Feasibility Study of Alternative-Fuel Vehicles

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Introduction and Background

This report documents a feasibility study of alternative fueled vehicles for the services provided by Jaunt, Inc. (Jaunt). The analysis presented herein reflects Jaunt's efforts to support the adopted climate goals of its stakeholders, the City of Charlottesville, and surrounding counties, which seek to reduce their jurisdictions' greenhouse gas emissions. Currently, the City of Charlottesville has adopted a carbon emissions reduction goal of 45% by 2030 and seeks to achieve carbon neutrality by 2050.

Jaunt operates within the greater Charlottesville-Albemarle region in Virginia and provide public transit service to residents throughout the City of Charlottesville as well as Albemarle, Buckingham, Fluvanna, Greene, Louisa, and Nelson Counties. Jaunt also provides accessible paratransit services to Charlottesville Area Transit (CAT), the City of Charlottesville's fixed transit route provider.

In June 2022, Jaunt retained Kimley-Horn to review the services provided by Jaunt and establish the feasibility of transitioning the Jaunt fleet to alternatively fueled vehicles including consideration for electric vehicles, hydrogen vehicles, and compressed natural gas (CNG) vehicles. Note that this study was initiated in parallel to on ongoing study by CAT to determine the feasibility of and impact on infrastructure of transitioning CAT's fleet to low- or zero-emissions vehicles. As of the publication of this report, CAT's study is ongoing.

This report discusses the short and long-term goal of transitioning the Jaunt fleet to alternative fueled vehicles with the goal to reach zero carbon emissions by 2050 without sacrificing level of service. This is discussed in the context of current and future technology advancements with a focus on technical viability.

The following sections are contained in this report:

- Introduction and Background
- Stakeholder Engagement
- Existing Conditions and Service
- Operational Feasibility Analysis
- Findings and Discussion
- Recommendations and closing

STUDY PURPOSE

The purpose of this analysis is to evaluate the technical and economic feasibility of transitioning Jaunt's fleet to alternative fuel vehicles based on commercially-available technology. As the Jaunt fleet is comprised of light- and medium-duty transit vehicles, this study focused on vans and cutaway-style buses.

Transitioning demand-response and ADA paratransit fleets to alternative fuels have been less documented than transitions for standard heavy-duty transit buses. The market continues to emerge for these uses, but has been preceded by both transit bus and consumer vehicle markets. To gather additional first-hand experience and information, Kimley-Horn conducted interviews with two transit agencies that had experience transitioning and operating demand response and paratransit service with alternative fuel vehicles.

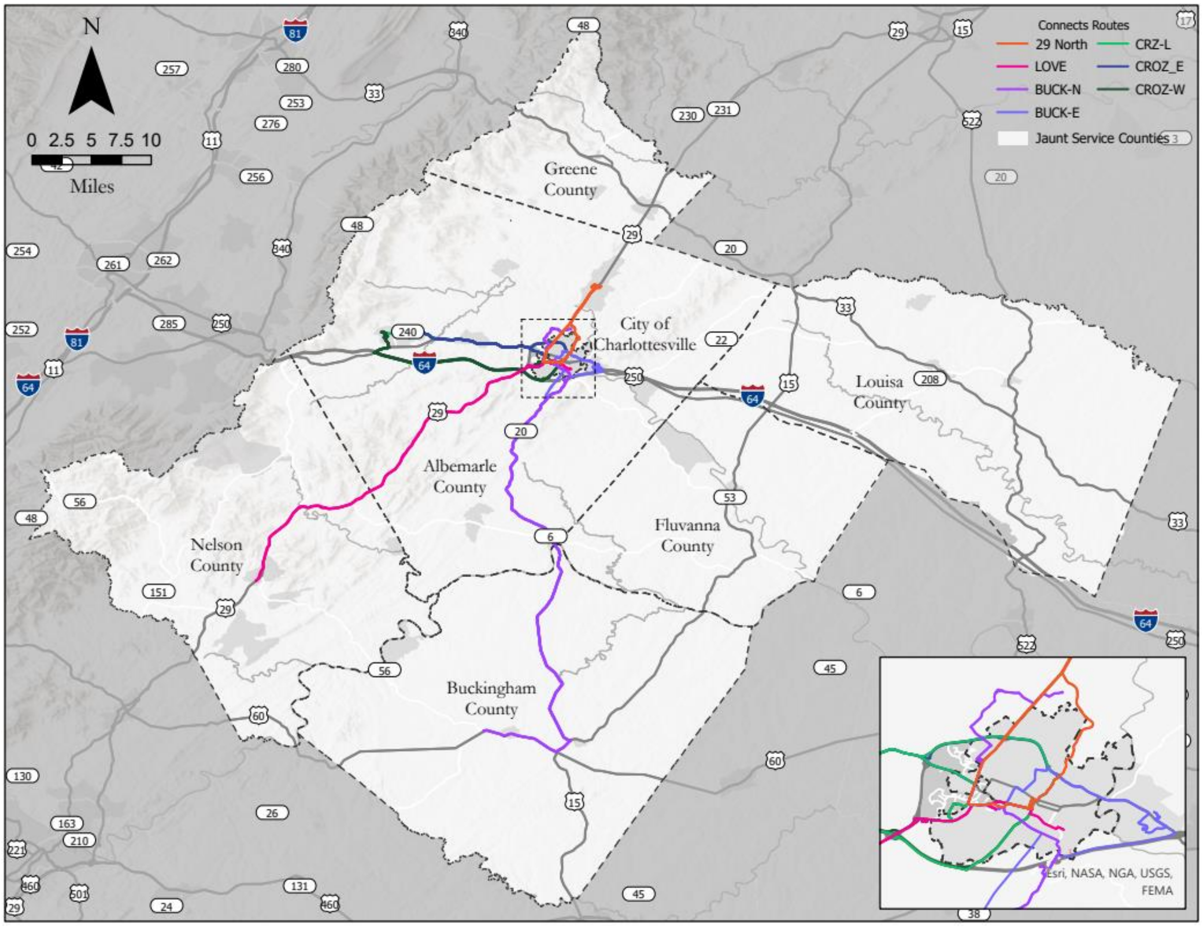
The analysis for this feasibility study is focused on service performance, cost, and technical requirements. Factors that were considered are required vehicle range, vehicle size, capital and life cycle costs, fuel costs per mile, infrastructure costs associated with depot and on-route chagrining, and maintenance costs per mile and over the life of the vehicle. Analysis and Kimley-Horn's recommendations are based on the factors are documented within this report.

STUDY AREA

Jaunt provides paratransit, commuter bus, and demand response services to six counties and one independent city in the greater Charlottesville area (service area is shown in **Figure 1**). Jaunt provides ADA paratransit services to CAT, the City of Charlottesville, and urbanized Albemarle County, and demand response service to Charlottesville, Albemarle County, Nelson County, Buckingham County, Fluvanna County, and Louisa County. Connect provides fixed-route commuter bus service to the city of Charlottesville from Albemarle, Buckingham, and Nelson Counties. Greene County Transit provides commuter service to Charlottesville from Greene County as well as demand response circulator service within Greene County.

Jaunt serves a population of 334,535 over an area of 2,595 square miles. Most of Jaunt's service population is center in the City of Charlottesville and the urbanized areas of Albemarle County such as Crozet, Pantops, and the I-29 corridor which surround Charlottesville's city limits. The rest of Jaunt's service area is rural and low density.

Figure 1: Jaunt Service Area



Alternative Fueling Information

According to the Alternative Fuels Data Center, there are currently 44 public alternative fueling sites in Jaunt's service area: 42 sites provide electric vehicle charging and two provide E85 ethanol biofuel/biodiesel fueling. Of the 42 publicly-available electric vehicles fueling locations, 28 locations are Combined Charging System (CCS) chargers, 12 locations contain Tesla chargers, and two locations contain Tesla superchargers. More detail regarding electric vehicle charging infrastructure and charger levels is included in the Industry Background section of this report.

The 28 CCS charging locations are primarily centered around the City of Charlottesville and the urbanized regions of Albemarle County surrounding Charlottesville, with several others located in the outer region of Albemarle, Louisa, and Fluvanna Counties. There are no CCS locations within Greene County, Buckingham County, or Nelson County. Among the 28 CCS locations, there are five Level 1 chargers, 40 Level 2 chargers, and 19 Level 3 DC chargers. Similarly, most of the Level 3 DC chargers are centered around Charlottesville, but there are four Level 3 DC chargers at the CCS location in Louisa County.

Tesla chargers are proprietary to Tesla vehicles. Adapters are available for non-Tesla vehicles to access Tesla chargers (non-Superchargers only). Note that Tesla Superchargers are the proprietary version of Tesla's DC fast charger which are only available for Tesla vehicles. It is undetermined if non-Tesla owners would be required to pay a monthly membership fee in addition to the price per kilowatt-hour (kWh) and the cost of an adapter (Katje, 2022). If Jaunt utilized Tesla chargers, the paratransit vehicles Jaunt intends to procure will use the CCS charger plugs: J1772 (Type 1) and CCS1 charging connectors for AC charging and DC charging, respectively.

The number of CCS charging locations is likely to increase within Jaunt's service area as the adoption of electric vehicles increases amongst the public. Most of this growth will likely be in urbanized areas of Jaunt's service area, but the non-urbanized areas will likely see some increase in due to rising public demand and governmental incentives.

The distribution of electric vehicle chargers by count and community is indicated in **Table 11** and **Table 22** for all and for non-Tesla charges, respectively. The locations of existing electric vehicle charging stations is shown in **Figure 2**.

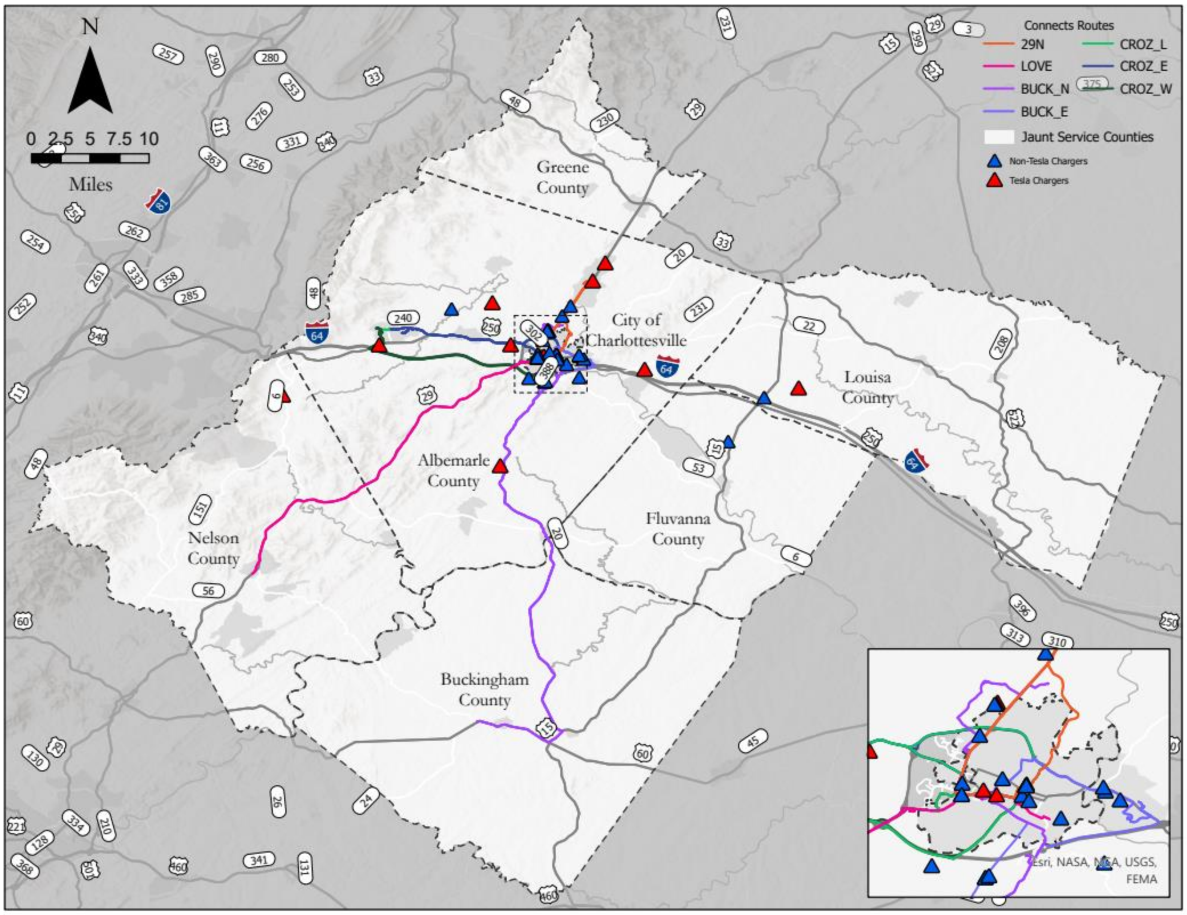
Table 1: Service Area Electric Vehicle Chargers

Number of Alt Fuel Charging Sites	
Electric	42
E85	2
Number of Electric Chargers	
Level 1	5
Level 2	71
Fast Charger	35
Location of Electric Charging Sites	
Charlottesville	36
Afton	1
Crozet	1
Keswick	1
Louisa County	1
Zion Crossroads	1
Palmyra	1
Number of Chargers Per Location	
Charlottesville	
Level 1	5
Level 2	59
Fast Charger	31
Afton	1 (Level 2)
Crozet	4 (Level 2)
Keswick	3 (Level 2)
Louisa County	2 (Level 2)
Zion Crossroads	4 (Fast Chargers)
Palmyra	2 (Level 2)

Table 2: Service Area Electric Vehicle Chargers (CCS/Non-Tesla)

Number of Alt Fuel Charging Sites	
Electric	42
E85	2
Number of Electric Chargers	
Level 1	5
Level 2	71
Fast Charger	35
Location of Electric Charging Sites	
Charlottesville	26
Zion Crossroads	1
Palmyra	1
Number of Chargers Per Location	
Charlottesville	
Level 1	5
Level 2	59
Fast Charger	31
Zion Crossroads	4 (Fast Chargers)
Palmyra	2 (Level 2)

Figure 2: Existing Electric Vehicle Charging Stations



INDUSTRY BACKGROUND

This section discusses the status of the low- and zero-emissions transit industry including national factors, trends in the State of Virginia, and lessons learned from peer agencies actively deploying and using alternative fuel vehicles.

National Market Trends

Low- and zero-emissions transit vehicles are becoming widely studied across the United States with an industry-wide push to reduce the carbon emissions resulting from transit. With significantly more Federal funding available as a result of the 2021 Infrastructure Investment and Jobs Act (IIJA, H.R.3684), transit agencies are moving to implement transition programs for fleets vehicles. Described below are the capabilities and opportunities regarding low- and zero-emissions vehicles including Compressed Natural Gas, Battery Electric, and Hydrogen Fuel Cells.

Compressed Natural Gas Vehicles

While some vehicle technologies are considered zero emissions, there are market-available vehicles that have a lower carbon emission potential compared to traditional gasoline or diesel vehicles. The primary (and most available) combustion-based alternative fuel is natural gas. When compressed, it can be stored onboard a vehicle and used as a fuel much like gasoline or diesel. Compressed Natural Gas (CNG) vehicles have similar performance standards to diesel or gasoline vehicles and current CNG paratransit vehicles on the market have driving ranges of 300 miles. CNG is the most widely adopted and established alternative fuel and has been used by transit agencies for decades. Nearby examples include the Greater Richmond Transit Company (GRTC) in Richmond and Arlington Rapid Transit (ART) in Arlington County.

Figure 3: CNG Vehicle Fueling

Image Source: https://img.fleetmaintenance.com/files/base/ebm/fm/image/2012/04/maturalgasledephotonew_10705860.png?auto=format,compress&fit=crop&h=556&w=1000&q=45

CNG Fueling

The infrastructure needed for CNG fueling varies based on the station's configuration. Transit agencies commonly use a buffeted fast-fill station configuration as this allows for vehicles to be fueled quickly and sequentially (American Gas Association). A buffeted fast-fill station configuration requires the following equipment:

- Dryer
- Compressor
- Priority-Sequential Panels
- Cascade storage tanks
- Hose/dispenser

CNG Sourcing

Sourcing for CNG, and thus environmental impact, varies based on the manner of methane production. The main method of producing natural gas is through mining natural deposits with methods such as hydraulic fracturing ("fracking") which is a non-renewable sourcing method. Natural gas derived from renewable sources is called renewable natural gas (RNG), and can be obtained from agricultural capture from livestock, anaerobic digesters of septic waste, or landfill methane capture. Since the heating value (Btu) of pure RNG tends to be less than non-renewable natural gas, it is often mixed into the gas distribution system rather being sold on its own.

RNG and non-renewable natural gas have the same GHG emissions when combusted, but RNG is considered to have lower overall GHG emissions as it is capturing methane emissions that *would have* been released into the atmosphere rather than creating new emissions. This is because methane has a much higher impact on the atmosphere as a greenhouse gas when compared to carbon dioxide, so combustion of methane into carbon dioxide is considered to reduce the emission.

The primary barrier to implementing RNG is its scalability. Currently, RNG is not considered to have the same production potential as non-renewable natural gas, and as RNG is sourced opportunistically using the byproduct from other industries/uses, RNG cannot be reliably produced at scale. Unless a direct sourcing and delivery system is established, natural gas for transit vehicles is likely to require the purchase of renewable gas credits to offset emissions and likely would rely on the existing natural gas distribution network.

Battery Electric Vehicles

The most widely adopted zero emission technology for paratransit and demand response vehicles in the United States is battery electric. Electricity is stored onboard the vehicle in large batteries, then delivered to an electric motor to provide traction power. Additionally, all vehicle systems are powered by the battery including climate control and accessible wheelchair equipment.

As of publication of this report, there are several battery electric models of shuttles and paratransit vehicles on the consumer market. Their stated range averages approximately 100-150 miles but some models can reach up to 210 miles (Evenergi, 2022). However, the range of battery electric vehicles during operation varies greatly based on external factors such as elevation gain, weather, driver aggression, or the use of climate control equipment. The prevailing industry standard is that battery electric vehicles can achieve up to 70% of their stated range, but adverse conditions, such as cold weather and strenuous topography, can reduce a battery electric vehicle's operational range to only 60% of its stated range. Additionally, the vehicle chassis/platform impacts battery range performance, where larger vehicles such as cutaways with accessible equipment have a shorter range than an electric mobility-style van which is lighter and often equipped with consumer market equipment.

A battery electric vehicle's batteries, similar to smartphone or laptop batteries, gradually lose the amount of charge they can hold every time they are recharged. This is known as *battery degradation*. As the wide-scale adoption of battery electric vehicles for transit purposes has only occurred relatively recently, exact lifespan/the amount of battery degradation per year is still undetermined. Battery life for transit buses has been assumed as being between 5 and 10 years (McGrath, Blades, Early, & Harris, 2022). However, the rate of battery degradation varies depending on how frequently they are recharged, the rate of charge used to recharge them, and the level of charge the battery is allowed to hit. Charging a battery at a higher rate will lead to faster degradation and may result in an accelerated range reduction over the lifespan of a vehicle.

Figure 4: Example of New Battery Electric Cutaway Vehicle

Image Source: https://assets.website-files.com/61565c6de1a9737e67cbbf65/617494578d8dbc408b9bec78_ac2a2180-4c80-46ef-9210-322c2e0abaed_rw_1920.jpg

Charging Equipment

Refueling/recharging a battery electric vehicle requires the use of a charger. Batter electric vehicle chargers are classified by their power output. There are three main types of electrical chargers:

- Level One (120 volts AC, 1.3-2.4 kW),
- Level Two (240 volts AC, 4-8 kW),
- Level Three, also known as DC Fast Chargers (50-350 kW)

Level One and Level Two chargers both use Alternating Current (AC) and differ in the amount of electrical power they can supply; level 2 chargers can supply greater power than a level one charger and thus charges electric vehicles faster. Level 2 chargers typically take 8-10 hours to fully charge a paratransit vehicle.

Level 3 DC chargers use Direct Current (DC) to charge electric vehicles and recharges vehicles faster than the AC chargers. Due to their high-power output, Level 3 DC chargers stop “fast charging” once a vehicle’s battery hits 80% charge. The DC fast charger will then either charge the other 20% at non-fast charging speeds or stop charging all together. This 80% threshold on fast charging is a safety measure to slow the degradation of the vehicle’s battery. While Level 3 DC chargers can supply up to 350kW of electrical output, not all battery electric vehicles can take advantage of the power output due to limitations in their max charge rate. Most battery electric paratransit vehicles and shuttle buses on the market have a max charge rate of 50 kW and thus cannot be charged at rates of 150 kW or 350 kW. The energy storage capacity of most battery electric paratransit vehicles and shuttle buses ranges from 100 to 150 kWh, so a DC fast charger will take around 2-3 hours to fully charge the vehicle.

