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EXECUTIVE SUMMARY
The Vineyard Transit Authority (VTA) operates a successful transit service that has grown significantly over the past ten years. Alternative fuel and alternative fuel vehicles present an opportunity for VTA to operate cleaner, quieter vehicles; reduce VTA’s consumption of fossil fuels and greenhouse gas emissions; and potentially lower operating costs. There are, however, potential challenges associated with switching vehicles and fuel types including investment costs and the ability of alternative fuel vehicles to work within VTA’s operational practices. This analysis examines the opportunities and constraints associated with different alternative fuel technologies and recommends an alternative fuel investment strategy for VTA.

VTA Operational Needs
VTA established a set of operating practices that support the agency as it responds to both the local operating environment and the transportation needs of residents and visitors on Martha’s Vineyard. VTA’s operating practices mean the agency has clear expectations for transit vehicles:

- **Ability to operate for up to 300 miles per day on a single fueling** – VTA’s vehicles stay in service for the entire day and travel starting at 200 and up to 400 miles per day.

- **Offer seating and standing capacity for 70 passengers** – Ridership data and anecdotal evidence suggests that passenger volumes on VTA routes during peak periods can be extremely high, with many routes carrying standing room only loads.

- **Ability to accelerate into traffic with full passenger loads** – VTA operates as “flag stop” service that allows passengers to hail the bus at any safe location. As a result, VTA vehicles need sufficient torque and acceleration to be able to pull in and out of traffic, often with full passenger loads.

- **Options for narrow vehicle body width capable of navigating narrow streets and turns** – VTA buses operates in a combination of rural roads with limited shoulder space and very narrow village streets, many of which allow two-way traffic, including two-way bus traffic. Given these operating constraints, VTA prefers narrow buses that are 96” wide (or less).

- **Ability to operate efficiently in congested corridors** – Martha’s Vineyard’s road network is frequently congested during the summer. Vehicles must be able to operate in traffic, including stop and go conditions. Ideally buses operate quietly and with minimal emissions in these areas.

- **Operate at relatively low operating speeds overall** – There are no high speed roadways on Martha’s Vineyard, so VTA’s operating speeds overall are relatively low. This creates maintenance issues because newer diesel engines are most effectively cleaned when the engine operates a high speeds.

- **Need for infrastructure that is sensitive to community character** - Martha’s Vineyard prides itself on its natural beauty and historic communities. This emphasis on community aesthetics and character may limit development of additional fuel supply equipment.

Conventional and Alternative Fuels
As part of this project, the study team examined four alternative fuel systems and technologies (biodiesel, electric, natural gas, and propane) plus diesel fuel and hybrid-electric diesel fuel systems. VTA currently uses ultra-low sulfur diesel (ULSD) (also known as clean diesel) fuel in its daily operations. ULSD is a fuel blend mandated by the U.S. Environmental Protection Agency (EPA) and is significantly cleaner than earlier diesel fuels. After transitioning to ULSD, the primary way for VTA to reduce emissions further is to consider alternative fuel or hybrid-electric vehicles. Each alternative fuel and alternative fuel vehicle offers VTA different strengths and weaknesses, with none of the alternatives offering a significant advantage in all of the categories evaluated. Key points from the analysis include:
Alternative Fuels Assessment and Feasibility Study
Vineyard Transit Authority

- Alternative fuel vehicles have fewer greenhouse gas (GHG) emissions and typically are cleaner and quieter as compared with diesel.

- Historically, alternative fuels have been less expensive as compared with diesel, but this is not true in 2016, given historically low diesel prices. Alternative fuels, however, do offer more stable fuel prices and are more widely available domestically. Lower fuel costs tend to offset minor differences in lower fuel economy as compared with diesel.

- Alternative fuel vehicles tend to be more expensive to purchase. Natural gas and electric vehicles are roughly 20% to 55% more expensive as compared with diesel vehicles, while diesel-electric hybrid are about 40% more expensive.

- Since VTA does not currently have the fueling infrastructure for natural gas, propane, or electric vehicles, investments would needed.

- Significant building upgrades in VTA’s maintenance facilities would be required to accommodate natural gas vehicles, CNG or LNG. These are safety upgrades required to maintain vehicles operating with gaseous and liquid fuels.

**Market Trends for Alternative Fuels**

Our research included an analysis of the market for transit vehicles and fuels in the United States. We examined the overall fleet, looked at the experience in California and reviewed vehicle manufacturing. This data shows:

- **Diesel is still the most popular fuel in the transit industry** - Diesel engines account for about 56% of all U.S. transit buses.

- **The all-electric market is growing** – Electric transit vehicles are starting to have an impact on transit vehicle sales and the number of electric vehicles used in transit operations is growing. The largest North American transit vehicle manufacturers as well as several new manufacturers are investing in all-electric transit technology. There are more than five manufacturers producing electric transit vehicles; combined they offer more than 10 vehicle types.

- **Continued relevance of natural gas vehicles** – Natural gas vehicles are continuing to increase their market share (albeit from a larger base as compared with electric vehicles). The existing major vehicle manufacturers in North America (New Flyer, Gillig and Nova Bus) have natural gas options for most or all of their vehicles. Engine manufacturers are also working to ensure natural gas vehicles can meet California’s zero emissions at the tailpipe.

- **Electric Vehicle Charging Systems** – there are two predominant types of systems emerging to charge transit vehicles: shorter-range vehicles that use on-route fast charging systems to stay in operations; and longer-range vehicles that can stay in service for longer distances but are not designed for fast charging. Longer-range vehicles are starting to experiment with on-route charging, but use wireless or inductive connections with electrical sources to maintain the battery state of charge. Both systems have advantages and disadvantages. Inductive charging systems are being tested in Lancaster, CA (Antelope Valley Transit Authority) and Wenatchee Washington (Link Transit).

- **Charging System Compatibility** - a challenge with both types of charging systems is compatibility. Currently, charging transit systems are proprietary to the manufacturer (i.e. Proterra charging equipment can’t be used to charge a BYD bus). Given the high cost associated with charging equipment, especially fast and inductive charging, being tied to a single vehicle manufacturer is a problem for many transit agencies. The American Public Transportation Association (APTA) has begun to address this issue. As of June, 2016, however, electric vehicle charging systems continue to be proprietary.
• **Fuel Prices** – another consideration is the price of fuel. It is difficult to anticipate the future price of any good or service, but fuel prices are particularly challenging. The price of diesel, biodiesel and propane has fluctuated tremendously in the past 15 years, while CNG and electricity has been more stable. The price of electricity has consistently been stable and low. There has also been a lot of investment in diversifying ways to produce and generate electricity, which suggest continued stability over the longer term.

**Recommended Investment Scenario**

Our analysis of VTA’s service needs as well as the strengths and weaknesses of fuel and vehicle types suggests that no single strategy meets all of VTA’s need. Instead, each alternative fuel and vehicle technology has unique advantages and disadvantages that balance in different ways. VTA’s primary motivations for pursuing alternative fuel options include:

• VTA will be replacing 22 vehicles, roughly 70% of its fleet over the next five years. Buses have a useful life of between 10 and 12 years, so VTA wants to be sure its investment strategy reflects the most appropriate and effective technology possible.

• An important part of VTA’s mission is ensuring investment decisions are an effective use of taxpayer resources.

• Diesel vehicles have historically worked well for VTA and the fuel continues to be appropriate for much of its service. However, recent fuel blends and exhaust treatments have made the vehicles more difficult to maintain.

• VTA, as a transportation provider, is an important part of ensuring a robust, sustainable future for Martha’s Vineyard. Its services reduce the need for single occupancy vehicle travel. Operating alternative fuel vehicles strengthen this mission by reducing vehicle emissions associated with local air pollution, greenhouse gases/climate change pollutants and by reducing consumption of fossil fuels.

With these goals in mind, VEIC identified a four step plan for how VTA could replace transit vehicles reaching their useful life at the same it continues to diversify its fuel options. This implementation plan calls for the purchase of 22 vehicles by 2020 and making an investment of roughly $11 million, including:

1. **Continue investment in clean diesel technology and vehicles.** In the short-term, VTA could continue to invest in new clean diesel technology and vehicles, while experimenting with an electric bus pilot project. Removing sulfur from diesel fuel, equipping vehicles with diesel exhaust equipment and maintaining these systems greatly reduces vehicle emissions. A portion of VTA’s fleet is already equipped with these systems and despite some challenges with vehicle maintenance, the systems works. With minimal investment or change in operating practices, VTA can expand implementation of these technologies as it purchases new vehicles. This approach includes the purchase of 15 30’ diesel buses costing roughly $6.2 million over five years. The cost estimate assumes VTA will buy 30’ New Flyer MiDi buses (estimated cost $413,000 each) and the cost of individual buses will not increase over time. While this approach does not embrace new systems or technologies, from a vehicle emissions perspective it is a reasonable, realistic course of action.

2. **Conduct electric bus pilot project.** In the next year or two, VTA should initiate an electric bus pilot project to gain experience with the electric buses and understand the opportunities and challenges associated with integrating them into VTA operations. Electric vehicles are both more efficient (better fuel economy) and have lower fuel prices. Operating costs savings can offset the cost of the vehicle and infrastructure investments. VEIC estimates a pilot project would require two years; roughly nine months to get a bus on-site (assumes three months for procurement and six months for production); plus another 12 to 18 months to evaluate operations and
maintenance over changes in climate and operating schedules. The last three months of this cycle can be used to evaluate the experience with the electric bus.

VEIC conservatively estimates the cost of an electric vehicle pilot project at roughly $500,000, including $450,000 for the vehicle plus about $50,000 for installing charging equipment at VTA’s facility, purchasing and installing a backup charging equipment at the Tisbury Park and Ride lot, and small amounts of funding for marketing. This is roughly $90,000 more than the cost of a similarly sized clean diesel vehicle. But fuel costs savings over the 12 year life cycle of the vehicle are estimated at $84,000.

3. Depending on results of pilot, expand electric vehicle fleet - VTA could operate the electric bus pilot for 12 – 18 months, tracking both the qualitative and quantitative aspects of the vehicles. If appropriate, VTA may make a bigger investment into electric bus technologies. The cost to increase VTA’s electric bus fleet from one vehicle to seven (adding six vehicles) is estimated at $3.7 million1. This estimate includes:

- $2.7 million to purchase six electric buses, assuming the 2016 price of $450,000 per vehicle
- Between $500,000 and $1 million to install wireless (inductive) on-route charging infrastructure at key locations in VTA’s service network. With seven vehicles, it is likely VTA would only need one on-route charger, but this depends on VTA’s operational plans (VEIC’s overall budget assumes two systems are installed). Inductive charging system costs are estimated at roughly $500,000 per site, inclusive of the cost to purchase ($350,000) and install ($150,0002) the equipment.
- $100,000 to upgrade the electrical infrastructure at VTA’s facility and to develop an electric bus charging station in the parking lot. These may be reduced slightly from investments made during the pilot phase.

4. Initiate partnership to develop renewable natural gas locally on Martha’s Vineyard. Start talking with Island stakeholders to broadly assess interest in renewable natural gas.

Natural gas offers a potential investment for VTA because it can be easily be integrated into VTA’s existing operations. It also creates an opportunity for VTA to transition its entire (fixed route and paratransit) fleet to an alternative fuel source, an option not available with any other fuel choice. However, the impacts of having to upgrade the maintenance facility and relying on a virtual pipeline to fuel vehicles makes the ongoing operating costs too high to achieve a positive return on investment.

Natural gas may be feasible as a fuel source if it were produced locally as a renewable resource. This could be achieved as part of a longer-term partnership between VTA and the towns on Martha Vineyard. Natural gas (biogas) can be produced through the waste water treatment process. Initial investment costs are high (up to $1 million per site) and it is unclear if Martha’s Vineyard could produce sufficient amounts of natural gas, but the environmental benefits for both VTA and the local communities are significant. Wastewater treatment plants could generate natural gas, sell it to VTA and generate revenue to support operations. VTA could burn locally produced, clean burning, renewable fuel. However, VTA would almost certainly need a supplemental or backup source of fuel to maintain operations and VTA would need fuel prices to be within market rates. Federal grants to offset part of the infrastructure investment are likely required to make this project feasible.

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1 As a comparison, six diesel bus would cost $2.5 million, roughly $1.2 million less than the investment required for electric buses.

2 Installation costs will vary but assume some cable work will be required. It is possible that VTA may be able to select locations for inductive charging based on installation costs.
1.0 INTRODUCTION
The Vineyard Transit Authority (VTA) provides a combination of fixed-route and demand response public transportation services on Martha’s Vineyard, an island community of six towns located just south of Cape Cod, Massachusetts. For much of the year, Martha’s Vineyard has a population of less than 20,000; during the summer months, the island’s population increases dramatically with as many 100,000 people on the island, including summer residents and tourists. VTA matches service levels to meet these demands. The agency operates service year-round, but increases service significantly during the summer months. This service model has proven to be successful; VTA’s ridership grew by 69% over the past ten years, and 18% over the past five years.

VTA currently maintains a fleet of 38 vehicles, 32 of which are used in fixed-route service and six of which support demand response operations. Between 2016 and 2020, VTA is scheduled to replace 26 of these vehicles, including half of the vehicles used in demand response service and nearly 70% of the vehicles used in fixed-route service. Anticipating this replacement schedule, VTA contracted with a team of consultants led by the Vermont Energy Investment Corporation (VEIC) to assess the potential of transitioning part or all of the fleet to vehicles powered by something other than traditional diesel including alternative fuels and diesel electric hybrid buses.

Alternative fuel and alternative fuel vehicles present an opportunity for VTA to operate cleaner, quieter vehicles, and to reduce VTA’s consumption of fossil fuels and greenhouse gas emissions. They may also improve VTA’s overall fuel economy, lower operating costs, and reduce vehicle maintenance costs. There are, however, potential challenges associated with switching vehicles and fuel types including concerns about the ability of the vehicles to meet the operating conditions on Martha’s Vineyard and to work within VTA’s operational practices, especially during the peak periods.

Report Organization
Not including this introductory chapter, the final report is comprised of an executive summary, four technical chapters, and three appendices.

- Chapter 2: VTA Service Profile, contains an overview of VTA’s service and requirements for alternative fuels.
- Chapter 3: Alternative Fuels and Alternative Fuel Vehicles provides an overview of the fuels and vehicles evaluated and highlights some of their key characteristics.
- Chapter 4: Preliminary Recommendations, considers market trends in the transit industry and develops a potential investment strategy for VTA.
- Chapter 5: Implementation lays out an implementation plan for realizing the investment strategy.

The report also contains three appendices; Appendix A provides a detailed introduction to each of the alternative fuels and alternative fuel vehicles under consideration. Appendix B highlights bulk transportation shipping requirements. Appendix C contains additional information on funding sources available to support VTA’s investment in alternative fuels and alternative fuel vehicles.
2.0 VTA Service Profile

Background

Martha’s Vineyard is an island in the Commonwealth of Massachusetts, located seven miles off of Woods Hole, just south of Cape Cod. It is accessible from the mainland via ferry and air services. The island has a land area of about 100 square miles and consists of six towns: Aquinnah, Chilmark, Edgartown, Oak Bluffs, Tisbury and West Tisbury. Martha’s Vineyard is unique because of the size of its summertime community. Although the year-round population has grown considerably over the past few years, the summertime population increases to nearly five times the number of people on the island during the off-peak seasons. The agency operates service year-round, but increases service significantly during the summer months. This service model has proven to be successful; VTA’s ridership grew by 69% over the past ten years, and 18% over the past five years.

VTA’s service is available year-round, seven days a week and operates on most parts of the island (see Figure 1). The only days buses don’t run are Thanksgiving Day and Christmas Day. In addition, VTA operates complementary paratransit service in accordance with the Americans with Disability Act (ADA). Branded as “the Lift”, the service operates in parallel with the fixed-route service and is available year-round, seven days a week, with service hours and availability fluctuating with the fixed-route service.

Figure 1: Vineyard Transit Authority – Fixed-Route Transit Network

Source: Martha's Vineyard Commission
Service Overview

VTA operates 12 year-round routes, plus two routes that are available during the summer peak season. The individual transit routes are organized into a hub and spoke system around four hubs. The hubs are located in the Vineyard’s largest communities (Vineyard Haven, Oak Bluffs, Edgartown and West Tisbury). With one exception (Route 12), all VTA routes serve at least one hub. Connecting to and between hubs allows passengers to transfer between routes and increases accessibility to the island’s major services and destinations. VTA also interlines buses on Routes 3, 5 and 6 to offer one-seat rides between Vineyard Haven, Aquinnah and Edgartown. During some parts of the year, Routes 11 and 8 are also interlined to provide a one-seat ride from the park and ride lot outside of Edgartown to South Beach.

One of the unique aspects of VTA’s service is that it has peak periods related to the season, but not the time of day. Many transit agencies organize service around peak periods on weekdays, usually related to traditional commute times. For these agencies, the majority of agency vehicles and drivers are in service during weekdays and commute times. In comparison, VTA has a flatter daily operating cycle, with most buses in service for most of the day and limited variation between week day and weekend day service. On the other hand, VTA has seasonal peaks, when the majority of the fleet is in service for long days. This operating system has advantages and disadvantages. One advantage is that during the off-peak season the maintenance team can take vehicles out of service and work on them for longer periods of time. The disadvantage is that the peak season is demanding on the fleet, vehicles are in service daily and for long periods of time.

The seasonal differences between VTA’s peak, shoulder (transitional period between peak and off-peak) and off-peak service are significant. Of the 1.1 million service miles operated annually, nearly 33% are operated during the 79 days of the peak season, between June 20 and September 7. Ridership is even more oriented towards the summer months, with just over 60% of VTA’s annual riders using VTA services during the peak season. Additional differences between peak, shoulder and off-peak service are the frequency and span of service (see Figure 2 for peak season service overview).

Fixed-Route Service

VTA fixed-route services operate as scheduled services, with most trips on most routes departing every 30 minutes. A handful of routes offer hourly service. Two of the highest ridership routes – Route 1 and Route 13, as well as Route 11 operate as headway based service during middle of the day in the peak season. This means that the buses depart every 15-20 minutes but do not necessarily adhere to a scheduled or published time. In the off-peak season, the highest ridership routes operate 30 minute service and a larger portion of the routes have an hourly schedule. No routes operate with a headway schedule.

All of VTA’s routes have several scheduled stops and time points, included in the schedule and map. With the exception of Route 1 in Edgartown, VTA passengers are also allowed to flag or hail the bus to stop at any safe location along the route. The hail and ride system makes the service more accessible, especially in the rural parts of the island, where bus stops are not easily located.
Within VTA’s service network, there are different types of routes, which have different operating characteristics. Generally speaking, however, VTA routes can broadly be broken down into two types: shuttle-type services that travel shorter distances and operate with higher frequencies; and longer distance routes that provide connections between the individual communities; employment and service centers; and tourist destinations. There are four routes that operate as shuttle type services (note all estimates for daily ridership, revenue miles and revenue hours are for the peak season):

- **Route 8: South Beach Route** – operates year round between downtown Edgartown and South Beach. The route is about nine miles round trip and takes about 25 minutes to complete. Buses assigned to Route 8 operate for 15 hours and travel about 240 miles each day.

- **Route 10: Tisbury Park and Ride** – travels between a park and ride lot outside of Vineyard Haven and the Steamship Authority Terminal in the center of Vineyard Haven. The route is roughly 3 miles round trip and has scheduled travel time of 15 minutes, allowing time for congestion on State Road. Buses travel about 135 miles a day and are in service roughly 17 hours.

- **Route 10A: West Chop Loop** – travels from downtown Vineyard Haven to the West Chop Lighthouse. The trip is roughly five miles (round trip) and takes about 15 minutes to complete. During the peak season, Route 10A will travel 150 miles each day and be in service for nearly 13 hours.

- **Route 11: Downtown Edgartown** – operates during the summertime only and travels from the Upper Main Street Park and Ride lot to downtown Edgartown. The service is designed to alleviate parking demand in downtown Edgartown. The route is about a half-mile (one-way) and has a scheduled travel time of about six minutes. Buses travel between 110 and 160 miles each day during the peak season and are in service for nearly 17 hours.
The remaining eight routes travel longer distances and primarily provide connections between Island towns and the Island’s main tourist attractions. Longer distance routes include:

- **Route 1: Vineyard Haven to Edgartown** – travels directly between the Steamship Authority Terminal in Vineyard Haven and downtown Edgartown along the Edgartown-Vineyard Haven Road. Route 1 is VTA’s highest ridership route and carries nearly 1,900 people per day during the peak. During the peak season, multiple buses are assigned to the route, with each bus traveling up to 250 miles a day and operating for 20 hours.

- **Route 2: West Tisbury to Vineyard Haven** – is a loop route that travels between the Steamship Authority Terminal in downtown Vineyard Haven and West Tisbury, traveling via the Lambert’s Cove Road Street and Old Colony Road. The trip is roughly 20 miles (round trip) and takes about 30 minutes to complete. During the summer, the bus travels about 170 miles a day and operates for nearly 12 hours.

- **Route 3: West Tisbury to Vineyard Haven** – like Route 2, Route 3 is a loop route. It travels between the Steamship Authority Terminal in downtown Vineyard Haven and West Tisbury but uses a combination of Old Colony Road and State Road. The route is roughly 14.5 miles (round trip) and takes about a half an hour to complete. Route 3 is interlined with Route 6, so Route 3 buses continue on to Edgartown. A bus assigned to Routes 3 and 6 during the summer are on the road for between 17 and 18 hours a day and travel nearly 300 miles.

- **Route 4: West Tisbury to Chilmark and Menemsha** – travels between West Tisbury and Chilmark serving the Town Parking Lot in Chilmark, the Chilmark Community Center and Menemsha Bay. Route 4 is 10 miles one-way and takes about 26 minutes to complete. During the summer months, Route 4 operates for nearly 17 hours and travels about 315 miles a day.

- **Route 5: West Tisbury to Chilmark and Aquinnah** – connects the West Tisbury Chilmark Community Center and Aquinnah and the Gay Head Lighthouse. The route is roughly 12 miles one-way and takes 24 minutes to complete. Route 5 is among VTA’s highest mileage routes, with 430 daily revenue miles. VTA reports that during summer months, they often swap out this vehicle as part of providing supplemental service (Route 5X). The route operates an 18 hour day during the peak.

- **Route 6: Edgartown to Airport to West Tisbury** – travels between downtown Edgartown (Church Street) and West Tisbury with a stop at the Airport. The route is 19 miles round trip. As mentioned, Route 6 is interlined with Route 3, so that buses arriving at West Tisbury continue on to Vineyard Haven. This means the bus is on the road for between 17 and 18 hours and travels nearly 300 miles on a summer peak day.

- **Route 7: Oak Bluffs to Airport** – is a loop route that travels between Oak Bluffs and the Airport via County and Barnes Roads. It is paired with Route 9 and travels the same route in an opposite direction outside of routing through the center of Oak Bluffs. Buses assigned to Route 7/9 travel nearly 300 miles during the peak season and are on the road between 17 and 18 hours a day.

- **Route 8: Oak Bluffs to Hospital to Airport** – is a loop route that travels between Oak Bluffs and the Airport via County and Barnes Roads. It is paired with Route 7 and travels the same route in an opposite direction outside of the routing through the center of Oak Bluffs. As mentioned, a bus assigned to Route 7/9 travels 300 miles and is on the road for nearly 18 hours each day during the summer.

- **Route 12: Chilmark In-Town Route and Sunset Bus** – includes two separate pieces; an in-town loop through Chilmark (10 miles) and a Sunset Bus that connects the Chilmark Community Center and Menemsha Beach. Route 12 operates during the summer peak only. Buses are on the road for about 200 miles and 10 hours.
• **Route 13: Edgartown to Oak Bluffs to Vineyard Haven** – connects Edgartown and the Steamship Authority Terminal in Vineyard Haven traveling via Oak Bluffs along Beach Road. Route 13 is one of VTA’s highest ridership routes. VTA assigns at least seven buses to the route during the peak period. It operates nearly 21 hours a day during the summer and each bus travels between 200 and 250 miles each day.

