Zero-Emission Bus Transition Plan – FY2023

Utah Transit Authority

Issue and revision record

Revision	Date	Originator	Approver	Description
0	4/13/2023	MM	CT	

Table of Contents

Tables

Figures

Acronyms and Abbreviations

A-BRT	Automated Bus Rapid Transit
AQI	Air Quality Index
APTA	American Public Transportation Association
BEB	Battery Electric Bus
BEERD	Bus Efficiency Enhancements Research and Demonstration
BFMP	Bus Fleet Management Plan
BIL	Bi-Partisan Infrastructure Law
BRT	Bus Rapid Transit
CTE	Center for Transportation and the Environment
CNG	Compress Natural Gas
EV	Electric Vehicle
FCEB	Fuel Cell Electric Bus
FTA	Federal Transit Administration
HVT	High Valley Transit
NITC	National Institute for Transportation and Communities
OEM	Original Equipment Manufacturer
PM	Particulate Matter
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
RMP	Rocky Mountain Power
TAZ	Traffic Analysis Zone
TNC	Transportation Network Companies
TRAX	Transit Express
UCAIR	Utah Clean Air Partnership

URSTA	Urban Rural Specialized Transit Association
UTA	Utah Transit Authority
VW	Volkswagen
XC	Xcelsior CHARGE
ZEB	Zero Emission Bus
ZEP	Zero-Emission Plan
ZEV	Zero-Emission Vehicle

1 Introduction

The Zero-Emission Plan (ZEP) provides comprehensive information requested by the Federal Transit Administration (FTA) to apply for the Low or No Emission Grant Program and the Grants for Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b)), for projects related to Zero-Emission Vehicles (ZEV).

UTA serves the region along the Wasatch Front, an area with significant seasonal air quality issues. The major population centers are located in mountain valleys which trap poor air in the winter and summer months. UTA has taken significant steps to reduce emissions with the implementation of a 45-mile light rail system, Compressed Natural Gas (CNG) bus fleet, and clean diesel buses. Moving toward 50% alternatives technologies powered fleet will enable UTA to help make a significant positive impact on air quality. This plan includes the FTA requirements for the grant applications, including a long-term fleet management plan, current and future status transition resources, technology policies and legislation, current and future facility assessment, provider partnership relationships study, and workforce impact assessment. A brief description of each requirement is included below:

Bus Fleet Management Plan (BFMP): The BFMP provides current information on UTA's bus fleets and facilities, describing its current condition and provides information of funded and planned projects. The BFMP also includes information of current and projected ridership, bus operation characteristics, maintenance philosophy, reliability performance, and measures used to gather information on service quality and on-time performance is included. UTA's BFMP is included for reference in Appendix A.

Current and future resources for transition costs: As outlined below, UTA has adopted a comprehensive zero emission transition plan. An important component of this plan is the Board of Trustees adopted 5-year financial plan which includes the purchase of 289 vehicles and supporting infrastructure during the period ending December 31, 2026. UTA will continue to work with the FTA and its partners to attain full funding for its transition plan including the pursuit of federal grant funds. UTA will work closely with our State, Local and public/private partnerships on other funding/grant opportunities to implement its transition plan.

Policy and legislation: UTA´s Government Relations department works with lawmakers, stakeholders, partners, and consultants to assure UTA staff is informed of and compliant with all local, state, and federal laws and guidance. The Government Relations staff tracks Congressional and State legislation and shares passed legislation and impacts with UTA staff. UTA has participated in training, webinars, and conferences to learn about the Bipartisan Infrastructure Law (BIL) requirements and has implemented processes to ensure compliance. The Government Relations department thoroughly vets state legislative proposals and bills that effect UTA. We also have contracted federal consultants to help ensure we are notified of any changes nationally. We work with many stakeholders in the area dealing with related issues such as Utah Clean Air Caucus, Utah Clean Air Partnership, Utah Clean Energy, and Rocky Mountain Power.

Existing and future facility evaluation: UTA works collaboratively with vehicle, infrastructure suppliers, and sub-system suppliers to fully define the infrastructure and equipment needs to support the vehicles, and associated changes to existing maintenance facilities. UTA's BFMP describes the infrastructure and equipment needed to support the vehicles and the associated changes to existing facilities**.** The BFMP does also include facility assessments and future expansions. Ref: *4.3. Electrical Infrastructure* and *Appendix A BFMP, 3. Existing Transit Centers and Operating Business Units.*

Alternative fuel provider partnership: Describes the cooperative partnership with the utility provider Rocky Mountain Power and the collaborative strategy to pursue innovative and clean energy objectives. Ref: *4. Utility Provider Partnership.*

Workforce impact assessment: Describes UTA´s workforce training strategy since introducing the first Battery Electric Bus (BEB) and the technology-specialized skill improvement philosophy as well. Ref: *6. Workforce Development*.

2 Overview of UTA

Utah Transit Authority (UTA) has been the service provider for public transportation along the Wasatch Front since August of 1970. The service area is approximately 800 square miles and serves six counties, including many nearby municipalities. The average annual ridership from 2014 to 2018 exceeded 45 million trips. For years 2016 to 2020 average annual ridership was 40,535,768.

In 2022, the active bus fleet included 506 service buses and 22 contingency buses which were serviced by four (4) maintenance facilities. One of these facilities is in Ogden (Mt. Ogden), three (3) are in the Salt Lake area (Central/Depot District, Meadowbrook, Riverside), and one (1) is in Orem (Timpanogos). The Riverside facility houses Special Services, a demand response system serving people with disabilities.

The Depot District will replace the 45-year-old Central Bus Garage, which is fast approaching the end of its useful life. Currently, 100 buses are maintained at the existing garage facility. The current facility cannot be expanded due to a lack of available adjacent land. The lack of space makes it impossible for UTA to expand bus service, as there is no available room to store and maintain the additional vehicles. The new Depot District Clean Fuels Tech Center will provide UTA with bus storage and maintenance resources. It will initially be capable of storing and maintaining up to 150 buses and is expandable to 250 buses. The facility is designed to house alternative fuels, including CNG and battery-electric buses. In addition, the project is building a new bus maintenance shop, bus wash, administrative offices, and bus canopies.

UTA maintains the bus fleet to ensure that the average UTA fixed route bus has a life expectancy consistent with the FTA minimum requirement of 12 years. UTA's bus fleet will continue to change accordingly in size as ridership dictates and as funding is available. UTA expects a steady increase in bus revenue miles as the regular bus service is expanded and new Bus Rapid Transit (BRT) systems are implemented through 2040 as outlined in the 2019-2050 Wasatch Front Regional Transportation Plan (https://wfrc.org/vision-plans/regional-transportation-plan/). Refer to the Bus Fleet Management Plan Rev. 9 included in Appendix A for more information.

UTA's Zero Emission Transition Plan has set a target of 50% alternatively fueled vehicles by 2040. The 2040 target is as follows:

- Clean Diesel: 50%
- Electric: 36%
- CNG: 14%

3 UTA's Electrification

In 2016 UTA began the transition to electrify its bus fleet. This section presents the state of electrification and UTA's plan to continue deploying electric buses. It will also provide an overview of UTA's transition plan, including vehicles, depots, bus routes, and other goals the Agency aims to achieve in the next decade and beyond.

Due to lower costs and the mature state of technology of BEBs as compared with Fuel Cell Electric Bus (FCEB), UTA has chosen the BEB technology. Due to the current limited (but rapidly increasing) range of BEBs, operation of this fleet will require the installation of some on-route charging and may require service modifications adding to the total fleet requirement and operational costs. Drop-down pantograph technology will be used for charging at line terminus and on-route locations. For maintenance depots, plug-in charging technology will be used, consistent with the approach followed by several peer agencies in the United States. UTA will also continue considering using FCEB technology, especially for services that would be difficult to operate with BEBs due to range limitations.

3.1 Current state of electrification

UTA and the University of Utah participated in a joint procurement to acquire five (5) 40' New Flyer Xcelsior CHARGE (XC) NG BEBs, refer to Figure 1. Three (3) of these vehicles belong to UTA's fleet and the remaining two (2) vehicles belong to the University of Utah. UTA is the lienholder for all vehicles obtained through this joint procurement. The University of Utah operates and maintains the two vehicles assigned to them and UTA performs an annual inspection of these vehicles. A plug-in charger is available at the University of Utah.

Figure 1. New Flyer's XC40

These five (5) vehicles were procured in 2016 and have been in revenue service operation since 2018. Since 2016, UTA has continued procuring BEBs, their current bus fleet composition (not including BEBs operated and maintained by the University of Utah) is shown in Figure 2.

PROPULSION TYPE	QUANTITY
Clean Diesel	321
CNG	47
Electric	14
Hybrid	44
Total	426

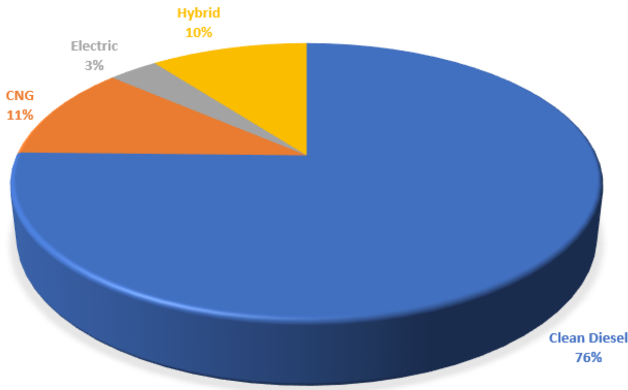


Figure 2. March 2023 UTA's Bus Fleet Composition

The remaining BEBs are currently being operated and maintained by the Central Business Unit who's charging infrastructure consists of plug-in chargers, shown in Figure 3.

Figure 3. Plug-in Charging Infrastructure at Central Business Unit

Currently, a new Business Unit facility has been constructed. As a result, all operations will be transferred from the Central Facility to the Depot District Clean Fuels Technology Center.

UTA has two existing on-route charges at Salt Lake Central Station, which have been in operation since the end of 2019. They currently are used by UTA's three 40' New Flyer Xcelsior CHARGE buses, which run on routes 2 and 509. Long term, these chargers can support many other routes which serve this critical transit hub.

As outlined in UTA's transit development plan, a new Depot District Clean Fuels Technology Center maintenance facility is under construction. The facility is scheduled for completion in the Spring of 2023 and will support the BEB fleet including overhead charging infrastructure as seen in Figure 4.

Figure 4. Overhead Chargers at the Salt Lake Central Station.

Charging infrastructure is also being installed at the Mount Ogden Business Unit as part of the facility expansion and upgrade. The charging infrastructure consists of plug-in chargers for 12 BEBs, one of them located inside the main building, the rest installed outside as shown in Figure 5.

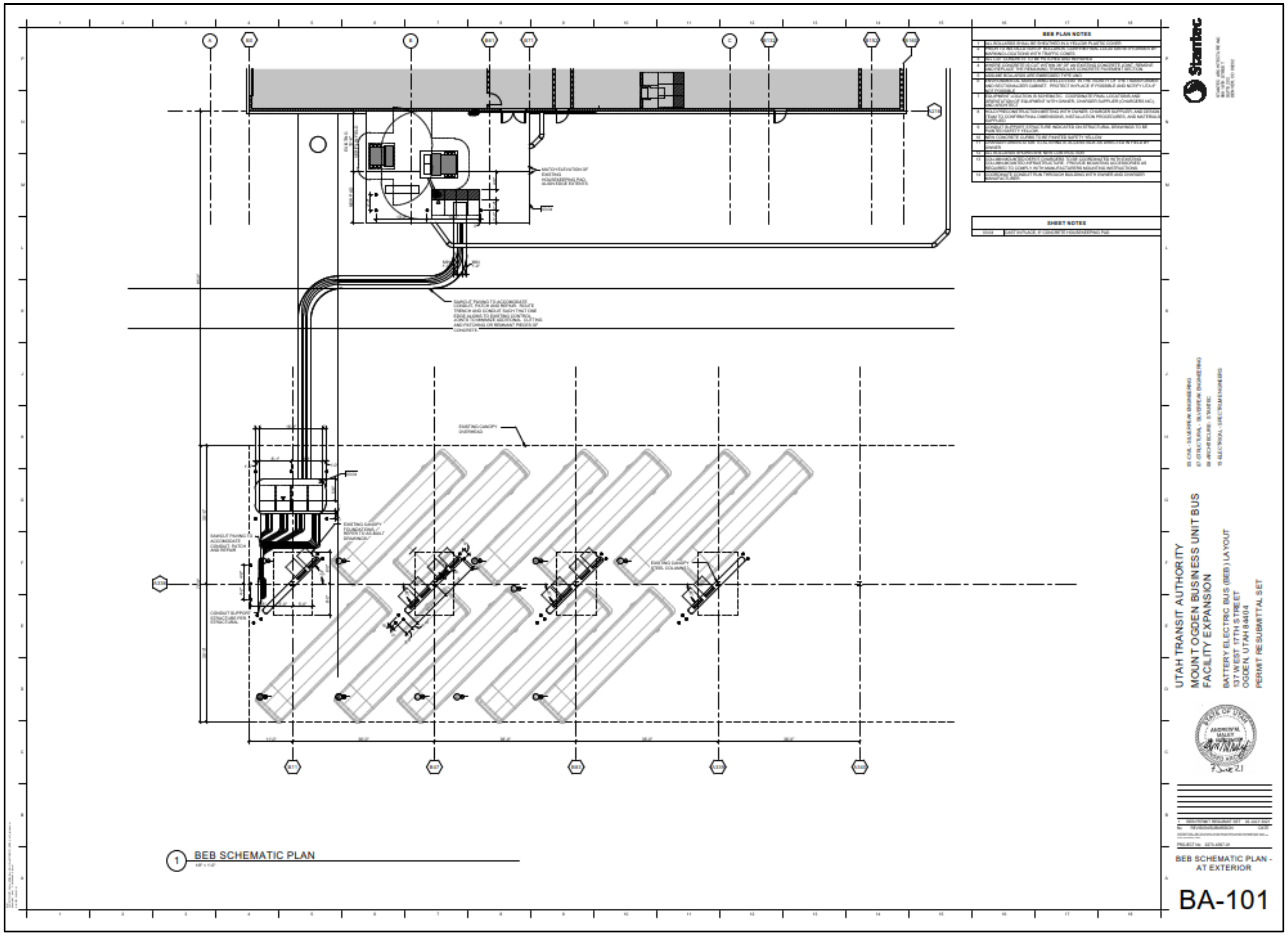


Figure 5. Charging Infrastructure Plans at Mt. Ogden Business Unit

3.2 On-going Procurement BEB and Charging Infrastructure

In April 2021, UTA signed a five-year bus procurement contract with Gillig LLC for BEBs and associated charging infrastructure. This was a joint procurement, including UTA, Park City, and High Valley Transit (HVT).

