from 6:30 am until 8:00 pm.

Figure 3: PresidiGo Around-the-Park Route Map (source: Presidio Trust)



PresidiGo transit fleet profile

The Trust currently owns a fleet of nine (9) buses fueled by Compressed Natural Gas (CNG) via an on-site fueling station. This includes three (3) medium-duty (MD) shuttle bus “cutaway” style vehicles such as the one shown in Figure 4 to serve the ATP routes. The shuttles operate continuously throughout the day, accruing over 30,000 miles each year per vehicle. Two of the shuttle buses in the current fleet have 7-year / 200,000-mile Altoona⁶ rated lifespans, while one of the shuttle buses carries a 10-year / 350,000-mile rating. These lifespans and their presumed annual mileage accrual of 28,000 and 35,000 miles, respectively, are ideal for their utilization in the PresidiGo fleet, meaning the annual mileage accrued over 7- or 10-years are in line with the mileage rating.

⁶ Federal Transit Administration, Altoona Bus Testing, information available online at: <https://www.transit.dot.gov/research-innovation/bus-testing>.

Figure 4: Around-the-Park shuttle bus (source: Presidio Trust)



Six (6) 35' or 40' heavy-duty (HD) transit buses, including the El Dorado XHF shown in Figure 5, serve the Downtown route and accrue less than 17,000 miles each year, per vehicle. During the morning and evening commute periods, the service operates all six buses to provide 10-minute headways, but during non-commute times, the service operates only one bus to achieve one-hour headways. The characteristics of the Downtown service minimizes overall mileage accrued by each vehicle. The FTA considers HD transit buses as 12-year assets rated for 500,000 miles of use, presuming 40,000 miles per year of use. At their current utilization, the buses in the PresidiGo fleet will not reach that level of use within 12-years, and are likely to have longer operational lives. Heavy-duty transit bus platforms are necessary to provide sufficient capacity to meet the demand experienced along the Downtown route. Smaller buses would require significantly more vehicles to meet this demand, subsequently requiring more drivers with a significant impact on operational costs. Expertly maintaining a low-mileage HD fleet can facilitate reliable operations beyond of their 12-year rated lifespans. Preserving the HD fleet for as long as possible will help the Trust realize returns on their investments.

Figure 5: PresidiGo Downtown transit bus (source: Presidio Trust)



The smaller MD shuttle buses serving the ATP loops accrue significant annual mileage because they operate continuously throughout the day, every day. The ATP buses also experience high utilization, often with full passenger loads on steep, hilly terrain, so they experience substantial wear and tear. The shuttle bus fleet requires regular replacement, in-line or before their rated lifespans. In addition, they

require careful and extensive maintenance as they reach mileage-based service intervals quickly. The Trust has experienced several issues with their shuttle buses due to design flaws, including the Ford engine, which has required frequent top-end replacement due to poor top end oiling; and experienced poor body construction quality of the StarCraft bus, including a broken floor and frequent repairs. Parts availability is generally less of a concern for the MD shuttle bus fleet, as parts are widely available for most commercial truck-based platforms. However, CNG-powered shuttle buses from any manufacturer are relatively low-volume vehicles (compared to gasoline or diesel counterparts), and can suffer from parts availability issues as well.

The current fleet includes vehicles purchased ten years ago as well as a few recent acquisitions. The bulk of the existing fleet will require replacement within the next 7 years, with replacements starting in 2019. The following section details the anticipated replacement schedule for the full fleet.

Fleet replacement horizon

Table 2 below provides a comparison between the existing fleet’s rated lifespans, anticipated life serving their respective routes, and a replacement year target for consideration. Actual replacement years may vary based on the specific condition of vehicles in the fleet; some may require replacement sooner while others may provide reliable service and not require replacement until later. In general, the MD shuttle buses will require replacement sooner than the HD transit buses. This should provide the Presidio Trust with an opportunity to strategically plan the fleet’s replacement and retire vehicles once they have secured a replacement, and prior to the vehicle’s condition requiring its removal from service.

Table 2: Vehicle life ratings and anticipated replacement horizon

Bus ID	Bus Type	Purchase Year	Altoona Rating (yrs)	Altoona Rating (miles)	Anticipated Life (yrs)	Anticipated Life (miles)	Replacement Year Target
183	HD ED XHF	2008	12	500,000	15+	250,000+	2023+
249	HD ED XHF	2009	12	500,000	15+	250,000+	2024+
201	HD ED XHF	2010	12	500,000	15+	250,000+	2025+
202	HD ED XHF	2010	12	500,000	15+	250,000+	2025+
203	HD ED XHF	2010	12	500,000	15+	250,000+	2025+
1024	HD NF	2017	12	500,000	15+	250,000+	2032+
226	MD Shuttle (CC)	2012	7	200,000	7	200,000	2019
256	MD Shuttle (SA)	2013	10	350,000	10	350,000	2020
1025	MD Shuttle (CC)	2018	7	200,000	5	300,000	2023

ED=El Dorado; NF = New Flyer; CC = Champion Challenger; SA = StarCraft Allstar

Operations infrastructure considerations

The current fleet of MD and HD buses all run on CNG and rely on an existing CNG fueling station in the Fort Scott area of the Presidio. The Trust inherited a CNG fueling station from the Presidio military base, which they have maintained to fuel their transit fleet. In recent years, it was substantially deteriorating and at times unusable. When the station was not functioning, the transit operator had to drive the buses a substantial distance to fuel them off site, which created additional operational costs and challenges.

In 2018, the Trust completed substantial repairs to the CNG fueling station, installing a new compressor and associated hardware. The restored on-site fueling capabilities will support the viability of CNG as a fuel source for at least 10 years. This provides the Trust with an opportunity to coordinate implementation of their long-term fleet transition strategy and capitalize on planned redevelopment activities, including construction of a new transit fleet storage, maintenance, and operations area at Fort Scott.

The Trust is currently reviewing proposals for redevelopment of the Fort Scott area, planned for completion in the next three to five years. The current location of the bus yard and CNG fueling station is in a parking area directly adjacent to the Fort Scott campus. Because the current bus yard and station is so close to the site and better suited for visitor parking, the Trust has identified an alternative nearby location for the bus yard and fueling station north of Storey Avenue.

The design and construction of the new bus storage area will have a direct and significant impact on the future fleet and its operations; however, the legacy fleet can continue to operate from the existing location until construction. The redevelopment of Fort Scott may provide an ideal timeframe to construct a new bus yard and charging facility. As the Trust begins to retire CNG buses and replace them with BEBs, they can reduce the footprint of the CNG fueling station. There may be a transition period where some CNG charging infrastructure – such as a tube-trailer – could facilitate support of legacy buses at the new bus yard, allowing for the complete removal of the CNG station

To facilitate effective planning, this report evaluates up to three fuel scenarios for the future fleet, including the current Compressed Natural Gas (CNG) fuel as a baseline, a bio-CNG (also referred to as Renewable Natural Gas or RNG) scenario, and an all-electric scenario. Prior discussions included incorporating on-site bio-CNG reforming through a composting process; however, upon further investigation, the Trust established they do not produce enough compostable material on-site to generate the quantity of fuel needed. The bio-CNG scenario explored in the analysis assumes the existing gas supplier provides fuel. This does not result in any operational changes, as the fuel is interchangeable with traditional CNG, but would yield modest emissions reductions.