Figure 5: Example of Battery Electric Vehicle Chargers

Image Source: https://cdn.motor1.com/images/mgl/YBz1y/s1/4x3/electric-vehicle-charging-levels-explained.webp

Charging Strategies

Battery electric vehicles take substantially longer to charge compared to fueling conventional vehicles; multiple hours compared to several minutes. As such, running out of charge is a detriment in providing consistent or reliable transit service with battery electric vehicles. As such, running out of charge is a detriment in providing consistent or reliable transit service with battery electric vehicles. Transit agencies have developed charging strategies to work around the issue of range. The first strategy is called “depot charging.” This is a straightforward process as vehicles are fully charged at their depot/maintenance facility when not in service, often overnight. The vehicles are then put into service and return once their runs have been completed or when they run out of charge. If a vehicle is likely to run out of charge before their service is completed, a spare vehicle may be swapped in by the driver or a new driver and vehicle may be sent out to complete the remaining service.

Depot charging can be employed using Level 2 chargers, Level 3 DC chargers, or through a combination of the two types of chargers. Depot charging using slow chargers will require a 1:1 or 1:2 vehicle to charger ratio, depending on the selected equipment. A 1:1 vehicle to charger ratio requires additional facility space but are often the more reliable depot charging strategy especially for transit agencies without much experience with battery electric vehicles (when compared to multi-dispenser or fast charging). Using Level 3 DC chargers or a charger with multiple dispensers can reduce the amount of space and capital needed as less chargers are needed to charge the fleet. However, depot charging with a higher vehicle to charger ratio is more prone to service impacts from charger malfunctions (Leper, Burget, & McKenzie, 2022). Alternatively fast charging at a depot requires staff time to monitor charge states and move vehicles as they are recharged.

The second charging strategy is the use of on-route charging. On-route charging uses high-powered chargers to refuel a battery electric vehicle while it’s still in service, instead of taking the vehicle out of service and returning it to a depot. On-route charging is usually employed in conjunction with depot charging as a range extension strategy. An on-route charging only strategy uses the on-route fast chargers as the only fueling infrastructure, and it requires fast chargers at strategic points in a vehicle’s route to fully recharge a near-depleted vehicle multiple times through its operational run. A strategy using both on-route and depot charging will use an on-route charger once or twice per a vehicle’s operational run to “top-off” its battery so the vehicle can complete its run.

Currently, on-route charging technology for paratransit vehicles and shuttle buses is not as developed as it is for transit buses: there are no pantographs for shuttle buses and most models of transit vehicles are not capable of using induction charging. Additionally, the max charge rate of the vehicles Jaunt will likely use means that it would require 2-3 hours to achieve a full charge instead of 10-20 minutes that most models of battery electric transit buses can achieve. Level 3 DC fast chargers also tend to stop fast charging once a vehicle’s battery hits 80% charge to slow the degradation of the vehicle’s battery.

Hydrogen Fuel Cell Vehicles

Hydrogen fuel cell, also known as fuel cell electric, is also a zero-emission vehicle propulsion technology. The drivetrain of a hydrogen fuel cell vehicle operates similarly to a battery electric vehicle, using an electric motor to provide traction power (as opposed to an internal combustion engine). However, the battery on a hydrogen fuel cell vehicle is typically much smaller than that of a battery electric vehicle and is repeatedly changed as needed by a hydrogen fuel cell unit that produces electricity, heat, and pure water. In this sense, the hydrogen fuel cell is a range extender for a battery-electric drivetrain. Given this power train and the heat byproduct of the unit (which can be used for cabin climate conditioning), a hydrogen fuel vehicle is capable of ranges in parity with traditional fossil-fuel combustion vehicles.

Although the technology is similar to that of battery-electric vehicles, hydrogen fuel cell vehicles are not as widely adopted by transit agencies. This is primarily the result of hydrogen fuel sourcing: the hydrogen fuel must be either self-generated by the agency or delivered by truck. As of the publication of this report, there are few commercially available hydrogen suppliers in the United States, most of which operate in California. However, there is anticipated to be rapid change in the hydrogen supply chain as the United States Department of Energy is investing in a national "Hydrogen Energy Earthshot" program. The program will invest in four large-scale generation and end use regions across the United States (termed "hydrogen hubs") and help to establish hydrogen as a more widely-adopted fuel.

Figure 6: Example of Hydrogen Fuel Cell Cutaway Vehicle

Image Source: https://img.oemoffhighway.com/files/base/acbm/ooh/image/2014/07/dsc00022-copy2-11267712_11545450.png?auto=format%2Ccompress&q=70

Hydrogen Fueling

The infrastructure needed depends for hydrogen fueling varies based on what state the hydrogen arrives in and at what pressure the hydrogen intends to be dispensed at. Common elements across all hydrogen fueling stations are:

- Compressor
- Cascade storage tanks
- Precooler/chiller
- Hose/dispenser

Hydrogen arriving in liquid form require additional equipment:

- Cryogenic storage
- Liquid pump
- Vaporizer

Hydrogen stations which dispense hydrogen at high pressures require a booster and an accumulator in addition to the common fueling items. The capital costs for a liquid supply and a gaseous supply fueling stations are similar with gaseous supply fueling stations tending to have slightly higher capital costs. The main factors which increase the capital costs of the hydrogen fueling stations are boosters, and the number of consecutive fills the fueling station can perform based on fleet size (Pratt, Terlip, Elgowainy, Ainscough, & Kurtz, 2015).

Figure 7: Hydrogen Fueling Equipment Example

Image Source: https://www.plugpower.com/wp-content/uploads/2016/09/H2Infrastructure.jpg

Hydrogen Production

While the most comment supply chain for fuel cell vehicles is to have gaseous or liquid hydrogen delivered by truck and store onsite, there is the potential to self-generate hydrogen from either pure water or natural gas. Hydrogen for transportation or other large-scale uses can be produced primarily through two methods: steam methane reformation (SMR) or electrolysis. SMR is the more common of the two methods, as it is more efficient at an industrial scale. Hydrogen created through SMR originates as methane molecules (CH_4). The methane molecules are heated to a point where the carbon atom separates from the four hydrogen atoms and is emitted as a byproduct. SMR production that emits carbon into the atmosphere is referred to as grey hydrogen and it produces upstream greenhouse gas (GHG) emissions. The byproduct carbon from SMR can be captured, and SMR production which captures its excess carbon is referred to as blue hydrogen.

Hydrogen can also be obtained through electrolysis. While not as commonly used as SMR, electrolysis is receiving greater research and grant money as the US Department of Energy pursues its “Hydrogen Energy Earthshot.” Hydrogen (H_2) created through electrolysis originates as water. A positive and negative electrical current is passed through water which splits water molecules, H_2O, into oxygen molecules, O_2, and hydrogen molecules, H_2. As electrolysis uses electricity to produce hydrogen, electrolysis is considered to be carbon-free. The overall GHG emissions from electrolysis production depends on the electricity generation source. Yellow hydrogen refers to hydrogen produced through electrolysis from the local electric grid. Hydrogen produced from electrolysis using electricity from all renewable, carbon-free sources is called green hydrogen. A main goal of the “Hydrogen Energy Earthshot” is to get the price of green hydrogen down to a dollar per kilogram within a decade, approximately 2031.

Currently, only one transit agency in the United States is using hydrogen fuel cell vehicles for paratransit Stark Area Regional Transit Authority (SARTA) of Stark County, Ohio, but more transit agencies are beginning to order hydrogen fuel cell paratransit vehicles. As of 2022, there is one hydrogen fuel cell paratransit vehicle on the market. The model (manufacturer: Ideanomics US Hybrid) has a stated range of 300 miles. Refueling a hydrogen fuel cell vehicle takes around six to ten minutes.

Inflation Reduction Act

The Inflation Reduction Act of 2022 became public law on August 16th, 2022. The law contains tax credits for electric vehicles and their infrastructure. Relevant credits for Jaunt may be the commercial vehicle tax credit and the EV charging equipment tax credit. The commercial vehicle tax credit is available until the end of 2032, and the tax credit provides funding for either 30% of the sales price of the electric vehicle or the incremental cost of the electric vehicle, whichever one is less costly. The incremental cost is the cost difference between the selected EV with a comparable internal combustion vehicle. The tax credit is also capped at $40,000 for vehicles with a gross vehicle weight rating of more than 14,000 lbs. There are also no battery or mineral sourcing requirements for the tax credit.

The EV charging equipment tax credit is available until the end of 2032 and is available for commercial uses. The tax credit for commercial uses comes with the requirement that they be placed in either low-income community or non-urban area. Low-income communities are defined in the law as an area where 20% of the population is under the federal poverty rate or where the median family income doesn't exceed 80% of the statewide or metropolitan area median family income, depending on whether the census tract is located within a metropolitan area or not.

Trends in Virginia

Virginia is currently in the infancy stage of transitioning transit revenue vehicles to alternative fuels. More than one half of Virginia's 2,168 transit buses still use diesel, and one third still use gasoline (Gordon, 2022). The rest of the buses run on either compressed natural gas, propane, or battery electric. As of April 2022, only around one percent of Virginia's transit buses were battery electric. Commuter bus and demand response vehicles are even further behind on the transition. However, several transit agencies within the state have started to adopt long-term adoption of zero emissions vehicles.

Interview and Lessons Learned from Peer Agencies

As there has been limited research and documentation on the transition and performance of alternative fueled paratransit vehicles, the project team conducted industry research on transit agencies operating alternatively fueled paratransit vehicles. A list of 13 transit agencies from across America was compiled. These transit agencies were selected for the list based on the similarity of their service to Jaunt's, the similarity of their service area to Jaunt's, the alternative fuel they chose to operate, and their expertise with said alternative fuel. These 13 transit agencies were then ranked based on the previous categories, and four transit agencies were selected as the peer agencies to be interview: SunLine Transit Agency, Stark Area Regional Transit Authority (SARTA), Heart of Iowa Regional Transit Agency (HIRTA), and CT Transit Waterbury.

Following preliminary outreach, scheduling emails were sent to the four peer agencies. Interviews were accepted and scheduled with SunLine and SARTA, but other interview attempts were unsuccessful. As such, the sections below contain notes from the two interviews, and literature reviews from other agencies are considered in the market overview section(s) above.

SunLine Transit Agency, August 12th, 2022, Thousand Palms, California
Riverside County, California

Basic Information

- 85 fixed-route buses, 35 paratransit vehicles
- 1,130 square mile service area
- 4 million annual trips
- 472,427 service area population

Current Service/Operations

While SunLine Transit Agency currently uses a mix of hydrogen fuel cell, battery electric, and CNG buses for their fixed-route transit buses, their paratransit fleet is all CNG. SunLine has been operating CNG since 1994 and began to introduce hydrogen fuel cell buses to their fleet in 1999. SunLine produces approximately 900 kgs of hydrogen per day hydrogen on site and sells excess hydrogen to the public. Originally, the agency produced hydrogen through micro-channeled SMR, but recently introduced an electrolysis plant in 2019 to supplement and eventually replace the SMR plant. In conjunction with this deployment, SunLine plans to build a 2.4-acre solar farm to power the hydrogen electrolyzer. SunLine’s existing hydrogen plant is 80 feet by 60 feet (4,800 sq ft) and cost $2.6 Million for the equipment, installation, and other soft costs. The interviewed representatives from SunLine noted that transition from CNG to hydrogen was relatively straightforward, although a few upgrades needed for the plant.

SunLine selected hydrogen fuel cell as their preferred technology in the future since the California Air Resources Board (ARB) passed the Innovative Clean Transit regulation which required all transit vehicles to be zero emission by 2040. SunLine selected hydrogen fuel cell over battery electric vehicles mainly due to operational considerations. Their paratransit routes require over 200 miles in range, and the agency was unable to procure a battery electric paratransit vehicle capable of completing the runs. The representatives from SunLine also cited range reductions in battery electric vehicles due to the hot climate in the summers; their hydrogen fuel cell buses provided enough range to mitigate impacts as a result of heat. Additional concerns over refueling times with battery electric vehicles were cited as a reason for choosing hydrogen fuel cell; their hydrogen fuel cell vehicles only take seven minutes to refuel compared to multiple hours with their battery electric vehicles.

SunLine plans to deploy hydrogen fuel cell paratransit vehicles by the end of 2022. They noted that their deployment was delayed due to supply chain issues for hydrogen fuel cell cutaways. The paratransit vehicles they are procuring are from US Hybrid, built on Ford E350 chassis with a range of 200 miles.

Additional Key Points of Discussion

- CNG vehicles aren’t affected by weather
- CNG vehicles can run 170,000 miles before they need to be replaced
- Their CNG paratransit vehicles were purchased through Creative Coaches and used a Ford chassis
- Electrical power is expensive in California and was another factor in guiding SunLine towards hydrogen vehicles
- Liquid hydrogen is better for transit operations than gaseous hydrogen
- Hydrogen fuel cell vehicles do lose some range in extreme weather but not the same extent as battery electric vehicles
- SunLine’s operators are union, and they have mandatory training meetings every month
- SunLine created a centralized training program for hydrogen fuel cell vehicles
- SunLine has an operator mentor program to get new operators used to driving hydrogen fuel cell vehicles

Stark Area Regional Transit Authority, August 25th, 2022, Canton, Ohio
Stark County, Ohio

Basic Information

- 36 transit buses, 30 demand response buses
- 581 square mile service area
- 1.3 million annual trips
- 375,595 service area population

Current Service Operations

SARTA is currently using hydrogen fuel cell and CNG for both their fixed-route transit buses and their paratransit fleet. They were the first transit agency in the Unites States to deploy hydrogen fuel cell paratransit vehicles, and they plan to transition their whole fleet to hydrogen fuel cell.

Their hydrogen fuel cell paratransit vehicles are procured from US Hybrid. They have a 300-mile driving range and are capable of a 16-hour shift. Their models carry 13.5 kgs of hydrogen on-board. SARTA's representative stated that the price for purchase and operations of hydrogen fuel cell vehicles was about 50% higher than tradition gasoline and diesel deployment.

SARTA chose to adopt hydrogen fuel cell vehicles over battery electric vehicles due to operational capabilities. The 100-125 ranges of battery electric paratransit vehicles weren't enough for SARTA's paratransit requirements. SARTA's CEO found that hydrogen fuel cell paratransit vehicles had enough driving range and were operationally resilient to the point where service would not require alteration to accommodate the vehicles.

Key Points of Discussion

- SARTA's CEO has been informed that many transit agencies which rapidly adopted battery electric vehicles have paused their deployment and have begun switching to hydrogen vehicles due to operational limitations of battery electric vehicles
- Liquid hydrogen delivery is the cheapest and easier method of procuring hydrogen
    - Transit agencies only need a storage tank, vaporizer, and a compressor if their hydrogen is delivered in liquid form
    - SARTA switched away from producing hydrogen on-site through SMR
    - Electrolysis and SMR production works best when it is constantly running
    - On-site hydrogen production will always produce excess hydrogen, so hydrogen storage is essential
    - The SARTA CEO recommended against installing a new on-site hydrogen production plant since the technology is rapidly changing
- SARTA currently pays around $4.40 per kilogram for hydrogen
- Hydrogen fuel cell vehicles get around seven miles per kilogram of hydrogen
- Rebuilding a hydrogen fuel cell engine cost $40,000 which is cheaper than rebuilding a diesel engine

- The batteries in hydrogen fuel cell vehicles are the weakest part - SARTA had to replace their hydrogen fuel cell batteries earlier than anticipated due to degradation
- Hydrogen fuel cell vehicles start to experience maintenance issues if they are not constantly in service - a month is too long for a hydrogen fuel cell vehicle to be out of service
- Drivers need training to best operate the new vehicles - drivers need to be less aggressive on the accelerator and become used to regenerative breaking
- Before deploying hydrogen vehicles, make sure the vehicles and infrastructure is ready for full service
- The market is shifting away from CNG and RNG vehicles. SARTA's CEO stresses to not be on the backfoot when it comes to zero emission technology
- SARTA CEO suggested making hydrogen fueling infrastructure open to the public to show belief in the technology

Stakeholder Engagement

Jaunt formed an advisory committee to support the project team and provide perspective on the project findings. The committee charter and member ship is included in **Appendix A**. Feedback gathered during advisory committee meetings represent ideas and concerns that Charlottesville area communities, advocacy groups, and transit riders have regarding Jaunt's transition to alternative fueled vehicles. This information provides qualitative insight on community views and opportunities, complementing the data-driven analysis of the broader project.

Members of the project advisory committee represent a variety of groups including:

- Lucas Aimes: Jaunt's Board of Directors/Global Online Academy
- Hal Morgan: Jaunt's Board of Directors
- Elizabeth Cromwell: Charlottesville Chambre of Commerce
- Susan Kruse: Community Climate Collective
- Patrick A Clark: UVA Parking and Transportation
- Christine Jacobs: Thomas Jefferson Planning District
- Ethan K Heil: UVA Department of Sustainability
- Peter Krebs: Piedmont Environmental Council
- Donna Baker: JABA
- Sandy Shackleford: Thomas Jefferson Planning District

The project team met with the advisory committee three times throughout the project:

- June 2022 to introduce the project and provide technical background on zero emissions vehicles.
- September 2022 to review technical analysis and discuss the comparison of transition scenarios.
- November 2022 to discuss preliminary recommendations and incorporate feedback into final study deliverables and outcomes.

Major Takeaways and Ideas

The following sections document major takeaways from the project team's meetings with the advisory committee.

Advisory Committee Meeting #1 (June 2022)

- Members are interested in the potential of using solar energy to supply power to electric vehicles and their chargers.
- Some committee members were inquisitive of the role natural gas might play in achieving the desired greenhouse gas reduction goals.
- Committee members were curious of the potential alternative's upstream greenhouse gas emissions as well as their impacts on local air pollution.
- The committee was concerned around the amount of training maintenance staff might need for a transition to an alternative technology.
- Committee members were interested in how Jaunt's and CAT's alternative fuel feasibility studies were interplay with one another.
- Committee members were interested in a hybrid technology solution.

Advisory Committee Meeting #2 (September 2022)

- The advisory committee showed a preference towards battery electric vehicles and were interested in potential fast charging options.
- Committee members were interested in potentially piloting battery electric vehicles before committing to the technology completely.
- The advisory committee showed a hesitation and concern towards a potential transition to using natural gas fuel, even as a temporary reduction measure.
- Committee members reacted positively to a phased deployment of electric vehicles.
- Jaunt's Board of Directors is looking into acquiring more land as committee members recognized than any fuel transition is likely to require more vehicles or fueling infrastructure.

Advisory Committee Meeting #3 (November 2022)

- Committee members asked clarifying questions related to the negative greenhouse gas emissions resulting from the use of RNG and expressed continued concern over the use of natural gas as a fuel type.
- Committee members asked clarifying questions related to the cost assumptions in the comparison table for different technology types and deployments.
- The advisory committee discussed the consultant recommendation for battery electric vehicles (described later in this report). The following feedback was provided:
  - The recommendation "felt right" given the background information and desire of the Jaunt board.
  - The recommendation appeared to be right, though the number of zero emission vehicles deployed at first is still up for discussion. The advisory committee discussed that implementation plans would need to be developed further in the future.

  - The advisory committee likes that Jaunt would be "leading the way," but want to ensure capacity is not reduced for current trips. The vehicles still need to be elderly friendly and accessible for everyone.
- The advisory committee recognized that a small initial deployment of zero emissions vehicles is a step towards meeting goals and is reflective of the potential challenges a transition in technology may impose on Jaunt staff.

Existing Conditions and Service

This section documents the services provided by Jaunt and the analyzed system and vehicle needs based on data provided by Jaunt.

SERVICE DESCRIPTIONS

Jaunt provides three different services: Jaunt, Connect (commuter bus), general public demand response including complementary American with Disabilities Act (ADA) paratransit, and intercounty or "Link" service. These are described in the sections below.

Demand Response and ADA Paratransit

Jaunt provides curb-to-curb demand-response service in the counties of Buckingham, Fluvanna, Greene, Louisa, Nelson, and rural Albemarle. Jaunt also provides ADA paratransit service in the City of Charlottesville and urban Albemarle County. Jaunt's ADA paratransit service operates within a three-quarter mile radius of Charlottesville Area Transit's fix route bus service.

There are 19 different run classes within Jaunt's demand response service. The demand-response service has two different forms of operation: link service and circulator service. The link services are similar to commuter service as it transports riders from the outer counties into Charlottesville and urban Albemarle County during the morning hours and runs return service from during the afternoon. The link service run classes are not operated continuously and there's approximately a six- to ten-hour break between morning and afternoon service. The circulator service transports passengers anywhere within their county of origin. The circulator service operates continuously, often between the hours of 8:00 AM and 4:00 PM.

Jaunt requires reservations to be made at least a day in advance to use either their ADA paratransit or demand response services. Riders can make a reservation by phone or by email, and riders must provide their desired trip date, the street address of their pickup point, their desired pickup time, and the location of their destination. As of October 19th, 2022, Greene County residents can schedule same day reservations for the Greene Circulator Service from 10:00 AM to 2:00 PM. After a reservation has been made, the customer is given a 25-minute pickup window.

Connect

Connect provides fixed-route commuter service to the University of Virginia (UVA) and downtown Charlottesville from Crozet, Route 29 to the north, Buckingham County, and Nelson County. Connect operates like a fixed-route bus service and does not require a reservation to ride. Connect has four fixed route services:

- Crozet Connect
- 29 North Connect
- Buckingham Connect
- Lovingston Connect

Connect is a commuter service, so routes are not continually operated throughout the day. The fixed route services are operated during morning and evening peak hours, typically 5:30 AM to 9:00 AM in the mornings and 3:30 PM to 7:00 PM in the evenings.

FACILITY AND FLEET

Facility

Jaunt's combined headquarters, maintenance building, and vehicle storage facility is located in the Southeastern section of the City of Charlottesville near Interstate 64.