UTA's second procurement started in 2022 and was partially funded by the Volkswagen (VW) Clean Air Act Civil Settlement through the State of Utah Department of Environmental Quality. The Base Order will furnish delivery of forty-four (44) BEBs, four (4) overhead chargers, sixteen (16) plug-in depot chargers, workforce training, special tools, and an extended warranty. The contract also has a provision for option for up to 95 additional BEBs over five (5) years. By the second quarter of 2023, UTA plan to have received delivery of 20 of these all-electric buses, one of which can be seen in Figure 6 below. The Agency will destroy 20 diesel buses being replaced per the DEQ requirements. A breakdown of this order is provided in Table 1.

Figure 6. UTA Gillig 40' BEB at the APTA Mobility Conference - Columbus, OH, May 2022.

Table 1. BEB Base Order for Gillig BEBs and Charging Infrastructure

Quantity	Description	Order Breakdown
9	Thirty-five (35') foot BEB – Transit	Qty. 4 for HVT

		Qty. 5 for Park City (Now 7 with 2 options used)
20	Forty (40') foot BEB – Transit/Suburban Bus	Qty. 20 for UTA (from VW Settlement)
4	Forty (40') foot BEB – Suburban bus with commuter style interior layout	Qty. 4 for HVT
11	Forty (40') foot BEB – BRT	Qty. 11 for OGX Ogden BRT route
4	On-Route Chargers – Drop-down pantograph	Qty. 4 for UTA
16	Depot Chargers – Plug-in chargers	Qty. 5 for UTA's Mt. Ogden Business Unit for OGX. The remaining units to be split between UTA, Park City and HVT
1	Workforce Training	
1	Special Tools	
1	Spare Parts	
1	Maintenance and Training Manuals	
44	Extended Warranty	

After the base contract was executed, Park City added two (2) optional vehicles to their order, leaving 93 BEBs remaining as part of the contract's options.

Figure 7 indicates the expected Bus fleet composition for the end of year 2023.

PROPULSION TYPE	QUANTITY
Clean Diesel	314
CNG	59
Electric	34
Hybrid	34
Total	441

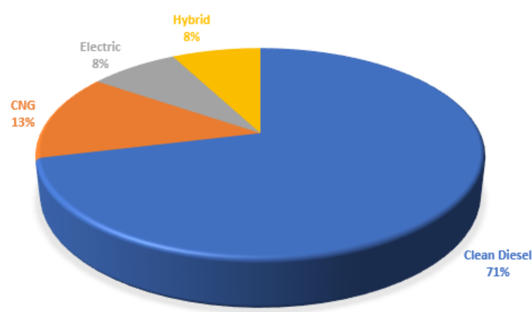


Figure 7. UTA End of 2023 Bus Fleet Composition

3.2.1 VW Charging Plan – Initial Evaluation

As part of the VW BEB charging plan, UTA's Operations and Planning department evaluated specific sites which were rated based on several components, including:

- Number of routes at each site based on the 5-year service plan.
- Ease of constructing a new transit hub / charging station at each location.
- Land ownership (UTA, City of Utah, or University of Utah).
- Existing electrical service.
- Operator facility locations.
- Bus charging load balance (switch ON/OFF) based on Light Rail sub-station power requirements.

From the Charging plan, a project budget was created. An update of the VW BEB project budget status is provided in Table 2.

Table 2. VW BEB project budget status

Buses

Item Description	Qty	Unit Cost	UTA	VW	UTA/other	Total Cost
Buses	20	$ 992,887	$ 446,799	$ 10,921,757	$ 8,935,983	$ 19,857,740
Bus configurable/spare parts/warranty/bike rack	20	$ 70,000	$ 31,500	$ 770,000	$ 630,000	$ 1,400,000
Project Management	4	$ 50,000	$ 22,500	$ 110,000	$ 90,000	$ 200,000
Training	4	$ 35,000	$ 15,750	$ 77,000	$ 63,000	$ 140,000
Tools	4	$ 75,000	$ 33,750	$ 165,000	$ 135,000	$ 300,000
shop improvements	4	$ 20,000	$ 9,000	$ 44,000	$ 36,000	$ 80,000
TOTALS			**$ 550,299**	**$ 12,043,757**	**$ 9,853,983**	**$ 21,977,740**

Charging Infrastructure

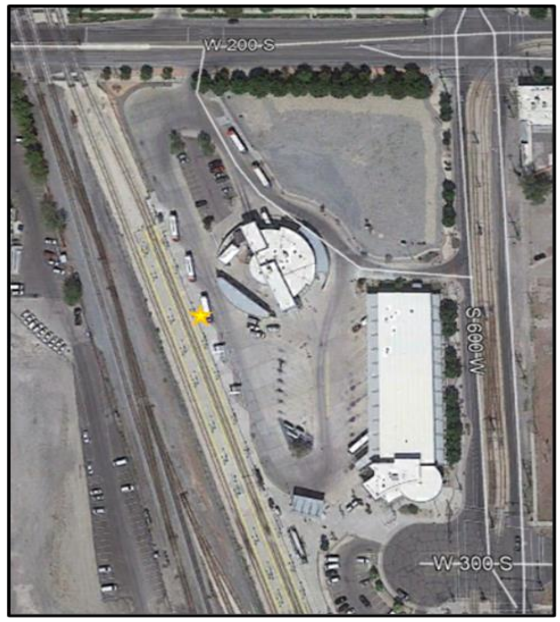
Item Description	Qty	Unit Cost	UTA	Partner: RMP?, CMAQ, STP	UTA/other	Total Cost
On Route Charging Equipment	1	$ 314,000	$ 94,200	$ 219,800	$ 94,200	$ 314,000
On Route Charging Equipment	3	$ 352,000	$ 105,600	$ 739,200	$ 316,800	$ 1,056,000
bus charger (orange street)	1	$ 352,000	$ 105,600	$ 246,400	$ 105,600	$ 352,000
On Route A&E Services	4	$ 65,000	$ 19,500	$ 182,000	$ 78,000	$ 260,000
Depot Charging Equipment (8 units)	8	$ 116,000	$ 34,800	$ 649,600	$ 278,400	$ 928,000
Contigency charger	1					
Depot Charger Construction Services	8	$ 80,000	$ 24,000	$ 448,000	$ 192,000	$ 640,000
install contigency and existing charger	2	$ 80,000	$ 24,000	$ 112,000	$ 48,000	$ 160,000
Software	3	$ 3,600	$ 1,080	$ 7,560	$ 3,240	$ 10,800
Training	3	$ 15,000	$ 4,500	$ 31,500	$ 13,500	$ 45,000
On Route Construction Services (charger locations Central Station 3rd charger, 2100 South 2 chargers, Wasatch 3900)	4	$ 700,000	$ 210,000	$ 1,960,000	$ 840,000	$ 2,800,000
UTA Project Management	4	$ 35,000	$ 10,500	$ 98,000	$ 42,000	$ 140,000
Contingency	9	$ 100,000	$ 30,000	$ 629,948	$ 270,000	$ 899,948
TOTALS		**$ 2,212,600**	**$ 663,780**	**$ 5,324,008**	**$ 2,281,740**	**$ 7,605,748**

VW Project Total Budget				**$ 17,367,765**	**$ 12,135,723**	**$ 29,583,488**
			Cost Share Percentages - LoNo Project			
Grants and Funding sources won to date						**Match Amount**
VW funds						$ 13,079,240.00
UTA						$ 14,000,000
WFRC						$ 2,500,000
Subtotal won:						$ 29,579,240.00

3.2.2 Base plan

The base plan developed by the Capital, Service, and Operations Planning is to install the chargers at the following locations:

- One charger station at Salt Lake Central Station
- One charger at the Orange Street End-of-Line Facility
- Two chargers at Central Pointe Station



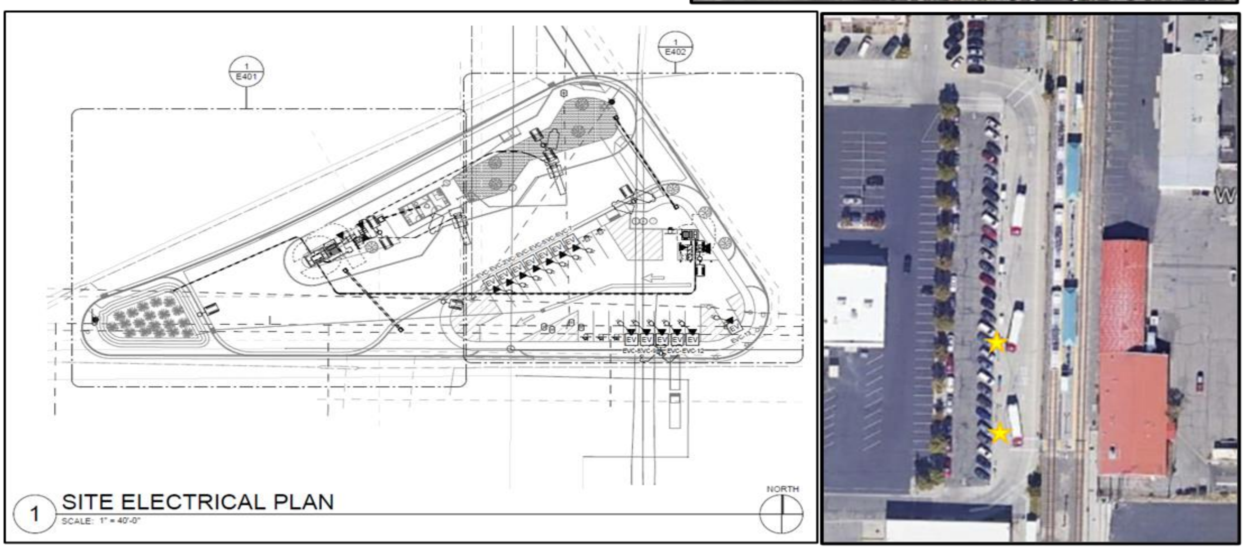


Figure 8. Charger installation locations

The buses have also been proposed to be used on the Westside Express project if the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant funds are received. If so, the four chargers will be installed at the following locations:

- One additional charger at Salt Lake Central Station
- Two chargers at 5600 W. Old Bingham Hwy Station
- One additional charger at the Orange Street End-of-Line Facility

Figure 9. West Side Express Charging Station Project

Other Charging locations:

UTA is also working with High Valley Transit (HVT) to implement electric buses on the Park City – SLC Connect Service. UTA currently operates bus service to Park City as part of an interlocal agreement that outlines service expectations and funding responsibilities. UTA and HVT are working to transition the responsibility for owning, operating, maintaining, and funding this service to HVT. As part of this effort, UTA is supporting the development of two on-route chargers. One will be constructed at UTA's the Salt Lake Central Station, which will be the transfer point between the bus and rail. UTA will operate and maintain this charger. UTA is also supporting HVT in building a charger at their Kimball Junction hub, which HVT will operate and maintain.

3.3 Initial Service and Route Analysis

UTA partnered with the National Institute for Transportation and Communities (NITC) to conduct an analysis titled: *Bi-objective Optimization for Battery Electric Bus Deployment Considering Cost and Environmental Equity*. As indicated by its title, the analysis was conducted with two objectives. The first objective is to minimize the cost of purchasing BEB and installing both on-route and in-depot charging stations while maintaining current bus schedules. The second objective is to maximize environmental equity by incorporating the disadvantaged population in the decision-making process.

The developed bi-objective spatiotemporal optimization model and the result are integrated via a unifying interactive visualization platform to support querying, navigating, and exploring various BEB deployment scenarios. The platform allows users to explore the designated buses to be replaced with BEBs with their customized inputs, the siting of corresponding charging stations, and the impacts of various BEB deployment strategies in terms of cost and environmental/social benefits. Only empirical data was used but the platform can be refined as actual data is gathered from the BEB currently in service. As part of this analysis, several BEB deployment scenarios were explored. The outputs of the platform are the corresponding parameter for each of the scenarios analyzed, e.g., charging station locations.

