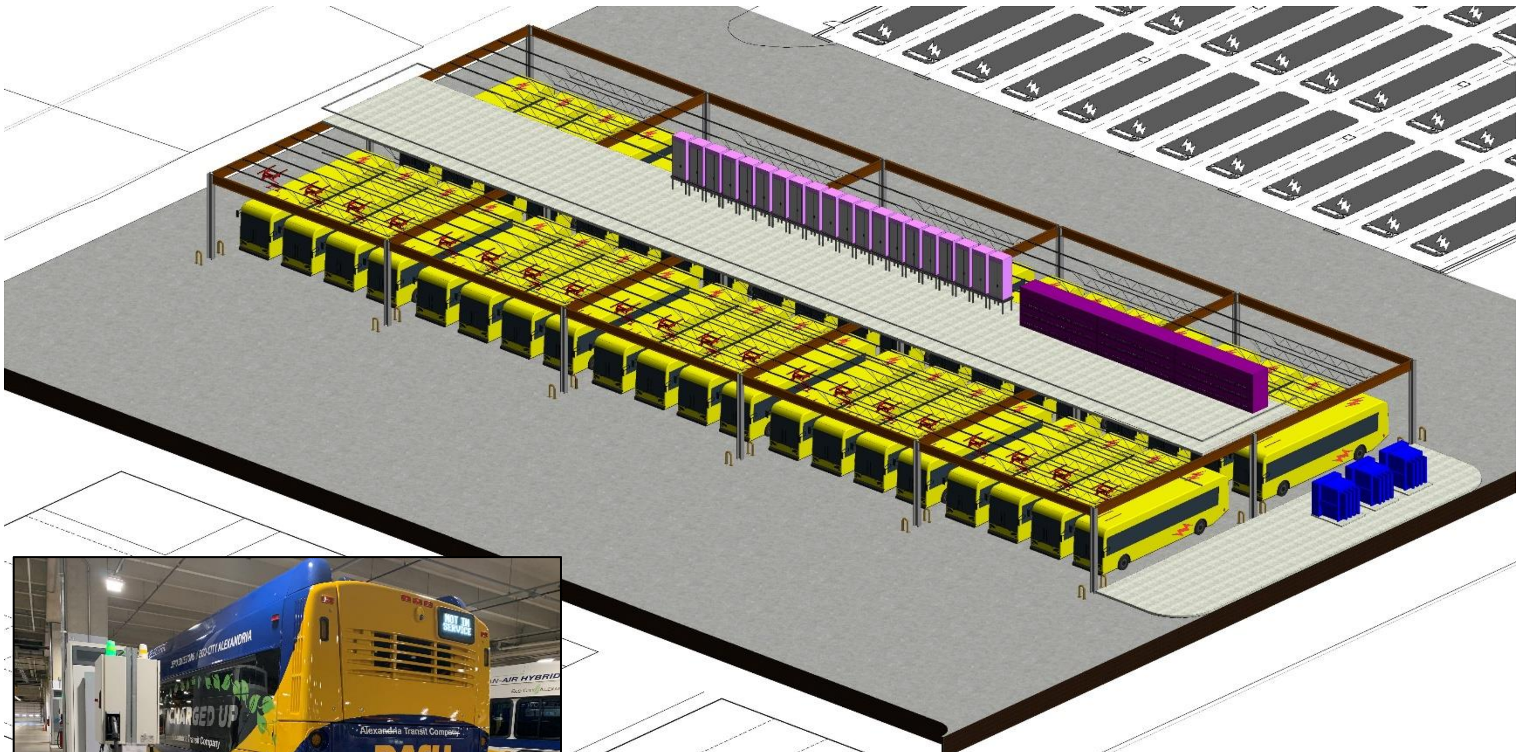
DASH ZEB IMPLEMENTATION FINAL REPORT

Zero Emission Bus (ZEB) Implementation Study

Alexandria Transit Company (DASH)

Alexandria, VA



Prepared by:

May 2021

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ACKNOWLEDGEMENTS

The WSP Team would like to thank the following Alexandria Transit Company (DASH) and City of Alexandria staff that have participated in the development of the Zero Emission Bus (ZEB) Implementation Plan. Their support and insight were critical to the development of the information presented herein.

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INTRODUCTION

BACKGROUND

DASH, as part of the City of Alexandria's "Eco-City Initiatives", is committed to have a 100% zero emission bus (ZEB) fleet by 2040. *Note that DASH has a goal to have a 100% ZEB fleet by 2037.* This ZEB Implementation Study is one of several steps that DASH is taking to transition to a 100% zero emission fleet. Other efforts, all of which need to be coordinated with this ZEB Implementation Study, include:

- A ZEB Feasibility Study completed in December 2019
- Installation of six chargers (3 ABB and 3 Proterra) to support the initial six BEBs (3 New Flyer and 3 Proterra) with completion expected in January 2021.
- Design and construction of a facility expansion to support up to 40 additional buses. Design to start in 2021 with construction in FY22 and FY23.
- Installation of additional BEB charging infrastructure both at the DASH facility and en-route opportunity charging.

The purpose of this ZEB Implementation Study is to:

- Provide a roadmap, with specific tasks and schedule, to reach the goal of operating a 100% ZEB fleet by 2040.
- Determine the optimal charging strategy and related infrastructure investments.

METHODOLOGY

The WSP Team approach to facility planning and design is based on a clear understanding of the unique operating characteristics and functional requirements of transit operations. This ZEB Implementation Study will impact the DASH operations for many years. The WSP Team approach maximized DASH's input while making the best use of time through a series of workshops. These workshops brought together key DASH staff, other interested City staff, and the study team to quickly review and evaluate a range of options before making critical decisions that impact the implementation plan.

The Study was divided into two phases. Phase 1 includes required tasks related to facility planning. Phase 2 includes optional tasks generally related to fleet planning.

Phase 1

- Phase 1, Task 1: Planning and Project Outline
- Phase 1, Task 2: Compilation of Known Data
- Phase 1, Task 3: Facilities Assessment
- Phase 1, Task 4: Short Range Infrastructure and Equipment Needs
- Phase 1, Task 5: Analysis of Charger Location/Facility Layout

Note that to improve the efficiency and cost effectiveness of delivering the ZEB Implementation Study, Tasks 3, 4, and 5 were combined into one comprehensive task. Technical memos and/or meeting notes were submitted as necessary to document discussions and decisions made with DASH. The draft Final Report and Final Report are the primary deliverables for Phase 1 and will address the elements in the Phase 1 scope.

Phase 2

- Phase 2, Optional Task 1: Fleet Assessment
- Phase 2, Optional Task 2: Fuel Assessment
- Phase 2, Optional Task 3: Maintenance Assessment
- Phase 2, Optional Task 4: Evaluation of Utility Grid Infrastructure and Sufficiency
- Phase 2, Optional Task 5: Total Cost of Ownership Analysis
- Phase 2, Optional Task 6: ZEB Pilot Analysis

Note that none of the Phase 2 tasks have been authorized as of May 2021.

PROJECT GOALS

The following goals were identified during the project kick-off meeting on December 8, 2020.

1. Complete Phase 1 (Tasks 1 through 5) by the end of April 2021 in order to dovetail with the upcoming planning and design of the DASH facility expansion project.
2. Reduce facility design risk as ZEBs begin to phase into the fleet.
3. Identify and summarize infrastructure needs and potential to impact expansion.
4. Produce solutions that work within DASH's $8.1M budget, (which comes from different funding sources) including:
    a. $2M charging infrastructure
    b. $6.1M facility expansion
5. Focus should be on 100% ZEB transition by 2035.
    a. Internal DASH policy targets that all bus procurements after 2027 will be zero emission buses.
6. Continue operations at the existing facility throughout construction of the charging infrastructure and facility expansion

ITEMS IMPACTING THE ANALYSIS

Fleet Size and Mix Projections

The current and projected DASH bus fleet directly impacts the requirements for maintenance, parking, nightly servicing, and infrastructure requirements to support zero emission buses (ZEBs), whether they are battery electric buses (BEBs) or fuel cell electric buses (FCEBs).

Critical information includes bus fleet replacement and expansion (quantity and schedule), size of bus (30-foot, 35-foot, 40-foot, 45-foot, 60-foot, other), type of bus (van, cut-away, standard transit, commuter over-the-road, articulated, double deck, other), and fuel type (diesel, gasoline, compressed natural gas, hydrogen, other).

For BEBs, the size of battery is critical to determining the charging requirements.

Initial BEB Program

DASH is implementing an initial BEB project with three 40-foot New Flyer BEBs received in 2020 and three 40-foot Proterra BEBs to arrive in 2021. These BEBs are being charged in the existing bus parking area with plug-in dispensers.

The type of dispenser (plug-in, inverted pantograph, induction) to be used in the future will impact the charging infrastructure requirements and the bus specifications. The dispenser type will be addressed in future tasks of this study.

The initial program will give DASH an understanding of the BEB capability to provide reliable service in their operating environment. Analysis of the initial program is not included in Phase 1 of this study. If authorized, this will be addressed in Phase 2.

DASH Facility Expansion Project

DASH plans to expand its facility to accommodate additional bus parking. Initial concepts included a new, stand-alone bus parking facility located west of the existing DASH facility.

The proposed facility expansion could help facilitate implementation of ZEBs while minimizing disruption to existing operations.

DASH has opened the possibility that this facility could be enclosed and heated, enclosed and unheated, canopy covered, or outdoor.

Power Availability

ZEB infrastructure requires significant power which may not be currently available at the site. Note that while initial information on power availability was requested by the study team, the evaluation of the utility grid infrastructure and its sufficiency is not included in Phase 1 of this study. If authorized, this will be addressed under Phase 2, Optional Task 4.

Phase 2 Optional Tasks

As of May 2021, the optional tasks in Phase 2 have not been funded or authorized. These tasks should be authorized as soon as possible to provide critical information necessary for DASH to make informed decisions regarding the implementation of ZEBs in the future.

- Optional Task 1: Fleet Assessment
- Optional Task 2: Fuel Assessment
- Optional Task 3: Maintenance Assessment
- Optional Task 4: Evaluation of Utility Grid Infrastructure and Sufficiency
- Optional Task 5: Total Cost of Ownership Analysis
- Optional Task 6: ZEB Pilot Analysis

Information Provided by DASH

The study team relied upon information provided by DASH, including the following items:

1. As-built drawings of the existing DASH Administration, Operations, and Maintenance Facility including civil, architectural, structural, mechanical, electrical, plumbing, equipment, and piping.
2. List of current and projected vehicles and equipment, including bus replacement and expansion schedule.
3. Policies and Procedures. Brief narratives describing the following:
   a. How buses pull into the facility and park
   b. How buses move from bus parking, through nightly service, and return to bus parking
   c. Activities that are part of the nightly servicing cycle
2. Drawings for upper level deck refurbishment.
3. Drawings and specifications for flood gates being designed.
4. General information regarding Dominion service to the facility.

BASIS FOR DESIGN

Current DASH Facility

The layout of the existing DASH facility is depicted in Exhibit 1 with Maintenance, Bus Parking, and Fuel and Wash located on the first floor as shown. Administration and Operations is located on the second floor along with employee parking above the bus parking area. The ZEB Implementation Study does not address any elements of the Administration and Operations facilities.

The facility structure is pre-cast concrete with double tee beams supporting the roof system. The parking deck over the bus storage area is being refurbished, however, the timing for this work is unknown.

The DASH facility has been subject to periodic flooding and a project to install flood gates at key locations is underway. Location of ZEB infrastructure components will take potential flooding into consideration.

The parcel immediately west of the existing facility is city-owned property currently used as an impound lot by the City. This is the area designated for DASH facility expansion.

Existing Facility Vehicle Flow

Exhibit 1 shows the existing bus circulation patterns.

1. Buses enter the facility from Business Center Drive.
2. Buses turn left (counterclockwise) into a designated bus parking row and pull as far west as possible in the row as shown. Typically, each sub-fleet is parked together with an empty row between sub-fleets.
3. To start the nightly service cycle, service personnel start the bus and drive it west and exit the building, turn left and make their way to the fuel lanes in a counterclockwise flow.
4. The service person brings the bus into the fuel position where it is fueled, fluid levels are checked, the interior is cleaned (swept and the driver area and step wells are vacuumed), the tires are bumped, and the exterior is checked for damage. The farebox is also pulled, emptied, and returned to the bus in the fuel position.
5. After the service work is finished in the fuel position, the service person drives the bus through the bus washer.
6. After leaving the bus washer, the service person returns the bus to the assigned row in the bus parking area.
7. During morning pull-out, the driver goes to the assigned bus and performs a pre-trip inspection.
8. After completing the pre-trip inspection, the driver drives the bus west, exits the building, turns left, and exits the site to Business Center Drive.

ZEB Servicing

It is assumed that if FCEBs are used, the service cycle described above will continue. Dispensing hydrogen indoors will need to be evaluated.

BEBs will be charged in the bus parking area and taken through the service cycle described above for interior cleaning, fare retrieval, and exterior bus wash.

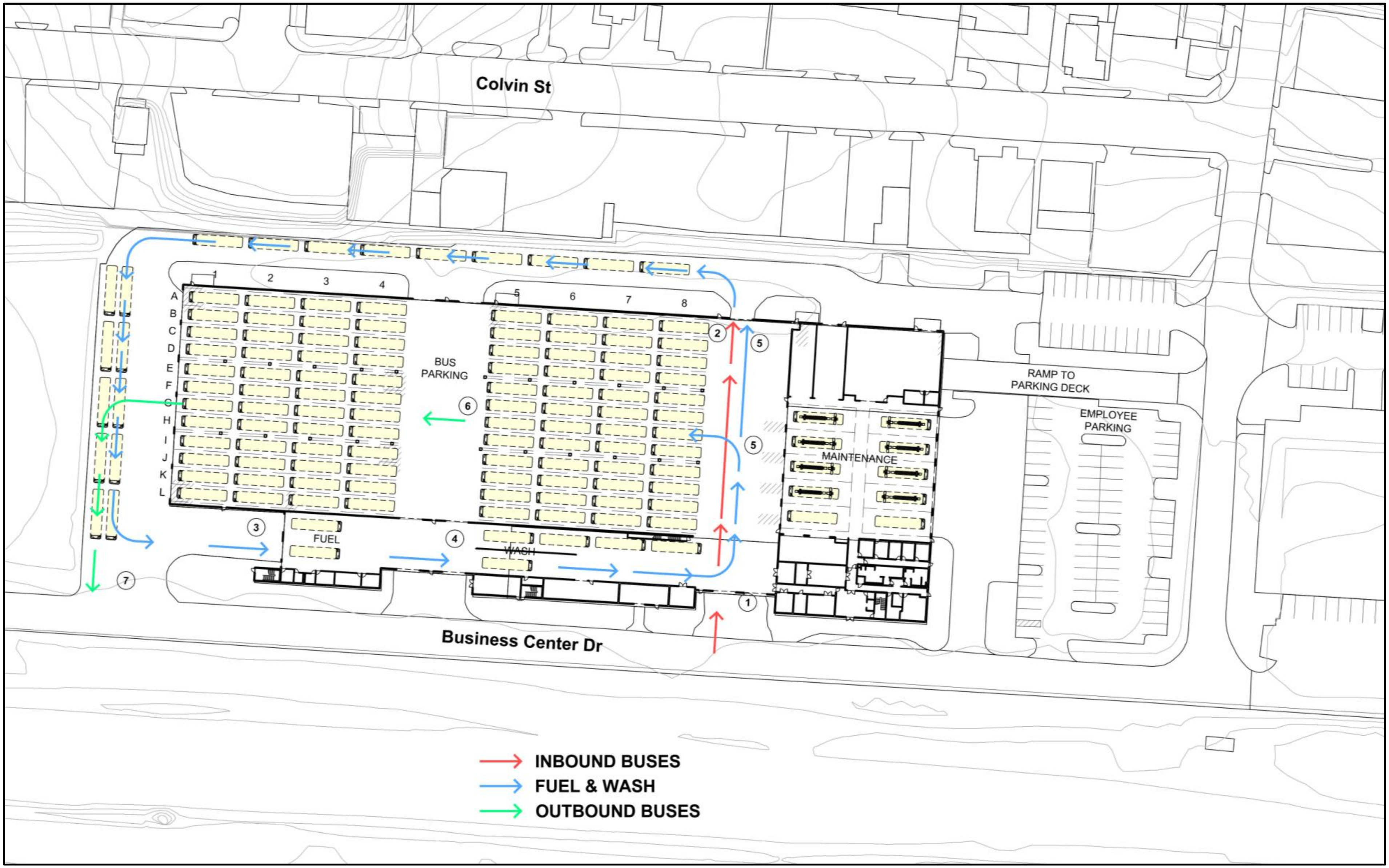
Bus Parking

It is assumed that buses will continue to park as shown and that the current use of steering column lines and stop lines will continue. These lines may be reconfigured to assure that the buses are properly aligned with dispensers, in the case of BEBs.

Work Rules

It is assumed that there are no work rules that would restrict a driver from plugging in a cord from a dispenser or engaging other dispenser configurations (i.e. overhead inverted pantograph or induction).

Exhibit 1: Existing DASH Facility First Floor Plan with Vehicle Circulation



Current and Available Nearby Property

Exhibit 1 shows several parcels north of the existing DASH facility along Colvin Street; however, these are not owned by the City or DASH. DASH is open to considering acquisition of parcels if necessary, however, this has not been previously considered. If the analysis indicates that additional space is needed, the City/DASH will provide information (size, valuation, and availability) on the parcels along Colvin Street.

Context: Witter / Wheeler Master Plan

The City of Alexandria owns a 23-acre site known as the Witter-Wheeler Campus which is bound by Wheeler Avenue / Duke Street / Colvin Street on the north and Business Center Drive and the railroad tracks on the south (see Exhibit 2). This is the largest area of City-owned properties, many buildings therein have exceeded their life expectancy or operational needs and the uses for which are expanding beyond current capabilities.

The City of Alexandria is developing a master plan for the Witter / Wheeler Campus to guide the development of the campus to best use the existing site.

Exhibit 2: Existing Witter / Wheeler Campus

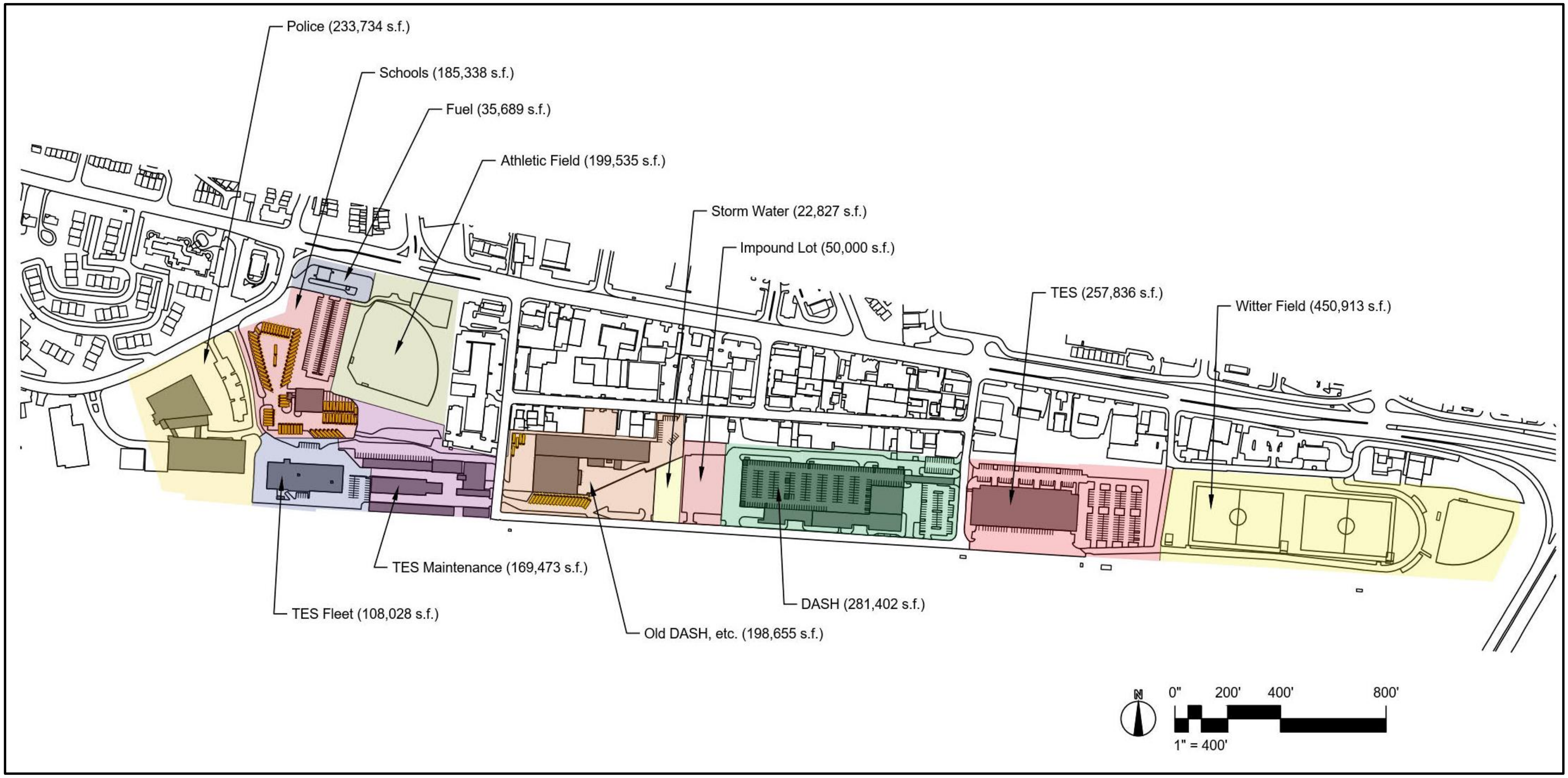


Exhibit 3 shows the existing area around the DASH facility and Exhibit 4 shows the reconfiguration of that area proposed by the Witter / Wheeler Master Plan. Note that the existing Impound Lot west of the DASH facility would be relocated to provide for the expansion of the DASH facility to accommodate a larger fleet.