**Ridership**

VTA’s ridership has grown consistently over the past ten years; ridership grew from roughly 750,000 riders in Fiscal Year 2005 (FY05), to 1.1 million riders in FY10 to 1.3 million riders in FY15, an increase of 69% over the ten year period and 18% over the past five years. As discussed, ridership is also heavily skewed towards the peak season in the summer months. Roughly 60% of all trips on VTA services are taken during the summer months (see Figure 3).

![Figure 3: VTA Annual and Seasonal Ridership (Fiscal year 2011 – 2015)](image)

Source: VEIC based on data provided by VTA

VTA’s ridership is also characterized by significant variation between routes. In particular, two routes, Route 1 and Route 13, carry high volumes of riders. VTA Route 1 connects Vineyard Haven and Edgartown traveling via an inland route. It carries nearly 2,000 riders per day during the peak season, or roughly 20 passengers per hour (on average). Route 13 connects Vineyard Haven, Oak Bluffs and Edgartown, traveling along Beach Road. This route carries nearly 5,000 riders per day, more than double Route 1 and ten times more than most other VTA routes. Peak ridership averages to 61 riders per hour.

Ridership data is available as aggregated daily and hourly totals (see Figure 4), so it is difficult to accurately measure actual ridership on the most crowded times and days. Routes with extremely high average daily ridership and/or high average ridership per trip are likely very crowded during high ridership times. Route 13 Edgartown to Vineyard Haven, for example, carries an average of 60 riders per hour during the peak months. Normal fluctuations of ridership during the day, suggest that during peak times of the day, ridership is likely significantly higher. Anecdotal information confirms this; staff and drivers report that many trips operate at capacity during peak times with standing room only. In some cases, staff reported that passengers must wait for a second bus to get on.

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3 Calculated using the highest value recorded in either July or August in FY15
Management and Operations

VTA, like all regional transportation authorities in Massachusetts, contracts with a private transportation provider for the operation of public transportation services. VTA staff includes the management and vehicle maintenance teams. This team manages VTA’s contract with Transit Connection (TCI), a private operator who has held the contract with VTA for several years. TCI employs drivers, dispatch staff and a management team to operate VTA’s transit service. During the off-peak season, TCI employs about 50 people to cover 35 full time equivalent (FTE) positions. In the summer, the number of drivers increases to roughly 100 individuals, who fill 70 FTEs. About half of the summer hires are return drivers and the other half are drivers that are new each year.

VTA has a maintenance team that includes a service coordinator, a shop foreman/technician and two technicians. The maintenance facility is open from 6:00 am to 6:00 pm during the peak season and from 6:00 am to 5:00 pm during the off-peak. The team services all VTA vehicles as well as the Martha’s Vineyard School District buses. This arrangement largely works because school buses are in service and need maintenance during VTA’s off-peak season.

VTA’s current operating practices involve sending a bus out in the morning and keeping the vehicle in service for the entire day. Driver breaks and changes in assignments are completed with staff driving to the route. In the peak season, some buses travel as far as 350 miles in a single day. Other buses cover less distance, but still log over 150 miles a day. Buses are fueled and cleaned once during the day. In the winter time, drivers are responsible for fueling the buses and maintenance staff runs the buses through the washer. In the summer, a nightshift worker fuels and cleans the vehicles.

Vehicle Storage, Fueling and Fueling Infrastructure

VTA’s vehicles are maintained and stored at the agency headquarters in the Airport Business Park at 11 A Street, Edgartown. There is one building on site that houses VTA and contractor offices. The building is connected to a maintenance facility that includes four repair bays, a wash bay, and storage space for tires and parts. The site also includes fuel storage tanks and fuel pumps as well as parking for VTA buses, vans and vehicles. All VTA vehicles are stored outside.

VTA vehicles currently operate with diesel fuel and unleaded gasoline. All fixed-route vehicles run on diesel fuel while demand response vans use unleaded gasoline. There are no fuel pipelines between the mainland and Martha’s Vineyard; instead, fuel is shipped via barge from New Bedford, Massachusetts.
VTA, as a public agency, does not pay federal or state taxes on fuel. VTA’s fuel rates are based on the published wholesale “rack” rate, plus an operations fee to cover transportation, operations and profit. In January 2016, the operations fee added $0.2485 per gallon of diesel and $0.355 per gallon of unleaded gasoline. In the winter 2016, these prices translate to $1.42 for a gallon of diesel and $1.71 for a gallon of unleaded gasoline, inclusive of fuel and transportation costs. VTA fixed these prices through FY 2016.

VTA has two fuel tanks on its property, plus a tank for diesel exhaust fluid (DEF), which are dispensed through three fueling pumps. DEF is available at one pump only. The diesel tank holds 8,000 gallons (usable space is about 7,200 gallons) and the unleaded tank has capacity for 2,500 gallons. The DEF tank holds 1,000 gallons of fluid. In Fiscal Year (FY 2015), VTA purchased 158,454 gallons of diesel and spent roughly $225,000 on diesel fuel.

Funding, Management and Vehicle Replacement
Transit agencies in the United States are funded through a combination of federal, state and local resources. Federal grants administered by the Federal Transit Administration (FTA) are available to help fund capital purchases, such as vehicles. Generally speaking, in Massachusetts regional transit authorities purchase vehicles using a combination of FTA, state and local funds. Typically (but not always), Massachusetts RTA’s use FTA grants to cover 80% of the cost of a vehicle and state resources account for the remaining 20%.

The FTA sets rules for how its funds can be used for vehicle purchases. These rules govern how many vehicles a transit agency can purchase and how long a vehicle must be used in service before it is replaced. Buses purchased with FTA resources must also participate in a federal testing program that examines a variety of structural and operational components of the vehicle. The three main rules governing the use of FTA funds include:

1. Vehicle purchases are governed by a **spare ratio**, or the number of vehicles a transit agency can own/operate in relation to the amount of service it provides. The FTA allows a spare ratio of 20% relative to the number of vehicles in service during peak times. For example, if a transit agency has 100 vehicles in service during peak periods, they can use FTA funds to purchase up to 120 vehicles. Most transit agencies have a daily peak that reflects increased service levels during commuter times. VTA, as discussed, has a seasonal peak, but no daily peaks. This also means peak periods for VTA are more intense because vehicles used in peak are in service all day and in many cases, seven days per week.

2. Vehicle replacement plans are governed by a **vehicle’s useful life**, or how long the vehicle must be in service before FTA funds can be used to replace it. A vehicle’s useful life is set by the FTA and varies by vehicle type. It is measured by the vehicle’s age and number of miles driven and is intended to reflect the age (or mileage) when a bus should be retired because the cost to maintain the vehicle is no longer cost effective. For a heavy duty transit bus, the useful life is typically 12 years and 500,000 miles. A medium duty vehicle has a useful life of 7 years and between 250,000 and 350,000 miles.

3. Buses purchased with FTA funds must also be tested and certified by the federal bus testing laboratory according to the **FTA New Model Bus Testing Program**. This program is often referred to as the “Altoona Test” because the testing facility is located in Altoona, Pennsylvania. The testing program examines new transit bus models for safety, structural integrity and durability, reliability, performance, maintainability, noise and fuel economy. Additional testing procedures for emissions and breaking are under development. Test results for a particular bus

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4 Diesel Exhaust Fluid is a non-hazardous solution (32.5% urea and 67.5% de-ionized water) that is sprayed into the exhaust stream of a diesel vehicle to break down NOx emissions into nitrogen and water.
model are compiled in a report; an FTA grantee must certify that it has received a copy of the test report prior to final acceptance of the first vehicle⁵.

**VTA Vehicle Fleet**

VTA operates with a fleet of 38 vehicles, including 32 larger transit vehicles that range from at least 29' up to 40' in length. These buses are used in VTA fixed-route service operations. The fixed-route transit vehicle fleet is largely supplied by one of three manufacturers: Eldorado, International or New Flyer. One of the characteristics of VTA’s fixed-route fleet is that it consists of a combination of heavy duty and medium duty vehicles. The fleet also consists of six vans, which are used for paratransit service (see Figure 5). The paratransit vans are powered with unleaded gasoline and between 18 and 22 feet in length.

![Figure 5: VTA Fleet Inventory (Fixed-Route and Demand Response)](image)

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Length</th>
<th>Fuel</th>
<th>Useful Life</th>
<th>Age</th>
<th>Mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Route</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bluebird</td>
<td>37</td>
<td>Diesel</td>
<td>10 yr/350K</td>
<td>14</td>
<td>240,826</td>
</tr>
<tr>
<td>Eldorado</td>
<td>32</td>
<td>Diesel</td>
<td>12 yr/500K</td>
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<td>385,426</td>
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<td>Diesel</td>
<td>12 yr/500K</td>
<td>11</td>
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<td>Diesel</td>
<td>12 yr/500K</td>
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<td>416,035</td>
</tr>
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<td>12 yr/500K</td>
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<td>375,396</td>
</tr>
<tr>
<td>Eldorado</td>
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<td>Diesel</td>
<td>12 yr/500K</td>
<td>9</td>
<td>319,920</td>
</tr>
<tr>
<td>Eldorado</td>
<td>32</td>
<td>Diesel</td>
<td>12 yr/500K</td>
<td>9</td>
<td>380,493</td>
</tr>
<tr>
<td>Eldorado</td>
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<td>Diesel</td>
<td>12 yr/500K</td>
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<td>300,258</td>
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<tr>
<td>INTERNATIONAL RE</td>
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</tr>
<tr>
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<td>Diesel</td>
<td>10 yr/350K</td>
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<td>161,409</td>
</tr>
<tr>
<td>INTERNATIONAL RE</td>
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<td>Diesel</td>
<td>10 yr/350K</td>
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<td>228,562</td>
</tr>
<tr>
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<td>Diesel</td>
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</tr>
<tr>
<td>INTERNATIONAL RE</td>
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<td>Diesel</td>
<td>10 yr/350K</td>
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<td>241,078</td>
</tr>
<tr>
<td>INTERNATIONAL HC</td>
<td>29</td>
<td>Diesel</td>
<td>7 yr/200K</td>
<td>6</td>
<td>217,445</td>
</tr>
<tr>
<td>INTERNATIONAL HC</td>
<td>29</td>
<td>Diesel</td>
<td>7 yr/200K</td>
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<td>219,783</td>
</tr>
<tr>
<td>INTERNATIONAL HC</td>
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<td>Diesel</td>
<td>7 yr/200K</td>
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<td>214,887</td>
</tr>
<tr>
<td>INTERNATIONAL HC</td>
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<td>Diesel</td>
<td>7 yr/200K</td>
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<td>133,057</td>
</tr>
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<td>INTERNATIONAL RE</td>
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<td>Diesel</td>
<td>10 yr/350K</td>
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<td>160,740</td>
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<td>Diesel</td>
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<td>182,978</td>
</tr>
<tr>
<td>INTERNATIONAL RE</td>
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<td>Diesel</td>
<td>10 yr/350K</td>
<td>3</td>
<td>89,002</td>
</tr>
<tr>
<td>INTERNATIONAL HC</td>
<td>30</td>
<td>Diesel</td>
<td>7 yr/200K</td>
<td>2</td>
<td>117,299</td>
</tr>
<tr>
<td>INTERNATIONAL RE</td>
<td>40</td>
<td>Diesel</td>
<td>10 yr/350K</td>
<td>2</td>
<td>83,365</td>
</tr>
<tr>
<td>INTERNATIONAL RE</td>
<td>40</td>
<td>Diesel</td>
<td>10 yr/350K</td>
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<td>83,665</td>
</tr>
<tr>
<td>INTERNATIONAL RE</td>
<td>40</td>
<td>Diesel</td>
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<td>69,834</td>
</tr>
<tr>
<td>INTERNATIONAL RE</td>
<td>40</td>
<td>Diesel</td>
<td>10 yr/350K</td>
<td>1</td>
<td>36,782</td>
</tr>
<tr>
<td>New Flyer/Midi</td>
<td>30</td>
<td>Diesel</td>
<td>10 yr/350K</td>
<td>1</td>
<td>20,534</td>
</tr>
<tr>
<td>New Flyer/Midi</td>
<td>30</td>
<td>Diesel</td>
<td>10 yr/350K</td>
<td>1</td>
<td>19,481</td>
</tr>
<tr>
<td>New Flyer/Midi</td>
<td>30</td>
<td>Diesel</td>
<td>10 yr/350K</td>
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<td>25,854</td>
</tr>
<tr>
<td>New Flyer/Midi</td>
<td>30</td>
<td>Diesel</td>
<td>10 yr/350K</td>
<td>1</td>
<td>24,454</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demand Response Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford Cutvan</td>
</tr>
<tr>
<td>Ford Econoline Van</td>
</tr>
<tr>
<td>Ford E350 Van</td>
</tr>
</tbody>
</table>

⁵ FTA webpage on Bus Testing (http://www.fta.dot.gov/12351_4584.html)
VTA manages its fleet according to the FTA guidance with vehicles replaced as they reach their useful life. VTA’s fleet is well managed, and there are no vehicles used in operation that have exceeded their useful life in terms of age and miles (a handful of vehicles have exceeded one but not both criteria). VTA will be replacing 26 vehicles over the next five years, including 22 fixed route vehicles and four demand response vehicles (see Figure 6). This means about 70% of the fixed-route fleet and 67% of the demand response vehicle fleet will be replaced. This creates an opportunity to transform the fleet, if appropriate. Vehicles scheduled to be replaced include:

- VTA’s Bluebird bus is 14 years old with a mileage of nearly 241,000 miles. The vehicle is beyond its useful life in terms of age, but has about 100,000 miles left.
- The next oldest vehicles are the Eldorado buses. These are heavy duty vehicles with a 12-year useful life. Two Eldorado buses will reach their 12-year useful life in 2016 and two more will be ready for retirement in 2017.
- The International vehicles are medium duty. Medium duty vehicles have a shorter useful life, either seven years/200,000 miles or 10 years/350,000 miles. Three of the seven-year International buses have already exceeded the mileage limitation of their useful life and will be ready for replacement in the near term. VTA generally prefers medium duty vehicles, given their annual mileage and operating constraints.

**Figure 6: VTA Replacement Schedule (Fixed-Route and Demand Response)**

<table>
<thead>
<tr>
<th>Replacement Year</th>
<th>Fixed-Route Vehicles</th>
<th>Demand Response Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 (or earlier)</td>
<td>1 Bluebird (37’)</td>
<td>1 Ford 18’ Cutaway Van</td>
</tr>
<tr>
<td></td>
<td>2 Eldorado 32’ buses</td>
<td>1 Ford E350 Van</td>
</tr>
<tr>
<td>2017</td>
<td>2 Eldorado 32’ buses</td>
<td>1 International HC 29’ bus</td>
</tr>
<tr>
<td></td>
<td>1 International HC 29’ bus</td>
<td>2 Ford E350 Vans</td>
</tr>
<tr>
<td>2018</td>
<td>2 Eldorado 32’ buses</td>
<td>2 International HC 29’ buses</td>
</tr>
<tr>
<td></td>
<td>2 International HC 29’ bus</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>3 Eldorado 32’ buses</td>
<td>1 International HC 29’ bus</td>
</tr>
<tr>
<td></td>
<td>1 International HC 29’ bus</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>2 Eldorado 32’ buses</td>
<td>1 Eldorado 29’ bus</td>
</tr>
<tr>
<td></td>
<td>2 International RE 40’ buses</td>
<td>3 International RE 35’ buses</td>
</tr>
<tr>
<td></td>
<td>3 International RE 35’ buses</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

Source: VEIC adapted from VTA data

**Implications for Alternative Vehicles and Fuel Technology**

VTA’s existing services and operations shape VTA’s vehicle needs in terms of both individual vehicles as well as the fleet overall. The most critical needs include:

- **Ability to operate for up to 300 miles per day on a single fueling** – VTA’s vehicles stay in service for the entire day. During the summer months, one of VTA’s vehicles is in service for up to 400 miles; several other vehicles operate between 300 and 350 miles per day. Another segment of the fleet is in service for between 200 and 250 miles. An important attribute for alternative fuel vehicles, therefore, is the ability to be in service at least 200 miles and up to 300 miles on a single fueling or charge.
• **Offer seating and standing capacity for 70 passengers** – Ridership data and anecdotal evidence suggests that passenger volumes on VTA routes during the peak period, especially during “fair weather days”, can be extremely high, with many routes carrying standing room only loads. VTA requires at least 15 high capacity vehicles to service its highest ridership routes (Routes 1, 4 and 13). This means a significant portion of the fleet must be large enough to accommodate large passenger loads.

• **Ability to accelerate into traffic with full passenger loads** – VTA operates as “flag stop” service that allows passengers to hail the bus at any safe location. As a result, VTA vehicles need sufficient torque and acceleration to be able to pull in and out of traffic with full passenger loads.

• **Options for narrow vehicle body width capable of navigating narrow streets and turns** – VTA buses operate in a combination of rural roads with limited shoulder space and very narrow village streets, many of which allow two-way traffic, including two-way bus traffic. A majority of the narrow roadways are in Edgartown. Five of VTA’s routes serve Edgartown, including some of the systems highest frequency services. On a peak service day, as many as 15 vehicles may operate in Edgartown for at least part of their trip. Given these operating constraints, VTA prefers narrow buses that are 96” wide (or less).

• **Ability to operate efficiently in congested corridors** – Martha’s Vineyard’s road network, especially in town centers, is frequently highly congested during the summer, making travel times difficult to predict or schedule. The vehicles must be able to operate in congestion, including stop and go traffic conditions. As a result, VTA values vehicles that operate quietly and with minimal emissions in congested conditions.

• **Operate at relatively low operating speeds overall** – Consistent with high traffic volumes and the fact that there are no high speed roadways on the island, VTA’s operating speeds overall are relatively low. This can create issues for vehicle maintenance because newer diesel engines are most effectively cleaned when the engine operates a high speeds. Not being able to regularly run engines at high speeds creates some regular maintenance issues associated with clogged filters and systems.

• **Need for infrastructure that is sensitive to community character** - Martha’s Vineyard prides itself on its natural beauty and historic communities. According to the Island Plan, published by the Martha’s Vineyard Commission, managing growth is one of the most significant challenges facing the community. This includes protecting open space and natural areas as well as the historic communities. VTA is a partner in growth management efforts and represents one of the best strategies the Island has to manage traffic congestion. An emphasis on community aesthetics and character may limit development of additional fuel supply equipment, such as fuel tanks or overhead charging equipment, outside of the Airport Business Park.

• **VTA manages a diverse fleet comprised of different sized vehicles** - One of the main advantages of a diverse fleet is that VTA is able to match vehicle size with ridership demand. A primary disadvantage of the diverse fleet is that not all vehicles are easily deployed on all routes at all times. Smaller vehicles, for example, can be used on nearly all routes during the winter, but do not have sufficient capacity to be used on all routes during the summer.

The complexity of VTA services and existing fleets creates opportunities and challenges with regard to integrating new fuel and vehicle technology into daily operations. It is difficult for an alternatively fueled vehicle, or any transit vehicle, to meet all the requirements of VTA’s operations (i.e. carry sufficient fuel supply to operate 300 miles, have capacity for 70 passengers and be less than 100” wide). This is especially the case in the context of VTA’s preference for medium-duty vehicles. There may be opportunities for some new and alternative fueled vehicles to offer VTA sufficient flexibility that they can be used on most, but not all, routes.
3.0 **Alternative Fuels and Alternative Fuel Vehicles**

**Overview**
The purpose of this chapter is to inventory both the alternative fuels and the alternative fuel vehicles considered by VTA. This chapter compares and contrasts fuel and vehicle attributes associated with transit operations. The analysis considers four alternative fuels, plus diesel and biodiesel and a variety of traditional and alternative fuel vehicles. Diesel and biodiesel fuel are included to create a comparative baseline against which alternative fuel vehicles can be compared. The analysis focuses on two fuel attributes (fuel price and fueling infrastructure) and two vehicle attributes (vehicle cost and noise). A more detailed overview of the individual alternative fuels and their applicability to VTA operations is included as Appendix C.

**Alternative Fuels**
VTA directed the VEIC team to investigate six fuel types, including four alternative fuels (biodiesel, electric, natural gas and propane), plus hybrid-electric and diesel fuel vehicles. These fuels make up the vast majority of the transportation fuels available in the United States. In addition to providing an overview of each of these fuel types, this section also includes a comparison of fuel costs and fuel infrastructure development costs.

- **Diesel** is the primary fuel used to power medium and heavy-duty vehicles in the United States, including transit buses. New “clean” diesel blends mean VTA’s existing fixed-route vehicle fleet is powered by ultra-low sulfur diesel, which is significantly cleaner than earlier diesel blends. By removing sulfur from the fuel, diesel exhaust technologies are more effective, further reducing pollutants. It is the most common fuel source in the transit industry; just over half (56%) of all transit vehicles in the United States (U.S.) operate with diesel fuel6.

- **Biodiesel** is produced from soybean oil, waste cooking grease, or other organic matter that is blended into petroleum diesel fuel. Biodiesel is a derivative of diesel fuel that can be used in diesel engines in different quantities; it tends to be referenced by the portion of biodiesel to traditional diesel, i.e., B20 is a diesel blend with 20% biodiesel and 80% regular diesel. An advantage of biodiesel is that it can be integrated into a traditional diesel engine without changes to the vehicle or engine.

- **Hybrid-electric diesel** buses use both an internal combustion (diesel) engine and electric motor to power a bus’s propulsion system and vehicle accessories. Hybrid technology integrates these systems in different ways, but in nearly all cases, hybrid vehicles have smaller diesel engines and rely on the electric motor for at least a portion of the vehicle propulsion. These types of systems increase vehicle fuel economy; hybrid-electric vehicles are cleaner and quieter. Hybrid-electric vehicles have been popular with transit agencies in the U.S. and account for roughly 18% of the transit fleet nationally7.

- **Electric vehicles** are powered solely by an electric motor fueled by energy stored in a battery, located on the vehicle. Vehicle batteries are charged by plugging in or connecting wirelessly to an electrical source. In addition, auxiliary vehicle systems – including the motor and accessories - are powered by electricity, resulting in cleaner and quieter operations. Electric transit vehicles, in some respects, are best categorized as an emerging technology because use of electric buses in transit operations is growing, but the current market share is quite small, at one percent.

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6 American Public Transportation Authority (APTA) 2015 Public Transportation Fact Book.
7 APTA 2015 Public Transportation Fact Book
• **Natural gas** is hydrocarbon gas, largely methane. The vast majority of natural gas is a fossil fuel but it can also be renewable (Renewable Natural Gas or RNG) when methane is produced from waste products, such as water treatment plants and landfills. In transportation applications, natural gas is used as compressed natural gas (CNG) or liquefied natural gas (LNG). Natural gas fuels can be used in the same natural gas vehicle/engine; the difference between CNG and LNG vehicles is mainly in how the fuel is stored on the vehicle and delivered to the engine. The vast majority of all natural gas vehicles in the transit industry operate with CNG. CNG has a roughly 18% market share in the U.S. transit fleet\(^8\).

• **Propane** is a by-product of natural gas or the crude oil refining process. Propane vehicle engines operate similarly as diesel engines. It is a commonly used transportation fuel, but is not widely used to power heavy-duty vehicles. As of 2016, there are no heavy-duty transit propane vehicles manufactured in the United States. Propane has, however, been adopted by transit agencies as an alternative fuel to power paratransit vehicles.

**Fuel Costs**

Diesel and gasoline have been and continue to be the primary transportation fuel used in the United States. Diesel and gasoline fuel are also the primary fuel used in the U.S. transit industry with roughly 75% of all transit vehicles powered by diesel or hybrid diesel-electric engines\(^9\). Gasoline and diesel are also the dominant fuel source for most transportation, including most light, medium and heavy duty vehicles. This gives traditional fossil fuels an advantage in terms infrastructure, such as supply chains and storage resources, but also the design of maintenance facilities and maintenance technician training. At the time this report was written (June 2016), diesel and gasoline prices are near historic low prices (see Figure 7), increasing the attractiveness of the fuel for transit operations. For alternative fuels to be competitive with diesel, therefore, costs need to include the cost to develop a fuel supply and storage system as well as the unit cost of the fuel.