Typical BEB analysis focuses on cost or environmental benefits associated with the deployment of BEB fleets. This analysis also considered social equity as many transit-dependent communities served by UTA tend to suffer the most from poor air quality as they often reside in areas with a high concentration of air pollutants. Replacing diesel or Compressed Natural Gas (CNG) buses with BEB vehicles in these neighborhoods further improves environmental and social equity.

For this analysis, a mathematical model was developed, which considers the different parameters, decision variables, and constraints necessary to meet the two objectives established for this analysis. However, no single solution exists that simultaneously optimizes both goals. Increasing the budget will likely lead to more BEB deployment, thus improving environmental equity.

a. The bus considered for the analysis is the New Flyer XC 40', and actual performance data gathered from service operations were used in the mathematical model. Some of these parameters are:
b. Driving range varies from 62 – 200 miles in the winter.
c. Driving range varies from 75 – 294 miles in the summer.
d. Electric heater can take up to 50% of battery consumption.
e. Air conditioning can take a considerable amount of battery consumption, but less than 50%.
f. Considering the steep elevation rise along the UTA routes, a safe 62 miles range assumption is used.
g. Standard on-route charging time is 10-13 minutes, no partial charging is assumed in this study. Thus, only terminals in which any bus dwells more than 10 minutes are deemed as potential sites for building on-route charging stations.

Under these parameters and assumptions, the following was found:

- There are 114 buses in UTA's fleet of 467 with daily mileage less than 62, indicating no on-route charging is needed. An estimated 51 buses will run out of battery power before charging due to the long distance between stops.
- This results in 71 potential charging stations for the study area. In addition, four bus garages on the Wasatch Front are qualified as in-depot charging stations for overnight charging without space limitations (refer to Figure 10).
- Among the remaining 302 buses operated by UTA on weekdays, 82 cannot be fully charged because they dwell less than 10 minutes at any terminals, which means they are not qualified as replacements given the current parameters.
- It leaves 220 buses in total that require in-depot charging and on-route charging.

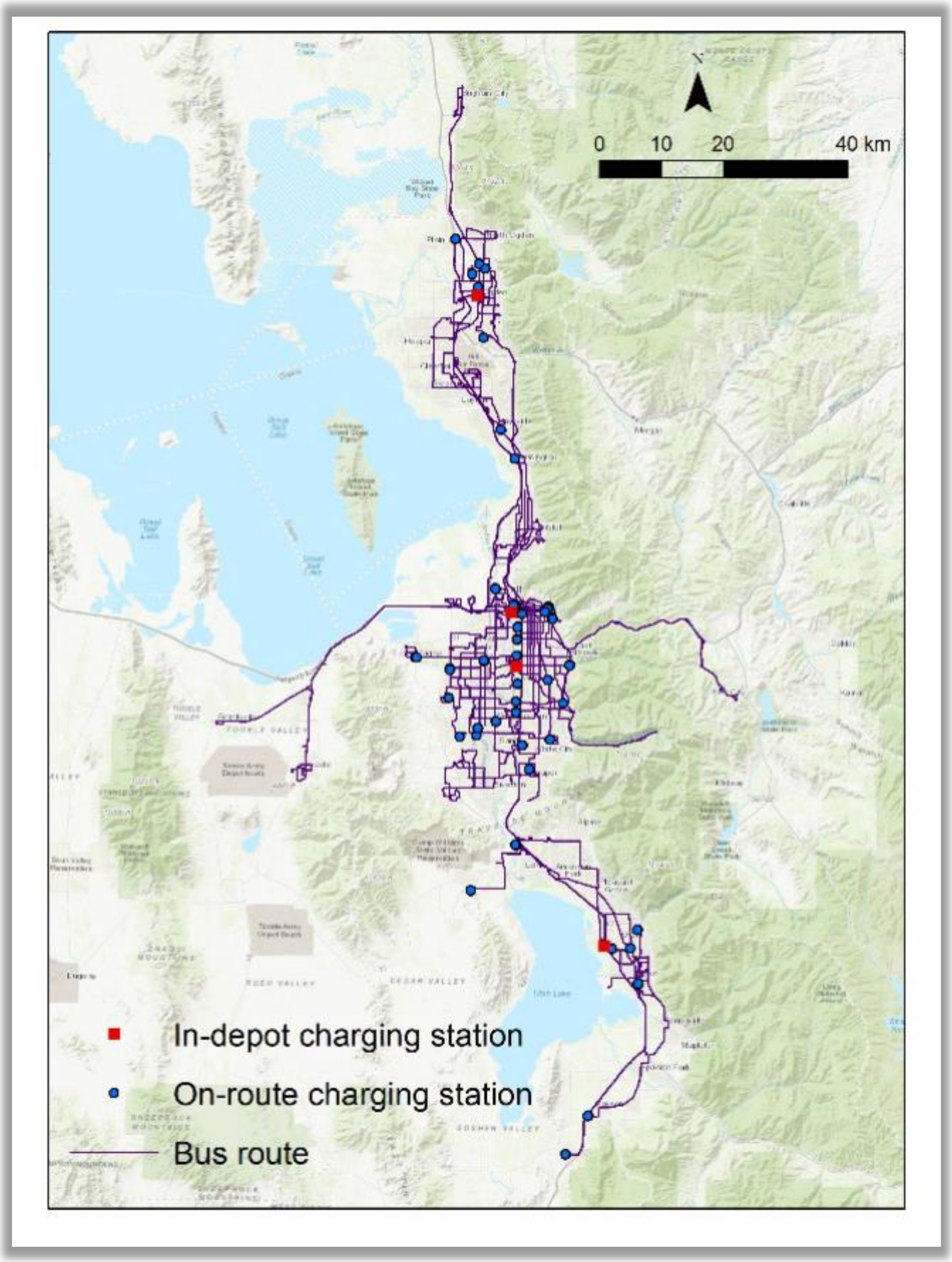


Figure 10. Study Area

3.4 Low-Income Population

The analysis assumes that low-income populations depend heavily on public transit for mobility and fulfilling their daily activities. Population groups with incomes ranging from $0 to $34,999 are considered low-income in Utah, refer to Figure 11.

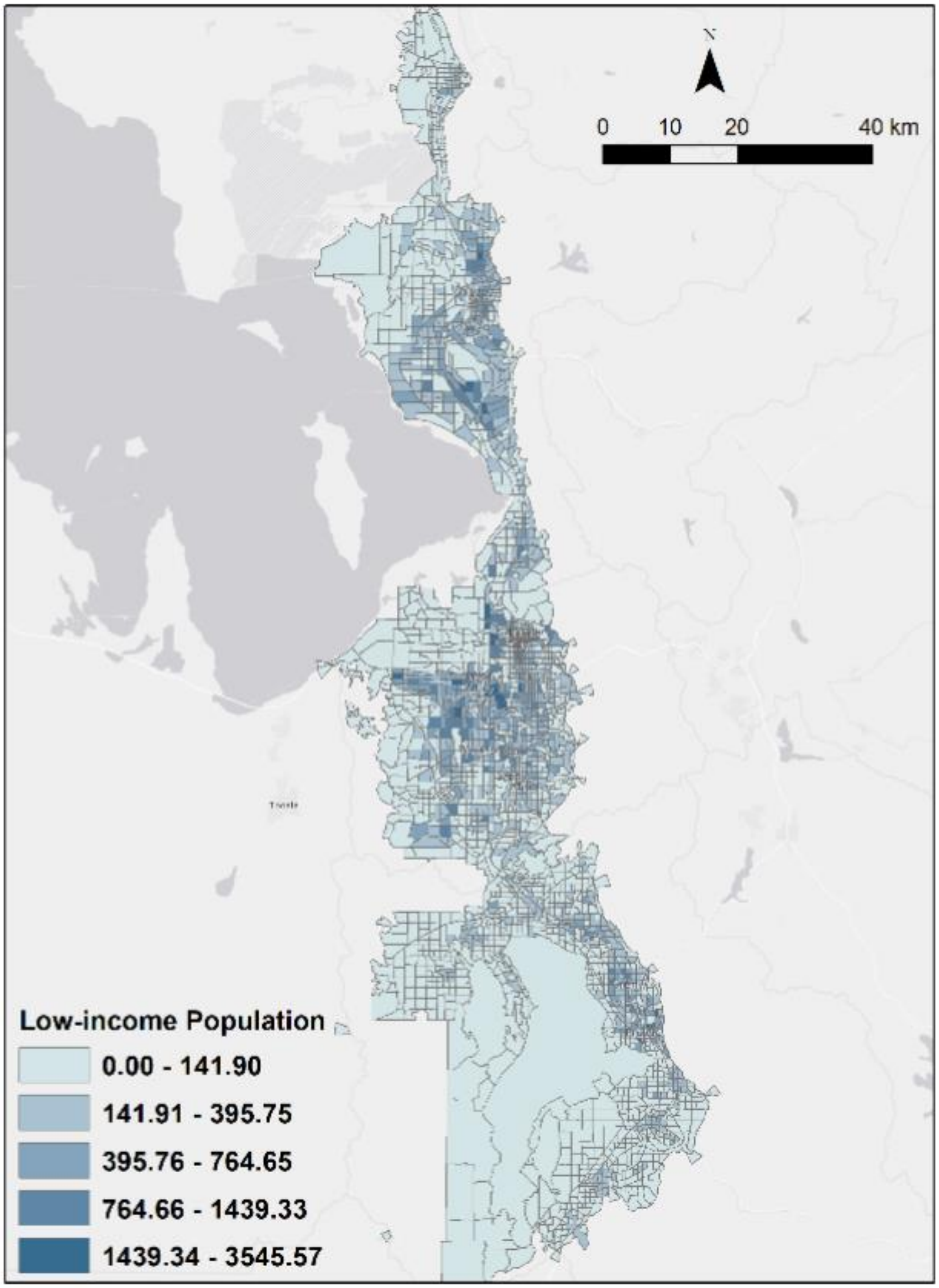


Figure 11. Distribution of Low-Income Populations

3.5 Air Pollution Data

Air pollution data was collected to model the environmental equity outcomes resulting from BEB deployment. UTA obtained this information from PurpleAir, an air quality monitoring network built on a new generation of laser particle counters that provide real-time measurement of Particulate Matter (PM) PM1.0, PM2.5, and PM10 (particulate air pollution size measured in µg/m³, where µg/m³ is micrograms of gaseous pollutants per cubic meter of ambient air). There are over 400 public sensors distributed across Utah. Figure 12 shows a sample screenshot for PurpleAir Air Quality Index (AQI) reading in Utah on April 8th, 2020.

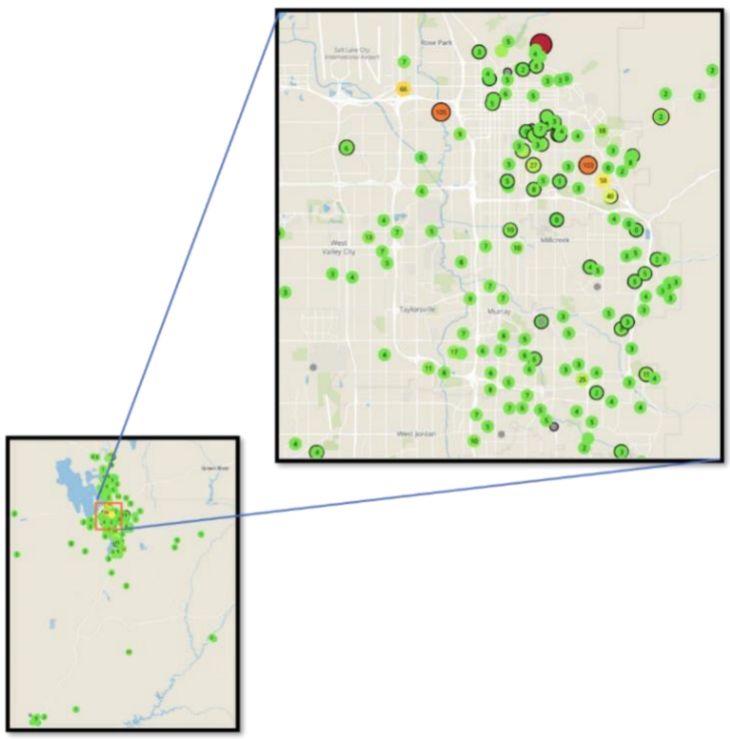


Figure 12. Sample Screenshot of PurpleAir Sensor Distribution in the State of Utah on 04/08/2020

Data retrieved PM2.5 concentration from all sensors in the state of Utah from October 1st to October 14th, 2019 and calculated the average for each site. The data were further processed to interpolate the pollutant level at the unit of Traffic Analysis Zone (TAZ).

This analysis focuses on deploying BEBs so that the low-income populations who are exposed to the worst air conditions can be given priority. To this end, the concentration of PM2.5 (µg/m³) is treated as the indicator of air pollution level in this study. Figure 13 shows the resulting average PM2.5 concentration delineated by TAZ. Comparing Figure 11 and Figure 13, it is noted that most of the low-income population resides in TAZs with higher PM2.5 concentration. For example, in central Salt Lake City, where PM2.5 concentration is the highest, there is a cluster of TAZs with a larger low-income population, accounting for more than 50% of the total low-income populations in the studied region. Also, the area to the east of the Great Salt Lake shows similar patterns where low-income populations reside in areas with a higher concentration of PM2.5.