CNG, Bio-CNG (RNG), and Electricity are all feasible energy sources for the PresidiGo transit fleet in the long term; however, only Battery-Electric Buses (BEBs) can help the Trust eliminate local emissions from

its transit vehicles and continue to qualify for ever more stringent air quality funding opportunities, while also holding the potential to reduce maintenance costs. As a result, the Trust's executive leadership has indicated a long-term preference for an all-electric transit fleet. This preference aligns with state and local goals, expressing a desire to electrify all transit bus fleets. California's Air Resources Board (CARB) has Proposed Innovative Clean Transit (ICT) 2018 Regulation,⁷ a vision to electrify the statewide transit fleet by 2040. San Francisco Municipal Transit Authority (SFMTA) passed a resolution to convert their entire transit bus fleet to battery-electric by 2035.⁸ As part of this report, the project team has developed a list of applicable pilots evaluating the feasibility of HD and MD electric buses, presented in Appendix A: Ongoing Battery Electric Bus Pilots.

Site Visit Summary

The Volpe team traveled to the Presidio for a site visit in late July 2018, meeting with representatives from the Trust during the morning of the July 23. The Trust provided an overview of their PresidioGo transit service, bus fleet, and ridership characteristics. Many of the buses in the fleet are approaching the end of their useful lives, with some of the shuttle buses requiring near-term replacement. Ridership trends are increasing, especially demand for capacity on the Downtown route during commute periods. One of the major destinations for morning ridership in the Presidio is the Letterman District, where approximately 50% of employees work within the Presidio. In 2017, the Trust acquired a CNG-fueled New Flyer 40' transit bus to augment the downtown bus fleet and provide additional capacity, and the Trust believes they may have to consider additional vehicles to meet demand that is still growing. The Trust also purchased a new CNG powered shuttle bus, to replace a legacy vehicle experiencing frequent mechanical breakdowns.

The Trust also discussed various development activities including the Fort Scott Request for Proposals (RFP) and the Tunnel Tops project, which will complete landscaping over the Doyle Drive freeway tunnel and connect the Main Post district with Crissy Field. These projects will take place over the next 5 years, and will have a direct impact on ongoing and future fleet operations. The project team toured the current fueling facility and bus storage area, as well as the proposed location for the new bus storage facility. This future site currently consists of a paved parking lot with a large dirt pile, which will soon to be removed for use by the Tunnel Tops project.

For the remainder of the first day, the project team toured the Presidio Transit Center, rode all three transit lines, and examined certain areas along the route for road characteristics including maximum grades, maneuvering limitations, and areas where bus stops were located or where buses were frequently parked (such as behind the Transit Center). Route observations confirmed no limiting factors exist that would prevent BEB operation, confirmed later by representatives from Motiv Power Systems.

⁷ California Air Resources Board, Innovative Clean Transit 2018, Rulemaking Activity (Status Updates), available online at: <https://www.arb.ca.gov/regact/2018/ict2018/ict2018.htm>.

⁸ "San Francisco Commits to All-Electric Bus Fleet by 2035", SFMTA Press Release, Tuesday, May 15, 2018. Available online at: <https://www.sfmta.com/press-releases/san-francisco-commits-all-electric-bus-fleet-2035>.

Motiv Power Systems presentation

Prior to the site visit, Presidio Trust staff identified Motiv Power Systems (Motiv) as a company developing the technology for battery-electric MD transit shuttle buses. BEB MD buses are currently very limited in their availability: Motiv is an electric-drive systems supplier to Ford for its commercial truck segments, and it is the only mainstream electric-drive system supplier supplying technologies approved by the vehicle manufacturer (Ford). These same commercial truck chassis serve as the baseline vehicle for the existing shuttle bus fleet serving the Around-the-Park loops within the Presidio. The Motiv drivetrain powers similar shuttle buses that serve the Google Campus in nearby Mountain View, California.⁹

Ahead of the site visit, the Trust invited representatives from Motiv Power Systems to present on their technologies to the project team. In attendance was Kash Sethi, Director of Sales at Motiv as well as Jillian Solomon, the local sales lead representative. Motiv presented an overview of their offerings, including vehicles built off the Ford F450, F550 (in design phase), and F59 chassis. Motiv is a Qualified Vehicle Modifier (QVM) partner with Ford. Their electric-drive system as installed preserves the full Ford warranty, and includes a 3-year, 50,000-mile warranty on the Motiv power system. Motiv also offers driver and mechanic training, as well as direct technical support via field technicians. Vehicles featuring the Motiv power system are CARB-approved and eligible for key in-state incentive programs such as the Hybrid Vehicle Incentive Program (HVIP), which provides vouchers based off the vehicles Gross Vehicle Weight Rating (GVWR) to offset the incremental costs of hybrid- and battery-electric heavy-duty vehicles. Figure 6 includes HVIP credits available for Motiv-based vehicles.

After the presentation, a representative from Motiv carried out a preliminary route analysis that confirmed that the Around-the-Park routes would be feasible for a battery-electric cutaway, and offered a more comprehensive route analysis that could inform specification of a replacement vehicle once the Trust was ready to consider purchase.

⁹ Mountain View Shuttle Website, available online at: <http://mvcommunityshuttle.com/>.

Figure 6: HVIP Vehicle Credits (Source: Motiv)



California | HVIP

CURRENTLY ACCEPTING APPLICATIONS UNTIL FUNDS ARE EXHAUSTED

PLATFORM	BASE FUNDING (per vehicle)	ADDITIONAL	INFRASTRUCTURE	CONDITIONS
Ford E-450	\$80,000	Additional \$10,000 for fleets in Disadvantaged Communities	Offers \$30,000 for new fueling equipment (not labor)	Voucher served on first-come first-served basis Must operate in CA for at least 3 years PO is needed to request voucher
Ford F-59	\$90,000			
Ford F-650	\$90,000	Additional \$10,000 for first 3 vouchers	Must be tied to HVIP vehicle	
	\$95,000			

On-site bus storage and fueling facility

The project team toured the existing bus storage and fueling area, which consists of a small CNG compressor and dispenser with multiple filling stations. The buses are refueled a few at a time after their shifts and then rotated to complete fueling of the full fleet. As noted earlier, the Trust recently acquired necessary equipment to refurbish the fueling station and restore reliable operation for the next decade or more. There is no shelter provided, and the site consists of a paved parking area with some parking areas separated with a chain link fence. The fleet operator indicated there has been a spate of recent break-ins and theft attempts. While generally flat, there are no concrete pads or paved areas where the surface is completely level. As a result, the fleet operator limits on-site maintenance and carries out significant repairs at an alternate location in South San Francisco. The existing location is an ad-hoc solution for bus fueling and storage and not well designed with this purpose in mind. Figure 7 highlights the existing bus facility (circled in blue) and the potential new bus facility location, which is currently covered in a dirt pile and large black tarp (circled in red). The detail view (below, right) depicts the current bus storage and parking area, with the fueling station located at the top-right. The fenced in area below the compressor includes parking with refueling nozzles for overnight slow fill of the buses.

Figure 7: Bus Storage and Fueling Facility, with detail inlay (Source: Presidio Trust / Google Maps)



The Trust had plans for redeveloping the bus fueling and staging area prior to this analysis, and had pursued potential design and cost estimates. These earlier estimates did not consider the needs of an electrified fleet. A new bus storage location in general should provide a consistent and flat grade with adequate drainage and parking locations for each vehicle in the fleet. Considerations for an electric fleet include concrete for parking areas, a shade canopy, and concrete pads or other locations for charging equipment. While only light maintenance occurs at the storage location, the Trust should consider incorporating an inspection or light service and maintenance area. The area should also feature a concrete pad, approximately 15-foot wide by 45-foot long, a shade canopy, and a means to facilitate access to the undercarriage of vehicles. A flat, concrete service and inspection area can help facilitate safe use of jacks, wheel lift stands, ramps, or other means to lift the vehicle to access the undercarriage. A concrete inspection area could also include an integrated raised platform or ramps to elevate the vehicle.