![Figure 7: U.S Average Fuel Prices April 2000 – October 2015](source: Alternative Fuel Data Center (U.S. Department of Energy))

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\(^8\) Ibid.

\(^9\) Ibid.
**Fuel Costs**

Fuel costs are determined by two primary factors: the unit cost of the fuel, and fuel economy, the relationship between the distance traveled and the amount of fuel consumed. Alternative fuels typically have lower per unit costs as compared with diesel fuel, but as discussed, the current low diesel prices mean a gallon of diesel costs the same or less than most of the alternative fuels examined. The fuel economy of individual fuels vary, but tends to be the same or slightly better as compared with diesel fuel. The exception to these rules is electric vehicles, which offers both lower fuel costs and improved fuel economy.

To understand relative fuel costs, VEIC compared the estimated costs to drive a bus 100 miles, using the fuel economy of a 40’ standard transit vehicle\(^{10}\) and the cost per unit of fuel (see Figure 8). Data is based on published fuel economy, not operational experience. The data shows as compared with diesel fueled vehicles:

- Electric vehicles have lowest fuel costs, and are as much as 80% less expensive to operate as compared with a diesel vehicle.
- Diesel-electric hybrid vehicles offered minor fuel operating savings.
- Natural gas and propane vehicles have higher fuel operating costs. However, natural gas and propane prices reflect national prices and are compared with VTA’s negotiated price for diesel.

**Figure 8: Transit Vehicle Fuel Costs, Fuel Economy and Cost to Drive 100 Miles**

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>Diesel-Electric Hybrid</th>
<th>Electric</th>
<th>Natural Gas (CNG)</th>
<th>Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per unit of fuel*</td>
<td>$1.42/gallon</td>
<td>$1.42/gallon</td>
<td>10.927 cents/kWh</td>
<td>$2.11/gallon</td>
<td>$2.38/gallon</td>
</tr>
<tr>
<td>Fuel Economy**</td>
<td>4.89 mpg</td>
<td>5.89 mpg</td>
<td>4.34 mpg</td>
<td>4.3 mpg</td>
<td></td>
</tr>
<tr>
<td>Cost to Drive 100 miles</td>
<td>$29.04</td>
<td>$24.01</td>
<td>$6.04</td>
<td>$48.61</td>
<td>$55.34</td>
</tr>
</tbody>
</table>

Source: VEIC

Notes: * All costs based on national prices for fuels, except diesel fuel, which reflects VTA’s current (January 2016) costs. This is a negotiated rate that is more favorable than can be assumed for other fuels. ** Fuel economy is based on 50% of the miles driven in urban or central business district (CBD) miles and 50% of the miles driven in arterial conditions. Propane fuel economy based on school buses.

**Fueling Infrastructure**

As discussed, as the dominant fuel source, the supply and storage infrastructure for diesel fuel and gasoline is widely available. This is not always the case with alternative fuels, so changing fueling systems almost always require investments in fuel storage and supply systems. In some cases, investments are required to retrofit maintenance facilities to accommodate alternative fuels and ensure the proper safety requirements are met (see also Figure 9). Findings from this analysis show:

- The infrastructure to support diesel, biodiesel, diesel-electric hybrid vehicle and propane are available on Martha’s Vineyard and at VTA, including fuel storage resources. No additional investments are needed for diesel fuel or biodiesel. Minor investments are likely needed to activate VTA’s propane systems.

- The investment costs associated with electric vehicles is between $150,000 and $600,000 depending on the charging systems and number of vehicles.
  - Investing in electric vehicle technology requires equipment to charge the vehicles. Depot chargers cost about $50,000 each and can fully charge a bus battery in about 90 minutes.

\(^{10}\) VEIC chose a 40’ vehicle because it is the most common vehicle available and one where standard measurements could be collected across fuel types.
minutes. On-route charging systems can charge a vehicle in five to seven minutes. However, these systems are significantly more expensive and cost roughly $400,000 per charger\textsuperscript{11}. Accommodating multiple electric vehicles at VTA would also likely require about $100,000 worth of electrical system upgrades.

- Natural gas requires the largest investment of the alternative fuels, largely because there is no natural gas pipeline from the mainland to Martha’s Vineyard and building one is not a feasible option at this time. Additionally, natural gas would require upgrades to the maintenance facility.
  - Natural gas can be delivered via a ‘mobile’ pipeline where high pressure storage tanks are delivered to VTA on a trailer and are equipped to dispensing equipment. Shipping 150,000 gallons of CNG via a mobile pipeline would cost – at a minimum - $200,000 per year\textsuperscript{12}. Vehicles would be fueled from the mobile pipeline tanks; fueling times with a mobile pipeline are equivalent to diesel and would constitute a “fast fill” process. LNG would require an installation of a station costing approximately $1.5 - $2 million. VTA could also rent an LNG station for roughly $170,000 annually\textsuperscript{13}.
  - The use of natural gas vehicles would require modifications to VTA’s maintenance facilities. Natural gas is lighter than air, so proper ventilation is extremely important especially in the case of a leak. Upgrades could cost anywhere between $200,000-$400,000 (or more) for air handing and ventilation systems, methane detection systems, ceiling designs, and up-grades to heating systems including no open flame or high temp heat source near the ceiling.

**Figure 9: Fueling Infrastructure Needs and Indicative Cost Estimates**

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>Diesel-Electric Hybrid</th>
<th>Electric</th>
<th>Natural Gas</th>
<th>Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel supply</td>
<td>Available</td>
<td>Available</td>
<td>Available</td>
<td>Need supplier</td>
<td>Available</td>
</tr>
<tr>
<td>Fuel storage systems</td>
<td>Available</td>
<td>Available</td>
<td>Not applicable</td>
<td>Mobile pipeline (see below)</td>
<td>Available – may require minor investment</td>
</tr>
<tr>
<td><strong>Fueling System</strong></td>
<td>Available</td>
<td>Available</td>
<td>$50,000 - $400,00 for charging infrastructure</td>
<td>$200,000 annually for CNG mobile pipeline</td>
<td>Available</td>
</tr>
<tr>
<td>Maintenance Facility</td>
<td>No change required</td>
<td>No change required</td>
<td>$100,000</td>
<td>$200,000 to $400,000 to retrofit facility</td>
<td>No change required</td>
</tr>
</tbody>
</table>

Source: VEIC

**Alternative Fuel Vehicles**
The transit vehicle – or bus – market in the United States is dominated by a handful of vehicle manufacturers, primarily New Flyer, Gillig and Nova Bus. Most of these manufacturers also offer alternative fuel models of their standard diesel vehicles. This means some vehicle models (i.e. 40’ coach) can be purchased as a diesel, hybrid or natural gas vehicle and in some cases, electric. There are no full sized transit buses available as propane models. In 2016, most of the major transit vehicle manufactures

\textsuperscript{11} Estimate only, does not include installation costs.
\textsuperscript{12} Estimated by Mobile Fuel Solutions; based on a volume of 1,000 gallons per day.
\textsuperscript{13} Estimated by Mobile Fuel Solutions
only offered demonstration electric models. As a result, the electric transit vehicle market is dominated by a handful of smaller manufacturers that only make electric buses. In 2016, there are two manufacturers with buses tested at the FTA Bus Testing Facility (Proterra and BYD Motors), plus a third manufacturer entering the market (Green Power Bus).

This section identifies alternative fuel vehicles that meet VTA’s operating needs and broadly compares and contrasts vehicle characteristics. For purposes of this analysis, VEIC primarily relied on data in the Altoona Bus Test database. In some cases, this data was supplemented with information available from manufacturers. VEIC also used a 40’ transit bus as our “design” vehicle. While we recognize VTA may be more likely to operate a slightly smaller, medium duty vehicle, there are multiple fuel options available in a 40’ vehicle and it tends to be the first model to be tested at Altoona. As a result, using the 40’ bus allowed a consistent comparison between fuel and vehicle types.

**Vehicle Cost**

The cost of a 40’ bus ranges from about $425,000 to over $700,000, depending on the manufacturer and propulsion system. The cost of a 40’ natural gas or electric is roughly 20% to 55% more than the cost of a diesel vehicle. These price differentials are considered indicative only and represent the price of the 40’ vehicle models (see Figure 10).

**Figure 10: Transit Vehicle Indicative Costs**

<table>
<thead>
<tr>
<th>Vehicle Manufacturer/Model</th>
<th>Diesel</th>
<th>Diesel-Electric Hybrid</th>
<th>Electric</th>
<th>Natural Gas</th>
<th>Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Flyer – 40’ Excelsior¹</td>
<td>$450,000</td>
<td>$570,000</td>
<td>$700,000</td>
<td>$550,000</td>
<td>Not available</td>
</tr>
<tr>
<td>Gillig – 40’ Low Floor²</td>
<td>$425,000</td>
<td>$640,000</td>
<td>n/a</td>
<td>$480,000</td>
<td>Not available</td>
</tr>
<tr>
<td>Proterra – BE35³</td>
<td></td>
<td></td>
<td>$779,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BYD Motors -33¹¹⁴</td>
<td></td>
<td></td>
<td>$625,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: VEIC
Notes: 1) Bids from various transit agencies, including WMATA, Chicago RTA and Hamilton Ontario; 2) Bid to TriMet, Portland Oregon; 3) Proterra literature; 4) Skagit Transit (Washington State) bid

**Vehicle Noise**

One of the assumed advantages of alternative fuel vehicles is that they are quieter. Operating quieter vehicles is important to VTA for several reasons, including the local community’s focus on environmental stewardship and quality of life. Noise differences, therefore, were included as part of this initial analysis. Finding accurate noise testing for all the alternative fuels is difficult and the actual level of noise will depend greatly on the vehicle and its configuration.

Altoona Bus Tests includes tests of exterior noise data measures for four different fuel versions of the New Flyer Excelsior. New Flyer does not make a propane vehicle, so the noise data is taken from the Bluebird Vision bus, which is a 39’ school bus. Since CNG and LNG vehicles use the same engines, the noise level of an LNG bus should be comparable to and CNG bus. As a reference, engineering standards suggest at least a three decibel d (B) a difference in noise levels is required for most humans to notice a change. Noise levels as measured on the right side of the vehicle when the vehicle is stationary, including data points with the air conditioning (AC) on and off (see Figure 11) suggests:

- Diesel-electric, natural gas and propane vehicles are marginally quieter as compared with diesel vehicles, especially when the air conditioner is on.
- Electric vehicles are significantly quieter as compared with diesel vehicles and quieter than all other vehicles included in the analysis.
Summary of Findings

Each alternative fuel and alternative fueled vehicle offers VTA different strengths and weaknesses, with none of the vehicles offering a significant advantage in all of the categories evaluated. Key points from the analysis include:

- Generally speaking, diesel, diesel-electric hybrid, and natural gas vehicles are widely used by transit agencies in the United States. Diesel engines account for about 56% of all U.S. transit buses, while diesel-electric and natural gas vehicles have a market share of about 17.5% each. Electric transit vehicles are new to the market and have a small market share overall. Propane is not widely used in the transit industry\(^\text{14}\).

- Diesel, CNG, LNG and propane all operate with conventional internal combustion engines. Electric transit vehicles have electric motors and drive trains, while diesel-electric hybrid vehicles have both a diesel engine and an electric motor. Electric vehicles have an electric motor.

- Several of the largest transit vehicle manufacturers – including New Flyer and Gillig – have vehicles models that are available as diesel, hybrid, and CNG models. New Flyer has all an electric model of its 40’ Xcelsior vehicle.

- Alternative fuel vehicles were largely developed as cleaner burning versions of the diesel vehicles. They have fewer greenhouse gas (GHG) emissions and typically are quieter as compared to diesel vehicles.

- Historically, alternative fuels were less expensive as compared with diesel, offer more stable fuel prices, and are more widely available domestically. Lower fuel costs tend to offset minor differences in lower fuel economy as compared with diesel.

- Alternative fuel vehicles tend to be more expensive to purchase. Natural gas and electric vehicles are roughly 20% to 55% more expensive as compared with diesel vehicles, while diesel-electric hybrid are about 40% more expensive.

- Since VTA does not currently have the fueling infrastructure for natural gas or propane, investments in both would need to be made. These investments would either be made up front or through payments with the purchase of fuels.

- Significant upgrades in VTA’s maintenance facilities would need to be made in order to utilize natural gas vehicles, CNG or LNG.

\(^{14}\) APTA 2014 Fact Book
4.0 DEVELOPMENT OF RECOMMENDATIONS

Overview
The goal of this analysis is to recommend a future course of action for VTA regarding alternative fuels and alternative fuel vehicles. The next step in our evaluation examined the costs and benefits associated with alternative fuels within the specific opportunities and constraints on Martha’s Vineyard. As part of developing and supporting those recommendations, our analysis considered the transit vehicle market generally as well as a more detailed and applied analysis of the financial costs and benefits associated with different strategies. Potential investment scenarios are included in the final section.

Market Trends
Alternative fuels and alternative fuel vehicles are gaining broader acceptance domestically and internationally as a solution to reducing vehicle emissions harmful to human health and contributing to global warming. Transit vehicles operating in the United States are still largely powered by diesel fuel; however, the share of transit vehicles not powered solely by diesel doubled between 2007 and 2014, from 20% to 44% (see Figure 13). It is also worth noting that the data used to populate the design year is based on prior year data. This suggests that the national transit fleet could have more alternative fuel vehicles than shown.

**Figure 13: U.S. Transit Fleet - All Vehicles by Fuel Type**

National transit fleet data shows historic trends. The California market provides insights into vehicle fuels generally and specifically for the transit industry. California leads the nation in terms of setting aggressive goals for reducing greenhouse gas (GHG) emissions and reducing its economy’s dependence on imported petroleum products. It supports these goals with legislation, regulation and funding. One California program, the Alternative Renewable Fuel and Vehicle Technology Program uses funds from vehicle registration and smog fees to provide up to $100 million annually for projects that will “transform California’s fuel and vehicle types”. Consequently, California fleets are moving more quickly towards alternative fuels; their choices and investments offer lessons for the rest of the country.
In addition to looking at trends and opportunities in California, VEIC spoke with several vehicle manufacturers. Manufacturers have slightly different insights into market trends, and of course, each manufacturer has a unique perspective on the market. VEIC combined these perspectives to develop the following perspective on transit vehicle trends:

- **All-electric is growing** – Electric transit vehicles are starting to have an impact on transit vehicle sales. In 2010, Foothill Transit was on the leading edge of the transit industry when it started operating all-electric vehicles, but today they are joined by scores of other agencies who have adopted the technology. These transit agencies include large urban operators, like Foothills, but also smaller rural operators. Another sign of the growing influence of electric is that the largest North American transit vehicle manufacturers – Gillig, New Flyer and Nova Bus – have developed and/or are currently testing all-electric options. There are also new OEMs entering the all-electric transit vehicle market, including Proterra and BYD, but also manufacturers such as GreenPower in British Columbia and Motive Power in California.

- **Continued relevance of natural gas vehicles** – Natural gas vehicles are continuing to increase their market share (albeit from a larger base as compared with electric vehicles). The existing major vehicle manufacturers in North America (New Flyer, Gillig and Nova Bus) have natural gas options for most or all of their vehicles. Engine manufacturers are also working to ensure natural gas vehicles can meet California’s zero emissions at the tailpipe. This investment reflects competition from all-electric vehicles, but also recognizes that natural gas vehicles offer a relatively easy option for transit agencies to improve emissions without major disruptions in service operations.

- **Investments in fuel cell/hydrogen vehicles** – Even as electric vehicles gain market share, California and a handful of transit agencies around the country are testing the potential of hydrogen cell vehicles. The vehicles are significantly more expensive (roughly $2 million per vehicle) as compared with other technologies, but offer increased fuel economy and reduced emissions. Several transit agencies are currently testing (or gearing up to test) hydrogen cell vehicles, including in Flint, Michigan; Hartford, Connecticut; and Canton, Ohio.

- **Transit vehicle manufacturers are investing in larger vehicles** – The mainstay of the traditional transit vehicle manufacturers is heavy-duty vehicles. When asked about future markets, most manufacturers reported looking forward to larger, higher capacity vehicles. This is especially true for electric and hybrid operating systems, where transit vehicle manufacturers expect 60’ articulated alternative vehicle models where they do not already exist. Interest in shorter, 35’ or 30’ vehicles was less robust. Most operators offer a 35’ version of their 40’ vehicle, but the vehicle is nearly identical except for a slightly shorter body. Manufacturers typically do not offer price differentials for smaller vehicles, so there is little incentive for operators to consider shorter vehicles.

- **BYD Motors offers an alternative perspective and business model** – As compared with traditional vehicle manufacturers who offer a limited line of vehicles but make them available in a variety of fuel and propulsion systems, BYD builds and sells a diverse portfolio, but only offers all-electric vehicles. Their vehicle portfolio includes smaller 23’ and 30’ buses, plus over-the-road coaches and 60’ articulated vehicles. BYD also benefits from its role in the Chinese transit market. China incentivizes electric vehicles, including financial discounts for electric buses. These incentives combined with the size of the market, gives BYD tremendous opportunities to test and develop electric vehicles and technologies.

- Other engine manufacturers, including Rousch and Arboc collaborate with chassis manufactures like Ford and Chevrolet to make smaller, medium duty alternative fuel vehicles, including vehicles powered by natural gas and propane. Several of the larger transit systems (Cleveland, Dallas and Santa Monica) are beginning to purchase and operate propane and natural gas paratransit vehicles. A similar trend is also apparent in the school bus market, which is diversifying into natural gas, propane and to a lesser extent, electric.
- **Electric Vehicle Charging Systems** – there are two predominant types of systems emerging to charge transit vehicles: shorter-range vehicles that use on-route fast charging systems to stay in operations; and longer-range vehicles that can stay in service for longer distances but are not designed for fast charging. Long-range vehicles are starting to experiment with on-route charging; these systems use frequent connections to a power source (usually inductive) to maintain the battery state of charge. Both systems have advantages and disadvantages, depending on transit system needs. Inductive charging systems are being tested in Lancaster, CA (Antelope Valley Transit Authority) and Wenatchee Washington (Link Transit). Another inductive charging demonstration is moving ahead in Howard County, Maryland.

- **Charging System Compatibility** - a challenge with both types of electric vehicle charging systems is compatibility. Currently, charging transit systems are proprietary to the manufacturer (i.e. Proterra charging equipment cannot be used to charge a BYD bus). Given the high cost associated with charging equipment, especially fast and inductive charging, being tied to a single vehicle manufacturer is a problem for many transit agencies. The American Public Transportation Association (APTA) has begun to address this issue. As of June, 2016, however, electric vehicle charging systems continue to be proprietary.

- **Fuel Prices** – another consideration is the price of fuel. It is difficult to anticipate the future price of any good or service, but fuel prices are particularly challenging. The price of diesel, biodiesel and propane has fluctuated tremendously in the past 15 years, while CNG and electricity has been more stable (see Figure 14). The price of electricity has consistently been stable and low. There has also been a lot of investment in diversifying ways to produce and generate electricity, which suggest continued stability over the longer term.

---

**Figure 14: U.S Average Fuel Prices April 2000 – October 2015**

- CNG
- Propane**
- Diesel
- B20
- Electricity*

Source: Alternative Fuel Data Center (U.S. Department of Energy)
Vehicle Recommendations

As part of the alternative fuels assessment, VEIC identified a handful of vehicle models that meet VTA’s operational needs. Vehicle options are discussed separately according to fixed route and paratransit vehicles.

Fixed Route Vehicles

VTA’s operational needs for fixed-route service include 1) the ability to operate for long distances (up to 300 miles a day) on a single fueling; 2) provide capacity for 50 to 70 passengers; and 3) offer options for a more narrow vehicle body capable of navigating narrow streets. Given these requirements, some of the most appropriate vehicle options, including clean diesel, alternative fuel and hybrid-electric options include:

- **New Flyer MiDi** – VTA purchased four 30’ New Flyer MiDi diesel vehicles in 2014 (put into service in 2015) and to date has had a positive experience operating them. VTA mechanics and drivers are familiar with the vehicle. Additionally, the vehicles have been well received by members of the public. The MiDi is available in 30’ and 35’ models. Both versions are 8’ wide, or 96”, which meets VTA’s needs for operating service in town centers. The vehicles are equipped with 75-gallon tanks and with an expected fuel economy of 4.89 mpg (50% ART and 50% CBD miles), the bus can travel 367 miles on a full tank. New Flyer expects to start selling a natural gas version of the MiDi in the short term, as soon as late 2016. A diesel version of the MiDi costs approximately $400,000.

- **Gillig 29’ Low Floor Standard Coach** – Gillig makes a 29’ heavy-duty, low floor transit vehicle that is available in a variety of fuel models. The vehicle is 102” wide, which is wider than VTA prefers for operations on narrow streets. However, the fuel tanks hold 75 gallons of fuel (or equivalent), allowing for roughly 350 miles on a full tank. These vehicles are available in clean diesel, diesel-electric hybrid and compressed natural gas (CNG) versions. The list price of the vehicles is $413,600, $620,100 and $460,600 for the diesel, hybrid and CNG versions respectively. It takes 18-20 months for an ordered bus to be delivered on site.

- **Build Your Dream (BYD) K7 or K9M Vehicles** – BYD makes a line of all-electric transit vehicles some of which partially meet VTA’s needs – the K7 and K9M. The K7 model is 31’ long, 95.7” wide and has capacity for 35-40 passengers, including standees. The vehicle range is 144 miles. The vehicle is only available in an all-electric extended range model and has a list price of $450,000. The K9M vehicle is 40.9’ long and 101.2” wide and has capacity for 65-70 passengers, including standees. The vehicle range is 161 miles and lists for $750,000.

Paratransit Vehicles

Paratransit vehicles have different duty cycles as compared with vehicles used in fixed-route services. They travel fewer miles and carry fewer passengers, but are in service for long periods of time. Paratransit riders typically have limited mobility; this means the drivers spend time driving, but also at the stops, helping passengers embark or disembark at their destinations. There are a handful of alternative fuel vehicles that meet VTA’s operational requirements:

- **Arboc Mobility CNG Vehicle** – Arboc Mobility offers a CNG fueled paratransit vehicle that is built on a General Motors 3500 or 4500 chassis. The Arboc vehicles have a 6.0-liter engine and two 29 gasoline gallon equivalent (GGE) tanks on each bus for 58 GGE, for a travel range of about 400 miles. The vehicles cost about $100,000 each, which is a premium of between $20,000 and $25,000 over a similarly sized gasoline or diesel vehicle. Arboc CNG paratransit vehicles are in use in several transit agencies in Texas (Corpus Christi and Dallas) plus California (Santa Monica).

- **Rousch Clean Tech Propane Vehicle** – Rousch Clean Tech offers a propane fueled paratransit van built on a Ford E-450 chassis. The engine is built using Ford’s 6.0-liter V-10 engine with extended range (64 usable gallons of propane autogas) capable of traveling 350 miles on a full
tank. A propane fueled E-450 paratransit van costs about $50,000, which is roughly $15,000 more than a similar gasoline powered vehicle. Several transit agencies, including the Greater Cleveland Regional Transit Authority, converted their paratransit fleets to propane in the past two to three years.

- **BYD C6 All-Electric Coach Bus** – As of April 2016 there are no all-electric paratransit van or cutaway vehicle. BYD does offer a small bus (C6) that is 23’ long, has seating for 20 people plus two wheelchair positions. The vehicle has a range of 124 miles on a full charge, which is suitable for many of VTA’s daily paratransit vehicle assignments. Visually the vehicle is a small bus, so it looks different from the traditional cutaway vehicle used in most paratransit operations. It is not a low floor vehicle, but similar to cutaway vehicles, has a wheelchair ramp. The list price for the vehicle is $230,000.

**Cost Analysis**

As part of evaluating the financial benefits and costs of individual fuel sources, the VEIC team developed a financial analysis that evaluated the cost of alternative fuel vehicles. Costs were evaluated on an annualized basis, over the 12-year useful life of the vehicles. We used a simple cost analysis to compare the cost of a single vehicle. The costs include fuel costs and investments needed to upgrade VTA’s facilities to either fuel or maintain the vehicles (see Figure 16). Our assumptions do not discount the value of future investments. The cost analysis includes current fuel prices and annual rate increases consistent with average historical experience. The cost of diesel and natural gas are increased by three percent per year, where electricity costs are increased by one percent annually.