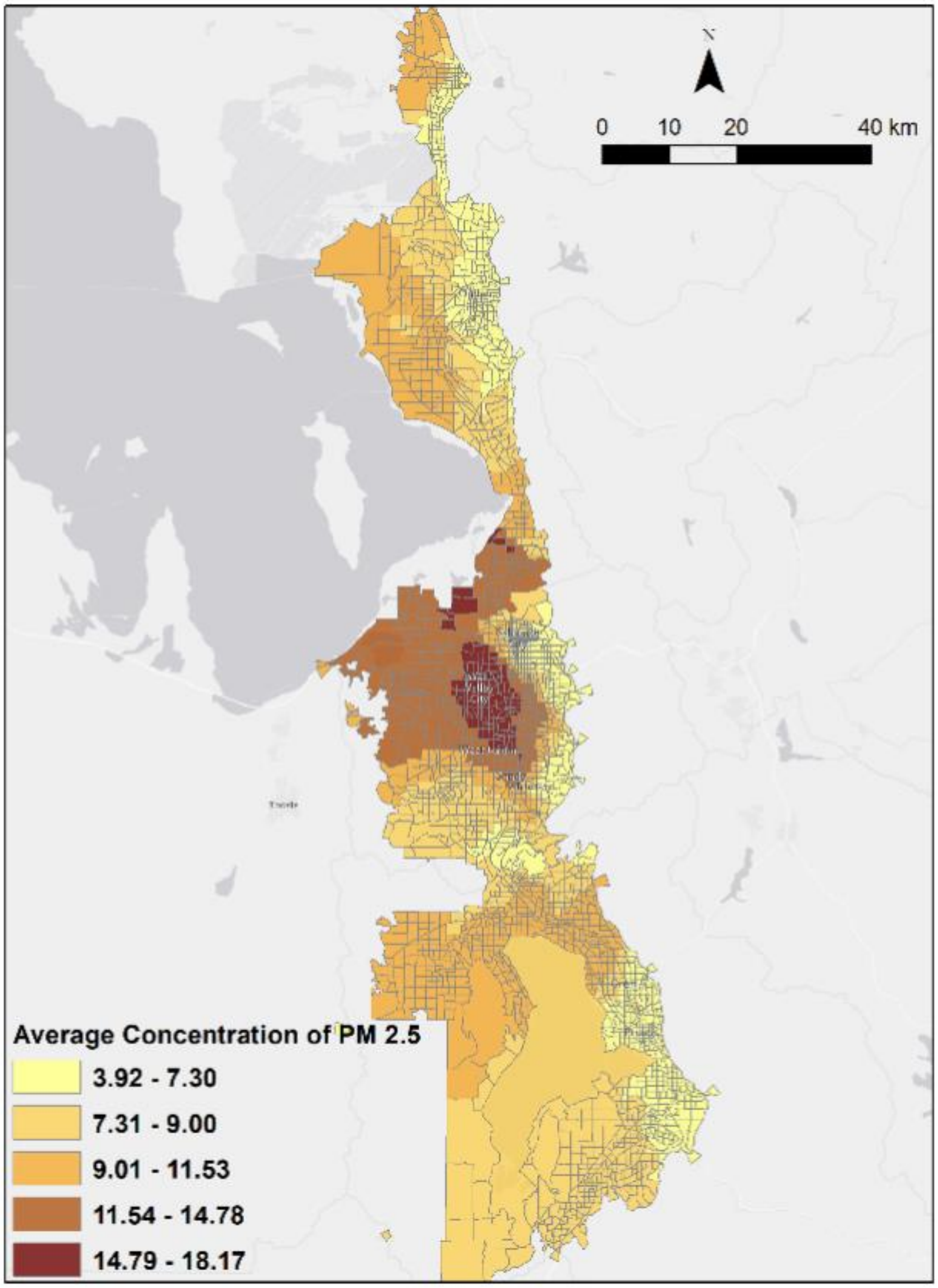


Figure 13. PM2.5 Concentration delineated by TAZ for Utah

3.6 Results and Analysis

The intention is to identify the trade-off between environmental equity and cost incurred by replacing the current fleet with BEBs. Different deployment plans can be presented by varying budget constraints/funding availability. Each plan would produce the set of locations for charging stations and replaced buses, given a fixed budget and the maximum environmental equity it could yield. Figure 14 shows the trade-off curve between budget and environmental equity each unique plan could produce. There is a clear positive correlation between budget and environmental equity. As the budget increases, the number of buses applicable for replacement goes up as well as the number of on-route and in-depot charging stations.

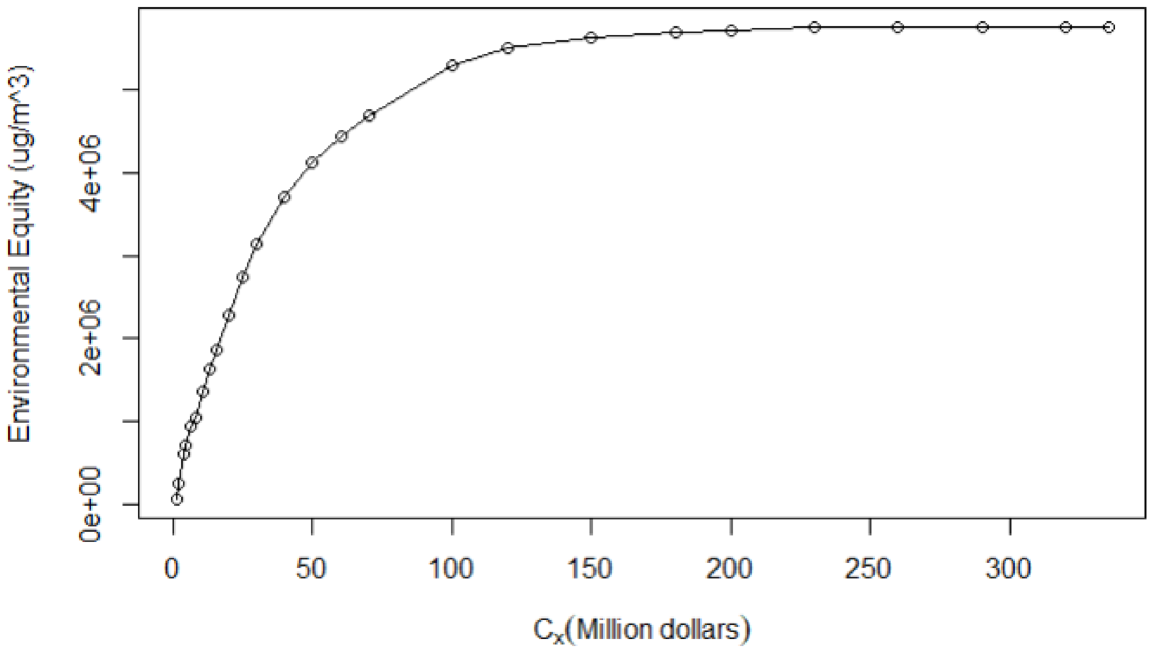


Figure 14. Trade-off Curve between Cost and Environmental Equity

Based on the analysis done as part of this study, out of a fleet of 467 buses, 51 buses will run out of battery power during service due to the long distance between stops, and 82 buses cannot be fully charged because their dwell time is less than 10 minutes at any terminals, which means they are not qualified as replacements given the current parameters (on-route chargers installed only at terminals, and a 10 minutes minimum dwell time at terminals).

Therefore, out of the 467-bus fleet, potentially 334 buses are eligible for replacement to BEB. Out of the 334 BEBs, 114 do not require on-route charging stations as their daily mileage is less than 62. The maximum environmental equity achievable would correspond to the scenario where all 334 buses are replaced with BEBs. Such a scenario requires 46 on-route charging stations and 112 in-depot charging stations. The total cost for BEBs and charging stations would approximately be $335.366 million, whose environmental equity reached is 5.76 × 106 $\mu g/m^3$, as seen in Figure 14.

Figure 15 shows the deployment plan while the budget is set as $25 million, which is approximately 13% of the total cost for replacing all buses. The environmental equity achieved is 2.75×10^6 $\mu g/m^3$., which is around 47.7% of the scenario when all buses are replaced with BEBs. While the Budget is $25 million, 26 buses are replaced, two on-route charging stations and nine in-depot charging stations are built. These 26 buses all require on-route charging and serve 11 routes whose distances range from 6.88 miles to 18.90 miles with an average of 11.48 miles. The two on-route charging stations are sited at West Valley Central Station (3650 S 2880 W) and Millcreek (Wasatch Blvd at 3900 S). The daily mileage of the buses ranges from 161.89 miles to 263.33 miles, with an average of 202.98 miles.

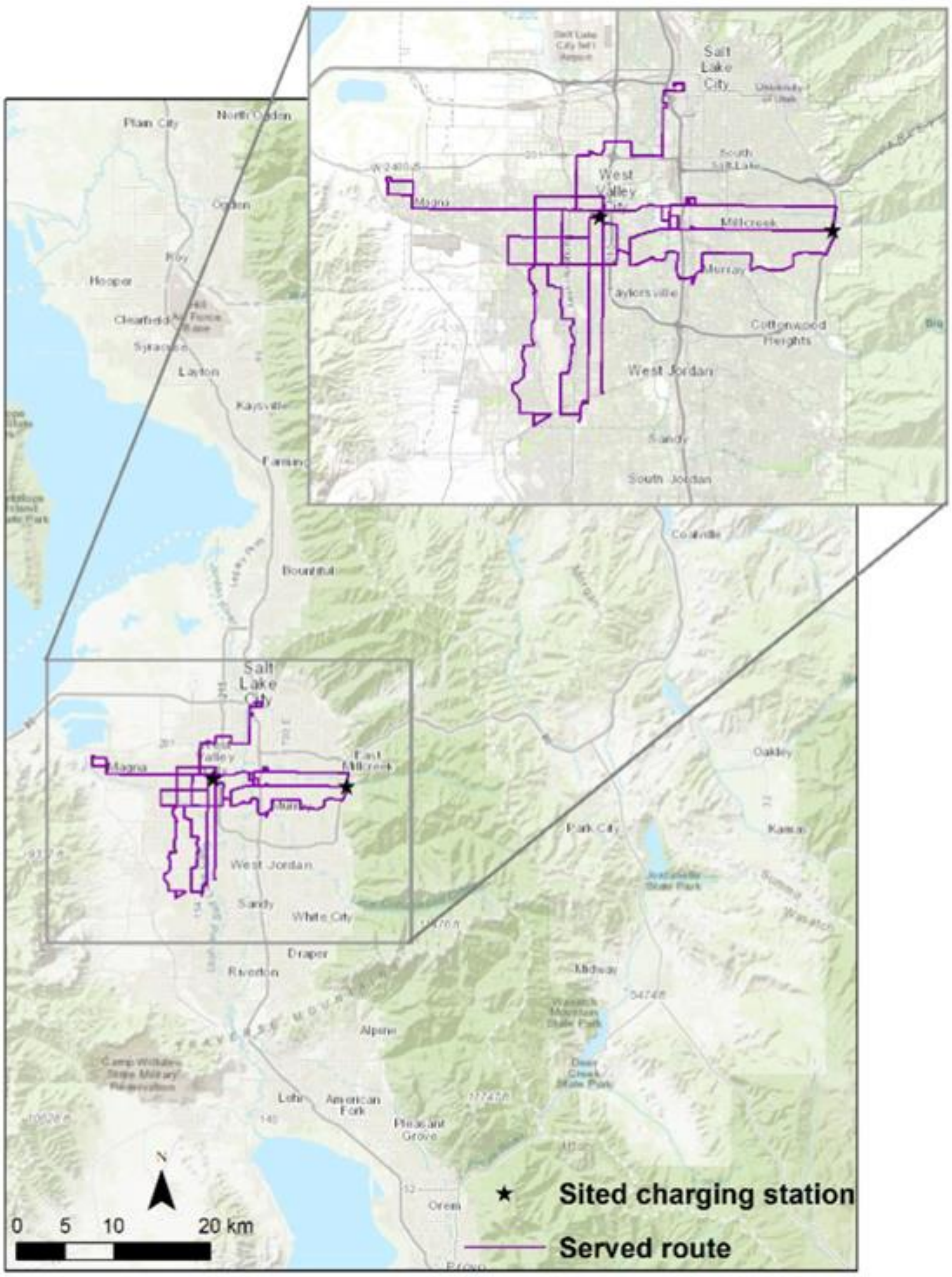


Figure 15. BEB Deployment when the Budget is set at $25 million

If the budget is set at $60 million, 63 buses will be replaced with BEBs while five on-route charging stations and 21 in-depot charging stations will be built. Figure 16 demonstrates the actual deployment plan. It brings 4.44×106 μg/m^3 environmental equity outcome, which is 77.1% of the total environmental equity that the system can possibly achieve. Two out of five on-route charging stations are built at Millcreek (Wasatch BLVD at 3900S), while the other three are located at three different terminals in West Valley Central Station (3650 S 2880 W), North Temple Station (490 W 240 N), and Salt Lake Central Station (300 S 600 W). The 63 buses replaced serve 20 routes whose distances range from 5.45 miles to 18.90 miles, with an average of 10.63 miles. The daily mileage of the 63 buses ranges from 62.78 miles to 263.33 miles, with an average of 176.20 miles.