The prior work noted above included estimates for a new CNG station and fueling area, going so far as conceptual design sketches and cost estimates. A cost estimate from August of 2016 for site design and construction of a new parking area and CNG station, along with associated curbing, road and general construction costs came to roughly \$2 million, with \$800,000 in costs associated with the CNG station.

For an electric vehicle fleet, considerations should include benefits from locally available renewable power sources. The general recommendations for the bus storage location made above include shade

canopy structures for the vehicles, as well as the inspection area. Providing shade for the vehicles protects them from the elements and the degradation associated with ultraviolet exposure, and helps to preserve the investments made in the transit fleet. For the inspection area, providing shade during the day can mitigate the impact of working outdoors on the maintenance crew, and the structures can provide a surface to mount overhead lighting, enabling mechanics to continue servicing vehicles after dark, or provide an ideal mounting point for charging equipment.

Shade canopies are also ideal locations to consider mounting solar photovoltaic (PV) panels to provide locally generated clean, renewable power. The large surface areas required to provide shade for transit vehicles also provides sufficient surface area for solar power. Taking advantage of this unused space by incorporating solar power generation can provide a substantial portion of the future fleet's energy needs. The Volpe team recommends the Trust consider ways to provide on-site solar energy generation and energy storage, as the Trust pursues designs for redevelopment of the Fort Scott area. The Trust indicated interest in the idea, and requested a high-level conceptual cost estimate, which is included below. **Note:** this is merely a "representative" system and **not** intended to power a future all BEB fleet at the Presidio. A 200 kW solar array would not provide sufficient energy to operate the full fleet on renewable power generated on-site alone, and a future system should be comprehensively planned for, once more variables are known.

A modest 200 kilowatt (kW) solar, shade-canopy mounted array would cost roughly \$1,000,000, and could incorporate a 250 kilowatt-hour (kWh)¹⁰ on-site energy storage system (ESS) for an additional \$1,000,000. A 200 kW system would require between 10,000 and 15,000 square feet of space for the solar panels. A solar canopy shade structure for the buses could provide nearly half the required footprint, and additional canopies over bus maintenance areas, and employee parking areas, or nearby structures could provide additional space for increased capacity.

The ESS would help lower overall emissions and reduce utility charges by allowing energy captured from the solar canopy to be stored while buses are in operation, and to charge the buses when parked. An ESS can help compound savings in the long-term, provide the ability to charge the fleet with 100% renewable power, offer resiliency to preserve transit operations during periods of power loss/blackout, and generally leverage the PV Solar investment by enabling it to be more productive and utilize as much power generated on-site as possible. A high-level cost estimate is included in Table 3 below and assumes construction is coordinated with site development. Costs associated with providing the utility power service backbone, grading, drainage, paving, etc. for the broader bus storage site are not included.¹¹ Further considerations for future on-site solar power generation and energy storage are found in the Transition Strategy section for Fort Scott.

¹⁰ A 250 kWh system serves as a representative system for an example cost estimate; a final system design will incorporate a goal for the ESS' intended function and informed by the platforms chosen to comprise the future fleet.

¹¹ EV related costs shown in Table 2 represent costs to add the related infrastructure to an already existing site consisting of a paved parking lot and relatively nearby access to utility power. Additional information on EV charger installation costs available online: <http://tompkinscountyny.gov/files2/itctc/projects/EV/Tompkins%20EVSE%20Installation%20Analysis%20FINAL.pdf>.

**Table 3: Estimated Cost & Size Requirements for:
Conceptual 200 kW PV Solar Canopy Shade Structure with 250kW Energy Storage**

Item	Quantity	Description	Cost / Unit	Cost
PV Solar Shade Canopy	200,000 watts	200 kW solar shade canopy structure installed, approx. 12,000 square feet	\$4.50 / watt (DC – installed)	\$900,000
Energy Storage System (battery)	250,000 watts	250 kW/kWh energy storage system (ESS), container-mounted.	\$4.00 / watt (Installed cost)	\$1,000,000
Charging System	3-4	Manufacturer supplied chargers, priced each. Ideally integrated mounting and drop-down plugs with canopy structure.	\$45,000	\$135,000 - \$180,000
Contingency	5%	Contingency for project costs, PM and overhead for site-work and high-voltage systems installation	5% of project costs	\$100,000
			Total Cost:	\$2,180,000
PV solar system spatial requirements are generic, do not account for all local conditions, and are generally representative. The following equation approximates the spatial requirements for a solar system: ‘Size (kW) = Array Area (m ²) x 1 kW/m ² x Module Efficiency (%)’ [Source: NREL PVwatts]. Modules vary in efficiency from 12-20%. Assuming premium solar panels with 19% efficiency, approximately 12,000 square feet would be required to generate 200 kW. Actual size requirements will vary based on actual desired system capacity, local conditions, technologies chosen, available space, etc.				

Other takeaways impacting fleet operations

The following factors identified during the site visit are critical to the success of the future fleet.

Maneuverability Concerns: The ATP shuttle buses must complete several tight turns throughout portions of their route. Technical information such as turning radius drawings can help assuage concerns; however, a demonstration vehicle (if available) could help establish any limitations with both maneuverability as well as overall performance. The ATP routes also include some moderately steep hills, but Motiv’s initial route analysis suggests that the BEB drivetrain should have sufficient gradability. However, the hills will affect power needs.

Adequate Gross Vehicle Weight Ratings: The shuttle bus fleet has experienced build-quality issues, particularly on StarCraft buses. Smaller shuttle buses rated up to 16,500 lbs. GVWR can reach or exceed capacity during high demand times. New shuttle buses of sufficient capacity and GVWR would avoid exceeding weight ratings. The Trust should pursue new shuttle buses built on the F550, F650, or F59 Ford chassis, all rated for at least 19,500 lbs. GVWR. Purchasing heavier-duty vehicles will help ensure adequate passenger capacity without exceeding safety limits and suffer fewer structural issues.

Value Added by Contractor: The contract operator has a documented history of performance and proactive effort, often going beyond their responsibilities outlined in the contract including facilitating repairs to the on-site fueling station. The Trust should consider past performance in the contract renewal processes along with the familiarity the existing contractor has with the fleet and infrastructure.

Long-term Maintainability of the Heavy Duty Bus Fleet: The Trust should work with the bus manufacturer and with the operator over time, to establish a long-term maintenance plan that includes identification of critical parts likely to require replacement, periodic review of parts availability, and advance notification when parts are soon to become “No Longer Available (NLA).” Notification when parts may become NLA can provide an opportunity to purchase parts in advance.

Transit Fuel Evaluation

The transit fuel evaluation considered the three independent routes served by the PresidiGo fleet, the two Around-the-Park (ATP) loops served by the shuttle buses, as well as the downtown route served by the heavy-duty transit bus fleet. The entire fleet currently runs on CNG, provided by the on-site fueling station – recently rehabilitated to restore reliable operation. While CNG and its renewable natural gas counterpart RNG (or bio-CNG) are feasible for current operations and could support the future PresidiGo fleet, BEBs will best meet the Trust’s long-term goals for sustainability, emissions reduction, and cost-effectiveness.

Emissions Considerations

The project team’s analysis showed that new CNG buses and BEBs would provide significant reductions in emissions, including reducing carbon monoxide (CO), Nitrogen Oxide (NOx), and Volatile Organic Compound (VOC) emissions. These reductions are due to more stringent environmental regulations for current model year vehicles, and advances in combustion management. Table 4 shows benefits of new CNG heavy-duty transit buses, and Table 5 shows benefits of new CNG medium-duty shuttle buses. Table 6 shows the cumulative local air pollutant emissions from both fleets eliminated with a 100% battery-electric bus fleet.