The cost of a single vehicle, as mentioned, includes infrastructure investments. In most cases, the investment costs would be shared over multiple vehicles. For natural gas vehicles, VEIC assumed VTA would transition all 22 vehicles to natural gas, so infrastructure costs are shared over a larger fleet. VEIC evaluated two scenarios for electric buses; the first assumed VTA purchased three vehicles; and the second assumed VTA transitioned its entire fleet (22 vehicles). In the case of electric vehicles, the investment costs to transition 22 vehicles as compared with three vehicles is significantly higher because more electric vehicles require a greater investment in charging infrastructure.

VEIC’s cost analysis does not incorporate savings associated with reduced maintenance costs. Experience suggests that maintenance costs will be reduced with electric and natural gas vehicles, but VEIC did not include potential savings because 1) maintenance costs savings can be difficult to realize, especially for smaller transit agencies like VTA where most maintenance costs are fixed (facility and staff); 2) it is difficult to find consistent data sources for actual maintenance cost savings.
Figure 15: Assumptions: Alternative Fuel and Capital Costs

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>Hybrid Electric</th>
<th>Electric 3 buses</th>
<th>Electric 22 buses</th>
<th>Natural Gas 22 buses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Investments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost for 30’ Vehicle – one bus</td>
<td>$413,600</td>
<td>$620,000</td>
<td>$450,000</td>
<td>$450,000</td>
<td>$460,600</td>
</tr>
<tr>
<td>Fueling/Charging Infrastructure Costs</td>
<td>$0</td>
<td>$0</td>
<td>$25,000</td>
<td>$1,000,000</td>
<td>$0</td>
</tr>
<tr>
<td>Facility Upgrades</td>
<td>$0</td>
<td>$0</td>
<td>$95,000</td>
<td>$250,000</td>
<td>$300,000</td>
</tr>
<tr>
<td><strong>Operating Cost Assumptions (30’ vehicle)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Price (cost per gallon /kWh)</td>
<td>$1.42</td>
<td>$1.42</td>
<td>$0.10957</td>
<td>$0.10957</td>
<td>$4.10</td>
</tr>
<tr>
<td>Fuel Economy</td>
<td>4.89 mpg</td>
<td>5.89 mpg</td>
<td>2.065 kWh/m</td>
<td>2.065 kWh/m</td>
<td>4.34 mpg</td>
</tr>
<tr>
<td>Annual Mileage</td>
<td>35,000</td>
<td>35,000</td>
<td>35,000</td>
<td>35,000</td>
<td>35,000</td>
</tr>
</tbody>
</table>

Source: VEIC and CFO

Note: Vehicle prices reflect the cost of a 30’ vehicle based on the best available information about the most appropriate vehicle model. For Diesel, Hybrid-Electric and Natural Gas this is the New Flyer MiDi. For electric this is the BYD K9 vehicle. 1) Costs assume entire fleet is transitioned and VTA would purchase and install two inductive charging systems; 2) Natural gas will be delivered via virtual pipeline, so fueling/charging costs are included in cost of the fuel.

Fixed Route Vehicles

The annualized costs of owning and operating a diesel vehicle is about $46,500 (see Figure 15). This includes the annualized costs\(^\text{15}\) of buying the vehicle and driving the bus 35,000 miles, but not maintenance. Key findings from the analysis (see Figure 16) suggest:

- Diesel vehicles are the least expensive vehicles for VTA to own and operate. Diesel vehicles have higher fuel costs, but benefit from the fact that VTA does not need to make any upgrades to its facilities or fueling infrastructure to operate the vehicles.

- Electric vehicles have the lowest fuel costs and are cost competitive with diesel vehicles. However, the capital costs associated with upgrading the electrical infrastructure and installing charging stations means it would cost VTA more money to operate electric vehicles as compared with diesel.
  - If diesel prices rise to roughly $2.50 per gallon, electric vehicles become cost effective.

- Hybrid-electric vehicles are not cost effective because the vehicle is more expensive to purchase, fuel costs are the same and fuel economy is only marginally higher. Savings generated through increased fuel economy are not large enough to cover the increased vehicle cost.

- Natural gas vehicles are not cost effective. Higher costs reflect higher priced vehicles, higher fuel prices and investments to the VTA maintenance facility.

\(^\text{15}\) Assumes the purchase price of the vehicle divided by the vehicle’s assumed useful life of 12 years.
Figure 16: Findings: Alternative Fuel and Capital Costs

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>Hybrid Electric</th>
<th>Electric Costs shared by three buses</th>
<th>Electric Costs shared by 22 buses</th>
<th>Natural Gas Costs shared by 22 buses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized costs per vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital costs</td>
<td>$34,467</td>
<td>$51,667</td>
<td>$40,833</td>
<td>$42,235</td>
<td>$46,667</td>
</tr>
<tr>
<td>Fuel costs</td>
<td>$12,020</td>
<td>$9,979</td>
<td>$8,370</td>
<td>$8,370</td>
<td>$39,105</td>
</tr>
<tr>
<td>Total costs</td>
<td>$46,487</td>
<td>$61,646</td>
<td>$49,203</td>
<td>$50,604</td>
<td>$85,771</td>
</tr>
</tbody>
</table>

Total costs per bus, 12 year vehicle life

| Capital costs       | $443,600| $620,000| $490,000| $506,818| $473,636|
| Total fuel costs    | $114,242| $119,753| $100,435| $100,435| $469,253|
| Total costs         | $557,842| $739,753| $590,435| $607,253| $942,889|

Source: VEIC and CFO
Note: 1) Costs assume entire fleet is transitioned and VTA would purchase and install two inductive charging systems; 2) Natural gas will be delivered via virtual pipeline, so fueling/charging costs are included in cost of the fuel.

Paratransit Vehicles
There are also opportunities to transition paratransit vehicles to alternative fuels, although the options are limited to natural gas and propane. This analysis (see Figure 17) demonstrates:

- Gasoline vans are the most cost effective paratransit vehicles to own or operate.
- An investment in CNG has potential to lower operating costs, but operating costs savings are not sufficient to cover the premium associated with the vehicle capital costs – roughly $15,000. Ultimately investing in CNG for paratransit does not make sense unless it is part of a broader, more comprehensive investment in developing renewable natural gas on Martha’s Vineyard. Even then, the investment would require access to grant programs to offset capital investments.
- Propane could recoup its investments, but only if VTA does not have to pay the entire cost premium. Assuming VTA is able to negotiate favorable propane prices and the Federal Transit Administration (FTA) pays 80% of the cost of the vehicle and filling station, VTA could recoup its investment cost through increased fuel economy. The challenge with propane is that the system only works for paratransit vehicles.

Figure 17: Return on Investment for Paratransit Alternative Vehicles

<table>
<thead>
<tr>
<th>Capital Investments</th>
<th>Gasoline</th>
<th>Natural Gas</th>
<th>Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost for E0450 Van</td>
<td>$32,000</td>
<td>$100,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>Fueling/Charging Infrastructure Costs</td>
<td>$0</td>
<td>$0¹</td>
<td>$35,000</td>
</tr>
<tr>
<td>Facility Upgrades</td>
<td>$0</td>
<td>$288,000</td>
<td>$0</td>
</tr>
<tr>
<td>Operating Cost Assumptions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Price (cost per gallon)</td>
<td>$1.71</td>
<td>$4.10</td>
<td>$2.85</td>
</tr>
<tr>
<td>Fuel Economy (mpg)</td>
<td>11.0</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>Annual Mileage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replace Four Vehicles</td>
<td>n/a</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Source: VEIC and CFO
Note: 1) Natural gas will be delivered via virtual pipeline, so fueling/charging costs are included in cost of the fuel.
Potential Investment Scenarios

Our analysis of VTA’s service needs as well as the strengths and weaknesses of fuel and vehicle types suggests that no single strategy meets all of VTA’s need. Instead, each alternative fuel and vehicle technology has unique advantages and disadvantages that balance in different ways. VTA’s primary motivations for pursuing alternative fuel options include:

- VTA will be replacing 22 vehicles, roughly 70% of its fleet over the next five years. Buses have a useful life of between 10 and 12 years, so VTA wants to be sure its investment strategy reflects the most appropriate and effective technology possible.

- An important part of VTA’s mission is ensuring investment decisions are an effective use of taxpayer resources.

- Diesel vehicles have historically worked well for VTA and the fuel continues to be appropriate for much of its service. However, recent fuel blends and exhaust treatments have made the vehicles more difficult to maintain.

- VTA, as a transportation provider, is an important part of ensuring a robust, sustainable future for Martha’s Vineyard. Its services reduce the need for single occupancy vehicle travel. Operating alternative fuel vehicles strengthen this mission by reducing vehicle emissions associated with local air pollution, greenhouse gases/climate change pollutants and by reducing consumption of fossil fuels.

With these goals in mind, some of the potential paths – or courses of action – that VTA may want to consider include:

- **Continued investment in ULSD clean diesel vehicles with advanced exhaust technologies.** Removing sulfur from diesel fuel, equipping vehicles with diesel exhaust equipment and maintaining these systems greatly reduces vehicle emissions. A portion of VTA’s fleet is already equipped with these systems and despite some challenges with vehicle maintenance, the systems works. With minimal investment or change in operating practices, VTA can expand implementation of these technologies as it purchases new vehicles. While this approach does not embrace new systems or technologies, from a vehicle emissions perspective it is a reasonable, realistic course of action.

- **Purchase one or two 30’ electric buses in the immediate term** that work within VTA’s existing operational needs. Electric vehicles are both more efficient (better fuel economy) and have lower fuel prices. Operating costs savings can offset the cost of the vehicle and infrastructure investments. Given the comparable costs of the BYD K7 ($450,000) and the New Flyer MiDi ($400,000), there is potential for operating cost revenues to cover investment costs. Given the vehicles would most likely be deployed on VTA Routes 10 and 11, the buses would interact with lots of passengers and pedestrians, maximizing the impact of the vehicle.

  Transitioning more of the fleet increases savings, but also means VTA will likely need to purchase and install on-route fast charging equipment. This increases costs by an estimated $1 million. Grant funds may be available to pay for part or all of the charging system but without funding, it is unlikely the operating costs savings could pay for such a large capital investment.

- **Develop longer-range plan to transition to natural gas that includes partnerships with local wastewater treatment plans to produce renewable natural gas.** Natural gas offers a potential investment for VTA because it can be easily be integrated into VTA’s existing operations. It also creates an opportunity for VTA to transition its entire (fixed route and paratransit) fleet to an alternative fuel source, an option not available with any other fuel choice. However, the impacts of having to upgrade the maintenance facility and rely on a virtual pipeline to fuel vehicles makes the ongoing operating costs too high to achieve a positive return on investment.
Another option for VTA would be to adopt a long-term strategy that involves entering into partnerships with the towns on Martha Vineyard to develop a local source of renewable natural gas. While the initial investment costs are high (up to $1 million per site), the environmental benefits for both VTA and the local communities are significant. Towns could also transition their vehicles to natural gas and wastewater treatment plants could generate revenue to support operations. It is also likely that federal or state grants would be available to support part or all of the investment. Even with locally produced renewable natural gas, VTA would need a virtual pipeline to act as a supplemental or backup source. In this scenario the cost per unit of fuel would likely be higher than quoted in this study, but the amount of fuel purchased would be significantly lower.

Two additional, slightly less attractive, alternative fuel options available to VTA include:

- **Integrate biodiesel (B20) into VTA’s diesel fuel.** Biodiesel offers VTA a fast and inexpensive option for reducing vehicle emissions. The fuel has proven successful in many transit applications. Many of the potential trouble spots have already been identified and solutions can be incorporated into an implementation plan. For example, VTA could begin experimenting with biodiesel in the late fall, after or as part of shoulder season operations, before the weather turns cold. This short pilot phase could lead to a more comprehensive implementation in the spring. The downside with biodiesel is that it is not currently available on Martha’s Vineyard.

- **Transition VTA’s paratransit fleet to propane.** VTA could reduce vehicle emissions associated with its vehicles by transitioning the paratransit vehicles to propane. Propane vehicles are cleaner, quieter and produce fewer vehicle emissions as compared with vehicles operating with unleaded gasoline. In addition, most of the vehicle models currently operated by VTA (Ford E-350 vans) are available in propane models. There are costs associated with transitioning to propane, including premiums on vehicle prices and costs associated with developing a propane fueling station. Fuel cost savings may accrue to VTA, but the revenue stream is tenuous. From a purely financial perspective, the investment makes the most sense if the FTA pays for most of the additional costs and/or VTA works with local partners, like the school district, to transition to propane and a willingness to share investment costs. Additionally, a local propane provider could be willing to help cover part of the costs of developing a fueling station in exchange for a long-term fuel contract.
5.0 IMPLEMENTATION PLAN

Overview
VEIC identified four options for how VTA could continue evaluating alternative fuels and begin to diversify its fuel options:

A. **Continue investment in clean diesel technology and vehicles.** In the short-term (see Figure 1), VTA could continue to invest in new clean diesel technology and vehicles, while experimenting with an electric bus pilot project and bringing together stakeholders to discuss renewable natural gas.

B. **Conduct electric bus pilot project.** In the next year or two, VTA should initiate a pilot project to gain experience with electric buses and understand the opportunities and challenges associated with integrating them into VTA operations.

C. **Depending on results of pilot, expand electric vehicle fleet.** VTA may operate the electric bus pilot for 12 – 18 months, tracking both the qualitative and quantitative aspects of the vehicles. If appropriate, VTA may make a bigger investment into electric bus technologies.

D. **Initiate partnerships to develop renewable natural gas locally on Martha’s Vineyard.** VTA could start talking with Island stakeholders to broadly assess interest in renewable natural gas. These early conversations can be used to gauge interest and enthusiasm for pursuing a larger project.

This implementation plan costs an estimated $11 million, including costs for replacing existing buses with clean diesel vehicles, an electric bus pilot project, expanding VTA’s electric bus fleet to include six buses and two on-route inductive charging stations, and a natural gas feasibility study (see Figure 18). A general implementation schedule of the recommended program is included as Figure 19. More detail on each stage of the implementation plan is provided in the following section; information on the funding is available in Appendix B.

**Figure 18: VTA Alternative Fuel Vehicle Implementation Budget – Proposed**

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace buses with clean diesel vehicles</td>
<td>$826,000</td>
<td>$1,239,000</td>
<td>$1,652,000</td>
<td>$1,652,000</td>
<td>$826,000</td>
</tr>
<tr>
<td>Replace paratransit vehicles (gasoline)</td>
<td>$150,000</td>
<td>$150,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implement electric bus pilot project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of electric bus</td>
<td>$450,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required infrastructure improvements</td>
<td>$50,000</td>
<td></td>
<td></td>
<td>$100,000</td>
<td></td>
</tr>
<tr>
<td>Renewable natural gas feasibility study</td>
<td></td>
<td></td>
<td></td>
<td>$75,000</td>
<td></td>
</tr>
<tr>
<td>Evaluate electric vehicle pilot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$75,000</td>
</tr>
<tr>
<td>Optional - may be prepared internally</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expand use of electric buses in fleet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase six vehicles</td>
<td></td>
<td></td>
<td></td>
<td>$2,700,000</td>
<td></td>
</tr>
<tr>
<td>Inductive / wireless on-route chargers</td>
<td></td>
<td></td>
<td></td>
<td>$1,000,000</td>
<td></td>
</tr>
<tr>
<td>Infrastructure improvements</td>
<td></td>
<td></td>
<td></td>
<td>$100,000</td>
<td></td>
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<tr>
<td>Total - five year program</td>
<td>$1,476,000</td>
<td>$1,314,000</td>
<td>$1,877,000</td>
<td>$1,652,000</td>
<td>$4,726,000</td>
</tr>
</tbody>
</table>

**Buses Purchased**

<table>
<thead>
<tr>
<th>Type</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Route Bus - Diesel</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Fixed-Route Bus - Electric</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Demand Response</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: VEIC
Notes: Assumes cost of 30’ diesel bus is $413,000 (New Flyer MiDi) and the cost of 30’ electric bus is $450,000. Prices are not adjusted to account for inflation. Gasoline paratransit vehicles are assumed to cost $75,000 each.
A. Continue Investing in Clean Diesel Vehicles
Since 2010, diesel engines and vehicles have become cleaner. Clean diesel advanced when engine manufacturers were able to combine ultra-low sulfur fuel blends with diesel particulate filters and emissions exhaust controls. The new fuel blends increased the effectiveness of the exhaust control systems, so newer (model year 2010 and beyond) diesel vehicles are significantly cleaner and greatly reduce emissions.

VTA’s current vehicle replacement plan involves replacing diesel buses that have reached the end of their useful life with new models. As the fleet turns over and buses built before 2010 are replaced, VTA’s buses will become increasingly clean with significantly fewer emissions.

Implementation
VTA has a vehicle replacement plan that adheres to the guidance and requirements of the FTA and the Massachusetts Department of Transportation (MassDOT). VTA works closely with the statewide transit association (Massachusetts Association of Regional Transit Authority, MARTA) to guide the statewide vehicle procurement process. Consequently, replacing diesel vehicles with newer generation diesel vehicles will be relatively straight-forward. It should reduce fleet emissions and improve the overall fleet fuel economy.

An additional step VTA may consider over the next five years is to increase data collection. VEIC recommends recording additional maintenance costs associated with maintaining and cleaning the higher technology diesel exhaust equipment. This data will help VTA better evaluate and assess the costs and benefits of different systems.
2 International HC 29’ buses
3 Eldorado 32’ buses
1 International HC 29’ bus

2019

Total

22

$1,652,000

2020

2 Eldorado 32’ buses
1 Eldorado 29’ bus
2 International RE 40’ buses
3 International RE 35’ buses

2**

$826,000


15

$6,195,000

Source: VEIC adapted from VTA data
Note: Assumes all replaced vehicles will be 30’ New Flyer MiDi buses with a price of $413,000 each; *Assumes VTA will purchase one electric bus in 2016; ** Assumes VTA purchases six electric vehicles.

Cost and Funding
This approach to turning over the fleet will cost roughly $6.2 million over five years, and includes the purchase of 15 30’ diesel buses. This assumes VTA purchases one electric vehicle in 2016 and six more in 2020; if VTA does not buy electric buses, the cost for diesel vehicles will increase. The cost estimate assumes VTA will buy New Flyer MiDi buses (estimated cost $413,000) and the cost of individual buses will not increase over time. Funding for these replacement vehicles should be available from traditional transit funding programs available through the FTA and MassDOT.

B. Conduct an Electric Vehicle Pilot Project
Electric transit vehicle technology is sufficiently mature: it has passed FTA testing programs and proven successful in a variety of operating environments nationally. Electric buses are cleaner, quieter and more fuel efficient than traditional diesel vehicles, and are less expensive to operate. Despite these attributes, there are some challenges and questions regarding the deployment of electric buses—largely associated with limited travel range. VEIC recommends that VTA initiate a pilot project to test an electric vehicle in operation on Martha’s Vineyard, track and record their experience with the vehicle, and use these findings to make decisions regarding future deployments. One advantage of a pilot project is that VTA can gain experience with the technology without making expensive capital investments.

VEIC recommends conducting the pilot project with a Build Your Dreams (BYD) 30’ K7 model bus. This bus is marginally more expensive than a similar diesel model, but higher fuel economy and lower fuel costs make the vehicle less expensive to operate and cost effective over the lifetime of the vehicle. Integrating one or two electric buses into the fleet means VTA will be able to test the vehicle’s performance in operations and explore the effectiveness and efficiency of using electricity as a vehicle fuel source.

In the short term, the main benefits achieved by the electric transit bus pilot include reduced vehicle emissions, quieter operations and lower operating costs. Over the longer term, an investment in electric vehicle technology can protect VTA against fluctuations in the price of diesel and positions the agency to integrate clean renewable energy into its operations, such as solar and wind.

Implementation
VEIC estimates a pilot project would require two years; roughly nine months to get a bus on-site (assumes three months for procurement and six months for vehicle production); plus another 12 to 18 months to both drive the bus and experience operations and maintenance over changes in climate and operating schedules. The last three months of this time period can be used to conduct an evaluation of VTA’s experience with the electric bus. This schedule positions VTA to expand the number of electric buses in its fleet in time for FY19 and FY20 procurements. The probability of a successful pilot project increases with planning. VEIC recommends the following steps:

- **Begin discussions and negotiations with Cape Light Compact**: As soon as VTA confirms their interest in an electric bus pilot, they should begin talking with Cape Light. These early
conversations will ensure Cape Light knows about VTA’s project and ensures VTA understands electricity charges, including where there are opportunities to lower their rates and where higher rates may be charged (demand charges).

Purchasing an electric bus will change VTA’s relationship with Cape Light. VEIC estimates that operating an electric vehicle, will increase VTA’s electricity consumption by between 6,500 and 7,500 kWh per month\textsuperscript{16}, or roughly 78,800 to 90,000 kWh annually. Assuming, VTA pays $0.10 per kWh, this will increase VTA’s electricity costs by $650 - $750 per month, or up to $9,000 per year. Actual costs will depend on VTA’s negotiations with Cape Light. Being classified as an industrial consumer of electricity, for example, would reduce winter electricity rates by 40%. Other questions about charging practices will have a direct impact on how much VTA pays for electricity.

Cape Light will likely encourage VTA to charge buses at night, especially during the summer months to avoid times when electricity demand is highest. Information on time of use rates, demand charges and peak periods/peak seasons are not available at this time, but it is common for utilities to charge higher rates during times of peak demand and in peak seasons. Understanding these charges are important so that VTA does not inadvertently charge the vehicle when prices are high (i.e., late afternoon).

- **Consider Site Modifications and Upgrades:** BYD includes a charging unit with the vehicle purchase that can charge the buses’ battery in two to three hours. Given that VTA’s initial step will be to only purchase one electric bus and operate it as a pilot, we do not anticipate the need for substantial upgrades to its facility on 11 A Street in Edgartown. For the pilot project (assuming it is one vehicle), VEIC recommends installing the charger (and parking the bus) as close to an electrical source as possible (see Figure 21) to limit the amount of site work needed. The cost to install a depot charger, assuming it is placed conveniently near an electrical source, is roughly $10,000.

\textsuperscript{16} Broad estimate based on vehicle being charged twice a day, one full charge and one charge when battery is at a 50% state of charge. Assumes charging process is 80% efficient and 30 days per month.
**Evaluate Service Integration:** The (seemingly) most logical route to operate with an electric vehicle is Route 10. This route travels a short distance between the Tisbury Park and Ride lot and the Steamship Authority Terminal in downtown Vineyard Haven. This is an appropriate deployment of the electric bus because daily mileage is within the vehicle range; and the route includes downhill travel, allowing the battery to be charged through regenerative braking. Route 10 travels a congested route; electric bus engines shut down when idle, reducing fuel consumption and noise. VTA may test the vehicle on other routes to better understand vehicle performance and how the range varies under different operating conditions.

**Meet with the Town of West Tisbury to discuss potential of backup electric vehicle charging station at West Tisbury Park and Ride Lot:** Assuming VTA deploys the electric bus on Route 10, VEIC recommends installing a second vehicle charger at the Tisbury Park and Ride lot. Although not technically required, the additional charging station will provide some redundancy in the system and reduce the chance a bus driver runs out of power. VTA will need to negotiate the siting of the charging equipment with the Town of Tisbury, including how to measure and report electrical usage (and costs). This could be done by installing a sub-meter, estimating costs, or installing a networked charger that can track use. This discussion should also consider if VTA and the Town would like to make any electric vehicle charger available to members of the public.

Although there is electrical power at this location, some site work may be required. VEIC recommends budgeting $15,000, about $2,500 for the charging equipment (power interface), plus up to $12,500 to install the charging system. This budget should be sufficient to cover other installation costs, such as signage, bollards to protect the charger from snow plowing, striping, and locks to protect it against vandalism.