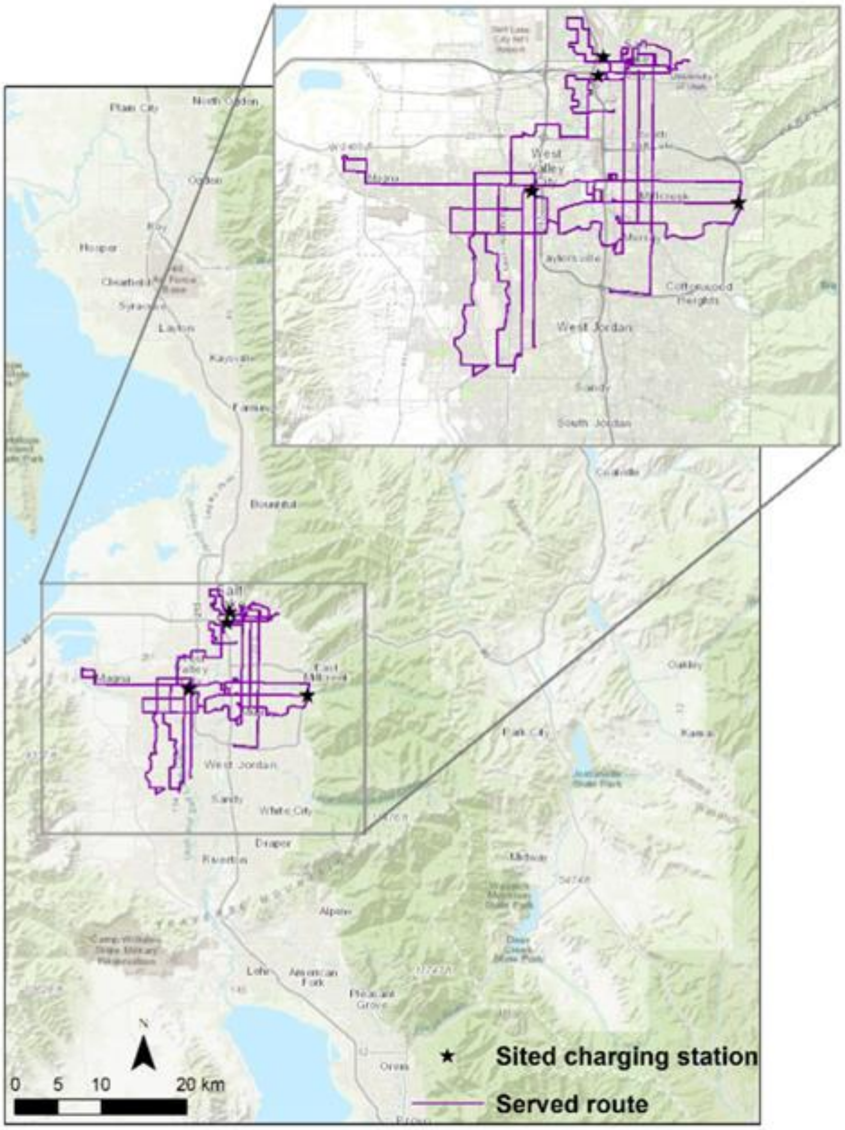


Figure 16. BEB Deployment Plan when Budget is set at $60 million

Furthermore, if the budget is raised to $120 million, 122 buses will be replaced with 14 on-route charging stations and 41 in-depot charging stations built. This option brings 5.51×106 µg/m^3 environmental equity and accounts for 95.7% of the total. As shown in Figure 17, the 14 on-route charging stations are located across the region in Millcreek, West Valley, Salt Lake, South Salt Lake, Sandy, South Ogden, Orem, and Murray. The 122 buses replaced serve 32 routes whose distances range from 5.45 miles to 23.15 miles, with an average of 11.53 miles. The daily mileage of the 122 buses ranges from 62.78 miles to 263.33 miles, with an average of 170.52 miles. The increase in environmental equity brought by replacing additional BEBs drastically declines because buses that could reach the most environmental equity are already included in the first 63 buses. If we continue to raise the budget to $200 million, 99.3% of the total environmental equity will be reached, with 203 buses replaced and 24 on-route charging stations, and 68 in-depot charging stations built.

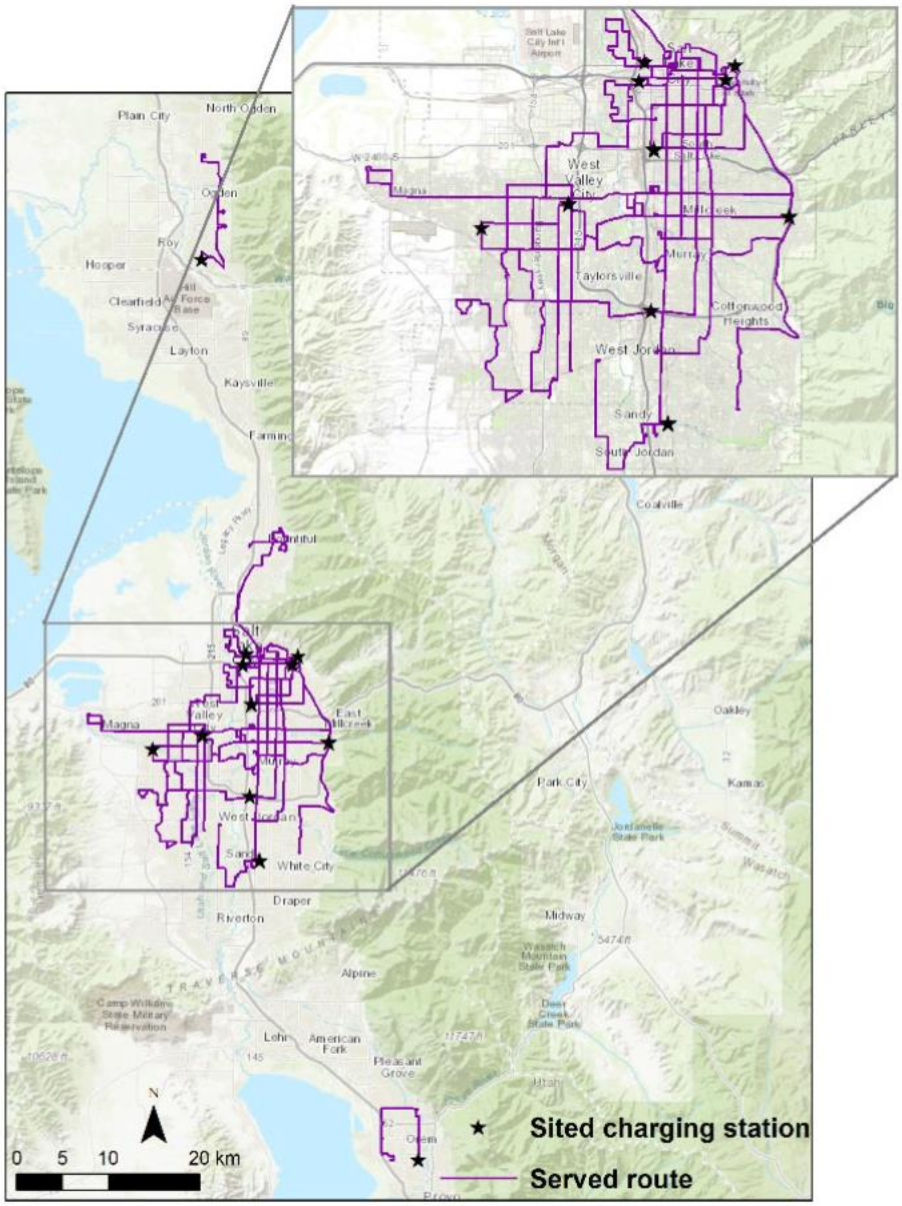


Figure 17. BEB Deployment Plan when Budget is set at $120 million

3.7 Data

In addition to the mathematical model and simulation of various BEB deployment scenarios, UTA continues gathering field data from the BEB fleet telematics. Some of the key information being collected and analyzed includes the charge and discharge performance of the batteries and the different battery ranges obtained from running the BEB through different types of routes and during various times of the year to ensure the extreme temperature ranges experienced in the region are represented. Figure 18 shows a sample graph that provides information related to the state of charge of a battery and odometer miles during an entire day of operation. In this example, the bus completed a 170 miles trip on March 8th, 2022.

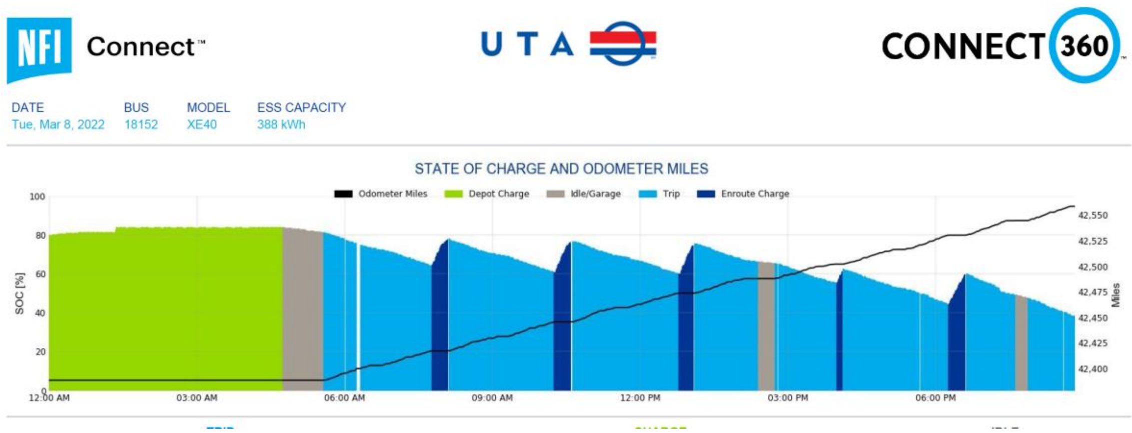


Figure 18. Bus 1852 Sample State of Charge and Miles Traveled vs. Time

Some of this real-world data has been used to inform the mathematical model, as it is known that battery range varies based on the bus operating conditions. For example, Figures 19 and 20 show the difference in energy consumption when running a BEB during the month of October (79.94 °F average ambient temperature) vs. running a BEB during the month of November (52.32 °F average ambient temperature). As can be seen in the graphs, the use of electrical heater for passenger comfort during the trip in November uses 38% of the battery capacity, which results in an average energy consumption of 2.88 kWh/mile (26.00 kWh/hour). On the other hand, less energy was consumed in October when interior heat was not used, 1.71 kWh/mile (16.47 kWh/hour).