Jaunt vehicles are fueled at public gas stations, thus no fueling infrastructure is provided at the facility. This allows for Jaunt's facility to have more parking spaces/storage for vehicles. However, many of Jaunt's vehicles are parked/stored overnight at their respective drivers' homes. Jaunt's current electric utility provider is Dominion Energy, and their gas utility provider is the City of Charlottesville. An aerial image of Jaunt's facility is shown in **Figure 8**.

Figure 8: Jaunt Headquarters

Greene County transit service shares a storage facility with Greene County. In addition to providing parking for paratransit vehicles, the County stores school buses and other County vehicles at a municipal facility parking lot. This facility is located off Route 33 at 74 Industrial Drive Ruckersville, VA, 22968. The electric utility provider in this area is Rappahannock Electric Cooperative, and its gas utility provider is Columbia Gas Services. Utility service areas are shown in **Figure 9** and **Figure 10**.

Under existing conditions, many of Jaunt's fleet vehicles are stored at drivers' homes overnight. The practice enables drivers to minimize non-revenue miles between service start and depot locations. This also reduces the required real estate at depot and parking locations.

Figure 9: Electric Service Territories

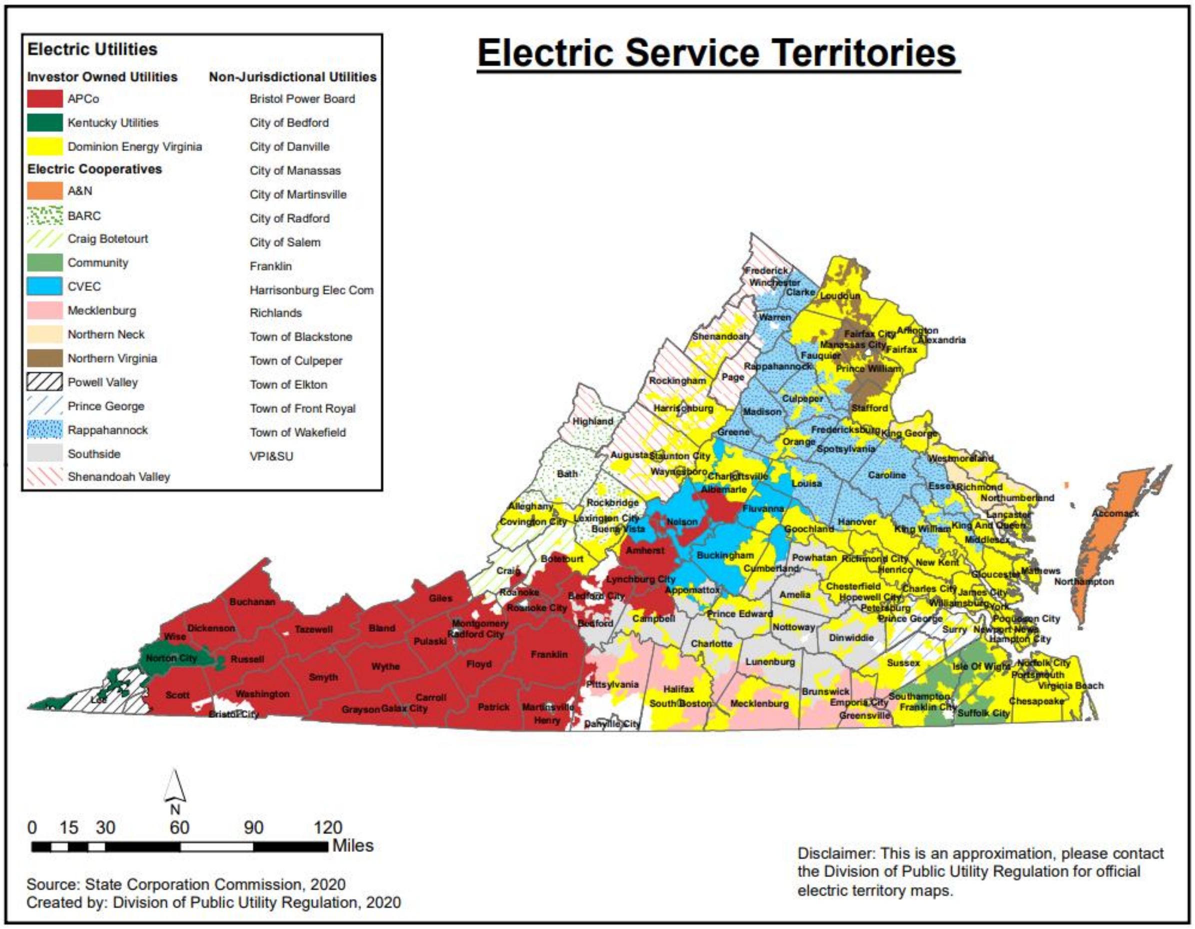
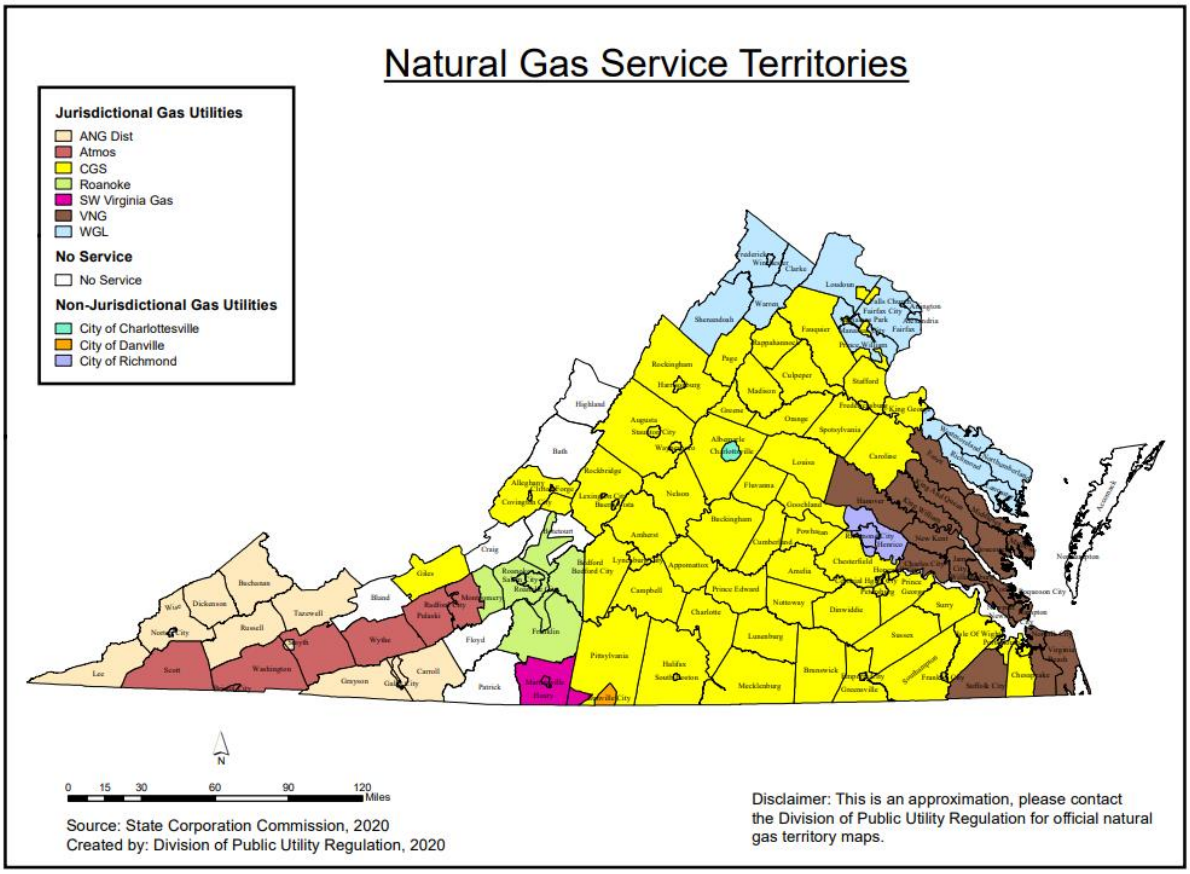


Figure 10: Natural Gas Service Territories



Fleet

Jaunt currently maintains 108 vehicles in its fleet. Most vehicles in Jaunt's fleet are cutaway, body-on-chassis buses. Jaunt also maintains vans and minivans as service vehicles. All of Jaunt's vehicles use gasoline except for one electric battery Ford Transit van. Jaunt owns 93 of its vehicles with the other 15 vehicles being privately owned. Considering Jaunt's 20% spare ratio requirement, 86 of Jaunt's 108 vehicles can operate at peak service while 22 are maintained as spares. Based on Jaunt's current fleet roster, 13 vehicles are assigned to commuter bus service, while 95 vehicles are assigned to demand response service. Additionally, nine vehicles are considered out of service. **Table 33** summarizes Jaunt's current fleet and vehicle assignments.

Table 3: Jaunt Fleet Roster and Assignment

Total Fleet	Demand Response	Commuter Bus	Vehicles Available for Peak Service	Spares	Down Line
108	95	13	86	22	9

To meet the FTA's Minimal Asset Useful Life Standards, the vans, minivans, and the cutaway buses under 25 feet in length are required to be in service for at least four years and operate at least 100,000 miles. Cutaway-style buses that are 25 feet in length or longer need to be in service for at least five years and operate at least 150,000 miles.

Operational Feasibility Analysis

This operational analysis includes a description of the assumptions used in this study, analyzes the requirements of demand response service, analyzes the requirements of fixed route service, and documents some of the requirements of alternative scenario implementation.

Data used in this study is based on Jaunt's current fleet and services as of Summer 2022. Run mileage was determined using a historical review of trip distances from the period spanning May 1, 2021, through April 30, 2022.

ASSUMPTIONS

Mileage requirements for each run class needed to be calculated to test the operational capabilities of the various alternative fuel technologies. Jaunt provided datasets containing every daily run made by every vehicle (demand response and fixed route) in the system, and the total miles traveled by each vehicle. The project team then compiled one year's worth of these runs and then sorted the total mileage data by run class.

Box-and-whisker plots were created for every demand response and fixed-route run class to visually represent each run class's mileage requirements and to capture the variability of run class distance requirements throughout the year. The box-and-whisker plots display minimum value, second quartile, median value, third quartile, and maximum value of the dataset.

To compare against the range capabilities of alternative fuel vehicles, the following specification of vehicle ranges were used:

- Battery Electric: 130-mile stated range, 30% range reduction to represent average loss, 40% range reduction to represent range loss during strenuous conditions.
- Hydrogen fuel cell: 300-mile range
- CNG: 300-mile range

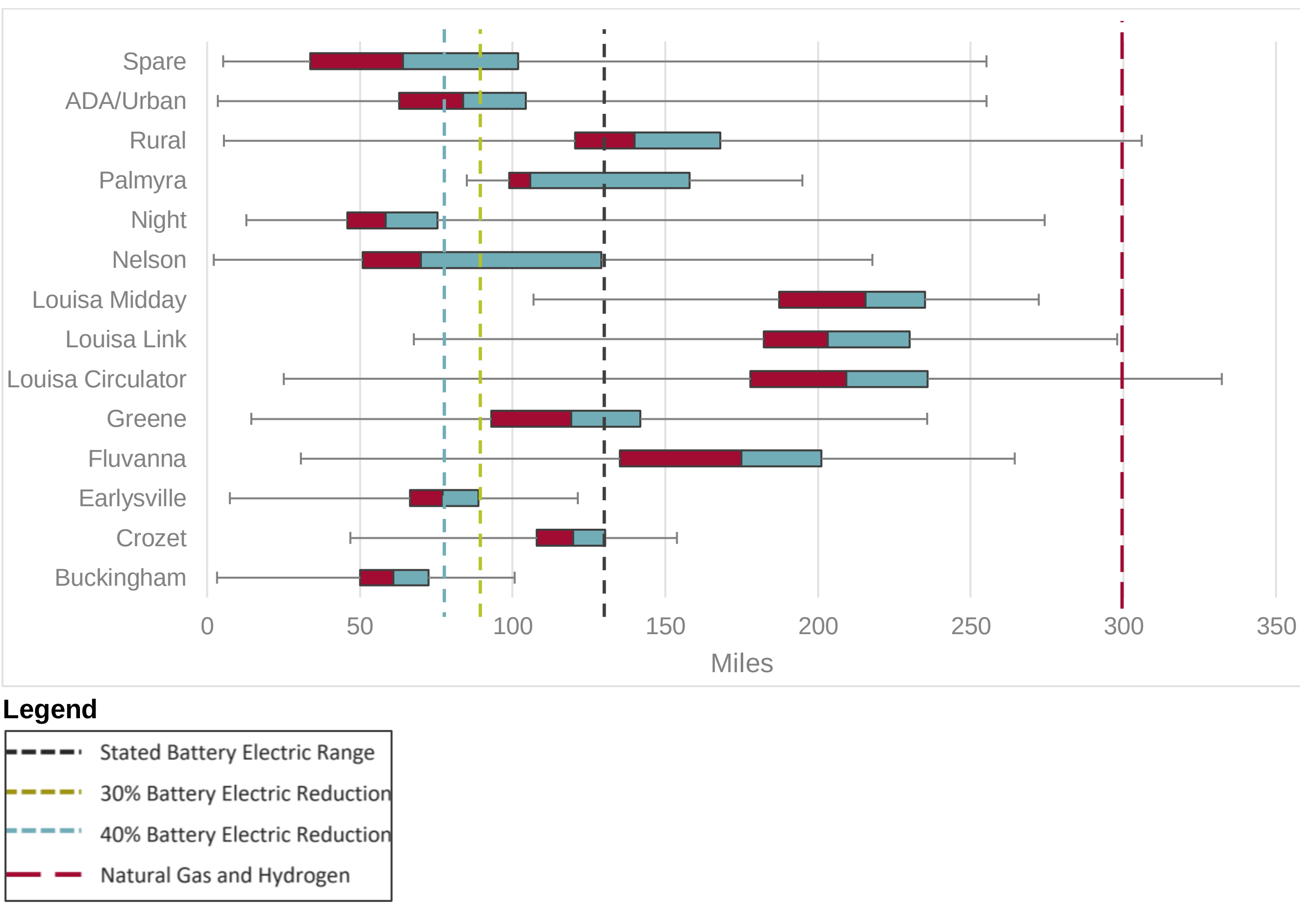
Note that since Jaunt needs to maintain an entirely accessible fleet (e.g., all vehicles must maintain equipment or ramps for mobility-impaired persons), Jaunt's preference is to maintain cutaways as the primary vehicle type. These vehicles provide sufficient cabin space for multiple wheelchair-equipped passengers and have sufficient ground clearance for locations services by the system. As a result, the vehicle range may be limited with current technology, and other vehicle platforms such as vans may provide additional range or faster charging equipment when deployed as a battery-electric vehicle.

As Jaunt and Greene both provides several forms of demand response service (including ADA paratransit), the service was assessed together for the operational analysis.

DEMAND-RESPONSE SERVICE

Vehicles serving demand response run classes experience a large range in vehicle miles traveled. Vehicles serving run classes on the lower end of the range record around 50 to 75 miles in a day, while vehicles serving run classes on the higher end of the range record between 150 and 200 miles in a day. The Louisa County run classes were by far the longest with the median miles traveled for a vehicle being over 200 miles. The demand response run classes also have a wide range of mileage requirements for vehicles. Nine of the 13 run classes (69%) have daily mileage workloads than range by 200 miles. A summary of the demand-response service run classes with mileage percentile breakdown is shown in **Figure 11**.

Figure 11: Demand Response Run Class Range Requirements



Compressed Natural Gas and Fuel Cell

CNG and Fuel Cell vehicles, with ranges of 300 miles, could accommodate the mileage requirements for Jaunt's and Greene's demand-response run classes. For some runs on the Louisa County or rural

Albemarle County run classes which approach 300 miles, CNG and Fuel Cell vehicles might need to be rerouted to be refueled. On cold winter days, additional Fuel Cell vehicles may require refueling on longer routes mid-service.

Battery Electric

Given current technology, battery electric vehicles would have more difficulty handling the mileage requirements for Jaunt's and Greene's demand run classes. The model battery electric vehicle used in the analysis completes 100% of the runs for none of the run classes (assuming a 30% range reduction). Zero run classes can be 100% complete assuming a 40% range reduction.

Assuming a 30% range reduction, a battery electric vehicle would complete over 75% of the runs on the Buckingham, Night, and Earlysville run classes. A battery electric vehicle would struggle to complete the Rural, Louisa, Fluvanna, Palmyra, Greene, and Crozet run classes as it would complete less than 25% of runs.

A tabulation of successful battery electric vehicle runs under a 30% and a 40% range reduction scenario is shown in **Table 44**.

Table 4: Battery Electric Vehicle Demand Response Run Successes

Percentage of Run Complete	30% Range Reduction	40% Range Reduction
100%	None	None
Between 100% and 75%	Buckingham, Night, Earlysville	Night, Buckingham
Between 75% and 50%	ADA/Urban, Nelson County	Earlysville, Nelson
Between 50% and 25%		ADA/Urban
Between 25% and 0%	Palmyra, Greene, Rural, Louisa Link, Louisa Circulator, Fluvanna, Crozet	Rural, Palmyra, Louisa Link, Louisa Circulator, Greene, Fluvanna, Crozet
0%	Louisa Midday	Louisa Midday

Based on the analysis above, the implementation of battery electric vehicles' range limitations may affect demand response levels of service. Potential solutions may be employed to mitigate range limitations but are based on the total fleet vehicle count or potential non-revenue duration available to charge.

The amount of demand response service Jaunt and Greene provides each day varies based on ride requests. To capture the impact of this, a maximum deployment was analyzed from historical data, taking the maximum number of vehicles deployed per run class per day. The number of vehicles deployed for each run class under each scenario was then be multiplied by the percentage of trips which exceed 91 miles (30% reduction) to calculate the number of vehicles per run class per day which fail to achieve their daily service requirements. The results were rounded to the nearest whole number and shown in **Table 55**.

Table 5: Maximum Vehicle Count Required for Demand Response Service

Run Class	Trip range over 91 miles	Maximum Vehicles Deployed	Vehicles not Achieving Service Requirement
ADA/Urban	41%	31	12
Rural	87%	2	2
Night	15%	4	1
Nelson	38%	3	1
Louisa Midday	100%	1	1
Louisa Link	98%	1	1
Louisa Circulator	97%	6	6
Fluvanna	92%	2	2
Earlysville	23%	1	0
Crozet	92%	1	1
Buckingham	2%	2	0
Greene	77%	8	5
Spare	31%	4	1
Total	**N/a**	**66**	**33**

Based on aggregated historical run data

For a day maximum demand, 66 demand response vehicles would be deployed and approximately 33 vehicles would run out of charge. Without any mid-day charging, this requires an additional 33 vehicles to be deployed for demand response service. In total, this would require a maximum of 99 vehicles. Considering a 20% spare ratio and 13 vehicles assigned to fixed route/commuter service, the Jaunt fleet would be required to increase to a total of 135 vehicles (assuming all vehicles are in operational conditions, e.g., no vehicles on down line).

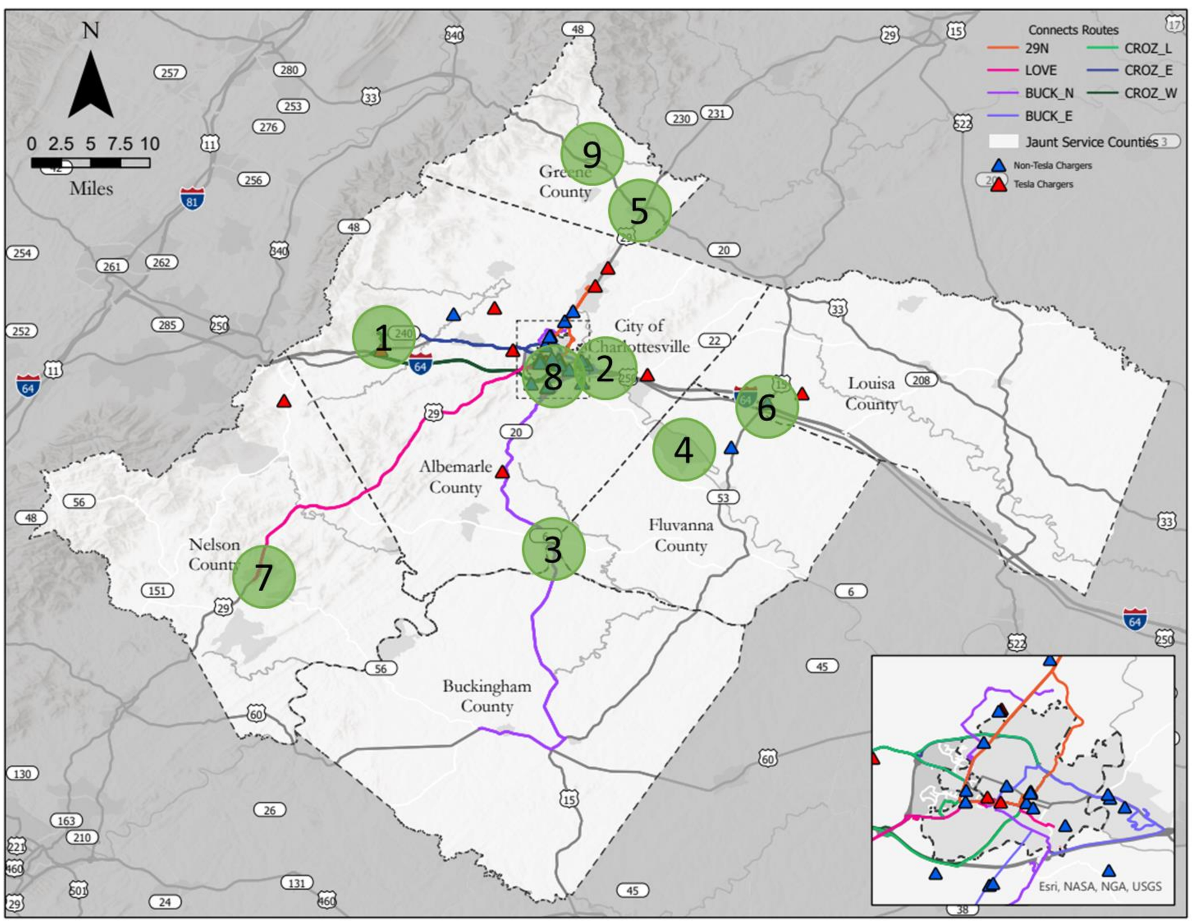
Alternatively, the number of additional vehicles needed could be reduced or eliminated through the application of on-route charging with Level 3 DC chargers or strategic vehicle assignment rotations where one or more spare vehicles could be swapped through services on multiple run classes. In conversation with Jaunt staff, and in review of service locations, the project team identified several potential locations for on-route charging. These locations are listed in **Table 66** and shown in **Figure 12** (on top of the publicly-available electric vehicle charging locations map). An estimated number of potential charges was also provided based on the number of routes which cannot be completed on a single battery electric vehicle charge. Note that these conceptual locations were also coordinated with the respective electric service providers in each area and described further in the **Findings and Discussion** section, below.