Exhibit 3: Existing Area Around DASH

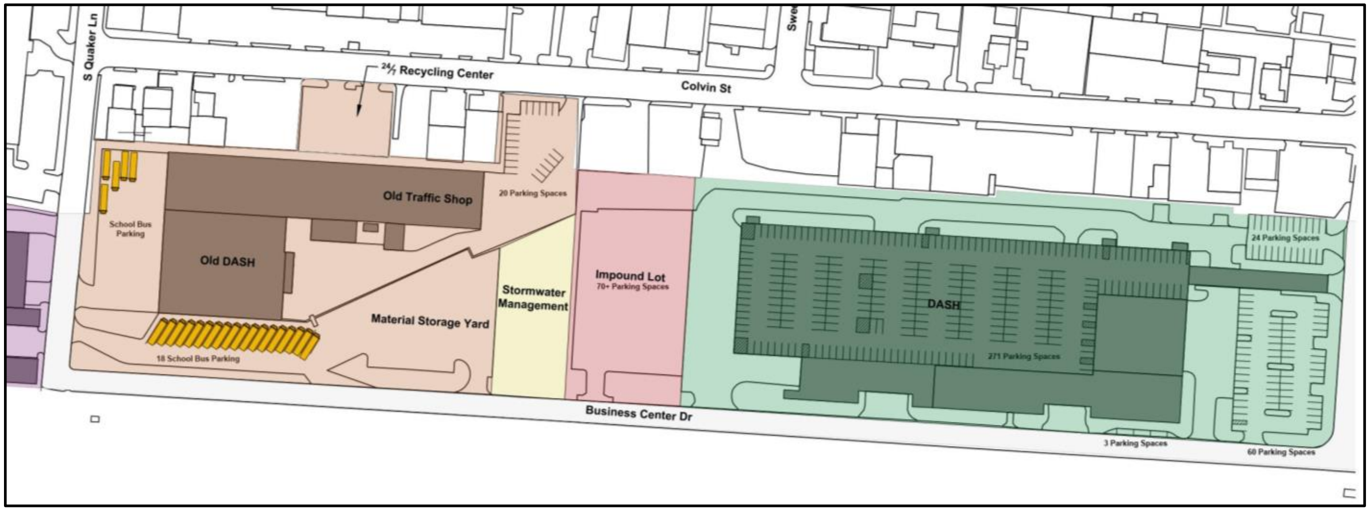
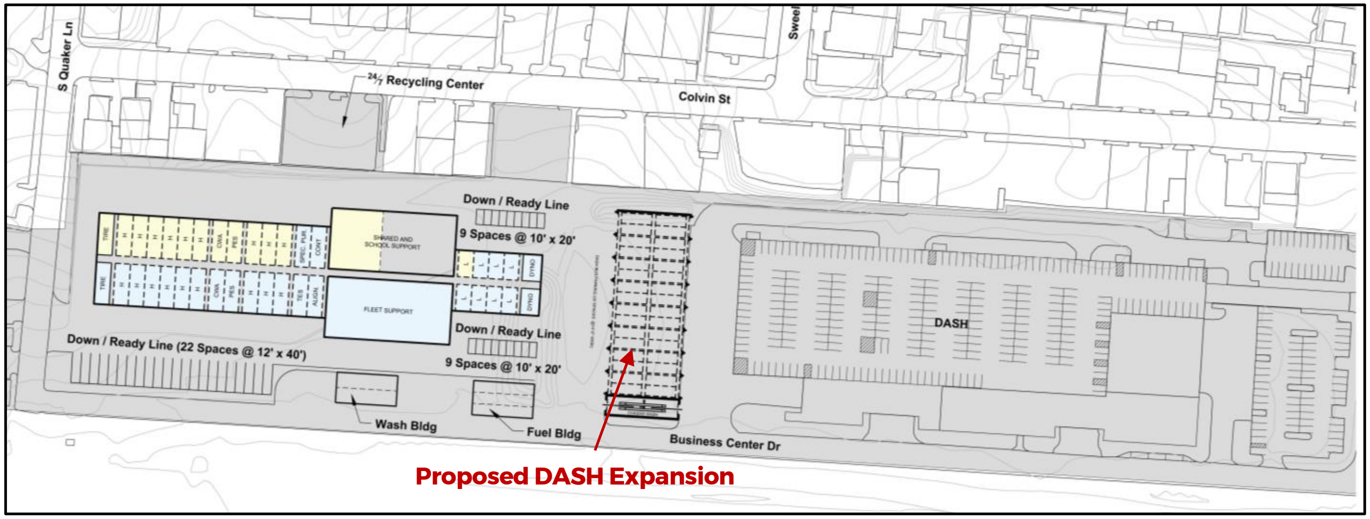


Exhibit 4: Reconfiguration Proposed by the Witter / Wheeler Master Plan



DASH Fleet Size and Mix Projections

DASH provided the projections to FY37 as shown in Exhibit 5.

The total active fleet is projected to grow from the current fleet of 93 buses to a total of 119 buses. About 75% of the fleet is currently 30-foot and 35-foot buses and the other 25% is 40-foot buses (with no articulated buses)

The fleet is projected to grow to 119 buses with fifteen 30-foot or 35-foot buses (approximately 13%), fifteen 60-foot articulated buses (approximately 13%), and 89 forty-foot buses (approximately 74%)

Note that 104 forty-foot buses plus 15 articulated buses is the equivalent of 127 forty-foot buses. This has an impact on the bus parking configuration as will be shown in the conceptual layouts presented later in this report.

The original design of the facility was based on 40-foot long buses.

Exhibit 5: DASH Fleet Projections by Bus Length and Propulsion Type

Active Fleet	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37
30' Hybrid Trolley	5	5	5														
40' Hybrid Trolley	1	1	1	1	1	1	1										
35' Clean Diesel Transit	30	30	30	32	32	32	32	32	32	32	18	2	2	2	2		
40' Clean Diesel Transit	5	5	5	13	18	18	18	18	18	18	18	13	13	13	13	5	
35' Hybrid Transit	34	34	34	27	22	22	15	2	2								
40' Hybrid Transit	12	12	12	9	4	4	4	4	4								
35' Electric Trolley				5	5	5	5	6	6	6	6	6	6	6	6	6	6
35' Electric Transit												16	16	16	16	18	18
40' Electric Transit	6	10	10	10	21	33	40	53	53	53	67	67	67	67	67	75	80
60' Electric Artic Transit		4	4	4	4	4	4	4	4	10	10	15	15	15	15	15	15
Total (Active Fleet)	93	101	101	101	107	119	119	119	119	119	119	119	119	119	119	119	119

Source: Information Provided by DASH

104 forty-foot buses + 15 articulated buses
= 127 vehicle equivalents (VEs)

Existing Power and Electrical Infrastructure

The existing electrical service for the DASH Maintenance and Operations Facility enters via underground distribution via Business Center Drive and is sized at 34.5 kv. The site's electrical service feeds into a pad-mounted transformer located in the green space on the north side of Business Center Drive adjacent to the south exterior wall of the wash lanes just east of the emergency access drive as shown in Exhibit 6.

Exhibit 6: Existing Transformer Location

From the transformer, the electrical service is routed underground into the facility and rises into the main electrical room (located adjacent to the transformer location) where it feeds the facility's main switchboard. The main switchboard is a 3,000 KVA unit with 1,745.9 connected KVA alongside a 400 KVA spare. Power is then fed to three main distribution panels (MDP1, MDP2, MDP3) and the bus wash and reclaim system. The facility is backed up by a 1,500 kW 480v diesel emergency generator located on the second story of the facility above the fueling area. The emergency generator is fed from the in-ground diesel storage tanks near the existing fuel lanes.

Per information provided by DASH, the battery electric bus initial fleet (with six BEBs) will use all of the existing spare electrical service to the site. All potential future battery electric bus charging infrastructure will require new or additional electrical utility service from Dominion. The new service will also require additional transformers and switchboards to distribute the required power.

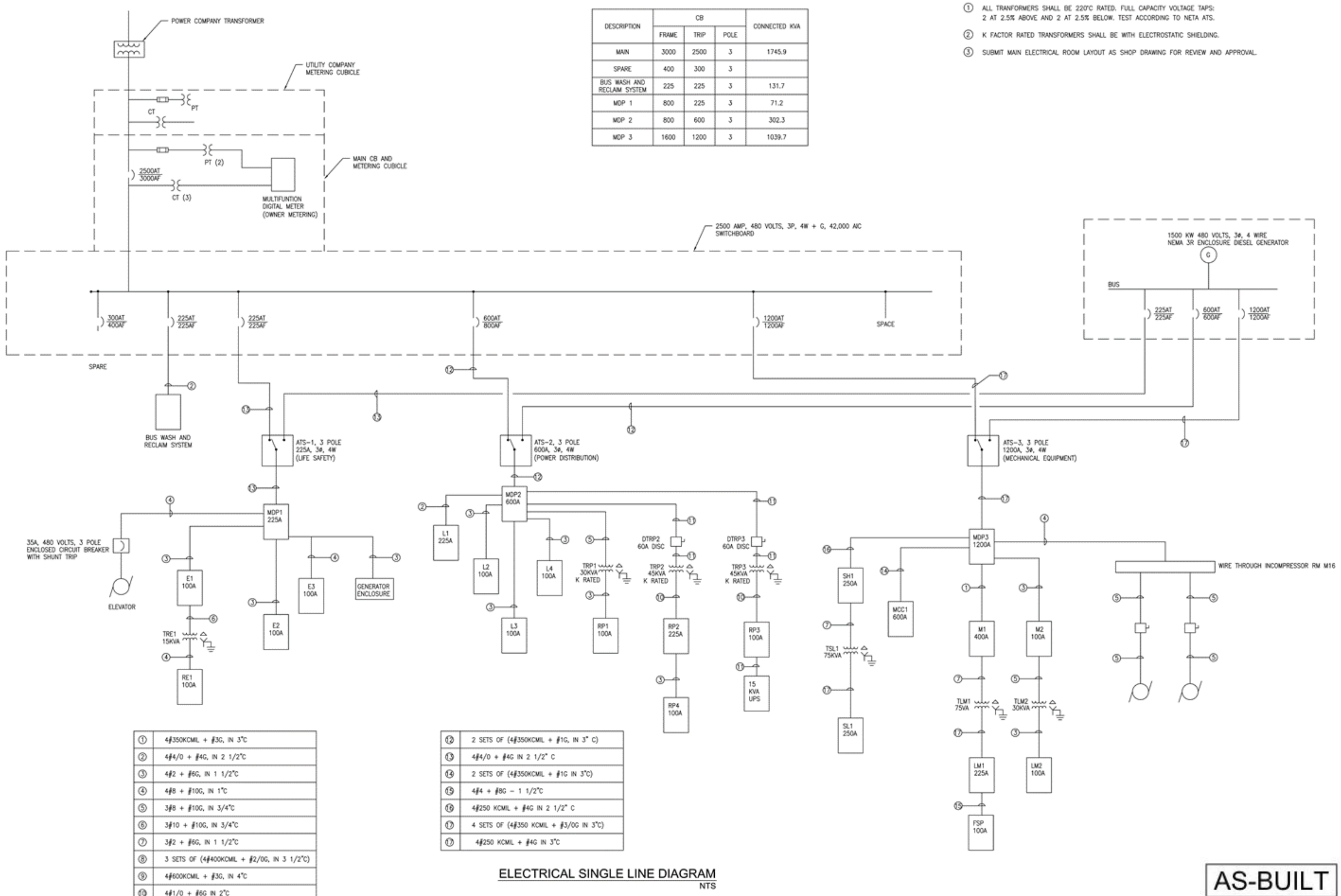
Exhibit 7 provides supporting information taken from as-built drawings provided by DASH.

Exhibit 7: Existing Electrical System Information from As-Built Drawings

NOTES:

1. ALL TRANFORMERS SHALL BE 220°C RATED. FULL CAPACITY VOLTAGE TAPS: 2 AT 2.5% ABOVE AND 2 AT 2.5% BELOW. TEST ACCORDING TO NETA ATS.
2. K FACTOR RATED TRANSFORMERS SHALL BE WITH ELECTROSTATIC SHIELDING.
3. SUBMIT MAIN ELECTRICAL ROOM LAYOUT AS SHOP DRAWING FOR REVIEW AND APPROVAL.

DESCRIPTION	CB			CONNECTED KVA
	FRAME	TRIP	POLE	
MAIN	3000	2500	3	1745.9
SPARE	400	300	3	
BUS WASH AND RECLAIM SYSTEM	225	225	3	131.7
MDP 1	800	225	3	71.2
MDP 2	800	600	3	302.3
MDP 3	1600	1200	3	1039.7

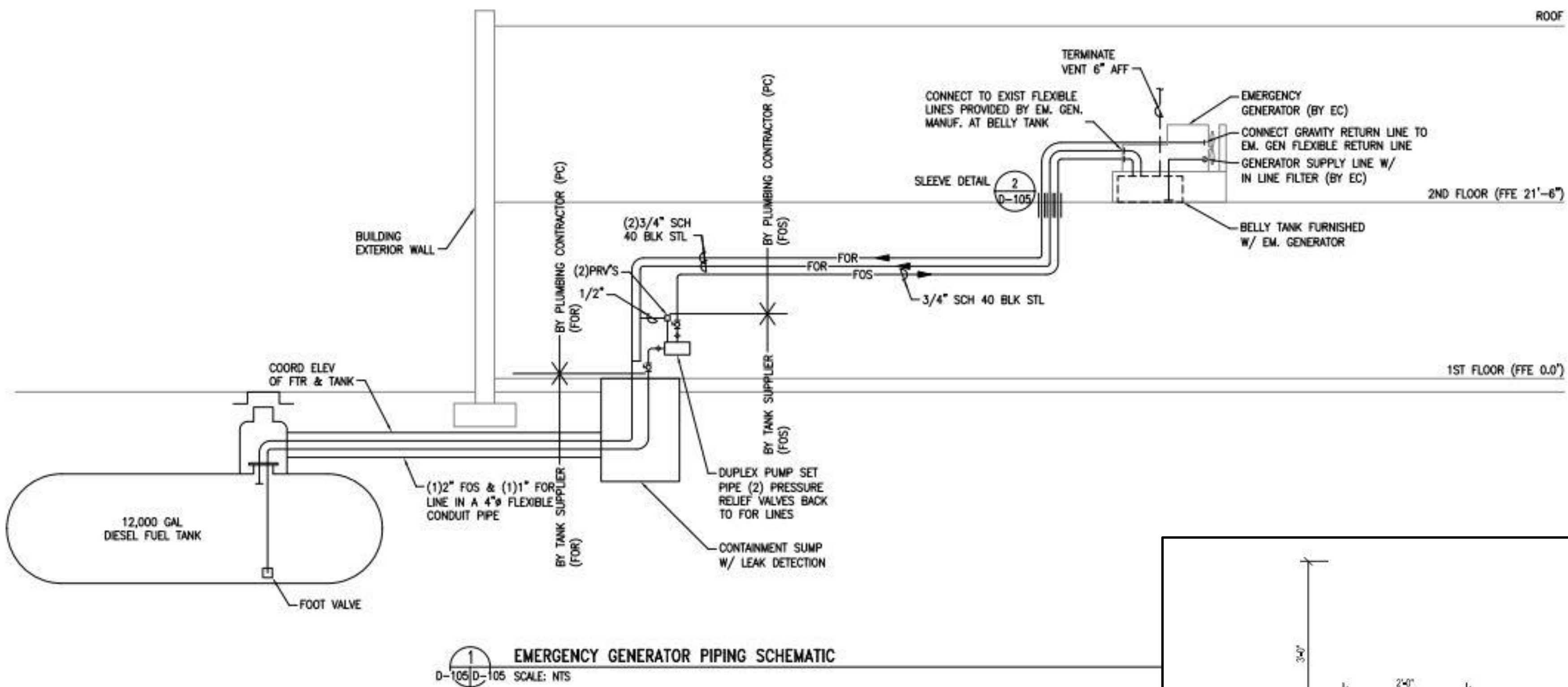


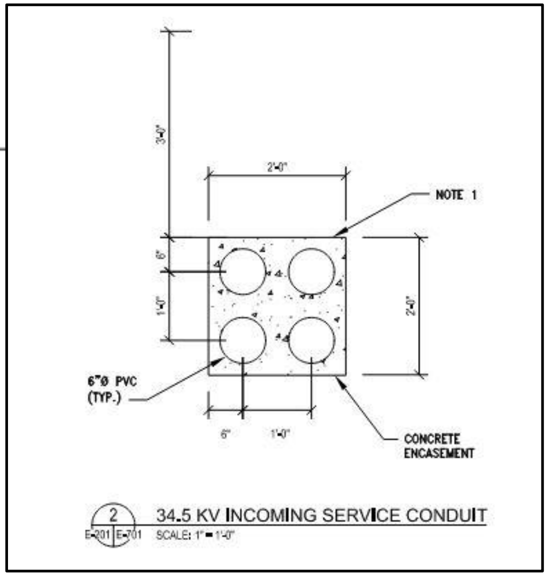
1	4#350KCMIL + #3G, IN 3"C
2	4#4/0 + #4G, IN 2 1/2"C
3	4#2 + #6G, IN 1 1/2"C
4	4#8 + #10G, IN 1"C
5	3#8 + #10G, IN 3/4"C
6	3#10 + #10G, IN 3/4"C
7	3#2 + #6G, IN 1 1/2"C
8	3 SETS OF (4#400KCMIL + #2/0G, IN 3 1/2"C)
9	4#600KCMIL + #3G, IN 4"C
10	4#1/0 + #6G IN 2"C
11	3#6 + 10G IN 3/4"C

12	2 SETS OF (4#350KCMIL + #1G, IN 3" C)
13	4#4/0 + #4G IN 2 1/2" C
14	2 SETS OF (4#350KCMIL + #1G IN 3"C)
15	4#4 + #8G – 1 1/2"C
16	4#250 KCMIL + #4G IN 2 1/2" C
17	4 SETS OF (4#350 KCMIL + #3/0G IN 3"C)
17	4#250 KCMIL + #4G IN 3"C

ELECTRICAL SINGLE LINE DIAGRAM
NTS

Exhibit 7: Existing Electrical System Information from As-Built Drawings (continued)

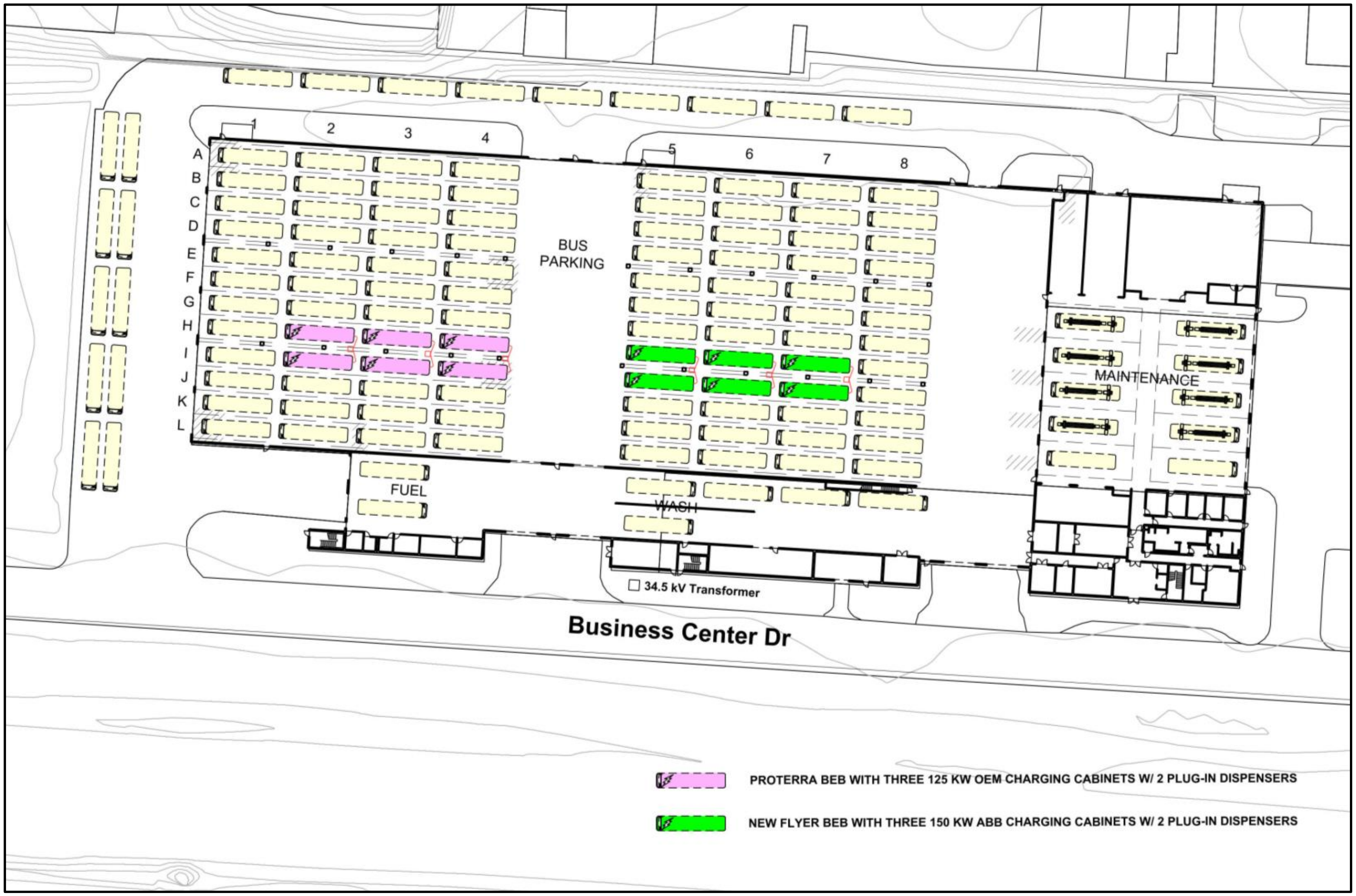




Initial BEB Charging Configuration

Discussions with DASH indicate that the bus charging infrastructure for the initial buses is as shown in Exhibit 8 with three dual plug-in dispenser charging cabinets for the three Proterra BEBs and a duplicate configuration for the three New Flyer BEBs. Note that the graphic shows the total number of BEBs (twelve total) that could be charged with the equipment in the initial program.

Exhibit 8: Initial BEB Charging Configuration



ZERO EMISSION BUS (ZEB) ALTERNATIVES

There are only two technologies available today that will meet zero emission standards – battery electric (BEB) and fuel cell electric (FCEB). DASH completed a ZEB Feasibility Study in December 2019. Based on the Feasibility Study, DASH directed the WSP Team to briefly address the use of FCEBs, but to focus efforts on the use of BEBs.

The following is a brief outline of some of the advantages and disadvantages of FCEB and BEB. Note that both types of buses will require additional training for bus mechanics, facility maintenance staff, and bus operators.

Both fuel cells (on FCEBs) and batteries (on BEBs) should be changed out at mid-life of the bus (about 6 years).

FUEL CELL ELECTRIC BUS (FCEB)

Fuel cell electric buses use hydrogen fuel cells to generate power to keep smaller batteries charged that drive the bus. The most cost-effective source of hydrogen is delivery of liquid hydrogen, if it is readily and reliably available.

Advantages

- Range of FCEBs is similar to diesel buses (however fuel cells degrade).