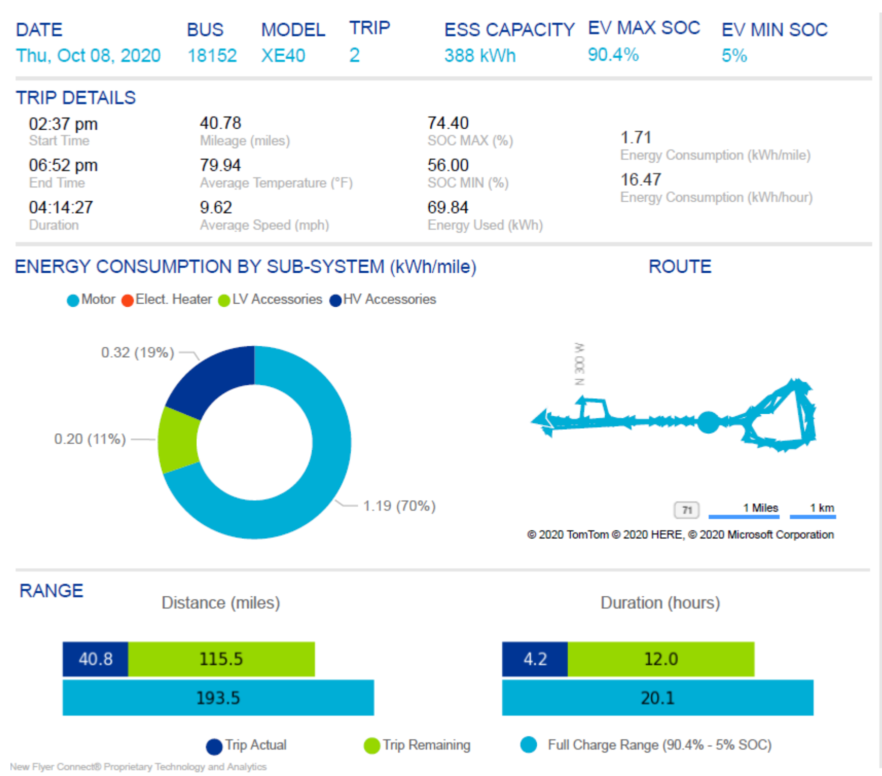


Figure 19. Energy consumption data of BEB operated in October 2020

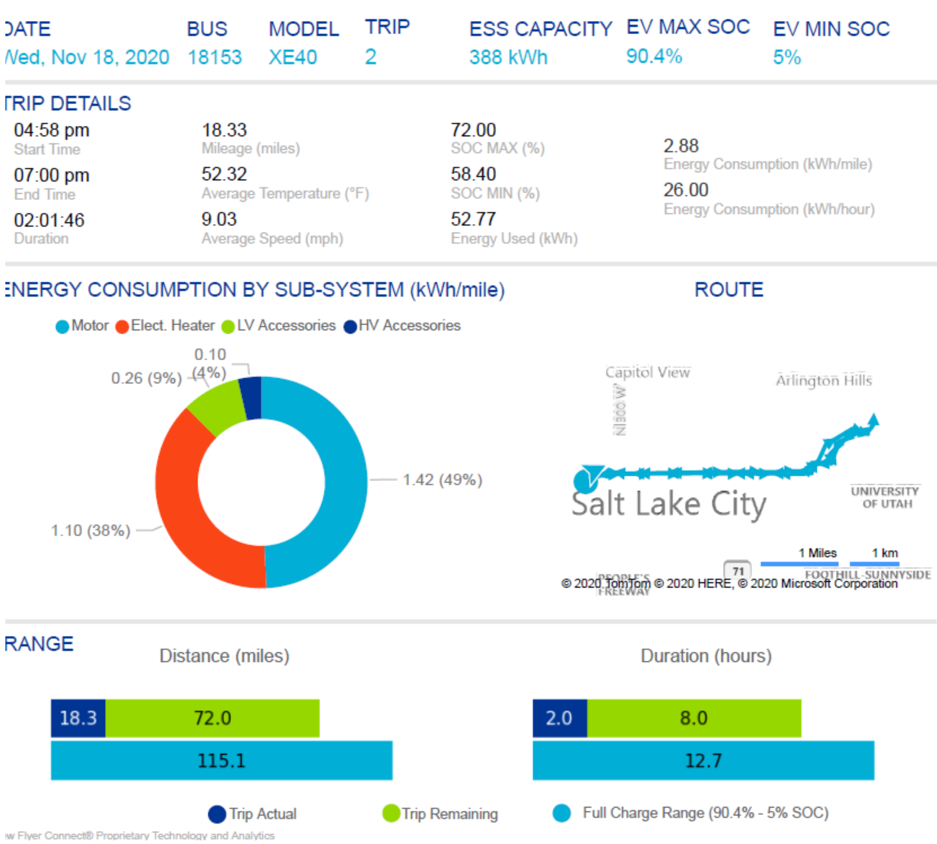


Figure 20. Energy consumption data of BEB operated in November 2020

3.8 Service and Route Analysis Next Steps

UTA will continue gathering information from the telematics systems of the BEB fleet and charging infrastructure to better understand and continue learning about the equipment performance under different operating conditions. This information will continue to be used to inform the mathematical model. The objective will be to continue refining the model by adding other variables that highly impact the performance of the vehicles. These additional variables will include topography, passenger load, different traffic conditions, on-route charging, and weather conditions. The plan is to incorporate further goals other than budget and environmental equity to make the system robust, efficient, and effective. These goals can also be prioritized at different stages for UTA to make informed planning-level decisions according to our short-term and long-term goals.

Additionally, UTA will consider the rapid increase in technology performance to refine the model as these improved technologies become commercially available. Also, UTA will evaluate other emerging technologies for consideration and potential implementation, e.g., wireless charging system.

4 Utility Provider Partnership

Utah Transit Authority entered a cooperative partnership with Rocky Mountain Power (RMP) in September of 2020. This partnership is intended to lead to the discovery of innovative solutions to the shared concerns of public safety, equal access and opportunity, air quality, and the demands of population growth. In addition, both parties are committed to responsibly using clean energy to power Utah's future, collaborating in joint consideration of a range of projects and opportunities.

Table 3 below summarizes the collaborative initiatives both parties intend to pursue under this partnership.

Table 3. Partnership Collaborative Initiatives

Energy Efficiency	Electric Vehicles	Electrical Infrastructure	Grid Resilience	Research and Grants
Wattsmart Program	Electric Buses	Bus & Car Charging Stations	System Redundancy	Vehicle Drive System
Power Usage Evaluation	FrontRunner Electrification	Power Storage and Substations	Smart Grid	Batteries and Peak Demand Management
Upgrading Old Systems	Autonomous Vehicles	Rail Expansion and Electrification	Solar-supplemented Grid	Grant Initiatives
		North Temple Transit Hub		

Clean and Efficient Energy Partnership Opportunities

4.1 Energy Efficiency

UTA and RMP strive each day to reduce wasteful energy consumption. The transportation sector is one of the largest contributors to energy consumption in the United States. With assistance from RMP, UTA intends to manage its power usage better and achieve the highest energy efficiency standards in the industry.

4.1.1 Wattsmart Program

This program has helped and can continue to help UTA finance the installation of new energy-efficient equipment. RMP's Wattsmart program provides business cash incentives for installing electrical systems and equipment that meet the highest energy efficiency standards. Both UTA and RMP strive to conserve energy wherever possible to encourage others to find mindful of their energy consumption. Saving energy by using energy-efficient equipment helps Utah grow sustainably into the future.

4.1.2 UTA Power Usage Evaluation

With the aid of RMP energy experts, UTA can evaluate its energy usage to find areas where energy can be used more efficiently. Together, UTA and RMP can create an energy management plan to implement innovative solutions to increase energy efficiency.

4.1.3 Upgrading Outdated System

UTA carries out routine preventative maintenance of its electrical equipment (e.g., signaling equipment, train and bus repair shop equipment, wayside storage, and distribution systems) to increase its lifespan and ensure everything is in safe and working order. As electrical systems age and become outdated, however, they need to be replaced with new equipment. Rocky Mountain Power energy experts can help UTA identify outdated systems and plan to replace the systems with the most up-to-date equipment.

4.2 Electric Vehicles

Currently, diesel buses comprise just over 85% of UTA's bus fleet. By 2040, UTA intends to reduce the number by approximately half of the fleet. A combination of CNG and BEBs will replace these buses. UTA is also considering electrifying paratransit buses, vanpool vans, on-demand service vehicles, white fleet vehicles, and eventually FrontRunner (commuter rail). The significant increase in Electric Vehicles (EVs) will require power storage upgrades and an expanded network of charging stations. One of UTA's goals is to improve air quality, and EVs allow UTA decrease its carbon emissions significantly. With the help of Rocky Mountain Power, this electric vision can be made possible.

4.2.1 Electric Buses

With help from federal grants and interagency partnerships (including RMP), UTA has acquired five electric buses which have been in operation since late 2018. Electric buses are a big step toward promoting clean energy in Utah. UTA was awarded funding from the Volkswagen settlement for the incremental cost of purchasing 20 BEBs. Bus rapid transit (BRT) is an effective means of mass transit. Future BRT projects could use electric buses if funding is available. Working with Rocky Mountain Power to secure funding for the vehicles and charging equipment will ensure progress towards more zero-emissions vehicles.

4.2.2 FrontRunner Electrification

The 2018 Future of FrontRunner report outlines plans to eventually electrify FrontRunner. There are several ways a train can be electrified, but the most effective method is to combine the locomotive and passenger cars into electrical multiple units (EMUs) powered by overhead catenary wires. This configuration removes the need for a separate locomotive and is like the system currently used for Transit Express (TRAX) light rail, but at a larger scale. In California there is a comparable example where Caltrain is replacing their existing diesel fleet with new Stadler Kiss bi-level EMUs manufactured locally at Stadler's Salt Lake City, Utah facility. The extensive infrastructure implications of electrifying FrontRunner would require close collaboration between UTA and Rocky Mountain Power early in the planning and design phases of the project.

4.2.3 Autonomous Vehicles

There is a growing trend in America towards adopting of autonomous vehicles, which can drastically decrease the number of traffic-related deaths. UTA has experimenting with autonomous vehicles to study how they can enhance people's accessibility to transit by shuttling them to and from transit stops, thus tackling the first-mile last-mile problem of transit accessibility. Potential future use cases include automated microtransit and Automated Bus Rapid Transit (A-BRT). Assuming the autonomous vehicles would be electric, a partnership between UTA and Rocky Mountain Power would make the planning, design, and installation of necessary charging infrastructure a much smoother process.

4.3 Electrical Infrastructure

Electrical power networks are the lifeblood of modern civilization. Almost every aspect of daily life, including transportation, is made possible through this electrical infrastructure. UTA needs to maintain a robust electrical infrastructure for TRAX to move people safely and reliably to their destinations. UTA is also in the process of electrifying a third of its bus fleet and eventually FrontRunner. Establishing an efficient system to power these vehicles is one of UTA's top priorities. A partnership with RMP is essential to ensuring these systems are implemented effectively.

4.3.1 Bus and Car Charging Stations

As UTA obtains more electric buses and possibly electric vanpool vans, paratransit buses, and support fleet vehicles, major investments will need to be made in charging infrastructure. Large-scale charging stations and high-capacity electrical storage are needed to maintain consistent power to the fleet vehicles. UTA also hopes to install EV charging stations at park and ride facilities and other UTA facilities. By doing this, UTA hopes to join RMP in supporting the Live Electric community partnership. These added amenities allow partnering with Transportation Network Companies (TNC) that use EVs, like Lyft and Uber, to provide customers with free rides to and from transit stations. Partnering with Rocky Mountain Power will ensure that these systems are integrated into the existing electrical infrastructure without compromising the electrical grid's stability.

Since 2019 UTA has operated UTA On Demand microtransit service through a public-private partnership. The microtransit service is powered by UTA's business partner, VIA Transportation, Inc. (VIA). Currently VIA's vehicle fleet consists of Toyota Sienna minivans, Chrysler Voyager minivans, and includes wheelchair accessible vans of both models. All the current vans are gasoline-powered. UTA and VIA representatives are developing a plan to integrate clean, zero-emission electric vehicles into the microtransit fleet to gradually replace all gasoline powered vans. While the initial electric vehicle capital expense is higher, expected future operating benefits of this transition should include lower fuel costs and lower ongoing maintenance expenses. This partnership creates opportunities for more electric vehicle projects in the future.

4.3.2 Power Storage and Substations

As UTA expands its network of TRAX, FrontRunner, and streetcar lines, additional substations and power storage facilities need to be built to power the vehicles. Some of the initial TRAX system lines have already expanded to the point where the original substations are insufficient and need to be upgraded. A thorough assessment of existing and future electrical infrastructure will identify locations where upgrades are needed most. Having RMP as a project partner and financial contributor for these infrastructure improvements will help keep these systems in excellent condition.

4.3.3 Rail Expansion and Electrification

UTA's 2040 Strategic Plan includes expanding TRAX and FrontRunner lines, including Frontrunner extensions to Brigham City and Santaquin and TRAX extensions to Lehi and southwest Salt Lake County. As mentioned above, extending rail lines requires large-scale electrical infrastructure investments. All TRAX lines are powered solely by electricity, and eventually, FrontRunner will also run-on electricity. Partnering with Rocky Mountain Power during the planning phases of these projects is essential to ensure sufficient electrical infrastructure expansions can reasonably be constructed.

4.3.4 North Temple Transit Hub

UTA is interested in developing a transit hub near North Temple Power Station light rail platform. Salt Lake is doing a study to identify the location. Depending on the final site selection UTA may be interested in purchasing or leasing property from RMP. This property may have the potential to be used for a transit hub that would facilitate electric buses and their needed charging infrastructure. Having this facility would help UTA implement clean energy transportation for the west side of SLC.

4.4 Grid Resilience

The transportation sector takes its place as one of the largest energy consumers. While petroleum-based fuels are currently the most common energy source for vehicles, a transition to EVs is underway and is becoming a more popular choice. Rapid adoption of EVs will put an unprecedented strain on the electrical grid. Consequently, UTA is seeking grid resilience solutions to prepare for the increased electricity use at UTA's various facilities. With RMP, UTA can employ system redundancy, smart grid, and renewable energy strategies to maintain a stable electric grid.

4.4.1 System Redundancy

Electrifying buses and trains can pose risks to reliable public transportation if a resilient power system is not in place. For example, if the power goes out during an emergency, vehicles would not be able to run their routes, leaving many people stranded. A partnership with RMP would help UTA establish system redundancy and backup power sources to mitigate the adverse effects of a power failure.

4.4.2 Smart Grid

Advancements in sensor and data collection technologies have given rise to the possibility of constructing a smart grid. As these sensors are installed in more and more electricity-consuming devices, appliances, and vehicles, the electrical grid can become a two-way communication between energy providers and consumers. RMP could use this real-time energy usage data to manage its energy resources more efficiently. UTA can install smart grid capabilities in its electric vehicles and equipment to construct a reliable and efficient smart grid to be more environmentally responsible.

4.4.3 Solar-Supplemented Grid

Enhanced grid resilience can be achieved by adding solar power as an additional energy source. Solar power has the flexibility of being produced on- or off-site and can be produced virtually anywhere via photovoltaic cells. Generating power on-site is an excellent way to sustain an ample reserve of backup energy and can reduce strain on the energy grid at peak usage times. In 2013, RMP's Blue Sky Program funds were used to construct four (4) solar-powered TRAX stations on the Green Line. With the help of RMP and its Blue Sky Program, UTA can implement solar power generation at more TRAX stations and facilities such as the future Depot District Clean Fuels Technology Center.

4.5 Research Grants

UTA is constantly seeking new opportunities to research cutting-edge ideas and technology to improve transit performance and the quality of life for members of the community. UTA seeks grants and other funding from various public and private programs to keep up with the latest advancements in transportation technology. UTA and RMP has some overlapping research interests, therefore, a partnership in this area could help both parties secure research funding. Currently, UTA and RMP in cooperation with Utah State University have a project underway to evaluate and mitigate the grid impacts of adding BEBs to the Salt Lake Central Station. This work was completed in 2021.