The calculations shown in Table 4 do not represent the actual PresidiGo heavy-duty transit bus fleet, but compare two representative fleets of model-year 2009 (MY2009) buses versus an all-new fleet of MY2019 buses to highlight how new CNG vehicles compare to a representative vehicle from the respective fleet. The HD transit bus fleet is comprised of long-term assets to be replaced starting with the oldest legacy vehicle in operation. Replacing a MY2008-2010 CNG HD transit bus with a MY2019 CNG HD transit bus would save 294 kg of CO, 30.67 kg of NOx, and 1.68 kg of VOCs per bus, annually based on 16,669 miles per year accrued by each bus.

Table 4: Emissions benefits of new CNG HD buses

Emission Type	MY2009 emissions rate¹² (kg/mile)	Annual Emissions (MY2009 buses, 100,193 total miles)	MY2019 emissions rate (kg/mile)	Annual Emissions (MY2019 buses, 100,193 total miles)	Reduction
CO	0.0302116254	3,026.99 kg	0.0126090647	1,263.34 kg	58%
NO _x	0.002306608	231.11 kg	0.0004685215	46.94 kg	80%
VOC	0.0001593330	15.964 kg	0.0000588078	5.892 kg	63%

Buying new CNG shuttle buses would also yield emissions benefits in the same three emissions types; however, the shuttle bus fleet is generally newer, with modern combustion and emission controls, and powered by smaller engines. The calculations shown in Table 5 do not represent the actual PresidioGo shuttle bus fleet, but compare two representative fleets of model-year 2012 (MY2012) shuttle buses versus an all-new fleet of MY2019 vehicles. Since the existing shuttle bus fleet is generally newer, new CNG vehicles do not offer as dramatic emissions benefits. However, the shuttle buses see heavier use of around 32,266 miles per year for each bus, are cheaper to purchase, and have shorter life spans. New CNG shuttle buses are a low-cost solution to achieve near term emissions benefits.

Table 5: Emissions benefits of new CNG MD buses

Emission type	MY2012 emissions rate¹² (kg/mile)	Annual Emissions (MY2012 buses, 96,798 total miles)	MY2019 emissions rate (kg/mile)	Annual Emissions (MY2019 buses, 96,798 total miles)	Reduction
CO	0.0218745426	2,117.41 kg	0.0171767491	1,662.67 kg	21.5%
NO _x	0.0009567285	92.6 kg	0.0005618715	54.38 kg	41%
VOC	0.0001593330	15.423 kg	0.0000588078	5.692 kg	63%

Because BEBs do not have tailpipe emissions, converting the fleet to BEBs would effectively reduce local emissions to zero. For example, one new BEB shuttle bus replacing one existing CNG shuttle bus would eliminate 705.8 kg of CO, 30.9 kg of NO_x, and 5.14 kg of VOC emissions each year. As a result, BEBs would best meet the Presidio Trust’s sustainability goals and maximize the Trust’s competitiveness for local air quality grant funding (discussed in the Funding Opportunities section below). Reducing local air pollutant emissions and lowering costs are critical goals held by the Presidio Trust and align with goals articulated by the City of San Francisco and the State of California, who have committed to all-electric transit bus fleets aimed at drastically reducing local emissions.¹³

¹² Emissions rates from EPA’s MOVES model, with localized transit bus emissions data, 2020 evaluation year.

¹³ “San Francisco Commits to All Electric Bus Fleet by 2035,” San Francisco Municipal Transportation Agency (SFMTA), available online at: <https://www.sfmta.com/press-releases/san-francisco-commits-all-electric-bus-fleet-2035>.

Table 6: Emissions benefits of new battery-electric bus (full) fleet

Emission type	Annual Emissions (Current Fleet, 196,991 miles)	Annual Emissions (all-electric fleet, 196,991 miles)	Reduction
CO	5,144.4 kg	0 kg	100%
NOx	323.71 kg	0 kg	100%
VOC	31.387 kg	0 kg	100%

Operations and Maintenance Costs

In addition to reducing local emissions, BEBs would reduce operations and maintenance costs for the Trust. If the heavy transit fleet were transitioned to fully electric, it is projected to save \$17,000 per year¹⁴ in fueling costs compared to current fuel costs, given electric rates for current vehicle charging infrastructure located within the Presidio.¹⁵ Savings may increase or decrease with fluctuations in energy costs; electricity and CNG costs are both subject to unforeseen policy changes and market fluctuations. Historically, electricity costs have more stability compared to costs associated with fossil fuels. To enhance future pricing certainty and ensure low energy costs into the future, the Trust should consider infrastructure investments to complement their future vehicle fleet, including on-site solar generation and energy storage. Since the Presidio Trust oversees its own infrastructure as well as operates its own utility power service, they should pursue strategies proven to reduce electrical loads, reduce peak demand charges, and enhance resiliency of their electrical grid.

A fully electric heavy-duty transit bus fleet traveling roughly 100,000 miles per year will save \$25,000 per year in maintenance costs based on a savings rate of \$0.25 per mile. A California Air Resources Board examination of several BEB fleets analyzed maintenance costs across several demonstration programs of BEBs versus conventional buses (buses utilizing an internal combustion engine, transmission, and typical drivetrain such as employed by the current CNG bus fleet), and concluded “the results of their evaluation are consistent with manufacturer estimated savings for battery electric buses.”¹⁶ The evaluation also concludes that: “the electric drive system cost savings from these studies are expected to be a lower bound estimate because they do not reflect expected higher repairs for engine component failures that are expected later in the life of the bus (e.g., turbos, hoses, belts) whether included in planned maintenance or unscheduled maintenance.” The Presidio Trust does not currently incur maintenance costs directly. The service provider MV Transportation incorporates maintenance costs in an hourly rate per service-hour

¹⁴ All cost estimates are in 2018 dollars.

¹⁵ The Presidio Trust supplied cost information for CNG use, split between the two fleets by mileage and relative fuel efficiency of the two vehicle types. Charging costs calculated by mileage, manufacturer-supplied (and in-use test confirmed) fuel efficiency of current generation BEB 40-foot transit buses of 2 kWh/mile, and Presidio-supplied electricity utility rates from current EV charging (\$0.08/kWh).

¹⁶ “Literature Review on Transit Bus Maintenance Costs, California Air Resources Board, available online at: https://www.arb.ca.gov/msprog/bus/maintenance_cost.pdf

The Around-the-Park shuttle buses operating on the Crissy Field and Presidio Hills routes provide continuous service throughout the day, which would likely require two BEBs for each CNG-shuttle in use, based on currently available technology.¹⁷ However, BEB shuttle buses will save roughly \$16,500 per year in fueling costs and \$15,000-\$20,000 per year in maintenance costs across the shuttle bus fleet. The shuttle bus fleet travels nearly 100,000 miles per year, or roughly 33,000 miles per bus, significantly more annual mileage than the HD buses.

In all, battery-electric buses project to save the Presidio Trust approximately \$30,000 annually in energy costs and \$45,000 annually in maintenance costs while eliminating all local emissions; these benefits, combined with generous state incentive programs to offset capital investment costs helped the Trust decide to focus further efforts on transitioning the current CNG-powered fleet toward battery-electric.

Charging considerations

This analysis did not consider fast-charge battery-electric bus offerings, primarily because they are only available for the heavy-duty transit bus platform. The PresidiGo heavy-duty bus fleet operates on a split shift, and individual vehicles do not accrue significant daily mileage. Slow-charge battery-electric buses have more than adequate range capability to meet the service demands along the Downtown route and do not require expensive fast-charging equipment that might potentially require installation outside of the Presidio. In addition, they do not rely on on-route charging, enabling drivers to deviate from the route to avoid particularly bad congestion, construction, or accidents that arise throughout the course of a typical day. Slow charging the buses overnight also avoids charging during periods of high-demand on the grid.