Disadvantages

- Hydrogen is a lighter-than-air fuel. Care must be taken to avoid accumulation of combustible gas when a FCEB is indoors.
- Making provisions for proper ventilation in the DASH facility would be very costly.
- The footprint for hydrogen fueling equipment is very large and the existing DASH site (including the proposed expansion area) would not accommodate this equipment. Note that this equipment is typically located at-grade.
- Additional property north of the existing DASH facility would be required to accommodate the hydrogen fueling equipment. Note that setback requirements for this equipment may even preclude the use of properties north of the existing DASH facility.
- Higher purchase price for FCEBs and a limited number of manufacturers.
- Higher initial capital cost for hydrogen fueling infrastructure. Additional study would be required to determine the number of FCEBs needed to make investing in the required infrastructure worthwhile, however, other agencies are projecting a fleet of at least 100 FCEBs would be needed.
- Fuel cells degrade about 15% over 6 years.

BATTERY ELECTRIC BUS (BEB)

Battery electric buses rely on large batteries to drive the bus. While battery technology is quickly evolving, current battery sizes used are currently 466 kWh for 40-foot buses and 660 kWh for 60-foot buses.

Advantages

- Lower purchase price for BEBs and multiple manufacturers available.
- Lower initial capital cost for charging infrastructure.
- Easily scalable with proper planning.
- Additional ventilation / exhaust is not needed for BEB operation indoors.
- While chargers and switchgear can take significant space, they can be located above the bus parking area.

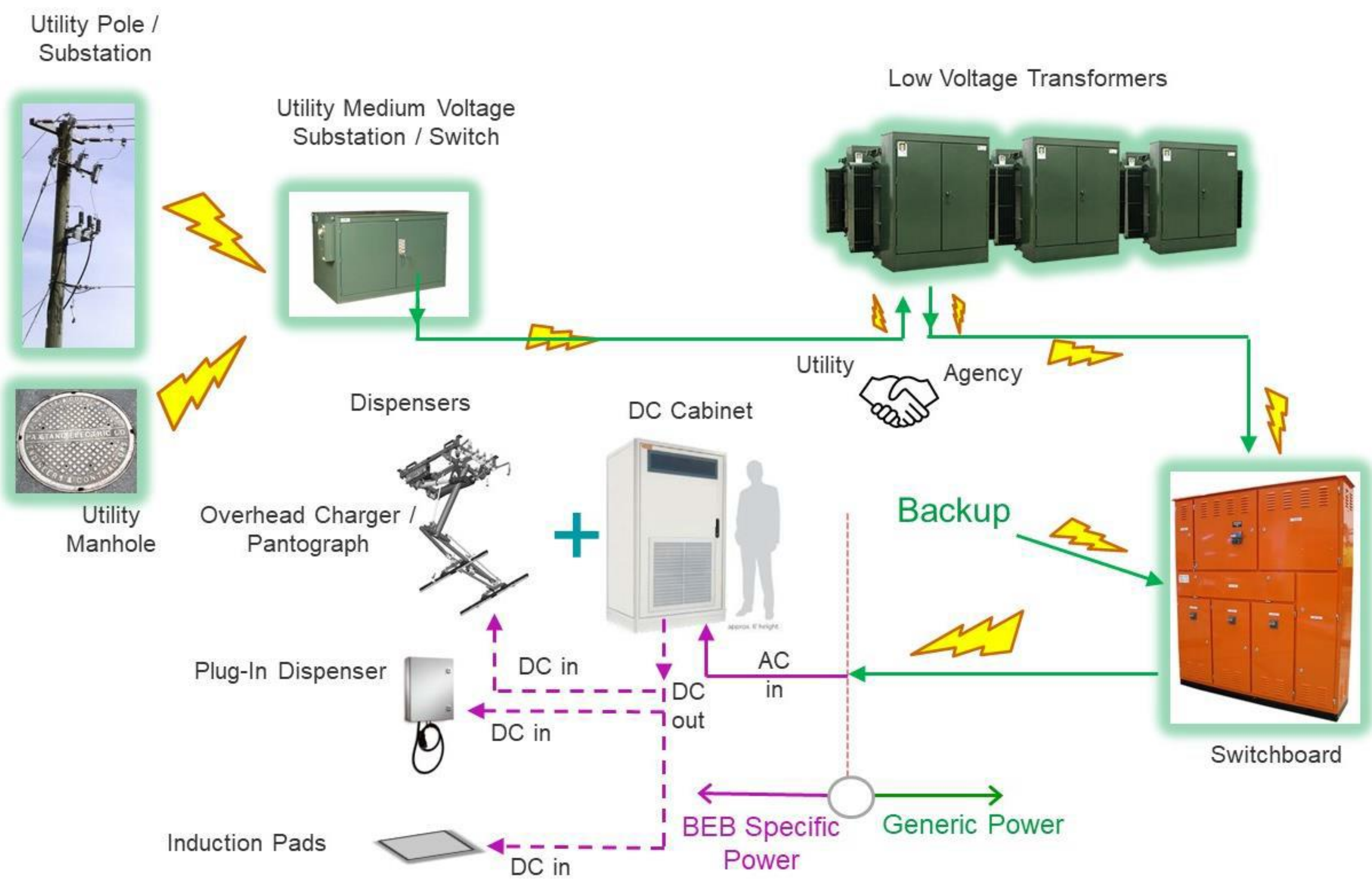
Disadvantages

- Current range of BEB's may require some blocks to have en-route charging or additional BEBs that would be charged
- The cost of power can fluctuate throughout the day and battery charging must be carefully timed to take advantage of the lowest rates.

CHARGING SYSTEM COMPONENTS

Exhibit 9 provides an overview of the charging system components to give a common understanding of terminology. Note that the power utility (Dominion) typically provides the power up to the transformer(s) and the agency (DASH or the City) takes responsibility for all components downstream from the transformer. The battery electric bus specific equipment is the charging cabinets that converts AC power to DC power which in turn powers the dispensers. Dispensers can be an overhead inverted pantograph or a plug-in dispenser (either at grade or overhead) or an induction pad as shown.

Exhibit 9: Charging System Components



CHARGING INFRASTRUCTURE COMPONENT OVERVIEW

CHARGING DISPENSER OVERVIEW

The following are the basic types of charging dispensers.

1. **Ground mounted plug-in**
   - DASH current initial configuration
   - Requires significant floor space
2. **Overhead drop-down plug-in cord or pantograph**
   - Fed from remote charger (within 300 feet)
   - DASH bus parking overhead clearance = 15-feet (ideal)
3. **Ground mounted induction**
   - Impacts floor slab
   - Fed from remote charger (within 50 to 100 feet)

The following is a brief evaluation of each type charging dispenser along with illustrations of each.

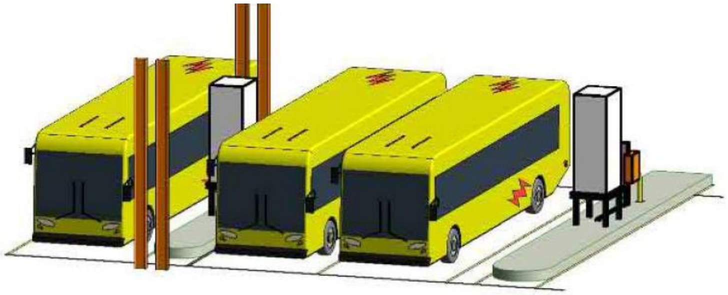
GROUND MOUNTED PLUG-IN

PROS

- Charging cabinet is accessible at ground level for maintenance or replacement.

CONS

- Occupies large portion of vehicle parking and reduces site capacity.
- Requires new curbs in existing parking areas to protect ground-mounted equipment.
- Requires operator to plug in heavy charging cord (labor issue).
- Charging cord must be managed or risk of damage from buses driving over.
- Requires trenching throughout the site to distribute power to cabinets & dispensers – major operational impacts during install.
- Reconfiguration of charger layout based on fleet changes is difficult and requires trenching with extended operational downtime.



CHARGING INFRASTRUCTURE COMPONENT OVERVIEW

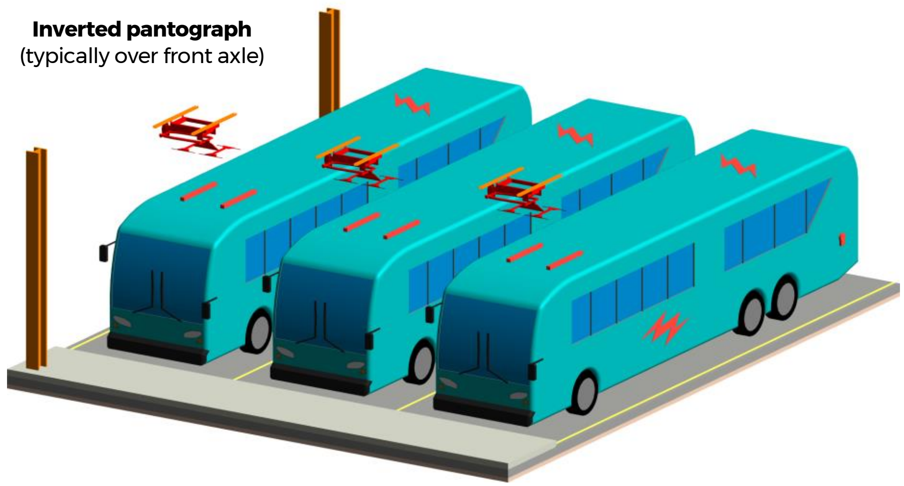
OVERHEAD DROP-DOWN PLUG-IN OR PANTOGRAPH

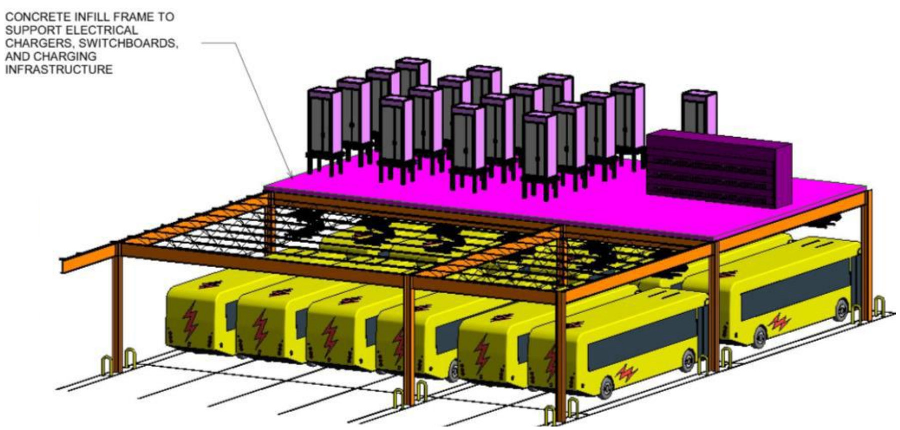
PROS

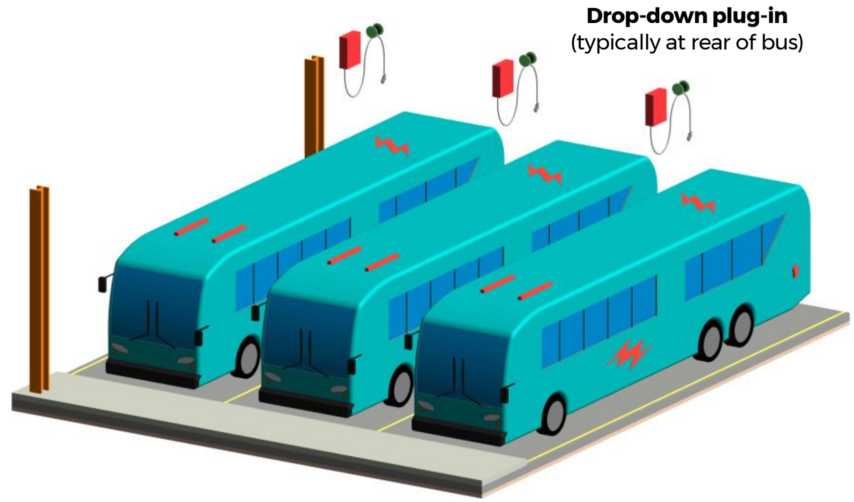
- Can be mounted to existing overhead structure with no operator interaction with the charging process is required (pantograph).
- Minimal footprint in the parking areas allows for highest site capacity.
- Rapid reconfiguration of charging positions possible via remounting pantographs with no trenching required. Capable of adjusting with fleet.
- Lowest amount of trenching to the site. Distribution is carried via overhead conduit.
- Mixed technology compatible.

CONS

- If charging cabinets remain at ground level, there are longer conduit runs to dispensers. (If charging cabinets are mounted on the roof, as proposed, the conduit runs are minimized, thus minimizing cost.
- Must confirm existing structure is compatible. If not, an independent support frame is required.







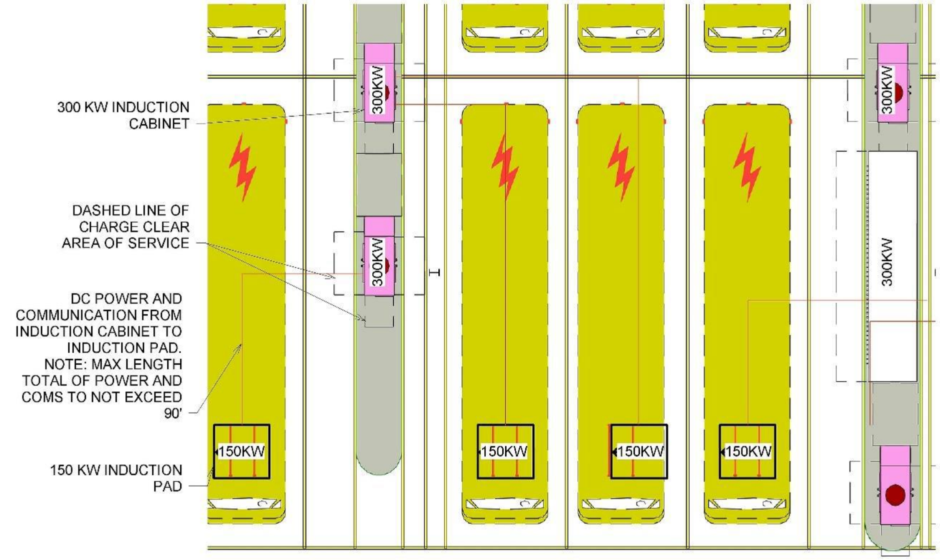
GROUND MOUNTED INDUCTION

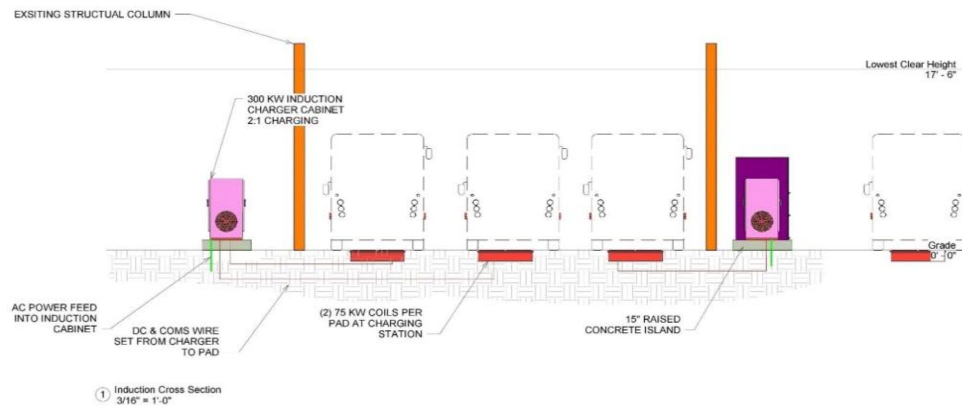
PROS

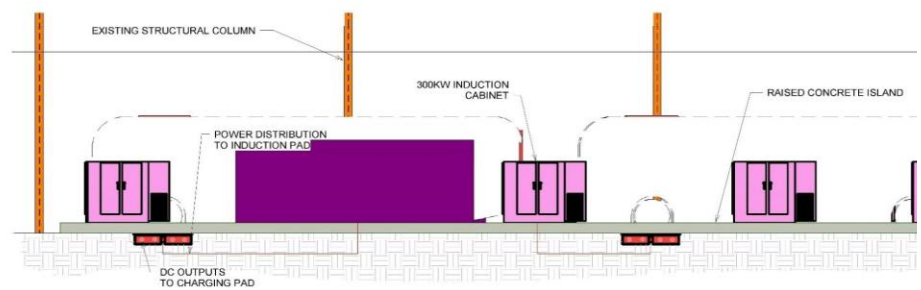
- No requirement for new overhead structure / frame or mounting equipment above.
- Charging cabinet is accessible at ground level for maintenance or replacement.
- Nor requirement for driver to engage the charging equipment – automatically connects.

CONS

- Occupies large portion of vehicle parking and reduces site capacity.
- Requires new curbs in existing parking areas to protect ground-mounted equipment.
- Requires trenching throughout the site to distribute power to cabinets and dispensers – major operational impacts during install.
- Equipment must be mounted 50 to 100 feet from the induction pad (varies by vendor).







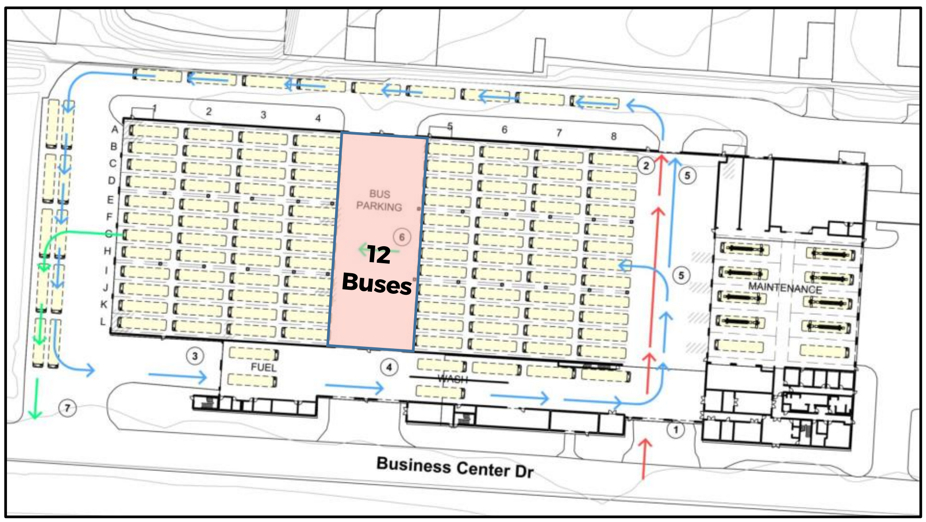
BUS PARKING EXPANSION OPTIONS

Expansion options for bus parking fall under two categories – expanding the existing bus storage area and constructing a new bus storage facility. The following options were identified and evaluated.

1. Expand Existing Bus Storage
   a. Middle aisle (Exhibit 10)
   b. To the north (Exhibit 11)
   c. To the south (Exhibit 11)
   d. To the west (Exhibit 11)
   e. Exhibit 12 shows a matrix comparing these options
2. Construct New Bus Storage West of Existing Facility
   a. Enclosed and heated (Exhibit 13)
   b. Outdoor / Covered (Exhibit 14)
   c. Exhibit 15 shows a matrix comparing these options

Exhibit 10: Expand Existing Middle Aisle

96 forty-foot buses currently + 12 in middle aisle = only 108 forty-foot VEs (127 needed)



This is a $0 capital cost option that can be combined with other expansion options.

Exhibit 11: Expand Existing North – South - West

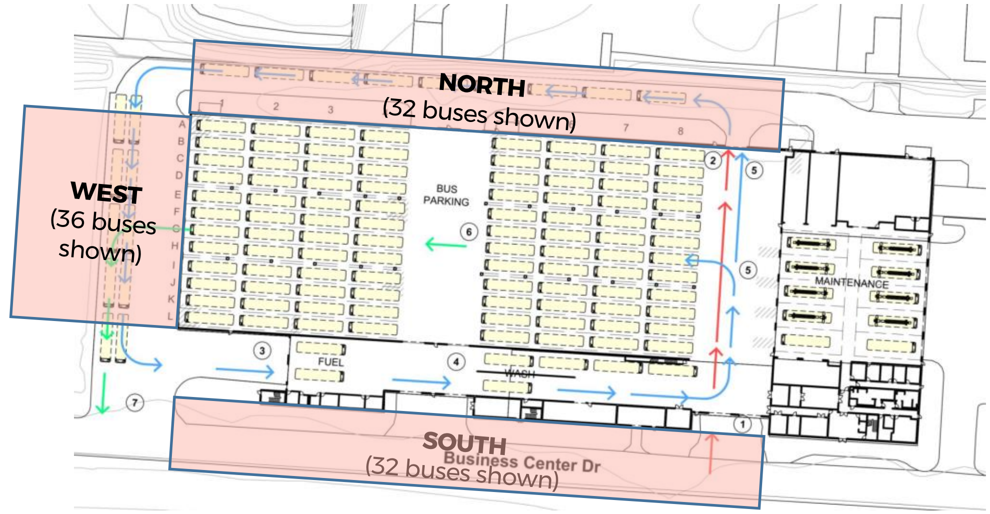


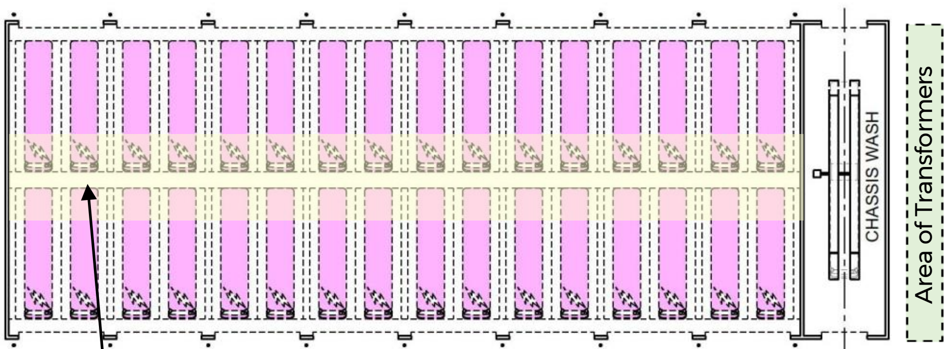
Exhibit 12: Comparison of Expanding Existing Bus Storage Options

	North	South	West
Number of Buses	▪ 32 forty-foot shown (or 24 if too wide) ▪ Total VE with existing96 + 24 = only 120 (127 needed)	• 32 forty-foot shown (or 24 if too wide) • Total VE with existing 96 + 24 = only 120 (127 needed)	• 36 forty-foot • Total VE with existing 96 + 36 = 132 (127 needed)
Advantages	▪ Could be built without interrupting on-going operations during construction	▪ None come to mind	▪ More area for expansion
Disadvantages	▪ Not enough space – probably need to reduce to 24 buses (3 lanes) ▪ Drainage issues ▪ Blocks delivery truck exit from stores ▪ Expands into area most prone to flooding ▪ Eliminates fire truck access on north side of building	▪ Not enough space – probably need to reduce to 24 buses (3 lanes) ▪ Blocks existing bus entry during construction (probably 12 to 18 months) ▪ Would require vacating Business Center Drive ▪ Utility relocations required ▪ Eliminates fire truck access on south side of building	▪ Blocks bus exit during construction (probably 12 to 18 months) ▪ Reversing bus flow was brought up – but vehicle circulation is not efficient and modifying fuel and wash is very expensive and disruptive. Also would result in clock-wise traffic flow – not recommended.