Table 6: Potential Electric Vehicle Fast Charging Locations

Service County	Community	Potential Charger Count
1. Albemarle – West	Crozet	4
2. Albemarle – East	Pantops (west of I-64/US250)	4
3. Albemarle – South	Scottsville/Esmont	1
4. Fluvanna	Lake Monticello	2
5. Greene	Ruckersville/Stanardsville	5
6. Louisa	Zion Crossroads (I-64/US15)	7
7. Nelson	Lovingston	1
Storage/Depot Location	**Community**	
8. Jaunt HQ	Charlottesville	n/a*
9. Greene County	Stanardsville	8

**The count of chargers at Jaunt HQ could be accommodated as part of depot charging equipment*

Figure 12: Potential Electric Vehicle Fast Charging Locations

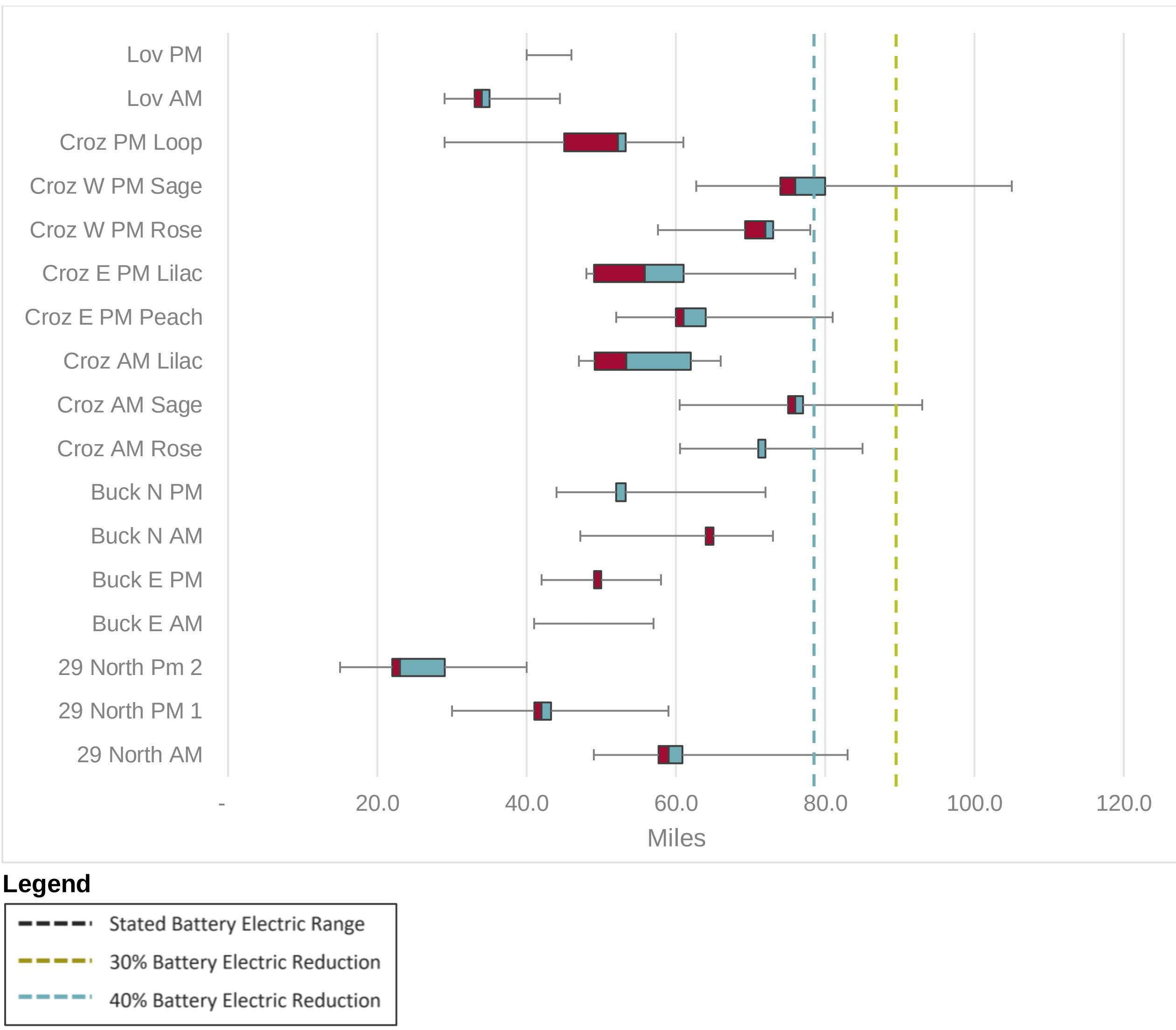


FIXED-ROUTE SERVICE (CONNECT)

Jaunt's Connect service operates seven commuter bus routes and has 17 different run classes throughout the day. Most vehicles servicing these run classes perform between 40 and 80 service miles. Vehicles serving the fixed-route run classes have less variable daily mileage requirements as compared to the demand response services described previously, making these services more straightforward to implement zero emissions vehicles.

A summary of the fixed route service run classes with mileage percentile breakdown is shown in **Figure 13**. Note that the maximum battery electric range of 130 miles is indicated, natural gas and hydrogen fuel cell maximum ranges extend beyond the range of the graphic.

Figure 13: Fixed Route Run Class Range Requirements



Compressed Natural Gas and Fuel Cell

Mileage requirements for the Connect fixed route run classes are well within the capabilities of CNG and Fuel Cell vehicles. Poor weather conditions and other negative externalities are unlikely to prevent CNG or Fuel Cell vehicles from completing their routes.

Battery Electric

A battery electric vehicle with a stated range of 130 miles is capable of managing most of the mileage requirements for Connect's fixed route run classes using depot-only charging. These vehicles would complete all the run classes except for the Crozet West PM Sage and Crozet AM Sage under a 30% range reduction. A vehicle with a stated range of 130 miles completes nearly all run classes under a 40% reduction except for the highest mileage runs from the Crozet AM Rose, 29 North AM, and the Crozet West Sage run classes. Based on adverse conditions and potential battery degradation, a battery electric vehicle may struggle to complete highest mileage runs on the Crozet Sage run class.

As a battery electric vehicle's range can be reduced through external factors, some Connect routes may be affected by BEB's with lower ranges (stated manufacturer ranges of 100 miles). The vehicles servicing the Crozet Connect run classes have the highest average service miles. As such, electric vehicles may struggle to complete these routes during cold or hot weather, or if the vehicle's battery is older with reduced battery capacity. However, similar to demand response services, there are opportunities to ensure success including swapping vehicle run class assignments based on range requirements and midday charging. As most Connect routes operate a set schedule and do not operate in the middle of the day, vehicles could return to a depot charging location following morning service and recharge in advance of afternoon runs.

ALTERNATIVE SCENARIOS

This section describes potential fleet deployment scenarios for natural gas, battery electric, and fuel cell vehicle technology for Jaunt and related services. Considerations for a 100% fleet transition are provided with regards to the fleet requirements, facility and fueling requirements, and potential opportunities for further consideration and study.

Planning-level costs for rolling stock, facilities, and maintenance are included for comparison purposes only. Costs presented in this document should not be used for budgeting or estimation. Preliminary implementation study and engineering design should be completed prior to any cost estimation and budgeting.

Natural Gas (CNG)

Fleet

The CNG vehicles under consideration for Jaunt's fleet have operating ranges of 300 miles with no noticeable loss in range from external factors. These vehicles could complete every fixed-route service block and most demand response run classes. In cases where a vehicle must travel over 300 miles, the vehicle could be refueled during operator change-out or between runs. As such, no fleet expansion would be required to provide the same level of service as existing conditions.

A transition to CNG vehicles could be done through a 1:1 replacement ratio with Jaunt's existing fleet. The average purchase price of a CNG shuttle bus is currently around $80,000 (California Air Resource Board, 2020). To complete a 1:1 replacement of all 108 of Jaunt's vehicles would cost $8.6 million.

Argonne National Laboratory estimates that light-duty commercial CNG vehicles have a fuel efficiency of 12.3 miles per gasoline gallon equivalent (GGE), and the average price of CNG as of July, 2022 is $2.76 per GGE (Argonne National Laboratory, 2019; Alternative Fuels Data Center, 2022). This gives a CNG equivalent to Jaunt's paratransit fleet a fuel cost of $0.22 per mile. Using Jaunt's annual vehicle miles traveled (VMT), the annual fuel cost would be approximately $336,000.

The maintenance cost (scheduled and unscheduled) of a CNG paratransit vehicle is estimated to be approximately $0.27 per mile (California Air Resources Board, 2020). Based on Jaunt's annual VMT, annual maintenance costs would be approximately $404,000 a year.

Considering Jaunt's current VMT and a 100% fleet conversion to CNG, the potential carbon emissions and reduction compared to today's fleet is shown in **Table 77**. The emissions were calculated using Argonne National Laboratory's AFLEET Tool 2020. Emissions comparison was assuming light-duty commercial trucks as the closest comparison to paratransit cutaway vehicles. The input fuel efficiency was then edited to match the fuel efficiency of paratransit vehicles/shuttle buses of the respective fuel types. The feedstock sources for the CNG used for modeling was 66% conventional and 34% shale. For comparison purposes, RNG from municipal wastewater is shown as well assuming Jaunt may be able to establish a reliable long-term sourcing option and to consider maximum potential emissions reduction.

Table 7: CNG Fleet Emissions Comparison

Pollutant	**Existing**	**CNG**	**Reduction(%)**	**RNG**	**Reduction(%)**
CO_2 (Tons)	1,355	1,140	15.9%	-633	146.7%
CO (lbs)	4,264	4264	0%	4,264	0%
NO_x (lbs)	79.2	79.2	0%	79.2	0%
$PM_{2.5}$ (lbs)	18.7	18.7	0%	18.7	0%
PM_{10} (lbs)	107.8	107.8	0%	107.8	0%
VOC (lbs)	575.8	193.3	76.4%	193.3	76.4%

As described in the **Industry Background** section, RNG reflects a *negative* greenhouse gas emission, suggesting that use of RNG removes emissions from the atmosphere. This negative value reflects the potential offset and benefit of capturing more impactful greenhouse gases such as methane (CH_4), then combusting them to release carbon dioxide (CO_2) into the atmosphere. The negative value comes from the fact that methane emissions are nearly 25 to 30 times more potent than carbon dioxide, and combustion mitigates their release. Actual emissions at the tailpipe of a vehicles fueled by RNG would be nearly identical to those from a CNG vehicle.

Facility

As there are no existing public CNG fueling stations in Jaunt's service area, a CNG fleet would require the construction of a CNG fueling station. Jaunt could construct a CNG fueling station on its own property or enter into an a shared-use agreement for a CNG fueling station with the City of Charlottesville (for shared use with CAT or City of Charlottesville public works). Constructing a new CNG fueling station capable of servicing Jaunt's fleet would cost an estimated $2.3 million (Smith & Gonzales, 2014).

There are additional opportunities which can decrease the financial impact of implementing CNG or share resources for scale of efficiency. These are described in the **Findings and Discussion** section, below.

Battery Electric

Fleet

Based on the analysis presented above and considering the capabilities of today's battery electric vehicle technology, a transition of Jaunt's fleet to battery electric vehicles would likely require the addition of multiple vehicles to continue Jaunt's current level of service. The number of vehicles needed for full battery electric vehicle deployment depends on several factors:

- The model of vehicle procured
- Jaunt's deployment and vehicle assignment strategy
- Use of on-route charging

Jaunt may be able to minimize the number of additional vehicles were to employ on-route charging and purchasing vehicles with high-capacity batteries. Up to 33 additional vehicles may be required if depot-only charging was employed throughout the system and vehicles were swapped throughout the day between runs or as charge was depleted.

The cost of a battery electric vehicle is dependent on the make and model. For the purposes of this study, a purchase price of $120,000 was assumed for battery electric vehicles. Assuming a replacement ratio of 1:1 existing to replacement battery electric vehicle, a full fleet transition of all 108 of Jaunt's vehicles would cost approximately $13.0 million. Assuming a maximum demand scenario of 33 additional vehicles, the vehicular capital costs would increase a total of $16.2 million.

Operational costs include maintenance costs for the vehicles and fueling infrastructure, and the cost of 'fuel' (electricity). The cost of electricity varies throughout the day depending on demand and utility provider. The average per kWh industrial rate from Dominion Energy, Jaunt's depot electrical provider, is $0.053 (Dominion Energy). Depending on weight and size of electric vehicle, paratransit vehicles would be assumed to have an average fuel economy of between 1.3 to 2.0 miles per kWh (California Air Resources Board, 2020). Given the rate of power and assumed fuel economy fuel costs may range from $0.027 to $0.041 per mile. Considering Jaunt's annual vehicle miles traveled (May 2021-April 2022) for its on-demand service was 1,290,126 miles and its annual vehicle miles traveled (May 2021-April 2022) for its commuter bus/fixed route service was 207,199 miles, Jaunt's annual cost for fuel may cost to up to $61,400 (though actual rates would need to be established with electric utilities during implementation).

Typical market-accepted maintenance costs for light to medium duty battery electric vehicles is still unknown. Initial research indicates that battery electric vehicles have maintenance costs around 30% lower than a diesel equivalent (California Air Resources Board, 2020). The California Air Resources board estimates the cost for a diesel cutaway shuttle as $0.29 per mile, thus a battery electric equivalent would have a maintenance cost of around $0.2 per mile (2020). Based on Jaunt's annual vehicle miles traveled, the annual maintenance costs of Jaunt's vehicles would total around $307,000.

Maintenance costs for electrical chargers will vary based on the service contracted/provided, but a typical standard cost may be assumed at $500 per charger (California Air Resources Board, 2020). More powerful chargers will cost more to maintain, and agreements with selected equipment manufactures may mitigate costs from unexpected maintenance or repairs.

Changes in staffing will have a significant impact on operations costs, but potential changes in staffing as a result of battery electric vehicle deployment cannot be determined at this phase of study. It is likely that Jaunt would be required to hire more vehicle operators and more maintenance staff to monitor vehicle charging infrastructure at depots. As a result, Jaunt's staffing and labor costs are likely to increase.

Considering Jaunt's current VMT and a 100% fleet conversion to battery electric vehicles, the potential carbon emissions and reduction compared to today's fleet is shown in **Table 8**. The emissions were calculated using Argonne National Laboratory's AFLEET Tool 2020. Emissions comparison was assuming light-duty commercial trucks as the closest comparison to paratransit cutaway vehicles. The input fuel efficiency was then edited to match the fuel efficiency of paratransit vehicles/shuttle buses of the respective fuel types. The electrical grid's mix used for modeling was based of the U.S. Energy Information Administration's regional mix for the Southeastern United States.

Table 8: BEV Fleet Emissions Comparison

Pollutant	**Existing**	**Battery Electric**	**Reduction (%)**
CO_2 (Tons)	1,355	641	52.7%
CO (lbs)	4,264	0	100%
NO_x (lbs)	79.2	0	100%
$PM_{2.5}$ (lbs)	18.7	13.2	30.4%
PM_{10} (lbs)	107.8	102.3	5.1%
VOC (lbs)	575.8	0	100%

Facility

A transition to a completely battery electric fleet would require Jaunt to procure electric vehicle chargers for installation at Jaunt's maintenance facility. This equipment would be used to charge vehicles overnight or to add partial range to vehicles midday. As indicated above, depot charging can be done with either Level 2 AC chargers or Level 3 DC chargers. A Level 2 AC charger with a power level between 10-20 kW costs between $3,000-$6,500, and the installation costs per charger (varying based on the number of chargers being installed) is approximately $1,200 per unit for a large installation of chargers (California Air Resources Board, 2020). Purchasing and installing the necessary Level 2 AC chargers assuming a maximum 1:1 ratio depot charging scenario would cost between $414,000-$897,000 to purchase and $165,500 to install.

Considering the range challenges indicated in the operational feasibility analysis for battery electric vehicles, Level 3 DC chargers could be installed throughout Jaunt's service area to 'top-off' vehicles and extend their range. As most battery electric paratransit vehicles have a max charge rate of 50 kW, electric charger capable of power levels exceeding 50 kW are unnecessary given today's technology. A 50 kW electric charger costs approximately $50,000 per unit and approximately $45,500 per charger for a small installation and $17,700 per charger for a larger installation (California Air Resources Board, 2020). The installation costs of Level 3 DC chargers are much higher than Level 2 AC chargers as the site's electrical infrastructure needs to be upgraded or expanded to accommodate the increase in electrical demand. The number of Level 3 DC fast chargers needed for depot charging depends the number of plugs on the charger, but assuming 32 chargers throughout Jaunt's service area based on the analysis provided above in the **Operational Feasibility Analysis**, charger costs would cost approximately $3.1 Million.

Lastly, Jaunt's current practice of parking vehicles at operators' homes may be a challenge to maintain under a battery electric vehicle scenario for several reasons:

- Drivers would need to install and maintain equipment at their home, incurrent potential additional capital costs or complicating driver contracts
- Any charging performed at a private residence would need to be tracked and reimbursed appropriately
- Charge malfunctions or other maintenance activities may impact service without redundancy of equipment or available spare vehicle

Based on the above, Jaunt would be required to store all vehicles at one or more depot locations overnight, potentially requiring additional real estate.

There are additional opportunities which can decrease the financial impact of implementing battery electric vehicles or the potential to leverage community partnerships. These are described in the **Findings and Discussion** section, below.

Hydrogen Fuel Cell

Fleet

Hydrogen fuel cell vehicles compatible with Jaunt's needs have a range of 300 miles and experience slight reductions in their range during cold weather. Based on the analysis presented in this document, hydrogen fuel cell vehicles could complete every fixed-route service block and most demand response run classes. In cases where a vehicle must travel over 300 miles, the vehicle would need to refuel during operator change out or between run classes. However, refueling a hydrogen vehicle takes a matter of minutes, and should have no impact to operations or level of service.

A transition to a fleet of 100% hydrogen fuel cell vehicles could be done through a 1:1 replacement. There's currently only one hydrogen fuel cell paratransit vehicle on the market, and the estimated cost for the vehicle has not been made publicly available. To best estimate the cost of a hydrogen fuel cell paratransit vehicles, the analyst team took the percentage price increase of a hydrogen fuel cell transit bus compared to a battery electric transit bus and applied it to a battery electric paratransit vehicle. The average cost of a 35' to 40' battery electric bus is $887,308, and the average cost of a similar hydrogen fuel cell vehicle is $1,500,000 (Aamodt, 2021; SunLine Transit Agency, 2017). This equates to a hydrogen fuel cell bus being 69% more expensive than a battery electric bus. As the average purchase price for a battery electric paratransit vehicle is estimated to be $120,000, a hydrogen fuel cell vehicle would be around $203,000. Using this estimated price, the cost of completing a 1:1 replacement of all 108 of Jaunt's vehicles with hydrogen fuel cell vehicles would be approximately $21.9 million.

To calculate fuel costs, the analyst team assumed Jaunt would receive its hydrogen through liquid truck delivery (see section below). A class 2b-3 hydrogen fuel cell vehicle is estimated to have a fuel efficiency of 31.1 miles per kg of hydrogen, and Trillium Energy estimates the cost of LH_2 delivered hydrogen to be $6.39 per kg when delivered at a rate of 1,000 kgs a day (California Air Resources Board, 2020). This result in hydrogen fuel cell paratransit vehicles costing $0.21 a mile in fuel. Using Jaunt's current VMT, the annual cost of fuel would be around $308,000 a year. These costs were derived from California data sources, and California is far ahead of other US states in hydrogen fuel use and production. In the present day, Jaunt's fuel costs would likely be higher due to the scarcity of hydrogen providers in Virginia.