4.5.1 Vehicle Drive System

Since diesel and gasoline engines have historically been the primary sources of vehicle propulsion, drive system technology for these engines has been developed to achieve maximum efficiency. Until recently, however, vehicle drive systems using alternative fuels have not had the same level of research investment. UTA is branching out to explore new technologies and alternative fuels to help Utah grow sustainably into the future. To that end, UTA hopes to research better vehicle drive systems for alternative fuels such as electric batteries and CNG. Researching more efficient electric drive systems and battery technology could increase electric vehicles on the road, resulting in expanded revenue opportunities for RMP and improved air quality for the region.

UTA has partnered with Center for Transportation and the Environment (CTE) for their Paratransit diesel bus fleet. This partnership has led to the development of the Eparc system that significantly reduces the diesel engine idling on the Paratransit fleet. In turn, this reduces operational costs, reduces energy consumption, and reduces air pollution. The University of Texas Center for Electromechanics, Mobile Climate Control, Transworld Associates, and the University of Utah, are also partners in the project. This project has been made possible by the FTA Bus Efficiency Enhancements Research and Demonstration (BEERD) program.

UTA are also working with CTE on their Electro Microtric project. This project consists of three (3) phases.

- Phase 1 – CTE are using a screening model to evaluate expected energy needs for each bus vehicle to determine if zero-emission technologies have sufficient range to complete every scheduled service day.
- Phase 2 – CTE will simulate various charging scenarios to guide charging equipment decisions.
- Phase 3 – CTE will evaluate the vehicle and charger performance over three months after deployment using data provided by UTA. This will include an evaluation of vehicle energy consumption, estimated vehicle range in mileage and service hours, and required charging time.

The overall results gained from the charge modeling will determine if any changes are required to the vehicle specifications or service schedules to optimize vehicle operations.

4.5.2 Batteries and Peak Demand Management

UTA is interested in partnering with Rocky Mountain Power to research the use of batteries and supercapacitors to manage peak energy demand. Storing energy in batteries during non-peak times to be used during peak times could result in a more even distribution of energy usage throughout the day. On-board supercapacitors could lessen the energy surges of accelerating TRAX vehicles, and regenerative braking could charge the supercapacitors as the vehicles decelerate. UTA and RMP would benefit from a joint research effort to explore these and other peak management solutions.

4.5.3 Other Research

There are several other areas of research that UTA and RMP could collaborate on. UTA, RMP, and Salt Lake City could conduct a land use study around the North Temple Station to find ways to enhance public space and transit accessibility. Another research focus could be power usage and grid optimization. To maximize the efficient use of energy resources, additional studies could be done to target areas in UTA's systems that use excess power or put excessive strain on the grid. Finally, more research can be done on the effects of current technological developments such as autonomous vehicles and TNCs. Keeping up to date on the latest developments in science and technology can enable UTA and RMP to provide their customers with the best services available.

4.5.4 Grant Initiatives

UTA seeks funding from various public and private entities that support sustainable growth and the use of advanced technologies to improve the quality of life in cities. RMP partners with UTA to provide supporting funds for projects funded through FTA grant programs (i.e., the Low or No Emission Vehicle Program (Low-No)). Additional funding programs are available through the U.S. Department of Transportation, the U.S. Department of Energy, and other federal agencies. More locally, the Utah Clean Cities Coalition and the Utah Clean Air Partnership (UCAIR) offer grant programs to support emission reductions. Partnered together, UTA and RMP will be eligible for more grant funding and will be more effective in identifying new funding opportunities.

5 Existing and Planned Fleet Procurements

UTA's goal is to replace buses on a 12 to 14-year cycle on transit buses, and 18 years on commuter buses. The actual replacement schedule is driven by funding availability while ensuring continued safe and reliable service. The type of technology and/or propulsion type is evaluated on a year-to-year basis and will be dependent on grant funding availability.

As indicated in Section 3.2, UTA is currently under a 5-year contract with Gillig for 44 BEBs with options for an additional 95 vehicles. This order is being split between UTA, Park City, and HVT. After the base contract was executed, Park City added two (2) option vehicles to their order, leaving 93 BEBs remaining as part of the contract's options.

If UTA are successful in securing the LOW-NO Grant, they aim to replace ten (10) busses at their Central/Depot District facility in 2024 and another ten (10) at their Meadowbrook facility in 2026. All 20 buses will be replaced with Gillig's BEB vehicles.

The bus replacement plan as of May 2022 is included below in Table 4. This plan includes service expansions which are currently in progress. There is no provision for service expansion due to the natural growth within the UTA service area, as this type of service expansion is evaluated on an annual basis.

The transition between the different propulsion sources is included below in Figure 21.

This plan reflects UTA's intention to move toward utilizing Low to Zero-Emission Revenue Vehicles.

Table 4. Bus Replacement Plan 2021 - 2050

Original Model Year	Replacement Procurement Year	Type	Original Propulsion	Replacement Propulsion	Qty	Annual Total
2002	**2021**	Commuter	Clean Diesel	Clean Diesel	9	
2007	**2021**	Transit	Clean Diesel	Clean Diesel	9	
2007	**2021**	Canyon Service	Clean Diesel	Clean Diesel	2	20
2004	**2022**	Commuter	Clean Diesel	Clean Diesel	13	
2006	**2022**	Transit	Clean Diesel	Clean Diesel	5	
2006	**2023**	Transit	Clean Diesel	Electric	20	
2010	**2022**	Transit	Hybrid Diesel	Clean Diesel	20	
Expansion	**2022**	Transit	N/A	Electric	11	69
2007	**2023**	Transit	Clean Diesel	CNG	11	
2009	**2023**	Transit	Clean Diesel	Clean Diesel	38	49
2010	**2024**	Transit	Clean Diesel	Clean Diesel	36	
2012	**2024**	Transit	Hybrid Diesel	Clean Diesel	9	
Expansion	**2024**	Transit	N/A	Electric	10	55
2007	**2025**	Transit	Clean Diesel	Clean Diesel	11	
2011	**2025**	Canyon Service	Clean Diesel	Clean Diesel	30	
2013	**2025**	Transit	Clean Diesel	CNG	24	65
2012	**2026**	Transit	Clean Diesel	Electric	15	
2012	**2026**	Transit	Clean Diesel	Clean Diesel	15	
Expansion	**2026**	Transit	N/A	Electric	20	50
2009	**2027**	Transit	Clean Diesel	Electric	5	
2013	**2027**	Transit	Clean Diesel	Electric	2	

2015	**2027**	Transit	CNG	CNG	23	
2013	**2027**	Canyon Service	Clean Diesel	Clean Diesel	2	32
2014	**2028**	Transit	Clean Diesel	Clean Diesel	10	
2014	**2028**	Transit	Clean Diesel	Electric	10	20
2017	**2029**	Transit	Hybrid Diesel	Electric	25	25
2016	**2030**	Canyon Service	Clean Diesel	Clean Diesel	5	
2018	**2030**	Transit	Electric	Electric	3	
Expansion	**2030**	Transit	N/A	Electric	9	17
2017	**2031**	Transit	Clean Diesel	Clean Diesel	31	
2017	**2031**	Transit	Clean Diesel	Electric	12	
2017	**2031**	Transit	Clean Diesel	Electric	14	
2017	**2031**	Canyon Service	Clean Diesel	Clean Diesel	7	64
2018	**2032**	Transit	Clean Diesel	CNG	12	
2018	**2032**	Transit	Clean Diesel	Clean Diesel	12	
2018	**2032**	Trolley	Clean Diesel	Electric	4	28
2019	**2033**	Transit	Clean Diesel	Electric	10	10
2020	**2034**	Transit	Clean Diesel	Electric	10	
2020	**2034**	Canyon Service	Clean Diesel	Clean Diesel	9	
2022	**2034**	Transit	Electric	Electric	11	30
2021	**2035**	Transit	Clean Diesel	Clean Diesel	23	
2021	**2035**	Canyon Service	Clean Diesel	Clean Diesel	2	
2021	**2035**	Transit	Clean Diesel	Electric	9	
2023	**2035**	Transit	CNG	CNG	11	45
2022	**2036**	Transit	Clean Diesel	Clean Diesel	45	
2024	**2036**	Transit	Electric	Electric	10	55
2023	**2037**	Transit	Clean Diesel	Clean Diesel	38	
2025	**2037**	Transit	CNG	CNG	24	62
2024	**2038**	Transit	Clean Diesel	Clean Diesel	45	
2026	**2038**	Transit	Electric	Electric	35	80
2021	**2039**	Commuter	Clean Diesel	Clean Diesel	10	
2025	**2039**	Transit	Clean Diesel	Electric	11	
2025	**2039**	Canyon Service	Clean Diesel	Clean Diesel	30	

2027	**2039**	Transit	CNG	CNG	23	
2027	**2039**	Transit	Electric	Electric	5	79
2022	**2040**	Commuter	Clean Diesel	Electric	13	
2026	**2040**	Transit	Clean Diesel	Electric	15	
2028	**2040**	Transit	Electric	Electric	10	38
2027	**2041**	Transit	Clean Diesel	Clean Diesel	2	
2029	**2041**	Transit	Electric	Electric	25	
2027	**2041**	Canyon Service	Clean Diesel	Clean Diesel	2	29
2028	**2042**	Transit	Clean Diesel	Electric	10	
2030	**2042**	Transit	Electric	Electric	12	22
2031	**2043**	Transit	Electric	Electric	12	12
2030	**2044**	Canyon Service	Clean Diesel	Clean Diesel	5	
2032	**2044**	Transit	CNG	CNG	4	
2032	**2044**	Trolley	Electric	Electric	4	13
2031	**2045**	Transit	Clean Diesel	Clean Diesel	45	
2031	**2045**	Canyon Service	Clean Diesel	Clean Diesel	7	
2033	**2045**	Transit	Electric	Electric	10	62
2032	**2046**	Transit	Clean Diesel	Clean Diesel	20	
2034	**2046**	Transit	Electric	Electric	21	41
2035	**2047**	Transit	CNG	CNG	11	11
2034	**2048**	Canyon Service	Clean Diesel	Clean Diesel	9	
2036	**2048**	Transit	Electric	Electric	10	19
2035	**2049**	Canyon Service	Clean Diesel	Clean Diesel	2	
2035	**2049**	Transit	Clean Diesel	Clean Diesel	32	
2037	**2049**	Transit	CNG	CNG	24	58
2036	**2050**	Transit	Clean Diesel	Clean Diesel	25	
2038	**2050**	Transit	Electric	Electric	71	96

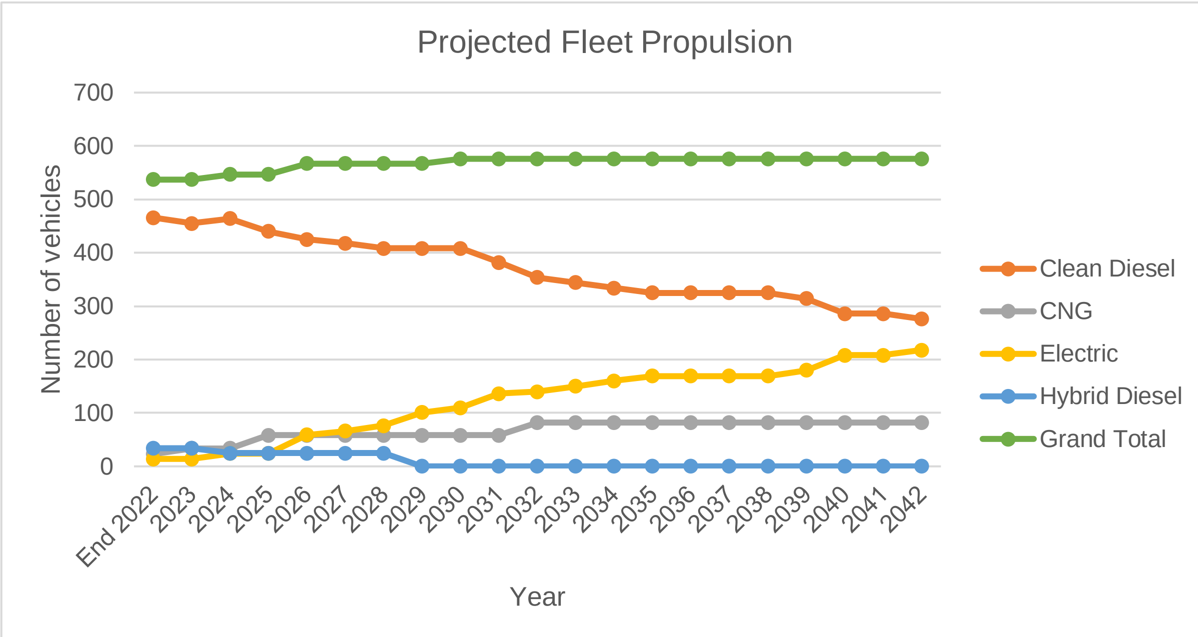


Figure 21. Projected Fleet Propulsion

6 Workforce Development

To ensure UTA's workforce is prepared to transition to Zero Emissions Bus (ZEB), UTA has developed a transition plan for our Bus Operations and Maintenance personnel. The transition plan includes needs assessments, workforce training and deployment, and first responder training.

To understand our current workforce skills, UTA will conduct a needs assessment. The needs assessment will also include questions to target areas of concern. This will help the agency address those concerns and prevent anxiety surrounding the deployment of Battery Electric Bus (BEB). Based on the information from the needs assessment, UTA's Management will determine if further action is needed outside of training.

Additionally, UTA's Management will conduct a pre-coordination meeting. This meeting will focus on lessons learned from previous ZEB deployments and establish best practices from FTA and APTA. A formal debrief of the needs assessment will also be presented which will allow Management to determine how many employees from operations and maintenance personnel will receive initial Original Equipment Manufacturer (OEM) training and what specific OEM training topics are required.