Note that only the West Expansion option provides for the number of projected buses

Exhibit 13: Separate Facility Enclosed and Heated

96 forty-foot buses currently + 32 in expansion = 128 forty-foot VEs (127 needed)

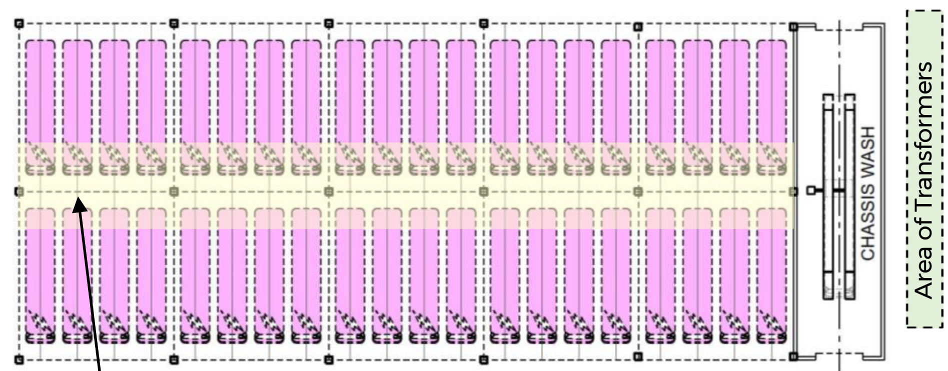


DASH BUS PARKING (32 SPACES @14'-0" WIDE)

Deck above for chargers and switchgear

Exhibit 14: Separate Facility Outdoor / Covered

96 forty-foot buses currently + 40 in expansion = 136 forty-foot VEs (127 needed)



DASH BUS PARKING (40 SPACES @11'-0" WIDE)

Deck above for chargers and switchgear

Note that Exhibits 13 and 14 illustrate the evolution of the concepts developed with DASH. The proposed layout is like Exhibit 14 with Chassis Wash eliminated, and parking spaces expanded to 12'-0" wide.

Exhibit 15: Comparison of Separate Facility Expansion Options

	Enclosed	Outdoor/Canopy	Expand Existing West
# of Buses	32 forty-foot buses	40 forty-foot buses	36 forty-foot buses
Advantages	▪ Minimizes disruption of on-going operations during construction ▪ Buses parked in enclosed, heated space ▪ 14'-0" wide spaces allow wheelchair ramp to be cycled in-place ▪ Scalable ▪ Adaptable to automated bus yard ▪ Could eliminate need to add any charging infrastructure to existing facility ▪ Photovoltaic panels can be placed on the roof	▪ Minimizes disruption of on-going operations during construction ▪ Park more buses in about the same space as enclosed ▪ Least expensive expansion option ▪ Easily scalable ▪ Easily adaptable to automated bus yard ▪ Could eliminate need to add any charging infrastructure to existing facility ▪ Framework can be designed to support canopy cover in future ▪ Photovoltaic panels can be mounted on overhead framework	▪ More area for expansion than expanding existing north or south
Disadvantages	▪ Higher capital cost than outdoor / canopy covered ▪ Higher operating cost (maintaining doors and heating) than outdoor / canopy	▪ 12'-0" wide spaces will not allow exercising wheelchair ramp in place during pre-trip inspection, but takes full advantage of automated bus yard abilities ▪ May require pre-heating bus prior to pull-out	▪ Blocks bus exit during construction (probably 12 to 18 months) ▪ Reversing bus flow was brought up – but vehicle circulation is not efficient and modifying fuel and wash is very expensive and disruptive. Also would result in clock-wise traffic flow – not recommended.

Observations for Separate Facility Outdoor / Covered Expansion Option

1. Easily scalable
   a. Could be developed in phases as funds available
   b. Can maximize use of available funding for Phase 1
2. Lends itself to various project delivery methods
   a. Design-Bid-Build
   b. Design-Build
3. Easily adaptable to automated bus yard
4. Makes best use of available space
5. Gives DASH flexibility to take advantage of emerging technology

MAINTENANCE EXPANSION OPTIONS

Maintenance Requirements

1. There are 10 existing repair bays (at 20' x 55' each) plus one chassis wash sized for 40-foot buses for a total of 11 bays
2. Industry standard are generally one bay per 10 buses including:
   a. Running repair (1 per 20 buses)
   b. Preventive maintenance (1 per 50 buses)
   c. Tire repair (1 per 150 buses)
   d. A/C repair (1 per 100 buses)
   e. Chassis Wash (1 per 150 buses)
3. For a 119-bus fleet with 15 articulated buses. There should be a total of 12 bays including:
   a. Ten standard bays + 2 articulated bays = 12 total + 1 chassis wash for articulated buses
4. Non-revenue vehicles (could be maintained by City in future)
5. Wash frequency: Every bus everyday

Maintenance Bay Options

The following options were identified and evaluated for providing the total number of maintenance bays required to support the projected fleet.

Option A: Existing Maintenance Bays (1 artic repair bay)

- Option A.1: Existing Flat Bays (with portable lifts) (see Exhibit 16)
- Option A.2: Existing End Bay (with new in-ground lift) (see Exhibit 17)

Option B: Bus Circulation Corner (1 artic repair bay) (see Exhibit 18)

Option C: Bus Parking Area (2 artic repair bays)

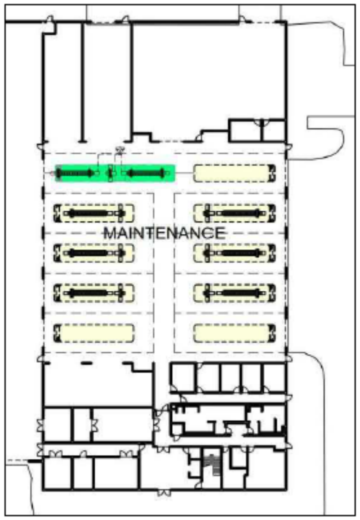
- Option C.1: Bus Parking Area Side-by-Side (3 lanes) (see Exhibit 19)
- Option C.2: Bus Parking Area Side-by-Side (4 lanes) (see Exhibit 20)
- Option C.3: Bus Parking Area Linear (2 lanes) (see Exhibit 21)

Exhibit 16: Maintenance Bay Option A.1 (Existing Flat Bays)

- ✓ No facility modifications
- ✓ Utilize existing portable lift
- ✓ Does not impact bus parking area
- ✓ Easy access to support spaces
- ✓ Easy to supervise

- Does not provide bays needed to support 119 buses
- Blocks center circulation aisle
- Impacts bay to the east

Exhibit 17: Maintenance Bay Option A.2 (Existing End Bay)

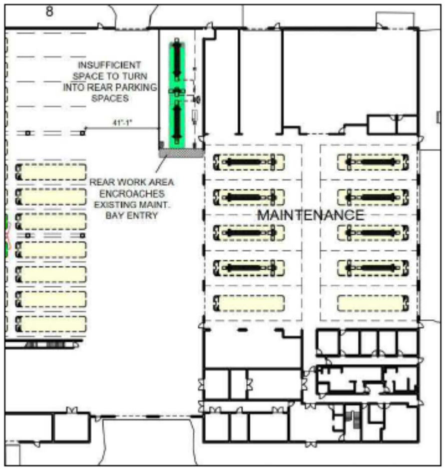


- ✓ Could replace existing 2-post in-ground lift with 3-post or use existing portable lift
- ✓ Does not impact bus parking area
- ✓ Easy access to support spaces
- ✓ Easy to supervise

- Does not provide bays needed to support 119 buses
- Blocks center circulation aisle
- Impacts bay to the east

EXPANSION OPTIONS

Exhibit 18: Maintenance Bay Option B (Bus Circulation Corner)



- ✓ Could accommodate in-ground lift

- Does not provide bays needed to support 119 buses
- Blocks bus circulation to 4 bus parking spaces
- Does not allow new bay to be fully enclosed and heated
- Work area encroaches on entry to existing repair bay
- Bay width restricted – not wide enough

Exhibit 19: Maintenance Bay Option C.1 (Bus Parking Area)

- ✓ Provides bays needed to support 119 buses
- ✓ Bays are fully enclosed and heated
- ✓ Bays reasonably close to parts storeroom and other support spaces
- ✓ Can use portable or in-ground lifts

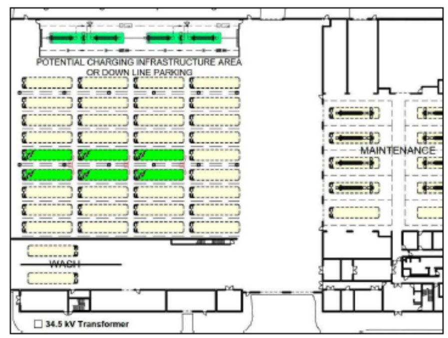
- Impacts bus parking area, but 119 buses can still be accommodated
- One bay has restricted width – not wide enough

Exhibit 20: Maintenance Bay Option C.2 (Bus Parking Area)

- ✓ Same as Option C.1 but repair bay wider
- ✓ Provides bays needed to support 119 buses
- ✓ Bays are fully enclosed and heated
- ✓ Bays reasonably close to parts storeroom and other support spaces
- ✓ Can use portable or in-ground lifts

- Impacts bus parking area, but 119 buses can still be accommodated by using center drive aisle

Exhibit 21: Maintenance Bay Option C.3 (Bus Parking Area)



Identified as preferred option by DASH

- ✓ Provides bays needed to support 119 buses
- ✓ Bays are fully enclosed and heated
- ✓ Repair bays can be drive-thru
- ✓ Bays reasonably close to parts storeroom and other support spaces
- ✓ Can use portable or in-ground lifts

- Impacts bus parking area, but 119 buses can still be accommodated

PROPOSED EXPANSION AND BUS PARKING LAYOUTS

Based on the previous discussion the proposed configuration was developed showing the preferred maintenance bay location for articulated buses and the separate facility for bus parking expansion to the west of the existing facility, as shown in Exhibit 22. The existing charging infrastructure in the existing bus parking area will remain to charge up to 12 buses as shown. The new expansion will accommodate 40 battery electric buses up to 40-feet each.

Exhibit 22: Proposed Expansion for Bus Parking and Maintenance

PROPOSED CHARGING INFRASTRUCTURE + BUS PARKING LAYOUTS

Exhibit 23 shows the plan view of the bus parking expansion with 12-foot wide parking spaces arranged two-deep in a drive through configuration. The transformers would be located along Business Center Drive (similar to the existing transformers) and the switchgear and chargers would be located on a deck above the bus parking area. Chargers will be 2:1 with each 150 kW charger supporting two overhead inverted pantograph dispensers. The deck could be a partial deck as shown or a full deck to provide full cover over all forty buses. See the appendix for additional illustrations of each

Exhibit 24 shows a rendering from the southwest of the proposed expansion.

Exhibit 25 shows a close-up of the rendering.

Exhibit 23: Proposed Bus Parking Expansion

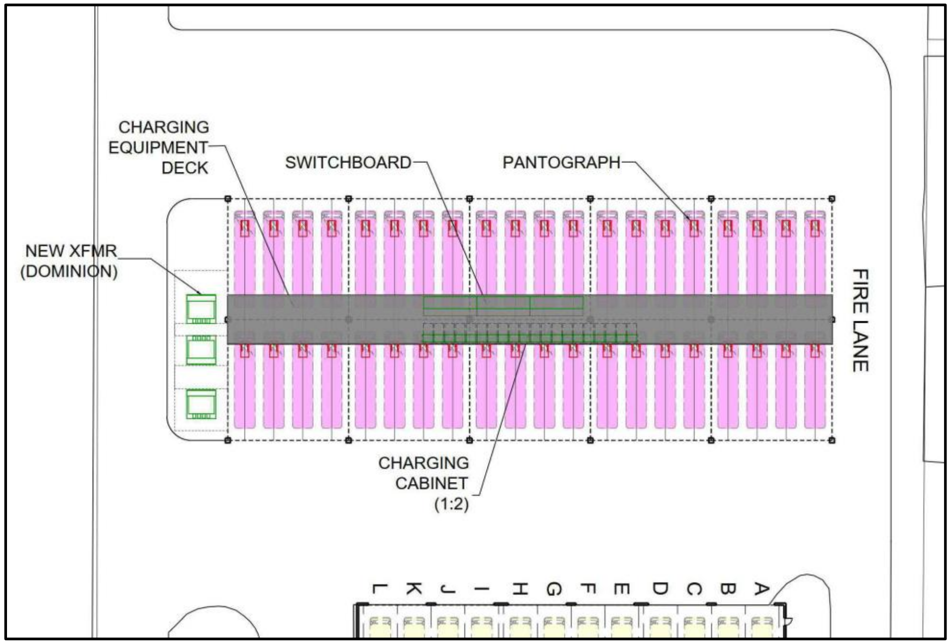


Exhibit 24: Rendered View from the Southwest

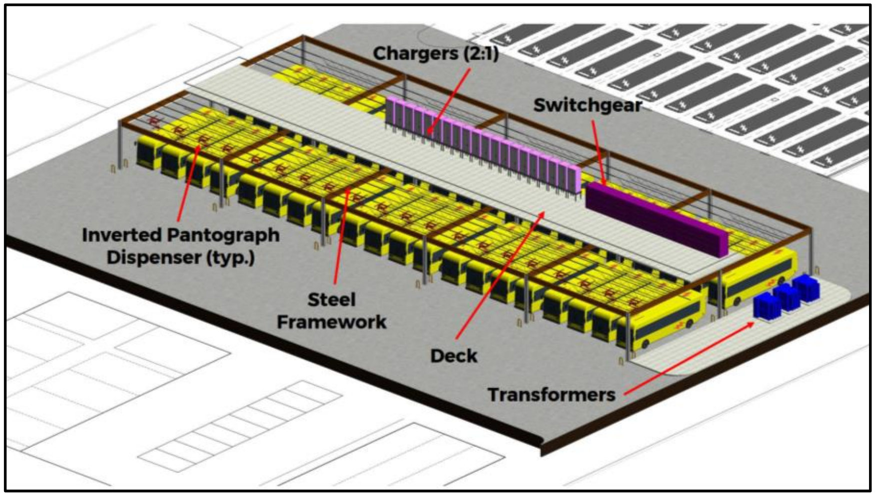
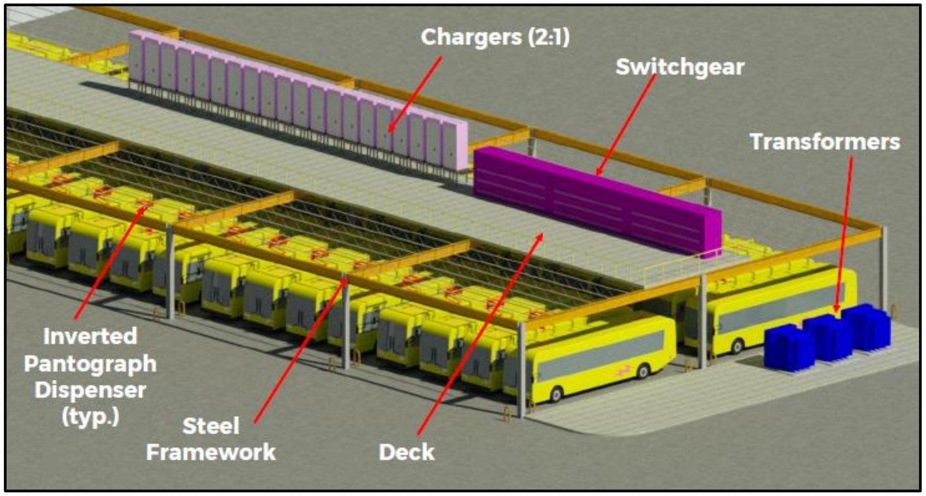


Exhibit 25: Detail of Proposed Bus Parking Expansion



PROPOSED CHARGING INFRASTRUCTURE + BUS PARKING LAYOUTS

Exhibit 26 shows the west elevation of the proposed bus parking expansion.

Exhibit 27 shows the south elevation of the proposed bus parking expansion with a partial deck to support the chargers and switchgear over the bus parking area.

Exhibit 26: West Elevation

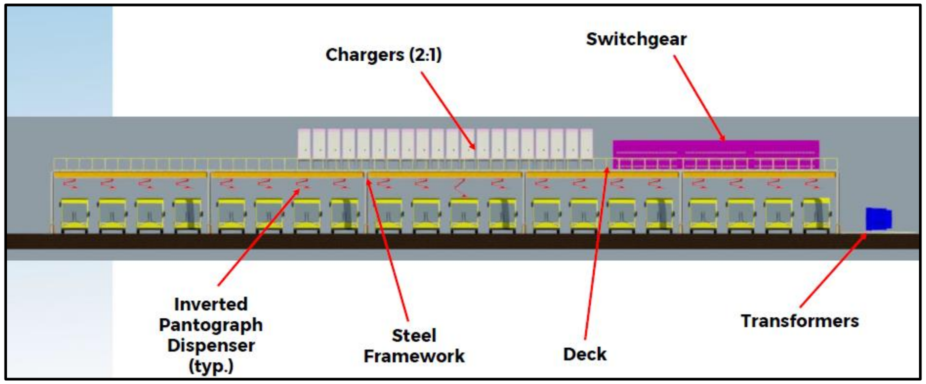
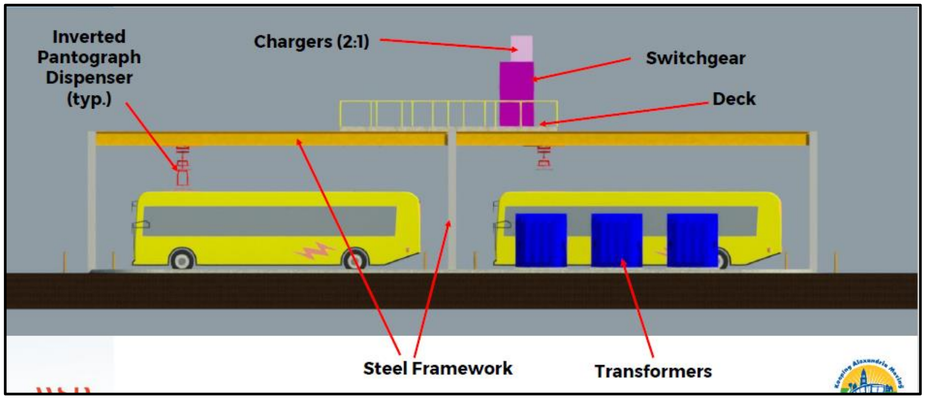


Exhibit 27: South Elevation (from Business Center Drive)



OPERATIONAL/PROCEDURAL CONSIDERATIONS

INITIAL

When the initial phase of facility expansion is completed, buses will be parked two-deep facing west in the bus parking expansion facility. BEBs will be parked under the 20 overhead inverted pantograph charging dispensers which will be manually engaged when the bus is to be charged. In about FY 26, the remaining 20 parking positions in the expansion facility will need to be equipped with overhead inverted pantograph charging dispensers. This will provide a total of 52 charging positions (including the 12 existing positions in the existing facility).

The existing plug-in chargers installed as part of the initial program will continue to be used as they are currently. All buses will be driven through the existing service lanes for interior cleaning and vault pull before being driven through the existing bus washer.

FUTURE (AUTOMATED BUS YARD CONCEPT)

In FY29, based on the projected BEB fleet growth, DASH will need to consider whether to continue to have a dispenser over each bus parking space or if buses will be moved (platooned) so that two buses can be charged by the same dispenser during the night. Buses could be moved manually or by implementing an automated bus yard. The following is a brief explanation of the automated bus yard.

The Automated Bus Yard

Retrofit buses with Advanced Driving-Assistance Systems (ADAS) enabling buses to drive autonomously within the yard.

- Optimal Operating Design Domain (ODD).
- Less risk than operating during revenue service.
- Immediate operational and financial benefits.
- ADAS sensors (LiDAR, radar, and HD cameras) connect with Drive-by-Wire system that controls actuators.
- Automated yard demonstration is included within FTA's Strategic Transit Automation Research (STAR) Program.

How It Works

- ADAS sensors and computer are the "Eyes, ears, and brain of the vehicle."
- Vehicle perception – LiDAR, Radar, HD cameras.
- Drive-By-Wire – Connects to actuators (brake, steering, and propulsion).

The WSP Approach

Benefits

- Increase yard capacity by 25-30%.
- Decrease number of electric chargers by 1/3.
- Save an average of 15-minutes with pull-in and pull-out each trip.
- Integrate remote start and automated bus valet with existing pull-out schedule.

Expertise

- Connected vehicle ConOps development.
- Asset management and lifecycle cost analysis for ADAS sensors.
- Safety and security system integration.
- Transit system ITS integration for real-time, autonomous fleet management.
- Labor assessment and job training solutions.
- Cost-benefit analysis demonstrating high ROI within 12-year timespan.

WSP Automated Yard Partner

- Robotic Research: Defense and commercial automation software firm with 20+ years of experience:
  - Leading bus platooning pilot for **Port Authority XBL**
  - Leading precision parking and **platooning pilot at CTFastrak**

2030 Vision – Automated Transit Fleet

POWER IMPLICATIONS

BEB Fleet Size and Mix – To Charge Daily

Exhibit 28 shows the number of battery electric buses that would need to be charged each day, assuming a 20% spares ratio.

Exhibit 28: Number of BEB's to Charge by Year

	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37
BEB Fleet Only																	
35' to 40' Electric	6	10	10	15	26	38	45	59	59	59	73	89	89	89	89	99	104
60' Electric	0	4	4	4	4	4	4	4	4	10	10	15	15	15	15	15	15
Subtotal	6	14	14	19	30	42	49	63	63	69	83	104	104	104	104	114	119
Less Spares (20%)	1	2	2	3	6	8	9	12	12	13	16	20	20	20	20	22	23
BEB's to Charge Daily	5	12	12	16	24	34	40	51	51	56	67	84	84	84	84	92	96

Enclosed:

- 12 existing charging positions + 32 charging positions in expansion = 44 charging position x2 charging windows each evening = charging for **88 buses per night**

Outdoor / Canopy:

- 12 existing charging positions + 40 charging positions in expansion = 52 charging positions x2 charging windows each evening = charging for **104 buses per night**

Assumptions
Battery Size (40-foot bus): 466 kWh
Battery Size (60-foot bus): 660 kWh
State of Charge: 30%
Spares Ratio: 20%

This shows that the bus parking expansion option with a separate facility that is outdoor/canopy covered can accommodate the projected fleet with 40 new charging positions (each used to charge two buses per night) when combined with the 12 existing charging positions (each used to charge two buses per night). This would require buses to be moved each night (platooned) so that each dispenser can charge two buses during the nightly charging window.