Typical market-accepted maintenance costs for light to medium duty hydrogen fuel cell vehicles is still unknown. Initial research from Ballard Power and UC Davis has come to different conclusions. Ballard Power recommends for hydrogen fuel cell buses to add $0.20 to the per mile maintenance costs of a battery electric bus, while UC Davis found that hydrogen fuel cell vehicles show a 50% reduction in maintenance costs compared to diesel equivalents (California Air Resources Board, 2020). Controlling the maintenance costs for full-size transit buses to be in line with the maintenance costs of a diesel cutaway shuttle ($0.29 per mile), the maintenance cost for a hydrogen fuel cell cutaway shuttle/paratransit vehicle is either $0.27 per mile (Ballard Power) or $0.15 (UC Davis). When comparing the cost per mile to Jaunt's annual VMT, the annual cost of maintenance for a hydrogen fuel cell transition would be between $217,000 and $409,000. Maintenance costs are likely to be higher in the earlier years of the deployment as the maintenance staff is becoming accustomed to fuel cell vehicles.

Considering Jaunt's current VMT and a 100% fleet conversion to hydrogen fuel cell, the potential carbon emissions and reduction compared to today's fleet is shown in **Table 9**. The emissions were calculated using Argonne National Laboratory's AFLEET Tool 2020. Emissions comparison was assuming light-duty commercial trucks as the closest comparison to paratransit cutaway vehicles. The input fuel efficiency was then edited to match the fuel efficiency of paratransit vehicles/shuttle buses of the respective fuel types. The type of hydrogen used for the emissions modeling was delivered gaseous hydrogen produced through SMR.

Table 9: Hydrogen Fuel Cell Fleet Emissions Comparison

Pollutant	**Existing**	**FCEV**	**Reduction(%)**
CO_2 (Tons)	1,355	771	43.1%
CO (lbs)	4,264	0	100%
NO_x (lbs)	79.2	0	100%
$PM_{2.5}$ (lbs)	18.7	13.2	30.4%
PM_{10} (lbs)	107.8	102.3	5.4%
VOC (lbs)	575.8	0	100%

Facility

There are no existing public hydrogen fueling stations in Jaunt's service area, so transitioning to a hydrogen fuel cell fleet would require the construction of a hydrogen fueling station. Jaunt could construct a hydrogen fueling station on its own property or enter into an a shared-use agreement for a fueling station with CAT or another public entity.

Jaunt would be required to either produce hydrogen, or have it delivered and stored on site. Hydrogen can be produced on site through either steam methane reformation (SMR) or electrolysis (use of electrical current to break water into hydrogen and oxygen gas). However, from the information gathered from the peer interviews, hydrogen delivered as liquid is preferred from an operations and technical standpoint. Delivered hydrogen does not require as large of upfront capital costs and can more easily be scaled to the needs of Jaunt's service, unlike the on-site generation methods. On-site generation also required plant equipment maintenance and staffing to ensure continuation of operations. Based on market research and peer interviews, and for comparison purposes and the purposes of this feasibility study, the project team will assume liquid hydrogen delivery and fueling. Currently, the nearest major hydrogen suppliers are approximately 225 miles away (by road) to Jaunt's service area. The nearest facilities are in:

- New Castle, Delaware (approximately 225 miles),
- Kingsport, Tennessee (approximately 275 miles), and
- Charleston, West Virginia (approximately 250 miles).

The cost of constructing a new hydrogen facility depends on the method of hydrogen production and the amount of hydrogen produced/dispensed a day. During the peer agencies interviews, SARTA's CEO stated their hydrogen fuel cell vehicles hold 13.5 kg on hydrogen on-board. Using the same estimate for Jaunt's vehicles, and assuming all 77 vehicles available for peak service are fueled in a day, Jaunt would need a station capable of producing/dispensing 1,000 kg of hydrogen a day. Using estimates compiled from the National Renewable Energy Laboratory, the capital costs for a fueling station would be around $3,500,000 if the hydrogen is delivered in liquid form, $6,500,000 if the hydrogen is produced on-site through SMR, and around $7,000,000 if the hydrogen is produced on site through electrolysis (Melaina and Penev, 2013). The National Renewable Energy Laboratory estimates the yearly operational and maintenance costs are to be 11% of the capital costs for a LH_2 truck delivery station, and 7% of the total capital costs for an onsite SMR station and an on-site electrolysis station (Melaina and Penev, 2013). This would equate to $385,000 a year for the LH_2 truck delivery station, $455,000 a year for the on-site SMR station, and $490,000 a year for the on-site electrolysis station. The yearly O&M costs will be influenced by the cost of staffing, the cost of power, and the age of the equipment.

There are additional opportunities which can decrease the financial impact of implementing hydrogen fuel cell vehicles or share resources for scale of efficiency. These are described in the **Findings and Discussion** section, below.

Findings and Discussion

This section elaborates on potential applications and considerations for the alternatives described in this study. Included are potential opportunities for further study during potential future implementation stages.

Compressed Natural Gas

A transition to CNG (and/or RNG) would be simplest transition scenario for Jaunt. CNG vehicles can handle the workload and ranges currently being done by Jaunt's gasoline-powered vehicles, so a 1:1 transition from gasoline to CNG could be completed and run classes would not require adjustment. Compressed natural gas vehicles is a mature technology with numerous applications and is highly reliable. A full-scale deployment of CNG vehicles would also be the cheapest option.

A transition to CNG would likely require Jaunt to partner with another public agency or transit provider: the City of Charlottesville, Charlottesville Area Transit (CAT), or the University of Virginia's University Transit Service (UTS). A partnership with another organization would reduce costs through economies of scale and help Jaunt with space restraints as a joint fueling facility does not have to be located on Jaunt's facility. Additionally, a partnership with another organization would be beneficially in information sharing and negotiating utility rates. As of the publication of this study, the City of Charlottesville and CAT are conducting their own separate decarbonization studies. Any potential partnership discussion coincides with the progression of that study.

The primary challenge with CNG is that it's not a zero-emission fuel. While a switch to CNG would provide a reduction in Jaunt's GHG emissions and emittance of other harmful pollutants, switching purely to CNG would not be congruent with the City of Charlottesville's carbon emissions reduction goal of becoming carbon neutral by 2050 or the vision expressed by multiple members from Jaunt's advisory committee. The purchase of renewable natural gas provides a further reduction in carbon emissions, though is establishing a reliable and direct RNG source is likely to be challenging. There is a potential to purchase carbon offset credits through Charlottesville's natural gas utility, however any combustion-based technology will continue to emit greenhouse gases and particulate matter into the community.

A potential long-term deployment method for a CNG may be to use CNG as a transition fuel to a long-term hydrogen system. CNG and hydrogen fuels are both gaseous fuels onboard vehicles and required fueling infrastructure is similar between both technologies. There is research that suggests natural gas infrastructure can be purpose-built and reused for hydrogen, with some modifications. A long-term solution may be to identify a longer-term hydrogen partnership with CAT or another heavy vehicle operator such as the City of Charlottesville Public Works to transition multiple fleets over the course of several years from CNG to hydrogen as the technology matures.

Battery Electric

The operational analysis results show that the commercially available battery electric vehicles are capable of servicing Connect's fixed route service but would struggle to complete most of Jaunt's and Greene's demand response run classes. On-route charging could help vehicles mitigate range challenges, but operations may suffer considering the time required for the vehicle to recharge. Alternatively, a battery electric vehicle system requires Jaunt to increase the size of its fleet (therefore requiring additional storage/facility space) or require changes to Jaunt scheduling and operations.

DC fast charging may be able to mitigate some range requirements, but complete analysis, manufacturer specification, and route modeling may need to be conducted to determine viability of application. Level 3 DC chargers are designed to stop fast charging once a vehicle's battery achieves 80% charge in order to protect the battery and reduce degradation. The DC fast charger will then either charge the other 20% at non-fast charging speeds or stop charging all together. Most battery electric paratransit vehicles have a battery that can store between 120 and 150kWh and support a maximum charge rate of 50 kW. This means most models on the market will take around 2-3 hours to reach the 80% charge threshold.

Resiliency of operations is a critical consideration for all technology types. Whereas most liquid and gaseous fuels can still be pumped into vehicles during a power outage through the use of generators, a battery electric fleet would require enough generation power or other electrical source in the event of a grid outage. This equipment can be expensive to purchase and maintain; for example, a 1 MW generator can cost approximately $240,000, but only provide enough power to charge 20 vehicles simultaneously. This may be offset in emergency cases with public charging equipment, though the reliability and availability of this equipment cannot be guaranteed during a power service outage.

Other factors that potentially impact the feasibility of deployment for battery electric vehicles are summarized below:

- Solar Energy
  - Photovoltaic solar arrays are often deployed with electric vehicle infrastructure, though the actual power output of these arrays is far less than then power requirement of charging equipment (10% during peak generation) and provide peak output when vehicles are usually in service.
  - More often, solar arrays are deployed to provide auxiliary building power or sell power ‘to the grid’ to offset carbon emissions instead of providing charging power.
- Partnerships
  - Partnerships would provide Jaunt to ability to leverage efficiency of scale without incurring (or reducing) capital costs.
  - Partnerships with retailers would potentially enable Jaunt to take advantage of distributed fast charging infrastructure in the communities noted in the **Operational Feasibility Analysis** section.
    - This partnership would allow for a set block of time during which Jaunt vehicles could charge at these locations
    - Jaunt may be able to enter into an agreement for easement to install equipment, and/or tie into existing site electrical infrastructure
  - A partnership with Greene County would possibly allow shared charging equipment at the County’s storage facility on Route 33.
  - A partnership with the City of Charlottesville would enable shared charging equipment at locations throughout the City, enabling vehicles to charge sporadically as necessary.
    - This partnership would also potentially find some scale of efficiency in coordination with CAT for medium-duty vehicles
- Charging Strategies
  - Jaunt may be able to reduce the number of chargers at depot locations by selecting higher-power chargers with multiple dispensers (e.g., a 150-kW charge may be able to charge up to three vehicles simultaneously).
  - Smart charging using an automated and computerized system may be used to charge multiple vehicles in sequence without staff time, potentially overnight.
- Utility coordination and challenges
  - Installing electric vehicle chargers at Jaunt’s facility will reduce the parking capacity of the site, requiring both charging equipment and potential utility equipment such as a transformer.
  - Utility providers have provided feedback on potential fast charging equipment installation feasibility as select locations. The following locations currently have grid capacity (including 3-phase circuits) without additional utility upgrades:
    - Albemarle West (Crozet)
    - Albemarle West (Pantops)

- Albemarle South (Scottsville)
- Jaunt HQ (Charlottesville)

Hydrogen Fuel Cell

Hydrogen fueling infrastructure is similar to natural gas infrastructure and the range of fuel cell vehicles are greater than battery electric vehicles. Additionally, refueling a fuel cell vehicle takes only six to ten minutes meaning fleet operations can be performed similarly to existing operations with gasoline vehicles. Hydrogen deployment also becomes more cost effective with larger fleets since fueling infrastructure remains nearly the same with an increase in fleet size. From the interviews with peer agencies and market research, an increasing number of transit agencies are transitioning to hydrogen fuel instead of battery electric technology due to its reliability in transit operations. If Jaunt were to adopt hydrogen fuel as a preferred fuel type, Jaunt would not be required to change their service structure or fleet count.

Challenges to hydrogen fuel include the cost and availability of hydrogen fuel cell paratransit vehicles. Hydrogen fuel is still maturing and not widely used for municipal purposes outside of California, thus few manufacturers currently produce paratransit-style vehicles. Additionally, Jaunt would likely have hydrogen fuel delivered by truck or construct a hydrogen production facility. The closest industrial hydrogen production plants to the City of Charlottesville are over 300 miles away. However, further funding and research through initiatives including the Department of Energy's "Hydrogen Energy Earthshot" will help to reduce the cost of hydrogen in the future, targeting a cost of $1 per 1 kg hydrogen compared to approximately $9 per 1 kg of hydrogen in today's market.

Environmental considerations related to hydrogen include the upstream emissions required to produce hydrogen fuel. Currently, based on the assumptions documented in the emissions calculations, a 100% fleet conversion to hydrogen fuel will not hit the emissions reductions goals set by this project. The primary hydrogen production method is grey hydrogen (hydrogen produced through SMR without carbon capture) which, while having lower GHG emissions than diesel or CNG, has an environmental impact. Alternatively, electrolysis is an energy intensive process, and emissions as a result of production vary based on the composition of the electrical grid. Green hydrogen (hydrogen produced through electrolysis using electricity from carbon neutral sources) has great potential for GHG reductions and efforts are underway to increase its production. Only though this process and a decarbonization of the electric grid would Jaunt be able to convert to a hydrogen fuel fleet and achieve sustainability goals. However, a near-term transition to hydrogen fuel would require a proportion of grey hydrogen while technology and supply chains develop.

An effective transition to hydrogen fuel would likely require Jaunt to partner with another public agency or transit provider such as the City of Charlottesville (CAT), or the University of Virginia's University Transit Service (UTS). A partnership with these organizations would likely reduce costs through an economy of scale and potentially reduce real estate constraints if located on City land. Currently, the City of Charlottesville is conducting an alternative fuel study and potential partnership conversations should occur through that study.

Comparison of Scenarios

Based on the information above, **Table 10** summarizes the numerical comparison of each alternative scenario for greenhouse gas emissions, capital costs, and operational costs.

Table 10: Summary Comparison of Scenarios

Scenario	Number of Vehicles	Emissions Reduction		Vehicle Costs	Facility Costs	Operational Costs[1] (Fuel+Maintenance)
		Long-term	Near-term			
Current	108	n/a		$6.9 M	n/a	$813,000
Battery Electric	135	100%[2]	53%	$16.2 M	$1.1 M	$422,400
Battery Electric w/ Fast Charging	108[3]	100%[2]	53%	$13.0 M	$4.2 M[4]	$422,400[4]
Hydrogen	108	100%[2]	43%	$21.9 M	$3.5 M[5]	$1.1 M[1]
CNG/RNG	108	146.7%[6]	15.9%	$8.6 M	$2.3 M	$552,000

[1]Based on current maintenance and fuel costs
[2]Assuming net zero electric grid and green hydrogen sourcing
[3]May require additional vehicles based on further evaluation
[4]Installation and maintenance costs depend on fast charging partnerships or agreements
[5]Assuming liquid hydrogen delivery and fuel station
[6]Assuming RNG derived from municipal wastewater

Recommendations and Closing

Each of the technologies presented in this study vary in difficulty of implementation based on scale and size of deployment. The recommendation presented in this section is based on available knowledge and research conducted as part of this study and at time of publication; as such, and as technology and market conditions change, Jaunt should reevaluate feasibility and measure performance of any zero-emissions technology deployed prior to future phases of implementation.

RECOMMENDATION 1

Implement battery electric vehicles as the initial deployment technology on select run classes.

Battery electric vehicles are recommended as the initial zero emission technology choice as they are cost efficient at smaller scales and have reached a degree of maturity in the light-duty commercial market. For an initial deployment, this study recommends using depot-charging operations where vehicles would charge overnight, pull out to perform their revenue service, return to the depot to charge midday between routes, pull out to complete afternoon service, then return to the depot for overnight charging. As part of this recommendation, Jaunt should install the required infrastructure at the existing Jaunt depot and conduct appropriate design and engineering work.

An initial deployment should focus on deploying vehicles on run classes that are most compatible with zero emissions technologies and in a geographic region with existing infrastructure. Optimal routes consist of deploying up to six vehicles on the following run classes:

- 29 North Connect
- Buckingham Connect
- Lovingston Connect
- Urban paratransit

The service areas of the above include the City of Charlottesville, which contains the greatest density of publicly available electric vehicle chargers in the region. As such, there is a degree of resiliency for on-route charging in the event of faster battery depletion resulting from passenger load, weather, or other factors.

Lastly, implementing battery electric vehicles would enable Jaunt to take advantage of combined emissions reductions of both Jaunt and the electric grid as a whole. Currently Dominion Energy has a net zero emissions target by 2050; as such, if Jaunt were to run a 100% electric vehicle fleet, all operating emissions would follow the rate of decarbonization of the electric grid.

RECOMMENDATION 2

Pursue a small-scale, initial deployment of zero emissions vehicles in fixed-route services.

A scaled deployment of up to 6 vehicles would also limit the potential real estate impacts and is likely able to be implemented at Jaunt's existing storage facility based on information provided from Dominion Energy throughout this study.

Gradually transitioning Jaunt's fleet to zero emission vehicles will allow for Jaunt to capitalize on the emerging information to better plan their service with the new vehicular technology or pivot to an alternative vehicle technology. A gradual transition will also allow Jaunt to take advantage of the maturation of the zero emission technologies which could bring about lower vehicle and fuel costs, vehicles with longer driving ranges, additional options for resiliency, or more efficient chargers. A small-scale deployment would also allow Jaunt staff to gain experience both in the operation and maintenance of these vehicles without creating disruptions in service.

Additionally, paratransit vehicles are replaced on a schedule of 4 to 5 years (depending on size), so fleet vehicle replacements occur at a frequency which may facilitate an accelerated deployment to achieve the desired 45% greenhouse gas reduction goal by 2030.

This recommendation is also consistent with funding opportunities presented by the Inflation Reduction Act to offset vehicle and equipment purchase costs.

RECOMMENDATION 3

Conduct future evaluation of initial deployment performance.

Given the speed of change within the alternative fuel vehicle market and unknowns associated with deployment of alternative fueled vehicles, this study recommends that Jaunt use the initial scaled deployment of battery electric vehicles to test and evaluate performance of battery electric technologies.

Over the course of two years, Jaunt should evaluate the degradation of their vehicles' batteries, analyze the range reduction throughout service, and evaluate whether the battery electric vehicles are adequately meeting their service requirements. If the battery electric vehicles and infrastructure are not operating correctly or are not meeting Jaunt's service requirements, Jaunt should re-evaluate their path forward with zero emission vehicles.

It is also likely that hydrogen as an alternative fuel will advance significantly in the coming two years, and new opportunities for partnership may become prevalent through partnerships with CAT and the City of Charlottesville.

RECOMMENDATION 4

Conduct partnership conversations with government entities, businesses, and utilities.

As part of the full-fleet transition strategy, Jaunt should begin to set the groundwork for further alternative fuel deployment by establishing relationships and partnerships with the entities described below.

- Utility Providers – electric grid capacity and shared charging infrastructure
    - Dominion Energy
    - Appalachian Power
    - Rappahannock Electric Cooperative
    - Central Virginia Electric Cooperative
- Government Entities – shared infrastructure, funding opportunities, and collaboration on group transportation utility rates (e.g., electric vehicle charging rates)
    - City of Charlottesville
    - CAT
    - Virginia Department of Rail and Public Transportation (DRPT)
- Private Businesses – shared infrastructure and potential land easements/sharing
    - Locations and corporations vary based on charging location identified in **Figure 12**

Conversations with the above entities should consist of sharing strategic direction of respective organizations (alternative fuel technology, scale of deployment, and/or timing of transition). These conversations could help to inform future deployments and identify opportunities for shared equipment.

Additionally, conversations with utilities should include descriptions of potential charging locations and size of deployment to aid these organizations in anticipating future load increase.

NEXT STEPS AND CLOSING

Based on the above recommendations, the next steps for Jaunt following the completion of this feasibility study are as follows:

- Work with Jaunt's board of directors to adopt a preferred alternative fuel technology strategy
- Complete a time-constrained implementation plan for immediate, near, and long-term alternative fuel vehicle deployment
- Identify funding sources and allocate budget to purchase and install initial zero emissions vehicles
- Establish performance metrics to monitor and evaluate initial deployment of battery electric vehicles for performance and scalability
- Procure initial vehicles and charging equipment
- Procure contractor(s) to design and install charging infrastructure

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Appendix

APPENDIX A: ADVISORY COMMITTEE MEMBERS AND CHARTER

Name	Organization
Lucas Ames	Global Online Academy
Donna Baker	JABA
Elizabeth Cromwell	Chamber of Commerce
Ethan Heil	UVA
Christine Jacobs	Thomas Jefferson Planning District Commission
Peter Krebs	Piedmont Environmental Council
Susan Kruse	Charlottesville Climate Collaborative
Hal Morgan	Jaunt Board of Directors
Randy Parker	J. Randolph Parker
Liz Russell	Monticello
Becca White **Kendall Howell** **Patrick Clark**	University Transit Service

Alternative Fuel Advisory Committee Charter

BACKGROUND

Jaunt, Inc. has partnered with Kimley-Horn to develop a high-level feasibility assessment for alternative fueled vehicles. In concert with this effort, Jaunt will convene an advisory committee of approximately 10-12 representatives from the community to share their opinions and perspectives, study issues, and develop recommendations in a focused, small group structure.

PROPOSED CHARGE

This advisory committee will review the critical issues related to Jaunt's potential transition to alternative fueled vehicles at key points throughout the study, in order to be able to discuss, formulate, and forward well-developed, thoughtful recommendations to Jaunt's leadership on key decisions addressed during the course of the study. In making decisions, Jaunt's leadership will consider the input from this advisory committee.

GOALS / EXPECTED WORK PRODUCT

Develop a recommendation for Jaunt's transition to alternative fueled vehicles.