Renewable Natural Gas (RNG) - immediate benefits for the existing fleet

The Trust could pursue fueling their existing fleet with RNG to realize immediate emissions reductions compared to conventional CNG. RNG performs equally well to traditional CNG and offers emissions benefits; due to a lower carbon intensity, short-lived climate pollutants (SLCPs) are reduced in-use. However, most benefits are achieved during the production of the fuel, not through its use. Since the tail pipe emissions from RNG are the same as conventional CNG, purchasing RNG would not improve grant eligibility. RNG is available for use at the Presidio and can provide a means to lower emissions

¹⁷ A “deep dive” route and service shift analysis offered by Motiv can help identify final requirements if the Presidio Trust chooses to electrify the Around-the-Park shuttles. The analysis would determine the total number of vehicles required to perform service, and suggest optimization of shift scheduling to minimize charging requirements. The Motiv F650 option (in development) may yield adequate range to provide a 1:1 replacement strategy and offers a higher gross vehicle weight rating (GVWR) in order to ensure sufficient carrying capacity at full load.

while the fleet transitions to battery-electric. Clean Energy, the contractor that maintains the Presidio's CNG station, has an RNG credit program. By purchasing RNG credits, the Presidio could reduce the equivalent of the CO₂e emissions from the PresidiGo fleet by 75 percent at no cost.

Infrastructure development driving energy source selection

CNG (or RNG) and battery-electric are both viable for the Presidio in the long-term, but they require different charging infrastructure. The current effort to begin redevelopment of the Fort Scott area, provides the mechanism and impetus for committing to the long-term vision of the transit fleet. Infrastructure investments are long-term, 30-year assets. Incorporating site design and construction requirements into the Fort Scott redevelopment to support electrification of the vehicle fleet is paramount to minimizing costs and maximizing return on investment.

Transition Strategy

The redevelopment of the Fort Scott Area is expected to take 3-5 years to complete, and during that time, the Trust can begin to replace vehicles in the fleet. Developing the new bus storage area to serve BEBs will enable the Trust to begin replacing vehicles within the next few years. Both of these timelines align well with state incentive programs (discussed in detail in the Funding Opportunities section below) that provide generous financial assistance in procuring electric and hybrid vehicles, as well as assistance for associated charging infrastructure. Leasing vehicles can provide a temporary solution to meeting near term capacity needs, and could be an alternative to purchasing more CNG-powered vehicles that would extend the fleet electrification timetable. However, leasing transit buses does not make sense as an alternative to purchase, because of minimum mileage requirements for leased assets. (Lessors typically require vehicles reach stipulated mileage thresholds before a vehicle can be replaced.) High-dollar assets such as transit buses typically have lease rates set with the expectation of constant transit-style use that would result in over 20,000 miles of use per year. The PresidiGo HD transit fleet does not accrue sufficient mileage for leasing to be a cost effective alternative.

Early investments

The future bus storage, charging, and light maintenance facility should proceed with a design to support full fleet electrification, and employ design elements noted in section 2.2 above. A modular approach could provide means to stage rollout of chargers or solar capacity as the transit fleet turns over, but requires careful design and consideration of future fleet needs.

The Trust should attempt to maximize their access to current incentive programs for vehicle financing while funding is available, and consider multiple vehicle and charger purchases starting in the next two years. This timeframe will also allow manufacturers to offer next-generation batteries with substantially greater range; most manufacturers are releasing updated battery systems by 2020. These initial vehicles will take one year After Receipt of Order (ARO) for delivery, but charging equipment is often available within 180 days ARO for delivery. This allows for receipt of charging equipment approximately six months ahead of vehicle delivery, enabling installation, training, and troubleshooting of on-site infrastructure before receipt of vehicles, so they can enter service as soon as possible with minimal downtime.

Potential BEB shuttle bus pilot

To accelerate deployment of BEBs, the Trust should consider piloting a battery-electric shuttle bus on the Around-the-Park loops, to develop a familiarity with the new technology on-board the vehicle, as well as gaining experience with the charging infrastructure and general operation of an electric vehicle

(EV). A charger for the pilot shuttle bus may require identifying a temporary alternate location¹⁸ pending progress with the redevelopment at Fort Scott.

Heavy-duty transit bus platform selection

There are several ongoing technology evaluation programs examining currently available BEB transit buses. San Francisco’s Municipal Transportation Authority (SFMTA) is currently conducting one that is of particular interest. The SFMTA is attempting to identify an ideal bus platform for San Francisco’s unique characteristics, including steep hills, which may be similar to the needs of the Downtown PresidioGo route. SFMTA also has local resources at their maintenance facility that may be of continued benefit to the Presidio. The Presidio’s transit operator has previously utilized New Flyer technical assistance via SFMTA, and could potentially continue to benefit from on-site technical support at SFMTA should a common platform be suitable. Other relevant bus pilot evaluation programs are included in Appendix A: Ongoing Battery Electric Bus Pilots.

Available HD BEB platforms are limited to a few manufacturers, including Proterra, New Flyer, El Dorado, and Build-Your-Dreams (BYD). Only Proterra has made their products available for Federal Fleet Purchasing through the General Services Administration (GSA). Purchasing through the GSA provides a measure of support, as the GSA would enter an agreement with the Presidio and act on their behalf to develop specifications, iron out ordering details and timelines, and be available for post-delivery and warranty support assistance. Additionally, Proterra’s headquarters are just south of San Francisco in Burlingame, CA, and would likely be able to offer prompt technical support.

Fort Scott transit infrastructure buildout

The site work associated with the new bus storage and maintenance location should proceed as part of the redevelopment of Fort Scott, and with a design that provides for supporting the high-voltage and utility power connections. Construction can install primary utility power access, conduits, concrete parking pads, shade structures and initial general wiring, and hardware as fully and as early, as is practicable. The design should provide for some flexibility in selecting a final vehicle platform(s), which may require slight considerations for unique equipment; however, no fast-charging options are in consideration and slow-charge or “extended range” buses on the market or expected by 2023 will have ample range to meet the daily use requirements for the fleet. Preliminary estimates are that the heavy-duty transit buses serving the downtown route will require roughly 250 kWh of onboard energy storage to yield 100 bus-miles of range per day. This mileage range is sufficient to operate similarly to the current schedule, and midday downtime could provide an opportunity to recharge partially before the

¹⁸ An alternate location should be close to utility power to minimize installation costs, or powered by a mobile generator or natural gas power unit.

afternoon commute period. Bus manufacturers can provide comprehensive route energy analyses to help inform how much capacity is required on-board the bus, and can help suggest operational strategies to maximize energy efficient operations.

After identifying a heavy-duty bus platform, the Trust can arrange to complete the final design elements. BEB manufacturers will typically supply charging equipment optimized to the vehicle, its energy storage system, and energy management systems. In some instances, charging equipment will also communicate with the manufacturer, the vehicle, the operator, and potentially with other infrastructure.

A final design for the vehicle storage, parking and charging area should be completed and designed with input from the vehicle manufacturer and (if possible) manufacturers or installers of solar PV power generation and energy handling or storage assets. A collaborative effort and integrated design is encouraged.