Impact of Platooning or Automated Bus Yard

Exhibit 29 shows that half of the charging equipment and half of the power would be needed if an automated bus yard or platooning was implemented.

Exhibit 29: Charging Equipment and Power Needed

	Current Approach	Platooned Approach
Dispensers	96	46+
Charging Cabinets (2:1) 150 kW each	48	23+
Additional Power Needed (est.)	6.5 MW	3.0 MW+

Exhibit 30 was a preliminary projection of the number of chargers (2:1) and dispensers needed to accommodate the battery electric bus fleet as it grows. The estimate of probable construction cost shown later in this document confirms that approximately 10 chargers and 20 dispensers can be provided with the current budget for the facility expansion. This will accommodate the fleet through FY26 when additional chargers and dispensers will be needed.

Exhibit 30: Projected Equipment and Power Needed by Year

	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37
BEB Fleet Only																	
35' to 40' Electric	6	10	10	15	26	38	45	59	59	59	73	89	89	89	89	99	104
60' Electric	0	4	4	4	4	4	4	4	4	10	10	15	15	15	15	15	15
Subtotal	6	14	14	19	30	42	49	63	63	69	83	104	104	104	104	114	119
Less Spares (20%)	1	2	2	3	6	8	9	12	12	13	16	20	20	20	20	22	23
BEB's to Charge Daily	5	12	12	16	24	34	40	51	51	56	67	84	84	84	84	92	96
Chargers (2:1) 150 kW - Existing	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Chargers (2:1) 150 kW - New in Existing Parking										2	8	12	12	12	12	12	12
Chargers (2:1) 150 kW - New in Expansion				2	6	11	14	20	20	20	20	20	20	20	20	20	20
Total Chargers (2:1) 150 kW	6	6	6	8	12	17	20	26	26	28	34	38	38	38	38	38	38
Dispensers (Plug-in) - Existing	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Dispensers (Plug-in) - New in Existing Parking																	
Dispensers (Pantograph) - New in Expansion				4	12	22	28	40	40	40	40	40	40	40	40	40	40
Dispensers (Pantograph) - New in Existing Parking *										4	16	24	24	24	24	24	24
Total Dispensers	12	12	12	16	24	34	40	52	52	56	68	76	76	76	76	76	76
Total New Chargers 150 kW				2	6	11	14	20	20	22	28	32	32	32	32	32	32
Total New Power Needed (mW)				0.3	0.9	1.65	2.1	3	3	3.3	4.2	4.8	4.8	4.8	4.8	4.8	4.8
Charger @ $120,000				$ 240,000	$ 720,000	$ 1,320,000											
Dispenser @ $27,000				$ 108,000	$ 324,000	$ 594,000											
				$ 348,000	$ 1,044,000	$ 1,914,000											

* Start in Row D (5 - 8) and expand south to rows E, F, G, J, K, L

Years when platooning needed unless additional chargers & dispensers added

$2M max. for charging equipment

RESILIENCY STRATEGIES

There are multiple strategies that DASH can employ to ensure that future ZEB options are resilient to power outages. This includes redundant power feeds, photovoltaics ("solar panels"), battery storage, backup generators, on-route charging, charge management, and microgrids. With ample space, time, and funding, DASH can ensure that its ZE investments are protected and risks to service delivery goals and performs in an emergency. The goal of incorporating these strategies is two-fold:

- Ensure that backup power exists to meet service requirements in the event of short-term outages.
- Ensure that backup power exists to meet service requirements during a longer-term power outage.

Both of these items require further analysis of the demands of a ZEB fleet, the reliability of the utility, specific policies and requirements of the agency, and the risk tolerance of DASH. A more in-depth analysis of climate change threats would also be helpful to inform future investments.

The following sections detail the preliminary analysis of the potential benefits that some of these strategies can yield for DASH.

Redundant Power Feeds

Dominion is charged by the Virginia regulators with providing reliable power at a low cost. However, reliability differs from location to location. One option to increase reliability is to ask Dominion to provide fully redundant feeders from separate substations. This will take up additional space and increase costs, but this redundancy will enhance DASH's protection from any possible localized outages resulting from failures of a single substation or feeder. This option can sometimes be quite expensive, so it should be carefully evaluated and weighed against other alternatives.

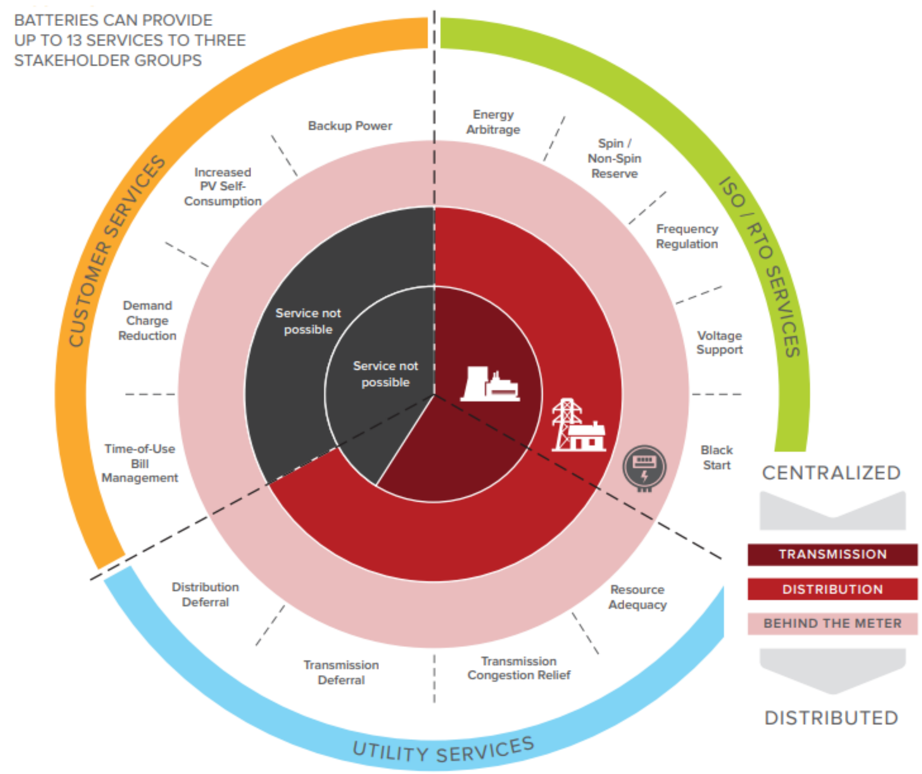
Battery Storage

Stationary batteries are used to store electrical energy at the facility for a limited duration. They can be used to provide emergency power during short outages but may not currently be cost effective as compared to alternative emergency power systems for power requirements exceeding one or more hours. With further advancements in battery technologies, this may be subject to change in the future. Batteries require a considerable amount of space, though they can also be elevated onto supporting steel since they have no moving parts.

Batteries can be used to flatten a facility's peak load throughout the day, resulting in potential operating cost and capital cost savings (assuming that the space and costs of higher voltage service exceeds that of a battery).

There is also potential to use stationary batteries as a source of revenue. Batteries can respond to changing electrical conditions on the grid very rapidly and can participate in markets operated by PJM Interconnection LLC, the regional transmission organization that coordinates the movement of wholesale electricity throughout Virginia (and 12 other states). For instance, DASH can operate stationary batteries during the day to participate in these electricity markets while then using the batteries to back up the BEB fleet at night.

RMI (formerly Rocky Mountain Institute) estimates that there are thirteen different services to customers (including airports), distribution utilities, and regional transmission organizations[1]. See the RMI graph of services below.



[1] https://rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf

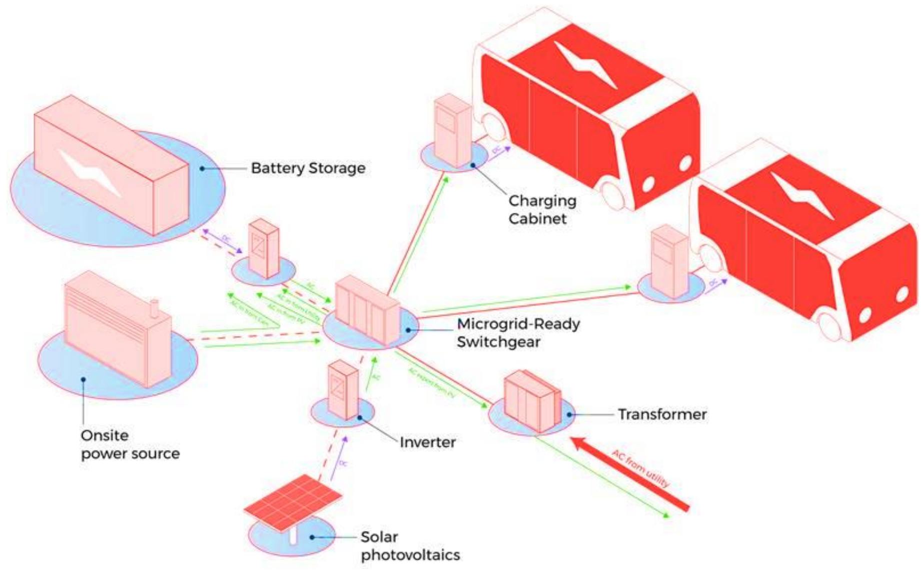
Photovoltaic Solar Power

Photovoltaics ("solar panels") can use solar energy to produce renewable and relatively cheap power when the sun is shining. Solar panels can be installed on top of buildings or on supporting steel above parked buses. Most solar installations are not designed to produce resilient power during an outage, but this can be done using a microgrid strategy. The amount of solar power produced by covering a bus parking area with solar is only a small fraction of the daily energy needed by the buses to charge the batteries. Therefore, there may be enough existing loads to absorb the solar energy during the day time, which is the most cost effective installation. Otherwise, the solar panels can be "net metered", which allows the solar power produced on site to export to the Dominion grid during the day for a credit towards electricity used for charging buses at night.

Microgrids

If on-site power generating assets are configured as a "microgrid", these assets can produce power during blackout conditions, and keep the fleet running despite any issues on the Dominion grid. The most common modern microgrid systems integrate a combination of solar, batteries, and natural gas generators. Additional options may include integrated diesel generators, gas turbines, gas engines, or stationary fuel cells depending on requirements. On-site power generation may generate power at a lower cost than purchasing from the grid, leading to long term reductions in operating costs. Due to the complexity of operations and revenue opportunities, WSP ZE Team recommends that third party ownership be considered for this type of asset. Exhibit 31 illustrates the components of a microgrid.

Exhibit 31: Microgrid Components



Source: WSP

Charge Management

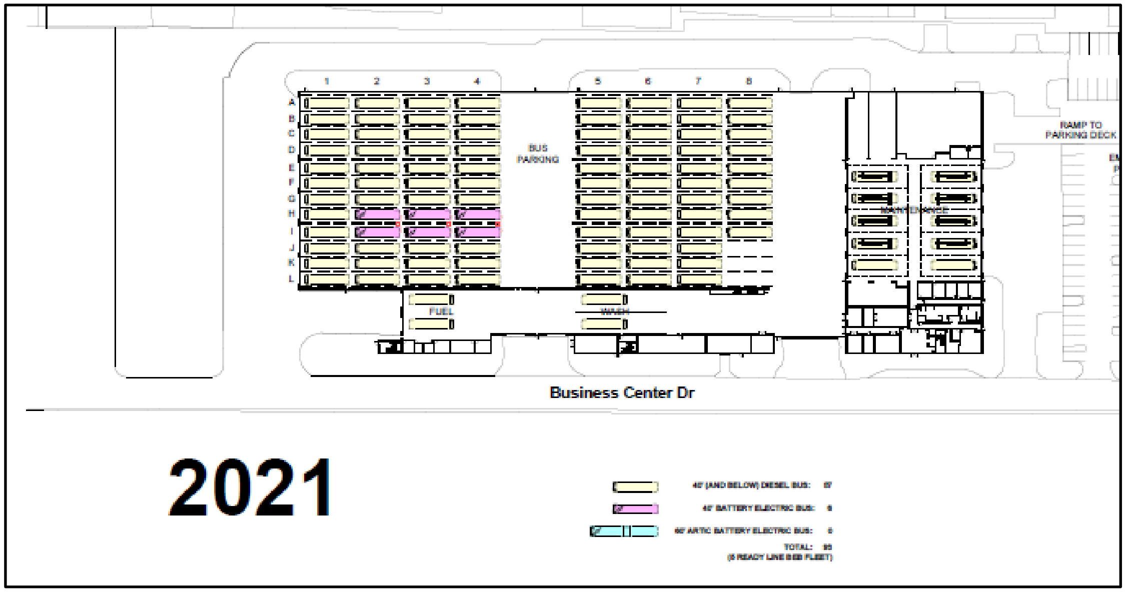
Charge management software ("CMS") is key to cost-effectively charge the fleet while maintaining service requirements. Electricity markets are constantly changing, and electricity rates change several times per day. The CMS software manages the charging loads to ensure pull-out each morning with the most advantageous operating costs. In addition, good software programs can earn revenues for DASH by performing grid services for Dominion and PJM, such as demand response, similar to the battery. DASH may want to consider third party ownership of the charge management system.

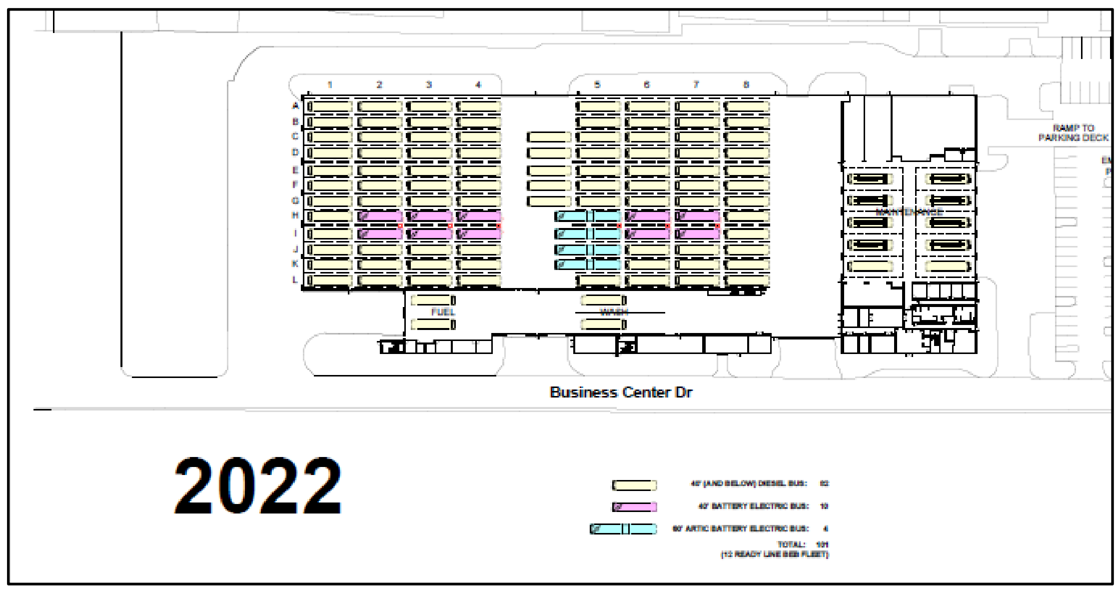
On-Route Charging

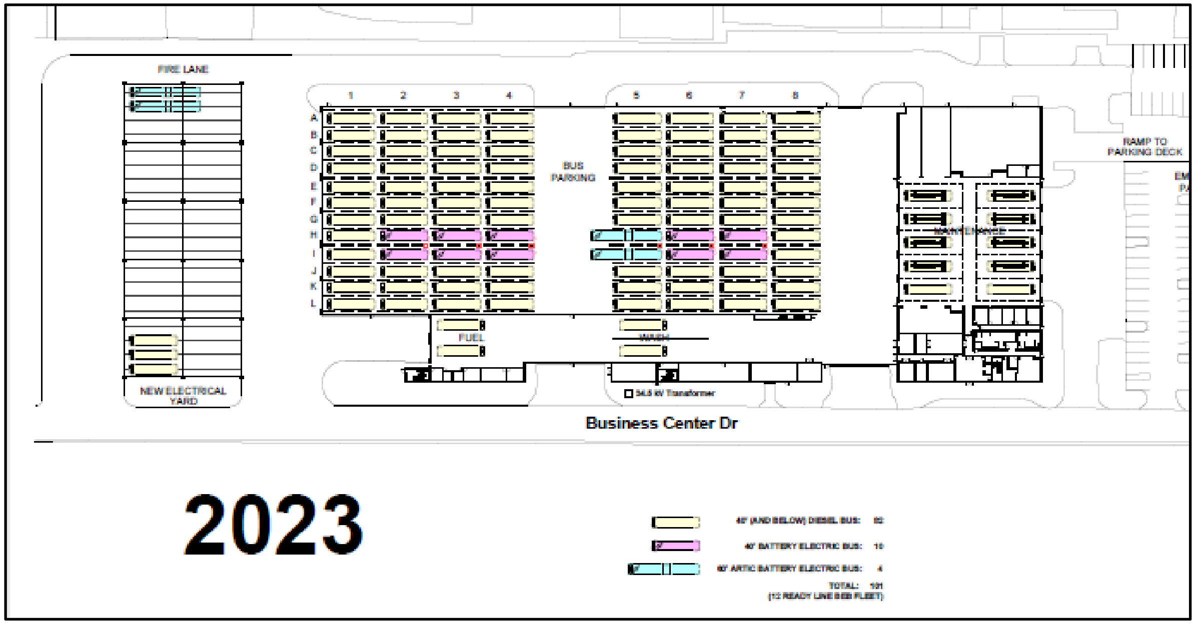
While on-route charging is not inherently resilient, incorporating on-route chargers as part of the ZEB strategy can potentially reduce the impact of localized power outages. In addition, they may lower the peak demand requirements at the facility, and if these chargers are powered by a smaller microgrid, they can support DASH's resiliency goals.

PHASING

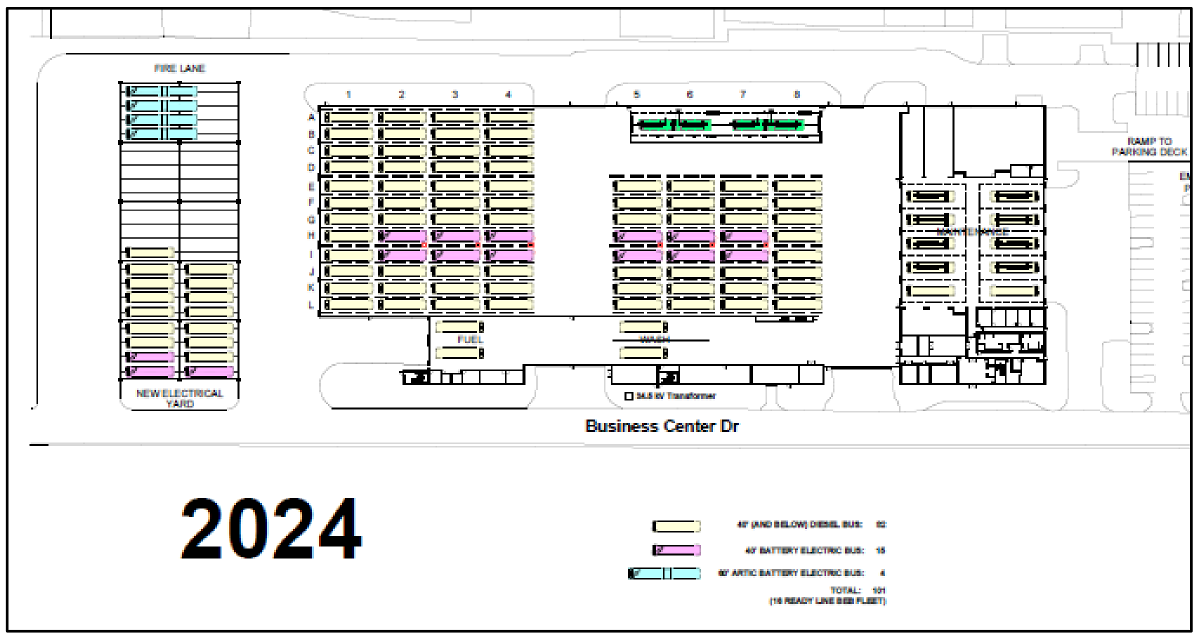
The following diagrams illustrate the proposed phasing as the fleet grows and transitions to battery electric buses.