GENERAL TIMEFRAME

Kimley-Horn will proceed with work at the approximate pace estimated to be completed over 5-8 months. The three advisory group meetings will occur at the following times:

- Beginning of study – anticipated to kick off in June 2022
- Following initial analysis of KHA's evaluation of the technical and economic feasibility of alternative fueled buses
- Following completion of KHA's presentations of findings including its completed analysis and recommendations

ROLES AND RESPONSIBILITIES

- **Board of Directors** – The president of the Jaunt Board of Directors will appoint committee members and serve as a liaison between the Board and the committee to keep the Board informed on the progress of the advisory committee and to provide information and context to the committee as needed.
- **Staff** – the director of public relations will work cooperatively with the advisory committee and KHA to provide complete and up-to-date information to keep the committee informed and communicate any critical feedback to the ultimate decision makers.
- **Advisory committee** – Work to understand the challenges and opportunities presented by converting to alternative fueled vehicles; provide a recommendation for feasibility and timeframe for Jaunt using alternative fueled vehicles; and promote community support for the recommendations.

MEMBERSHIP SELECTION

Jaunt will seek membership from each of the localities we serve representing a broad cross-section of the community to lend diverse perspectives and voices to the effort.

APPENDIX B: ADVISORY COMMITTEE PRESENTATION 1

Jaunt

Feasibility Study of Alternative Fueled Buses

Advisory Committee Meeting 1: June 27, 2022

Jaunt WHERE CAN WE TAKE YOU?

Kimley»Horn Expect More. Experience Better.

Agenda

- Introductions
- Overview of Project
  - FTA Requirements
  - Project Tasks
  - Roles & Responsibilities
  - Project Schedule
- Project Goals
- Technology Overview
- Questions & Discussion

Introductions

Project Overview

- FTA "Lo-No" Funding:
  - Requirements (6 items)
  - Due May 31, 2023
- DRPT Goals (E&M Study)
- Project Tasks:
  1. Project Management
  2. Feasibility Study
  3. Stakeholder Coordination

Requirements (6 items):

1. Long-term fleet management plan
2. Current and future resources
3. Policy and legislation
4. Existing and future facilities
5. Partnership with utility or fuel provider
6. Workforce transition

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Feasibility Study Elements

- Comparison of multiple fuel types, including:
  - Battery Electric
  - Compressed Natural Gas
- Peer agency interaction
- Presentation of tradeoffs, advantages, and disadvantages for technologies
- Start the relationship with utilities/fuel providers
- Impact of technology on operations and procurement
- Stakeholder Coordination:
  - 3 Advisory Group Meetings
  - 1 Jaunt Board Presentation of Findings

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Roles & Responsibilities

- Jaunt Staff and Advisory Committee
  - Provide strategic direction
  - Review and provide comments on deliverables
- Jaunt Staff
  - Provide agency data, technical input, and review
  - Support analysis and conceptual design
- Consultant Team
  - Guide project and decision-making processes
  - Aggregate and analyze client input
  - Produce planning and conceptual documentation

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Project Schedule

- Duration: Approximately 5 months after kickoff
- Key dates:
  - Jaunt budget process begins at end of 2022
  - DRPT MERIT Grants Due February 2023
  - Low-No and Bus Facilities Grants Due May 2023
- Two More Advisory Committee Meetings:
  - Existing Conditions and Opportunities: September 2022
  - Recommendations and Implementation Plan: November 2022
- Presentation to Jaunt Board of Directors: December 2022

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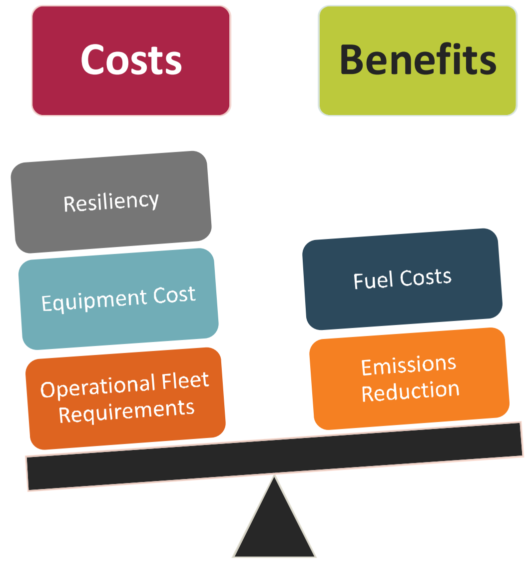
Project Goals

Comparisons and Tradeoffs

- Project will weigh costs and benefits for Jaunt
- Align outcomes and recommendations with goals
- Present scenarios for consideration
  - Single or combination of options
  - Quantify the impacts for emissions and costs



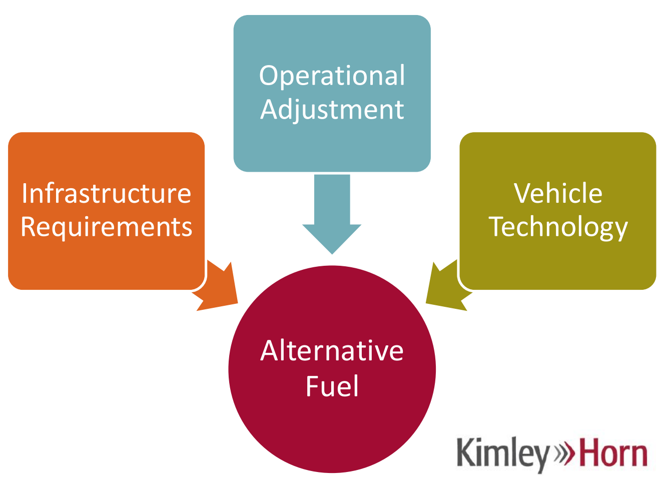
Project Goals

- Achieve 30% GHG reduction by 2030; net zero by 2040
- Determine a preferred cleaner fuel type for Jaunt
  - Consider trade-offs including operating and capital cost, emissions impact, and operational viability
  - Balance the current level of service with practicality of low or no emissions vehicles (minimize impact to operations)
  - Consider well-to-wheel impact of propulsion technology on emissions
- Determine high level implementation strategy and timeline of the preferred fuel type

Technology Overview

Technologies

- 'Traditional' Diesel or Gasoline Fossil Fuel
- **<u>Compressed Natural Gas (CNG)</u>** – *Natural or Renewable*
- **<u>Battery Electric</u>**
- Others:
  - Hybrid Electric
  - Hydrogen Fuel Cell Electric
  - Propane (Liquified Petroleum Gas, LPG, or AutoGas)
  - Biodiesel



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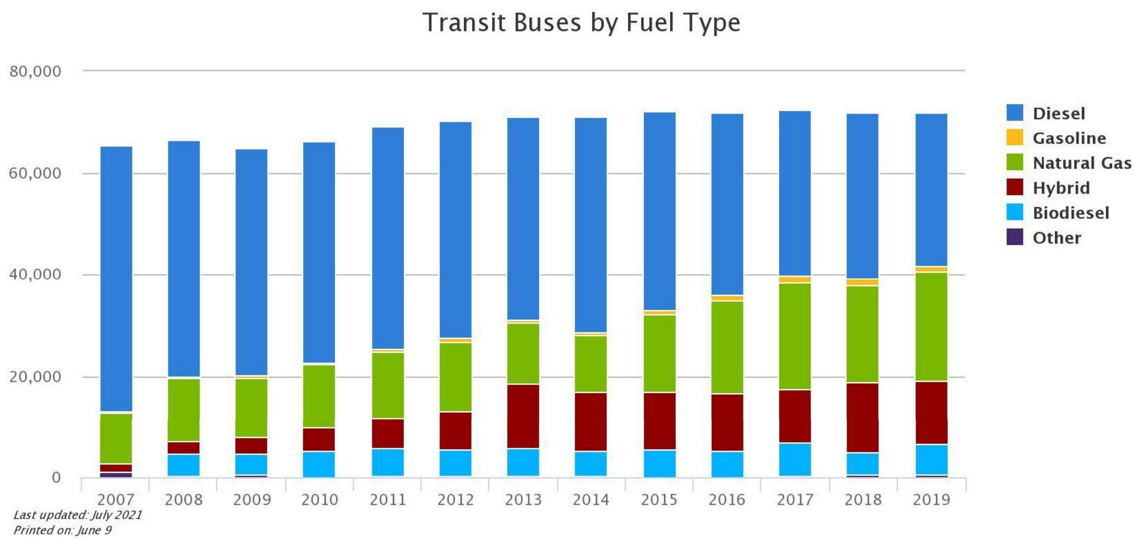
Current Share of Transit Bus Fuel Type



Source: Derived from Tables 21 and 34 in Appendix A of the 2020 Public Transportation Fact Book from the American Public Transportation Association
Notes: "Natural Gas" includes compressed and liquefied forms. "Other" up to 2007 included propane, bio/soy fuel, and biodiesel. After 2007, "Other" included battery-electric, hydrogen, and propane.

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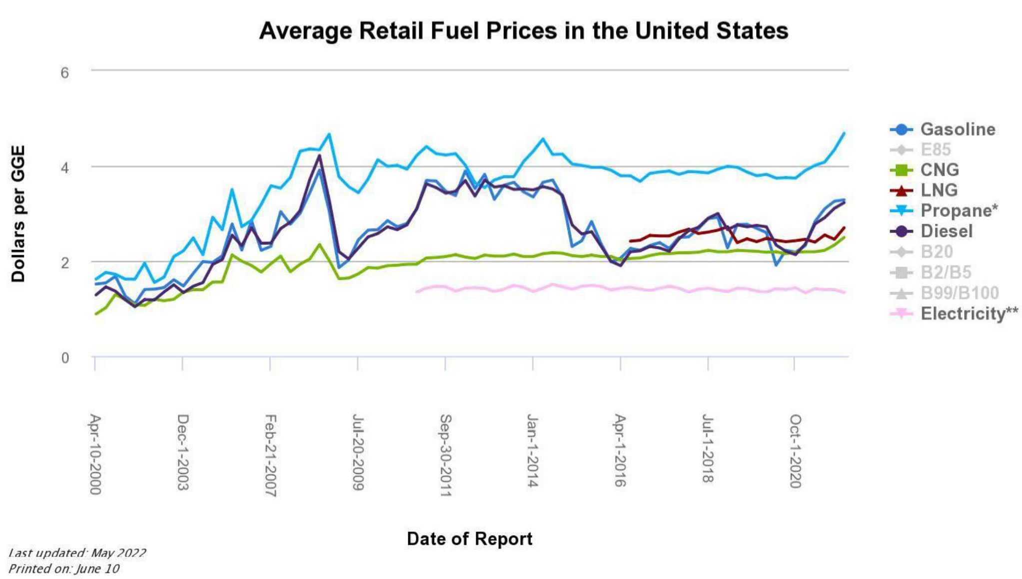
Cost of Fuel per Gasoline Gallon Equivalent (GGE)



Source: Clean Cities Alternative Fuel Price Reports | Electricity prices are from EIA's Real Prices Viewer.
Notes: Fuel volumes are measured in gasoline gallon equivalents (GGEs).

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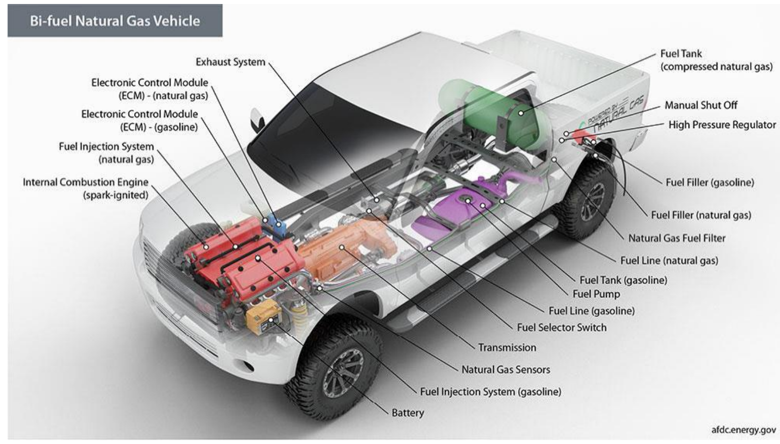
Compressed Natural Gas and Propane AutoGas



- Combustion-based fuel
- Similar to conventional gasoline and diesel vehicles (can even be bi-fuel)
- Range is similar to traditional
- Emissions are dependent on fuel sourcing
  - Natural Gas is primarily Methane and may be derived from fossil sources, anaerobic digesters, agriculture, or landfills
  - Propane can also be made renewably, or sourced as a fossil fuel

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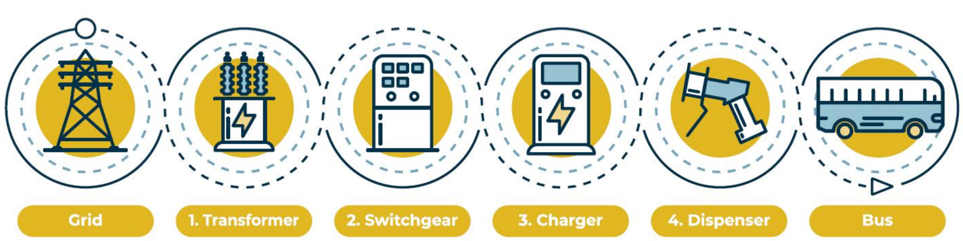
Battery Electric

- Non-combustion propulsion
- Range can vary based on equipment, weather, and a number of other factors, but most vehicle will perform 100-200 miles
- Can be supplemented with fossil fuel heating units to extend range in cold weather
- Emissions are dependent on electric grid generation source



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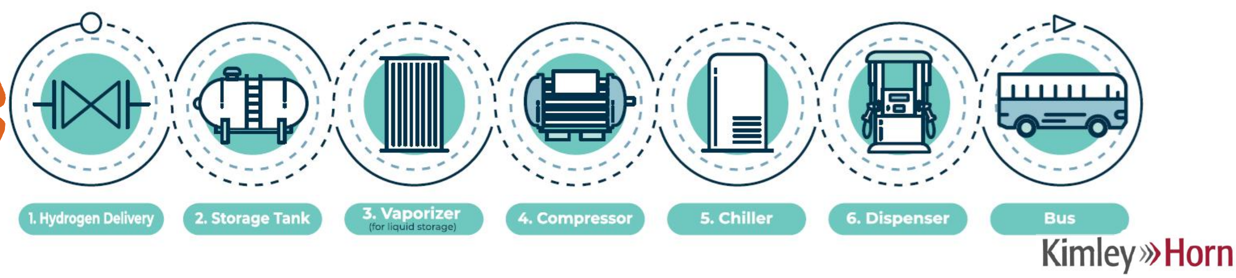
Hydrogen Fuel Cell

- Non-combustion propulsion, similar to Battery Electric
- Fuel is either gaseous or liquified hydrogen
- Range varies based on operating conditions, though generally in parity with traditional diesel vehicles
- Emissions are highly dependent on hydrogen generation

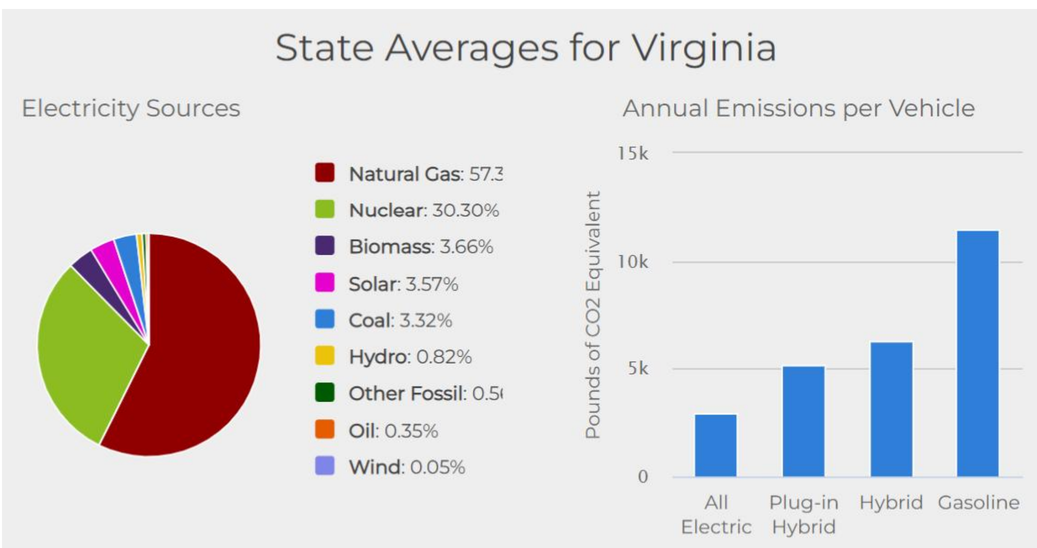


Questions & Discussion

Backup Slides

Supplemental Data

Electric Grid Mix for Virginia



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Lifecycle GHG

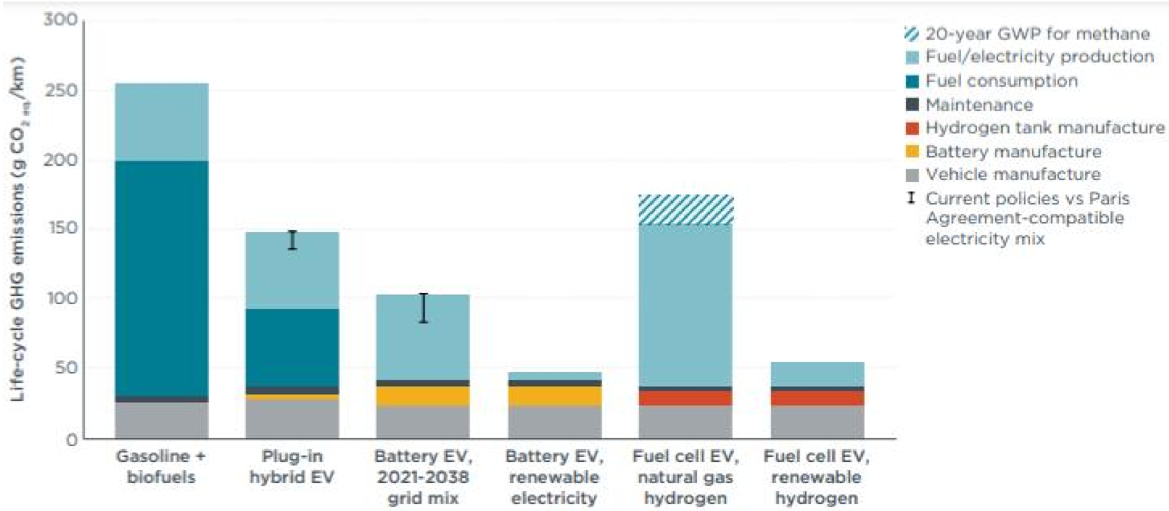

Figure 4.1. Life-cycle GHG emissions of passenger car segment gasoline ICEVs, PHEVs, BEVs, and FCEVs registered in the United States in 2021.

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Lifecycle GHG

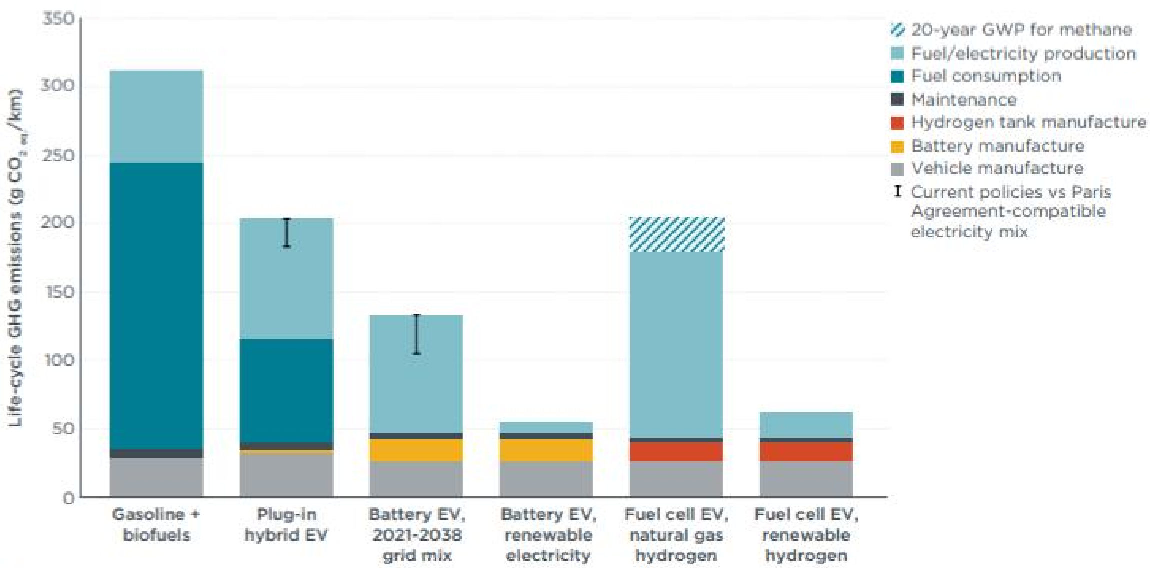

Figure 4.2. Life-cycle GHG emissions of SUV segment gasoline ICEVs, PHEVs, BEVs, and FCEVs registered in the United States in 2021.