**Consider driver and mechanic training needs:** VTA drivers and mechanics will need to be trained on electric vehicle technology, including how to charge, drive and maintain the vehicles.
This training should be provided by the vehicle manufacturer and include both on-site assistance as well as follow up support. In terms of driver assignments, experience of other transit agencies suggests offering training on the electric bus to interested drivers. Allowing drivers to self-select participation in the project helps ensure drivers are supportive of the technology and are more likely to be committed to its success.

- **Explore marketing opportunities:** One of the primary benefits of operating electric transit vehicles is improved public perception of VTA services as cleaner, greener, and quieter. By developing and executing a pilot project, VTA is demonstrating leadership in vehicle technology; they will be the first rural system in Massachusetts and New England to operate electric buses. VTA should leverage these attributes and ensure members of the public are aware of the electric bus. This may include advertising the vehicle’s attributes with decals placed on the bus or through posters and printed material displayed at bus stops and tourist facilities.

- **Issue a Request for Proposal for 30’ Electric Vehicle:** Given VTA’s preferences for a smaller vehicle and their operating needs, VEIC recommends VTA explore BYD’s K7 vehicle. This vehicle is 30.7 feet long, 95.7 inches wide and 126.9 inches tall and capacity for 40 passengers (including standees). The vehicle has a published range of 144 miles, a range that VTA can plan around. According to BYD, the range estimate assumes heating or cooling systems are operating and that the driver has minimal experience. It also accounts for some erosion of the battery capacity over time.

  Information provided by BYD indicates the K7 model costs $450,000 and takes roughly six months from the time the vehicle is ordered to delivery. As part of the procurement process, VTA should require training for drivers and mechanics, access to an on-site mechanic for up to 30 days, and technical support for at least one year. Vehicle specifications should include a vehicle warranty (five years); battery warranty (12 years); battery management system and a managed charging system that automates charging times.

**Costs and Funding**

VEIC conservatively estimates the cost of an electric vehicle pilot project at roughly $500,000, including $450,000 for the vehicle, plus about $50,000 for installing charging equipment at VTA’s facility, purchasing and installing charging equipment at the Tisbury Park and Ride lot, and small amounts of funding for marketing. This is roughly $90,000 more than the cost of a similarly sized clean diesel vehicle.

The electric vehicle is expected to have lower operating costs. Assuming VTA operates the electric transit bus 35,000 miles each year and the average cost per kWh of electricity is $0.10 (diesel is estimated at $1.50 per gallon), based on these approximate calculations VTA will save roughly $7,000\(^1\) as compared with the fuel costs of a diesel vehicle (or roughly $84,000 over the lifetime of the vehicle). These operating costs savings cover most of the increased cost of piloting a single electric bus; however, if VTA opts to expand its fleet of electric buses, additional costs such as installing additional chargers will need to be considered (see next section).

VTA may fund its pilot project using its existing capital program. The increased capital costs of an electric bus over a diesel vehicle, estimated at around $90,000, may be within the discretion of VTA’s capital budgeting process. Using VTA’s existing capital program to fund the pilot allows VTA to begin implementation in FY17.

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\(^1\) Assumes bus travels 35,000 miles per year; a diesel bus has a fuel economy of 6.0 miles per gallon and the cost of diesel fuel is $1.50 and an electric bus has a fuel economy of 2.065 kWh per mile and the cost of electricity is $0.10957 per kWh.
C. Expand use of Electric Vehicles

Depending on its experience with the electric bus pilot project, VTA may opt to integrate more electric buses into its fleet. An ideal time to make this decision would be in FY18, after VTA has experience with the electric bus pilot but in advance of FY20, when VTA is scheduled to replace eight buses. Assuming VTA is able to begin work on the pilot project during FY17, it should have sufficient experience with electric vehicle technology to evaluate strengths, weaknesses and opportunities.

Implementation

VTA’s decision to expand use of electric buses in its fleet will be based on two factors: experience with the pilot project and funding. Implementation plans, therefore, must account for both of these steps.

The pilot project will guide VTA’s investment plans regarding electric buses. In anticipation of this decision, VTA should treat the initial purchase of an electric bus as a true pilot or demonstration project by monitoring and tracking performance of the vehicle. Critical data points include:

- Costs to fuel/charge the vehicle
  - Cost of nighttime charging at VTA’s facility
  - Cost of ad hoc charging at Tisbury Park and Ride lot
  - Compare with estimated costs
  - Compare with cost to operate diesel bus

- Charging experience and vehicle range in the field
  - Assess (qualitatively) ease/challenges associated with charging buses
    - In depot charging
    - Ad hoc charging at park and ride
  - Vehicle range achieved in field
    - Variations by time of year, route, driver and passenger loads

- Inventory driver experiences with and perspectives on vehicle performance

- Inventory maintenance experience with vehicles
  - Mechanics’ perspectives
  - Track days vehicle is in service
  - Track maintenance costs associated with electric bus
  - Compare / contrast with diesel vehicles

- Collect community and riders’ comments about the bus

Quantitative data associated with the operating and maintenance costs, and the vehicle range will help VTA understand the monetary savings associated with operations, as well as to what extent the electric buses can be integrated into service (including which routes). Qualitative data collected from drivers and mechanics will help VTA understand how well the vehicle performs and handles in the field, especially in times of heavy usage.

Expanding the number of electric buses in its fleet will require additional investments, both to accommodate charging at the VTA facility but also to support transit operations. The two main investments include 1) upgrading VTA’s facility to accommodate increased electric usage and installing vehicle chargers at a designated location in the bus parking area; and 2) expanding use of on-route charging systems, potentially including the installation of inductive charging. These activities likely mean that VTA will need to apply for grant funds.
Costs and Funding
The cost to increase VTA’s electric bus fleet from one vehicle to seven (adding six vehicles) is estimated at $3.7 million\(^{18}\). This estimate includes:

- $2.7 million to purchase six electric buses, assuming the 2016 price of $450,000 per vehicle
- Between $500,000 and $1 million to install wireless (inductive) on-route charging infrastructure at key locations in VTA’s service network. With seven vehicles, it is likely VTA would only need one on-route charger, but this depends on VTA’s operational plans (VEIC’s overall budget assumes two systems are installed). Inductive charging system costs are estimated at roughly $500,000 per site, inclusive of the cost to purchase ($350,000) and install ($150,000\(^{19}\)) the equipment.
- $100,000 to upgrade the electrical infrastructure at VTA’s facility and to develop an electric bus charging station in the parking lot. These may be reduced slightly from investments made during the pilot phase.

VTA should be able to access federal grant funds to expand use of electric buses. FTA funding includes vehicle replacement programs as well as specific programs to support investments in clean fuel technologies. Several of these programs have funds set aside for rural agencies (see Appendix C). In addition, as of 2016, the Commonwealth of Massachusetts’ Department of Energy Resources (MA DOER) has grant funding available to support an inductive charging demonstration project.

A challenge with the funding, however, is timing. Funding for alternative fuel transit vehicles is governed by the FAST Act, which is authorized from 2016 until 2020. This funding, therefore, should be available to VTA, if and when the agency decides to purchase additional alternative fuel vehicles. In addition, part of new administrative rules incorporated into the FAST Act requires the FTA to be more consistent with grant application schedules. As a result, VTA should be able to anticipate funding announcements. Nonetheless, as soon as VTA thinks it may be interested in purchasing more electric buses, it should begin to work with MassDOT and follow grant schedules.

The MA DOER funding for inductive charging is less certain than the FAST Act and it may be on a schedule that is different from VTA’s usual grant cycles. Additionally, the MA DOER funding may take several months to be awarded and distributed. VTA should begin working with the MA DOER sooner rather than later in order to access these funds for a potential project, even if VTA is not entirely certain it will further advance the technology.

D. Develop Natural Gas Locally on Martha’s Vineyard
Natural gas is an appealing choice for VTA because natural gas vehicles are compatible with VTA’s operations and can be integrated into VTA route network with minimal planning or adjustments. In addition, VTA’s current fleet could operate with natural gas, including fixed-route and paratransit vehicles. Without access to a pipeline, however, using natural gas is cost prohibitive for VTA.

An alternative option would be to generate renewable natural gas (or biogas) locally on Martha’s Vineyard. Natural gas could be produced on Martha’s Vineyard by developing anaerobic digestion capabilities at the island’s waste water treatment plants\(^{20}\). Locally produced renewable gas sold to VTA would create a sustainable, closed system where energy is both produced and consumed locally. There

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\(^{18}\) As a comparison, six diesel bus would cost $2.5 million, roughly $1.2 million less than the investment required for electric buses.

\(^{19}\) Installation costs may vary but assume some cable work will be required to bring electricity to the location where buses will charge. It is possible that VTA may be able to select locations for inductive charging based on installation costs.

\(^{20}\) There are other options for producing natural gas locally, including through landfills or livestock, but the present scale of wastewater treatment operations on Martha’s Vineyard is not large enough to produce significant quantities of biogas.
are challenges with this strategy, however, including 1) ensuring enough natural gas can be produced locally to support VTA’s needs, especially in the summer months; 2) finding grant funds to support the infrastructure costs needed to build the production and distribution systems; and 3) the cost and opportunities associated with developing redundancy in the system, so VTA is assured of always having access to the gas needed to operate service.

VEIC did not conduct a full analysis of the production potential of natural gas on Martha’s Vineyard. However, the “rule of thumb” from the U.S. Environmental Protection Agency (EPA) is that 100 gallons of treated wastewater produces about one cubic foot of natural gas; one cubic foot of gas equals about 0.012 gallon equivalent units. Based on a report published by the Martha’s Vineyard Commission in 2007, the five waste water treatment plants (Edgartown, Oak Bluffs, Tisbury, Airport [Dukes County] and Wampanoag) have capacity to treat about 1.3 million gallons each day. If used to capacity, the five treatment plants would produce about 156 gallons of natural gas a day, enough to meet about one-third of VTA’s daily needs. Published information on waste water treatment on Martha’s Vineyard dates back to 2007. This data suggests that waste water treatment plants were treating less than 15% of all waste water on the island and processing about 300,000 gallons of water per day, or about 105 million gallons of water annually. This suggests that historically, the island has not treated sufficient volumes of waste water to meet VTA’s needs, but there is potential to increase treatment levels.

One potential strategy to increase renewable natural gas supply may be to incorporate food waste to waste water treatment plants; a process referred to as co-digestion. In November 2012, the Massachusetts Department of Environmental Protection (Mass DEP) amended its solid waste management facility and wastewater treatment facility operation, maintenance and pretreatment regulations to increase in-state capacity to process and recycle organic materials. In 2014 the Mass DEP banned the disposal of commercial organic waste by large institutions and businesses. These two state initiatives increase the potential that if a waste water treatment plant on Martha’s Vineyard was to invest in an AD system, they could practice co-digestions to increase natural gas production.

Implementation
The first steps towards implementation involves convening a working group to assess the level of interest on Martha’s Vineyard to move this type of project forward. An early meeting will include estimates of current waste water treatment levels (how many gallons per day) and other updates regarding waste water facilities and treatment levels. This group should inventory the existing volume of waste water being treated on the island and other potential methods to expand production.

VTA is best suited to be a partner in the process, rather than as a lead agency. Of particular interest to VTA is the ultimate cost per unit (gallon equivalent) of natural gas produced. A starting point in the conversation may be setting a goal to produce natural gas at roughly the same cost – or slightly higher – as diesel fuel.

Costs and Funding
Given the current level of production and the fact that even at full capacity, existing waste water treatment plants are unable to fully meet the VTA fuel needs, development costs should include increased facility capacity plus at least one anaerobic digester. The actual cost of purchasing and installing an anaerobic digester system will vary greatly depending on a number of factors, which are not well known. MA DEP offers financial support to public entities interested in installing anaerobic digester systems.

The system requires additional investment on the part of VTA. To use gas from an anaerobic digester system, VTA would need to install a gas scrubber/upgrader, a gas compressor, and a fueling station, which could cost between $3 million and $6 million. Each waste water treatment plant would need its own anaerobic digester in order to harness the gas produced. This gas could then be theoretically piped to one location to be scrubbed, upgraded, and compressed for use in vehicles. It should be noted that the cost for these systems have gone down significantly in the last few years and it is predicted their
costs will continued to drop. Funding is likely available to support part, but not all of the needed infrastructure.

The total cost of the infrastructure, including the investments to produce renewable natural gas and the investments to compress it and create a fueling station will determine the cost per unit. Part of the analysis of costs and benefits should include how much the unit of gas (gallon equivalent) will end up costing VTA. As mentioned, VTA may express their interest in buying fuel, but set limits on the amount it is willing to pay per unit. Funding to guide the development process and/or early technical analyses maybe available from the U.S. Department of Agriculture, specifically the Rural Energy for America Program (see section on Funding).
APPENDIX A

A.1 Ultra-Low Sulfur “Clean” Diesel (ULSD) Fuel and Biodiesel

Diesel fuel is one of the most common types of transportation fuels in the United States. It is the primary fuel used in medium and heavy duty vehicle applications, including public transit. Like gasoline, diesel is made from crude oil. About 60% of crude oil is produced domestically and 40% is imported from other countries. As compared with gasoline, diesel is heavier, denser, less flammable and less volatile. The strength of diesel fuel over gasoline is that it has more energy per gallon; so vehicles using diesel have better fuel economy. Vehicles operating with diesel fuel, however, require a high compression engine, which is more expensive to build.

Most heavy duty vehicles in the United States, including VTA, run on ultra-low sulfur diesel (ULSD), a variation of diesel fuel that has substantially less sulfur. Refining diesel to burn as ULSD is required by the U.S. Environmental Protection Agency (EPA) in combination with regulations mandating cleaner burning engines. ULSD is more expensive to refine as compared with earlier types of diesel fuel, but it burns significantly less sulfur with earlier blends of diesel fuel.

The implementation of diesel fuel blends with lower sulfur contents also increases the effectiveness of engine exhaust control systems. These systems are installed on new engines and can be retrofitted to existing engines. Exhaust control systems reduce particulate matter emissions (diesel oxidation catalysts (DOCs); diesel particulate filters (DPFs); closed crankcase ventilation (CCVs); and exhaust gas recirculation (ERG)) as well as nitrogen oxide (NOx) emissions (selective catalytic reduction (SCR); lean NOx catalysts (LNCs); and lean NOx traps (LNTs)). In addition, EPA regulations require that heavy duty vehicles add diesel exhaust fluid (DEF) to their exhaust systems. DEF is a nontoxic, nonpolluting, non-hazardous solution that reduces nitrogen oxide emissions. It improves engine combustion and fuel efficiency and reduces vehicle maintenance. DEF costs between $4.00 and $5.00 per gallon and vehicles use three to four gallons of DEF (3-4%) per 100 gallons of diesel fuel. The end result of fuel blends and engine and exhaust emission control systems is significantly cleaner vehicles and much reduced emissions.

All on-road diesel vehicles, including transit vehicles, manufactured after 2010 operate with ULSD. VTA’s existing transit fleet burns ULSD. ULSD is the baseline fuel against which alternative fuels will be compared. The price for ULSD on February 29, 2016 was $1.78 per gallon; this is higher than VTA’s negotiated cost of $1.42.

Biodiesel

Bio-diesel is a derivative of diesel fuel used by many transit agencies. Biodiesel blends are mixtures of petroleum diesel fuels and fuels produced from soybean oil, waste cooking grease, or other organic matter. Biodiesels may contain different concentrations of organic fuels ranging from two percent to levels approach 100 percent by volume. Most vehicles, including transit vehicles, can use concentrations of up to 20% biodiesel without changes to the engine.

The advantages of biodiesel include that it is safe, biodegradable and produces less emissions as compared with regular diesel fuel. Biodiesel also improves fuel lubricity and can reduce wear on engine parts. The challenges with biodiesel is that it has lower fuel economy, can be more expensive to buy as compared with ULSD, and supplies can be limited. Some transit agencies also experienced challenges with higher concentrations of biodiesel degrading engine seals, fuel filters and fuel injectors. As of

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21 U.S. Energy Information Administration
22 Autozone
23 U.S. Energy Information Administration, Weekly Retail Gasoline and Diesel Prices – East Coast PADD1 January, 11, 2016
February, 2016, biodiesel was not available on Martha’s Vineyard. It is available on Cape Cod, however, and could be transported by truck to the island; costs for B20 (20% biodiesel/80% diesel) would be roughly equivalent to diesel costs.

**Fueling Systems**

As discussed, there are no fuel lines to Martha’s Vineyard and diesel fuel is transported to the island by barge. Shipments arrive on the island daily. Both the transportation shipping (barge) company and VTA have on-site storage, so back up supplies are available if the transportation service is interrupted. VTA has two fuel tanks on its property, plus a tank for diesel exhaust fluid (DEF)\(^25\), which are dispensed through three fueling pumps. DEF is available at one pump only. The diesel tank holds 8,000 gallons (usable space is about 7,200 gallons) and the unleaded tank has capacity for 2,500 gallons. The DEF tank holds 1,000 gallons of fluid. In Fiscal Year (FY15), VTA purchased 158,454 gallons of diesel and spent roughly $225,000 on diesel fuel.

**Potential Application for VTA**

VTA currently operates clean diesel vehicles. VTA’s newest vehicles not only burn ULSD diesel fuel formulations but also incorporate new exhaust technology, which reduces vehicles emissions as compared to earlier diesel vehicles and many alternative fuel vehicles. A realistic course of action, therefore, would be to continue to invest in diesel technology, recognizing the fuel source is a clean and cost effective for operations. An investment in diesel technology also retains the potential to incorporate biodiesel into the fuel mix as a way to diversify fuels and reduce emissions further.

**Operational, Environmental, and Maintenance Impacts**

**Operations**

Diesel engines perform well in transit operations; this is one of the reasons the fuel has been so widely adopted in heavy-duty vehicle operators. VTA already uses diesel fuel; this means from an operations perspective it is the most simple and straightforward option. VTA has established fuel and storage systems, including an onsite storage tank and fuel dispensing system. Additional fuel storage is available through the fuel supplier, which creates some redundancy and security in the system. Vehicles can be fueled relatively quickly and are nearly always fueled overnight, so buses are ready to pull out in the morning.

Diesel fuel also has the advantage of offering the most variety in terms of vehicle types and availability. VTA replaced four diesel vehicles in 2014 and four more in 2015. These vehicles included the International HC (30’/7-year vehicle), the International RE (40’/10-year vehicle) and the New Flyer MiDi (30’/12-year vehicle). These vehicles have already been integrated into VTA operations and have performed well. The International and New Flyer vehicles also meet VTA operational needs in terms of their ability to travel up to 300 miles on a single refueling. Both vehicles are also 96” wide. The International RE has capacity for 52 passengers, while the 30’ MiDi has capacity for 24 passengers (seated) plus another 30 standees.

**Environmental**

Vehicle emissions are typically the primary environmental consideration associated with fuel use. Other environmental concerns include vehicle noise and to a lesser extent, perceptions about noxious odors and visible emissions. Another important consideration is the availability of the fuel from domestic sources and the ability of the fuel to be produced from renewable sources. In 2015, about 25% of the petroleum products used in the United States was imported\(^26\). Diesel is produced from crude oil, which is a petroleum product. Thus, while it is not a renewable fuel, a large portion of U.S. diesel fuel is produced domestically.

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\(^{25}\) Diesel Exhaust Fluid is a non-hazardous solution (32.5% urea and 67.5% de-ionized water) that is sprayed into the exhaust stream of a diesel vehicle to break down NOx emissions into nitrogen and water.

\(^{26}\) U.S. Energy Information Administration
Discussions about vehicle emissions usually refer to two types of pollution – regulated and unregulated pollutants. Regulated pollutants impact air quality and largely consist of carbon monoxide (CO), nitrogen oxide (NOx), and particulate matter (PM). These pollutants are policed by the EPA, consequently fuel blends are designed to minimize the amount of these substances emitted by vehicles. Unregulated pollutants include greenhouse gas emissions that contribute to global warming.

Data on vehicle emissions is difficult to collect and typically varies by vehicle make and model as well as operating conditions. With this caveat, VEIC collected emissions data from research published by EMARQ, which is part of World Resources Institute’s Ross Center for Sustainable Cities. This data was collected from transit vehicles in service. It is not a perfect data set or sample, but represents real-world experience and compares different fuels and technologies. According to EMARQ’s dataset, ULSD vehicles only meet EPA 2010 standards when they are also equipped with diesel oxidation catalyst systems (see Figure A1). With these technologies, however, emissions are significantly reduced, even over biodiesel and other alternative fuels. If similar technologies were applied to biodiesel, however, emissions could be further reduced.

Greenhouse gases (GHG) pollutants contribute to global warming and are largely and most simply measured as carbon dioxide (CO2). GHG emissions have a significant environmental impact, but are not regulated or tracked by the EPA. Fueling and exhaust systems, therefore, are not designed to meet GHG standards. However, with the growing importance of GHG emissions, data is available (also from EMBARQ) on vehicle performance relative to GHG. This data shows, consistent with the regulated pollutants, the combination of ULSD and exhaust technology are effective ways to reduce emissions.

**Figure A1: EPA Standards, Measured Diesel and Biodiesel Vehicle Emissions**

<table>
<thead>
<tr>
<th></th>
<th>EPA 2010 Standards</th>
<th>Diesel 15(^1)</th>
<th>Diesel 15 DOC(^2)</th>
<th>Biodiesel (B20)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulated Emissions (g/mile)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>15.5</td>
<td>2.256</td>
<td>0.433</td>
<td>1.802</td>
</tr>
<tr>
<td>Nitrogen Oxide (NOx)</td>
<td>0.2</td>
<td>12.193</td>
<td>8.487</td>
<td>11.200</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>0.01</td>
<td>0.307</td>
<td>0.088</td>
<td>0.163</td>
</tr>
<tr>
<td><strong>Unregulated Emissions (in grams/km)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>n/a</td>
<td>1,538.21</td>
<td>1,178.57</td>
<td>1387.00</td>
</tr>
</tbody>
</table>

Source: Exhaust Emissions of Transit Buses, Emarq (www.emarq.org)
Note: 1) Assumes a diesel sulfur content of 15 parts per million; 2) Assumes a diesel sulfur content of 15 parts per million, plus the addition of diesel oxidation catalyst (DOC), such as DEF.

**Maintenance**

VTA’s existing systems and infrastructure are designed to support diesel fuel. Staff is well versed in diesel engine maintenance needs and is familiar with the vehicle models operated by VTA. At the same time, new vehicle exhaust technologies incorporated into new vehicles have created maintenance challenges. Many of the vehicle exhaust cleaning systems are designed to burn off – or regeneration cleaning – debris out of filters. A challenge for VTA results because there are no high speed roadways on Martha’s Vineyard, so cleaning new vehicle exhaust systems has proven challenging. The cost impact of the newer exhaust systems has not been systematically recorded.

As discussed, biodiesel could be incorporated into VTA operations. Most transit agencies use biodiesel because it is cleaner, is almost always locally (or regionally) produced, and is biodegradable. Biodiesel also offers some maintenance benefits by improving the fuel lubricity and reducing wear on engine parts. Some transit agencies, however, have experienced challenges with biodiesel degrading engine seals, fuel filters and fuel injectors. In most cases, however, these challenges were associated with high concentrations of biodiesel\(^{27}\). National experience varies, however; some agencies have easily integrated biodiesel into their systems, while others have had more problems.

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\(^{27}\) St. Louis Metro Biodiesel (B20) Transit Bus Evaluation, National Renewable Energy Laboratory, 2008
Maintenance costs can be difficult to measure; and expected savings in maintenance costs can be difficult to realize, especially for a small agency like VTA. One way to measure maintenance cost savings is by comparing days a vehicle is in service. Another, more popular method is to estimate the cost per mile to maintain different vehicles. In either case, a comprehensive dataset that compares a variety of fuel types is not available. National data suggests that the cost to maintain a diesel vehicle is about $0.34 per mile. This does not include new exhaust technologies, nor does it consider local operating conditions. The data does suggest, however, that there is no measureable difference between vehicles burning diesel and biodiesel fuels (see Figure A2).