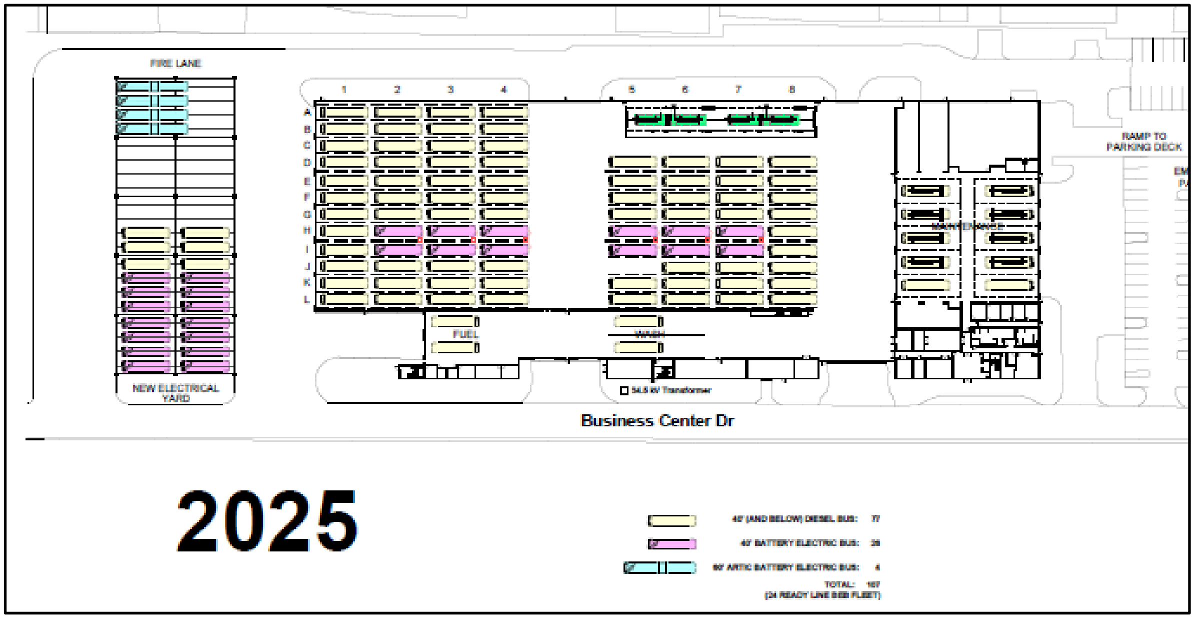


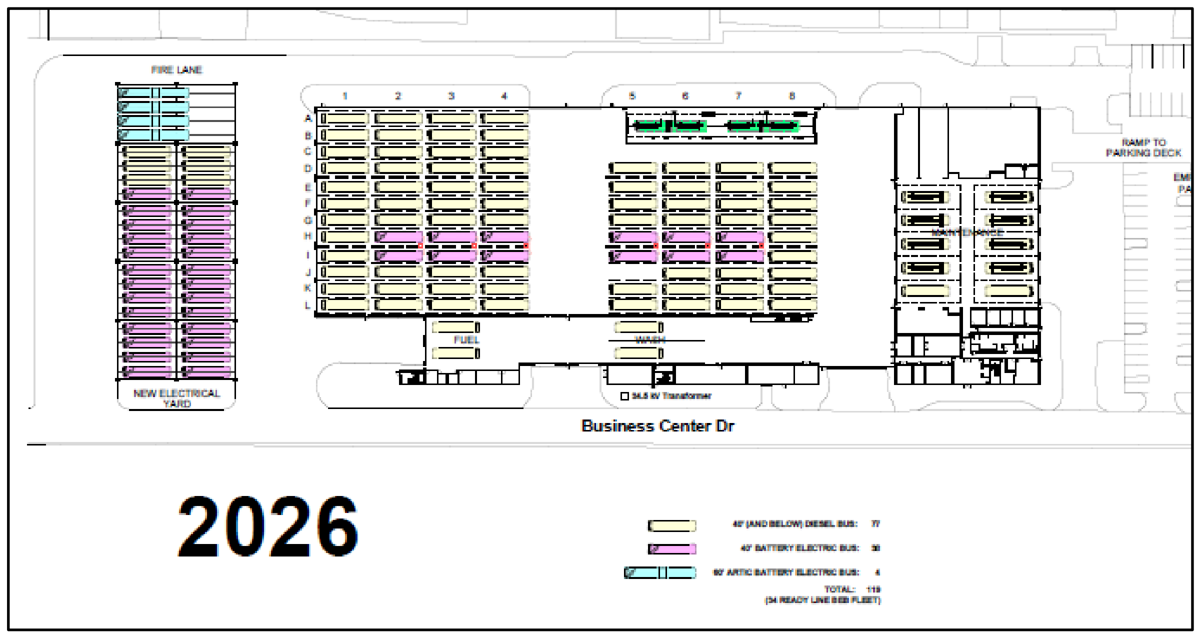


FIRE LANE
BUS PARKING
MAINTENANCE
RAMP TO PARKING DECK
FUEL
WASH
NEW ELECTRICAL YARD
34.5 kV Transformer
Business Center Dr
2023
40' (AND BELOW) DIESEL BUS:
40' BATTERY ELECTRIC BUS: 10
60' ARTIC BATTERY ELECTRIC BUS: 4
TOTAL: 101

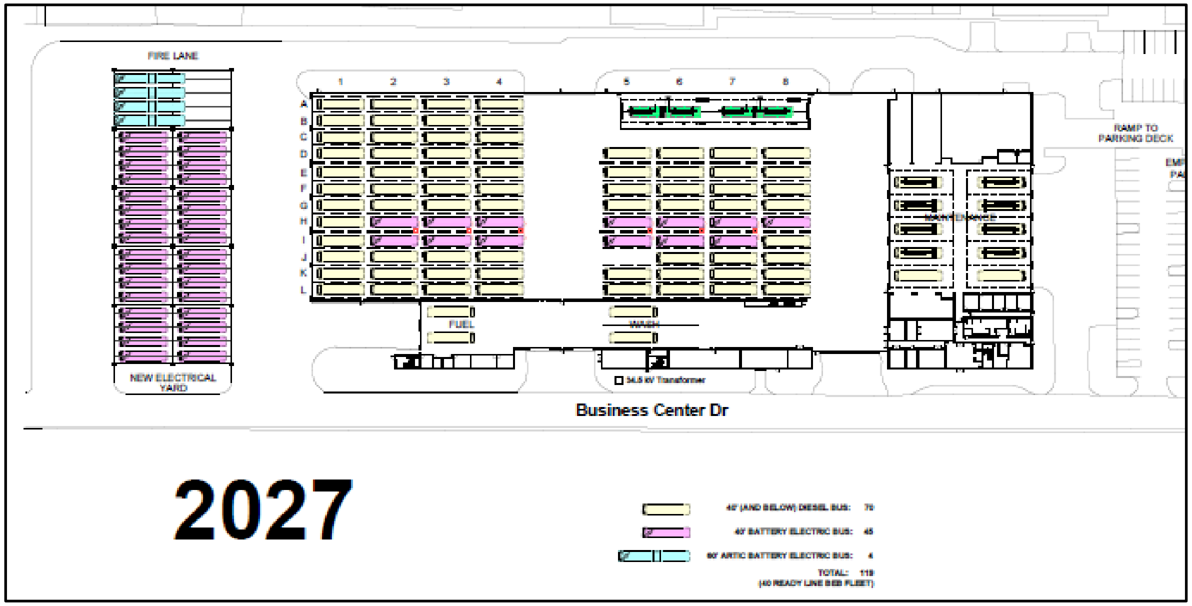


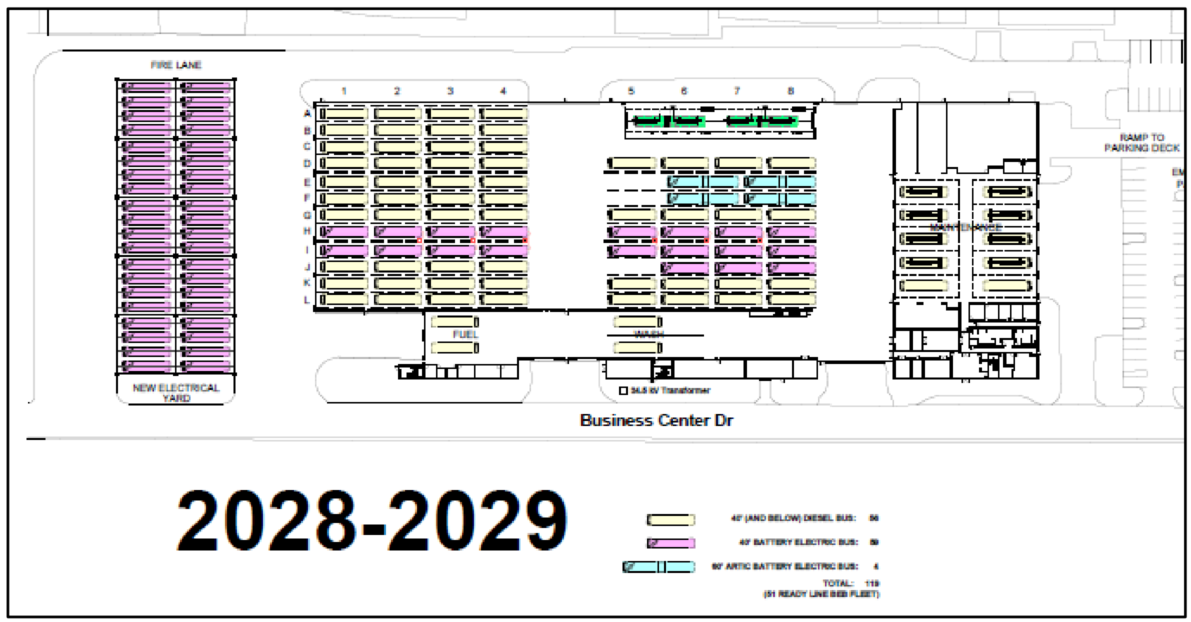
FIRE LANE
MAINTENANCE
RAMP TO PARKING DECK
FUEL
WASH
NEW ELECTRICAL YARD
34.5 kV Transformer
Business Center Dr
2024
40' (AND BELOW) DIESEL BUS:
40' BATTERY ELECTRIC BUS:
60' ARTIC BATTERY ELECTRIC BUS: 4
TOTAL: 101

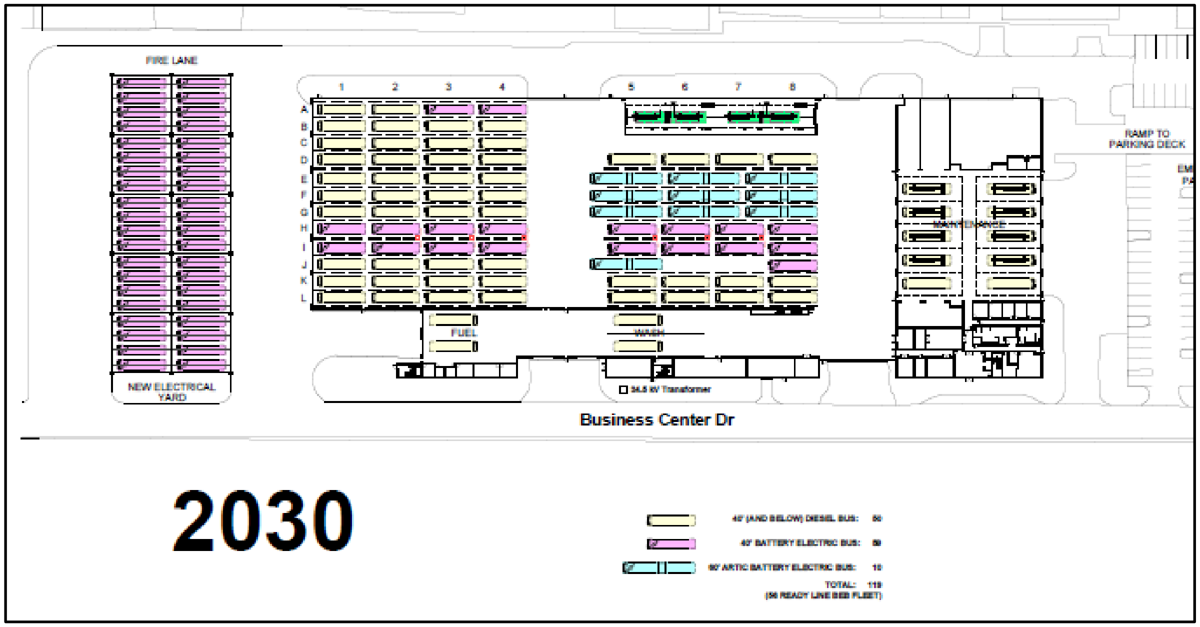

FIRE LANE
NEW ELECTRICAL YARD
FUEL
WASH
MAINTENANCE
RAMP TO PARKING DECK
Business Center Dr
2025
40' (AND BELOW) DIESEL BUS:
40' BATTERY ELECTRIC BUS:
60' ARTIC BATTERY ELECTRIC BUS:
TOTAL:

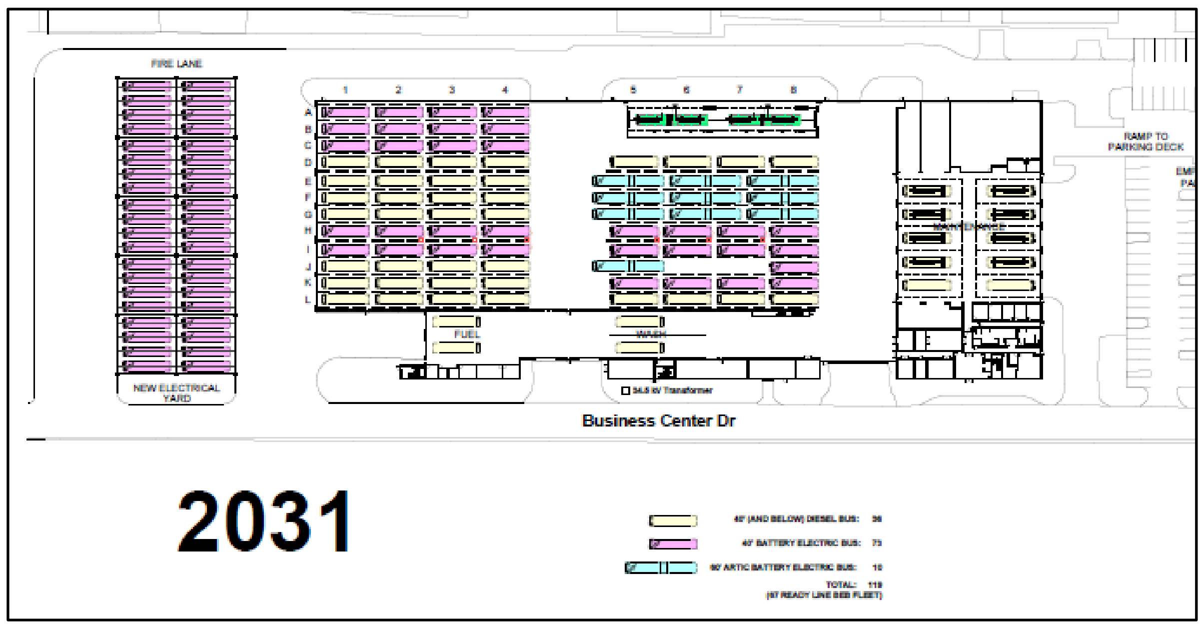

FIRE LANE
NEW ELECTRICAL YARD
FUEL
WASH
MAINTENANCE
RAMP TO PARKING DECK
Business Center Dr
2026
40' (AND BELOW) DIESEL BUS:
40' BATTERY ELECTRIC BUS:
60' ARTIC BATTERY ELECTRIC BUS:
TOTAL:

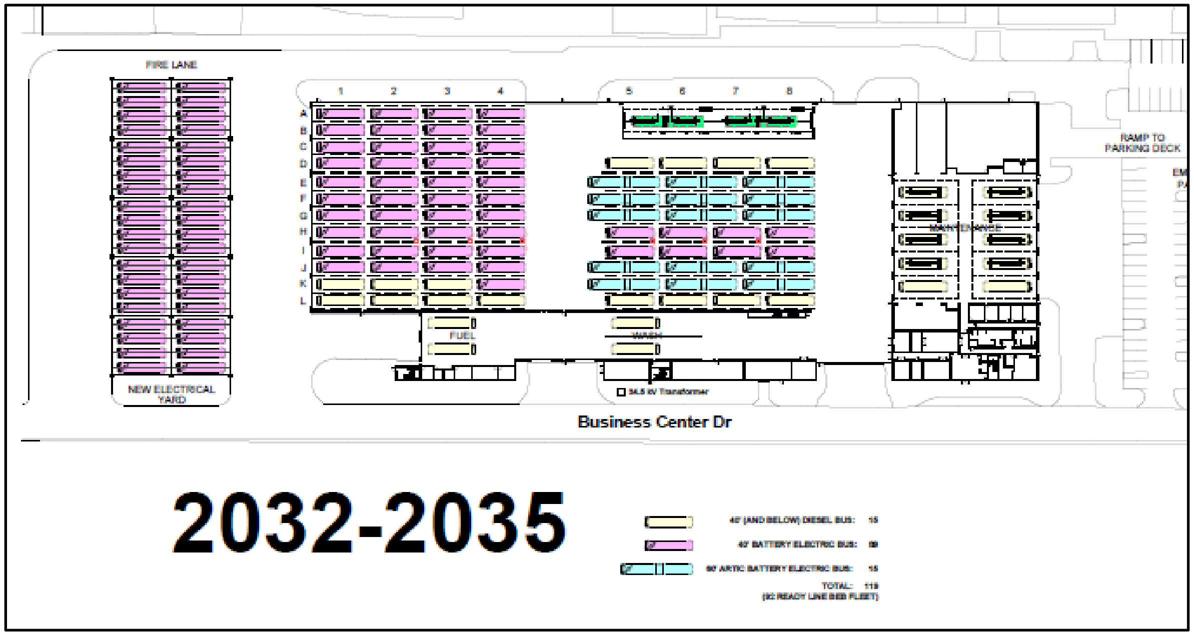
IMPLEMENTATION SCHEDULE



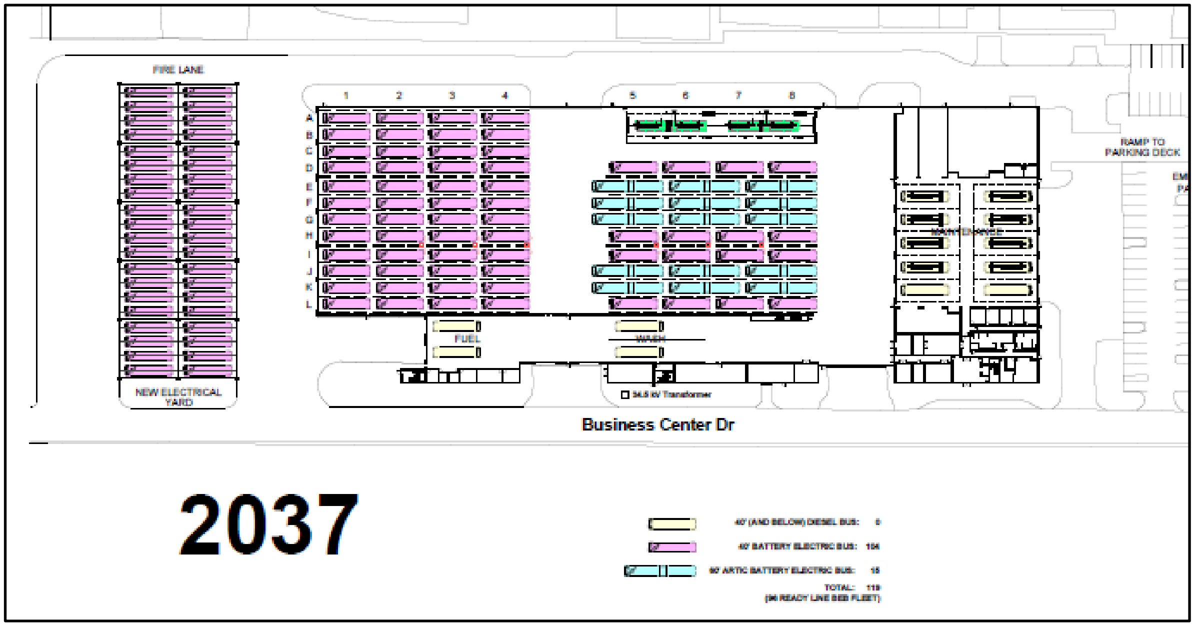


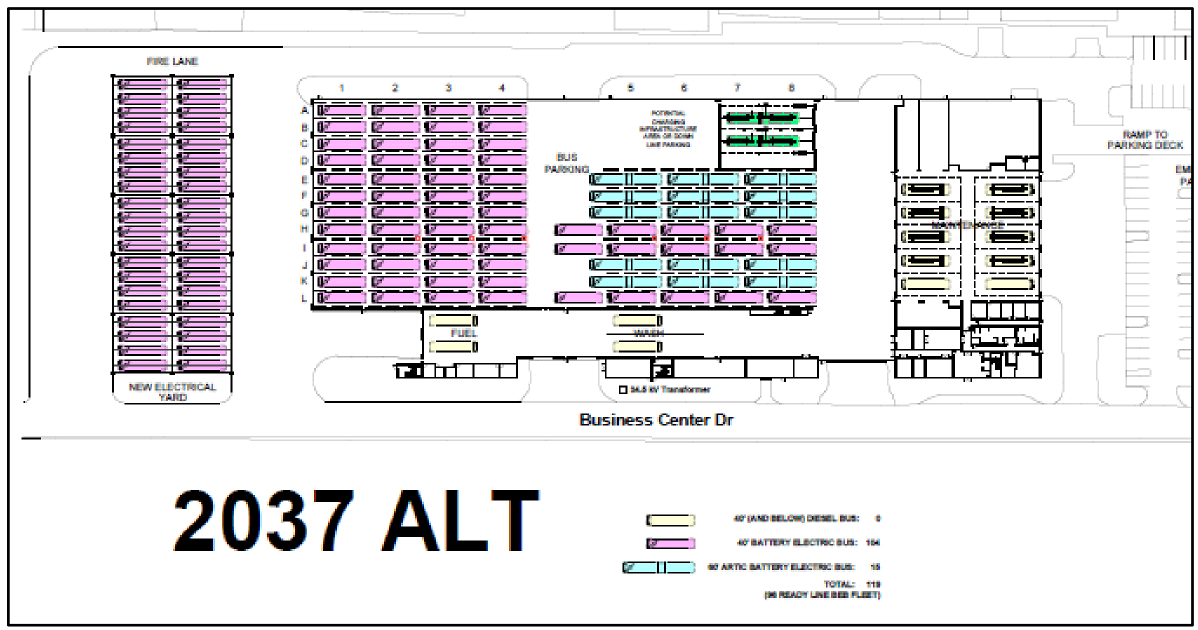

FIRE LANE
1
2
3
4
5
6
7
8
A
B
C
D
E
F
G
H
I
J
K
L
RAMP TO PARKING DECK
MAINTENANCE
FUEL
WASH
NEW ELECTRICAL YARD
34.5 kV Transformer
Business Center Dr
2030
40' (AND BELOW) DIESEL BUS:
40' BATTERY ELECTRIC BUS:
60' ARTIC BATTERY ELECTRIC BUS: 10
TOTAL: 119


FIRE LANE
1
2
3
4
5
6
7
8
A
B
C
D
E
F
G
H
I
J
K
L
RAMP TO PARKING DECK
MAINTENANCE
FUEL
WASH
NEW ELECTRICAL YARD
34.5 kV Transformer
Business Center Dr
2031
40' (AND BELOW) DIESEL BUS: 36
40' BATTERY ELECTRIC BUS: 73
60' ARTIC BATTERY ELECTRIC BUS: 10
TOTAL: 119


FIRE LANE
NEW ELECTRICAL YARD
FUEL
WASH
MAINTENANCE
RAMP TO PARKING DECK
Business Center Dr
2032-2035


FIRE LANE
NEW ELECTRICAL YARD
FUEL
WASH
MAINTENANCE
RAMP TO PARKING DECK
Business Center Dr
2036


FIRE LANE
NEW ELECTRICAL YARD
FUEL
WASH
MAINTENANCE
RAMP TO PARKING DECK
34.5 kV Transformer
Business Center Dr
2037
40' (AND BELOW) DIESEL BUS: 0
40' BATTERY ELECTRIC BUS: 104
60' ARTIC BATTERY ELECTRIC BUS: 15
TOTAL: 119


FIRE LANE
NEW ELECTRICAL YARD
BUS PARKING
FUEL
WASH
MAINTENANCE
RAMP TO PARKING DECK
34.5 kV Transformer
Business Center Dr
2037 ALT
40' (AND BELOW) DIESEL BUS: 0
40' BATTERY ELECTRIC BUS: 104
60' ARTIC BATTERY ELECTRIC BUS: 15
TOTAL: 119

IMPLEMENTATION SCHEDULE

Implementation Plan

The following is the proposed implantation schedule to provide the charging infrastructure to support the proposed ZEB fleet expansion.