A 200 kW solar array, as referenced above as an example, would not provide sufficient energy to operate the full fleet on renewable power generated on-site alone, and a future system should be comprehensively planned for, once more variables are known. A 200 kW system could be a good starting point to power initial BEB purchases, but would also require robust analysis and design work in cooperation with multiple stakeholders for successful integration. A future system could incorporate a modular design, with the ability to expand and provide additional solar power generation and energy storage as the fleet continues to “roll over”, and more BEBs are purchased. In all instances the solar system, charging of the buses, and integration of any on-site energy storage should be coordinated transparently with relevant stakeholder input. Management of bus charging, and management of on-site power generation and storage, will require systems that interface with each-other and share an overarching control methodology that should be optimized to address the Trust’s goals for the system.

Of potential interest, the U.S. Department of Energy (DOE) has issued guidance for Federal properties considering on-site solar power generation and energy storage systems, in which they note:

“The primary purpose of the PV plus storage system dictates the system design, configuration, and cost. For instance, a battery intended to provide resilience may be required to maintain a minimum state of charge at any given time, limiting the ability to also provide other economic benefits. If the primary purpose is to aid in utility bill management, islanding capabilities may be unnecessary and the battery can be optimally sized and dispatched for cost savings.”¹⁹

In other words, once the Trust has established ideal bus-replacement platforms for both their ATP and Downtown service, the Trust should work with vehicle manufacturers to establish utility-power requirements, optimal utilization and charging schedules, and should work with vehicle OEMs,

¹⁹ U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, “Considerations for Implementing PV plus Storage Systems at Federal Buildings and Campuses.” Available online: https://www.energy.gov/sites/prod/files/2018/08/f55/pv_plus_storage.pdf.

developers, and solar system providers along with technical analysts to develop multiple designs for consideration. The Trust should also consider the role of an ESS, including at the bus charging location and for broader infrastructure resilience. The ESS at the bus storage area will provide maximum cost-benefit if designed to minimize utility costs; and additional or complementary approaches could help aid in resiliency. For example, a CNG-fueled on-site back-up generator could provide resiliency benefits while leveraging residual CNG infrastructure, particularly as CNG will be required for partial fleet operations for many years to come. Such a system could provide power to charge the ESS or the buses directly during periods of utility power backup, or if the energy saved in the ESS has been depleted.

Broader infrastructure considerations

Once land redevelopment design at Fort Scott is complete, after gaining experience piloting a BEB shuttle bus and selecting a heavy-duty transit bus platform, and after building out on-site vehicle storage and charging infrastructure, the Trust can begin to consider the potential long term and non-service related benefits associated with owning a BEB fleet. Large BEBs are significant power consumers, but they are also potential resources. They are in essence, large mobile batteries that could serve as back-up power units to power infrastructure and buildings during times of power blackout or after natural disasters. None of these are current “off the shelf” capabilities of a BEB, but the potential for leveraging investment are up to the Trust and the bus platform selected. For example, the manufacturer may be interested in exploring strategies to minimize energy consumption through alternative uses of the vehicle and its power source or potentially re-purposing battery packs as vehicles age and their performance falls below a bus’s requirements (e.g., older batteries with reduced capacity are ideal candidates to be repurposed, such as utilizing them for back-up power applications).

The Trust can also enhance the sustainability and resilience benefits of a BEB fleet through installation of solar power generation wherever possible. Providing 100% renewable energy to power a future full-bus fleet would require additional solar capacity that would likely be unattainable given a relatively limited footprint for bus storage and operations at Fort Scott. Additional solar generation on local, non-historic rooftops could help pave the way toward powering the fleet with 100% renewable energy generated on-site within the Presidio.

Funding Opportunities

Volpe evaluated grant and other opportunities based on current fleet mix, future fleet projections, fuel type evaluation results, and the recommended transition strategy. Funding can be described as one-time or recurring and can be applied to capital or operating costs (or both). Further, funding programs can be uncertain and are subject to external factors that limit availability and reliability. The project team's research identified the opportunities listed below.

Funding Opportunities for Vehicle and Charging Infrastructure

Transportation Fund for Clean Air (TFCA) – Regional Fund

The Bay Area Air Quality Management District (BAAQMD) allocates a portion of vehicle registration fees to its Transportation Fund for Clean Air (TFCA) program to fund eligible projects. Sixty percent of TFCA funds are awarded directly to BAAQMD-sponsored projects and through the Regional Fund, which uses a competitive grant process. Eligibility is described in California Health and Safety Code (HSC) Section 44241; several mobile source and transportation control project types are authorized, including the local feeder bus/shuttle service provided by the Presidio Trust. Projects must meet a category-specific cost effectiveness threshold to be considered, and a local match is required.

The Presidio Trust currently receives \$100,000 in TFCA regional funds annually to support Downtown Shuttle route operations, and in the near term, the Trust is confident that it is well positioned to continue receiving funding based on the cost effectiveness of the project. Around-the-Park routes are not eligible for BAAQMD funding because the project must support residents or workers of multiple counties. BAAQMD has indicated that the cost effectiveness criterion, which depends on emissions reduced through shuttle service, will become more difficult to achieve in future cycles given the overall average reduced emissions of personal cars. However, the PresidiGo fleet will continue to reduce its overall emissions with the purchase of newer, cleaner vehicles, which will help to maintain a strong cost effectiveness result.

TFCA – County Program Manager Fund

The other forty percent of TFCA funds are allocated to county program managers of each of nine Bay Area counties within BAAQMD jurisdiction. The San Francisco County Transportation Authority (SFCTA) is the county program manager for San Francisco County. SFCTA must follow HSC Section 44241 to determine eligibility, and program policies largely follow the Regional Fund, including a mandatory cost effectiveness evaluation; however, SFCTA has local priorities (determined by the Transportation Authority Board) that further influence the selection of projects. The top tier of declared priorities include bicycle and pedestrian facility improvements, transit priority projects, traffic calming projects,

and transportation demand management projects. Shuttle service is listed directly after these project types as the second priority.²⁰

The Trust does not currently receive County Program Manager funding through SFCTA's application process and has not been effective based on the calculated cost-effectiveness in the past. In 2018, SFCTA funded allocated \$764,243 to eight projects. None of these projects were transit systems, but four of them were for electric vehicle chargers. The Volpe project team provided the Trust with sample calculations for the cost effectiveness of a new CNG bus and a new BEB using the SFCTA's cost effectiveness spreadsheet, showing that both projects would improve the cost effectiveness compared to previous applications, but a BEB – with effectively zero tailpipe emissions – would be more competitive.

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

In 2009, the California Air Resources Board (CARB) and CALSTART launched HVIP to accelerate the transformation of California's fleet through the purchase of cleaner, more efficient trucks and buses. Eligibility is determined on a vehicle and vendor basis, which means that all PresidiGo routes, including Around-the-Park routes, are eligible. In January 2018, CARB added \$133.2 million in voucher funding, having previously funded all voucher requests, and added another \$5.4 million in April 2018. As of August 2018, \$79.2 million remains available. It is possible to co-fund with HVIP and the Carl Moyer Program (see below).

HVIP offers incentives for purchasing or leasing zero-emission and hybrid buses that have been approved based on the use of engines that meet the optional low-NOx engine standard in California. Vouchers are worth up to \$95,000 per vehicle, depending on vehicle technology. In addition, the Trust could receive additional voucher funding (up to \$15,000) based on operations in Disadvantaged Communities (which may apply only to vehicles used for the Downtown route), and the Trust's first three vouchers are eligible for up to \$10,000 in additional funding. To obtain funding, the Trust first must find an eligible dealer and vehicle to purchase through the HVIP website. Next, the dealer submits the voucher request and verifies that funds are available. Once the vehicle is delivered to the dealer, the Trust completes the purchase for the reduced amount and receives the vehicle, and the dealer completes the process with CARB.