**Figure A2: Diesel Vehicles - Estimate Maintenance Costs**

<table>
<thead>
<tr>
<th>Maintenance Costs</th>
<th>Diesel</th>
<th>Biodiesel (B20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propulsion System Maintenance ($/mile)</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Facility Maintenance and Operation ($/mile)</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Total ($/mile)</td>
<td>.34</td>
<td>.34</td>
</tr>
</tbody>
</table>

Source: VEIC based on TCRP Report 146 Guidebook for Evaluating Fuel Choices for Post-2010 Transit Bus Procurements

**Transportation Costs**

Diesel fuel is available on Martha’s Vineyard. It is transported by barge. VTA pays $1.42 per gallon of diesel fuel, of which roughly $0.285 (20%) is associated with transportation, operations and profit. Biodiesel dealers typically match the local diesel fuel costs. The national price of biodiesel, however, is higher than the price of diesel.

**Strengths, Weaknesses and Considerations**

Diesel is the most common fuel used by transit properties and is currently used by VTA as well as nearly every other transit agency in New England. In 2016, diesel fuel is widely available at a low price. The long term price stability, however, is not guaranteed.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Lowest cost vehicle</td>
<td>- Fuel prices are volatile</td>
</tr>
<tr>
<td>- VTA staff is familiar with the technology</td>
<td>- Noisiest alternative</td>
</tr>
<tr>
<td>- Technology meets VTA operational needs</td>
<td>- Highest polluting alternative</td>
</tr>
<tr>
<td>- VTA has secured low cost fuel prices</td>
<td>- Vehicle models burning ULSD and DEF have ongoing maintenance issues</td>
</tr>
<tr>
<td>- Diesel vehicles available in fixed-route and paratransit models</td>
<td></td>
</tr>
</tbody>
</table>
A.2 Diesel Electric Hybrid

Technically hybrid-electric vehicles are not classified as alternative fuel vehicles because they burn diesel fuel. However, the technology was developed to increase fuel economy, reduce fossil fuel consumption and decrease vehicular emissions, traits that are consistent with the use of alternative fuels.

Diesel electric hybrid (“hybrid-electric”) vehicles operate with diesel fuel, so technically do not use alternative fuels; however, the engine technology is broadly classified as an alternative fuel vehicle. Hybrid-electric buses use technology similar to that used in hybrid cars and trucks (like the Toyota Prius), except buses are typically fueled by diesel instead of gasoline. Vehicles combine a conventional internal combustion engine propulsion system with an electric propulsion system to create a hybrid vehicle drive train. Including the electric system increases the vehicles’ fuel economy and helps reduce emissions and vehicle noise. Hybrid-electric technology is widely deployed in the United States; about 18% of the national transit fleet consists of hybrid-electric buses. Several major bus manufacturers, including Gillig, New Flyer and Nova Bus offer hybrid models.

Other advantages of hybrid vehicle technology include automatic start/shutoff and regenerative braking. Automatic start/shutoff shuts down the engine when the vehicle comes to a stop and restarts it when the accelerator is pressed. This reduces emissions and prevents wasting energy and during idling. Regenerative braking uses the electric motor to apply resistance to the drivetrain, causing wheels to slow down. In return, energy from the wheels turns the motor and converts the kinetic energy into electric energy, which is subsequently used to charge the vehicle battery.

Fueling Systems

Hybrid-electric buses are fueled with the same blend of ULSD as diesel buses and can operate with biodiesel. The battery is charged by the diesel engine, so there is no need to plug the vehicle into an electrical source. They also do not require DEF. VTA already has systems to supply and store diesel fuel, so the transition to hybrid-electric technology would be straight-forward.

The batteries installed in hybrid-electric buses need to be replaced every five to seven years. The estimated cost of the hybrid vehicle battery is $30,000 - $50,000 and it is likely that the battery will be replaced once during the useful life of the vehicle.

Potential Application for VTA

The challenge for VTA with hybrid-electric diesel technology is size (width) of the available vehicles. Most hybrid-electric transit vehicles are available as 40’ and 60’ vehicles, with only a handful of manufacturers offering 35’ models. Gillig does offer a hybrid-electric version of its 29’ low floor bus, but even that shorter vehicle is a heavy-duty vehicle that is 102” wide.

Operational, Environmental, and Maintenance Impacts

Operations

The advantage of hybrid-electric technology is that, from an operational perspective, there are few impacts. Hybrid-electric vehicles are essentially diesel vehicles with a smaller diesel engine supplemented by an electric motor. The vehicles generally operate with similar or improved conditions.

28 APTA, 2015 Public Transportation Fact Book
as compared with diesel; they are designed to have better fuel economy, so the range should be increased.

The challenge for VTA is that most of the hybrid-electric vehicles on the market are sized as heavy-duty vehicles and have vehicle widths of greater than 96", typically closer to 102" wide. Operating a larger, heavier duty vehicle will likely be more difficult for some drivers on some routes. Most of the differences, however, can be overcome with training and experience.

**Environmental**

As discussed, hybrid vehicle technology was designed to achieve environmental benefits, namely increased fuel economy, reduced emissions and quieter operations. Hybrid-electric vehicles also burn ULSD and depending on the engine configuration, may or may not incorporate advanced exhaust technologies. In practice, however, anecdotal evidence suggests hybrid-electric vehicles may reduce emissions (especially before higher tech exhaust systems were widely employed) but have not consistently delivered on improving fuel economy. Hybrid-electric vehicles are generally considered quieter as compared with diesel engines.

Figure A3: Vehicle Emissions: EPA Standards, ULSD and Diesel Hybrid-Electric

<table>
<thead>
<tr>
<th>Regulated Emissions (in grams/mile)</th>
<th>EPA Standards</th>
<th>Diesel 15</th>
<th>Hybrid-Electric Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>15.5</td>
<td>2.256</td>
<td>0.623</td>
</tr>
<tr>
<td>Nitrogen Oxide (NOx)</td>
<td>0.2</td>
<td>12.193</td>
<td>9.658</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>0.01</td>
<td>0.307</td>
<td>0.042</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unregulated Emissions (in grams/km)</th>
<th>EPA Standards</th>
<th>Diesel 15</th>
<th>Hybrid-Electric Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>n/a</td>
<td>1,538.21</td>
<td>1,458.86</td>
</tr>
</tbody>
</table>

Source: Exhaust Emissions of Transit Buses, Emarq (www.emarq.org) Notes 1) Assumes a diesel sulfur content of 15 parts per million

**Maintenance**

Maintenance systems required to support hybrid-electric vehicles are similar to those required for diesel vehicles, but have the additional maintenance needs associated with the electrical components. For transit maintenance shops that do not currently maintain electric motors, like VTA, adding hybrid-electric vehicles to the fleet will require staff training, as well as additional parts supply and storage. Vehicle maintenance for hybrid-electric vehicles requires a laptop computer to monitor systems.

Studies conducted by the National Research Energy Labs (NREL) estimated the maintenance costs of two generations of hybrid-electric vehicles, including those operated by New York City Transit and King County Metro. The data is mixed, with some transit operators reporting lower maintenance costs and others reporting higher costs. Data published by the Transportation Cooperative Research Program (TCRP) suggests the costs to maintain a hybrid vehicle are slightly higher as compared with a conventional diesel vehicle (see Figure A4).

Figure A4: Hybrid-Electric Vehicles Estimated Maintenance Costs ($ per mile)

<table>
<thead>
<tr>
<th>Maintenance Costs</th>
<th>Diesel</th>
<th>Hybrid-Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propulsion System Maintenance</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>Facility Maintenance and Operation</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Total</td>
<td>.34</td>
<td>.37</td>
</tr>
</tbody>
</table>

Source: VEIC based on TCRP Report 146 Guidebook for Evaluating Fuel Choices for Post-2010 Transit Bus Procurements

**Facility Maintenance and Infrastructure Costs**

VTA’s current infrastructure, including the maintenance facility and other vehicle infrastructure, such as fuel supply and storage system are designed to support diesel fuel. Hybrid-electric vehicles use diesel fuel, so no additional investment is required to store or fuel vehicles.
Hybrid-electric vehicles do have vehicles batteries that are typically replaced after about seven or eight years of operation. Batteries will need to be disposed of; in some cases, they can be recycled. However, most transit agencies that operate hybrid electric vehicles have not had to modify their facilities to accommodate battery disposal.

**Transportation Costs**
As mentioned, hybrid-electric vehicles use diesel fuel, which is available on Martha’s Vineyard and arrives by barge. VTA does pay a transportation fee to receive diesel fuel; this fee is estimated as $0.285 per gallon, or 20% of the cost of a gallon of diesel ($1.42).

**Strengths, Weaknesses and Considerations**
Hybrid-electric diesel vehicles are widely used in the transit industry, including in Massachusetts. Nantucket Regional Transit Authority (the Wave) operates hybrid buses, as does the Worcester Regional Transit Authority (WRTA) and Merrimack Valley Regional Transit Authority (MVRTA).

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Similar vehicles and operations as diesel, but with better fuel economy</td>
<td>- Vehicles cost 25-30% more as compared with diesel buses</td>
</tr>
<tr>
<td>- Somewhat quieter than diesel</td>
<td>- Transit agencies have had different experiences achieving reported fuel economy (some experience it but not all)</td>
</tr>
<tr>
<td>- Meet VTA operational requirements for range</td>
<td>- Dual mode engine more complicated to maintain</td>
</tr>
<tr>
<td>- Provides some buffer against volatile fuel prices</td>
<td>- Technology largely available for fixed-route vehicle models only</td>
</tr>
</tbody>
</table>
A.3 Electric

Electric transit vehicles, also known as all electric or battery electric (to avoid confusion with hybrid-electric) vehicles are powered solely by electricity stored in a battery pack. For purposes of this study, electric vehicles are defined as those powered by batteries rather than through overhead or catenary wires. In other words, for this study electric transit vehicles are those that must plug in or connect wirelessly to a power source to recharge the vehicle battery.

Electric transit vehicles have gained in popularity over the past few years largely because they produce no greenhouse gas or particulate emissions at the tailpipe. Depending on the source of the electricity, however, there may be emissions associated with electricity production. Other advantages of electric vehicles include that they have quieter engines, lower operating costs, and reduced maintenance costs as compared with diesel vehicles. The main challenge with electric vehicles is the cost of the vehicle, which can be significantly higher than conventionally fueled vehicles. Another challenge is vehicle range. Manufacturers are addressing range concerns with new battery technology that report ranges of 200 miles (or more) on a fully charged battery.

The electric drive train offers considerably better fuel economy as compared with a conventional diesel vehicle because the power train is more efficient overall and other systems, such as regenerative braking recovers energy during braking. As measured in miles per gallon equivalent (MPGe), electric transit vehicles have consistently recorded 22 MPGe as compared with 3.86 mpg for a diesel power transit vehicle.

As of March, 2015, at least three transit bus manufacturers have passed the FTA new Model Bus Testing program, including, Build Your Dreams (BYD Motors), New Flyer and Proterra. Each manufacturer has their own proprietary engine and drain technologies. Another manufacturer, Green Power Technologies, has a line of electric transit vehicles, (model designation EV350) that is scheduled for testing in April 2016.

Fueling Systems

A unique feature of electric vehicles is that instead of putting fuel into a fuel tank, electric vehicles plug into an electrical source to charge the batteries. Electricity is transmitted to Martha’s Vineyard via a cable connecting the mainland and the island. Eversource currently distributes electricity on the island and the Cape Light Compact supplies electricity by buying it from the wholesale market. The Cape Light Compact renegotiates its contract every six months, so rates change, although in general, electricity prices are more stable as compared with other fuel types. Rates for Cape Light Compact Basic Electric Service for January 2016 to July 2016 are: 9.613 cents per kilowatt hour (kWh) for residential; 10.927 cents/kWh for commercial customers and 10.675 cents/kWh for industrial clients.

Potential Application for VTA

Currently, BYD has a vehicle model (K7) that meets most of VTA’s needs in terms of vehicle size and capacity (see Figure A5). BYD also makes two other models that may be considered by VTA, including a 23’ coach bus and a 35’ heavy-duty vehicle. The 40’ K9M model is also included as a reference.

The BYD K7 vehicle meets VTA’s size and capacity needs. It has a range of 144 miles, which means it could be used in several of VTA routes, including Routes 10, 11 and potentially 10A. VTA could begin to transition some vehicles to electric operating systems for vehicles being replaced in 2018. Broader
implementation of electric vehicle technology, however, would almost certainly require some sort of on-route charging capability, potentially an inductive system that is better suited to community aesthetics.

**Figure A5: BYD All-Electric Vehicle Prices**

<table>
<thead>
<tr>
<th>Vehicle Models</th>
<th>Length</th>
<th>Width</th>
<th>Seating Capacity</th>
<th>Range (in miles)</th>
<th>List Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYD C6</td>
<td>23'</td>
<td>81.1&quot;</td>
<td>20</td>
<td>124</td>
<td>$230,000</td>
</tr>
<tr>
<td>BYD K7</td>
<td>30'</td>
<td>95.7&quot;</td>
<td>22+1</td>
<td>144</td>
<td>$450,000</td>
</tr>
<tr>
<td>BYD K9S</td>
<td>35'</td>
<td>102&quot;</td>
<td>32+1</td>
<td>145</td>
<td>$750,000</td>
</tr>
<tr>
<td>BYD K9M</td>
<td>40'</td>
<td>101.2&quot;</td>
<td>41+1</td>
<td>161</td>
<td>$750,000</td>
</tr>
</tbody>
</table>

Source: BYD Motors

**Operational, Environmental, and Maintenance Impacts**

**Operations**

While electric transit vehicles are becoming more widely deployed, they continue to be limited by their operating range. There are two predominant types of systems emerging to charge transit vehicles: shorter-range vehicles that use on-route fast charging systems to stay in operation; and longer-range vehicles that can stay in service for longer distances but are not designed for fast charging. New technologies also allow for inductive charging.

- **Fast charging systems** as discussed have small batteries and shorter ranges (typically 50-60 miles) and rely on being charged frequently and quickly on-route. These types of systems work best when buses return to a central hub or depot frequently. With this type of system, assuming vehicles frequently return to the charger, the range is essentially unlimited. There are two downsides with fast charging systems. The first is costs; the on-route charging systems cost roughly $350,000 to purchase, plus another $50,000 to $100,000 to install. One charger, however, could support multiple vehicles. A second concern with fast charging technology is that frequent charging degrades the life of a battery, most expensive part of the vehicle. The aesthetics of fast charging equipment may also be a challenge, especially if it were to be installed in the locations preferred from an operations perspective (i.e. downtown Vineyard Haven or Oak Bluffs).

- **Extended range vehicles** are designed with larger batteries and have longer ranges. These vehicles are designed to return to a base after being in service for 150 – 200 miles, depending on vehicle model, temperatures and operating conditions. Extended range vehicles do not require on-route chargers, so the systems tend to cost less. However, they are limited by the range; once the battery is depleted, the vehicle must be recharged. Extended range vehicles work well on routes that have shorter daily revenue miles, or systems that have morning and afternoon peaks, which allow extended range vehicles to be recharged between service peaks.

- **Inductive Charging** is a new technology that involves burying charging equipment in the pavement; vehicles park on top of the system in designated places, engage the controls and charge their batteries. The system allows for frequent, short charges that can be accomplished during vehicle layovers. Inductive charging is used with extended range vehicles. Operators use small amounts of charge to maintain sufficient battery charge to continue operations. The equipment is expensive – roughly $350,000 per unit plus another $100,000 or so to install. The advantage is the technology is not limited by the visibility impacts and would be more easily installed at the operationally desirable locations on the island. In April 2016, inductive charging is being tested in a handful of locations (Lancaster, California and Wenatchee, Washington).

VTA’s Route 10 that travels between the Tisbury Park and Ride lot and the Steamship Authority in Vineyard Haven is an attractive route for an electric bus because the bus travels downhill from the park and ride lot to the SSA hub; electric buses are able to capture energy from the breaking process - regenerative braking - to extend vehicle range. Energy (and range) captured through regenerative
braking works best in gradual conditions rather than sudden braking; traveling downhill in congested conditions, for example, is ideal for regenerative braking. Regenerative braking also increases the life of the brake system.

An electric bus could also be used as an overlay vehicle that is in-service for a shorter period of time, i.e. for six to eight hours instead of 12 to 14 hours. With inductive charging, electric buses could be used on most routes that travel 200 miles or less, as long as they are scheduled with five to ten minute layovers every two hours. The longer routes that travel on longer distance inland routes, however, could not easily be integrated into peak season operations.

**Environmental**

Electric vehicles have gained market share in large part because of their environmental impacts. Electric buses emit no pollutants at the tailpipe; they are also cleaner, quieter and produce no noxious odors or visible emissions. Electricity can also be generated locally through renewable sources, such as solar and wind. The impact of cleaner quieter vehicle operations on the local environment is significant. These benefits would likely be valued by Martha’s Vineyard visitors and residents, especially in crowded locations, such as Vineyard Haven, Oak Bluffs and Edgartown.

While the local environment sees considerable benefits, the use of electricity must also consider the production and generation of electricity. The Cape Light Compact purchases electricity that is distributed by Eversource; the purchase contracts are negotiated every six months, so the supply of energy could change. VTA would likely be classified as an industrial user. Cape Light purchases electricity for industrial customers from NextEra Energy Services Massachusetts. In 2016, NextEra Energy generated electricity by natural gas (37%) and nuclear (32%), plus smaller amounts of oil (9%), hydropower (7%) and coal (4%). The emissions associated with electric vehicle operations and electricity production is shown in Figure A6.

The GHG emissions shown in Figure A6 are not tailored to Massachusetts; as a result, it likely overstates emissions from electricity generation. Massachusetts is in the process of cleaning electricity generation statewide. It is planning to close the state’s only remaining coal-fired generator in 2017 and the state’s only nuclear plant, Plymouth Nuclear, in 2019. Massachusetts’ plan to replace the energy generated by these facilities is unclear. In the short-term, natural gas is likely to become a more important generation source, although the ability to maintain the supply at low prices is uncertain. Massachusetts will also likely increase use of renewable sources, including solar but also potentially wind. Wind power is highly relevant to Martha’s Vineyard and VTA. Energy companies are interested in developing wind power off the coast of Massachusetts and Rhode Island, south of Martha’s Vineyard. These wind farms are expected to be capable of producing large amounts of energy and could help Massachusetts – and Martha’s Vineyard – transition to cleaner, renewable sources of energy.

A final advantage of electric vehicles is that electricity can be produced locally. As discussed, Massachusetts’ electricity is primarily produced by natural gas, which is produced domestically. Wind farms, as discussed, could help Massachusetts and Martha’s Vineyard transition to not only a cleaner energy future, but also more local sources of power.

One of the disadvantages of electric vehicles is the batteries. Some vehicle models warrant the battery for the life of the vehicle, but others require replacing the batteries. Increasingly, vehicle batteries are being repurposed for energy storage. If not, they must be disposed, which requires special handling and disposal methods.

**Figure A6: Vehicle Emissions: EPA Standards, ULSD and Electric**

<table>
<thead>
<tr>
<th>Regulated Emissions (in grams/mile)</th>
<th>EPA Standards</th>
<th>Diesel 15¹</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>15.5</td>
<td>2.256</td>
<td>0.0</td>
</tr>
<tr>
<td>Nitrogen Oxide (NOx)</td>
<td>0.2</td>
<td>12.193</td>
<td>0.0</td>
</tr>
</tbody>
</table>
### Maintenance

Electric vehicles are expected to have lower maintenance costs. Lower maintenance costs result from the fact that the vehicle has a simple motor and power train system that consists of fewer parts. As a result, the vehicles require less routine maintenance (oil changes, brake pads, spark plugs). There are also fewer parts to purchase, inventory and store. TCRP data estimates the cost of electric vehicles at roughly half of the cost of maintaining diesel vehicles (see Figure A7). However, as discussed, realizing the lower maintenance costs can be challenging, especially when there are only a handful of electric buses in a fleet and for small transit agencies, like VTA, where the staff is small.

If electric vehicles are incorporated into the fleet, mechanics and technicians will need to be trained. Electric buses are not more complicated than internal combustion engine vehicles, but they are different. Training on charging systems is also required. Most electric vehicle manufacturers’ offer training for staff and should VTA decide to pursue electric vehicle technology, this should be negotiated.

#### Figure A7: Electric Vehicles Estimated Maintenance Costs ($ per mile)

<table>
<thead>
<tr>
<th>Maintenance Costs</th>
<th>Diesel</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propulsion System Maintenance</td>
<td>0.16</td>
<td>0.09</td>
</tr>
<tr>
<td>Facility Maintenance and Operation</td>
<td>0.18</td>
<td>0.13</td>
</tr>
<tr>
<td>Total Cost per Mile</td>
<td>0.34</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Source: VEIC based on TCRP Report 146 Guidebook for Evaluating Fuel Choices for Post-2010 Transit Bus Procurements

### Facility Maintenance and Infrastructure Costs

VTA would need to update its infrastructure to accommodate electric vehicles, especially with regards to the fuel storage and supply. As discussed, electric vehicles are charged by plugging into, or connecting to an electrical source. Charging systems vary by manufacturer, but regardless of the type of charging equipment purchased, VTA would almost certainly need to upgrade its electrical systems to accommodate higher usage levels. VTA would also need to purchase and install charging equipment, including running electricity to the charging bays.

VEIC estimated the cost of upgrading VTA’s existing facility at approximately $95,000 (see Figures A8 and A9). This cost estimate assumes that the charger is provided by the manufacturer and that VTA’s existing electrical equipment can supply 480 volt 3-phase power without the addition of transformers and that the size of the existing service entrance is 600 kVA.

The current upgrades assume VTA needs the capability to charge five or six vehicles simultaneously. With a managed charging system, VTA would be able to charge up to 10 vehicles in a single night, assuming each vehicle needs three to four hours to charge and vehicles are parked for eight hours. If VTA increases the number of electric vehicles in its fleets, however, additional upgrades to the electrical service entrance will be needed. VTA should consult with their electric utility to discuss the feasibility of an upgrade as well as a cost estimate. These costs would be in addition to the $95,000 estimate.

#### Figure A8: Order of Magnitude Costs: Electrical Upgrade to Support Electric Buses

<table>
<thead>
<tr>
<th>Upgraded</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrade electrical distribution and circuit protection systems</td>
<td>$30,000</td>
</tr>
<tr>
<td>Build charge stations (pads, posts, etc.)</td>
<td>$25,000</td>
</tr>
<tr>
<td>Purchase and install software for managed charging system</td>
<td>$20,000</td>
</tr>
<tr>
<td>Engineering design work</td>
<td>$10,000</td>
</tr>
</tbody>
</table>
Bury cables and install connections $10,000
Total $95,000
Source: VEIC

**Figure A9: Indicative VTA Facility Upgrade for Electric Vehicles**

Transportation Fuel Costs
Electricity on Martha’s Vineyard is provided by the Cape Light Compact and is transmitted via a cable that lies on the ocean floor. The cost of electricity on Martha’s Vineyard is about 11 cents per kilowatt-hour. As discussed, rates are negotiated every six months, so are subject to change.

**Figure A10: Cape Light Compact Published Electricity Rates**

<table>
<thead>
<tr>
<th></th>
<th>Electricity Rates (January – April 2016)</th>
<th>Electricity Rates (April – July 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>9.613 cents/kWh</td>
<td>9.613 cents/kWh</td>
</tr>
<tr>
<td>Commercial</td>
<td>10.927 cents/kWh</td>
<td>10.927 cents/kWh</td>
</tr>
<tr>
<td>Industrial</td>
<td>6.748 cents/kWh</td>
<td>10.675 cents/kWh</td>
</tr>
</tbody>
</table>

Source: VEIC adapted from Cape Light Compact

Strengths, Weaknesses and Considerations
The electric transit bus market is growing rapidly. Manufacturers are improving the technology and offering more vehicle choices. More and more transit agencies are also investing in electric transit buses. Electric transit vehicles are being used by transit agencies across the country, including smaller, rural systems in a variety of climates, such as Duluth, Minnesota, Skagit, Washington, the University of Montana, Stanford University and Worcester, MA. Among the major attractions of electric transit buses are cleaner, quieter engine technology as well as lower and more stable operating costs.
<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Quietest and cleanest vehicle available</td>
<td>- High upfront costs, requiring investments in more expensive vehicles and charging infrastructure</td>
</tr>
<tr>
<td>- Lowest operating costs</td>
<td>- Technology is still developing, making it difficult to know the right time to enter the market</td>
</tr>
<tr>
<td>- Electricity prices historically have been stable</td>
<td>- Technology largely available for fixed-route vehicle models only</td>
</tr>
<tr>
<td>- Developing technology</td>
<td>- Newer vehicle models being developed</td>
</tr>
<tr>
<td>- Vehicle models currently limited</td>
<td></td>
</tr>
</tbody>
</table>
A.4 Natural Gas

Natural gas is an odorless mixture of hydrocarbons, predominantly methane. There are currently two forms of natural gas being used as transportation fuel, compressed natural gas (CNG) and liquefied natural gas (LNG). CNG is methane in a gaseous, compressed state. LNG is methane liquefied at cold temperatures. Both LNG and CNG can be utilized in any engine designed to burn natural gas. The difference between a CNG and a LNG vehicle is the state of the fuel when it is stored on the vehicle and delivered to the engine.