FY 23: Complete Bus Parking Expansion (with 20 charging dispensers)

FY 24: Complete Maintenance Expansion

FY 25: Funding required for Additional Charging Capacity (20 additional charging dispensers)

FY 26: Add Charging Capacity in Bus Parking Expansion

FY 27: Evaluate Platooning / Automated Bus Yard

FY 28: Funding required for Additional Charging Capacity (if not platooning)

FY 31: Add Charging Capacity in Existing Bus Parking Area (if not platooning)

ESTIMATE OF PROBABLE CONSTRUCTION COST

INTRODUCTION

The estimate of probable construction cost presented in this section is based on the proposed concept design presented earlier in this report. The costs were developed for the following four scenarios:

- Partial Concrete Platform with 40 charging dispensers
- Full Concrete Platform with 40 charging dispensers
- Partial Concrete Platform with 20 charging dispensers
- Full Concrete Platform with 20 charging dispensers

DASH and the City of Alexandria have a budget of approximately $8.1 million for the proposed facility expansion and BEB charging infrastructure. This budget is split into two categories:

Facility Expansion ($6.1M)

- Grading, drainage, paving, striping
- Security (fencing, gates, access control)
- Steel structure, deck, and painting
- Lighting and low voltage systems (security, communications)
- Power (switchboard, conduit, wiring)
- Fees (Dominion, permitting, etc.)

BEB Charging Equipment ($2M)*

- Charging cabinets
- Dispensers (overhead inverted pantographs)

* *Possibly $2.3M to $2.4M*

Total ($8.1M)

- Including contingency and escalation

Possible Bid Alternates

- Maintenance expansion
- Maintenance equipment for expansion
- New lift in Chassis Wash for articulated buses
- Overhead crane

Not Included (see Appendix for more detailed listing)

- Design cost
- Hazardous material abatement
- Reconstruction of drive north of existing facility
- Off-site improvements
- Power resiliency
- Utility company (Dominion) back charges

A summary of the estimate of probable construction cost is shown in Exhibit 32. The detailed estimates are shown in the Appendix.

Exhibit 32: Estimate of Probable Construction Cost Summary

		40 Charging Dispensers (with full framework)		20 Charging Dispensers (with full framework)	
		Partial Concrete Platform	Full Concrete Platform	Partial Concrete Platform	Full Concrete Platform
Total (see Appendix)		$ 9,951,433	$ 10,239,767	$ 5,823,337	$ 6,111,671
Allowance for Grading + Drainage *		$ 500,000	$ 500,000	$ 500,000	$ 500,000
Allowance for Lighting + Low Voltage Systems *		$ 100,000	$ 100,000	$ 100,000	$ 100,000
Subtotal		$ 10,551,433	$ 10,839,767	$ 6,423,337	$ 6,711,671
Construction Contingency	10%	$ 1,055,143	$ 1,083,977	$ 642,334	$ 671,167
Owner's Contingency	10%	$ 1,055,143	$ 1,083,977	$ 642,334	$ 671,167
Escalation	3%	$ 316,543	$ 325,193	$ 192,700	$ 201,350
TOTAL		**$ 12,978,263**	**$ 13,332,913**	**$ 7,900,705**	**$ 8,255,355**

* *To be verified during next design phase*

Recommended

RECOMMENDATIONS

1. Use inverted overhead pantograph for all dispensers after the initial BEB project.
    a. Continue to use the 6 existing chargers and 12 existing plug-in dispensers.
2. Develop the facility expansion as an outdoor / covered space for up to 40 forty-foot battery electric buses with 12-foot wide spaces.
    a. Works with or without bus yard automation.
    b. Design to maximize use of available funding by:
        i. Full framework + Charging for as many chargers/dispensers as possible.
    c. Design with flexibility to allow framework to support a full roof, future installation of photo-voltaic panels, and enclosure of the space with overhead door access to bus parking on the east and west sides of the expansion.

    Note that the estimate of probable construction cost shown herein indicates that the full framework with a full roof (canopy) and 20 overhead inverted pantograph charging dispensers may be possible within the current budget.
3. Design to accommodate automated bus yard in the future.
4. Possibly replace the parallelogram lift in Chassis Wash with a similar lift that will accommodate articulated buses (and possibly add an overhead crane to accommodate removal of roof mounted equipment).
5. Develop two maintenance bays to accommodate articulated buses in the existing bus parking area (Option C.3 shown herein).
6. Follow the Implementation Plan outlined herein.
7. Determine the project delivery method to be used for developing the proposed facility expansion.
8. Consider authorizing Phase 2, Optional Tasks of the ZEB Implementation Study including:
    - Optional Task 1: Fleet Assessment
    - Optional Task 2: Fuel Assessment
    - Optional Task 3: Maintenance Assessment
    - Optional Task 4: Evaluation of Utility Grid Infrastructure and Sufficiency
    - Optional Task 5: Total Cost of Ownership Analysis
    - Optional Task 6: ZEB Pilot Analysis
9. Consider either as an extension of the ZEB Implementation Study contract or as a separate contract, refine the concept design presented herein to include:
    a. A boundary and topographic survey of the project site and surrounding area.
    b. Geotechnical investigation of the project site to determine the foundation and pavement requirements for the proposed expansion.
    c. Confirmation that hazardous materials do not exist on the project site, and if so, identify required remediation measures.
    d. Coordination with flood control measures that are in-progress.
    e. Identifying how to achieve the City's sustainability goal of LEED v4 Gold Level Certification for the proposed expansion.
    f. Coordination with Dominion to provide the necessary power to accommodate the proposed facility expansion to support the charging infrastructure for 40 additional battery electric buses. (Note that this is essentially Phase 2, Optional Task 4 above).
    g. Development of detailed design criteria for the proposed facility expansion.
    h. Refinement of the estimate of probable construction cost based on the refined conceptual design.
    i. Development of design-build bridging documents (if a design-build project delivery method is selected, like the way the DASH facility was developed).

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APPENDIX

APPENDIX: DETAILED ESTIMATES OF PROBABLE CONSTRUCTION COST

INTRODUCTION

The detailed estimates of probable construction cost are presented in this Appendix.

The estimated costs are derived from the following:

- The conceptual layouts presented in this report
- WSP experience with similar projects across North America

Assumptions

1. Estimates based on Means Building Construction Costs adjusted for Alexandria, Virginia project location
2. Rates include material and labor
3. General Contractors and Subcontractor's mark-ups have been included
4. Design Contingency is applied to account for the conceptual nature of the design to allow for unforeseen design issues. Note that this contingency should be reduced as the design progresses.
5. General Conditions and Requirements, Insurance, Bonds, and Overhead and Profit are included as a percentage of construction cost.

Not Included:

1. Hazardous material abatement
2. Environmental studies / improvements
3. Site drainage or other utility improvements (other than electrical)
4. Charge management software / subscriptions
5. Video and/or security upgrades
6. Construction contingency
7. Owner's contingency
8. Portable chargers for maintenance bays
9. New maintenance bays (and associated equipment) for articulated buses
10. New parallelogram vehicle lift to accommodate articulated buses in Chassis Wash
11. Interest expense
12. Owner's project administration
13. Architect / Engineer (A/E) fees
14. Construction of temporary facilities
15. Relocation expenses
16. Printing and advertising
17. Specialties, loose furnishings, fixtures, and equipment beyond what is noted
18. Sitework
19. Utility company back charges
20. Testing and inspections
21. Reconstruction of drive north of existing DASH building
22. Off-site improvements
23. Power resiliency (solar panels, microgrids, etc.)

A summary of the estimate of probable construction cost is shown on the next page followed by detailed cost breakdowns for:

- Partial Concrete Platform with 40 charging dispensers (Page A.3)
- Full Concrete Platform with 40 charging dispensers (Page A.7)
- Partial Concrete Platform with 20 charging dispensers (Page A.11)
- Full Concrete Platform with 20 charging dispensers (Page A.15)

ESTIMATE OF PROBABLE CONSTRUCTION COST SUMMARY

		40 Charging Dispensers (with full framework)		20 Charging Dispensers (with full framework)	
		Partial Concrete Platform	Full Concrete Platform	Partial Concrete Platform	Full Concrete Platform
Total (see Appendix)		$ 9,951,433	$ 10,239,767	$ 5,823,337	$ 6,111,671
Allowance for Grading + Drainage *		$ 500,000	$ 500,000	$ 500,000	$ 500,000
Allowance for Lighting + Low Voltage Systems *		$ 100,000	$ 100,000	$ 100,000	$ 100,000
Subtotal		$ 10,551,433	$ 10,839,767	$ 6,423,337	$ 6,711,671
Construction Contingency	10%	$ 1,055,143	$ 1,083,977	$ 642,334	$ 671,167
Owner's Contingency	10%	$ 1,055,143	$ 1,083,977	$ 642,334	$ 671,167
Escalation	3%	$ 316,543	$ 325,193	$ 192,700	$ 201,350
TOTAL		**$ 12,978,263**	**$ 13,332,913**	**$ 7,900,705**	**$ 8,255,355**

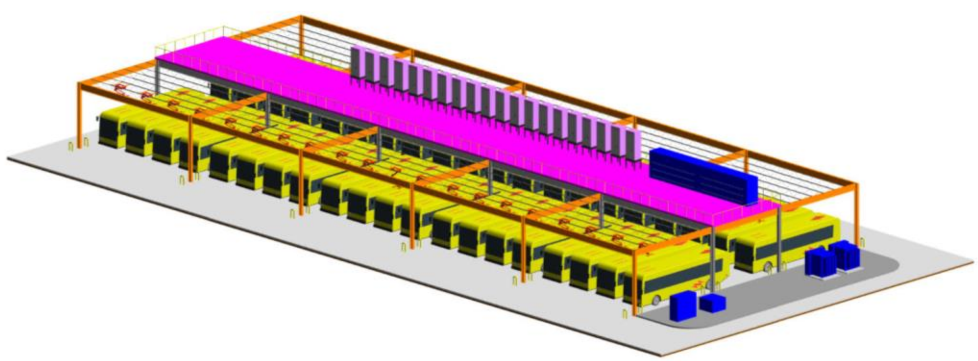
* *To be verified during next design phase*

Recommended

PARTIAL CONCRETE PLATFORM WITH 40 CHARGING DISPENSERS

EXECUTIVE SUMMARY

				TOTAL
A	**Charging Equipment**			$3,981,504
B	**Charging Infrastructure Support**			$1,403,922
C	**Support Frame**			$1,047,899
		Sub-total	-	**$6,433,324**
		Design Contingency	**20.0%**	$1,286,665
		Design Contingency sub-total		**$1,286,665**
				$7,719,989
	Markups			
	General Conditions and Requirements		12.0%	$926,399
	Insurance		0.75%	$57,900
	Bond		1.5%	$115,800
	Overhead and Profit		12.5%	$964,999
	Estimated Contract Award, Jan 2021			**$9,785,086**
	Pre- and Post-Construction Expenses ("Soft Costs")		1.7%	**$166,346**
	GRAND TOTAL			**$9,951,433**



CHARGING EQUIPMENT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
CHARGING EQUIPMENT					
DC Charging Cabinets and Pantographs					
DC Charging Cabinet - 150kW (includes DC switch)	20	EA	$124,000.00	$115,568	$2,311,360
Pantograph (includes charge control module)	40	EA	$27,000.00	$25,164	$1,006,560
Energy Storage					
Energy Storage Container - 2 MW (includes support equipment)	-	EA	$2,000,000.00	$1,864,000	$0
Installation					
Equipment Install - 20% of Equipment Cost	1		$663,584.00		$663,584

TO SUMMARY	**$3,981,504**

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 02 - DEMOLITION					
024119 Selective Demolition, Cutout					
Medium Voltage Utiity Switch / Interrupter to Transformer	881	CF	$36.00	$34	$29,568
DIVISION 03 - CONCRETE					
033000 Cast-In-Place Concrete (GC)					
Field surveys and verification	80	HRS	$95.00	$89	$7,083
033053 Miscellaneous Cast-In-Place Concrete					
CIP Concrete housekeeping pad					
at utility switch / Interrupter / XRFM curb	45	CY	$330.00	$308	$13,710
DIVISION 26 - ELECTRICAL					
260513 Medium Voltage Single Cables					
AC Utility Power Cable 750 Kcmil MV- 90 cable (1 set - 5 cables) - Interrupter to Medium Voltage Switchgear	1	CLF	$3,500.00	$3,262	$3,262
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Medium Voltage Switchgear to Low Voltage Transformer (12.7 kV - 480/277V)	5	CLF	$1,150.00	$1,072	$5,493
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Low Voltage Transformer to Distribution Panel (LVSG) (12.7 kV - 480/277V)	9	CLF	$1,151.00	$1,073	$10,084
260519 Low Voltage Electrical Power Conductors and Cables					
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG	182	CLF	$790.00	$736	$134,021
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG GND	61	CLF	$791.00	$737	$44,730
DC Power Cable Conductors (Positive and Negative) - Charging Cabinet to Pantographs	200	CLF	$790.00	$736	$147,492
DC Power - Interlocl - #19AWG - Charging Cabinet to Dispenser	100	CLF	$78.00	$73	$7,281
DC Power - Ground - #6AWG - Charging Cabinet to Dipenser	50	CLF	$155.00	$144	$7,235
DC Power - Aux Power #12 AWG - Aux Panel to Dispenser	50	CLF	$78.00	$73	$3,641
DC Power - Aux Power #12 AWG GND - Aux Panel To Dispenser	25	CLF	$78.00	$73	$1,820
260539 Underfloor Raceways for Electrical Systems					
6" Metal conduit Utility Interrupter to Medium Voltage Switchgear/Transformer	123	LF	$79.50	$74	$9,077
6" Metal conduit Low Voltage Transformer to Distribution Panel (LVSG)	188	LF	$79.50	$74	$13,930

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
260536 Cable Trays For Electrical Systems					
Aluminum DC Cable Tray 18" wide	801	LF	$24.85	$23.16	$18,551
Aluminum DC Cable Tray 24" wide	801	LF	$28.20	$26	$21,052
Aluminum AC Cable Tray 24" wide	467	LF	$28.20	$26	$12,274
Liquid- Tite Flex	47	LF	$25.00	$23	$1,095
Medium Voltage Switchgear					
5 - Way 12.4 kV, 600A, 23 kAIC	1	EA	$70,000.00	$65,240	$65,240
Transformer					
Medium Voltage to Low Voltage Transformer , 3000 kVA	2	EA	$20,000.00	$18,640	$37,280
Low Voltage Distribution Panel/ Switchboard					
6000A, 480/277 V, 4W, 100 kAIC at 480 Vac	2	EA	$165,000.00	$153,780	$307,560
Grounding & Testing	1	EA	$7,500.00	$6,990	$6,990
DIVISION 27 - COMMUNICATIONS					
271323 Communications Optical Fiber Backbone Cabling					
DC Data/Communication 8x Glass Fiber	2,504	LF	$210.00	$196	$490,083
DIVISION 31 - EARTHWORK					
Trenching / Excavation					
Transformer to Column	33	CY	$8.85	$8	$269
Backfill trench					
Transformer to Column	33	CY	$4.25	$4	$129
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	33	CY	$14.80	$14	$450
DIVISION 32 - EXTERIOR IMPROVEMENTS					
321313 - Concrete Paving					
Transformer to Column	43	SY	$38.00	$35	$1,540
DIVISION 33 - EXTERIOR IMPROVEMENTS					
337119 Electrical Underground Ducts and Manholes					
Handholes, pre-cast concrete, with concrete cover	2	EA	$1,600.00	$1,491	$2,982
TO SUMMARY					**$1,403,922**

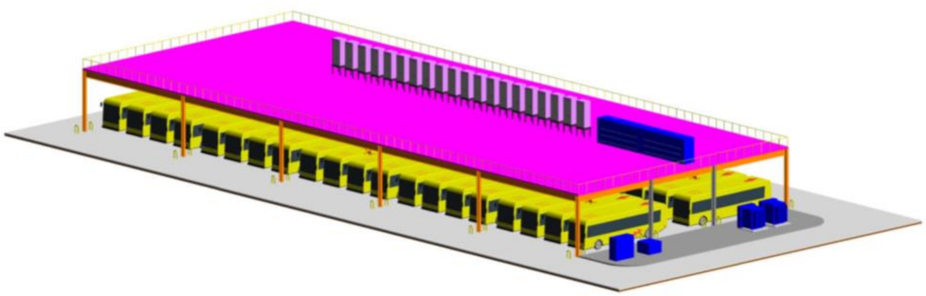
OVERHEAD SUPPORT STRUCTURE

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 03 - CONCRETE					
033053 Miscellaneous Cast-In-Place Concrete					
Regular concrete (4000 psi), 6" slab	7,500	SF	$4.56	$4	$31,874
321313.23 Concrete Paving Surface Treatment					
Conc. Pavement , fix form 24' pass, unreinforced , 8" thick	4,358	SY	$31.32	$29	$127,225
Reinforcing steel, 12 lb. / S.Y	4,358	SY	$7.32	$7	$29,734
DIVISION 05 - METALS					
050001 Miscellaneous and Ornamental Iron					
2' Wide U- Bollard	48	EA	$400.00	$373	$17,894
051200 Structural Steel					
Conduit support rack; galvanized	250	LF	$15.00	$14	$3,501
W12x120 Columns	236	LF	$202.00	$188	$44,336
W12x190 Columns	236	LF	$315.00	$294	$69,138
W8x8x1/8 Cross Bracing Columns / K- Bracing	180	LF	$71.43	$67	$11,983
W21x50 Beams (Platform frame Infill Beam)	1,250	LF	$90.00	$84	$104,850
W27x102 Beams (Open Frame Beam and Platform Frame Beam)	680	LF	$194.00	$181	$122,949
W24x 84 Beams (Open Frame Beam)	420	LF	$145.00	$135.14	$56,759
W27x146 Beams (Platform Frame Beam)	500	LF	$246.00	$229	$114,636
052119 Open Web Steel Joist Framing					
28LH09 Subframe Infill joist (panto only)	3,000	LF	$100.00	$93	$279,600
053113 Steel Floor Decking					
1.5" Steel Decking, 16 ga.	7,500	SF	$4.54	$4	$31,735
DIVISION 09 - FINISHES					
090007 Painting					
Prep & Paint columns & steel framing (not open web joists)	23,273	SF	$4.50	$4	$97,606
DIVISION 31 - EARTHWORK					
316326 Drilled Caissons					
Fixed end caisson pile, open, machine drilled, in stable ground, no casings or ground water, 48" diameter	720	LF	$134.00	$125	$89,919
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	217	CY	$14.80	$14	$2,992
BUSH MAIN- METAL RAILINGS					
055213 Railings, Pipe					
Galvanized, 1-1/2" diameter	560	LF	$67.00	$62	$34,969
Guard Rail	3	EA	$522.00	$487	$1,460
BUSH MAIN- METAL STAIRS					
055113 Metal Pan Stairs					
Metal Pan tread for concrete in-fill, picket rail 3'6" wide	105	Riser	$700.00	$652	$68,502
				TO SUMMARY	**$1,047,899**

FULL CONCRETE PLATFORM WITH 40 CHARGING DISPENSERS

EXECUTIVE SUMMARY

				TOTAL
A	**Charging Equipment**			$3,981,504
B	**Charging Infrastructure Support**			$1,403,922
C	**Support Frame**			$1,234,299
		Sub-total	**-**	**$6,619,724**
		Design Contingency	**20.0%**	$1,323,945
		Design Contingency sub-total		**$1,323,945**
				$7,943,669
	Markups			
	General Conditions and Requirements		12.0%	$953,240
	Insurance		0.75%	$59,578
	Bond		1.5%	$119,155
	Overhead and Profit		12.5%	$992,959
	Estimated Contract Award, Jan 2021			**$10,068,601**
	Pre- and Post-Construction Expenses ("Soft Costs")		1.7%	**$171,166**
	GRAND TOTAL			**$10,239,767**



CHARGING EQUIPMENT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
CHARGING EQUIPMENT					
DC Charging Cabinets and Pantographs					
DC Charging Cabinet - 150kW (includes DC switch)	20	EA	$124,000.00	$115,568	$2,311,360
Pantograph (includes charge control module)	40	EA	$27,000.00	$25,164	$1,006,560
Energy Storage					
Energy Storage Container - 2 MW (includes support equipment)	-	EA	$2,000,000.00	$1,864,000	$0
Installation					
Equipment Install - 20% of Equipment Cost	1		$663,584.00		$663,584

TO SUMMARY	**$3,981,504**

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 02 - DEMOLITION					
024119 Selective Demolition, Cutout					
Medium Voltage Utiity Switch / Interrupter to Transformer	881	CF	$36.00	$34	$29,568
DIVISION 03 - CONCRETE					
033000 Cast-In-Place Concrete (GC)					
Field surveys and verification	80	HRS	$95.00	$89	$7,083
033053 Miscellaneous Cast-In-Place Concrete					
CIP Concrete housekeeping pad					
at utility switch / Interrupter / XRFM curb	45	CY	$330.00	$308	$13,710
DIVISION 26 - ELECTRICAL					
260513 Medium Voltage Single Cables					
AC Utility Power Cable 750 Kcmil MV- 90 cable (1 set - 5 cables) - Interrupter to Medium Voltage Switchgear	1	CLF	$3,500.00	$3,262	$3,262
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Medium Voltage Switchgear to Low Voltage Transformer (12.7 kV - 480/277V)	5	CLF	$1,150.00	$1,072	$5,493
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Low Voltage Transformer to Distribution Panel (LVSG) (12.7 kV - 480/277V)	9	CLF	$1,151.00	$1,073	$10,084
260519 Low Voltage Electrical Power Conductors and Cables					
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG	182	CLF	$790.00	$736	$134,021
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG GND	61	CLF	$791.00	$737	$44,730
DC Power Cable Conductors (Positive and Negative) - Charging Cabinet to Pantographs	200	CLF	$790.00	$736	$147,492
DC Power - Interlocl - #19AWG - Charging Cabinet to Dispenser	100	CLF	$78.00	$73	$7,281
DC Power - Ground - #6AWG - Charging Cabinet to Dipenser	50	CLF	$155.00	$144	$7,235
DC Power - Aux Power #12 AWG - Aux Panel to Dispenser	50	CLF	$78.00	$73	$3,641
DC Power - Aux Power #12 AWG GND - Aux Panel To Dispenser	25	CLF	$78.00	$73	$1,820
260539 Underfloor Raceways for Electrical Systems					
6" Metal conduit Utility Interrupter to Medium Voltage Switchgear/Transformer	123	LF	$79.50	$74	$9,077
6" Metal conduit Low Voltage Transformer to Distribution Panel (LVSG)	188	LF	$79.50	$74	$13,930