On-Road Heavy-Duty Vehicles - Carl Moyer Program (CMP)

Now in its 20th year, the Carl Moyer Memorial Air Quality Standards Attainment Program is a state-funded program that seeks to reduce emissions by offering grants to replace existing heavy-duty vehicles and equipment. The California Air Resources Board (CARB) works with local air districts to

²⁰ See SFCTA's TFCA website: <https://www.sfcta.org/tfcacallforprojects-fy201819>; Fiscal Year 2018-19 TFCA Program Guidance: Fiscal Year 2018/19 Local Expenditure Criteria.

administer the program, and BAAQMD's share is approximately \$11 million for the application cycle that began in June 2018.

Eligibility is based on meeting minimum calculated emissions reduction and cost-effectiveness requirements under the current CMP Guidelines, and zero-emission projects are highly encouraged. The existing vehicle identified for replacement must have an engine model year of 2009 or older, although 2010 baseline engines may be considered case-by-case. Funding cannot be used for purchases that are already required by an existing regulation, local ordinance, or contract. Applications are accepted and evaluated on a first-come, first-served basis.

Grants of up to \$200,000 (or 95 percent of eligible costs) are available to replace the oldest PresidiGo buses with zero- and near zero-emissions vehicles. However, the cost-effectiveness calculation is based on existing vehicles, and PresidiGo's CNG fleet does not offer as much emissions reduction potential as diesel, for example.

The CMP allows funding for infrastructure projects that install fueling or energy infrastructure to fuel heavy-duty on-road vehicles, among others. Infrastructure projects are selected on a competitive basis, but there is not a specific cost-effectiveness threshold. Battery charging stations for heavy-duty vehicles, including new stations or conversion or expansion of existing charging stations, are called out as eligible projects. Eligible costs of infrastructure projects include costs of design and engineering, equipment (including non-grid power system), installation, and meters or data loggers. A vehicle project is not required to be submitted to be eligible for infrastructure funding.

To receive funding, applicants must provide at least two bids from qualified installers as part of their application, and applicants must also describe the process used to solicit and select the final bid. The Trust would also be required to demonstrate that they either own the land for the project or otherwise control it for the project duration.

Under CMP, replacement vehicles and equipment must be purchased, not leased. It is possible to co-fund with the HVIP, but per CMP guidelines, the Trust would have to apply to CMP (and complete the process) before placing an order or submitting a purchase order for HVIP. Given the possibly long lead time involved in preparing an application, receiving approval from BAAQMD, and fully executing the grant agreement with BAAQMD, the Trust may choose to pursue only HVIP funding for a near-term purchase. While this approach would preclude the Trust from co-funding with a CMP grant for near-term vehicles purchases, the Trust could pursue CMP and HVIP co-funding for long-term vehicle purchases.

Financing and Support for Renewable Energy Generation and Storage

Federal Energy Management Program – U.S. Department of Energy

The U.S. Department of Energy (DOE) provides technical assistance related to financing and contracting decisions for solar power generation and renewable energy storage projects for Federal agencies.²¹ The Federal Energy Management Program (FEMP) provides Federal agencies with expert assistance, guidance, and training to help them implement Energy Savings Performance Contract (ESPC) projects. ESPCs allow federal agencies to procure energy savings and facility improvements with no up-front capital costs or special appropriations from Congress. An ESPC is a partnership between an agency and an energy service company (ESCO). FEMP's activity in this area stems from the legislation that authorizes federal ESPCs, which also made FEMP the federal organization responsible for creating and providing services to enable all agencies to implement successful ESPC projects. FEMP is authorized by statute to establish appropriate procedures and methods for use by federal agencies with regard to the ESPC program. See 42 U.S.C. § 8287(b)(1)(A); 10 C.F.R. § 436.30(a).²²

The Trust purchases power from the Western Area Power Administration (WAPA), which works with the FEMP to help agencies meet renewable energy goals.²³ As such, the Trust may work with WAPA to explore available technical resources and financing options to support solar power generation and storage.

²¹U.S. Department of Energy, "Financing and Contracting Decisions for Solar Projects on Federal Sites": <https://www.energy.gov/eere/solar/financing-and-contracting-decisions-solar-projects-federal-sites>.

²² U.S. Department of Energy, "Energy Savings Performance Contracts for Federal Agencies": <https://www.energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies>.

²³ Western Area Power Administration, "Renewable Resources for Federal Agencies": <https://www.wapa.gov/Renewables/ForFederalAgencies/Pages/federal-agencies.aspx>.

Summary of Funding Opportunities

Table 7: Summary of Relevant Funding Opportunities

Funding Program	Funding Amount	Applicability to Presidio Trust Fleet	Eligibility Notes
TFCA – Regional Fund	\$100,000/year (current funding)	Currently funds Downtown Route operations.	Eligibility is determined by a cost-effectiveness ratio calculated by the BAAQMD.
TFCA – County Program Manager Funds	\$10,000/year	Could be used to fund Downtown Route operations, but PresidiGo has not been successful in pursuing funding in the past.	Eligibility is determined by a cost-effectiveness ratio calculated by the SFCTA.
HVIP	Up to \$95,000 per vehicle purchased.	Could fund purchase or lease of new battery-electric buses for the Downtown Route and Around-the-Park routes.	Eligibility is determined on a vehicle basis. (Motiv, currently only medium-duty BEB supplier, is eligible). The bus vendor submits a voucher request, which is applied to purchase. Can be combined with the CMP.
CMP	Up to \$200,000 per vehicle replacement or 95% of all costs	Could fund replacement of the Trust’s oldest vehicles (those with a model year of 2009 or older, with consideration of 2010 model year buses on a case-by-case basis. Can also fund charging infrastructure.	Eligibility is based on meeting minimum calculated emissions reduction and cost-effectiveness requirements under the current CMP Guidelines, and zero-emission projects are highly encouraged.
DOE Federal Energy Management Program (FEMP)	N/A; technical assistance and financing program to support solar projects	FEMP can provide technical assistance, guidance, and training to help the Trust finance solar energy development.	Technical assistance available to Federal agencies. The Trust’s energy provider, WAPA, works with FEMP.

Implementation Plan

Table 8 details a suggested implementation approach in a chronological fashion. Actual dates – such as completion of the Fort Scott redevelopment or the required timeframes for vehicle replacement – may vary based on external circumstances.

Table 8: Suggested Implementation Actions and Approximate Timeframe

Quarter & Year	Action	Notes	Estimated Cost
Q1, 2019	Integrate EV fleet needs into Fort Scott area redevelopment planning and design.	Refine cost estimate for solar PV canopy system (installed) with management systems and optional on-site energy-storage system (250kWh).	\$175,000
Q2, 2019	Procure one new battery-electric shuttle bus for piloting on ATP route(s).	Hometown Coach – The View with a Motiv Drivetrain – is the only currently available major domestic chassis with Qualified Vehicle Modifier (QVM) certified EV drivetrain in a medium-duty Class 6 ²⁴ platform. Lead time from initial order to delivery between 180-365 days.	\$400,000 (This price does not take into account rebates from HVIP or other funding sources listed above.)
Q4, 2019	Procure Motiv charging stations	Order at least 6-months in advance of vehicle delivery.	\$25,000
Q2, 2020	Install charging station	Installation to be at alternate location while redeveloping Ft. Scott area. May require modest pavement cutting / trenching, which is not included in the estimated cost.	\$5,000 - \$10,000 each (excludes trenching)
Q2, 2020	Receive new battery-electric shuttle bus & place into service	Manufacturer likely to offer on-site training upon delivery; drivers, maintenance staff, first responders, and anyone who might “touch” the vehicle should be trained on its operation and high-voltage safety procedures.	n/a
Q3, 2020	Select HD Transit Bus Platform and pursue contracting mechanisms	Identify most advantageous funding programs available. Older buses may have more funding available for replacement.	n/a

²⁴ United States Department of Transportation, Federal Highway Administration classifies commercial trucks platforms by Gross Vehicle Weight Rating (GVWR). Medium-duty trucks include both Class 5 vehicles with GVWR between 16,001-19,500 lbs., and Class 6 vehicles with GVWR between 19,501-26,000 lbs. More information available at: https://en.wikipedia.org/wiki/Truck_classification.