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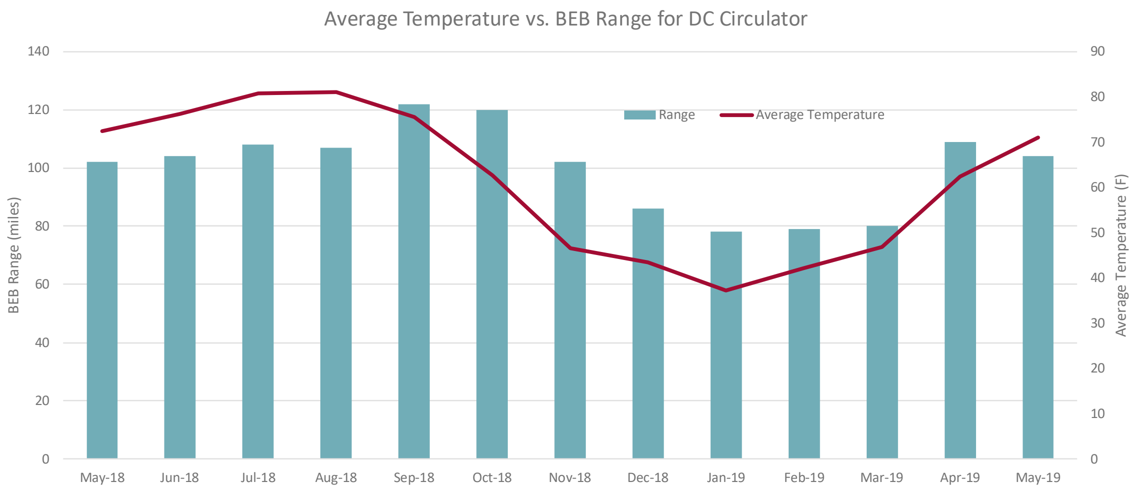
Vehicle Range vs. Temperature (DDOT)



DDOT Pilot Study Average Operating Range (By Month) Vs. Average Washington, DC, Temperatures
(District Department of Transportation, 2021)
(National Centers for Environmental Information (NCEI), 2021)

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APPENDIX C: ADVISORY COMMITTEE PRESENTATION 2

Jaunt

Feasibility Study of Alternative Fueled Buses

Advisory Committee Meeting 2: September 22, 2022

Jaunt WHERE CAN WE TAKE YOU?

Kimley»Horn Expect More. Experience Better.

Today's Objectives

Understand the potential impacts of alternative propulsion technologies to Jaunt.

Generate ideas to leverage the highest-value opportunities and work around barriers.

Agenda

- Project Goals Refresher
- Background and Analysis
  - Project Status to Date
  - Current System and Service Area
  - Assumptions and Range Analysis
- Technology Opportunities and Barriers
  - Battery Electric (EV)
  - Hydrogen Fuel Cell (FCEV)
  - Compressed Natural Gas or Renewable Natural Gas (CNG or RNG)
- Questions & Discussion
- Next Steps

Project Goals

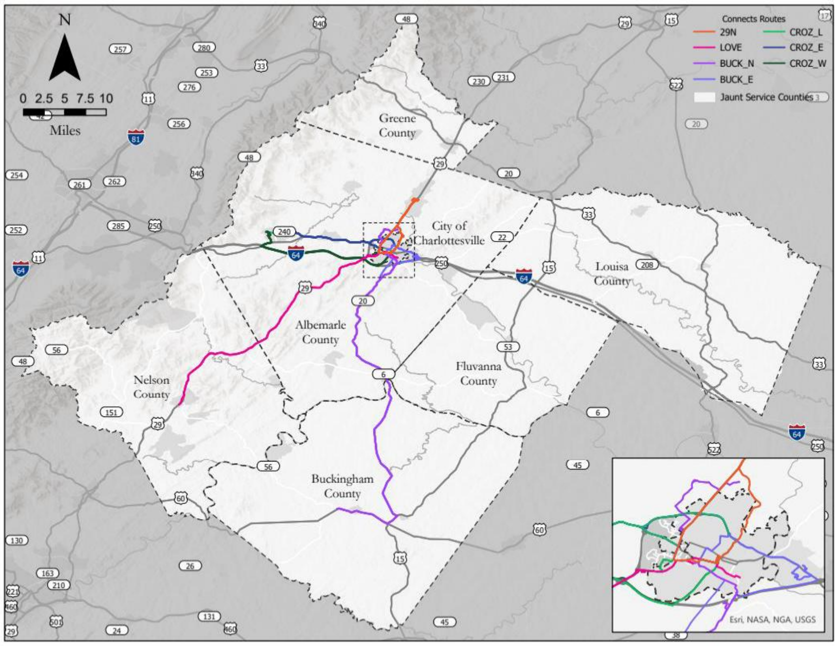
- Achieve **45%** GHG reduction by 2030; net zero by **2050**
- Determine a preferred cleaner fuel type for Jaunt
  - Consider trade-offs including operating and capital cost, emissions impact, and operational viability
  - Balance the current level of service with practicality of low or no emissions vehicles (minimize impact to operations)
  - Consider well-to-wheel impact of propulsion technology on emissions
- Determine high level implementation strategy and timeline of the preferred fuel type

Background and Analysis

Status to Date

- More than halfway through the feasibility study
- Conducted interview with two peer agencies: SARTA and SunLine
- Conducting interviews with utility providers
- Developing scenarios and cost analysis
- Preparing lifecycle greenhouse gas emissions

Jaunt's Current System

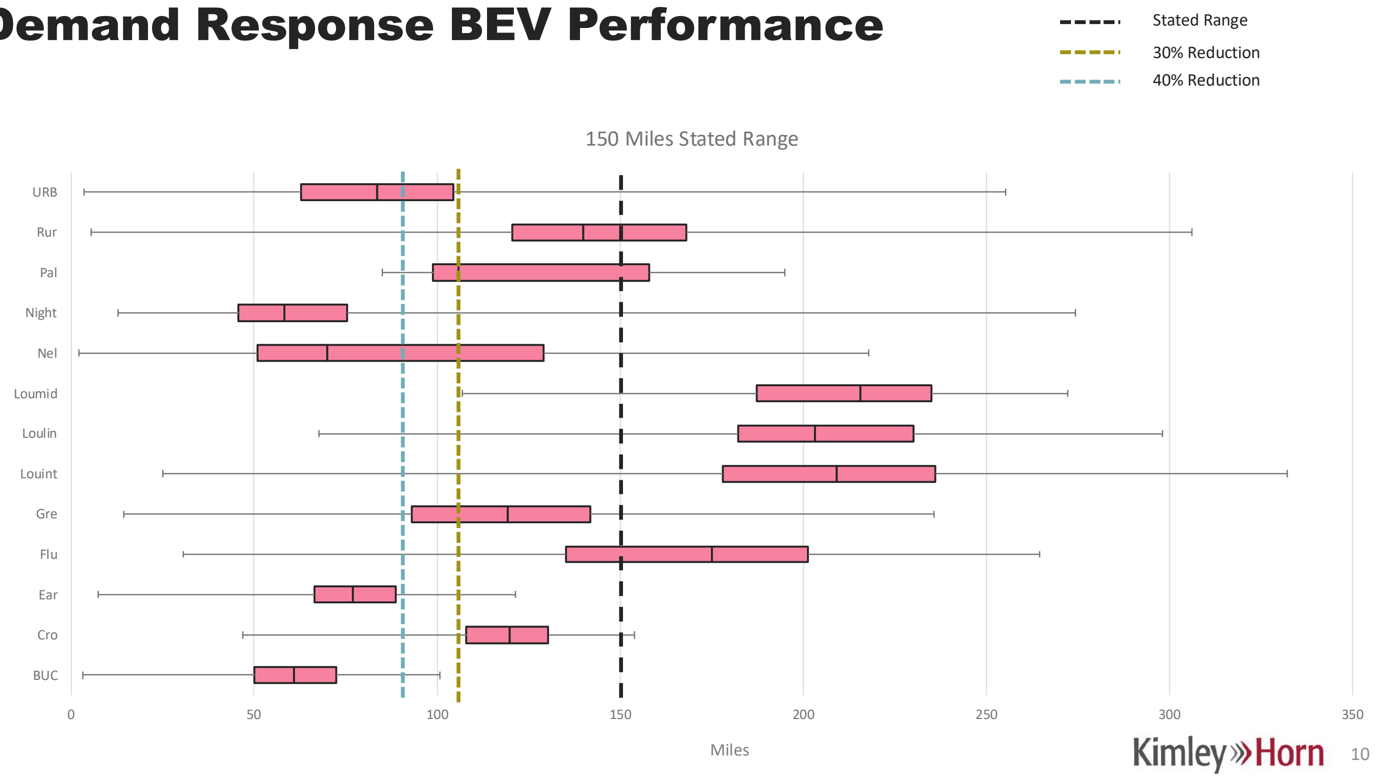


- Serves Charlottesville and six surrounding counties
- 7 fixed-route commuter service lines
- 19 demand response run classes
  - ADA Service
  - Links from the counties to Charlottesville
  - Circulator services within counties

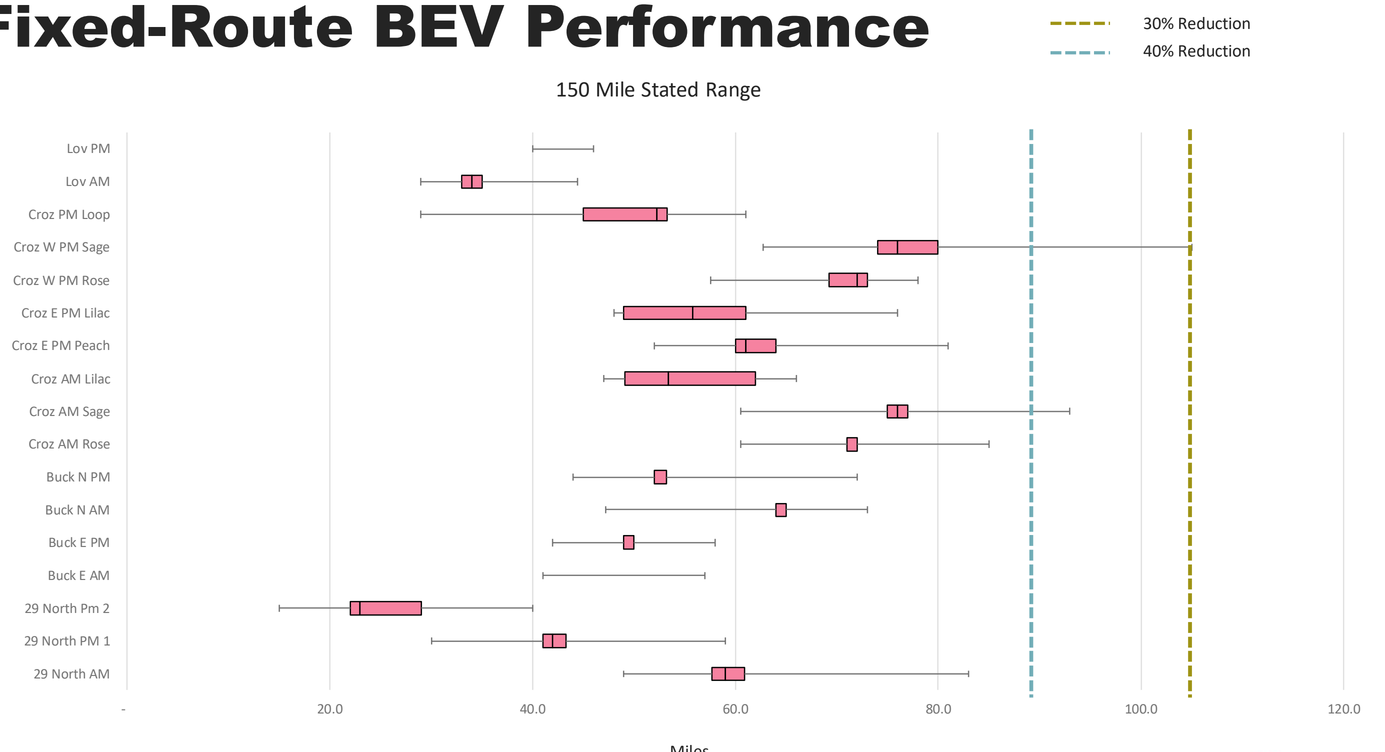
Analysis Assumptions

- Analysis was based on Jaunt's 2021/2022 existing conditions
  - 2022 Fleet and Run Classes
- Assumptions based on 2022 market trends and technology capabilities
- Analysis Assumptions
  - EV range of 100-150 miles
    - 30% and 40% reductions in range were used as benchmarks
    - Reductions were determined through industry standards and literature reviews
  - CNG and FCEV range of 300 miles

Demand Response BEV Performance



Fixed-Route BEV Performance



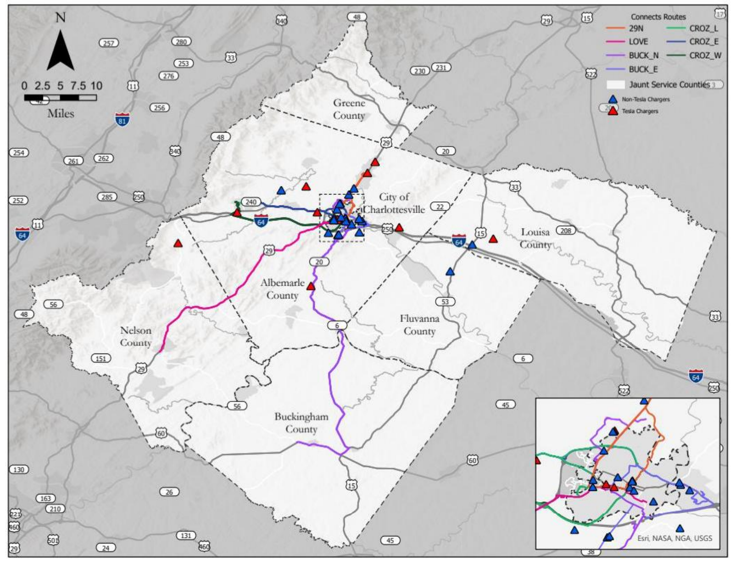
Technology Opportunities and Barriers

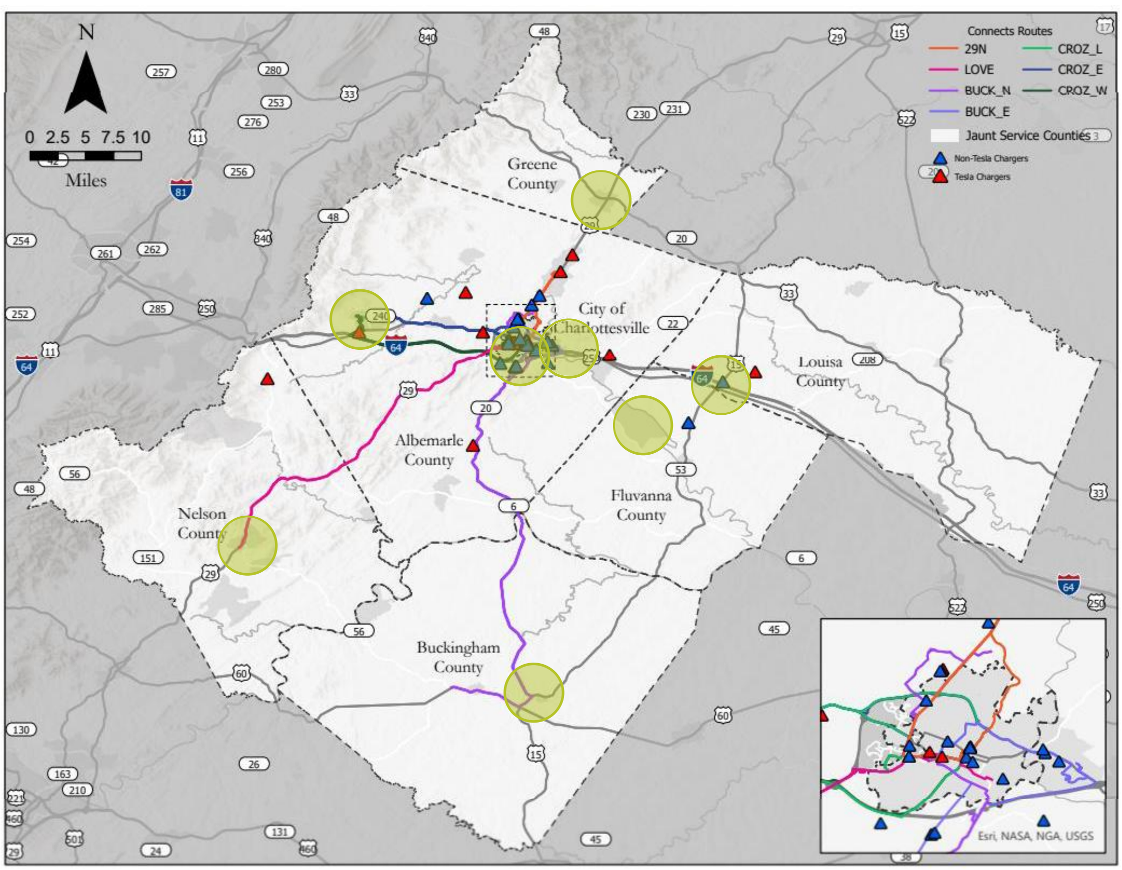
Battery Electric Vehicles

- Opportunities
  - Most (if not all) *fixed route* service could be accommodated with commercially-ready EVs
  - Technology is scalable to number of vehicles deployed
- Barriers
  - Range - Most *paratransit* service would **not** be completed with the same number of vehicles as today
  - Charging operations would require additional space and staff oversight
- Items for Discussion
  - What are opportunities for on-route charging locations and/or additional depots in each service area?
  - What is the desire to procure additional vehicles?

Battery Electric Charging Locations

- 28 public, non-Tesla charger locations
  - 64 Total Chargers
    - 5 Level One chargers
    - 40 Level Two chargers
    - 19 DC Fast Chargers
- Centered around the City of Charlottesville
- Most are available 24 hours a day





Potential Charging Locations

Jaunt County	Community
Albemarle -- west	Crozet
Albemarle -- east	Pantops (west of I-64/US250)
Buckingham	Dillwyn (Highway 20/US15)
Fluvanna	Lake Monticello
Greene	Ruckersville
Louisa	Zion Crossroads (I-64/US15)
Nelson	Lovingston
Charlottesville (City)	Jaunt HQ

Hydrogen Fuel Cell Electric Vehicles

- Opportunities
  - All fixed-route and demand response service could be accommodated with FCEVs
  - Hydrogen deployment is more cost-effective for systems with more vehicles
- Barriers
  - Sourcing – no distributors or commercial fueling stations in the Charlottesville area
  - Cost – hydrogen has a significant upfront costs with fueling/storage infrastructure and vehicle procurement
  - Upstream Emissions – Not all hydrogen production methods have zero carbon footprint and most commercial sources use natural gas reformation
- <u>Items for Discussion</u>
  - Could Jaunt or partners accommodate a local hydrogen production plant?
  - Is the hydrogen vehicle market mature enough for implementation?

Compressed and Renewable Natural Gas

- Opportunities
  - All fixed-route and demand response service could be accommodated with CNG vehicles
  - CNG is a widely-adopted technology
  - There may be renewable sources which could have *negative* carbon emissions
- Barriers
  - CNG is not zero emissions
  - Most renewable natural gas is mixed into the distribution network
- <u>Items for Discussion</u>
  - What is the perception of using natural gas as a fuel?
  - Would near-term deployment be worth installation if equipment could be later converted for hydrogen?

Comparison of Technologies

Scenario	Number of Vehicles	Emissions Reduction		Vehicle Costs	Facility Costs	Operational Costs (Fuel+Maintenance)
		Long-term	Near-term			
Current	108	-		$	-	$$
Battery Electric	157	●●●●●	●●●●	$$$$	$$$$	$
Battery Electric w/ Fast Charging	108-114*	●●●●●	●●●●	$$$	$$$$$	$$
Hydrogen	108	●●●●●	●●●	$$$	$$$	$$$
CNG/RNG	108	●●●●	●●	$	$$	$$

**Assumes standby vehicle in each County*

Long-term

Near-term

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Questions & Discussion

Questions for Discussion

- Which opportunities seem most feasible to act on?
- Which barriers seem the most insurmountable?
- Is Jaunt willing to acquire additional land?
- How could partnerships leverage opportunities or remove barriers?
- Is there an opportunity to use multiple technologies to achieve Jaunt's goals?

Next Steps

- Conduct an interview with Charlottesville Utilities
- Finalize transition scenarios
  - Develop numerical Greenhouse Gas emission comparison
  - Develop relative cost comparison
- Prepare initial prioritization
- Return to the Advisory Committee in November* for Prioritization and Recommendations

APPENDIX D: ADVISORY COMMITTEE PRESENTATION 3

Jaunt

Feasibility Study of Alternative Fueled Buses

Advisory Committee Meeting 3: November 14, 2022

Jaunt WHERE CAN WE TAKE YOU?

Kimley»Horn Expect More. Experience Better.

Today's Objectives

Discuss the priority of feasible technology options for implementation.

Discuss recommendations for implementation.