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
260536 Cable Trays For Electrical Systems					
Aluminum DC Cable Tray 18" wide	801	LF	$24.85	$23.16	$18,551
Aluminum DC Cable Tray 24" wide	801	LF	$28.20	$26	$21,052
Aluminum AC Cable Tray 24" wide	467	LF	$28.20	$26	$12,274
Liquid- Tite Flex	47	LF	$25.00	$23	$1,095
Medium Voltage Switchgear					
5 - Way 12.4 kV, 600A, 23 kAIC	1	EA	$70,000.00	$65,240	$65,240
Transformer					
Medium Voltage to Low Voltage Transformer , 3000 kVA	2	EA	$20,000.00	$18,640	$37,280
Low Voltage Distribution Panel/ Switchboard					
6000A, 480/277 V, 4W, 100 kAIC at 480 Vac	2	EA	$165,000.00	$153,780	$307,560
Grounding & Testing	1	EA	$7,500.00	$6,990	$6,990
DIVISION 27 - COMMUNICATIONS					
271323 Communications Optical Fiber Backbone Cabling					
DC Data/Communication 8x Glass Fiber	2,504	LF	$210.00	$196	$490,083
DIVISION 31 - EARTHWORK					
Trenching / Excavation					
Transformer to Column	33	CY	$8.85	$8	$269
Backfill trench					
Transformer to Column	33	CY	$4.25	$4	$129
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	33	CY	$14.80	$14	$450
DIVISION 32 - EXTERIOR IMPROVEMENTS					
321313 - Concrete Paving					
Transformer to Column	43	SY	$38.00	$35	$1,540
DIVISION 33 - EXTERIOR IMPROVEMENTS					
337119 Electrical Underground Ducts and Manholes					
Handholes, pre-cast concrete, with concrete cover	2	EA	$1,600.00	$1,491	$2,982
TO SUMMARY					**$1,403,922**

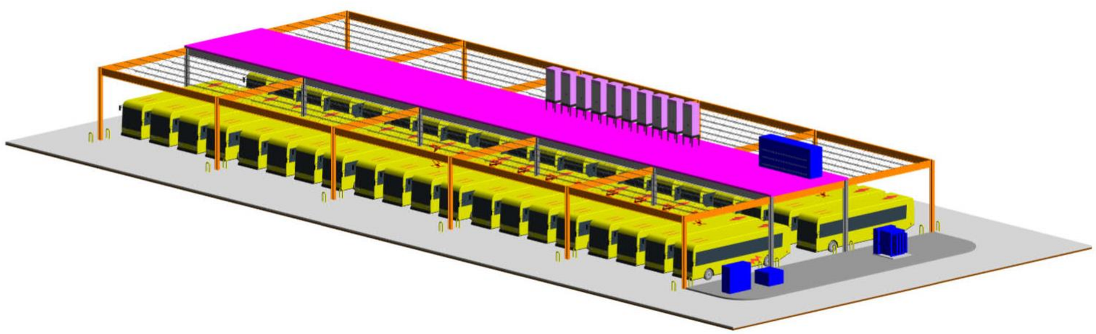
OVERHEAD SUPPORT STRUCTURE

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 03 - CONCRETE					
033053 Miscellaneous Cast-In-Place Concrete					
Regular concrete (4000 psi), 6" slab	25,250	SF	$4.56	$4	$107,310
321313.23 Concrete Paving Surface Treatment					
Conc. Pavement , fix form 24' pass, unreinforced , 8" thick	4,358	SY	$31.32	$29	$127,225
Reinforcing steel, 12 lb. / S.Y	4,358	SY	$7.32	$7	$29,734
DIVISION 05 - METALS					
050001 Miscellaneous and Ornamental Iron					
2' Wide U- Bollard	48	EA	$400.00	$373	$17,894
051200 Structural Steel					
Conduit support rack; galvanized	250	LF	$15.00	$14	$3,501
W12x190 Columns	471	LF	$315.00	$294	$138,276
W8x8x1/8 Cross Bracing Columns / K- Bracing	180	LF	$71.43	$67	$11,983
W21x50 Beams (Platform frame Infill Beam)	4,250	LF	$90.00	$84	$356,490
W27x102 Beams (Open Frame Beam and Platform Frame Beam)	600	LF	$194.00	$181	$108,485
W27x146 Beams (Platform Frame Beam)	1,000	LF	$246.00	$229	$229,272
052119 Open Web Steel Joist Framing					
28LH09 Subframe Infill joist (panto only)	-	LF	$100.00	$93	$0
053113 Steel Floor Decking					
1.5" Steel Decking, 16 ga.	25,250	SF	$4.54	$4	$106,840
DIVISION 09 - FINISHES					
090007 Painting					
Prep & Paint columns & steel framing (not open web joists)	40,211	SF	$4.50	$4	$168,646
DIVISION 31 - EARTHWORK					
316326 Drilled Caissons					
Fixed end caisson pile, open, machine drilled, in stable ground, no casings or ground water, 48" diameter	720	LF	$134.00	$125	$89,919
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	217	CY	$14.80	$14	$2,992
BUSH MAIN- METAL RAILINGS					
055213 Railings, Pipe					
Galvanized, 1-1/2" diameter	702	LF	$67.00	$62	$43,836
Guard Rail	3	EA	$522.00	$487	$1,460
BUSH MAIN- METAL STAIRS					
055113 Metal Pan Stairs					
Metal Pan tread for concrete in-fill, picket rail 3'6" wide	105	Riser	$700.00	$652	$68,502
				TO SUMMARY	**$1,234,299**

PARTIAL CONCRETE PLATFORM WITH 20 CHARGING DISPENSERS

EXECUTIVE SUMMARY

				TOTAL
A	**Charging Equipment**			$1,990,752
B	**Charging Infrastructure Support**			$725,975
C	**Support Frame**			$1,047,899
		Sub-total	-	**$3,764,625**
		Design Contingency	**20.0%**	$752,925
		Design Contingency sub-total		**$752,925**
				$4,517,550
	Markups			
	General Conditions and Requirements		12.0%	$542,106
	Insurance		0.75%	$33,882
	Bond		1.5%	$67,763
	Overhead and Profit		12.5%	$564,694
	Estimated Contract Award, Jan 2021			**$5,725,995**
	Pre- and Post-Construction Expenses ("Soft Costs")		1.7%	**$97,342**
	GRAND TOTAL			**$5,823,337**



CHARGING EQUIPMENT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
CHARGING EQUIPMENT					
DC Charging Cabinets and Pantographs					
DC Charging Cabinet - 150kW (includes DC switch)	10	EA	$124,000.00	$115,568	$1,155,680
Pantograph (includes charge control module)	20	EA	$27,000.00	$25,164	$503,280
Energy Storage					
Energy Storage Container - 2 MW (includes support equipment)	-	EA	$2,000,000.00	$1,864,000	$0
Installation					
Equipment Install - 20% of Equipment Cost	1		$331,792.00		$331,792

TO SUMMARY	**$1,990,752**

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 02 - DEMOLITION					
024119 Selective Demolition, Cutout					
Medium Voltage Utiity Switch / Interrupter to Transformer	720	CF	$36.00	$34	$24,157
DIVISION 03 - CONCRETE					
033000 Cast-In-Place Concrete (GC)					
Field surveys and verification	80	HRS	$95.00	$89	$7,083
033053 Miscellaneous Cast-In-Place Concrete					
CIP Concrete housekeeping pad					
at utility switch / Interrupter / XRFM curb	45	CY	$330.00	$308	$13,710
DIVISION 26 - ELECTRICAL					
260513 Medium Voltage Single Cables					
AC Utility Power Cable 750 Kcmil MV- 90 cable (1 set - 5 cables) - Interrupter to Medium Voltage Switchgear	1	CLF	$3,500.00	$3,262	$3,262
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Medium Voltage Switchgear to Low Voltage Transformer (12.7 kV - 480/277V)	2	CLF	$1,150.00	$1,072	$2,465
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Low Voltage Transformer to Distribution Panel (LVSG) (12.7 kV - 480/277V)	4	CLF	$1,151.00	$1,073	$4,291
260519 Low Voltage Electrical Power Conductors and Cables					
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG	78	CLF	$790.00	$736	$57,319
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG GND	26	CLF	$791.00	$737	$19,131
DC Power Cable Conductors (Positive and Negative) - Charging Cabinet to Pantographs	94	CLF	$790.00	$736	$68,975
DC Power - Interlocl - #19AWG - Charging Cabinet to Dispenser	47	CLF	$78.00	$73	$3,405
DC Power - Ground - #6AWG - Charging Cabinet to Dipenser	23	CLF	$155.00	$144	$3,383
DC Power - Aux Power #12 AWG - Aux Panel to Dispenser	23	CLF	$78.00	$73	$1,703
DC Power - Aux Power #12 AWG GND - Aux Panel To Dispenser	12	CLF	$78.00	$73	$851
260539 Underfloor Raceways for Electrical Systems					
6" Metal conduit Utility Interrupter to Medium Voltage Switchgear/Transformer	66	LF	$79.50	$74	$4,890
6" Metal conduit Low Voltage Transformer to Distribution Panel (LVSG)	80	LF	$79.50	$74	$5,928

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
260536 Cable Trays For Electrical Systems					
Aluminum DC Cable Tray 18" wide	430	LF	$24.85	$23.16	$9,959
Aluminum DC Cable Tray 24" wide	430	LF	$28.20	$26	$11,301
Aluminum AC Cable Tray 24" wide	212	LF	$28.20	$26	$5,572
Liquid- Tite Flex	24	LF	$25.00	$23	$559
Medium Voltage Switchgear					
5 - Way 12.4 kV, 600A, 23 kAIC	1	EA	$70,000.00	$65,240	$65,240
Transformer					
Medium Voltage to Low Voltage Transformer , 3000 kVA	1	EA	$20,000.00	$18,640	$18,640
Low Voltage Distribution Panel/ Switchboard					
6000A, 480/277 V, 4W, 100 kAIC at 480 Vac	1	EA	$165,000.00	$153,780	$153,780
Grounding & Testing	1	EA	$7,500.00	$6,990	$6,990
DIVISION 27 - COMMUNICATIONS					
271323 Communications Optical Fiber Backbone Cabling					
DC Data/Communication 8x Glass Fiber	1,171	LF	$210.00	$196	$229,188
DIVISION 31 - EARTHWORK					
Trenching / Excavation					
Transformer to Column	3	CY	$8.85	$8	$26
Backfill trench					
Transformer to Column	3	CY	$4.25	$4	$13
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	3	CY	$14.80	$14	$44
DIVISION 32 - EXTERIOR IMPROVEMENTS					
321313 - Concrete Paving					
Transformer to Column	32	SY	$38.00	$35	$1,127
DIVISION 33 - EXTERIOR IMPROVEMENTS					
337119 Electrical Underground Ducts and Manholes					
Handholes, pre-cast concrete, with concrete cover	2	EA	$1,600.00	$1,491	$2,982
TO SUMMARY					**$725,975**

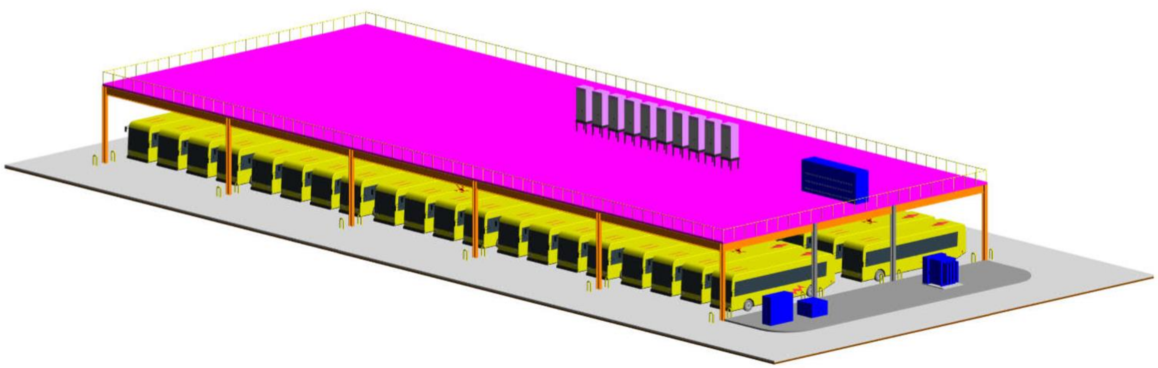
OVERHEAD SUPPORT STRUCTURE

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 03 - CONCRETE					
033053 Miscellaneous Cast-In-Place Concrete					
Regular concrete (4000 psi), 6" slab	7,500	SF	$4.56	$4	$31,874
321313.23 Concrete Paving Surface Treatment					
Conc. Pavement , fix form 24' pass, unreinforced , 8" thick	4,358	SY	$31.32	$29	$127,225
Reinforcing steel, 12 lb. / S.Y	4,358	SY	$7.32	$7	$29,734
DIVISION 05 - METALS					
050001 Miscellaneous and Ornamental Iron					
2' Wide U- Bollard	48	EA	$400.00	$373	$17,894
051200 Structural Steel					
Conduit support rack; galvanized	250	LF	$15.00	$14	$3,501
W12x120 Columns	236	LF	$202.00	$188	$44,336
W12x190 Columns	236	LF	$315.00	$294	$69,138
W8x8x1/8 Cross Bracing Columns / K- Bracing	180	LF	$71.43	$67	$11,983
W21x50 Beams (Platform frame Infill Beam)	1,250	LF	$90.00	$84	$104,850
W27x102 Beams (Open Frame Beam and Platform Frame Beam)	680	LF	$194.00	$181	$122,949
W24x 84 Beams (Open Frame Beam)	420	LF	$145.00	$135.14	$56,759
W27x146 Beams (Platform Frame Beam)	500	LF	$246.00	$229	$114,636
052119 Open Web Steel Joist Framing					
28LH09 Subframe Infill joist (panto only)	3,000	LF	$100.00	$93	$279,600
053113 Steel Floor Decking					
1.5" Steel Decking, 16 ga.	7,500	SF	$4.54	$4	$31,735
DIVISION 09 - FINISHES					
090007 Painting					
Prep & Paint columns & steel framing (not open web joists)	23,273	SF	$4.50	$4	$97,606
DIVISION 31 - EARTHWORK					
316326 Drilled Caissons					
Fixed end caisson pile, open, machine drilled, in stable ground, no casings or ground water, 48" diameter	720	LF	$134.00	$125	$89,919
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	217	CY	$14.80	$14	$2,992
BUSH MAIN- METAL RAILINGS					
055213 Railings, Pipe					
Galvanized, 1-1/2" diameter	560	LF	$67.00	$62	$34,969
Guard Rail	3	EA	$522.00	$487	$1,460
BUSH MAIN- METAL STAIRS					
055113 Metal Pan Stairs					
Metal Pan tread for concrete in-fill, picket rail 3'6" wide	105	Riser	$700.00	$652	$68,502
				TO SUMMARY	**$1,047,899**

FULL CONCRETE PLATFORM WITH 20 CHARGING DISPENSERS

EXECUTIVE SUMMARY

				TOTAL
A	**Charging Equipment**			$1,990,752
B	**Charging Infrastructure Support**			$725,975
C	**Support Frame**			$1,234,299
		Sub-total	-	**$3,951,026**
		Design Contingency	**20.0%**	$790,205
		Design Contingency sub-total		**$790,205**
				$4,741,231
	Markups			
	General Conditions and Requirements		12.0%	$568,948
	Insurance		0.75%	$35,559
	Bond		1.5%	$71,118
	Overhead and Profit		12.5%	$592,654
	Estimated Contract Award, Jan 2021			**$6,009,510**
	Pre- and Post-Construction Expenses ("Soft Costs")		1.7%	**$102,162**
	GRAND TOTAL			**$6,111,671**



CHARGING EQUIPMENT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
CHARGING EQUIPMENT					
DC Charging Cabinets and Pantographs					
DC Charging Cabinet - 150kW (includes DC switch)	10	EA	$124,000.00	$115,568	$1,155,680
Pantograph (includes charge control module)	20	EA	$27,000.00	$25,164	$503,280
Energy Storage					
Energy Storage Container - 2 MW (includes support equipment)	-	EA	$2,000,000.00	$1,864,000	$0
Installation					
Equipment Install - 20% of Equipment Cost	1		$331,792.00		$331,792

TO SUMMARY	**$1,990,752**

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 02 - DEMOLITION					
024119 Selective Demolition, Cutout					
Medium Voltage Utiity Switch / Interrupter to Transformer	720	CF	$36.00	$34	$24,157
DIVISION 03 - CONCRETE					
033000 Cast-In-Place Concrete (GC)					
Field surveys and verification	80	HRS	$95.00	$89	$7,083
033053 Miscellaneous Cast-In-Place Concrete					
CIP Concrete housekeeping pad					
at utility switch / Interrupter / XRFM curb	45	CY	$330.00	$308	$13,710
DIVISION 26 - ELECTRICAL					
260513 Medium Voltage Single Cables					
AC Utility Power Cable 750 Kcmil MV- 90 cable (1 set - 5 cables) - Interrupter to Medium Voltage Switchgear	1	CLF	$3,500.00	$3,262	$3,262
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Medium Voltage Switchgear to Low Voltage Transformer (12.7 kV - 480/277V)	2	CLF	$1,150.00	$1,072	$2,465
AC Power Cable 4/0AWG MV- 90 Cables (1 set - 5 cables) - Low Voltage Transformer to Distribution Panel (LVSG) (12.7 kV - 480/277V)	4	CLF	$1,151.00	$1,073	$4,291
260519 Low Voltage Electrical Power Conductors and Cables					
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG	78	CLF	$790.00	$736	$57,319
AC Power Cable - LV Dist Panel to Charging Cabinet #4/0 AWG GND	26	CLF	$791.00	$737	$19,131
DC Power Cable Conductors (Positive and Negative) - Charging Cabinet to Pantographs	94	CLF	$790.00	$736	$68,975
DC Power - Interlocl - #19AWG - Charging Cabinet to Dispenser	47	CLF	$78.00	$73	$3,405
DC Power - Ground - #6AWG - Charging Cabinet to Dipenser	23	CLF	$155.00	$144	$3,383
DC Power - Aux Power #12 AWG - Aux Panel to Dispenser	23	CLF	$78.00	$73	$1,703
DC Power - Aux Power #12 AWG GND - Aux Panel To Dispenser	12	CLF	$78.00	$73	$851
260539 Underfloor Raceways for Electrical Systems					
6" Metal conduit Utility Interrupter to Medium Voltage Switchgear/Transformer	66	LF	$79.50	$74	$4,890
6" Metal conduit Low Voltage Transformer to Distribution Panel (LVSG)	80	LF	$79.50	$74	$5,928

CHARGING INFRASTRUCTURE SUPPORT

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
260536 Cable Trays For Electrical Systems					
Aluminum DC Cable Tray 18" wide	430	LF	$24.85	$23.16	$9,959
Aluminum DC Cable Tray 24" wide	430	LF	$28.20	$26	$11,301
Aluminum AC Cable Tray 24" wide	212	LF	$28.20	$26	$5,572
Liquid- Tite Flex	24	LF	$25.00	$23	$559
Medium Voltage Switchgear					
5 - Way 12.4 kV, 600A, 23 kAIC	1	EA	$70,000.00	$65,240	$65,240
Transformer					
Medium Voltage to Low Voltage Transformer , 3000 kVA	1	EA	$20,000.00	$18,640	$18,640
Low Voltage Distribution Panel/ Switchboard					
6000A, 480/277 V, 4W, 100 kAIC at 480 Vac	1	EA	$165,000.00	$153,780	$153,780
Grounding & Testing	1	EA	$7,500.00	$6,990	$6,990
DIVISION 27 - COMMUNICATIONS					
271323 Communications Optical Fiber Backbone Cabling					
DC Data/Communication 8x Glass Fiber	1,171	LF	$210.00	$196	$229,188
DIVISION 31 - EARTHWORK					
Trenching / Excavation					
Transformer to Column	3	CY	$8.85	$8	$26
Backfill trench					
Transformer to Column	3	CY	$4.25	$4	$13
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	3	CY	$14.80	$14	$44
DIVISION 32 - EXTERIOR IMPROVEMENTS					
321313 - Concrete Paving					
Transformer to Column	32	SY	$38.00	$35	$1,127
DIVISION 33 - EXTERIOR IMPROVEMENTS					
337119 Electrical Underground Ducts and Manholes					
Handholes, pre-cast concrete, with concrete cover	2	EA	$1,600.00	$1,491	$2,982
TO SUMMARY					**$725,975**

OVERHEAD SUPPORT STRUCTURE

LOCATION	QUANTITY	UOM	RATE*	City Index	ADD
				93%	
DIVISION 03 - CONCRETE					
033053 Miscellaneous Cast-In-Place Concrete					
Regular concrete (4000 psi), 6" slab	25,250	SF	$4.56	$4	$107,310
321313.23 Concrete Paving Surface Treatment					
Conc. Pavement , fix form 24' pass, unreinforced , 8" thick	4,358	SY	$31.32	$29	$127,225
Reinforcing steel, 12 lb. / S.Y	4,358	SY	$7.32	$7	$29,734
DIVISION 05 - METALS					
050001 Miscellaneous and Ornamental Iron					
2' Wide U- Bollard	48	EA	$400.00	$373	$17,894
051200 Structural Steel					
Conduit support rack; galvanized	250	LF	$15.00	$14	$3,501
W12x190 Columns	471	LF	$315.00	$294	$138,276
W8x8x1/8 Cross Bracing Columns / K- Bracing	180	LF	$71.43	$67	$11,983
W21x50 Beams (Platform frame Infill Beam)	4,250	LF	$90.00	$84	$356,490
W27x102 Beams (Open Frame Beam and Platform Frame Beam)	600	LF	$194.00	$181	$108,485
W27x146 Beams (Platform Frame Beam)	1,000	LF	$246.00	$229	$229,272
052119 Open Web Steel Joist Framing					
28LH09 Subframe Infill joist (panto only)	-	LF	$100.00	$93	$0
053113 Steel Floor Decking					
1.5" Steel Decking, 16 ga.	25,250	SF	$4.54	$4	$106,840
DIVISION 09 - FINISHES					
090007 Painting					
Prep & Paint columns & steel framing (not open web joists)	40,211	SF	$4.50	$4	$168,646
DIVISION 31 - EARTHWORK					
316326 Drilled Caissons					
Fixed end caisson pile, open, machine drilled, in stable ground, no casings or ground water, 48" diameter	720	LF	$134.00	$125	$89,919
312020 Excavated Material Management and Disposal					
Disposal off site, assume clean but unsuitable	217	CY	$14.80	$14	$2,992
BUSH MAIN- METAL RAILINGS					
055213 Railings, Pipe					
Galvanized, 1-1/2" diameter	702	LF	$67.00	$62	$43,836
Guard Rail	3	EA	$522.00	$487	$1,460
BUSH MAIN- METAL STAIRS					
055113 Metal Pan Stairs					
Metal Pan tread for concrete in-fill, picket rail 3'6" wide	105	Riser	$700.00	$652	$68,502
				TO SUMMARY	**$1,234,299**