Quarter & Year	Action	Notes	Estimated Cost
Q1, 2021	Finalize design of bus storage / charging area including solar-shade canopy and potential on-site backup energy storage.	Charging needs and final full fleet power requirements / demands known based on HD bus platform selection, update power needs to size solar and ESS accordingly.	\$2,000,000 (rough construction cost, excludes site improvements and utility backbone)
Q2, 2021	Evaluate first year of pilot shuttle bus operations	Use lessons learned from pilot shuttle year to determine whether to transition the full shuttle bus fleet to BEBs, as well as any infrastructure or operational changes required.	n/a
Q2, 2022	Begin ordering new HD transit buses (2) – approximately 1-year from order to delivery.	Replace oldest buses first, e.g., #s 182 & 249. Cost estimate assumes marginal cost reductions in next 3 years. Pricing does not include grant-funding opportunities.	\$1.2M (\$600k ea.)
Q2, 2022	Order chargers for new HD buses	Chargers - ordered as needed with buses, or up-front if incentivized sufficiently or tied into Fort Scott Area. Hardware will require 6 months for delivery (Q1 2023).	\$30,000 each
Q4, 2022	Install chargers	Install on-site, facilitate training for Presidio Trust maintenance staff and operator maintenance staff. Ensure proper documentation and labeling of all HV wires and equipment.	n/a
Q2, 2023	Completion of Fort Scott Redevelopment	Date of completion may vary based on RFP, contracting, and construction timelines.	n/a
Q3, 2023	Receive two new battery-electric heavy-duty transit buses and place into service.	Manufacturer likely to offer on-site training upon delivery; drivers, maintenance staff, first responders, and anyone who might “touch” the vehicle should be trained on its operation and high-voltage safety procedures.	n/a
Q2, 2024	Order additional HD buses	Replace bus #s 201, 202, 203	\$1.8M (\$600k ea.)
Q2, 2024	Order additional chargers	(If ordering as-needed)	\$90,000 (\$30k ea.)
Q4, 2024	Install additional chargers	Install on-site. Ensure proper documentation and labeling of all HV wires and equipment.	n/a
Q2, 2025	Receive additional HD buses	n/a	n/a

Quarter & Year	Action	Notes	Estimated Cost
Q2, 2025	Begin ordering new shuttle buses as replacement required.	Hometown Coach or equivalent. *Pricing presumes significant cost reductions for battery packs.	\$300,000*

Beyond 2025, continue ordering new buses as needed. By this time, Volpe anticipates reductions in BEB costs as the technology matures. Considerations should also include build-out of potential on-site solar PV power generation capabilities, including rooftop installations on available non-historic structures that receive adequate sun exposure. The Trust should also prepare for an increased relationship between utility power demands, the BEB fleet’s charging needs, and any on-site renewable power generation. Deploy energy storage systems as on-site power generation capacity increases in order to harvest as much on-site renewable energy as possible for operating the transit service and local utility power needs.

Appendix A: Ongoing Battery Electric Bus Pilots

The following is a list of ongoing battery-electric bus (BEB) pilots, whose findings can help inform the Presidio Trust in future transition planning and vehicle selection.

SFMTA Battery Electric Bus Pilot Program (evaluation during 2019, report out 2020)

Evaluating Proterra, New Flyer and BYD battery-electric plug-in buses, over the course of one year of revenue service. Program targets include: greater than 21 miles-per-gallon diesel equivalent (MPGDE) energy efficiency, state of the art modular charging (providing for overhead mounted chargers to facilitate dense parking), and an advanced monitoring system to monitor driver behavior, route data, smart charging, and traditional ITCS/CAD-AVL functions. SFMTA is placing buses into service in 2019, with findings or determinations anticipated in 2020.

VTA BEB and Advanced Energy Management System (ongoing, no mentioned end date)

Santa Clara Valley Transportation Authority and Prospect Silicon Valley undertook a joint effort to pilot cutting-edge systems to manage charging and energy consumption (of buses) while reducing impact to the electrical grid. VTA hopes it will serve as a model for transit agencies looking to manage charging and utility loads for EV fleets. Next steps of the program include connecting an on-site energy storage system (battery) to existing solar installations. Program is ongoing and currently analyzing integration of on-site solar charging.

Link to presentation from August 2018 regarding both studies above:

https://www.spur.org/sites/default/files/events_pdfs/Miskell%20%2B%20Cox%20%2B%20Khatri%20Presentations.pdf

SFMTA program's goal is to identify an ideal BEB for San Francisco's unique characteristics, and SFMTA is a local partner with resources that can benefit the PresidiGo Transit fleet. The VTA pilot study will help inform strategies to minimize electrical utility loading while maximizing fleet charging efficiency.

Yuba-Sutter Transit Corridor Enhancement Plan (final document)

This plan documentation includes various scenarios of bus charging installations, including overhead canopies and solar. It explores the various infrastructure ramifications associated with different designs, and how solar canopies serve as mounting locations for charging infrastructures. The estimates for installation presented in Table 5-1 are relevant to the California market and are current as of December 2018, note: their bus fleet of 51 buses is approximately 5-times the size of the PresidiGo transit fleet and would involve four separate solar canopy structures.

<https://www.yubasuttertransit.com/files/93f21730c/Chapter+5-+Battery+Electric+Bus+Feasibility.pdf>

Department of Energy (DOE), National Renewable Energy Laboratory (NREL) evaluation programs:

- **Evaluation of Proterra Battery Electric (Fast-Charge) Buses at Foothill Transit (Second Report)**, available online at: https://www.afdc.energy.gov/uploads/publication/foothill_transit_beb_demo_results_2nd_rpt.pdf.
- **Evaluation Results of Proterra Battery Electric (Fast Charge) Buses at King County Metro**, available online at: <https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/115086/zero-emission-bus-evaluation-results-king-county-metro-battery-electric-buses-fta-report-no-0118.pdf>.
- **Center for Transportation and the Environment / FTA Evaluation Programs:** The Center for Transportation and the Environment (CTE) collaborates with the following ongoing/current programs, some using Federal funding for BEB deployments from the FTA's Low-No Grant Program. All programs are evaluating Proterra or New Flyer electric buses. Links to information on each program are available online:
 - AC Transit BEBs (and Fuel Cell Buses): <http://www.cte.tv/project/ac-transit-electric-bus-deployment/>
 - VIA Metro BEBs in San Antonio: <http://www.cte.tv/project/via-metro-battery-electric-bus-deployment/>
 - Madison, WI BEB Deployment: <http://www.cte.tv/project/madison-battery-electric-bus-deployment/>
 - Mountain Line BEBs in Missoula, MT: <http://www.cte.tv/project/mountain-line-electric-bus/>
 - Worcester, MA Clean Fuels Project: <http://www.cte.tv/project/worcester-clean-fuels-project/>, including evaluation of Proterra BEBs. The Sierra Club put together an exploration of cost benefit, available online: https://www.sierraclub.org/sites/www.sierraclub.org/files/sce-authors/u2387/MBTA%20Bus%20Cost%20Analysis_26%20Oct%202017.pdf.

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