Agenda

- Project Goals Refresher
- Background and Analysis
  - Project Status to Date
  - Current System and Service Area
  - Comparison of Technologies
- Scenarios and Recommendations
- Questions & Discussion
- Next Steps

Project Goals

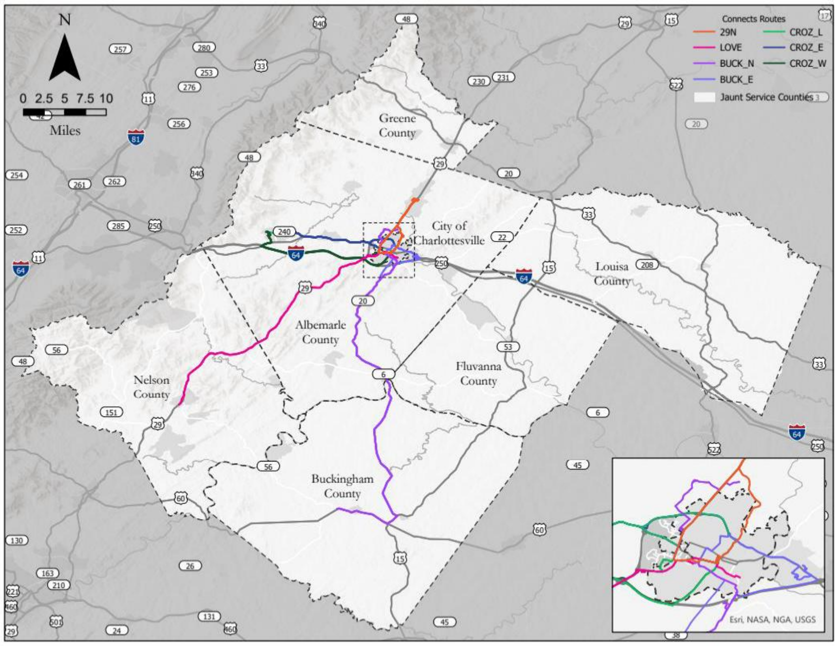
- Achieve **45%** GHG reduction by 2030; net zero by **2050**
- Determine a preferred cleaner fuel type for Jaunt
  - Consider trade-offs including operating and capital cost, emissions impact, and operational viability
  - Balance the current level of service with practicality of low or no emissions vehicles (minimize impact to operations)
  - Consider well-to-wheel impact of propulsion technology on emissions
- Determine high level implementation strategy and timeline of the preferred fuel type

Background and Study to Date

Status to Date

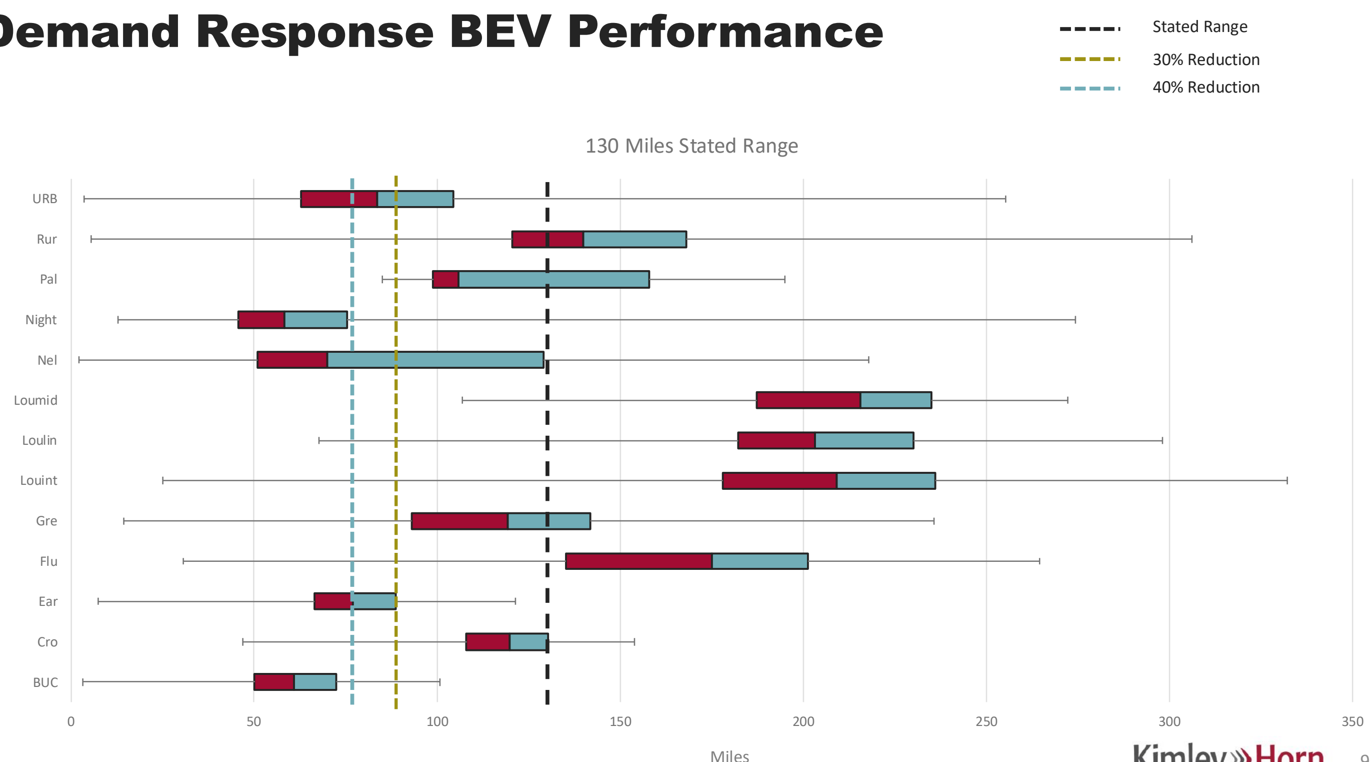
- Study is nearly complete
- Coordinated with Electric and gas utility providers
- Developed alternative scenarios
- Completed numerical emissions and cost analysis
- Developed recommendations

Jaunt's Current System

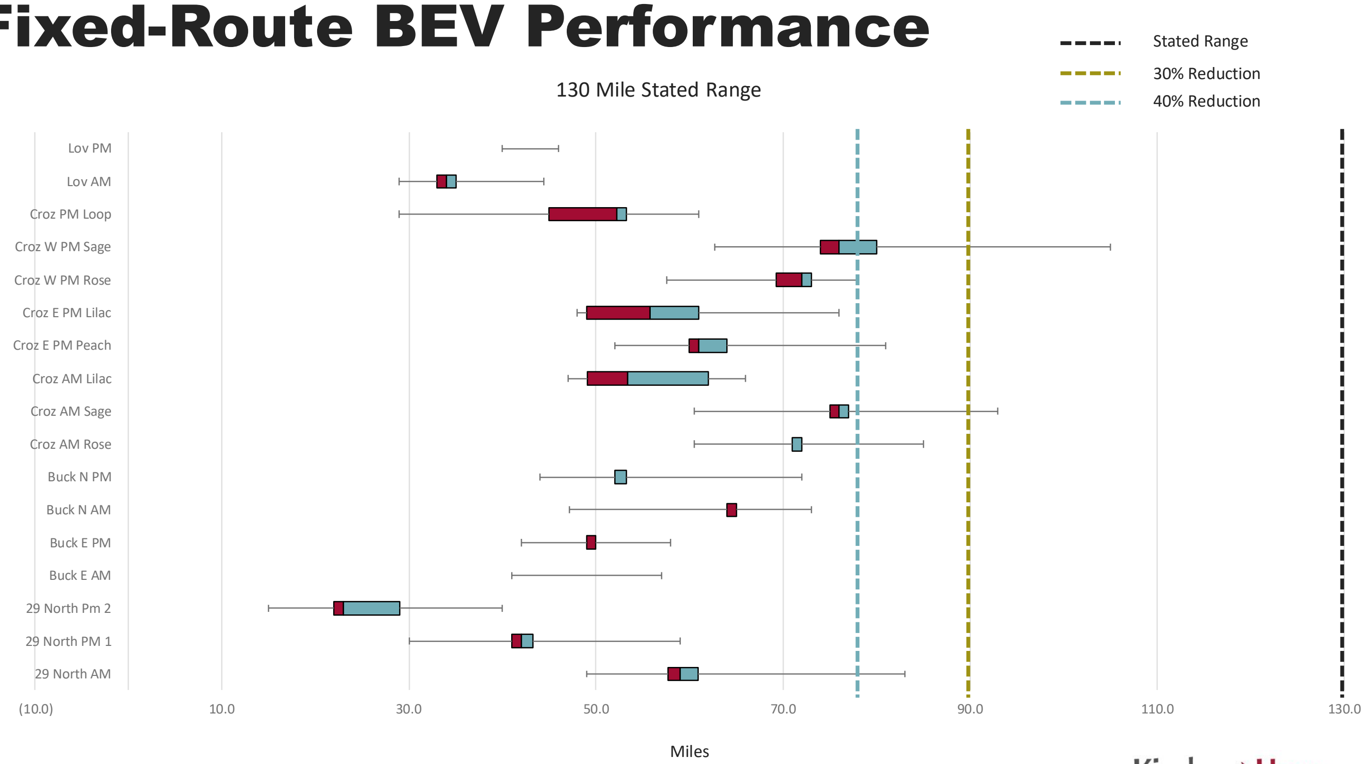


- Serves Charlottesville and six surrounding counties
- 7 fixed-route commuter service lines
- 19 demand response run classes
  - ADA Service
  - Links from the counties to Charlottesville
  - Circulator services within counties

Demand Response BEV Performance



Fixed-Route BEV Performance



Comparison of Technologies

Scenario	Number of Vehicles	Emissions Reduction		Vehicle Costs	Facility Costs	Operational Costs (Fuel+Maintenance)
		Long-term	Near-term			
Current	108	-		$	-	$$
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Battery Electric w/ Fast Charging	108-114*	●●●●●	●●●●	$$$	$$$$$	$$
Hydrogen	108	●●●●●	●●●	$$$	$$$	$$$
CNG/RNG	108	●●●●	●●	$	$$	$$

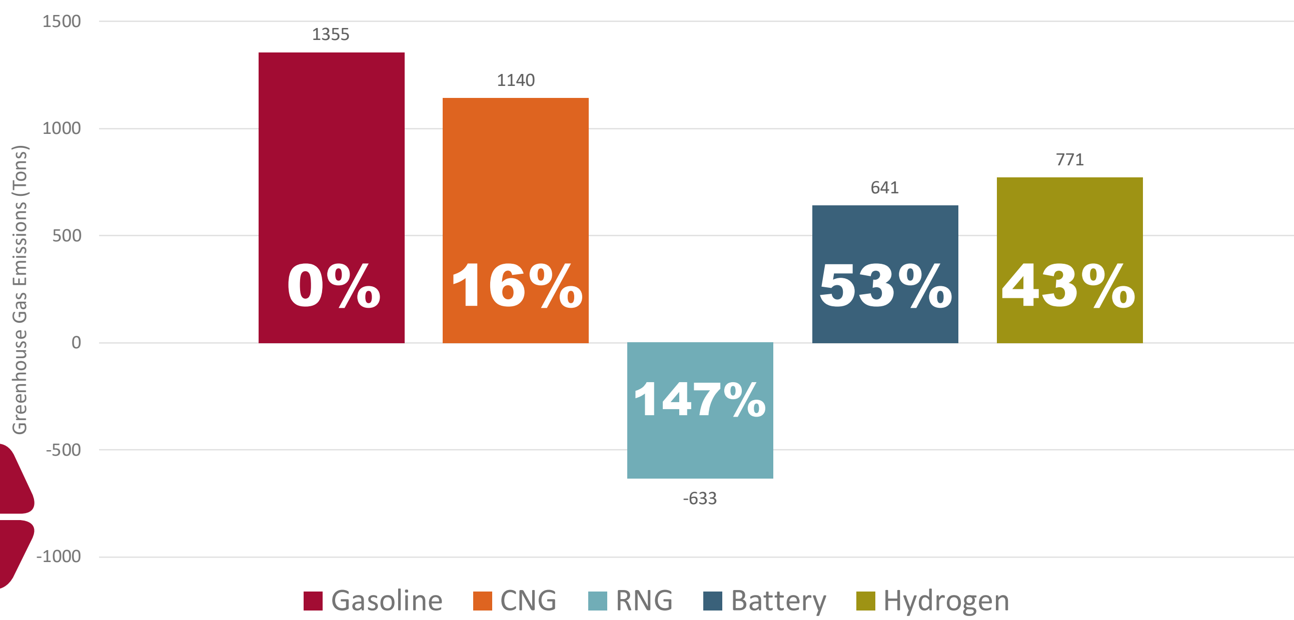
*Assumes standby vehicle in each County

Near-term

Long-term

Scenarios and Recommendations

Greenhouse Gas Emissions Reductions



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Comparison of Technologies

Scenario	Number of Vehicles	Emissions Reduction		Vehicle Costs	Facility Costs	Operational Costs (Fuel+Maintenance)
		Long-term*	Near-term			
Current	108	-		$6.9 M	n/a	$813,000
Battery Electric	135	100%	53%	$16.2 M	$1.1 M	$422,400
Battery Electric w/ Fast Charging	108	100%	53%	$13.0 M	$4.2 M	$422,400
Hydrogen	108	100%	43%	$21.9 M	$3.5 M	$1.1 M
CNG/RNG	108	147%	16%	$8.6 M	$2.3 M	$552,000

**Assumes carbon-neutral electric grid or pure RNG*

Near-term

Long-term

Key Considerations and Tradeoffs

Battery Electric

+ Deployable at Small Scale

− Large Fleet and Cost

CNG/RNG

+ Cost Effective

− Produces Emissions

Fast Charging

+ Diffused Charger Network

− Requires Extensive Partnership

Hydrogen Fuel Cell

+ Resilient Operations

− High Cost to Deploy

Recommendations

1. Implement battery electric vehicles as the initial deployment technology on select run classes.
2. Pursue a small-scale, initial deployment of zero emissions vehicles in fixed-route services.
3. Conduct future evaluation of initial deployment performance.
4. Conduct partnership conversations with government entities, businesses, and utilities.

Next Steps for Zero Emissions Transition

- Work with Jaunt's board of directors to adopt a preferred alternative fuel technology strategy
- Coordinate with DRPT to identify potential technical and funding assistance
- Complete a time-constrained implementation plan for immediate, near, and long-term alternative fuel vehicle deployment
- Identify funding sources and allocate budget to purchase and install initial zero emissions vehicles
- Conduct initial deployment
- Establish performance metrics to monitor and evaluate initial deployment of battery electric vehicles for performance and scalability

Questions & Discussion

Questions for Discussion

- Does the advisory committee agree with consultant recommendations?
- How does timing weigh in on potential phased deployment?

Next Steps for Feasibility Study

- Finalize the study technical memorandum
- Present recommendations to the Jaunt Board of Directors for consideration

Data Backup

Battery Electric Charging Locations

- 28 public, non-Tesla charger locations
  - 64 Total Chargers
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    - 40 Level Two chargers
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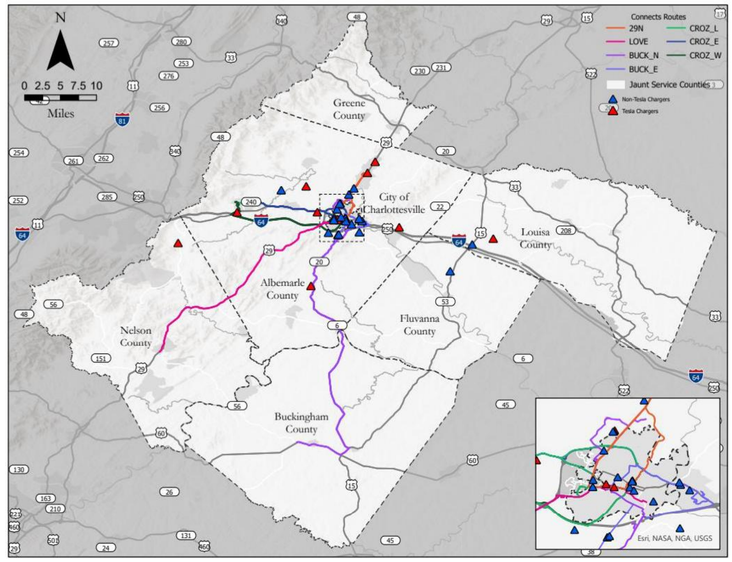

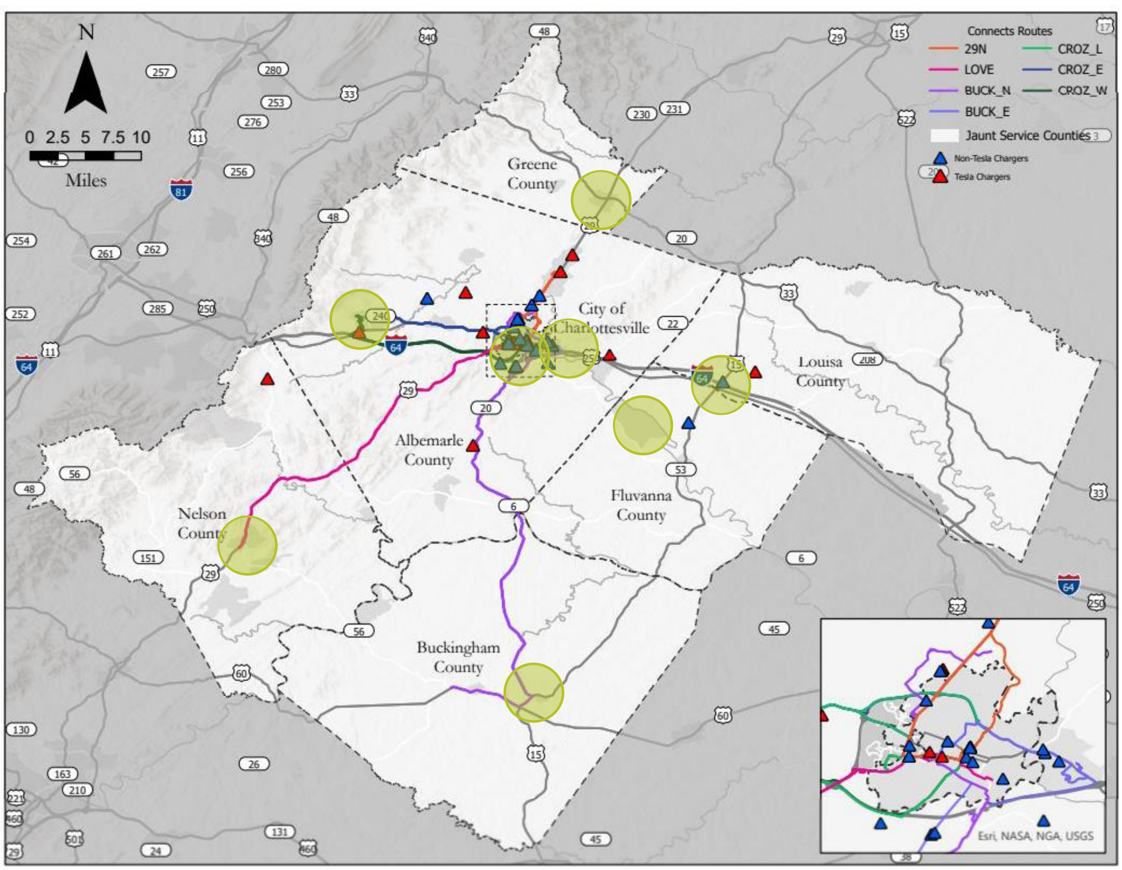

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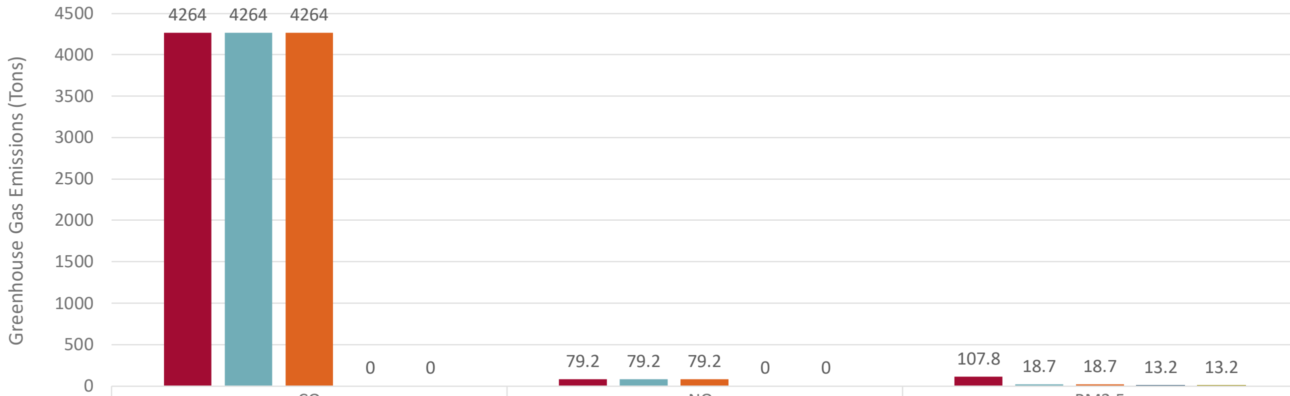
Nelson	Lovingston
Charlottesville (City)	Jaunt HQ

Other Tailpipe Emissions



	CO	NOx	PM2.5
Gasoline	4264	79.2	107.8
RNG	4264	79.2	18.7
CNG	4264	79.2	18.7
Battery	0	0	13.2
Hydrogen	0	0	13.2

Gasoline RNG CNG Battery Hydrogen

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