In the late 1990’s and early 2000’s, there were a handful of US transit agencies operating LNG vehicles and a few manufacturers offering LNG buses. In recent years, however, CNG has grown in popularity, while the use of LNG has largely faded out. CNG is less expensive and easier to handle than LNG; it also has the advantage that it only needs to be compressed (not cooled) which can be done straight from a pipeline (where available) at a fueling station. Conversely, LNG must be cooled and then delivered to station sights. As of April 2016, there are no purpose built LNG heavy-duty transit vehicles available for purchase. However, VTA could either special order an LNG vehicle or purchase LNG, allow it to warm and compress it on site for use in compressed natural gas vehicles.

Renewable Natural Gas

As discussed, natural gas can also be renewable (known as renewable natural gas, RNG) if it is from biogas or gases produced by decomposing organic matter. Biogas is regularly used to produce heat and electricity but in recent years, more entities have been upgrading to RNG and using it as a transportation fuel. RNG has a higher methane content than raw biogas and can be interchangeable with conventional natural gas.

RNG can either be pumped into utility pipelines or directly into fueling stations. In 2013, Pierce Transit in Washington State became the first transit agency in the nation to fuel their buses with renewable natural gas. Pierce Transit uses RNG captured from a local landfill to fuel 143 of their 155 buses29. Chittenden County Transportation Authority (CCTA) in Burlington, Vermont is also working with Vermont Gas on a natural gas project that may include the use of RNG for transit vehicles.

RNG is not currently available on Martha’s Vineyard. Creating a local source of RNG would require partnerships between VTA (as a consumer of the product) and producers (at least one and potentially two town waste water treatment facilities). An RNG system would require the installation of an anaerobic digester (to capture the biogas), upgrading equipment (to scrub the gas of impurities), and natural gas dispensers. Installing and maintaining an RNG system can be expensive but it offers the island the ability to increase its fuel independence and supports a transition to a renewable energy system. The cost of a RNG facility is determined by a host of factors, which were not inventoried as part of this study. An order of magnitude reference is between $750,000 and $1.5 million for an anaerobic digester system that could produce the biogas, not including the cost of an upgrading system and a natural gas fueling station. There are often grant funds available to support these types of investments.

Fueling Systems

CNG is normally delivered via utility pipeline to station locations, where it is compressed with on-site equipment and stored in above ground high pressure tanks. In these systems, the gas is dispensed on demand into vehicles. LNG is normally delivered via truck to station locations, where it is stored in cryogenic tanks as a liquid, and dispensed on demand into vehicles.

Without a natural gas pipeline, VTA would need to have either CNG or LNG delivered to the island. LNG’s traditional tanker transport provides a ready solution to the lack of traditional natural gas utility distribution. While CNG is not traditionally shipped, there are currently numerous entities that will ship CNG to locations without access to a pipeline; these are regularly referred to as “mobile” pipeline suppliers.

A mobile CNG pipeline system would involve transporting trailer-mounted, high pressure storage tanks. The tanks would be filled with compressed, high pressure gas on the mainland and delivered via truck to VTA. Storage tanks are either accompanied by dispensing systems or hooked into dispensing equipment available at VTA’s facilities. The empty storage tanks are removed and swapped with full tanks at regular intervals timed to the fleet’s fuel demand. Refueling, or fill, times are equivalent to diesel.

A mobile pipeline system does not require VTA to build a CNG fueling station, which reduces capital investments. However, costs associated with the mobile pipeline are added to the cost of fuel. A CNG provider estimated the cost of the mobile stations (including transport) for approximately $1.32 per gallon based on 1,000 Gasoline Gallon Equivalent (GGE) per day, seven days per week, for 52 weeks, in addition to roughly $0.78 per gallon to ship the fuel\(^{30}\). These costs are in addition to the cost of CNG; total costs are estimated at $4.10 per gallon (see Figure A11). Using this price as a guide, and assuming VTA purchases 150,000 gallons of CNG a year, fuel costs would be $615,000, more than double the amount VTA spent on fuel in FY15 ($225,000).

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs (per gallon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG</td>
<td>$2.00</td>
</tr>
<tr>
<td>Transportation (assumes ferry)</td>
<td>$0.78</td>
</tr>
<tr>
<td>Operations and Overhead</td>
<td>$1.32</td>
</tr>
<tr>
<td>Total (turnkey) Cost</td>
<td>$4.10</td>
</tr>
</tbody>
</table>

Source: VEIC based on quote from CNG provider

An LNG delivery system would require a fueling station at the VTA facilities. One LNG provider estimated that an LNG station would cost the VTA approximately $1.5 million for the equipment and installation; this does not include the cost of land or site development such as curbing, lanes, or storm water management. The VTA could possibly also lease a station from the fuel provider for approximately $179,000 annually. Operation and maintenance costs of an LNG system are around $6,000 - $8,000 per year. The fueling time for LNG would be equivalent to that of a diesel station.

Another option to fuel NGV is for LNG to be delivered to the VTA and then converted to CNG at the fueling site; this type of fueling station is known as L-CNG stations. An L-CNG station would add at a minimum $75,000 -$100,000 in equipment to a basic LNG station, primarily for high pressure compressors and storage. Additionally, the compressors would need to run off electricity, which would require about 1 kW/gal of fuel dispensed; this would add about $15,000 in costs annually.

**Potential Application for VTA**

Transitioning to natural gas vehicles would be relatively straightforward for VTA, especially when New Flyer releases a CNG version of its MiDi vehicle. The MiDi vehicle meets VTA’s operational needs and VTA’s drivers and mechanics are familiar with the vehicle. There are also CNG models of paratransit vehicles, which could allow VTA to operate with a single fuel source. The major disadvantage of using CNG on Martha’s Vineyard, however, is costs. Developing renewable natural gas locally is an interesting option that needs to be evaluated by Martha’s Vineyard towns and VTA. Key questions to consider include the supply of wastewater, production of existing facilities and required investment costs.

**Operational, Environmental, and Maintenance Impacts**

**Operations**

There are no major negative operational impacts facing VTA if it transitioned to natural gas vehicles. The driving range of a natural gas vehicle is directly related to the storage capacity available on the vehicle. Most natural gas vehicles come standard with enough storage to provide a similar range as a diesel bus, between 350 and 450 miles, but they can be designed with larger or smaller systems\(^{31}\). Refueling

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\(^{30}\) Mobile Fuel Solutions; volume reflects smallest volume available for price quote

\(^{31}\) [http://d2dti5nnlprf0r.cloudfront.net/tti.tamu.edu/documents/TTI-2011-7.pdf](http://d2dti5nnlprf0r.cloudfront.net/tti.tamu.edu/documents/TTI-2011-7.pdf)
systems would be developed based on a mobile pipeline that would connect with VTA’s existing fuel dispensing equipment. Refueling, or fill times are equivalent to diesel.

The performance and drivability of natural gas vehicles is similar to diesel buses, with a couple of exceptions. Natural gas vehicle engines are slightly less efficient than diesel engines, the fuel tanks make the vehicles heavier, so vehicles tend to be slower to accelerate and climb hills as compared with diesel vehicles. Natural gas vehicles also have lower fuel economy.

**Environmental**

The environmental benefits of natural gas vehicles are primarily related to fewer vehicle emissions. With the potential of using renewable sources for fuel, benefits extend to creating a renewable energy network. Natural gas is also largely produced domestically.

In terms of the emissions regulated by the EPA – CO, NOx and PM - CNG vehicles emit fewer emissions when compared with ULSD vehicles or diesel vehicles with the same exhaust treatments. CNG vehicles do; however, release emissions at the tailpipe (see Figure A12).

Most states allow some GHG tailpipe emissions as long as they are reduced as compared with diesel. However, other states including California require zero emissions. Cummings, the major manufacturer of CNG engines recognizes this challenge and is working to develop engine models that will have zero GHG emissions. As with electricity, the production of natural gas can also create GHG emissions. These emissions result from fuel exploration, processing and refining as well as refueling. However, emissions resulting from the “well to tank” operations are reduced as compared with diesel.

![Figure A12: Vehicle Emissions: EPA Standards, ULSD and CNG](image)

<table>
<thead>
<tr>
<th>Regulated Emissions (in grams/mile)</th>
<th>EPA Standards</th>
<th>Diesel 15</th>
<th>CNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>15.5</td>
<td>2.256</td>
<td>0.615</td>
</tr>
<tr>
<td>Nitrogen Oxide (NOx)</td>
<td>0.2</td>
<td>12.193</td>
<td>9.862</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>0.01</td>
<td>0.307</td>
<td>0.010</td>
</tr>
</tbody>
</table>

| Unregulated Emissions (in grams/km) | | | |
|------------------------------------| | | |
| Carbon Dioxide (CO2) | n/a | 1,538.21 | 1,181.49 |

Source: Exhaust Emissions of Transit Buses, Emarq (www.emarq.org) Notes 1) Assumes a diesel sulfur content of 15 parts per million

**Maintenance**

Natural gas vehicles normally have higher maintenance costs compared to diesel vehicles. Higher maintenance are attributable to natural gas engine configurations, which are spark-ignited. As a result, vehicle ignition systems, including spark plugs need replacing more frequently. Additionally, natural gas vehicles tend to be heavier than diesel vehicles causing more wear and tear on the vehicles breaks and suspension.

If VTA were to integrate natural gas vehicles into its fleet, staff would require additional training. Staff involved with vehicle repairs and vehicle fueling would need to become familiar with natural gas dispensing systems, bus systems, new maintenance facility safety features and protocols. It would also be prudent to support the training of local first responders including the local fire and police staff in responding to a natural gas accident.

Compressed natural gas (CNG) systems also require regular safety inspections of their cylinders. While CNG cylinders are more robust than diesel tanks, they can corrode and crack from road debris and the exposure to certain chemicals. CNG cylinders should be inspected by a certified professional every three years or 36,000 miles and after any fire, accident, or occurrence that could jeopardize the integrity of the cylinders. Transit agency staff can be certified as CNG cylinder inspectors, which makes the process less expensive and more convenient. LNG tanks do not need to be pressure tested or inspected...
by a certified professional, but they do need to be regularly checked for cracks, leaks, and wear and tear.

**Figure A13: Alternative Fuel and Alternative Fuel Vehicle Relative to VTA Needs**

<table>
<thead>
<tr>
<th>Maintenance Costs</th>
<th>Diesel</th>
<th>Compressed Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propulsion System Maintenance ($/mile)</td>
<td>0.16</td>
<td>0.18</td>
</tr>
<tr>
<td>Facility Maintenance and Operation ($/mile)</td>
<td>0.18</td>
<td>0.23</td>
</tr>
<tr>
<td>Total ($/mile)</td>
<td>0.34</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Source: VEIC based on TCRP Report 146 Guidebook for Evaluating Fuel Choices for Post-2010 Transit Bus Procurements

**Facility Maintenance and Infrastructure Costs**

If VTA purchased natural gas vehicles, the agency would need to upgrade its maintenance facility to meet safety and regulatory requirements. Natural gas requires reconfiguring maintenance facilities because CNG, unlike diesel, is a gas that is lighter than air. If there is a leak, natural gas will rise to the highest point of the facility. Because it is easily ignited, leaked gas is susceptible to explosion or fire. Generally speaking, retrofitting a facility to accommodate natural gas includes installing natural gas detection, an automatic ventilation system, and upgrading the electric to be explosion proof. Other changes include safe placement of all ignition sources and VTA’s open flame propane heating system would most likely need to be replaced with a non-open flamed system. These changes are required for CNG or RNG.

The exact cost of upgrading VTA’s facility for natural gas operations requires an on-site inspection by a certified engineer. VEIC broadly estimated the cost of facility maintenance investment costs at just less than $300,000 (see Figure A14). Most of the costs are associated with updating lighting to be explosion proof. Depending on the state of VTA’s current electric system, however, it may be possible to simply lower electrical units to 18 feet below the facility’s ceiling; moving the electrical units below the ceiling means that if a leak occurred, the gas would rise to the roof, making an explosion less likely. An inspection is required for this adjustment; it could greatly reduce costs.

**Figure A14: Order of Magnitude Costs: Facility Upgrades for Natural Gas Buses**

<table>
<thead>
<tr>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
</tr>
<tr>
<td>Replace furnace</td>
</tr>
<tr>
<td>Install explosion proof lights</td>
</tr>
<tr>
<td>Shunt trip breaker</td>
</tr>
<tr>
<td>Ventilation (exhaust fan, makeup air fan, leak detection system)</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: VEIC adapted by data available through RS Means, a construction cost estimating tool

**Transportation Fuel Costs**

Martha’s Vineyard does not have – and is unlikely to get – a natural gas pipeline. This means that VTA’s best option for supplying, storing and dispensing natural gas is by using a virtual or mobile pipeline. From a functional perspective, a mobile pipeline works well, especially because Martha’s Vineyard has regularly scheduled and reliable transportation options available year round to bring fuel to/from the island.

The challenge with the mobile pipeline is costs. The costs associated with transporting fuel to VTA, plus storing and dispensing have different costs as compared with building a filling station. As a starter, the storage and supply costs are added on to the fuel cost. This makes them operating rather than capital costs. It also means the cost of fuel for VTA to use natural gas is significantly higher as compared with diesel or other alternative fuels (see Figure A15).
As noted in the previous section, assuming VTA purchases 150,000 gallons of CNG a year, fuel costs would be $615,000, which is more than double the amount VTA spent on fuel in FY15 ($225,000). These costs are estimates only and would need to be negotiated based on volume.

**Figure A15: CNG fueling and Delivery Costs**

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs (per gallon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG</td>
<td>$2.00</td>
</tr>
<tr>
<td>Transportation (assumes ferry)</td>
<td>$0.78</td>
</tr>
<tr>
<td>Operations and Overhead</td>
<td>$1.32</td>
</tr>
<tr>
<td><strong>Total (turnkey) Cost</strong></td>
<td><strong>$4.10</strong></td>
</tr>
</tbody>
</table>

Source: VEIC based on quote from CNG provider, winter 2016

**Strengths, Weaknesses and Considerations**

Natural gas vehicles are widely used in the transit industry, including the Rock Region METRO (Little Rock, Arkansas), and the Roaring Fork Transit Authority (RFTA) in Colorado. Natural gas vehicles are cleaner than diesel vehicles and offer the similar power and range.

**Strengths**
- Domestically produced fuel
- Cleaner burning fuel with lower emissions
- Historically offers stable price as compared with diesel
- Potential for renewable natural gas from digesters and landfills
- Available as transit and paratransit vehicles

**Weaknesses**
- High cost/complexity of stations due to high pressure storage
- Mobile pipeline significantly increases operating costs
- Need for facilities modifications for gaseous fuel vehicle storage and maintenance
A.5 Propane

Propane, also known as liquefied petroleum gas (LPG or LP-gas), is a by-product of natural gas and petroleum refining. Propane has been used to power vehicles since the 1970’s and is the third most popular vehicle fuel (among all vehicles), after gasoline and diesel. However, it represents only a very small portion of fuel consumption among U.S. transit agencies. The benefits of propane as an alternative fuel stem mainly from its domestic availability, high energy density, clean-burning qualities, and relatively low cost for vehicles, fuel, and stations.

The recent introduction of Liquid Propane Injection engine systems has significantly improved the fuel efficiency, performance (power, torque, etc.), and reliability of new propane vehicles. In addition, because propane is a simple fuel, it burns relatively clean in engines. Therefore propane vehicles do not require emission control systems similar to diesel buses, such as diesel oxidation catalysts, diesel particulate filters, exhaust gas recirculation, or diesel emission fluid. Propane engines are simple and efficient, much like gasoline engines, and require less maintenance compared to modern diesels on a lifecycle equivalent basis.

Fueling Systems
Propane is delivered via truck to station locations, stored in above ground tanks (with volumes specified for individual fleet needs), and dispensed as a liquid into vehicles with similar user experience and fill times compared to diesel or gasoline. Since propane is a main heating fuel for buildings on Martha’s Vineyard, it is readily available with regular shipments arriving via ferry to the island. VTA could upgrade its fueling system to accommodate propane at minimal costs. Propane is a liquid at low pressure, this helps to make station equipment streamlined and affordable, with limited construction, equipment, and maintenance cost.

Propane is already used as a winter heating fuel for buildings on the island and is the heating fuel used by VTA. Therefore, vendors and supply chains currently exist, though additional tariffs and fees for bulk delivery to the island may impact the expected cost savings per gallon of propane. Many propane suppliers are willing to provide free refueling infrastructure in exchange for long term volume contracts, allowing favorable return on investment scenarios for a propane fleet with transit applications.

Potential Application for VTA
VTA has experience operating propane vehicles. They used to have a fill tank on-site and operated two propane-powered Bluebird buses. VTA had a mixed experience with these vehicles. Drivers noted the lack of power, specifically challenges associated with accelerating into traffic with heavy passenger loads.

There are, however, opportunities for VTA to transition its paratransit fleet from gasoline to propane. Propane paratransit vehicles are more widely available and slightly lower performance is acceptable to paratransit operations. Passengers would also benefit from cleaner, quieter vehicles. VTA would benefit from operating vehicles that have reduced air pollution and GHG emissions and slightly lower fuel costs.

Operational, Environmental, and Maintenance Impacts

Operations
Propane has less energy as compared with diesel or natural gas, so vehicles fueled by propane have reduced power. The lack of interest in propane reflects the fact that the fuel doesn’t offer the same power and as a result, lacks the torque and acceleration of diesel or other alternative fuels.

Propane has been popular in medium duty applications, such as school buses and paratransit vehicles. Boston Public Schools, for example, purchased 86 propane school buses in 2015 as part of its transition to a propane fleet. The transition to propane was initiated both as a way to reduce vehicle emissions and to reduce fuel and operating costs. VTA operates several medium duty vehicles that are similar to school bus vehicles, so theoretically propane could be a viable option. However, VTA has large passenger loads
and with the reduced power and torque associated with propane engines, the technology is likely less appropriate for operations on Martha's Vineyard.

**Environmental**
Most data suggests that propane burns cleaner than gasoline or diesel, especially if diesel vehicles are not equipped with the latest generation exhaust systems. Data collected from EPA certification tests suggest that propane is cleaner than diesel in terms of carbon monoxide, but not nitrogen oxide. There is no data on propane emissions from the EMARQ report and limited data for other sources. In general, pollutants emitted by propane fuel vehicles are similar to diesel-powered vehicles.

Propane is produced domestically either at U.S. crude oil refineries, or as part of natural gas processing. As a result, propane contributes to overall energy independence, but to date, there are no renewable options.

**Maintenance**
Propane vehicles are expected to have lower maintenance costs as compared with diesel with engines lasting up to twice as long as conventional diesel or gasoline engines. According to the Alternative Fuel Data Center at the U.S. Department of Energy, propane’s higher octane rating and lower carbon content help extend the engine's life. The Boston School District, for example, is expecting to save $1,500 to $2,000 annually in operating costs resulting from lower fuel prices and reduced maintenance costs. The time to refuel a propane vehicle is comparable to a diesel vehicle.

Maintenance staff would need to be trained in the proper handling and refueling practices to avoid any exposure to propane liquid or vapors. Additionally, propane is stored under pressure and therefore specialized safety measures should be taken when storing and utilizing the fuel. VTA would need to work with their local fire authorities to insure they are meeting all the requirements for storing propane.

**Facility Maintenance and Infrastructure Costs**
Propane is flammable, which means, like natural gas, the maintenance facility would need upgrades before mechanics or staff could work on propane vehicles or engines. Retrofits include installing propane detectors as well as explosion proof wiring, and ventilation systems to release leaked gas. Upgrades can be avoided by implementing policies that require vehicle propane tanks be closed off and the fuel systems purged before any indoor maintenance is conducted. Another option is for routine maintenance to be conducted outside, which may or may not be acceptable to VTA staff. The cost to upgrade VTA’s maintenance facility is assumed the same as the costs to upgrade a system to natural gas, roughly $288,000 (see Figure A14).

**Propane Fueling Stations**
Propane is delivered to stations via transport truck and is stored under pressure in carbon steel tanks, typically above ground. Fleets using propane typically develop a propane station that consists of a fuel storage tank, a fuel dispenser, pump and motor and a fuel management system. Propane stations can come either as skid-mounted or permanently installed systems. Skid-mounted stations are usually the more compact and less costly option. These systems typical come with 1,000 or 2,000-gallon storage tanks.

Some fleets prefer a permeant station that can be customized to their needs and have a higher storage capacity. The cost of a permanent 1,000-gallon propane station with a single dispenser is estimated at roughly $35,000. A 2,000-gallon tank with a duel dispenser cost twice as much, or roughly $59,000. VTA’s paratransit fleet used 13,620 gallons of unleaded gasoline in fiscal year 2015, which is roughly 1,135 gallons a week (see Figure A16).
Figure A16: Cost of Propane Fuel Dispenser

<table>
<thead>
<tr>
<th>Item</th>
<th>2,000 Gallon Fueling Station (Single Dispenser)</th>
<th>1,000 Gallon Fueling Station (Duel Dispenser)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>$500</td>
<td>$500</td>
</tr>
<tr>
<td>Concrete Pad</td>
<td>$4,000</td>
<td>$2,000</td>
</tr>
<tr>
<td>Storage Tanks (dispenser, values &amp; fitting)</td>
<td>$17,300</td>
<td>$8,650</td>
</tr>
<tr>
<td>Sub Electrical</td>
<td>$12,500</td>
<td>$6,250</td>
</tr>
<tr>
<td>Sub Fencing</td>
<td>$3,000</td>
<td>$1,500</td>
</tr>
<tr>
<td>Fuel Use Tracking System</td>
<td>$9,800</td>
<td>$9,800</td>
</tr>
<tr>
<td>Labor and Permits</td>
<td>$11,500</td>
<td>$6,250</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$58,600</strong></td>
<td><strong>$34,950</strong></td>
</tr>
</tbody>
</table>

Source: Clean Fuels Ohio

Propane Station

Transportation Fuel Costs
Propane is available on Martha’s Vineyard and is transported by truck on ferries operated by the Steamship Authority. The national cost for a gallon of propane is $2.85. On Martha’s Vineyard, the cost of propane (for home heating purposes) is about $2.99.

Strengths, Weaknesses and Considerations
Propane is used in the transit industry for paratransit vehicles, with several transit agencies adopting propane for their paratransit fleet as a way to reduce emissions and lower fuel costs. Example agencies that operate propane transit vehicles include the Greater Cleveland Regional Transit Authority, Delaware Transit Corporation and Broward County in Florida.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Domestically produced fuel</td>
<td>- Available for paratransit vehicles only</td>
</tr>
<tr>
<td>- Cleaner burning fuel</td>
<td>- Potential for price volatility in markets that rely on propane for winter heating (may be managed with longer term fuel contracting)</td>
</tr>
<tr>
<td>- Simple, low cost fueling stations and systems</td>
<td></td>
</tr>
<tr>
<td>- Does not require facilities modifications</td>
<td></td>
</tr>
<tr>
<td>- Potential operating cost savings as compared to gas</td>
<td></td>
</tr>
<tr>
<td>- Truck transported, no pipeline needed</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B: BULK TRANSPORTATION REGULATIONS AND COSTS

Transportation fuels used on Martha’s Vineyard are shipped via ferry or barge to the island. There are two primary transportation companies with licenses and authority to supply fuel to the Vineyard: the Steamship Authority (SSA) and Packer Transportation.