During the ZEB procurement, UTA will ensure funding is included or available to procure OEM training from the vendor. The procurement contract shall be written to request the opportunity to purchase OEM training materials, if possible. Alternatively, UTA will seek funding opportunities to contract for instructional design services to develop training content for internal use. Incorporating ZEB training into internal resources will ensure UTA continues to provide training to new employees and allow UTA to provide refresher training to the existing workforce. Additionally, UTA intends to incorporate ZEB training into our Bus Transit Repairer Apprenticeship program.

Furthermore, to provide the most comprehensive and safe training, UTA intends to seek funding opportunities to procure training aids and an electric bus simulator. Training aids, such as electric vehicle trainer provides students with the opportunity to demonstrate, troubleshoot, and fault-find on a real-life simulation of an electric vehicle system. Additionally, a simulator supports driver training specific to bus operations, regenerative braking, and energy-saving techniques.

As with all workforce training, safety will be a top priority. All employees operating or maintaining ZEB will receive safety training covering best practices and emergency procedures. Employees will also receive training on charging procedures and associated hazards as well as specific operational safety considerations (e.g., silent operations).

The primary focus of the initial OEM training will be to familiarize Operators with dashboard controls and warning signals, as well as the appropriate corrective procedures for when they appear. It will also be a priority to ensure Operators understand the battery State of Charge, operating time, estimated range, and other notifications. Optimal driving procedures will ensure operators know how to maximize efficiency. Other training concepts will include regenerative braking, mechanical braking, hill holding, and roll back.

Priority training for the maintenance technicians will be placed on high voltage safety. At a minimum, the following safety training topics will be provided:

- Electrocution hazards
- Arching hazards
- Short circuit hazard
- Lock-out tag-out procedure
- Personal protective equipment
- Safe handling and deactivation of high-voltage components
- Emergency shut down procedure

The maintenance technicians will receive OEM training on servicing and troubleshooting electric propulsion and auxiliary systems. Additionally, training will be provided on using the onboard diagnostic systems. Other training components may be provided based on identified needs such as preventive maintenance, entrance and exit doors, wheelchair ramp and restraint systems, brake system and axles, air system and ABS, front and rear suspension and steering, body structure, towing and recovery, and HVAC.

Lastly, UTA will coordinate OEM training for local first responders to ensure proper emergency response procedures are followed if an incident occurs. In addition, UTA will follow the Guidebook for Deploying Zero-Emissions Transit Buses suggested training topics.

6.1 Transit Technical Education Center

Understanding the importance of workforce training, UTA is working on developing a dedicated facility for bus maintenance training. The new facility is being built in an industrial building owned by UTA, located in a Federal Opportunity Zone, refer to Figure 22 and Figure 23. In 2022, UTA contracted with an architecture firm to start the redesign process

Figure 22. Existing building to be retrofitted as a Bus Maintenance Workforce Training Facility

This project has two primary objectives: support the maintenance of UTA's bus fleet and foster the development of Utah's workforce. The transit system benefits our region's air quality and provides access to essential jobs. UTA's mechanics ensure that vehicles are in good working order and can safely make pull-out. This new facility will foster the education of those mechanics, which is especially important as UTA strives to sustain and expand its workforce. In addition, having a dedicated facility will allow UTA to provide more training opportunities for employees, many of whom are members of a union and partner agencies.

UTA will make use of an existing asset with this project. Upgrades to the building will allow it to be used for the foreseeable future. This approach is more economically and environmentally sustainable than constructing a new facility. It is ideally located in the center of UTA's service area, with easy access to the Meadowbrook and Depot District (under construction) bus garages. A dedicated training facility will allow training to be more efficient by having more hands-on training stations and modules. UTA's current space only allows us to run one training class at a time, with borrowed shop space for hands-on demonstrations. This severely limits our capability to provide training to more individuals.

Additionally, due to limited classroom space, we are forced to limit the number of attendees. This has become a direct impediment to our apprenticeship program. In 2022, under these circumstances, the Maintenance Training team was able to provide 458 training opportunities to 237 employees. With adequate training space, UTA will double those training opportunities.

As of 2022, UTA has an average of 12,842 miles between maintenance road calls. UTA's ability to have high miles between road call incidents directly results from having competent, skilled technicians. In addition, UTA's ability to provide proactive training has resulted in technicians who can stay current with changing technologies, are highly skilled in troubleshooting, and have the wherewithal to fix mechanical issues the first time.

As the largest transit provider in Utah, we understand that having a strong transportation system benefit all, especially under-served, underrepresented, and rural populations. UTA's vision is to provide a space where training is provided for its own workforce and offer the available trainings to all rural public transit providers statewide. In addition, the training opportunities will be provided free of charge to external entities unless supplies are needed. UTA is partnering with Utah's Urban Rural Specialized Transit Association (URSTA), which will provide travel funding for Rural Transit Provider staff to attend the trainings.

Furthermore, UTA will be able to expand partnership opportunities with Utah State University and ASPIRE Research Center, which will provide further opportunities for employee training and development. These agencies can help support the development of enhanced training procedures and foster innovative technology. With this facility, UTA will also be able to advance workforce development for electric vehicles. UTA's training programs provide hands-on education and allow for career growth. The agency offers good-quality jobs that pay well. In addition, UTA works closely with the Amalgamated Transit Union to ensure employees' voices are heard. This new training center will address challenges currently faced by the Bus Maintenance Training group. Improvements will directly benefit UTA employees.

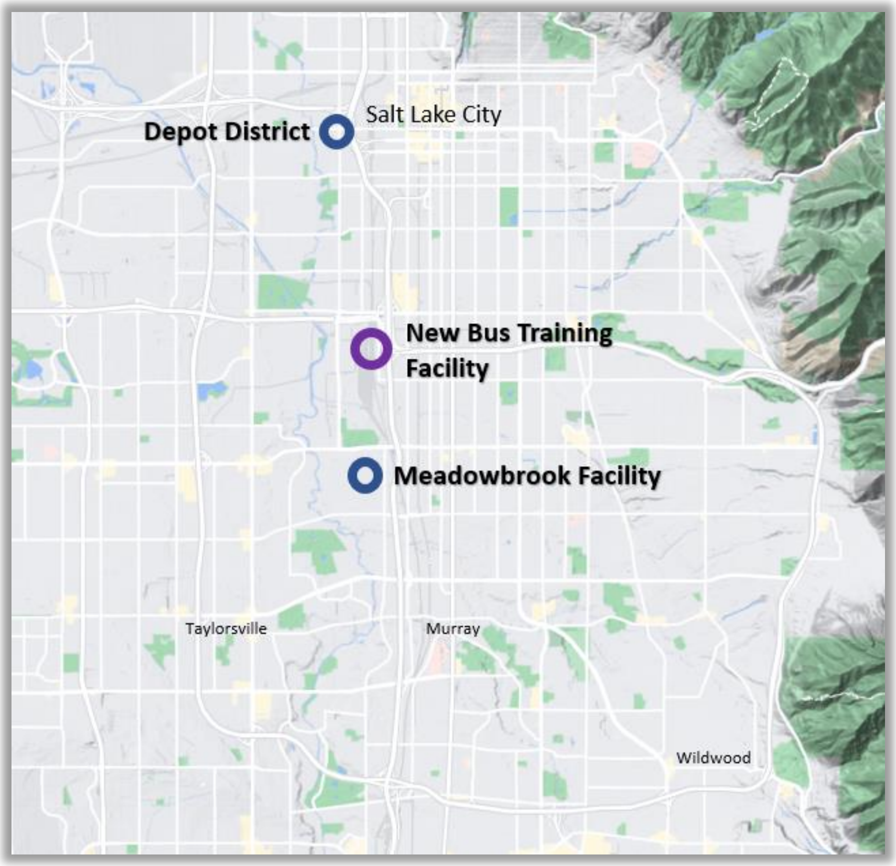


Figure 23. Location of new Bus Workforce Training Facility

When completed, this project will provide the following advantages and benefits:

- ✓ Support the transit network which benefits the region's air quality.
- ✓ Located in the center of UTA's service area, with easy access to the Meadowbrook and Depot District (under construction) bus garages.
- ✓ Foster job creation and career development, providing support for apprenticeship programs.

Provides the space needed to train mechanics on new technologies, including BEBs and Charging Infrastructure.

7 Current and future resources for transition costs

UTA is applying for a grant from the FTA as part of the Low or No Emission competitive program. If approved, this grant will allow the UTA to fund the procurement of the following equipment and services:

a. 20 BEB's

b. 7 Plug-in type depot chargers

c. 4 Drop-down pantograph type on-route chargers

d. Installation of charging equipment

e. Workforce Training

If approved, the objective will be to procure the 20 BEBs by exercising the options as part of the existing contract with Gillig. Table 5 provides a cost breakdown of equipment and services requested as part of this grant application, which includes the amount requested from the FTA and local match amount.

Table 5. Cost Breakdown of FTA Grant Application

Item Description	Qty.	Federal Amount Requested	Local Match Amount	Total Cost
BEB from UTA Options - Existing GILLIG contract	20	$ 570,000	$ 380,000	$ 19,000,000
Depot Charging Equipment - Existing GILLIG contract	7	$ 72,000	$ 48,000	$ 840,000
On-Route Charging Equipment - Existing GILLIG contract	4	$ 300,000	$ 200,000	$ 2,000,000
Design, constructionand installation of Charging Equipment	1	$ 2,460,000	$ 1,640,000	$ 4,100,000
Workforce Training on Charging Infrastructure - Existing GILLIG contract	1	$ 24,000	$ 6,000	$ 30,000
Workforce Training for BEB for GILLIG per options on their existing contract	1	$ 60,000	$ 15,000	$ 75,000
Workforce Training to develop internal UTA/BEB charger training	1	$ 1,057,600	$ 264,400	$ 1,322,000
Contingency (Approx. 10%)	1	$ 1,560,000	$ 1,040,000	$ 2,600,000
TOTALS		**$ 6,103,600**	**$ 3,593,400**	**$ 29,967,000**

8 Next Steps

The deployment of BEBs is a complex process that exerts huge impacts on transit systems which requires enormous capital investment, thorough feasibility study, and careful planning. The following are the next No-steps UTA plans to take in the medium and long term of this journey to electrify its bus system:

a. UTA will continue gathering information from the telematics systems of the BEB fleet and the charging infrastructure in place. This information will be used to continue analyzing the performance of BEBs on the different routes of the UTA system. In addition, other variables that highly impact the performance of the vehicles will be examined, including route topography, passenger load, traffic conditions during different days of the week, the performance of on-route charging equipment, and weather conditions, among others. The plan is for the UTA to have an electrified bus system that is robust, efficient, and effective. These additional goals can also be prioritized at different stages for UTA to make informed planning-level decisions according to our short-term and long-term goals.

b. Additionally, UTA will consider the rapid increase in technology performance to continue improving the implementation of zero-emission buses in their system. This includes evaluating emerging technologies for consideration and potential implementation, and FCEB technology for bus routes where battery range cannot accommodate the current service levels.

c. As indicated in this plan, using the heater system during winter months for passenger comfort dramatically reduces the battery range, resulting in lower schedule compatibility levels. UTA will continue working with OEMs to evaluate different types of passenger compartment heaters to identify a solution with lower battery consumption that allows service compatibility with minimum or no modifications, resulting in a reduced required on-route charging infrastructure.

d. The development and improvement of the zero-emission bus training programs are critical to UTA as the existing workforce can continue operating and maintaining these new systems. While fewer mechanical mechanisms require maintenance and repair in a zero-emission bus than a Diesel or Diesel-Electric hybrid bus, there is an increased level of software and electrical systems requiring specialized training to maintain, repair, and operate. Therefore, the UTA expects significant investment in workforce development will be necessary to ensure maintenance personnel has the specialized training and safety equipment required to perform these new job functions.

e. UTA will continue working with RMP on all the initiatives established in the partnership, specifically related to the responsibly use of clean energy to power Utah's mobility future. UTA and RMP will assess different renewable energy options (on-site and off-site) to determine the best path backup power plan for BEB technology. UTA will continue studying the installation of on-site solar energy equipment and assess its feasibility covering energy requirements for the maintenance and operation of the BEB fleet.

f. UTA will also continue working on charging strategies. A determination of available charging time windows for the BEBs to be charged in the facilities will be explored as more vehicles are added to the fleet. Different charging strategies will be analyzed to determine the most optimal charging scenarios, e.g., simple, or smart charging, and time-variable depending on energy rates.

g. As UTA continues operating and working with BEBs, maintenance and reliability information will be gathered, evaluated, and compared with current information from the baseline fleets. This information will allow UTA to develop maintainability, reliability, and performance requirements that can be used to inform future BEB and charging infrastructure procurements.

h. UTA faces constant challenges to improve the performance and quality of the critical services provided to the community. Understanding that Unions have a stake in the ability of the agency to meet these challenges, UTA is in the process of developing partnership with its Union to ensure the zero-emission training program is innovative, efficient, and effective. Some of the benefits expected from this partnership includes (a) improvement in performance and quality of services provided to the community, (b) provide to personnel equitable access to training on new technologies, helping employees to advance in their field and secure good paying jobs, and (c) improvement of the workforce work-life, allowing employees to progress and foster a more positive work environment.

Appendix A. Bus Fleet Management Plan