- The Steamship Authority operates a hazardous material ferry with (at least) one daily round trip between Woods Hole and Vineyard Haven. All materials are transported by truck and embark and disembark the ferry under their own power, i.e. roll-on/roll-off. SSA charges trucks traveling on their hazardous materials ferry based on the length of the vehicle. A 64’ truck would cost $389.26 one-way, not including the driver. Trucks carrying hazardous materials are considered hazardous on both ways of their travel.

- Packer Transportation runs a barge service between New Bedford and Vineyard Haven. They transport a significant portion of the Island’s transportation fuel. Packer specialized in the transportation of bulk good, which in the context of fuels includes anything that is not carried by a truck. Packer currently does not transport Propane and does not have experience with CNG or LNG. Packer also has storage facilities in Vineyard Haven capable of storing 100,000 gallons of gasoline and 64,000 gallons of diesel fuel.

Alternative fuels, including CNG, LNG and propane for transportation (LPG) would need to be shipped by either the SSA or Packer and stored at VTA’s facilities at 11 A Street on Edgartown. All alternative fuels, like gasoline and diesel are considered hazardous materials and transportation is governed by special regulations. Regulations and restrictions reflect the classification of the substance (see Figure B1). Federal regulations regarding the transportation of hazardous materials are governed by the U.S. Department of Transportation and regulated by Title 49 Code of Federal Regulations (CFR) 172.101. Additional regulations are also required by the Commonwealth of Massachusetts 527 (CMR) 8.0. LNG, CNG and propane are classified in the same CFR Hazard Class 2.1 rating. However, there are significant differences in the cost of the portable transportation tanks:

- Transporting LNG tanks is significantly more complicated than diesel or propane because LNG must be stored at -260 degrees Fahrenheit. This cryogenic temperature dictates that the tank construction requires specialized materials and industrial insulation. One LNG provider has estimated the cost of transporting LNG at $1.80 - $1.90/DGE.

- Transporting CNG tanks are pressurized at much higher than Propane, which increases the cost of the transportation. A CNG provided quoted an all in one price with no capital cost to VTA for $4.10/GGE. This price requires a volume of 1,000 Gasoline Gallon Equivalent (GGE) units per day, seven days per week and 52 weeks per year for period of no less than 5 years. This is nearly double the volume of fuel needed by VTA. CNG is sold for approximately $2.00 GGE, meaning that the cost to ship and provide a station is estimated at $2.10 GGE.

LNG transportation tanks transported on cargo vessels are rated in the CFR as stowage Category “D” so tanks can be stored “on deck” only. This restriction on LNG transportation will limit the number of vessels that can transport LNG to the island. By comparison, CNG and Propane fall into stowage category “E”, which allows tank stowage “on deck” or “under deck”, giving more flexibility to the transportation company. This may or may not be an issue for the Steamship Authority.
## Figure B1: Fuels and Hazardous Material Classification

<table>
<thead>
<tr>
<th>Flammable Liquid</th>
<th>Flammable Gas</th>
<th>Miscellaneous Dangerous Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>Compressed Natural Gas</td>
<td>Engines</td>
</tr>
<tr>
<td>Diesel Fuel</td>
<td>Liquid Natural Gas</td>
<td>Fuels Cells</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Propane</td>
<td>Batteries</td>
</tr>
<tr>
<td>Home heating fuel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: VEIC adapted from USDOT data


**APPENDIX C: FUNDING**

Based on the current vehicle replacement schedule, VTA will replace 22 buses and four demand response vans during the next five years. Purchasing these vehicles require roughly $9.4 million for all the 22 buses and four demand response vans, assuming VTA replaces all existing buses with conventionally fueled vehicles (see Figure C1). Transitioning to alternative fuels would further increase costs by between $350,000\(^{32}\) (Propane) and up to an additional $2 million for a full conversion of the fleet to electricity. The ability to fund the transition to alternative fuels is essential to advancing adoption of alternative fuel vehicles. There are numerous grants and programs available to support and encourage development of alternative fuel systems.

**Figure C1: Five-Year Vehicle Replacement Costs by Vehicle Fuel Type (in $millions)**

<table>
<thead>
<tr>
<th></th>
<th>Diesel/Gasoline</th>
<th>Partial Electric(^1)</th>
<th>Full Electric(^2)</th>
<th>CNG</th>
<th>Propane(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Route Buses</td>
<td>$9.1</td>
<td>$9.4</td>
<td>$9.9</td>
<td>$10.1</td>
<td>$9.1</td>
</tr>
<tr>
<td>Paratransit Vans</td>
<td>$0.3</td>
<td>$0.3</td>
<td>$0.3</td>
<td>$0.4</td>
<td>$0.4</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>-</td>
<td>$0.1</td>
<td>$1.3</td>
<td>$0.3</td>
<td>$0.3</td>
</tr>
<tr>
<td><strong>Estimated Cost</strong></td>
<td><strong>$9.4</strong></td>
<td><strong>$10.4</strong></td>
<td><strong>$11.5</strong></td>
<td><strong>$10.8</strong></td>
<td><strong>$9.8</strong></td>
</tr>
</tbody>
</table>

Source: VEIC Notes: 1) Assumes up to six electric buses; paratransit vans will be gasoline; 2) Only buses used in fixed-route service will be electric; demand response vans will remain gasoline; 3) Only demand response vans will be propane vehicles; fixed-route buses will remain diesel

**Transit Funding in Massachusetts**

The Vineyard Transit Authority (VTA) is part of Massachusetts’ Regional Transportation Authority (RTA) network and is one of four federally designated rural transportation providers in the state. As a rural transit provider, VTA does not receive formula funding directly from the FTA. Instead, the funding is distributed from the FTA to the Massachusetts Department of Transportation (MassDOT), who then distributes the funding to the rural transit agencies. Funding is distributed based on a combination of historical practices and each transit agency’s yearly request for funding, documented through an annual capital program. MassDOT reviews statewide funding needs and distributes resources based on an evaluation process. Awarded funds almost always need to be spent in the year they were awarded.

The funding analysis focuses on capital funding. Funding for these expenditures (buses, equipment, maintenance facility, facility expenditures) are largely provided by federal and state grants. VTA’s largest source of capital funding is the Federal Transit Administration (FTA) through the Non-urbanized (Rural) Area Formula Program (Section 5311) program. Another important source of capital funding is the RTA Capital Assistance Program (RTACAP). Generally speaking, Section 5311 funds are available for up to 80% of capital projects and the RTACAP funds will pay for the remaining 20%.

Despite having access to generous funding programs, there are challenges associated with accessing them to support alternative fuel investments:

1. **Funding for capital programs is limited.**
   
   o Federal funds can be used to support up to 80% of the cost of a capital project and state funds provide another 20%. But, the amount of funding available is limited. MassDOT must allocate limited capital funding among the RTAs. Vehicle replacement projects tend to rank favorably, but they must be balanced against other investment needs.

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\(^{32}\) Costs assumes only the demand response vans are propane vehicles; all fixed-route buses will be diesel.
If VTA requested to purchase more expensive alternative fuel vehicles, it is likely that MassDOT would at least partially, but not necessarily fully, fund the request. VTA’s ability to receive more funds to cover the cost of higher priced vehicles is less clear. Instead, MassDOT could provide partial funding, so VTA would be able to purchase fewer vehicles or would need to find additional funding to cover the increased cost.

2. RTAs are expected to spend 95% of their capital funds the same year they are allocated.

   The requirement to expend funds in a single year is challenging for many transit capital projects, including alternative fuel projects. Investing in alternative fuels requires coordinating multiple investments (vehicles, building upgrades, and fueling infrastructure) as well as developing new technologies. Successfully identifying, procuring and implementing multiple systems over a 12-month period will be difficult.

The new federal transportation legislation, Fixing America’s Surface Transportation (FAST) Act, includes a handful of programs where any transit agency can apply for funding directly. This may allow VTA to avoid some of the challenges associated with state funding, but it may mean VTA is not able to draw on RTACAP funding. More information on these opportunities are noted in the next sections.

**Funding Opportunities**

The federal government, including the U.S. Department of Transportation (DOT) is taking a leading role in advancing alternative fuel vehicles and technology. The FAST Act includes several new provisions and funding sources that support alternative fuel technology, including for transit agencies. These funds include grants provided by the Federal Transit Administration and the Federal Highway Administration. There are a handful of non-DOT funding programs that may or may not be applicable as well as tax credits that may indirectly help VTA achieve some of its goals.

The following section provides a high level overview of the funding program and their direct application to support alternative fuel projects initiated by VTA. A list of links that lead to more information on specific grant details is included as Appendix B.

**Federal Transit Administration (FTA)**

FTA funding programs can be used to purchase alternative fuel vehicles and/or upgrade facilities. These programs are the most straight-forward way to replace transit vehicles and they can be used to acquire alternative fuel vehicles. The amount of money available might not be sufficient to cover an equal number of higher priced vehicles. The FAST Act includes new programs and opportunities to support investments in alternative fuels.

1. **FTA Rural Area Formula Program (Section 5311):** Section 5311 formula grants for rural areas\(^{33}\) provide capital, planning and operating assistance to states and federally recognized Indian tribes to support public transportation in rural areas with populations less than 50,000. Eligible recipients are state, tribal, or local government authorities, nonprofit organizations, operators of public transportation or intercity bus service receiving funds indirectly through a recipient. Funds are allocated annually based on population and land area, bus revenue vehicle miles and low-income individuals.

   **Potential application to VTA alternative fuels:** The Commonwealth of Massachusetts was apportioned roughly $3.7 million in Section 5311 funding for fiscal year 2016 (FY16). Given Section 5311 is shared across four transit agencies and each has capital and operating needs, it is unclear if there will be sufficient resources to support a request from VTA to invest in

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\(^{33}\) Formula Funds are apportioned to States and Tribes based on a formula that includes land area, population, revenue vehicle miles, and low-income individuals in rural areas. [https://www.transit.dot.gov/funding/grants/grant-programs/formula-grants-rural-areas-5311](https://www.transit.dot.gov/funding/grants/grant-programs/formula-grants-rural-areas-5311)
alternative fuel vehicles. VTA should begin conversations with MassDOT about their interest in alternative fuels and the potential role of Section 5311 funds in supporting these goals.

2. **FTA Tribal Transit Program (Section 5311(c))**: The FAST Act continued funding for the Tribal Transit Program with $30 million for formula grants, plus another $5 million in discretionary (competitive) funding. Federally recognized tribes may use funding for capital, operating, planning and administrative expenses that meet the growing needs of rural tribal communities. The FTA does not require any matching funds or cost share for formula funds, but a ten percent match is required for discretionary projects. A Notice of Funding Opportunities (NOFO) for FY 2016 Competitive Funds for the Tribal Transit Discretionary Projects is open for public comments; a call for applications can be expected shortly.

**Potential application to VTA alternative fuels**: VTA may consider working with the Wampanoag Tribe of Gay Head (Aquinnah), a federally recognized Indian tribe to access 5311c funds to either purchase cleaner, quieter vehicle systems and/or operate them to/from Wampanoag’s lands in Aquinnah. Another potential use of funding could be an inductive charging project in the parking lot at the Cliffs of Gay Head tourist facility. Funding is competitive; chances for success may be strengthened by orienting the project towards economic development goals, potentially bringing tourists to the Cliffs and/or linking tribal members to jobs in other areas of the island.

3. **FTA Buses and Bus Facilities Program (Section 5339)**: FTA Section 5339 makes funding available to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities. Funds are distributed using a combination of formula and competitive grant programs according to three sub-programs:

- 5339(a) – capital funding distributed based on formula allocations
- 5339(b) - competitive capital funds with awards based on fleet age and condition
- 5339(c) - competitive grant funds to support the purchase of Lo or No Emission vehicles.

Competitive grant funds available under 5339(b) and (c) are set at $213 million, of which 10% is set aside for rural areas. The competitive grant program includes $55 million per year for grants to acquire or lease low and no emission buses (“LoNo”). Funds can be used for vehicles, charging infrastructure and/or facility improvements. The LoNo program funds the purchase of low or no emission vehicles at 85% and the cost of supporting equipment and infrastructure at 90%.

Applicants can be states or individual agencies. States are encouraged to pool formula programs to allow for larger procurements, suggesting that VTA may want to partner with other transit agencies in Massachusetts. At the same time, the FAST Act allows any transit agency that operates fixed route service can be a direct recipient of Section 5339 funding. Being a direct recipient of FTA funding, however, can be challenging.

**Potential application to VTA alternative fuels**: Given the annual set aside for rural areas and the fact that electric transit vehicle projects are more prevalent on the west coast, VTA may be a competitive applicant for LoNo funding. VTA could apply for these funds either a part of a joint application administered by MassDOT or as a sole applicant. Applying for LoNo Funds as part of a state application would increase the likelihood that VTA could match grant funds with RTACAP funding. Projects eligible for funding in FY16 were due in May 2016; however, additional funding should be available annually for four more years under the FAST Act (through 2020). If VTA is interested in applying for LoNo funds, they should initiate conversations early. This alternative fuels assessment should help VTA with the grant process. In addition, vehicle manufacturers have been assisting transit agencies with preparing grant materials.
Federal Highway Administration (FHWA)

The FHWA also has funding that can be used for public transportation services, including the purchase of alternative fuel vehicle systems and technologies. The most relevant of these funds is the Congestion Mitigation Air Quality Program (CMAQ). The FAST Act increased funding available to support projects that will reduce transportation-related pollutants, like alternative fuel projects. CMAQ funds generally can only be used to support projects in areas not in conformity with the National Ambient Air Quality Standards (NAAQS). As of 2012, the only place in Massachusetts designated as nonattainment is Dukes County (Martha’s Vineyard); Dukes County marginally exceeds the EPA standard for 8-hour ozone.

Despite being mostly in attainment for federal air quality pollutants, Massachusetts has funding from CMAQ allocations that remain unspent from previous allocations. These funds are administered by the Massachusetts Department of Energy Resources (DOER) and two of the funded programs are directly related to advancing alternative fuel vehicles and infrastructure.

1. Alternative Fuel Vehicles: In 2011, Massachusetts was awarded $12 million in CMAQ funding to develop alternative fuel opportunities in the state; of the $12 million, roughly $4 to $5 million has been awarded to specific projects. The funding is designed to help fund the conversion of vehicles to alternative fuels and/or to pay for part of the increased cost of an alternative fuel vehicle. Roughly half of the funds are directed to encourage electric vehicle projects and the other half intended for CNG projects. Funding can be used for up 80% of the differential of the cost of an alternative fuel vehicle (truck or bus), up to $40,000 per vehicle.

At the time of this report (May 2016) under 20% of the funds have been committed. Funds are being coordinated by the Clean Cities Coalition of Massachusetts and there is a Request for Requisitions under development for EV Charging stations for cities and towns. Overall, the program has been slow to distribute funds and to date the funds the committed funds have mostly been for CNG charging stations.

Potential application to VTA alternative fuels: The cost of an electric bus is about $36,000 more than a diesel bus and a natural gas bus is about $46,000 more than a diesel bus. VTA could apply for CMAQ funds to 80% of the increased cost. Given Dukes County is the only area out of attainment, VTA would likely be a strong candidate. CMAQ funds could be used to fund the purchase and installation of electric vehicle charging equipment installed at the Tisbury Park and Ride Lot, although funding may require that the charger is available to members of the public.

2. Battery Electric Buses with Wireless Charging. Massachusetts has CMAQ funds programmed to support a battery electric bus and wireless (inductive) charging demonstration project. The program is being managed by the Massachusetts Clean Cities Coalition (housed in the MA DOER); there is a live Program Opportunity Notice (PON)34 with funding to support replacement of diesel buses with battery powered electric busses and using inductive charging (i.e., wireless charging). There is $2.25 million available under the PON and selected grant recipient will be awarded up to a maximum of $750,000. Grant payment shall be made at the completion of the wireless charging equipment installation and the bus(es) placed into service. All awarded grant projects must be completed within two years of award date. According to Massachusetts Clean Cities staff no funds have been committed to date.

Potential application to VTA alternative fuels: VTA could apply for the CMAQ funds dedicated to the charging equipment, potentially requesting $750,000 to purchase an inductive charging system, pay for installation and upgrades to adjacent electric systems, and potentially for part of the cost of bus. Receiving these funds would take pressure off VTA’s traditional capital funding sources by transferring the cost of the infrastructure to another source. VTA would still need to

An Alternative Fuels Assessment and Feasibility Study
Appendices

raise matching funds and per the terms of the agreement, funds are paid upon successful completion of the project.

Non-Department of Transportation (DOT) Funds
Alternative fuel vehicles and technologies can be funded using non-DOT funding, including grant funding available through the Environmental Protection Agency (EPA); the Department of Agriculture (USDA) and Department of Energy (DOE). Some of these programs are administered by state agencies; others are available directly through federal agencies.

1. **Clean Diesel Funding Assistance Program (Fiscal Year 2016):** In FY16, the EPA provided funding to support diesel replacements, retrofits and/or repowers. The funds can be used for school buses or transit vehicles, with funds available to support up to 45% of the cost of the vehicle or retrofit. The opportunity applies to buses in non-attainment areas of the country under National Ambient Air Quality Standards (NAAQS) and falls under the Diesel Emissions Reduction Act (DERA) (see Figure C2).

VTA is eligible to apply for funding under this program, but it can only be used for vehicles purchased before 2007 and those not already scheduled for replacement. The competition for funding is national and the EPA anticipated awarding one to four cooperative agreements per EPA Region. Applications for grant fund were due April, 2016. Although not guaranteed, funding may be available in fiscal year 2018.

Potential application to VTA alternative fuels: Transit agencies typically do not apply for DERA funds because the matching requirements are significantly higher as compared to funding available through the FTA. In most cases transit vehicles exceed the set emission standards. As the program evolves, there may be opportunities for VTA to consider DERA funding. If VTA transitions to electric or natural gas systems, another public institution (school, town) could apply for DERA funds to transition the vehicles to alternative funds.

![Figure C2: DERA Grants – Availability of Funding by Project Type](image)

<table>
<thead>
<tr>
<th>Current Engine Model Year (EMY)</th>
<th>DOC¹ +/-</th>
<th>DPF²</th>
<th>SCR³</th>
<th>Vehicle Replacement EMY 2015 or Newer</th>
<th>Engine Repower EMY 2015 or Newer</th>
<th>Replacement or Repower: All-Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994 – 2007</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2007 - 2010</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: EPA Notes: 1) Diesel Oxidation Catalysts 2) Closed Crankcase Ventilation 3) Diesel Particulate Filter 4) Selective Catalytic Reduction

2. **Green Communities Grants:** The Massachusetts Department of Energy and Environmental Affairs manages a program, Green Communities, which is designed to help all Massachusetts cities and towns find clean energy solutions that reduce energy costs and promote local economic development. Currently, Tisbury and West Tisbury on Martha’s Vineyard participate in this program. Green Communities includes grants to fund a variety of projects and programs, potentially including a feasibility study for renewable natural gas and/or investments in local renewable natural gas infrastructure.

3. **Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans and Grants:** The USDA Rural Development program offers grants and loans to agricultural producers and small businesses in rural areas. Funds can be used for the purchase, installation, and construction of either renewable energy systems (biodiesel or developing anaerobic digesters); or energy efficiency improvements. Funding from this program can be used for grants (up to 25% of the cost of the project); or for loans (up to 75% of eligible project costs).
Potential application to VTA alternative fuels: It is unlikely that VTA would apply for these funds, but there are opportunities for partnerships with local farms or businesses, or potentially island towns. In addition, there are ongoing conversations on Martha’s Vineyard where VTA could engage as a stakeholder. For example, the island is embarking on a Comprehensive Study of Commercial Food Waste on island. This study emerged from the state’s new law banning commercial food waste from entering the waste stream. Martha’s Vineyard produces at least 20,000 pounds of potential crop waste every year, according to Island Grown Initiative, which runs a gleaning program to distribute unused produce to Island groups throughout most of the year. This process could contribute to the local production of natural gas and VTA could become a purchaser of the gas. USDA funds could help get the project underway.

Tax Credits
There are a handful of incentive programs designed to encourage and support the adoption of alternative fuel vehicles. In general, VTA’s non-profit, tax exempt status prohibits them from receiving these incentives. It may be possible, however, for a business or organization working with VTA to benefit from these programs. Savings could possibly be shared with VTA.

1. Alternative Fuel Infrastructure Tax Credit: This incentive originally expired on December 31, 2013, but was retroactively extended through December 31, 2016, by H.R. 2029 (PDF). The credit includes the following - fueling equipment for natural gas, liquefied petroleum gas (propane), liquefied hydrogen, electricity, E85, or diesel fuel blends containing a minimum of 20% biodiesel installed between January 1, 2015, and December 31, 2016, is eligible for a tax credit of 30% of the cost, not to exceed $30,000. Permitting and inspection fees are not included in covered expenses. Fueling station owners who install qualified equipment at multiple sites are allowed to use the credit towards each location. Consumers who purchased qualified residential fueling equipment prior to December 31, 2016, may receive a tax credit of up to $1,000. Unused credits that qualify as general business tax credits, as defined by the Internal Revenue Service (IRS), may be carried backward one year and carried forward 20 years. For more information about claiming the credit, see IRS Form 8911, which is available on the IRS Forms and Publications website. (Reference Public Law 114-113; 26 U.S. Code 30C and 38; and IRS Notice 2007-43 (PDF))

Point of Contact

2. Alternative Fuel Tax Exemption: Alternative fuels used in a manner that the Internal Revenue Service (IRS) deems as nontaxable are exempt from federal fuel taxes. Common nontaxable uses in a motor vehicle are: on a farm for farming purposes; in certain intercity and local buses; in a school bus; exclusive use by a non-profit educational organization; and exclusive use by a state, political subdivision of a state, or the District of Columbia. This exemption is not available to tax exempt entities that are not liable for excise taxes on transportation fuel. For more information, see IRS Publication 510 (PDF). Point of Contact, Excise Tax Branch, U.S. Internal Revenue Service Office of Chief Counsel, (202) 317-6855, http://www.irs.gov/.

3. Alternative Fuel Mixture Excise Tax Credit: NOTE: This incentive was retroactively extended multiple times, most recently through December 31, 2016, by H.R. 2029 (PDF). An alternative fuel blender that is registered with the Internal Revenue Service (IRS) may be eligible for a tax incentive on the sale or use of the alternative fuel blend (mixture) for use as a fuel in the blender’s trade or business. The credit is in the amount of $0.50 per gallon of alternative fuel used to produce a mixture containing at least 0.1% gasoline, diesel, or kerosene. Qualified alternative fuels are: compressed natural gas (based on 121 cubic feet), liquefied natural gas, liquefied hydrogen, liquefied petroleum gas, P-Series fuel, liquid fuel derived from coal through the Fischer-Tropsch process, and compressed or liquefied gas derived from biomass. The incentive must first be taken as a credit against the blender’s alternative fuel tax liability; any excess over this fuel tax liability may be claimed as a direct payment from the IRS. The tax credit is not allowed if an incentive for the same alternative fuel is determined under the rules for the ethanol or biodiesel tax credits. Under current law, this tax credit is applicable to fuel sold or

**Links to Funding Resources**

**Tribal Transit Program**
FY16 Notice of Funding Opportunity: [https://www.federalregister.gov/articles/2016/03/14/2016-05579/fy-2016-competitive-funding-opportunity-public-transportation-on-indian-reservations-program-tribal](https://www.federalregister.gov/articles/2016/03/14/2016-05579/fy-2016-competitive-funding-opportunity-public-transportation-on-indian-reservations-program-tribal)

**Lo No Emissions Program**

**Alternative Fuel Vehicles – Massachusetts Department of Energy Resources**


**Diesel Emission Reduction Act – Environmental Protection Agency**
FY 2016 Grant Announcement: [https://www.epa.gov/grants/clean-diesel-funding-assistance-program-fy-2016-grant-announcement](https://www.epa.gov/grants/clean-diesel-funding-assistance-program-fy-2016-grant-announcement)

**Green Communities Grants – Massachusetts Department of Energy and Environmental Affairs**